INSECT PEST MANAGEMENT
Cereal and Cash Crops

Volume 1

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FOREWORD

One of the most difficult thing in the world is transforming ideas and scribbles into an organized format. The present book is a testimony to the fact that Pakistani scientists have the capability and capacity to do so. With our own brand of ideas, beliefs, social values and a tendency to doubt the veracity of obvious, the present effort is a courageous and laudable step towards self-reliance in text books. It will help standardise and improve quality of education in plant protection and lessen dependency on foreign books. Although an onerous task, the book is based on the principle of inclusion of diverse experience and intellect in order to elicit a sense of national cohesion and identity-awaited for since the creation of Pakistan.

It is universally acknowledged that one of the factors that lead to the initiation and sustenance of the process of development is a sound footed education which is not possible without indigenous books.

The material presented is not a narration of the facts but a happening in which the real life situation about pest insects hitherto unrecognized has been subtly yet scholarly unfolded. There is a touch of futurism and a pinch of surrealism. The true aim is to achieve greater naturalism by exact analysis of diverse insect-plant interactions and available techniques to weaken this symbiosis.

After the publication of "Pests and Pesticides in Pakistan", this three volume book on Insect Pest Management is a breath taking sojourn into a realm of devotion and untiring stamina of Dr. Hashmi. The book symbolizes his perseverance, tenacity and insight about resolution of national issues.

It is a matter of great satisfaction to note that the book covers sufficient material to meet all the immediate and diverse demands of students, teachers, researchers, extension workers and above all progressive as well as small farmers and thus fulfills PARC mandate of dissemination of

knowledge. It is expected to bring a change in the style of thinking and acting of researchers and to facilitate wider practical application of the available knowledge to realities of life. This book will serve as a stimulus to further improvement of the principles and methods of integrated plant protection, and will further enhance the development of the new technologies for each and every crop and its zones of cultivation.

(Dr. Zafar Altaf)
Chairman
Pakistan Agricultural Research Council,
Islamabad

April, 1994

PREFACE

Global experience shows that even in the best managed agro-ecosystems where optimum levels of agro-chemicals and energy inputs are maintained the annual losses due to insects are as high as 20-30% of the total yield. These can be even higher for same crops in years of epidemic outbreaks.

Consequently one cannot seriously think of increasing the effectiveness and stability of agricultural production, unless the losses are reduced to minimum. Innumerable studies and practical experience has shown that adaptation of individual measures are insufficient to ensure long-term suppression of a number of harmful organisms. The great diversity of insect pests, the dynamics of their development and a whole range of susceptible commodities/crops, all make different demands on plant protection technologies.

During the last two decades three new concepts have entered the scenario of agricultural research in Pakistan. These are: Integrated Pest Management (IPM), Farming System Research (FSR) and National Coordinated Programmes (NCP) on various commodities.

There is also a group of researchers who have acquired specialized knowledge about different groups of organisms. Their knowledge and experience is equally useful for workers in IPM, FSR and NCP and it also sets a stage for inroads in research in the years to come.

All of these three themes require accurate, detailed and in-sequence information. For instance, for decision making in IPM, one needs proper diagnostics of all life stages of an insect, its life and seasonal history, host-plants and various options of control methods to subdue its population. For farming system research, the economic aspect of pre- & post-harvest pest control technology becomes a demanding element. And how the crops, and

animal husbandry technology should be meshed up for economically profitable, environmentally sound and socially acceptable endeavours? The commodity programmes for their successful optimization of yield aspect need a detailed information about the total insect pest complex of the crop and how the occurrence of various pest species is linked with the phenology of each crop. Is there any carry over of the pests on a commodity from one season to the other? What will be possible insect pest scenario under intensive agriculture?

In the educational institutions most of the teaching in entomology is carried along the taxonomic lines or individual pests are discussed as information communication unit. Thus, there are different groups of clients with different demands for information.

In this book, therefore, an effort has been made to meet the needs of all groups by apportioning the book into insect pests attacking agricultural crops, forests, stored grains, some special groups of insects and mites on which useful work at national level has been done. To these some material has also been added on the entomological industries e.g. apiculture, sericulture and lac culture.

The book tends to provide mostly the basic information and does not cover an extensive review of each and every insect. Part of this is that most research papers dealt with dose estimations of different insecticides, some of which never got into the recommendation domain. Thus, large number of research papers of this kind could not be utilized. The Fundamentals of General and Applied Entomology have been discussed in a separate book and it is expected that both books will be utilized simultaneously to reinforce the materials' utility.

March, 1994

Ali Asghar Hashmi

ACKNOWLEDGEMENTS

Credit for initiating the idea of writing indigenous text and reference books in various disciplines of agriculture goes to Dr. Amir Muhammed, who always motivated and encouraged the scientists to make efforts in line with national needs and aspirations. This book also owes debt to his inspiring imagination. Dr. Zafar Altaf, who believes in originality, creativity, pragmatism and dynamism, immediately sanctioned the necessary funds as soon as three-volume manuscript was presented to him for publication. A deep sense of gratitude is expressed for the kindness of both of them.

During the preparation of this book Mrs. Afzala Tashfeen, (Scientific Officer) and Mr. Gul Zaman, (P.A) gave lot of their time for proof reading, correcting and retyping of the manuscript, respectively. Mr. Javed Iqbal, Senior Scientific Officer, assisted in preparation of species index. The book got into the presentable form due to help in editing by Ms. Sabira Hussain.

It would not have been possible to give final shape to the book and ultimately publish it without technical input of the Directorate of Publications, PARC. The staff of the Directorate finally edited the manuscript before and during composing in frequent consultation with the author. They also designed and determined the format of three volumes of this publication and finally read and checked the composed manuscript, besides technically supervising their printing. In this context, the input rendered by Malik Mushtaq Ahmad, Mr. Nassar Iqbal, Mr. Afzaal Haider and Mr. Abdul Ghaffar is respectfully acknowledged.

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Such a stupendous task of writing a book could not have been possible without the patience of my wife Munazza Hashmi and my little loving son Kamal Asghar Hashmi.

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Chapter 1

INSECT PESTS OF PADDY CROP

Ali Asghar Hashmi*

Paddy crop in Pakistan is infested by 69 insects, which inflict about 15 to 17% loss on recurrent basis. Stem borers, leaf hoppers, plant hoppers and grass hoppers are of regular occurrence. The leaf eating caterpillars, mealy bugs, rice hispa, etc., occur periodically or as and when conditions are conducive for their population build up and spread. Some researchers have published a long list of insects as pests, which even exceeds 120 species. Actually these could be the insects associated with paddy crop but not necessarily to be categorised as pests. Significant insect pests are listed below:

STEM BORERS

Four species of stem borers are common in Pakistan. These vary in severity of damage and population. These are:

1. The yellow stem borer: *Scirpophaga incertulas* (Walker) (Pyralidae: Lepidoptera)
2. The striped stem borer: *Chilo suppressalis* (Walker) (Pyralidae: Lepidoptera)
3. The white stem borer: *Scirpophaga innotata* (Walker) (Pyralidae: Lepidoptera)
4. The pink stem borer: *Sesamia inferens* (Walker) (Noctuidae: Lepidoptera)

Stem borers are by far the most pervasive and injurious insects to rice crop. These also can devastate the crop to any imaginable extent.

The following four species are also come across at times:

5. Sorghum stem borer, *Chilo partellus* (Swinh.) (Noctuidae: Lepidoptera)

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6. Dark-head rice borer, *Chilo polychrysa* (Meyr) (Noctuidae : Lepidoptera)
7. Pink stem borer, *Sesamia uniformis* Ddg. (Noctuidae: Lepidoptera)
8. The Cossid moth, *Zeuzera* sp. (Cossidae: Lepidoptera)

SUCKING INSECTS

Insect species which suck the sap of the rice plant are mentioned below:

1. Green leafhopper, *Nephotettix nigropictus* (Stal.) (=*N. apicalis*) (Cicadellidae: Hemiptera)
2. Green leafhopper, *Nephotettix virescens* (=*impicticeps*) Ishihara (Cicadellidae : Hemiptera)
3. Green leafhopper, *N. cintticeps* (Cicadellidae: Hemiptera)
4. White-backed planthopper, *Sogatella furcifera* Horv. (Delphacidae: Hemiptera)
5. White-backed planthopper, *Sogatella catoptron* Fennah. (Delphacidae: Hemiptera)
6. Maize leafhopper, *Cicadulina bipunctella* Mats. (Delphacidae: Hemiptera)
7. Maize leafhopper, *Balclutha* sp. (Delphacidae: Hemiptera)
8. Paddy white leafhopper, *Cofana (Tettigella) spectra* (Distant) (Cicadellidae: Hemiptera)
9. Rice bug, *Leptocorisa acuta* Thunberg (Coreidae: Hemiptera)
10. Rice bug, *L. oratorius* Fabricius. (Coreidae: Hemiptera)
11. Rice bug, *Leptocorisa varicornis* Fabricius (Coreidae: Hemiptera)
12. Rice bug, *Riptortus linearis* (Fab.) (Coreidae: Hemiptera)
13. Rice Mealy bug, *Ripersia oryzae* Fabricius (Pseudococcidae: Hemiptera)
14. Green stink bug, *Acrosternum.* (=*Nezara*) *graminea*
15. Black paddy bug, *Scotinophora coarctata* (Thunberg)
16. Black paddy bug, *Creontiades pallidus* Ramb. (Pentatomidae: Hemiptera)
17. Maize leaf aphid, *Rhopalosiphum maidis* (Fitch) (Aphididae: Hemiptera)

LEAF FEEDERS

Caterpillars

1. Rice army worm, *Mythimna (=Pseudaletia = Leucania = Cirphis separata (=unipuncta)* (Wlk.)

2. Rice swarming caterpillar, *Spodoptera (= Prodenia) mauritia* (Boisduval)
3. Paddy cutworm, *S. cilium* Gn.
4. Cotton cutworm, *S. litura* (Fabricius)
5. Black or greasy cutworm, *Agrotis ipsilon* (Hfn).
6. Gram cutworm, *A. segetus* (Schiff)
7. Cabbage semi-looper, *Diachrysia orichalcea* (F.)
8. Hairy caterpillar, *Euproctis (=Porthesis) fraterna* Moore
9. Hairy caterpillar, *E. xanthorrhoea* (Kollar)
10. Hairy caterpillar, *E. virguncula* Walker
11. Hairy caterpillar, *E. cervina* Moore
12. Hairy caterpillar, *Daschira securis* Hubner
13. Hairy caterpillar, *Psalis pennatula* F. (Noctuidae: Lepidoptera)
14. Rice leaf roller/folder, *Cnaphalocrocis medinalis* (Guenee) (Pyralidae: Lepidoptera)
15. Rice leaf roller/folder, *Brachmia arotraea* (Meyr) (Gelechiidae: Lepidoptera)
16. Rice caseworm, *Nymphula depunctalis* (Guenee) (Pyralidae: Lepidoptera)
17. Jute hairy caterpillar, *Diacrisia obliqua* Walker. (Arctiidae: Lepidoptera)
18. Arctid moth, *Creatonotus gangis* L. (Arctiidae: Lepidoptera)
19. Rice skipper butterfly, *Panara (=Pelopides) guttata* Bremer and Grey (Hesperiidae: Lepidoptera)
20. Rice skipper butterfly, *Pelopides mathias* (Fabricius) (Hesperiidae: Lepidoptera)
21. Rice skipper butterfly, *Tephrina disputaria* Gn. (Hesperiidae: Lepidoptera)

Grasshoppers and Crickets

1. Rice grasshopper, *Hieroglyphus banian* F. (Acrididae: Orthoptera)
2. Rice grasshopper, *H. nigrorepletus* Bolivar (Acrididae: Orthoptera)
3. Small grasshopper, *Oxya multidentata* (Will.) (Acrididae: Orthoptera)
4. Small grasshopper, *O. chinensis* Thunberge (= *O. velox*) (Acrididae: Orthoptera)

5. Short-horned grasshopper, *Attractomorpha acutipennis* (Guer) (Acrididae: Orthoptera)
6. Short-horned grasshopper, *Eyprepacnemis plorans* (Charp.) (Acrididae: Orthoptera)
7. Short-horned grasshopper, *Shirakiacris shirakii* (I. Bol.) (Acrididae: Orthoptera)
8. Surface grasshopper,*Aiolopus tamulus* (Acrididae: orthoptera)
9. Surface grasshopper, *Chrotogonus trachypterus* Blanchard (Acrididae; Orthoptera)
10. Long-horned grasshopper, *Trigonocorpha* sp. (Tettigonidae: Orthoptera)
11. Mole cricket, *Gryllotalpa orientalis (=africana)* Burmeister (Gryllotalpidae: Orthoptera)
12. House cricket, *Acheta domesticus* (Linnaeus) (Gryllidae: Orthoptera)

Beetles and Weevils

1. Leaf eating beetle, *Cylindrothorax ruficollis* F. (Meliodae: Coleoptera)
2. Lightening beetle, *Idgia flavibuccis* Baurg (Prionoceridae: Coleoptera)
3. Flea beetle, *Chaetochnema basalis* Bally (Chrysomelidae: Coleoptera)
4. Flea beetle, *Haltica cyanea* Weber (Chrysomelidae: Coleoptera)
5. Flea beetle, *Phyllotreta chotanica* Duvi. (Chrysomelidae: Coleoptera)
6. Cotton weevil, *Myllocerus sabulosus* Mohi (Curculionidae: Coleoptera)
7. Rice weevil, *Myllocerus discolor* Bohr (Curculionidae: Coleoptera)
8. Paddy root weevil, *Hydronomidius molitor* Fst. (Curculionidae: Coleoptera)

STORED GRAIN INSECTS

1. Rice weevil, *Sitophilus oryzae* (L.) (=*Calandra oryzae* L.) (Curculionidae: Coleoptera)
2. Lesser grain borer, *Rhyzopertha dominica* (F.) (Bostrichidae: Coleoptera)

3. Red flour beetle, *Tribolium castaneum* Herbst. (Tenebrionidae: Coleoptera)
4. Confused flour beetle, *T. confusum* J. Duval (Tenebrionidae: Coleoptera)
5. Saw-toothed grain beetle, *Oryzaephilus surinamensis* L. (Tenebrionidae: Coleoptera)
6. Long-headed flour beetle, *Latheticus oryzae* Waterhouse. (Tenebrionidae: Coleoptera)
7. Khapra beetle, *Trogoderma granarium* (Everts) (Dermestidae: Coleoptera)
8. Cadella beetle, *Tenebriodes mauritanicus* L. (Tenebrionidae: Coleoptera)
9. Angoumois grain moth, *Sitotroga cerealella* Olivier (Gelechiidae: Lepidoptera)
10. Indian meal moth/meal' worm moth, *Plodia interpunctella* Hubner (Gelechiidae: Lepidoptera)
11. Rice meal moth, *Corcyra cephalonica* Stainton (Gelechiidae: Lepidoptera)

MISCELLANEOUS

Shootflies and gall midges

1. Paddy shoot fly, *Atherigona oryzae* Mall (Muscidae: Diptera)
2. Sorghum shoot fly, A. soccata Rond (Muscidae: Diptera)
3. Rice gall midge, *Pachydiplosis oryzae* (W.M.) (Cecidomyiidae: Diptera)
4. Rice gall midge, *Animala dilatata* Arrow (Cecidomyiidae: Diptera)
5. Rice gall midge, *A. dorsalis* F. (Cecidomyiidae: Diptera)

Thrips

1. Rice thrips, *Thrips* sp. (Thripidae: Thysanoptera)

Scirpophaga incertulas Walker **(Pyralidae: Lepidoptera**
(Yellow stem borer or paddy borer)

Synonyms: *Schoenobius incertellus, S. bipunctifer, S. punctellus* and *S. minutellus.*

DIAGNOSTICS

Egg: Colour creamy white, translucent at first, darkening during development, shape oval, flattened or elliptical, laid in clusters of 15-80 on the upper surface of leaf blades. Egg masses oblong covered with soft silky light brown buff coloured hairs. The number of eggs per female is 80-150, with an average of 100. An egg batch is 7 mm long and 3 mm wide, each egg measuring 0.14 x 0.11 mm.

Larva: General body colour ivory to greenish, full grown larva pale or yellowish white or with greenish tinge; head capsule orange yellow, worm like in appearance, tapering posteriorly from the first abdominal segment, head smaller in size as compared to body. Body shape slender, surface texture velvety. Average size 20-25 mm, body width 3 mm. There are four larval instars. It makes an exit hole and pupates within the larval tunnel, usually at the base of the plant in a white silken cocoon.

Pupa: General body colour pale-white or flesh to yellowish white, tinged green; distal margin of labrum slightly to markedly indented in middle; wing rudiments of female pupa with dark central mark.

Female pupa: Length 14.5 - 18.00 mm, diameter 2.5-3.00 mm
Male pupa: Length 11.5 - 15.00 mm, diameter 2.0 - 2.5 mm
Female bigger than male. Cocoon white, larger than length of pupa, measuring 18.0 - 20.0 mm

Adult: Shape pointed, body colour light brown (= straw) with brownish dots well-scattered, 5 black patches along submarginal area and 8 to 9 black dots near tip. Female progressively yellow from base to tip with central black dot. Hind wing pale straw. The diagnostic given by Chaudhry (1975) is black spot in the middle of yellowish fore wing.

Male: General body colour pale yellow, antennae filiform, notched and tufted on clavola, forewing brownish ochre with an indistinct black spot at the lower angle of the cell, an opaque brown band and a marginal row of black dots, a black spot in the middle, hind wings white.
Body length 10-13 mm, Fore wing span 21-22 mm and Hind wing span 15-16 mm.

Female: Antennae filiform. Fore wing orange yellow with a prominent black dot, hind wing light fuscous, oval, end of abdomen furnished with hairs.

Body length: 15-16 mm, Fore wing span: 30.00 mm and Hind wing span: 20.00 mm.

DURATION OF LIFE STAGES

According to Grist and Lever (1969) egg 8 (7-10), larva 40(35-46), pupa 8(6-10) and adult 4-5 days, respectively.

According to Chaudhry (1975), egg 6-7, larva 12-27, pupa 9-12 and adult 5-7 days, respectively.

ACTIVITY PERIOD

The light trap catches in Sindh during 1973 revealed that the yellow stem borer has been predominent and passed through five generations with their peaks on mid April, 2nd week of August, 1st and 4th weeks of September and 2nd week of October. The emergence of moths stopped around the end of October and the larvae entered hibernation in the crop stubbles (Mahar and Bhatti, 1974).

The moths emerge from the overwintering larvae after pupation in the end of March or beginning of April and remain active from April to October thus passing through 4-5 generations in this period (Chaudhry, 1975).

In Punjab the moths are most abundant during April-May and August-October and their population was negligible during June and July. The third period of abundance is from mid August to mid October (Dar and Majid, 1975).

According to Nayar *et al.* (1976) three to five (average four) generations or broods of the yellow stem-borer occur in South India. The period from October to December is characterized by cold weather, high humidity and low temperature, the environmental factors which are of crucial importance. In sum this borer is active from April to October and hibernates as full-grown larvae in rice stubbles from November to March. Pupation occurs in March in stubbles and the moths emerge in April. The pupal period is 7 to 11 days. The moths do not feed. They live for 4-10 days to perform reproductive function. A female usually lays a total of 12-150 eggs on the lower side of leaves. Eggs hatch in 6 or 7 days. The larvae pass through six instars in 16-27 days. The mature larvae cut an exit hole in the stem of the paddy plant above the water level in the field before becoming pupae. A complete life-cycle is spread over 35-71 days. There are four to five overlapping generations in a year. The yellow stem borer besides paddy, also attacks "dib", as an alternate host plant.

NATURE OF DAMAGE

After hatching the young larvae roam about for some'ime on the plant surface. They get dispersed with the aid of silken threads and wind. After about 24 hours, they enter into the stem from the upper node and eat their way down to the nodes below. Only one larva enters one plant. After destroying one plant the larvae migrate to other plant, generally, through a leaf boot. The initial boring and feeding by the larvae in the leaf sheath causes broad longitudinal whitish discoloured areas at feeding sites but only rarely does it result in wilting and drying of the leaf blade. About a week after hatching, the larvae from the leaf sheaths bore into the stem, stay in the pitch and feed on the inner surface of the walls. After entering the stem, the larva usually seals the entrance hole with threads so that the water does not enter the plant. The plants are easily broken at points where stems have been hollowed. Such a feeding frequently results in a severing of the apical parts of the plant from the base. When this kind of damage occurs during the vegetative phase of the plant, the central leaf whorl does not unfold, turns brownish, and dries up, although the lower leaves remain green and healthy. This condition is known as dead heart and the affected tillers dry out without bearing panicles. When the plant dies after dead heart formation, the larva may come out of it and enter fresh plants. In case the panicles have been initiated, severing of the growing plant parts from the base results in the drying of the panicles; they may not even emerge at all, and those that have already emerged do not produce grains. Such a damage is easy to recognize as the panicles being empty are very conspicuous in the field. They remain straight and are whitish. Because of whitish colour these are called white heads. If the panicles are severed at the base after grain formation has been partially completed, shrivelled grains are formed. The loss caused to rice production by this pest varies between 3 and 95 percent.

It has been experimentally demonstrated at IRRI by Pathak (1968) that plants can compensate for a low percentage of early dead hearts, but for every percent of white heads one to three percent loss in yield may be expected.

The Chinese equivalents for dead hearts and white heads are rotten core and pale spike, respectively; in the latter case the immature grains are unable to develop (Grist and Lever, 1969).

The full grown larvae pupate inside the stem in its basal portion. The pupation point is usually slightly above the roots of the paddy plant or sometimes near the upper layer of soil. And before pupating a larva cuts a hole in

the side of the stem and plugs it with a thin webbing to serve as an exit for the emerging moth. The damage by borer is less in the early crop but, due to increase in pest population as the season advances, it is heavy in the late crop like basmati (Chaudhry, 1975).

CONTROL METHODS

Cultural: Several cultural practices are known to have a profound bearing on the yellow stem-borer's population.

1. ARC (1973) recommended that nursery should not be sown before 20th May in Punjab (Dar and Majid, 1975) and 10th May in Sindh. Transplanting should be completed by 7th August in Punjab and at the end of July in Sindh. It could be said that if the age of the nursery is strictly restricted to between 30-35 days, no stem-borer is transferred to the transplanted crop. Borer incidence is higher in wider spaced seedlings than in closer planting (Grist and Lever, 1969).
2. Last date for transplanting in the field is 7th August for Punjab and 15th July for Sindh. This regulation is necessary for the protection of rice crop. Crop transplanted after this date gets a heavy infestation and its yield is also appreciably reduced (Chaudhry, 1975). However, the dates should be kept under review every year so that they coincide with the most critical period of the pest; as the life cycle could fluctuate with the ecological and meteorological changes (Ghouri, 1975).
3. Since the eggs of *S. incertulas* are laid near the tip of the leaf blade, clipping the seedling before transplanting a widely practiced procedure, greatly reduces the carry over of eggs from seed bed to the transplanted fields. Likewise, discarding of seedlings with dead hearts at the time of transplanting rice is a useful practice.
4. In Pakistan it has been found that the borers occur upto 9 inches deep in the stubbles, therefore, harvesting at ground level to remove majority of the larvae is suggested. It is believed that close harvest near the soil level wipes out the larvae from the field as they are carried with the straw and destroyed.

Routine methods of control formerly advocated were, flooding during December-January for 5 days, deep ploughing (often followed by flooding, which induces rottening of stubbles), burrying or burning of stubbles and delayed planting to minimize attack (Mahar and Bhatti, 1974).

Pathak (1968) suggested the decomposing of stubbles with low rate of calcium cyanide.

It must be emphasized that the last date for destruction of stubbles in each ecological zone of the country should be fixed by the entomologists concerned, keeping in view the meteorological data, biology of the pest, cultural practices in vague, and water supply, etc.

5. Clean cultivation and crop rotation were practiced to deny a continuous food supply to the insects. *Rabi* crop following rice, particularly wheat should be given nitrogenous fertilizers.

6. Rice sprouts in rabi crop or in stubble field should be collected and burnt because these provide food to the succeeding generation of months emerging from hibernating larvae during the month of March.

7. Sowing of berseem crop in the rice stubble field should also be discouraged since 90 percent of the hibernating larvae survive in the berseem field (Ahmed, 1975).

Mechanical: 1. This comprises destruction of egg masses, crushing them on the leaves, or their removal with the leaf tips. Records show that it may take one day to collect the eggs from only half an acre in fairly badly attacked fields. In Sen-Shu county (Szechwan) 7 million egg-massess were collected in 1939 (Grist and Lever, 1969).

2. Use of light traps in the transplanted paddy field and in the nurseries.

3. Picking and destroying of egg masses and dead hearts (ARC, 1973).

4. Chaffing of rice straw during winter to kill hibernating larvae.

5. Use of light traps on large scale during August and October on dark nights to be adopted as a regular practice.

6. Regular field scouting particularly during the period from 3rd week of August to 1st week of October should be done for checking the pest population on transplanted crop (Ahmed, 1975).

Chilo suppressalis (Walk) **(Noctuidae: Lepidoptera)**

(Striped rice stem borer)

Synonyms: *Crambus suppressalis, Chilo simplex, Chilo oryzae.*

DIAGNOSTICS

Egg: Eggs are scale like, white translucent when freshly laid and become dark as they approach near hatching. These are laid in clusters (=arranged in a thin elliptical plate) of 60-70 each and are not covered with hairs. A female lays about 300 eggs in masses of variable size on upper surface of leaf blades

along the mid-rib near the basal half, or on the under-surface of leaf sheath. Eggs hatch in 5-6 days.

Larva: Larva is greyish brown with a yellowish-brown head. There are three faint dorsal and two lateral, longitudinal brownish stripes. The full grown larva measures about 26 mm long.

Pupa: It is light brown, or reddish brown in colour. Measures 11-13 mm long and 2.5 mm broad.

Adult: General colour dirty brown. Fore wings uniform pale yellow and without any cluster of minute specks in the center. Hind wings are yellowish white with a ring of silken hairs along the cubital veins. Wings have dark spots arranged laterally near the tip of each wing. Measures 13 mm in length, with a wingspan of 23-30 mm. Females may measure upto 35 mm. Longevity 5-8 days.

DURATION OF LIFE STAGES

The eggs hatch in 5-6 days. The newly-hatched larvae feed a little on the leaf blade and leaf sheath, then they bore into the stems. The larvae have a tendency to congregate in a few tillers during the early instar period but later transfer from one tiller to another. The larvae become full-grown in 30-33 days after hatching and are 26 mm long and 2.5 mm broad. The mature larvae pupate within the rice stems, (=inside the larval tunnel) either near the middle or in the basal internode. The pupal phase lasts 5-6 days. The hibernating larvae remain in stems or stubbles after the crop harvest. The adults live for three to five days. The entire life-cycle is completed in 43-52 days. There are four generations in a year. This borer has also been recorded on maize and some wild grasses.

NATURE OF DAMAGE

Larval damage consists of boring in the stem resulting in 'dead-hearts' in the young plants and damaged stems in older plants. One caterpillar may destroy upto 10 plants.

CONTROL METHODS

Cultural and Biological: Clean cultivation is probably sufficient for control purposes in many areas, but in areas of intensive cultivation losses can be high. Where rice is grown under fairly natural conditions, levels of parasitism are usually high and it is often preferable to avoid the use of pesticides, for they may destroy more parasites than the pests themselves.

Chemical: Foliar sprays of parathion, and parathion methyl are successful, but their mammalian toxicity is too high for safe use on a large scale. Endrin, dieldrin, trichlorphon, dichlorvos and diazinon have also been successful, but several applications at weekly intervals are required. In India application of combination of lindane and carbaryl, each at 3 kg/ha, at 30 and 15 days intervals, respectively, gives appreciable control of the pest.

Note: In the literature *Chilo suppressalis* (Walk) as well as *Chilo polychrysa* (Meyr) have been reported as borers of paddy. The taxonomic status of these being same or different species and whether or not these occur in Pakistan needs to be verified.

Scirpophaga innotata (Walker) **(Pyralidae: Lepidoptera)**
(White stem borer)

DIAGNOSTICS

Egg: Colour creamy white, oval in shape but slightly flattened, laid in clusters (imbricated rows) on leaf blades, egg masses oblong covered with silky light brown hairs (some say greyish hairs), each egg measuring 0.14 mm x 0.11 mm resemble eggs of *S. incertulas* both in appearance and nature of covering.

Larva: Elongate, milky white with a well-divided prothoracic shield; full-grown larvae pale white or yellowish white or with green tinge, head orangish yellow. The distinct dark stripe seen on the back is actually the alimentary canal. Body length 25 mm.

Pupa: The only distinct morphological difference of *S. innotata* pupa from that of *S. incertulas* is confined to the distal margin of labrum which is either straight or slightly convex genae somewhat protuberant and shinning. Colour pale white, enclosed in a white silken cocoon. Wing rudiments of female pupa without dark central mark.

Female pupa: Length 14.5 mm - 19.5 mm diameter 2.5 - 3.5 mm

Male pupa: Length 12.5 mm - 14.5 mm; diameter 2.5 mm

Adult: Moth is slender, white and similar to the yellow stem borer, except for its orange (=pinkish) anal tuft of hairs, the absence of black spot on each wing, and the prominent black antennae. The antennae may appear white if coated with white scales from the wings.

The body colour alone serves to distinguish it from any other lepidopterous pests of paddy in Asia (Grist and Lever, 1969).

Male: White with an orange anal tuft of hairs. Smaller than the female (Chaudhry, 1975).
Wing span: 18 mm - 24 mm (Grist and Lever, 1969).

Female: Pure white with an orange anal tuft of hairs. Span 26 mm - 30 mm (Grist and Lever, 1969). Female bigger than male (Chaudhry, 1975).

DURATION OF LIFE STAGES

Egg 4-9 days, larva 25-31 days, pupa 7-11 days, adult 4-14 days; complete life cycle giving a normal cycle of 5-7 weeks (Grist and Lever, 1969). Chaudhry (1975) has reported, egg 6-7 days, larva 12-27 days, pupa 9-12 days and adult 5-7 days.

ACTIVITY PERIOD

In Java, *S. innotata* reaches pest status only in the low lands, i.e. upto 200 metres above sea level, where the monthly rainfall at the end of the dry season (October-November) is less than 200 mm (Grist and Lever, 1969). Chaudhry (1975) has commented the same as far *S. incertulas*.

NATURE OF DAMAGE

Larval injury to the internodes results in the same kind of dead hearts and white ears as for *S. incertulas*. Besides rice, it also attacks millets, sugarcane, wild rice and weeds.

In Java, the exceptionally high loss of 90 to 95 percent white ears had been recorded, such damage caused during the pre-flowering period, becomes obvious by means of its colour when the crop ripens. One larva may destroy upto six young plants. In Northern Territory of Australia the average incidence of dead heart damage is 11 percent (Grist and Lever, 1969).

CONTROL METHODS

Cultural: 1. Late planting is recommended in the Northern Territory of Australia so as to avoid oviposition by the main generation of moths which will have died by the time the seedlings are established.
2. Delaying time of sowing until after the main flights of the moth may be helpful.

3. Light trapping results in attracting more males than females.
4. Cutting the stubbles to a height of about 5 inches will isolate the larvae (Grist and Lever, 1969).

Mechanical: Collection of egg masses in the nursery gave good control (Grist and Lever, 1969). ARC (1973). Ahmed (1975) and Chaudhry (1975) reported the same mechanical measures as for *S. incertulas*.

Sesamia inferens Walker (Noctuidae: Lepidoptera)

(Purple stem borer, violet stem borer or pink stem borer)

Synonyms: *Lecucania inferens* Walker, *Nonogria inferens* Walker

DIAGNOSTICS

Egg: Colour creamy white when freshly laid, changes to brownish and ultimately to grey before hatching; shape hemispherical (= globular), shell with fine ridges running in regular order down to sides from the top; creamy white to flesh coloured flutings quite evident on the surface.

The eggs are laid in rows (3-8) on the inner side of leaf sheath and stem, and are difficult to detect. The eggs are not covered with hairs. The number of eggs per batch being 30-100 and the size of each batch 2-8 mm. Each egg approximately measures 0.6 mm x 0.4 mm. A single female could lay 400 or more eggs on one plant. The incubation period may be 7-17 days depending upon the season.

Larva: General body colour of freshly hatched larvae pale yellow, cervical region and anal plates dark brown, prothoracic shields pithy black. Head relatively larger than thorax, body tapering posteriorly.

Length 1.6 mm. Full-grown larva has glossy surface texture, is pale yellow with a purple tinge, head dark or orange red; a pair of caudal appendages at tip of abdomen, some authors say larva is distinctly segmented with two conspicuous posterior appendages. Length 24 mm - 29 mm; diameter 3 mm - 4 mm. Larval stage is completed in 1-2.5 months depending upon weather conditions.

Pupa: General body colour reddish brown or dark brown, head with purple tinge; anterior end of pupa with a characteristic blue powder; ventrum light brown, cremaster at caudal end with 4 spines. Male 12.5 mm long and 2.00

mm in diameter; Female 18.00 mm long and 4.00 mm in diameter. Pupation takes place either in the bore or under a leaf sheath where caterpillar was already living. Quite a number of larvae may be grouped together under same leaf for pupation. Pupa is enclosed in a case made up of finelly shreded minute pieces of stem of its food plant. Before pupation the larvae cut out a hole through leaf sheath for emergence of the moth.

Adult: Body stout, broad-shouldered, fawn coloured; (some describe it pale brown), head densely covered with hairs. Fore wing ochreous with faint rufous tinge, three black discal dots and an intermediate brown stripe, speckled with red brown along median vein and near apical angle. Hind wing and thorax white, legs brownish grey; abdomen whitish to brownish yellow but paler than thorax. Wing span 16-20 mm in male, 20-31 mm in female.

Male: General body fawn coloured or pale brown; head densely covered with hairs; antennae pectinate, thorax white, legs brownish grey. Fore wing ochreous with faint rufous tinge, evenly rounded at the outer margins and furnished with a transverse dark marginal line, three black discal dots and an intermediate brown stripe, span 28 mm. Hind wings white, span 20 mm. Abdomen whitish to brownish yellow.

Body length 14 mm. The adult male with fully expanded wings measures about 1 inch. Male smaller than female.

Female: General body fawn coloured, head covered with dark brown hairs; antennae filiform; legs brownish grey. Fore wings ochreous with faint rufous tinge, evenly rounded at outer margins and furnished with a transverse dark marginal three black discal dots and an intermediate brown stripe, span 35 mm. Hind wing white, span 23 mm.

Abdomen whitish to brownish yellow, paler than thorax. Adult female with fully expanded wings measures about 1 inch. Female bigger than male.

DURATION OF LIFE STAGES

The eggs hatch on an average in 7 (6-10) days depending upon the weather conditions, the larval life from eclosion to pupation is 36 (28-56) days. It undergoes 5-7 moults. Pupal stage occupies 10 (8-11) days (Grist and Lever, 1969). The pupation takes place either inside the stem or in between the stems and leaves. The adults live for 5 (4-6) days. The entire life cycle is completed in 46-85 days.

ACTIVITY PERIOD

In Pakistan it is active from March-April to November. In places where wheat is planted after rice or in fields adjacent to paddy, it may migrate on to wheat crop. It has been recorded on sorghum, maize, sugarcane (in NWFP) and on many wild grasses.

Four generations are known in Mysore where the adult life is about 4.5 days in males and 6.5 days in females (Grist and Lever, 1969).

This insect does not hibernate in winter, when the alernate host plants are available (Halimie and Iqbal 1974) rather it maintains certain degree of activity throughout the year. There are 4-6 generations.

NATURE OF DAMAGE

The tiny gregareous larvae on hatching from eggs feed on the leaf sheath (epidermal layer) which is decolourized and ultimately dries up. Later on it penetrates within the shoots. The larvae either bore into the stem of a plant (rice or wheat at an early stage of growth or a dead heart is formed due to drying up of the inner most whorl of leaves. It can be easily pulled out. Up to 20 percent of the shoots are thus damaged by this pest. But when the larvae bore into the plant at earing stage, the white heads (ears without grains) are formed. The larvae enter the stem at any point, (from side to top) boring through the nodes to tunnel in the stem which may collapse and dead hearts may thus develop.

In Vietnam upto five larvae have been recorded in a single stem, and several plants are often injured by migration of one larva (Grist Lever, 1969).

The eggs are laid in loosely adhering strings in several rows side by side on the inner surface of the leaf sheath where the margins overlap. They are not covered with hairs. Pupation usually takes place between the stem and leaf sheath.

The damage is less in early crop, but due to increase in pest population as the season advances, it is heavy in the late crop. A number of plants may be damaged by a single caterpillar, as the larvae could leave the old tunnels and prepare fresh ones. They are thus even termed as voracious. The larvae are also found in ears of wheat and rice.

HOST PLANTS

Mainly rice and maize are damaged, but it is also a pest of wheat and occurs on grasses, barley and sugarcane, causing about 1% damage, to the cane.

CONTROL METHODS

Cultural: 1. Earthing-up may kill young larvae, but their destruction by ploughing the stubbles is more important (Grist and Lever, 1969).
2. Latif and Bux (1954) noted that an off-season cultivation comprising of two ploughings with desi plough could cause 91-97% mortality of rice bores; whereas a fallow land showed only 66% mortality.

Mechanical: 1. *Clean Cultivation:* Weeds should, as far as possible, be eliminated from fields during early growth of the rice. When hand weeding is practised, the weeds should be burnt or burried to destroy eggs or larvae they harbour.
2. *Removal of Attacked Shoots:* As one larva can destroy several shoots, systematic cutting-out of dead hearts during the establishment of a new plantation and during early ratoon growth serves to minimize damage. It is important, however, to locate shoots which show early signs of attack. Those with central leaves completely dried out will contain few bores and their collection serves little purpose. The collected shoots should be destroyed to kill the borers they contain (Williams *et al.* 1969)
3. Picking and destroying of egg masses and dead hearts.
4. Use of light traps in the transplanted field (ARC, 1973).
5. Chaffing of rice straw during winter is also suggested to kill hibernating larvae which continue feeding even in dried straw.
6. Regular field scouting particularly during the period from 3rd week of August to 1st week of October should be done for checking the pest infestation on transplanted crop (Ahmed, 1975).

Chilo polychrysa (Meyr) **(Pyralidae: Lepidopetra)**
(Dark-head rice borer)

Egg: Eggs are scale like in appearance and are laid in batches of 30-200 in rows along the under surface of leaves. Hatching takes place after 4-7 days.

Larva: There are six larval instars. The mature caterpillars are 18-24 mm long and about 2.4 mm broad. They have a black head capsule and thoracic plate. Larval period extends from 16-43 days with an average of 30 days.

Pupa: The papal stage is of about six days.

Adult: Fore wing of adults is uniform pale yellow with a cluster of small dark spots in the centre. Hind wing is whitish. Moths are 10-13 mm long with a

wingspan of 17-23 mm. Adults live for 2-5 days. The total life-cycle takes 26-61 days, and there are probably six generations per year.

NATURE OF DAMAGE

The newly hatched larvae start feeding on the inner tissues of leaf-sheath. In the second or third instar they bore into the stems and feed on the inner tissues. The specific point where the larvae frequently feed is area around the nodes of the stem or right at the node. Thus the stems are weakened and are liable to be easily broken at this point. When the young plants are infested, dead hearts also appear.

HOST PLANTS

Besides rice, this insect can also occur on maize, sugarcane and grasses.

DISTRIBUTION

This insect has been recorded in India, Bangladesh, Burma, Malaysia, Indonesia, Thailand, Vietnam, Laos, Philippines, Sabah and Pakistan.

CONTROL METHODS

Chemical: For control of stem borers apply any one of the following granules after 25-30 days of transplanting the nurseries as a first chemical treatment at the dose indicated against each:

1.	Basudin 10 G	@ 7 kg
2.	Diazinon 10 G	@ 7 kg
3.	Sevidol 8.8 G	@ 9 kg
4.	Padan 3 G	@ 9 kg
5.	Furadan 3 G	@ 8 kg
6.	Advantage 5 G	@ 8 kg
7.	Lorsban 5 G	@ 9 kg
8.	Birlane 10 G	@ 7 kg
9.	Ekalux 5 G	@ 7 kg

Give second chemical treatment with any one of the following granules 50 days after transplanting the nurseries:

1.	Basudin 10 G	@ 9 kg
2.	Diazinon 10 G	@ 9 kg

3.	Sevidol 8.8 G	@ 10 kg
4.	Padan 4 G	@ 10 kg
5.	Furadan 3 G	@ 10 kg
6.	Lorsban 5 G	@ 9 kg
7.	Birlane 10 G	@ 9 kg
8.	Ekalux 5 G	@ 9 kg
9.	Advantage 5 G	@ 12 kg

When the populations of rice stem borers exceed the economic threshold levels, spray any one of the following insecticides

1.	Sumithion 50 EC	@ 500 ml
2.	Sumibas 75 EC	@ 400 ml
3.	Mipcin 50 WP	@ 900 ml

Zeuzera sp. **(Cossidae: Lepidoptera)** (Cossid moth)

DIAGNOSTICS

General body colour brownish pale, moths are medium sized and heavy bodied; wing motts present (wings pale and markedly with large black dots). Wings long and narrow; fore wing with arole very large, vein 11 given off from 10; hind wing with errect bar between vein 7 and 6 at end of 7, veins 4 and 5 are given separately. Fork of vein-let in cell of both wings broad. Both pair of wings with Cu_2 present and M furcate within 7. Antennae of male with proximal half bipectinate. The distal half of the antennae wholly simple in female.

The larvae of these insects are internal feeders and feed on the pith or the inner side of the plant. The prothorax is enlarged and head is united to it. The mandibles are large in young ones.

Nephotettix nigropictus (Stal) (= *N. apicalis* Motschulsky) and *Nephotettix impicticeps* Ishihara **(Deltocephalidae: Hemiptera)** (Green rice leaf hopper(s))

DIAGNOSTICS

Egg: Eggs are laid in the leaf-sheaths, when they hatch in about 6-7 days.

Nymph: Total nymphal duration is 16-18 days and there are five instars.

Adult: Smaller and slender than *Sogatella* spp. (3.2 - 5.3 mm long) but greenish in colour. They are characterized by the presence of black spots on wings and black wing tips.

DURATION OF LIFE STAGES

It is a sporadically occurring serious pest in the rice growing areas. Its population builds up quite rapidly. The females, after undergoing a pre-oviposition period of 6-9 days, lay eggs on the inner surface of the leaf-sheath in groups of 3-18. The eggs hatch in 3-5 days and the nymphal stage is completed in 12-21 days. The adults live for 7-22 days in summer. There are about six overlapping generations from March to November.

The insect overwinters in the adult stage. The pest population is the maximum in July-August and decreases markedly after a heavy rain.

NATURE OF DAMAGE

The nymphs and the adults cause direct damage by sucking of sap from the young leaves of plants, lower their vigour turn them yellow and ultimately brown. Its closely related species *N. impicticeps* transmits several plant viruses. When the number is small the damage is negligible. It is only when higher population appear that a considerable damage is done.

HOST PLANTS

Main host plant is rice, while alternate are *Panicum* spp. *Cyperus* spp. *Poa* spp. and other grasses.

DISTRIBUTION

India, Pakistan, Burma, Philippines, China, Indonesia, Papau New Guinea.

CONTROL METHODS

Same as for *Sogatella furcifera*

Cultural: 1. Remove weeds from around the crop fields to lower the population, as many of the weeds are alternate hosts for the leaf hoppers.

2. Adults are greatly attracted to light and hence population can be lowered by using light traps.

3. Use granules of Diazinon or Furadan with irrigation water.
4. Spray any one of the following insecticides carbaryl, malathion, azinphosmethyl and endosul for the weekly intervals.

Sogatella furcifera Horvath (Delphacidae: Hemiptera)
(White-backed planthopper)

DIAGNOSTICS

Egg: Eggs are laid in masses in the leaf-sheath, each egg is with a long narrow egg-cap. Hatching takes about 3-6 days.

Nymph: Greyish white, turns dark grey when near maturity. Some describe them as pale brown. Their size is 0.6 mm when young and 2.0 mm when fully developed. Nymphal period is 11-12 days.

Adults: Straw coloured, wedge-shaped, with white-back. Adult measures 3-4 mm. It is distinguished by the absence of a median transverse ridge on the vertex. The vertex is characteristic in giving the insect a long narrow face. The forewings are hyaline with dark veins, and a conspicuous dark spot in the middle of the posterior edge. The pronotum is pale yellow and the body black. The adults live about 18-30 days.

ACTIVITY PERIOD

The insect is available throughout the year on weeds and other alternate host plants. But its importance on rice is only sporadic. Its population becomes prominent during August-September. The nymphs and the adults are very active and can easily jump from one leaf to another on even a slight disturbance.

The adults lay eggs generally on the leaf sheath. The eggs hatch in 3.4 to 4.6 days. The nymphs feed on the leaves and become adults in 8.9 - 13.1 days. The life-cycle is completed in 12.3 to 17.7 days. The adult females live for about a week. There are several generations in a year. In the rice growing tract the insect remains inactive in the winter and its population becomes noticeable only from the month of May onwards on the paddy nursery.

NATURE OF DAMAGE

The damage is direct as the insect sucks cell sap from the leaf surface and tends to congregate on the leaf sheath at the base of the plant. The leaves of attacked plants turn yellow and later on rust red. Rice yellows cause

a reddish-yellowing of the folliage (hopper-burn) and the plants become stunted. These symptoms start from the leaf tip and spread to the rest of the plant. Numerous brownish spots also appear on the feeding-sites.

The attacked plants ultimately dry up without producing ears. The insect also excretes honeydew on which a sooty mould appears, imparting a smoky hue to the paddy field.

HOST PLANTS

Main host plant is rice, but alternatives include many species of grasses, maize and millet.

DISTRIBUTION

Bangladesh, India, Sri Lanka, Malaysia, Philippines, Indonesia, China, Korea, Japan and Pakistan.

CONTROL METHODS

Chemical: Same as for other leaf hoppers, the pest can be controlled by dusting BHC 10% or by spraying the crop at weekly intervals with a number of insecticides viz. carbaryl 0.1%; malathion 0.05%, endosulfan 0.04% Sumibas 75 EC @ 400 ml or Mipcin WP @ 900 ml. If Diazinon granules are used for stem borer, plant hoppers are automatically controlled.

Leptocorisa acuta Thunberg **(Coreidae: Hemiptera)**
(Rice bug or Rice seed bug)

DIAGNOSTICS

Egg: Round, flat, red to black in colour; these are laid in rows of 10-20 on the leaves of host plants

Nymph: The newly hatched nymphs are pale green measuring 2 mm in length. With advanced growth green colour deepens. Grown up brown nymphs resemble adults except size and in being wingless. There are five nymphal instars, distinct colour changes occur after each moult. The nymphal period lasts 17-27 days.

Adult: Adults are slender, 20 mm in length; greenish brown (some call it yellowish green) when alive; legs long, antennae 4-jointed. Some authors have recorded the longevity of adults upto 115 days under favourable conditions.

DURATION OF LIFE STAGES

The egg, nymphal and adult stages lost 6-7 days, 2-3 weeks and 33-35 days, respectively. The exact number of generations is not known.

The insect breeds all the year round on grasses and other plants and appears on paddy in August. The activity period continues upto November. The females do not mate for 12 to 14 days following their emergence as adults. A female usually lays round yellow eggs in rows of 10-20 eggs on the leaves. The eggs are laid for 3 days at the rate of 12-19 per day beginning from 3rd or 4th day after pairing. The eggs hatch in 6 or 7 days and there are six nymphal stages which take 2-3 weeks. The adults live 30-35 days. The insect can be easily located in the mornings or evenings when the temperature is low, it hides in plants when the temperature is high. Several generations occur in nature but the exact number is not known.

NATURE OF DAMAGE

The fields which are severely attacked, give out a repugnant smell. Because of such a foul smell the insect is also called gandhy bug. Both the adults and nymphs suck juice from the developing grains in the milky stage, causing incompletely filled panicles or panicles with empty grains. Before the grain is formed the bug will feed on succulent young shoots and leaves. Black or brown spots appear around the holes made by the bugs on which a sooty mould may develop. This insect appears as a pest of paddy only in certain years and factors for its appearance in higher populations in some years are not known. One view is that this insect is very destructive in areas where rainfall is evenly distributed throughout the year and also in irrigated crops. Yield losses of 10-40% are common, and in severe infestations the crop may be destroyed.

DISTRIBUTION

Pakistan, India, Sri Lanka, China, Philippines and Indonesia.

HOST PLANTS

Main host plant is rice whereas, alternatives include various species of wild grass.

CONTROL METHODS

Cultural: In general the same control measures as for leafhoppers and

planthoppers are used for the pest. Destroy the weeds and other plants which serve as alternate hosts.

Mechanical: Collect the insects with hand net and destroy them.

Physical: Collect the insects by using light traps and then kill them.

Biological: The nymphs and adults of bug are predated upon by *Cicindela sexpunctata* Fab. and the robber fly, *Ommatius* sp.

Chemical: Spray the crop with BHC or DDT 0.25% before flowering or dust the crop with BHC 5-10%, aldrin 2.5% or chlordane 5%.

Riptortus linearis Fabr. **(Coreidae: Hemiptera)**
(Rice bug)

DIAGNOSTICS

Dark cinnamon-brown; pronotum, scutellum, corium and lateral areas of sternum distinctly punctate; first, second and third joints of antennae, fascia at base of head between eyes, central fascia to head beneath, lateral angular spines to pronotum, disk of sternum, and abdomen black, a sublateral laevigate pale ochreous, fascia margined with black on each side of head and sternum. Lateral areas, base, and some black spots on abdomen, luteous, a small spot in middle of posterior pronotal margin, and the apex of the scutellum, pale luteous. Length 14 mm to 16 mm, breadth between pronotal angles 3mm to 1/32 mm.

The adults of bug suck the sap from the leaves, stems, and grains during the milk ripe phase of grain development. The grains turn yellow and later brown. In milky to yellow ripeness stage, empty panicles and husks and withered seeds may be observed.. Close observations revealed numerous pricks (sucking places) on the damaged rice plants.

HOST PLANTS

This insect is also found on maize and sorghum and at times on other millets. It infests the tender shoots of sweet potato. It is also a minor pest of lucerne and cowpeas.

Scotinophora coarctata (Thunb.) **(Pentatomidae: Hemiptera)**
(Black paddy bug)

Egg: Eggs are green or pink when freshly laid. These are laid in batches of

40-50 and a single female can lay several hundred eggs. An egg is about 1 mm long. The incubation period is 4-7 days.

Nymph: The general body colour of nymphs is brown, with a green abdomen. They moult five times and become adult after 25-30 days.

Adult: Adults are brownish-black, with a few indistinct yellow spots on the thorax. The tibiae and tarsi are pinkish. An adult measures 8-9 mm in length and can live upto 28-29 weeks. When in huge numbers, they make swarms and can be collected by light traps.

NATURE OF DAMAGE

Both the nymphs and adults feed, above the water level, at the base of stem. Its saliva is very toxic, hence young seedlings or severely infested plants often die. In less infested plants the growth is retarted and sometimes grains get shrivelled due to poor nutrient supply.

The development period is about 5-7 weeks but adult life could be prolonged for more than six months.

It is a periodic pest of rice which though is associated with the paddy plants but has seldom assumed a serious status.

Rhopalosiphum maidis (Fitch)
(= *Aphis maidis* Fitch) **(Aphididae: Hemiptera)**
(Maize aphid or corn leaf aphid)

DIAGNOSITCS

Adults winged or apterous; 2 mm in length, siphunculia short and with dark purplish areas around the base; long conspicuous setae on the cauda. Reproduction is mostly parthenogenetic.

Very little is known about its life history. The total life duration is about 8 days in the tropics.

This insect attacks leaves, leaf-sheath and inflorescence of maize (main host) or alternate hosts like sorghum, millets, sugarcane, wheat, barley, rice and many members of Gramineae besides several weeds. As aphids are known to produce honeydews, the infested parts become mottled and appear distorted. The new growth is retarded and inflorescence in severe infestation become sterile.

This insect is primarily famous for spread of about a dozen of virus diseases in cereals and other crops.

CONTROL METHODS

Cultural: Burning of the seed crop stubbles after harvest is a recommended cultural practice.

Chemical: Spraying of dimethoate if the extent of damage warrants a chemical approach.

Biological: In a healthy growing crop usually natural agents like *Coccinela sexpunctata* keep the population quite low.

Spodoptera mauritia (Boisduval)
(Noctuidae: Lepidoptera)
(Paddy armyworm, paddy swarming caterpillar)

DIAGNOSTICS

Egg: They are spherical in shape and are laid in clusters of 100-300 at the tip of upright leaves. These are covered with a brownish felt-like material with setae from the female body. Hatching takes place within 3-9 days.

Larva: The fresh larvae are greenish in colour, and about 2 mm in length. With advanced age body colour changes to brown. Full-grown larva is 35-40 mm long and is dark to pale green. Black head has a pale forked line. There are three lateral lines along the body with dark segmental marks above. The larval colour varies greatly and shows a phase variation pattern as in locust. When disturbed it curls into a ring, a characteristic common to all cutworms and armyworms. The larval period is 15-24 days.

Pupa: Pupa is dark brown in colour and bears two apical spines. Pupation takes place in the soil in the earthen cells and lasts for 7-14 days.

Adult: Body colour is pale brownish or grey-brown (some say light coffee-brown). The fore wings possess a prominent black spot also termed as dark blotches and several dark lines. The hind wings are whitish-brown with a thin dark margin. Moths are 15-20 mm long, and with wingspan are 30-40 mm. The moth is nocturnal and active after dark. During the day it hides in crevices. Generally it is not attracted to light. The entire life cycle is completed in 37-40 days.

NATURE OF DAMAGE

The young larvae eat leaves of rice seedlings, by initiating first nibbling the surface. A grown up caterpillar is very voracious. When they are in

sufficient numbers, they can destroy the whole crop in a very short period and then move to another field. The healthy and grown up paddy plants even if attacked by the caterpillars, are rarely severely damaged. Most of the damage is thus restricted to the seedling stage. The pest is nocturnal in habit.

HOST PLANTS

The major host is rice while the alternative include maize, sugarcane, cruciferae and various species of Gramineae.

DISTRIBUTION

Africa, Asia, Australia and Hawaii Islands.

CONTROL METHODS

Use 250-300 gm of Lannate 90 WSP or 500-750 gm of Orthene 75 SP.

Agrotis segetus (Schiff.) **(Noctuidae: Lepidoptera)**
(Turnip moth or gram cut-worm)

DIAGNOSTICS

Egg: Shape globular, colour pale, delicately ribbed and glistening.

Larva: General body colour pale grey, some specimens tinged with pink, a pale edged line running down the back. Head pale with two brown marks, the under surface is light grey and there is an X-shaped mark on the head; on the sides are black glossy spots each bearing a small hair. Full grown larva measures 40-45 mm.

Pupa: Exoskeleton smooth, brown, heavily chitinized; end of abdomen with two spines. It measures 10-12 mm.

Adult: Predominantly grey brown in colour, head and thorax brownish, sparingly speckled with black. Fore wing grey, brown or reddish brown, a distinct blackish reniform (kidney shaped) mark and four blackish wavy lines near centre and a marginal series of black spots.

Male: White brown, pale brown, or fuscous. Head and thorax brownish, sparingly speckled with black. Antennae brown, bipectinate, branches of moderate length. Palpi darker at sides, collar with dark line. Fore wings grey, brown or reddish brown with double waved sub-basal ante- and post medial lines, an obscure wavy submarginal line and a reniform with dark centres and edges, the claviform small and black. All such markings being much obscured

in the dark specimens. Hind wing semi-hyaline, irridescent white with dark marginal line and in some specimens with dark suffusion on margin, inner margin brownish. Moths have a wing span of 30 mm, abdomen white.

Female: Antennae simple, branches of moderate length, colour whitish brown, pale brown or fuscous. Palpi darker at sides, collar with dark line. Colour of fore wing varies from grey to brown or reddish brown; fore wing with double wavy sub-basal anti- and post medial lines, an obscure wavy sub-marginal line and reniform with dark centres and edges, claviform small and black. Hind wings white with dark marginal line, and some specimens with dark suffusion on margin. Wing span 30 mm. Abdomen white. All these markings being much obscured in the dark specimens.

DURATION OF LIFE STAGES

The duration of egg stage of *A. segetum* was 12 days at 30.5°C (86.9°F), the larval stage averaged 68 days at room temperature averaging 25.2°C (about 77.4°F), and there are five or six larval instars, the last of which is completed in about 40 days, including a prepupal stage of about 14 days by Fielder (1941).

ACTIVITY PERIOD

Adults of *A. segetum* are present from mid-May to the end of June and oviposit mainly in the first half of June. The larvae hatch in 8-14 days, feed until the end of September and then hibernate in tunnels in the soil. They prefer fine damp soil covered with weeds. The overwintered larvae usually come out to the surface and begin feeding in April, but temperature below 10°C (50°F) and heavy rainfall could delay their appearance. Pupation occurs in spring, with no resumption of feeding. By mid-May the pupa has worked its way out of the cell and moved to just below the surface of the ground.

Near Berlin *A. segetum* has one generation a year but very few individuals give rise to second generation (Fielder, 1941).

The adults which emerge in May are active until end of June. Oviposition begins 2-5 days after emergence, the eggs are laid singly or in groups on lower surface of leaves of both wild and cultivated plants and even on plant debris. The larvae hatch in later part of June and July and feed first on the leaves and then on the plant collar. The new adults appeared in July-September and the second generation larvae were feeding until autumn (Ionescu *et al.*, 1966).

There is only one generation a year in Europe but four generations occur in Central Africa (Grist and Lever, 1969).

The adult moths fly in June-July, and from May to early July each female lays over 1000 eggs on stems of plants closer to ground. The small newly hatched larvae feed mostly below ground. Feeding continues till autumn and caterpillars increase in size. The next April a second feeding period begins because the soil surface is moist; feeding occurs above and below ground. The large caterpillars are voracious and rapidly consume seedlings. Pupation occurs in April and terminates in May and June (Jones and Jones, 1974).

NATURE OF DAMAGE

The larvae of *A. segetum* have a habit of biting off fresh tender stems near the ground. The larvae which usually hatch at night, begin to be negatively phototactic during the second instar. Larvae in the third and subsequent instars were never found by day on the plants, but only under fallen leaves or just below the surface of soil. Young larvae feed on leaves of plants, mostly weeds, on which the eggs are laid, and reject only those that are very hairy or have a hard epidermis. The older larvae also eat food rich in chlorophyll, but as they cannot climb the stems they attack these parts of plants that are immediately above the ground

CONTROL METHODS

Mechanical: The clods in the fields should be broken and the fields should be flooded to control the pest in the infested fields (Nayar *et al.*, 1976).

Agrotis ipsilon (Hufn) **(Noctuidae: Lepidoptera)**
(Greasy cutworm or wooly bear)

DIAGNOSTICS

Egg: The ribbed eggs are laid in clusters of 30-50 on the underside of leaves or on parts of the stem lying close to the ground or in wet and muddy soils. A female lays about 300-350 eggs. The ribbed egg measures 0.5 mm.

Larva: General body colour greasy grey to brown with faint lighter stripes; head red. Newly hatched caterpillar 1.4 inch in length; fulfledged nearly 2 inches long, and dark-brown in colour. It coils itself and feigns death when disturbed. Cannibalism is seen among the larvae.

Pupa: Colour red brown, with a sharp spine like caudal extremity. Pupates in soil in an earthen cocoon. Length: 20 mm.

Adult: Fore wings sombre brown with numerous wavy lines and spots; more suffused with brown and with a black streak beyond reniform; submarginal line dentate with two black steaks below apex; hind wing fawn coloured. More or less suffused with fuscous brown; wing expanse 42-56 mm.

DURATION OF LIFE STAGES

According to Ionescu *et al.* (1966), the larval stage lasted 43-50 days at daily temperatures of 20-24°C (68-75.2°F).

According to Ionescu *et al.* (1966), the larval stage lasted 43-50 days at daily temperatures of 20-24°C (68-75.2°F).

Grist and Lever (1969) reported egg stage 2-9 days, larval stage 10-28 days and pupal stage 30 days.

Nayar *et al.* (1976) reported egg stage 2-13 days, larval stage 30 days, pupal stage 10-30 days, and the total life from 30 to 68 days, for summer and winter, respectively.

ACTIVITY PERIOD

In 1955-60, observations were recorded near Bucharest in Rumania on the cutworms like *A. segetum* and *A. ipsilon* that attack maize and it was concluded that the cutworms had two generations a year. The adults of overwintered generation were present from the end of May to July and the first generation larvae appeared in the mid-June, the first generation adults by the beginning of August and the second generation larvae in the 2nd week of August (Ionescu *et al.,* 1961).

The total life cycle occupies 1-2 months according to the climatic conditions in Indo-Pakistan. Two broods are present in the peak season. During the off-season the pest survives on some weeds.

According to Popov (1963), severe damage was caused to maize, tobacco and other crops in various parts of Bulgaria in the spring of 1963 by the larvae of *A. ipsilon* (Hfn.), which appeared in large numbers in April-May. The out-break was attributed to the weather in the preceding October-November. In the field,, 3rd instar larvae of the 1st generation were found as early as the second half of May, pupae occurred at the beginning of June, and adult emergence probably took place before the end of the month. The larvae of the second generation appeared in July, and the first pupa was noted at the beginning of August.

NATURE OF DAMAGE

Cutworms are polyphagous pests in all cultivated regions. Very often the damage they inflict is particularly great because they cut more young plants than they are able to eat. The cutworms become active at night and cut down newly emerged heads of rice, wheat, gram etc., mercilessly. They fell more plants than they can consume. They cut off or felled plants indicate the activity of the pest in the field. The stems of younger plants are cut at a height of about 5 cm from ground damaged. This results in retardation of growth and ultimate reduction in yield.

The larva in the beginning feeds on fallen leaves or leaves touching the soil. As it grows, it feeds on the other parts of the plants and becomes full-fed in 10-30 days in the different seasons.

The present researcher observed that caterpillars remain concealed in cracks in the soil during day time and come out at night for feeding purposes. Several caterpillars were seen crawling on the freshly emerged twigs of paddy plant near the light trap.

CONTROL METHODS

Cultural: Ploughing the soils and breaking the soils help in reducing the population in the soil.

Mechanical: The clods in the fields should be broken and flooding of infested field can also help control the pest (Nayar *et al.,* 1976).

Diachrysia orichalcea Fb. **(Noctuidae: Lepidoptera)**
(Cabbage semi looper)

DIAGNOSTICS

Egg: The moth lays 76-183 eggs, which hatch in 4-5 days. Laid in batches on leaves of food plants.

Larva: Colour bluish green, body slender, bearing dorsal white lines and a prominent lateral line and a few short dorsal hairs. Full-grown caterpillar about 25 mm long. Larva has five instars covered in 11-28 days.

Pupa: Found in folded leaves. Pupal period is 4-23 days.

Adult: Head, collar and vertex of thorax reddish orange, tegulae and fore wings pale red-brown; whole of outer area of fore wings except inner margin occupied by a brassy golden patch which extends toward base below median

vein. Hind wing pale at base, outer area fuscous and provided with dusky spots. Expanse 44 mm. Total life cycle is completed in 19-52 days.

NATURE OF DAMAGE

The larvae were observed roaming on fresh foliage of the plant. They do some kind of damage by bitting the leaves from the centre. On their activity place, several leaves were seen eaten.

HOST PLANTS

It is a pest of lucerne, berseem, gram, cowpea and oats. Caterpillars have been recorded on indigo. Caterpillars also damage cabbage, cauliflower from seedlings to harvest in West Bengal. These also feed on sunflower at early stage, leaves of niger and also occurs on linseed.

Euproctis fraterna Moore (**Lymantridae: Lepidoptera**)
(Hairy caterpillar)

DIAGNOSTICS

Egg: Colour creamy white to yellow, flat and round in appearance, circular in shape, usually laid on the lower surfaces of leaves in batches (masses) and covered with golden yellow hairs from anal tuft of female. Eggs turn brownish yellow near hatching. On an average egg cluster measures 1.4 mm x 0.5 mm. An egg measures about 1 mm. A female lays on an average 293 eggs.

Larva: The description of different larval instars is given below:

First Instar: The body colour of a newly hatched larva is creamy or light yellow, which changes to yellowish before moulting and a dark spot appears on the first abdominal segment. Head is bright orange. Body length varies 1.9-2.1 mm.

Second Instar: Head and eyes are bright orange brown, while body is greyish yellow. There are paired brown dorsal protuberances on the first, second and 8th abdominal segments. The dorsal and lateral verrucae of nearly all the abdominal segments bear very fine white spicules forming tufts, the ventral side being slightly yellowish. Body length varies 5–5.4 mm.

Third Instar: The general body colour is dark brown. The first abdominal segment with long lateral tufts of black hairs rising from prominent tubercles, the other segments are with dorsal and lateral tufts of white hairs; the 9th

and 10th segment with white dorsal spots; the 11th segment is with a dorsal black tuft of hairs. Body length is 8-8.5 mm.

Fourth Instar: Head is crimson, body colour is brownish black, but the hairs are thicker and longer. There is one white spot on each side of the dorsum of 9th and 10th abdominal segments.

Fifth Instar: General body appearance is similar to the fourth instar. However, the body length varies from 22-23.2 mm.

An overall description of an advanced larval stage, which is usually come across in publications is as under:

Early instar larvae have whitish hairs, full-grown larvae are hairy and dark reddish brown in colour. They have a red head, reddish brown body, first abdominal somite with long lateral tufts of black hairs arising from prominent tubercles, other somites with dorsal and lateral tufts of white hairs. sub-dorsal pale line, 9th and 10th somite with white dorsal spots, 11th somite with a dorsal black tuft,body length 22-23.2 mm.

Pupa: General colour dark brown to black, body covered with a thin-deep yellow cocoon interwoven with larval hairs, 9-10 mm in length and 4-4.5 mm in width across wing covers. Pupation takes place in leaf-folds or on plants in a thin cocoon of silk and hairs.

Adult: Body stout, colour yellow, light wavy markings on wings; head, thorax and fore wings bright orange yellow (=deep yellow of some authors) abdomen more or less tinged with fuscous, anal tuft orange, fore wing with ante-and post-medial curved pale lines, space between them being slightly powdered with dark; scales towards inner margin and black rounded dots along apical margin (= submarginal of some authors).

Male: Size smaller, head, thorax and fore wings bright orange yellow, abdomen more or less tinged with fuscous, fore wing being shorter and squarer, with ante-and post-medial pale lines, and with sub-marginal black spots, wing expansion 23-24 mm, male bigger than female, antennae bipectinate, fore wing with M2 basaly proximated to M3, Sc + R1 separated from Rs.

Female: Head, thorax and fore wings bright orange yellow, abdomen more or less tinged with fuscous, anal tuft orange, fore wing with ante-anal and post-medial curved pale lines, space between them being slightly powdered with dark, scales towards inner margin, and black rounded dots along apical margin, wing expansion 35-38 mm, female smaller than male.

DURATION OF LIFE STAGES

Egg stage lasts from 3 to 8 days, depending upon the prevailing season, with an average of 5.8 days. Larval stage occurs 35 to 80 days, larvae which hatch in November remain in this stage for 74 to 80 days or in other words winter is passed in larval stage. Feeding continues upto late December, it is resumed for a short period before it pupates in February. The shortest larval duration of 35 days occurs during May-June. There are 5 larval instars depending upon the season. Pupal stage lasts for 9 to 26 days with an average of 14.8 days. Adult life is 2 to 5 days in male and 3 to 6 days in female (Akhtar, 1961). The pre-oviposition period is 2-4 days.

According to Nayar *et al.* (1976) egg stage lasts 5 to 9 days, larval stage 29 to 35 days, pupal stage 10 to 12 days and total life cycle lasts 45 to 57 days.

ACTIVITY PERIOD

The pest passes through 5 generations during the year. As the generations overlap with a great variation, their number may accordingly vary from 4 to 6 and this mainly depends upon the temperature. The adults start emerging from the pupa of last generation around the end of February or beginning of March and copulate. The copulation period is 1.5-3 hours. The pre-oviposition period was 2 to 4 days and the females laid eggs on the lower side of leaves of available host plant. A female may deposit 85-161 eggs in 1-3 clusters on the leaves. The egg-stage lasted for 3-8 days depending upon the season. The larval stage lasted for 35 to 50 days during March-October while it may occupy 80 days in winter. The larvae when full-grown pupated in a loose silken cocoon on the leaves. Pupal stage lasted from 1 5 to 2 weeks, from March-April to October and up to 26 days in winter. After this the moths emerged and repeated the usual life cycle. The larval and pupal stages were much prolonged in winter. The eggs of last generation are usually laid in November and the larvae which hatch from these eggs within 7 to 8 days remain in this stage for about 80 days before pupation. The pupal stage in this case occupies about 3 weeks or a month. Thus almost all the stages of the pest are available throughout the year except from December to mid-February when only the larval and pupal stages are met with (Akhtar, 1961). The activity period for different generations in Punjab is as under:-

First generation	March - April
Second generation	May - mid-June

Third generation	Mid-June - last week of August
Fourth generation	End of August - end of October
Fifth generation	November-February

NATURE OF DAMAGE

Euproctis fraterna Moore is a very serious pest of fruit tree like apple *(Pyrus malus)*, crab apple *(Pyrus bacatta)*, ber *(Zizyphus jujuba)*, falsa *(Grewia asiatica)*, loquat *((Eriobotyria japonica)* and pear *(Pyrus communus)* agriculture crop like rice, cotton, berseem, shaftal, pulses and other plants like castor,etc. Generally speaking it is a leaf eating caterpillar and the newly hatched larvae feed gregariously on the soft parts of the leaves, leaving a net work of veins and rendering a major portion of the foliage of the trees as skeletonized. In their advanced states of development the caterpillars may eat the whole leaf if it is tender and soft, while in case of hard leaf they skeletonize it, leaving only the main veins. An estimated 10-24 per cent plants of castor could be damaged during August to November. Sometimes the skin of the fruit is also nibbled and scratched by the larvae and although such injuries are only skin deep, the fruit is invariably exposed to attack of fungi and scavanger beetles and is most likely to be spoiled due to rotting. The hairs covering the bodies of larvae and those of larval moults, pupal cases, egg clusters and of anal end of female moth are poisonous and cause severe iching, irritation and blisters on the human skin on contact. As far as behaviour is concerned on emergence the larvae cut holes through the cluster covering and start feeding on the green tissues of the leaf that carried the egg clusters. The newly hatched larvae feed gregariously on the surface tissue of leaves. As they grow in size, they scatter on the leaves for feeding. They are usually most active at night but also continue feeding during day. If disturbed the larvae make quick wriggling motion and raise their head and body hairs.

CONTROL METHODS

Mechanical: Collection and destruction of egg masses.

Biological: Caterpillars are parasitised by: *Henicospilus merdarius* Grov. *H. horsefields* Cam., *Apanteles* sp. and *Disophrys* sp.

Chemical: Use of contact poisons.

Euproctis virguncula Wlk. (Lymantridae: Lepidoptera)
(Hairy caterpillar)

DIAGNOSTICS

Egg: Eggs are laid in clusters. A female lays 103-145 eggs. These hatch in 3-4 days.

Larva: The full-grown larva is 2-3 cm long. There are 5-6 larval instars and total larval period is 28-35 days.

Pupa: Pupation takes place in ground for 9-10 days.

Adult: General body colour powdery white (snow white), end of abdomen in female provided with yellow bunch of hairs, head blackish on anterior-dorsal side. Antennae of male bipectinate up to apex, slightly curved almost in middle towards anterior side, antennae exceeding joint length of head and thorax usually ending on 1st abdominal segment, branches longer in male. Ocelli absent, palpi obliquely porrect, wing with veins 3, 4, 5 from near angle of cell 7, 8, 9, 10 stocked, 6 from below upper angle. Fore wing broader towards apical end and narrow towards base; underside of fore wing provided with very fine whitish silky thinly scattered hair, hind wing with veins 3 and 4 stocked or from angle of cell, 5 from above angle, 6 and 7 also stocked, along inner margin both the fore and hind wings are provided with silky whitish fringe on outer side; mid tibiae with one pair of long spurs, hind tibiae with two pairs, abdominal segments not easily divisible, covered with whitish powder, wing expanse 25-35 mm.

Male: Almost same as adult, antennae in male bipectinate. Average wing expanse is 19.7 mm.

Female: The abdominal end provided with prominent yellow bunch of hairs. Average wing expanse is 33.2 mm.

The pest is found in the field throughout the year and peak population is during August to October. In summer, there could be even five larval instars and larval period reduced to 23-31 days. While overwintering caterpillars may take up to 103-108 days for the completion of larval period. There are 3 generations per year, and total life cycle could be reduced to 40-50 days during summer.

NATURE OF DAMAGE

The same as that of *E. fraterna*.

HOST PLANTS

It mainly feeds on rice. But it also damages berseem, cowpea, bajra, sorghum, maize, Johnson grass and pastures. It has also been seen on wheat. It also causes annoyance to cattle.

CONTROL METHODS

Biological : It is parasitised by *Apanteles* sp., *Carcelia medicella* (Wulp) and *Exorista sorbillans* Wied.

Chemical : The recommended insecticides for *E. fraterna* also give good control for this because it is a species of the genus *Euproctis*.

Cnaphalocrocis medinalis Guen.(**Pyralidae: Lepidoptera**
(Rice leaf-folder or Leaf roller)

DIAGNOSTICS

Egg: Flat and oval, creamy white (= yellow) in colour, laid singly or in groups (arranged in longitudinal rows of 1-3 layers thick) on leaves and leaf-sheaths. A female lays on an average 56 eggs.

Larva: A newly emerged larva is dull white, or light yellow with a brown head. It turns greenish after feeding and usually feeds inside fold of leaves fastened together by silken thread. The full-grown larva is green and measures about 20-25 mm.

Pupa: Larvae pupate in loose silken webs in between leaves or in leaf sheaths. The pupa is dark brown. The pupal stage lasts 6-8 days.

Adult: Golden or yellow brown (= orange brown); wings with 2-3 wavy lines characterized by dark terminal bands (1 or 2 dark lines). The moth is 8-10 mm long and measures 16-20 mm in wing expanse.

DURATION OF LIFE STAGES

The duration of egg, larval and pupal stage is 3-4, 15-25 (av. 23.2), 6-8 (av. 7.4) days, respectively. The life cycle is completed in 25-35 days and there are four generations in a year.

ACTIVITY PERIOD

It is of sporadic occurrence, hence it would assume a pest status only occasionally. The moths are nocturnal and rest on the underside of the leaves during the day. The eggs are deposited on the leaves or leaf-sheaths. The

larvae on emergence feed on tender leaves without making a fold. The caterpillars undergo 5-6 instars. The grown up larvae fasten the longitudinal edges/margins of leaf together with a sticky substance and feed (some say live) inside the fold by scraping the green matter. The green tissues, particularly the chlorophyll are eaten by the caterpillars. The scraped leaves become membranous, turn white and finally wither. The heavily infested crop has streaks on the leaves and appears whitish and scorched from a distance. A single larva may damage a number of leaves as it migrates from one leaf to another.

As a result of the attack, photosynthetic activity of the leaves is interfered with and the plants are predisposed to fungal and bacterial infections. Attacked leaves dry up, weakening the plant. The yield of infested plants is reduced to the extent of 10-15 per cent. The pest is active from July to October and is at its peak during September-October.

DISTRIBUTION

Besides Pakistan, this pest has been reported from Indonesia, Korea, Japan, Philippines and India.

HOST PLANTS

Rice is the main host but it occurs on a number of grasses, weeds and wild plants.

CONTROL METHODS

Cultural: 1. Removal of grass and weeds from buds around the paddy fields helps to reduce the pest population.

2. Light trapping of adults has been successful in some instances.

Biological: The eggs are parasitized by *Trichogramma* spp., while larval parasites are *Apanteles* and *Bracon* spp.

Chemical: The pest can be controlled by dusting the crop with BHC 10%, or spraying it with any one of the following insecticides. BHC 0.2%, Malathion 0.05%, Carbaryl 0.1%, Fenitrothion 0.05%, 900 gm of Mipcin 50 WP in 100 litre of water.

Creatonotus gangis L. **(Arctiidae: Lepidoptera)**
(Arctid moth)

DIAGNOSTICS

The female moth lays 285-695 eggs. General body colour crimson with

countless black pigments scattered irregularly; antennae fasciculated in male, palpi short and porrect; hind tibiae with one pair of spurs; fore wings rather narrow, veins 3, 4, 5 from angle of cell, 6 from upper angle, 7, 8, 9 and 10 stocked; hind wing with veins 3, 4, 5 from angle of cell, 6 and 7 from upper angle, 8 from middle of cell. Fore wing in some specimens with vein 10 from cell and vein 5 in both wings sometimes from above angle of cell. Abdomen yellowish crimson, female with an abdominal tuft. Antennae fasciculated in male. Female with an abdominal tuft. A female moth lays 285-695 eggs. The eggs hatch in 3-5 days. There are seven larval instars and larval period lasts for 21-38 days. The pupal period is 6-11 days and the total life cycle is completed in 28-45 days.

The adult moths were observed in paddy fields on plant leaves, stems etc., but no special kind of damage was observed. In general same kind of damage has been observed as the other moths do.

HOST PLANTS

This insect feeds on rice, oat and groundnut leaves. It infests sorghum and maize, and is also a sporadic pest of lucerne, Johnson grass and pastures. On the fruit trees the newly hatched larvae scrap the chlorophyll from leaves while the older larvae defoliate the plants.

CONTROL METHODS

Biological: The caterpillars are parasitized by *Drino* sp.

Brachmia arotraea (Meyr.) **(Gelechiidae: Lepidoptera)**
(Leaf folder)

DIAGNOSTICS

In the literature this insect has been recorded on rice in nursery and at tillering in Behar, West Bengal and Assam. Its larvae roll the leaves longitudinally and feed on the chlorophyll matter from within. They thus skeletonize the leaves. A mature larva measures 9 mm in length. It pupates in a thin transparent cocoon within the leaf rolls.

Other species of this genus recorded on sweet potato include:

1. *Brachmia convolvulli* Wals.
2. *B. engrapta* Meyr.
3. *B. macroscopa* Meyr.

The taxonomic position of leaf folders of this genus needs clarification. Very little is known about these insects in Pakistan.

Nymphula depunctalis Guena (**Pyralidae: Lepidoptera**)
(Rice caseworm)

DIAGNOSTICS

Egg: Eggs are laid singly on the leaves. One female usually lays about 50 eggs. The eggs hatch within 2-6 days.

Larva: The caterpillar is pale translucent green, with a pale orange head. After few days of hatching the first instar larva constructs the first case. The larvae are semi-aquatic in habit and have slender gills laterally. The case is always filled with water, and larvae by virtue of gills can withstand immersion in the aquatic surroundings. There are four larval instars and the total larval period lasts 15-30 days The full-grown caterpillar may be 13-20 mm long.

Pupa: Pupation takes place inside the last larval case. The case is fastened to the base of stem. The pupal stage lasts 4-7 days.

Adult: The adults are small, delicate, snowy white moths with pale brown spots on the wings. They have a wingspan of 15-25 mm. They live up to 3 weeks.

NATURE OF DAMAGE

The caterpillar cuts tips of the leaves, makes the case and then lives inside it. The case is changed as the larva grows and moults. In severe infestations, the seedlings totally die off due to loss of photosynthesis. Younger plants can withstand the damage but mature plants are seldom attacked. The feeding spot of larvae is usually the lower side of the leaves.

HOST PLANTS

The main host is rice plant. Most often the insect comes across on aquatic or submerged weeds in the water channels, very close to rice fields.

DISTRIBUTION

It is found in most of the rice growing countries of Africa, Asia, South America, Australia. In Pakistan it is an insect of casual occurrence in paddy fields.

CONTROL METHODS

Cultural: 1 Draining the water from the infested field for 2-3 days kills the caterpillars.

2. Addition of kerosene film to the water.

Chemical: Application of insecticides such as Parathion, Malathion, etc.

Hieroglyphus banian Fabricius and *Hieroglyphus nigrorepletus* Bolivier (**Acrididae: Orthoptera**) (Rice grasshoppers)

DIAGNOSTICS

Egg: Laid in pods in the soil.

Nymph: Yellowish, with many reddish brown spots in early stages, turns greenish when older.

Adult: Shiny greenish yellow, 3 black lines running across pronotum, 40-50 mm long.

ACTIVITY PERIOD

These species are sporadic pests of rice.

The damage is caused by both nymphs and adults. The *Hieroglyphus* species have one generation in a year and pass the winter and dry part of summer in the egg stage.

The eggs are found in the soil and they hatch in June or in early July, a few days after the first shower of the monsoon. On emergence the nymphs start feeding activity and complete their development in seven stages within three weeks. The adults are seen feeding voraciously during August and September. When they are two months old, they mate. The female starts laying eggs, that are laid 5-8 cm deep in pods, each containing 30-40 of them.

The egg-laying continues from September to November and the adults die soon after, sometimes in the winter.

The greatest amount of damage is caused during August-September when both adults and nymphs feed on paddy and other crops, causing defoliation.

In certain years, they cause extensive damage, moving from field to field over large areas.

HOST PLANTS

Like other grasshopper species, these insects are polyphagous and feed on the leaves of rice, maize, millets, sugarcane, grasses, sunhemp, arhar, etc.

CONTROL METHODS

Chemical: The grasshoppers can be controlled by spraying the infested crops with any one of the following insecticides:-

BHC 0.2%, Dieldrin 0.02%, Methyl parathion, Heptachlor 0.04%, dusting with BHC 10% at 25-40 kg per hectare is also effective.

Oxya multidentata Will. **(Acrididae: Orthoptera)**
(Rice grasshopperor Paddy grasshopper)

DIAGNOSTICS

Size small, general body colour deep green yellowish, on dorsal side, a black stripe running from antero-dorsal aspect of head to hind margin of meta-thorax. Head medium sized, front downwardly slopping and distinctly convex with frontal carinae well-developed, frontal area palish in adults, basic colour of compound eyes greyish, eyes marked with dark stripes, lateral and median ocelli fully well-differentiated. Antennae greyish brown with their basal segment whitish, 22-24 segmented; throax well developed with pronotum saddle shaped, anterior margin of pronotum straight, while posterior one bluntly angulated, legs with well-developed femora, femora pinkish, tibiae and tibial spines somewhat greenish, black pigmentation on femoro-tibial joints, metalegs strongly developed. Abdomen laterally compressed, with under surface having some greyish pigments mixed with basic deep green colour of body, posterior end of abdomen also with brownish pigmentation, tegminae extending beyond abdomen to a great extent.

Length: 15-22 mm
Expanse of wings: 40-45 mm

The nature of damage is the same as that of *Oxya chinensis*

Oxya chinensis (= velox) Thunberg
(Acrididae: Orthoptera)
(Small rice grasshopper or Paddy grasshopper)

DIAGNOSTICS

Egg: Shape of egg-pods variable, generally cylindrical, thickened at bottom when containing fewer eggs.

Eggs numbering 10 to 20 are glued together by a red-brown gummy substance arranged in somewhat regular longitudinal rows and held in vertical position, micropylar area lies at lower end, entire egg-cluster covered by frothy material, which occupies nearly 1/3 to 1/4 top of the egg-pod. The length and breadth of an egg-pod vary from 10 mm to 19 mm and 3.5 mm to 6.5 mm respectively, the respective averages being 15.1 mm and 5.2 mm.

Nymph: *First Stage Nymph*. General body colour light green pale, pronotum dark at posterior end. Head triangular, a little raised above pronotum, upper margin appears slightly curved in profile, vertex slightly produced and angular terminally. Compound eyes greyish in colour and speckled with brown pigments, elongate, oval, large sized, and prominently developed. Two small pits, one on either side of median carina, separate compound eyes on the dorsum. Frontal carinae widely apart and somewhat divergent posteriorly, lateral and sub-ocular carinae indistinctly developed. Antennae located in centre of compound eyes, 12 to 13 - segmented, terminal segment being roughly spatula-shaped. A small median ocellus between frontal carinae, two lateral ocelli located little below base of antennae and on anterior most aspect of compound eyes. A sub-rectangular brownish spot below compound eyes on each side.

Pronotum broad and highly developed and overlies mesonotum dorsally and laterally; postero-lateral areas of mesonotum exposed as small triangles. Median carina and two lateral carinae conspicuous on pronotum, faint on meso- and meta-nota. Pronotum transversally sulcated by four furrows, equally developed not reaching lateral margins; second sulcus shortest and fourth indistinct on dorsal aspect but developed on lateral sides. Tegminal and wing rudiments produced as margins of meso- and meta-nota. Pro- and mesolegs small, having characteristic black spots, frequently distributed on femora, tibiae and tarsi bearing bluish appearance. Hind legs large with very well-developed femora, tibiae and tarsi. A light bluish pigmentation having light greyish colour on tarsus of each leg, femora bearing a pair of parallel rows of short black-tipped spines. On femoro-tibial joint of metalegs, three blackish spots are present, two on tibiae and one on femur.

Abdomen short, light greenish on dorsal side and palish on ventral aspect. Cerci well-developed, bearing numerous setae.

Second Stage Nymph: General body colour similar to first instar. Head deflected downwards when seen in profile, appears rather acute, vertex

produced anteriorly, angulated with rimmed edges. Two white spots, one on each side, at junction of edges of vertex with compound eyes. Compound eyes of bigger size, appear somewhat separated from above. Two greenish lateral ocelli, a whitish median ocellus. Frontal carina bearing a row of dark pigmented spots all along. Frons and clypeus bear numerous minute spots. Tips of maxillary palpi and antennae greenish, antennal tips light brown. A white dorsal median band running from the vertex to tip of abdomen.

Pronotum well-developed with three distinct transverse sulci, anterior margin convex and posterior slightly notched and concave. Hind margins of all thoracic segments bear dark spots. Tegminal and wing rudiments pushed postero-laterally and acquire a folded appearance. Metalegs well-developed, femora robust; tarsi and tibial spines of all legs bear a light green pigmentation, tibiae black tipped. On various parts of legs, ridges stripes – and numerous black spots present.

Abdomen short, paler than rest of body, dark pigmentation on anterior sterna; cerci elongated, pointed distally and bear a paler pigmentation and numerous hairs.

Third Stage Nymph: Two pale divergent bands appear behind vertex which run antero-posteriorly; mesonotum with pale patches on dorsum. Fifth and eighth segments of abdomen bear pale patches on dorsal side; ventrum of body whitish-pale with a tinge of grey on thoracic sterna and a few on anterior abdominal sterna.

Frons bear numerous black spots, frontal carinae convergent and originating below vertex and strongly marked, carinae gradually diverge while approaching epistomal suture. Latrum of labrum, and, labial and maxillary palpi with greyish pigmentation. White spots noticed on vertex in two preceding instars disappear. Spatula-shaped structure of antennae, is replaced by a somewhat cylindrical form. Sterna greenish with pigmentation towards tips.

Pronotum grows in size and acquires more intense green pigmentation; sulci well-developed; of all nota, mesonotum being shortest in size. Both meso- and meta-nota bear black spots on their posterior margins. The pro- and mesolegs slender, metalegs rather stoutly built, pretarsi of all legs acquire an intense green pigmentation.

Abdomen medium sized and bearing pale colouration on lateral sides. Cerci tipped with yellowish brown, like many other associated structures, bear numerous white hairs.

Fourth Stage Nymph: General body colour pale white, divergent bands observed behind vertex in third instar disappear, white patches on pronotum, metanotum and abdominal terga assume shape of a continuous line of black spots on either side of white median carina in female hoppers. Metafemora at trochanto-femoral joints and anterior part of frons bear dark green pigmentation, in female hoppers.

Head conspicuous, frons convex and lower part of face externally deflected, face thickly punctated with small black spots in both sexes; punctations closely approximated in female hoppers; eyes with regularly distributed longitudinal brown stripes in female and male. Antennae bear darker pigmentation on proximal and distal ends; 19-20 segmented in female and 19 segmented in male. Median ocellus colourless but shiny, lateral ocelli brownish and a little above origin of antennae.

Metatergum fairly large and sub-rectangular. In female hoppers wing rudiments lie over tegminal rudiments, in male remain independent. All legs bear terminally black tipped claws, setae on all tibiae tipped black, metalegs robust.

Abdomen elongated, cerci and genitalia well-formed; cerci and associated structures of pale colouration and bearing numerous minute hairs.

Fifth Stage Nymph: Female colouration deep green on frontal, dorsal and lateral sides of thorax and abdomen, on fronto-lateral and dorsal parts of the head and legs. Thorax, wings, tegminal rudiments and legs in female with green pigmentation; male comparatively lighter in colour.

Head conspicuous, frons and lower facial areas extremely deflected, eyes bearing unequally distributed dark brown pigmentation; regular stripes noticed in previous instar disappear. Antennae greenish in both sexes; in female flagellar segments pale, terminal segment a distinct, small, oval, segment of intense brown colouration. Antennae 22-segmented in female and 21 segmented in male.

Pronotum well-developed and saddle-shaped, anterior margin smooth and posterior distinctly angulated, posterior angle more acute in female hoppers. Meta-legs strongly developed.

Abdomen short and stumpy, sexes distinct, ovipositor valves well-developed, cerci acutely pointed, terminal parts of abdomen bear numerous white hair, dorsal band on abdomen of female attenuated, but guarded by indistinct dark margins, dorsal band in male represented by a white line.

Sixth Stage Nymph: Hoppers of light green pale colour, white band on dorsal side of body guarded by dark borders throughout its length in male hoppers,

these borders disappear in female hoppers. Head medium-sized, front downwardly slopping and distinctly convex. Basic dusky colouration of eyes marked with regularly arranged longitudinal stripes, five of these closely spaced and located towards anterior side of each compound eye, sixth one lie behind last one and widely spaced on anterior dorsal end. Each compound eye bearing an elongated brown spot in it, lateral ocelli rimmed with brown, running below each of these is lateral carina, vertex angulated anteriorly, antennae pigmented with light grey or brown, particularly in case of male hoppers; each antenna 24-segmented in female and 23-segmented in male.

Pronotum well-developed, anterior margin straight or only slightly concave, posterior margin regularly angulated in male, more bluntly in female. Femoro-tibial joints in both female and male hoppers and posterior end of abdomen only in male hoppers acquires a brownish pigmentation.

Abdomen laterally compressed, with under surface having some greyish pigments mixed with basic deep green colour of body. Male and female genitalia completely differentiated, hairs on cerci and associated parts elaborated.

Seventh Stage Female Hopper: Seventh instar is found in female hoppers only. General body colour light green with some dark patches on frons, clypeus, labrum and on anterior parts of metafemora, head medium sized, with face extremely deflected downwards; frons, clypeus and labrum bear minute punctations; frontal and lateral carinae as well as sub-ocular suture much better developed, antennae creamy white in colour, speckled with brown, especially on their terminal parts, and 25- or 26-segmented. Compound eyes dusky in colour, marked with anteriorly aggregated six long longitudinal stripes followed by 7th stripe which is spaced at a little distance from 6th stripe. Head bearing a whitish triangular band pointed anteriorly on its dorsal aspect. Pronotum well-formed, its anterior margin straight, while posterior one angulated. Four transverse sulci clearly marked, anterior most being a little indistinct dorsally, dorsal side of pronotum bearing a white band bordered by small dark stripes; pro- and mesolegs delicate and slender, metafemora well developed, tibial spines and terminal claws tipped black.

Abdomen elongate, gradually pointed posteriorly with dorusm having a median white band, surrounded by black borders, cerci well-developed and bear numerous white hairs, genitalia well-developed.

Adult: Male hoppers deep green pale; abdomen, lateral and ventral sides of three thoracic segments as well as hind femora acquire a deep yellow

colouration. Dorsal white band replaced by two parallel-running creamy white longitudinal stripes; separated rectangular greenish area running from antero-dorsal aspect of head to hind margin of meta-thorax and persisting even beyond onto tegminae.

Female of same colouration as male, intensity of yellow colouration on lateral and ventral sides of three thoracic segments, and hind femora not same as in male. Sexual dimorphism in adults very conspicuous.

Head in male medium sized with frontal carinae well-developed, punctations in areas of frons, frontal area acquires a pale colouration; basic colouration of eyes greyish, eyes marked with dark stripes, dark band of eyes becomes confluent at this stage; lateral and median ocelli fully differentiated; vertex slightly produced anteriorly with an angulated margin; antennae greyish brown with their basal segments bearing whitish pigmentation, each antennae 23-segmented.

Female head medium-sized with frontal carinae well-developed, punctations seen on areas of frons persist, frontal area acquires a brownish colouration, basic colouration of eyes becomes brownish, dark bands of eyes become confluent at this stage, antennae greyish brown with their basal segments bearing whitish pigmentation. Each antenna 29-segmented.

Thorax in male well developed with pronotum distinctly saddle shaped; brown stripes running behind each compound eye extend up to antero-lateral sides of pronotum; anterior margin of pronotum straight, while posterior one bluntly angulated, two anterior pairs of legs slender with thickened femora; metafemora are best developed, metatibiae deep greenish blue, terminal as well as tibial spines of three legs tipped black. Brownish pigmentation on femoro-tibial joints noticed earlier persists.

Female thorax same as in the case of male; abdomen in male dark green, in female pale coloured; various parts of external genitalia in both sexes sclerotized. Length 16 mm - 32 mm; expanse of wings 33 mm - 60 mm.

DURATION OF LIFE STAGES

Average pre-oviposition period 11.6 days, average incubation period 120.5 days, and average nymphal duration is 51.0 days. There are seven nymphal instars in the female and six in the male hoppers (Ahmed, 1962). The average pre-oviposition period is 11.6 days.

The eggs are laid in autumn in the soil and as many as 100 eggs are laid by a female and nymphal period is about 100 days (Nayar *et al.,* 1976).

ACTIVITY PERIOD

The observations recorded under semi-natural conditions, show that on an average one generation of the insect is completed in 183.1 days. This helps to conclude that 365 – 183.1 = 1.99 (roughly 2 generations are completed under semi-natural conditions).

Studies on bionomics of hoppers in relation to food were carried out at Kaleki (Gujranwala; District) from April to August 1960. Berseem, shaftal and lucerne in April, berseem and sugarcane in May and rice in July and August were surveyed for counting the nymphal population. These observations by Ahmed (1962) showed that the average nymphal population per sweep on berseem, shaftal and lucerne in April; on berseem and sugarcane in May and on rice in July and August was 27.6, 4.6, 2.4, 39 0, 10.2, 41.8, 43.4 individuals, respectively.

NATURE OF DAMAGE

Nymphs and adults feed on rice leaves. They cause serious damage in the nursery stage. The main damage consists in nibbling the tender florets or gnawing at the base of the ear stalk at the shoot blade stage. The nymphs or hoppers generally feed on grasses over the bunds of rice fields, before attacking the crop. The leaves are completely eaten, leaving behind the mid-rib and stalk. In the ear-head stage of crop adults attack the ears or nibble at the tender florets or gnaw into the base of the stalks causing them to dry up and thereby leading to the formation of white ears.

HOST PLANTS

Besides rice, insect also feeds on the groundnut leaves.

CONTROL METHODS

Cultural: 1 In Japan, when the fields are flooded in preparation for paddy transplanting, the eggs float and are collected (Grist and Lever, 1969).

2. The areas of egg laying should be located and the eggs destroyed on an organized scale by ploughing, digging or harrowing.

3. Trenches of about 45 cm deep and 30 cm wide should be dug across the front of marching hoppers and the hoppers can be driven to these trenches and destroyed. The trenches are generally provided with metal sheet barriers over which the hoppers cannot jump.

4. Hoppers congregated on bushes are burnt by using flame throwers (Nayar *et al.*, 1976)

Biological: 1. Eggs are parasitized by *Tumidiscapus oophagus* Gir, *Anastatus coimbatorensis* Gir and *Scelio oxyae* Gir.
2. The adult is parasitized by a sarcophagid mite and predated upon by frogs and birds. It is infested by the fungus *Aspergillus flavus.*

Attractomorpha acutipennis Guer. (Acrididae: Orthoptera)
(Short horned rice grasshopper)

DIAGNOSTICS

General body colour green when alive, changes to yellowish green when dry; body long and slender; head conical, longer than pronotum, fastigium about as long as eyes, front very oblique, frontal ridge compressed between antennae; antennae short, triquetral, subfiliform, very slightly depressed and widened at base in female, and inserted at tip of fastigium; eyes oblong, cheeks with a row of granules extending to middle coxae.

Pronotum sub-marginate in front, and obtusly angulated behind, very slightly tricarinate, sulci present, hind sulcus placed behind middle, deflexed lobes almost perpendicular, broader behind with hind margin arcuately incised, and hinder angle more or less produced behind. Tegmina pointed, with costal area slightly expanded towards base. Wings nearly as long as tegmina, pointed at tip, hyaline, and reddish at base. Legs slender, hind femora with externo-median area somewhat oblique and distinctly broader than lower area, knees shortly bilobate, hind tibiae smooth, with pointed spines, and an outer terminal spine. Abdomen slightly compressed, with last dorsal segment angularly excised, superanal lamina trigonate, cerci short, conical, valves of ovipositor sinuated, and slightly crenulated.

The nymphs or hoppers generally feed on grasses over the bunds of rice fields, before attacking the crop. The leaves are completely eaten, leaving behind the mid rib and stalk. In the ear-head stage of crop adults attack the ears or nibble at the tender florets.

Trigonocorpha sp. (Tettigonidae: Orthoptera)
(Long-horned grasshopper)

DIAGNOSTICS

General body colour greenish when alive, turning to fadded orange

when dry; antennae located between eyes; exceed total body length; pronotum saddle shaped with clear divisions of prozona and metazona; legs not modified for any special function, metafemur one and a half times length of pro- and meso-femora; hemi-elytra almost double the body length, tapper towards distal end, hind pair of wings covered by hemi-elytra, only last 1/8 exposed; abdomen with extended ovipositor valve and clearly visible cerci.

The main damage consists in nibbling the tender florets or gnawing at the base of the ear stalk at the shoot blade stage. The nymphs or hoppers generally feed on grasses over the bunds of rice fields, before attacking the crop. The leaves are completely eaten, leaving behind the mid-rib and stalk. In the ear-head stage of crop, adults attack the ears or nibble at the tender florets or gnaw into the base of the stalks, leading to the formation of white ears.

Cylindrothorax ruficollis F. (Meliodae: Coleoptera)
(Leaf-eating beetle, blister beetle or oil beetle)

DIAGNOSTICS

General body colour earthy, head black, prothorax orange yellow, elytra with sky blue hue, abdomen with shinny bluish tinge, coxae resembling abdomen colour, tibiae and tarsi orange yellow low, palpi externally visible. General body shape narrow and elongate, head strongly deflexed, joined to prothorax by a distinct neck, neck narrow, elytra soft and flexible, pronotum narrow than head or elytra, tarsal claws appendiculate and serrate. Legs long and slender, hind legs comparatively longer, fore-coxal cavity open behind, elytra almost covering abdomen, reaching beyond end of abdomen; antennae exceeding combined length of head and thorax. Prothorax making a clear distinction with head and abdomen, elytra clearly deflexed anteriorly, rounded toward posterior edge, appear to have uniform thickness and with relatively uniform width throughout. Length 1.5 cm – 2.25 cm.

The main damage is caused to the leaves and stems of paddy plant. Soon after sunset as the darkness appears the adults hide in the paddy plant stubbles near ground. Several individuals were observed on leaves of one plant. Star shaped sieve like white spots appear on leaves due to the feeding of the beetles' larvae.

HOST PLANTS

The blister beetle usually damage the flowers and tender grains of

sorghum and other millets, excepting maize. The insect is also found in pastures.

Idgia flavibuccis Baurg. **(Prionoceridae: Coleoptera)**
(Lightening beetle)

DIAGNOSTICS

General body orange coloured, head black located toward lower side of body; antennae thinning-out towards outer extremity, basal segment thicker toward outer end; pronotum having an edge on lateral side, elytra having blackish mark at proximal end; abdomen with a tuft of hairs at end; legs short and stumpy, tarsi five segmented, last segment provided with claw; head, prothorax and wing bearing segments located very little distance between them.

The adults feed on leaves of paddy plants by sucking the sap. At the panicle initiation growth phase the adults suck the milky juice from the grains panicles and due to this shrivelled grains are developed.

HOST PLANTS

Members of *Idgia* have been recorded feeding on flowers of sorghum and maize, pollen and grains of sorghum.

Chaetochnema basalis Bally **(Chrysomelidae: Coleoptera)**
(Flea beetle)

The flea beetle feeds on the foliage, causing minute round or irregular holes.

Haltica cyanea Weber.**(Alticidae formerly Halticidae) Chrysomelidae: Coleoptera)** (Steel blue beetle or flea beetle)

DIAGNOSTICS

General body dark blue, antennae blackish blue, scutellum nearly black; vertex impunctate, frontal tubercles triangular and raised, inter-antennal carina rather broad. Prothorax broader than long, laterum slightly

rounded, surface impunctate, basal transverse furrow sinuate and placed at some distance from basal margin, scutellum broad, impunctate, elytra punctate, punctures tend to form row. Length 5 mm.

The adults of the beetle feed on the weed plant *Ammania* in rice fields and mostly breed on the foliage of singhara (*Trapa bispinosa*) crop.

The present writer observed the adults of this beetle crawling on the paddy plant leaves, where they stay for a long time especially on the newly emerged leaves. At evening they hide in the paddy plant stem, usually about 6 inches above from ground level. Perhaps star-like white spots are due to the damage caused by the beetle.

Myllocerus sabulosus **Mohi (Curculionidae: Coleoptera)**
(Cotton weevil)

DIAGNOSTICS

Size small, elytra greyish white and have dark line, head with eyes sublateral and only slightly convex, forehead evidently broader than space between scrobes and usually with a small central fovea. Rostrum broader than long, about as long as head, sides very slightly narrow from base to middle and a little dilated at apex emargination rather shallow but acute, upper surface faintly impressed and tricarinate, central carina very fine and ascending to forehead. Antenna piceous, with dense grey scaling, funicle with two basal joints equal, and 3rd not longer than 4th, prothorax transverse, sides slightly rounded, faintly constricted near base, posterior angles acute, apical margin vertical laterally and with a very small median sinuation dorsally, base scarcely broader, shallowly bisinuate and with central lobe itself slightly sinuate, punctuation not visible through scaling. Elytra subtrucate at base, with a deep common sinuation in middle of base, and set with short, curved, stiff subrecumbent setae. Legs red brown, with dense greyish scaling, femora with a single tooth.

Length 3/44 mm – 5-1/8 mm, breadth 2 mm – 3/28 mm.

Adults of the weevil feed on leaves from the edges, while grubs remain in the soil feeding on roots of host plants. In severe cases the attacked leaves wilt and dry up.

HOST PLANTS

It has been recorded on cotton plant, sweet potato, ber and guara. In

some parts of Indo-Pakistan adults are defoliators on mango trees and fruit trees etc.

Atherigona soccata Rond. (Muscidae: Diptera)
(Sorghum shoot fly)

DIAGNOSTICS

Egg: Eggs are white, elongate (0.8x02mm), with a raised, flattened longitudinal ridge. These are laid on the underside of the leaves of 7-8 days old seedlings or very young tillers. One to three eggs are laid per leaf. Hatching takes 2-3 days.

Larva: The third instar larva is white to yellowish, with anterior spiracle of a rosette type with 8-10 digitations. Larval development takes 7-12 days. A larva may be 10 mm long and 1.3 mm broad.

Pupa: Pupation takes place in the base of the necrotic shoot, or rarely in the soil, and takes about seven days. If the environmental conditions are unfavourable, pupa may go in aestivation.

Adult: It is a small insect measuring 4-5 mm in length. The females have head and thorax pale grey, and abdomen yellowish with paired brown patches. The males are black in colour. The life cycle is completed in 17-21 days.

NATURE OF DAMAGE

The young larvae crawl down inside the sheath and then bore horizontally into the base of the young shoot. They feed and kill the growing point of the shoot of the seedling and cause a typical dipteran "dead heart". The youngest leaf eventually turns brown and withers. Often the attack results in tillering, and in case of severe infestation even tillers may be attacked. Damage by different Muscid species is indistinguishable.

HOST PLANTS

Primarily it occurs on sorghum species, but as its alternate hosts it infests maize, millet, rice, wheat and grasses and weeds like *Andropagon sorghum, Cynodon dactylon* and *Panicum*, spp.

DISTRIBUTION

Nearly 50-60 species of *Atherigona* are found on cereals in tropics and

sub-tropics. Very little work about these has been done. This species has been reported from African, Asian and European countries.

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Chapter 2

INSECT PESTS OF MAIZE AND SORGHUM

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Many insects damage maize from seedling to maturity stage. Dicke (1977) reported 81 insects attacking maize in USA while in Turkey 80 species have been recorded (Lodes, 1981). Mathur (1983) mentioned 27 maize insects and mites from India. Insects of major importance feeding on maize were 40 in America, 34 in Africa & Europe, and 26 in Asia (Chiang, 1978). In Pakistan 24 species have been reported feeding on maize. The annotated list of pests damaging maize is provided in Table 1.

Table 1. Annotated list of pests damaging maize

Common name	Technical name	Family	Order
	Crop Pests		
Stalk borer	*Chilo partellus* (Swinhoe)	Pyralidae	Lepidoptera
Shoot fly	*Atherigona varia* var *soccata*	Muscidae	Diptera
Shoot fly	*A. naqvii* Steyskal	Muscidae	Diptera
Shoot fly	*A. orientalis* Schiner	Muscidae	Diptera
Armyworm	*Mythimna separata* (Wlk)	Noctuidae	Lepidoptera

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Common name	Technical name	Family	Order
Armyworm	*M. ioreyi*	Noctuidae	Lepidoptera
Corn earworm	*Helicoverpa armigera* (Hb.)	Noctuidae	Lepidoptera
Pink borer	*Sesamia inferens* (Wlk.)	Noctuidae	Lepidoptera
Cutworm	*Ochropleura (Agrotis) ypsilon* (Hufn.)	Noctuidae	Lepidoptera
Cutworm	*Ochropoleura (Agrotis) segetum*	Noctuidae	Lepidoptera
Leafroller	*Marasmia trapezalis* (Gn)	Pyralidae	Lepidoptera
Grasshopper	*Hieroglyphus nigrorepletus* Bol.	Acrididae	Orthoptera
Grasshopper	*H. banian*	Acrididae	Orthoptera
Grasshopper	*Aiolopus thalassinus* F	Acrididae	Orthoptera
Grasshopper	*Catantops pingius* Stall	Acrididae	Orthoptera
Grasshopper	*Truxalis grandis* L.	Acrididae	Orthoptera
Grasshopper	*Acrida exaltata* Wlk.	Acrididae	Orthoptera
Grasshopper	*Oxya multidenta* Will	Acrididae	Orthoptera
Toka	*Chrotogonus trachypterus*	Pyrgomorphydae	Orthoptera

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Common name	Technical name	Family	Order
Corn leaf aphid	*Rhopalosiphum padi* (L.)	Aphididae	Hemiptera
Corn leaf aphid	*Myzus obtusirostris* David, Narayanan and Rajasingh	Aphididae	(Hemiptera
Corn leaf aphid	*Sipha maydis* (Pass.)	Aphididae	Hemiptera
Maize jassid	*Zyginia* spp.	Jassidae	Hemiptera
Leaf hopper	*Zyginidia guynmi*	Cicadellidae	Hemiptera
	Stored Grain Pests		
Lesser grain borer	*Rhyzopertha dominica*	Bostrichidae	Coleoptera
Saw toothed grain beetle	*Oryzaephilus surinamenses* (L.)	Bostrichidae	Coleoptera
Rice weevil	*Sitophilus oryzae* (L.)	Curculionidae	Coleoptera
Red flour beetle	*Tribolium castaneum Herbst*	Tenebrionidae	Coleoptera
Confused flour	*T. confusum* J. Duval.	Tenebrionidae	Coleoptera
Grain moth	*Sitotroga cerealella* (Oliv.)	Gelechiidae	Lepidoptera
Rice moth	*Corcyra cepalonica* (Stn.)	Pyralidae·	Lepidoptera

Chilo partellus (Swinhoe)
(Pyralidae: Lepidoptera)
(Stem borer of maize and sorghum)

DIAGNOSTICS

Egg: Freshly laid eggs are whitish but later on these change to orange yellow and become dark before hatching. These are flat, oval, scale like, overlapping and about 0.8 mm long. They are laid in clusters, generally on the underside of the leaves near the midribs.

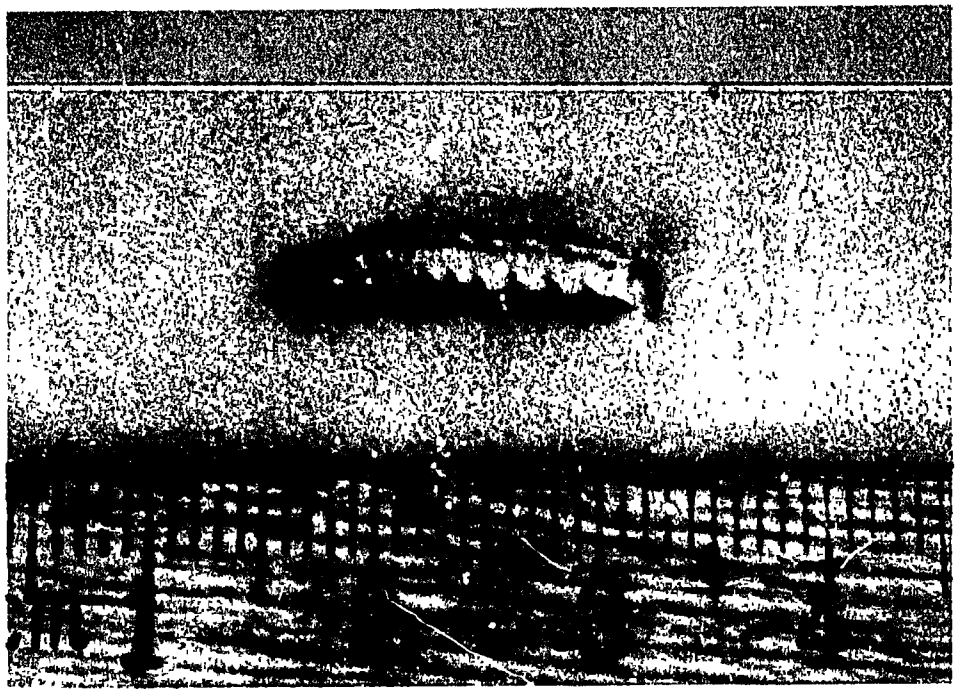
Larva: The larva is buff coloured with four longitudinal stripes, head capsule and thoracic shield are brown in colour. Newly hatched larva is light brown in colour with black head and pronotum. The head is larger and broader than body which narrows down posteriorly. The mouth parts are well developed and bright in colour. The full-grown larva (fifth instar) is dirty grey in colour with chocolate brown head and a black prothoracic shield. Four brown longitudinal streaks on its back are present.

Pupa: The pupa is cylindrical and tapering posteriorly. In early stages, the colour is brownish yellow but later on turns to reddish brown. The mouth parts are visible from ventral side. The male pupa is usually smaller than the female.

Adult: Medium sized, straw coloured, wing spread is 20-30 mm. The male is smaller and darker than female. Male has pale fore wings with dark brown scales forming a streak along the costa. The female has much paler fore wings and white wings. It is nocturnal in habit.

LIFE HISTORY

The biology of *C. partellus* has been studied by Katiyar (1962), Trehan and Butani (1950) and Butani (1966) in India. In Pakistan notable works are those of Rahman (1945), Khan (1975), Mohyuddin *et al.* (1973) and Moize and Qureshi (1967). Full-grown larvae hibernate in maize and sorghum stubbles in October and November. The larvae resume activity in the end of February-March at Rawalpindi. The larvae pupate in third week of March. At Yousafwala and Khanpur activity started about a fortnight earlier as compared with Rawalpindi on account of warmer region. There are over lapping generations (Mohyuddin *et. al.,* 1973).



DORSO-VENTRAL VIEW OF *CHILO PARTELLUS* LARVA

PUPA OF *CHILO PARTELLUS* IN MAIZE PLANT

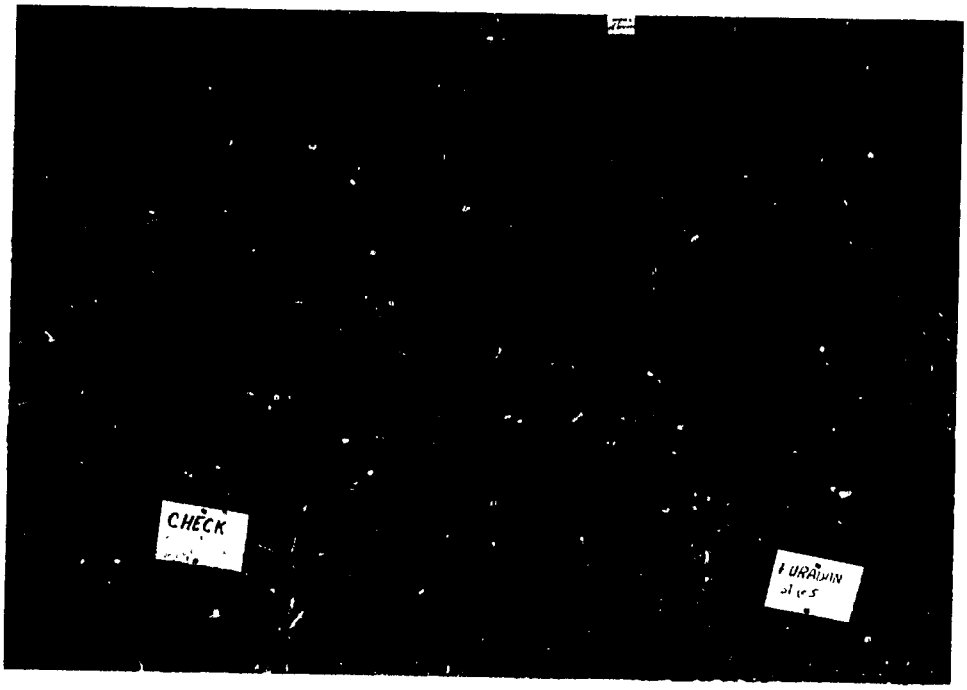
LEAF DAMAGE OF *CHILO PARTELLUS* LARVA

CHILO PARTELLUS DAMAGING MAIZE TASSEL

CHILO PARTELLUS IN MAIZE COB

DEAD-HEART OF MAIZE PLANT BY *CHILO PARTELLUS*

LABORATORY REARING OF *CHILO PARTELLUS* ON ARTIFICIAL DIET



INSECTICIDAL TREATMENT VS CHECK IN MAIZE CROP

Adults after emergence mate in the field and lay eggs on the underside of the leaves, in clusters during second fortnight of April. The adults become active after dusk. Females lay 8-12 clusters each containing 28-45 eggs. The number of eggs laid per female ranges from 265-361. The maximum number observed so far, has been 722 eggs. The egg period varied from 4 to 7 days depending upon temperature and humidity. It undergoes 6-7 instars and the full fed larva pupates within the stem for 2-15 days depending upon, the ecological conditions of the locality. The total life cycle is completed in 30-33 days during first generation. The adult life lasts 2-12 days during which the female oviposits for 1-3 days. The egg laying for second generation starts in second week of June and this generation requires about 27 to 32 days. For third generation, egg laying starts in mid of July and period needed for this generation is 23-28 days. Fourth generation starts in the first fortnight of August and the life stages are completed in 22 to 26 days. The fifth generation starts in the first fortnight of September. The full-grown larvae hibernate during winter in maize stubbles and start their activity during coming spring season. Khan (1975) reported five generations in Peshawar, while Mohyuddin *et al.* (1973) reported five generations at Rawalpindi and six at Yousafwala and Khanpur, which are warmer areas in the Punjab province. However, larvae do not undergo hibernation/diapause at Hyderabad and Karachi, which are more warm than Yousafwala, Peshawar and Rawalpindi.

NATURE OF DAMAGE

The newly hatched larva starts feeding on leaves and destroys the leaf surface and its midrib. Then it migrates to the top of the plant and enters the stem through the whorl. It makes tunnels into the stem centrally downwards, destroys the stem internally and kills the central shoot resulting in formation of dead hearts. Some plants however, recover before formation of dead hearts. At the tasselling stage the borer destroys the tassel by feeding on them. At ear formation stage, it sometimes enters the ear from its base and makes the tunnel in the centre of the cob. The larva also comes out from the centre of the cob and feeds on grains as well. It causes not only reduction in yield but also in quality of the grains. The holes in leaves and basal portion of stem and dead hearts are visible characters to ear mark the damage caused by stalk borer. This also indicates that all stages of the plants are attacked by the caterpillars.

DISTRIBUTION

It has been recorded from Mexico, Southern America, Ceylon, East Africa, Sudan, Sri Lanka, Nepal, India, Afghanistan, Thailand, Germany, France, Pakistan (Anon, 1964) and Mozambique (Goncalves, 1970).

HOST PLANTS

It attacks Baru *(Sorghum halepense* Pers.), sudan grass *(Sorghum sudanese* Stept.), sarkanda *(Saccharum sara* Roxv), maize *(Zea mays* L.), Sorghum *(Sorghum vulgare),* (Rehman, 1940), while, Ghani (1966) and Carl (1962) reported it from rice and sugarcane, respectively.

CONTROL METHODS

Cultural: 1. Destroy maize and sorghum stubbles so that the hibernating larvae are killed. This will reduce the adult population in the coming spring.

2. Khan (1983) reported that maize should be sown from mid-July and continued up to first week of August as June plantings are severely damaged by stalk borer in Peshawar valley. Rahman (1940) also reported that late planting minimized the borer infestation in Punjab.

3. Light traps if installed are a useful method of control. These can reduce the adult population.

4. Removal of weeds which are alternate host plants also help to reduce pest infestation. Removal of egg clusters and keeping these clusters in wire gauze cages near the field. The cages should be kept on a container having kerosenized water. Sharma and Sarup (1980) recommended sowing of 66,000 than 52,000 plants/ha as the former gave higher yield in maize.

Biological Control: The following natural enemies have been recorded in Pakistan:

1. *Trichogramma australicum* Gir, is an egg parasite.
2. *Apanteles flavipes* (Cam.) is a larval parasites.
3. *Bracon chinensis* Szep. is a larval parasites.
4. *Glyptomorpha deesae* (Cam.) is a larval parasite
5. *Xanthopimpla stemmatoi* Thumb. is a pupal parasite.
6. *Microbracon* sp.

7. *Coccinella septempunctata, Brumoides suturalis* (Fb.) and *Paederus fuscipes* Curt., are predators of the larvae.

The natural enemies are unable to suppress borer population, therefore, it is desirable to apply such insecticides like Endosulfan which have minimum effect on population of natural enemies (Sharma and Sarup, 1980).

Resistant Varieties: Neelum, Akbar, BR1, BR2 and Antigua were screened for resistance purposes. Antigua was found to be resistant against this pest (Mohyuddin *et al.,* 1973). Three hundred and fifty germ plasm were tested against borer conditions under natural infestation at NARC by Rahman and Javed (personal communication). Out of this 35 lines were selected depending upon borer infestation and other phenotypic characters.

Use of increasing seed rate to compensate the damage done by pest is also one of the control approaches.

Chemical Control: Bottrell and Smith (1982) and Heckman (1982) reported disadvantages of insecticides. However, it is difficult to control pests without the use of insecticides. Such insecticides should be used which cause less damage to natural enemies and environmental pollution. The experience has shown that insecticide granules are more effective than sprays. These chemicals and their method of application is as under:

Chemical	Rate/ha	Method of application
Furadan 3 G	17 to 20 kg	First application at the time of sowing; second application after 25-30 days of germination.
Sevin 20 G	10 kg	First application 7 days after germination while second after 20-25 days of first application.
Basudin 10 G	15 kg	First application 7 days after germination while second after 20-25 days of first application.
Thiodan 5 G	10 kg	First application 7 days after germination while second after 20-25 days of first application.

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Chemical	Rate/ha	Method of application
Padan 4 G	17 kg	First application 7 days after germination while second after 20-25 days of first application.
Diazinon 10G	7 kg for the 1st application	Apply in whorls on appearance of insect and then irrigate the field.
	9 kg for the 2nd application	Apply in whorls on appearance of insect and then irrigate the field.
Rogor 40EC Roxion 40 EC	300 ml for the 1st application	Spray when the appearance of the concerned insects has been noted.
Cygon 40 EC Perfekthion 40 EC	400 ml for the 2nd application	Spray when the appearance of the concerned insects has been noted.

The seed treatment with insecticides like Furadan and Advantage is also giving encouraging results.

Atherigona spp. (Muscidae: Diptera)

(Shoot fly)

This is very serious pest of spring maize, however, damage is also done during kharif season as well. *Atherigona soccata* Rondani is the most common species damaging maize. In India Davies *et al.* (1980) recorded 13 species damaging sorghum.

DIAGNOSTICS

Egg: Elongate, oval and slightly curved at the anterior pole. It varies in length from 1.14 to 1.3 mm and 0.25 to 0.6 mm in width. It is opaque white in colour. Distal part possesses two wings which run along the entire length of egg and enclose a central flattened area. Most of the ridges run from one pole to the other but some end in the way.

Larva: First instar larva is colourless/white but later on becomes yellowish.

Full-grown larva is yellowish brown with very small and rounded head which may be retracted completely within prothoracic segment. First instar larva is 1.3 mm long and 0.22 mm broad. Third and last instar larva is 3.23 to 6.2 mm long and 0.66 to 1.2 mm in width with two posterior black spiracular lobes. The body is cylindrically tapering anteriorly and tapers very slightly posteriorly.

Pupa: It is somewhat flattened dorsoventrally. The constrictions mark the position of segments on the dorsal side. Fresh pupa is pale white but changes to brown within 24 hours. The pupa of male is usually smaller than that of female.

Adult: It is just like a house fly in appearance but smaller in size, 4-5 mm long. The female has head and thorax pale grey, and abdomen yellowish with paired brown patches. The male is blacker and comparatively smaller than female.

LIFE HISTORY

The adults mate within 24 hours after emergence, and the egg laying starts next day. The eggs are laid on the leaf or on the soil near the base of plant. After hatching the larva crawls upwards until it reaches the base of the leaf blade. It enters the central shoots. This central shoot wilts and drops down within a day of entry of the maggot and finally becomes yellowish which give rise to dead hearts while other leaves remain green. The lower part of the dead heart turns yellowish and rots. The central shoot sometimes is entirely absent and the outside leaves appear unduly broad. The maggot may damage more than one tiller plant. It decreases the yield up to about 25-30% of the actual.

It remains active throughout the year. In spring and summer it is found on maize, sorghum and some grasses like madhana. It overwinters in grasses and wheat.

DISTRIBUTION

It is found in India (Davies *et al.,* 1980), Israel (Blum, 1979), West Africa (Deeming, 1971), North Africa, Uganda (Baliddawa and Lyon 1974). It has also been reported from Pakistan (Ghouri *et al.,* 1978), Burma, Thailand, Australia, Italy and in some parts of America.

HOST PLANTS

Maize, sorghum, wheat, barley, rye oats, foxtail and madhana grass.

CONTROL METHODS

Cultural: 1. Destroy alternate hosts present near the fields like madhana grass. Cultivation of sorghum as inter crop also reduces shoot fly infestation to maize.

2. Removal of dead hearts and burying them deep in the soil also helps. Sowing of resistant varieties can greatly reduce shoot fly damage.

Chemical: The following insecticides are beneficial for the control of shoot fly:

Insecticide	Dose in kg/ha	Method of application
Thimet 10 G	10	First application at the time of sowing while second application just before first irrigation.
Temik 10 G	10	
Disyston 10 G	10	
Furadan 3 G	17	First at sowing while second is whorl application.
Solvirex 10 G	10	15-20 days after germination.
Ekalux 5 G	20	-do-
Dimecron 100 E.C.	450 cc	Two applications: 7 and 20 days after germination.

Seed treatment with Furadan and Advantage 20EC @ 30-40 gm per kg of seed before sowing the crop also gave good control of shoot fly in rainfed areas.

GRASSHOPPERS

Fifty eight species of grasshoppers have been rcorded damaging rice, wheat, maize and other graminae plants. Of these *Ailopus thalassinus* F. (Baloch 1978), *Aiolopus simulatrix* (Wlk.), *Aiolopus strepens* Latr., *Acrida exalta* Wlk., *Acrida* sp. *Spathosternum prasiniferum* Wlk. (Anon., 1974) *Hieroglyphus banian* F., *Catantops pingius* Stall, *Oxya multidentata* Will. and

Chrotogonus trachypterus Blanch. were minor pests of maize in Pakistan. Twenty four species (Anon., 1974) and thirty two species (Perwin *et al.*, 1983) of grasshoppers have been reported from maize crop in Pakistan. Suitable soil and non-availability of host plants usually keep the grasshoppers population at a lower level. They are unlikely to constitute any major threat to agricultural wealth except during epidemic years. Some of the important species of grasshoppers are discussed as under:

Aiolopus thalassinus Fabr.

HOST PLANTS

The recorded host plants of this insect are *Triticum aestivum, Zea mays, Sorghum sudanense, S. halepense, Avena sativa, Arachis hypogaea, Cicer arietinum, Cynodon dactylon, Desmostachya bipinnata, Dichanthium annulatum, Gossypium* spp., *Echinochloa* sp. *Medicago sativa, Pennisetum typhoides, Pisum sativum, Saccharum officinarum.* (Anon., 1974).

BIOLOGY

Females lay eggs in moderately moist sandy loam soil. Egg pods are present in the field and on bunds. Each egg pod contained 12-21 eggs and incubation period is 17-23 days at 30°C. There are 5 to 6 nymphal instars and it takes 29-39 days (average 33) at 24°C 2 R.H. 72% (Anon., 1974). Baloch (1978) reported 5 instars when reared at 33 and 37°C.

Acrida exalta, Acrida sp. and *Truxalis grandis*

DISTRIBUTION AND HOST PLANTS

These are widely distributed in Pakistan. These are recorded from *Arachis hypogaea, Cynodon dactylon, Dichanthium annulatum, Desmostachya bipinnata, Echinochloa* sp., *Gossypium* spp., *Medicago denticulata, M. sativa, Oryza sativa, Pisum sativum, Saccharum officinarum, Sorghum halepense, S. sudanense* , *Trifolium alexandrinum, Triticum aestivum* and *Zea mays.* These were comparatively more abundant on cultivated crops rather than on wild grasses but could only be regarded as minor pests of maize, sorghum, wheat and rice.

BIOLOGY

These insects have one generation in a year and overwinter in the egg and nymphal stages (Anon., 1974).

Spathosternum prasiniferum Wlk.

DISTRIBUTION AND HOST PLANTS

This is collected from *Arachis hypogaea, Avena sativa, Brassica campestris, Cynodon dactylon, Cyperus rotundus, Desmostachya bipinnata, Dichanthium annulatum, Medicago denticulata, M. sativa, Oryza sativa, Sorghum halepense, S. sudanense, Trifolium alexandrinum, T. resupinatum, Triticum aestivum* and *Zea mays.* It is a minor pest of grasses. The additional grasshoppers recorded from maize in Pakistan are given below (Anon., 1974):

1. *Atractomorpha acutipennis* (Guer.)
2. *Chorthippus* sp., nr. *indicus* Uv.
3. *Chorthippus* sp.
4. *Duroniella* sp.
5. *Oedaleus obruptus* Thunb.
6. *Oedaleus senegalensis* Krauss.
7. *Paratettix scaber* Thunb.
8. *Phlaeoba panteli* (I. Bol.)
9. *Pyrgomorpha conica* B.B.
10. *Sphingonotus kashmirensis* Uv.
11. *Stenohippus* sp.
12. *Trilophidia annulata* Thunb.
13. *Trilophidia conturbata* (Walk.)

Hieroglyphus nigrorepletus Bolivar (Acrididae: Orthoptera)

(Phadka grasshopper)

The thorax has three to four longitudinal black stripes. The adults emerge in June to August. The females lay eggs along the sides of field bunds about 5-13 cm deep in the soil during September and October. Both the macropterous and brachapterous forms occur in this species. Those with short wings, mate repeatedly and eggs are laid in instalments; a female laying 3-6 egg-pods, each containing 23-53 eggs. These eggs hatch the following year

when sufficient moisture becomes available due to monsoon rains. The eggs remain viable up to 3 years.

The damage is usually caused to leaves of the plants by both the nymphs and adults. These insects can be controlled by dusting the infested crop with BHC, Chlordane or Dieldrin.

It is a destructive pest of millets, but causes considerable damage to maize, sorghum and paddy.

CONTROL METHODS

Grasshoppers are considered as minor pests of maize, however, in case of epidemic, one has to adopt some control measures. The most effective method to suppress their population is to control grasshoppers, in breeding areas. Some of the control measures are given below:

Cultural: Tillage operations will destroy many egg pods of grasshoppers by mechanical damage and by exposing them to predators and parasites, and adverse weather conditions. Clean cultivation also helps in destruction of grasses which are the alternate host plants of many grasshoppers.

Chemical: Effective insecticides in the form of spray or bait may be used for control of grasshoppers Dust formulations get wasted and are also more hazardous. The insecticides, like Acephate (Orthene), Carbaryl (Sevin), Diazinon (Basudin), Malathion, Chlorpyrifos (Lorsban) Methyl parathion are effective for control of grasshoppers and will not leave any harmful effect if properly used. A spray will usually give a higher initial control than a dust, and will continue to kill grasshoppers over a longer period of time with less total insecticide used. Sevin must be used with greater caution near apiaries.

Baits were previously considered good method of control but now this has been replaced by spray. When crop plants are only few inches tall, baiting is used for control of grasshoppers.

APHIDS

Myzus obtusirostris David, Narayanan and Rajasing, *Rhopalosiphum padi* (L.) and *Sipha maydis* (Pass.) have been found damaging maize in Pakistan. *M. obtusirostris* occurs only in the hills and has comparatively higher population in the Kaghan Valley (1,800-2,100 metres) than in the Murree Hills (2,000 metres) but is short lived in the Swat Valley (1,800 metres) (Hamid, 1984), *Rhopalosiphum maidis* (Fitch) (= *Aphis maidis* Fitch) is sometimes seen in colonies within the unopened leaves of sorghum, maize and other millets. It also infests unfurled central leaves of wheat, causing

yellowish discolouration. During March-April its nymphal period lasts for about 9 days. The adult has a life span of about 28 days. It is parasitised by *Aphidius transcapicus* Tele.

R. rufiabdominalis called rice root aphid, infests the mesocotyledon of wheat seedlings. Besides the preceding two aphid species, other namely, *Macrosiphum (Sitobion) miscanthi* infests leaves and earheads. *Longiunguis* sacchari (Zhnt), *Acyrthosiphon pisum* (Harris) and *Myzus persicae* (Sulz.) are the other aphid species that could occur on wheat.

CUTWORMS

Ochropleura (Agrotis) ypsilon (Hufn.) and *O. segetum,* are the two species of cutworms which have been identified damaging maize in Pakistan. The percentage attack of cutworm is more in maize followed by potato in case of spring maize.

NATURE OF DAMAGE

Feeding symptoms on leaves may be similar to the damage caused by other insects. Cutting of maize seedling is the typical sign of attack. In case of cut plants examine the soil around the plant, and larvae can be found in the soil. Larvae of cutworms feed at night and hibernate in the soil during day.

CONTROL METHODS

Spraying the field crop with Lorsban @ 1 to 1.7 litres a.i/ha can kill the insect. Other insecticides like Sevin (Carbaryl) @ 2.2 kg a.i/ha, Toxaphene (3.3 litre a.i./ha) are also important for controlling the cutworms. Band application of Sevin dust on the ridges late in the evening is also recommended.

Helicoverpa (= Heliothis) armigera (Hb.)

H. armigera is widely distributed in Europe, Asia, USSR, Africa, the Australasia and the Pacific Island. It is a polyphagous and has been reported from 127 host plants from Africa, Asia and Australasia (Read and Pawar 1982). Bhatnagar and Davies recorded 105 host plants in India while Saleem and Yunus (1982) mentioned 41 plant species. However, CIBC (1986) reared from 69 host plants in Pakistan. The larvae feed on maize silk, and upper portion of cob during September, October in Islamabad-Rawalpindi area while in Punjab the larvae are also collected during May. This is not a serious

APHIDS DAMAGING MAIZE PLANT

HELIOTHIS ARMIGERA **FEEDING ON MAIZE SILK**

CUTWORM DAMAGING MAIZE PLANT

DAMAGE OF ARMYWORMS VS NORMAL CROP

pest of maize. However, in case of heavy losses, Nuvacron (Monocrotophos) Dimecron (Phosphamidon), Sumicidin (Fenvalerate) are important insecticides for the control of this insect.

Zyginidia quyumi (Ahmed) (Cicadellidae: Hemiptera)
(Leaf hopper of maize)

The species has been described from maize *(Zea mays* Linn.), from Quetta, but also occurs all over Punjab on wheat. It also occurs on cucurbitace us plants in small numbers. The attack of this leaf hopper on the host plant results in extensive 'stippling' on the upper surface of leaves.

The species has been named after Dr. A. Qayum, former Government Entomologist, Balochistan. In characters, this species comes very close to *Zyginidia bindrai* and *Z. manaliensis* (Sing, 1969), from which it differs in the shape of pygofer process, and chaetotaxy of male plate.

Its description is as given below:

External features: Length of male 3.3 mm; head convex in front; median length of crown about half interocular width; ocelli absent; pronotum broader than long; scutellum with two black spots anterolaterally; posterior extremity black; general body colour pale; abdomen black dorsally; fore wings pale green.

Male genitalia: Male plate, in lateral aspect, sinuate in middle, basal half broader than apical half, with 4-5 microsetae near base, and some around apex, in ventral aspect with three macrosetae in basal half near midlength; pygofer disc rounded posteriorly, mostly devoid of setae; possessing a spiny arc-shaped process; connective Y-shaped, with stem short, and an antero-median lobe; aedeagus with a pair of ventral atrial processes as long as shaft, and quite close to the shaft; shaft possessing a mid-dorsal spine.

Amsacta moorei Butler (Arctiidae: Lepidoptera)
(Kutra moth, Red hairy caterpillar)

The caterpillars of this polyphagous pest do considerable injury to young sorghum, maize and bajra. The larvae are reddish-brown and hairy and are voracious feeders of the foliage.

Marasmia trapezalis Guen (Pyralidae: Lepidoptera)
(Sorghum leaf roller)

It is only a minor pest of millets but also infests sorghum. The moth is yellowish-brown with brown wavy markings on the wings. Eggs are laid singly on the upper leaf surface. The larvae fold leaves and feed on the chlorophyll from within. It has five larval instars and enters pupal stage after 12-20 days during July-September. Pupation takes place within the leaf folds for 6-8 days. In the field its infestation can be recognized by the presence of drying up of the leave tips.

The larvae are parasitised by *Goniozus marasmi*. The larvae can be controlled by a contact or even systemic insecticide.

Mythimna separata (Walker) (Noctuidae: Lepidoptera)
(Army worm, Rice-ear-cutting caterpillar)

The adult is a pale-brown moth measuring 35-40 mm across stretched wings. Eggs are laid in overlapping rows. The pest is usually present in the field during July-September and the average duration for eggs, larvae and pupae are 3, 21 and 10 days, respectively, under the field conditions. The larvae pass through six instars. The full-grown larva measures 38 mm in length and pupates in ground, cracks, crevices or clumps of paddy. The total life cycle in male and female is completed in 45 and 49 days, respectively. The respective adult life is 9 and 12 days for males and females. There are two generations between July and December.

The fresh larvae eat chlorophyll, the second and third stage larvae cut leaves while the 4th to 6th stage larvae can cut the thick part of whorls and feed on the silk of cobs. Sometimes the larvae remain in the whorls and feed on the newly emerging leaves of maize.

DISRTIBUTION

Pakistan, India, China, Korea, Japan, Philippine, Indonesia, Australia and New Zealand.

HOST PLANTS

Maize, sorghum, rice, sugarcane, tobacco, wheat, some pulse crops and grasses.

CONTROL METHODS

In case of severe infestation apply dusts in the central whorl. Dust containing 25% Parathion or 4% Zolone (phosalone) should be applied in the central whorl. If the damage is severe near silking stage Ambush (permethrin) or Sumicidin (fenvalerate) should be applied at a rate of 100 cc/ha. Before or near tasselling stage either Nuvacron (monocroptophos) @ 750 cc or Thiodan (endosulfan) @ 750 cc should be applied.

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Chapter 3

INSECT PEST COMPLEX OF WHEAT CROP

Ali Asghar Hashmi*

Wheat (*Triticum vulgare*) is an important food grain which is currently being cultivated on about 7.73 million ha in Pakistan. An average yield of 1863 kg/ha has been considered by the agriculture experts to be very low in the present era of science and technology. This poor output has been attributed to the primitive methods of cultivation, low-yielding varieties, lack of irrigation water, inadequate use of fertilizers and high incidence of pests and diseases. The insect infestation of wheat has not been a serious concern in the past, consequently very little attention was paid to the study of insect complex of this crop. During the last 10 years the government has been regularly launching a national derive to increase the wheat production in order to achieve the food grain target of 15.5 million tons during 1990-91 and to save about 120-300 million dollars which are being spent annually to import required quantity of grain. This has been done by introducing high yielding Mexican varieties, enhancing application of fertilizers and irrigation water. With this sort of intentional interference in the natural hormonious set up of a chemically free agroecosystem, a new environment for the crop attacking organisms is inevitable to emerge. It may also be asserted that nature is immensely complex. Often in ways about which our ignorance is awesome. Consequently, when we make major changes in the world of living organisms deliberately or, as is more frequently the case, accidently we are modifying enormously complex homeostatic mechanisms in such a way that we may not be able to foresee the consequences. Such an environment in the farm technology is not only apt to help the rapid build up of insect pest population but is also likely to turn certain insects of less importance into serious pests. Further only a few species can withstand the environmental stress and stay in stable populations in a changed millieu. Some even may go

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extinct. Very little information regarding the insects as pests of this crop has been made available under the modified set of conditions. A change in the environment reduces a compensatory change in the frequency distribution of different genotypes and phenotypes in the population. Therefore, an assessment of numerical abundance at various time intervals, if carried through several successive years may lead to the exact determination of the trend of a specific species in a particular locality. The present chapter, therefore, aims at reporting the established harmful insects as a part of the total insect complex of different wheat varieties. To make it suitable for the extension workers and non-taxonomists, descriptions limited only to few diagnostics have been provided.

Sminthurus viridis (L.) **(Sminthuridae: Collembola)**
(Spring tail)

DIAGNOSTICS

Antennae longer than head; body sub-supherical or globular, indistinct or obsolete segmentation due to fusion of thoracic and first four abdominal segments; forked springing organ or forcula on 4th and a hook (hamula) on 3rd abdominal segment; a groove of simple eyes or ocelli on each side of dorsum of head; a sucker like tube arising from ventral surface of 1st abdominal segment; cerci absent; 1-2 mm in length.

NATURE OF DAMAGE

It usually attacks the roots of the plant and the plants ultimately wither and die. These insects are also reported to make holes in the leaves of wheat crop and clover similar to those caused by flea beetles and they feed on the mesophyll tissue between the two epidermal layers, making the leaves appear transparent. Ultimately the leaves become skeletonized. Populations can become very large and then the pest becomes of economic importance. The extent of damage may reach up to 20 - 30 per cent of the crop.

Chrotogonus spp. **(Acrididae: Orthoptera)**
(Surface grasshopper)

DIAGNOSTICS

Adults stoutly built, small, flattened, short winged and stumpy; dorsum rough and earthy coloured, underside white speckled with black spots;

antennae shorter than head and pronotum together; head profusely tuberculated, shorter than pronotum; face and cheeks with fine tubercles; frontal carinae diverge slightly below antennal base, form an oval ridge around median ocellus, transverse yellowish band accommodating median ocellus, frontal carinae bear two pairs of small black spots near fastigium; four pairs of black spots on each of lateral carinae.

Antennae 13-14 segmented in male and 14 segmented in female, antennae greyish to black pigmented above and bluish below.

Pronotum rugose, thickly tuberculated, hind margin and lateral sides acutely angulated.

Pro- and meso-legs small and slenderly built, their femora and tibiae ringed with dull brown bands; meta-femora well developed, nearly as long as abdomen, expanded transversally at base, narrowed towards extremity, meta-tibiae pale yellow bearing a dull black band at base of each tibia, rest of surface marked with dull brown band; first two tarsal segments may exhibit a greenish appearance.

Tegmina shorter than abdomen in most females, longer in males, dusty brown in appearance with a yellowish tinge; considerably humped, furnished with numerous black spots arranged in rows; wings hyaline, bear light greenish yellow pigmentation towards their bases nearly as long as tegmina.

Abdomen brownish dorsally, pale white laterally, white grey ventrally.

Aiolopus tamulus (Fab.) **(Acrididae: Orthoptera)**
(Surface grasshopper)

DIAGNOSTICS

Adults small, green, brown or reddish with two parallel brown stripes on vertex; hind femora slender, green, yellow or reddish with brownish transverse bands; body medium sized, slenderly built; antennae as long as head and pronotum together; head distinctly thicker than pronotum, face and teeth smooth, very sparsely and finally punctured; frontal ridge broad, convex, feebly impressed at ocellum, sparsely punctured below latter, and densely above it, margins of ridges very obtuse, gradually divergent from fastigium downwards, disappearing just below median ocellum; temporal foveolae only half as long as broad, narrowed apically, very feebly impressed, regularly punctured, lower margin slightly distinct, interrupted by punctures, fastigium of vertex a little broader than long, almost horizontal, retundo-

pentagonal with a distinct transverse impression near base, margins slightly raised and obtuse.

Pronotum constricted a little behind fore margin, almost flat and strongly dilated in meta-zona, median keel rather thick and low, cut by transverse sulcus distinctly before its middle; hind angle obtusely rounded, with its disc straight, lateral lobes not much higher than long, very feebly narrowed downwards, margin straight and almost vertical, fore lower angle obtuse, hind angle straight, scarcely rounded at apex.

Tegmina long, extending much beyond meta-femora, thick at base, tapering towards extremity, about as long as or slightly shorter than abdomen.

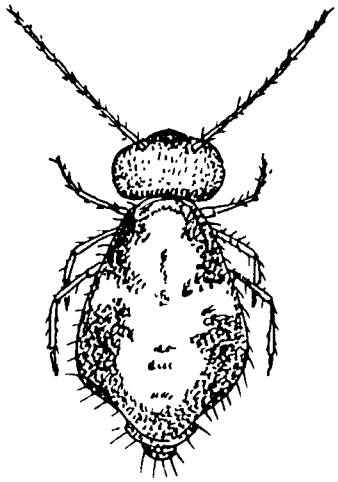
Wings hyaline with greenish tinge towards base, more or less dusty towards hinder margin.

Hind femur green or brown above, three transverse dark brown bands visible on upper inner area, inner side red in basal half, greenish towards apex with a large though interrupted black spot near base; knees with brownish semi-lunar spot outwardly and with a deep black spot of same shape inwardly; hind tibiae deep red gradually becoming paler towards base, with a small black sub-basal spot on inside and brownish on outside before middle; spines pale white tipped with black; hind tarsi pale yellow.

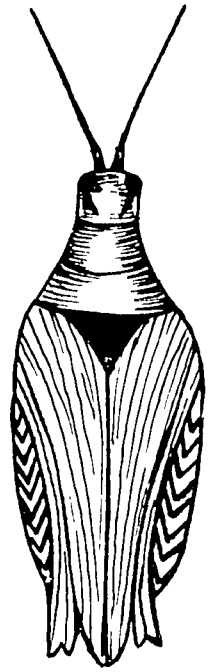
REMARKS

Species differ in colour. Some are green and white, others show shades of brown and red, still others are with a light ochreous tinge. There is one stripe of reddish brown colour on the vertex which runs between eyes to the back of the pronotum. There is a broad dark brown band running from the back of each eye to the end of pronotum which extends over the pleura, it is marked with white spots. The upper side of the dark band is bordered by a slender white line, which in the posterior part of the pronotum intersects the broad line turning obliquely outward.

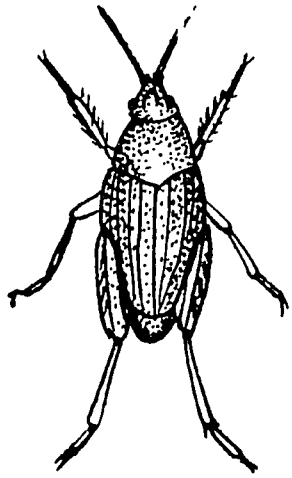
Tegmina also vary in colour, may appear brown or greyish yellow, apically sub-hyaline, mediastinal area with two alternate long brown and whitish spaces; the outermost of each broader, below the first brown space runs a bright greenish or yellowish stripe towards the second white space; apical one-third sub-hyaline, with indefinite brownish fasciae and several spots. Body length 19-25 mm; Expanse of left tegmen 19-25 mm



SMINTHURUS **SP.**



CHROTOGONUS **SP.**



AIOLOPUS TAMULUS **(FB)**

Schistocerca gregaria Forsk. **(Acrididae: Orthoptera)**
(Desert locust)

DIAGNOSTICS

Body very large and slender; front perpendicular, fastigium of vertex small, broader than long, depressed in middle, raised on lateral margins; carinae placed in front of eyes and pass in suture of frontal furrow; frontal furrow well spaced, quite straight throughout fronts, margins almost levelled to furrow, depressed slightly just below median ocellus; lateral carinae slightly curved in middle; pronotum thickly punctured, constricted in front, expanded and obtusely rounded behind, deflexed lobes depressed much laterally, median carina well marked, cut by four transverse sulci in anterior half, of which anterior one not well marked; prosternum provided with apex rounded straight spine.

Tegmina more than three times longer than abdomen; general body yellow to dark yellow; antennae reddish brown; face marked with blackish or dusky vertical lines, a median pale line with a dark brown or dark yellow border, sometimes running backward from fastigium of vertex to hinder margin of pronotum and forward on frontal furrow to reach epistomal suture, a dark line below eyes runs downward; tegmina of body colour, sub-hyaline, marked with irregularly brown spots; wings slightly shorter than tegmina, stained with yellow at base; meta-femur unicoloured, knees marked dark brown, dorsal carina marked with inconspicuous brown spots and a black longitudinal streak on outer side; meta-tibiae dull pink, equipped with black-tipped white spines; nine and twelve spines on outer and inner carinae, respectively.

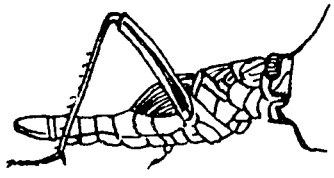
Acheta domesticus (L). **(Gryllidae: Orthoptera)**
(Black-headed cricket)

Synonym: *Gryllus domesticus (L.)*

DIAGNOSTICS

Medium sized, with light brown body; pronotum with brown patches.

EGG



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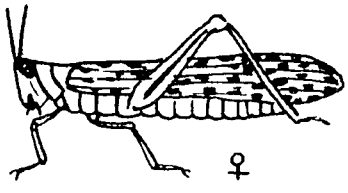

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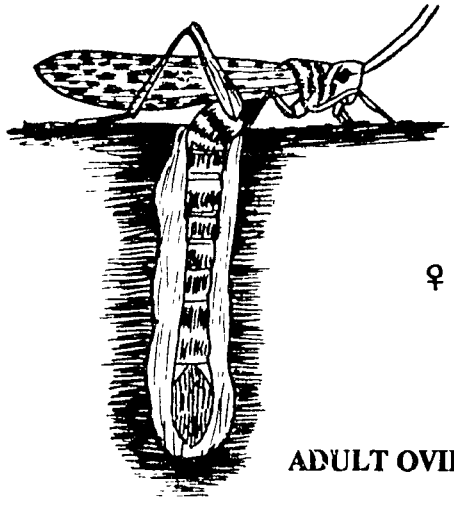
ADULT



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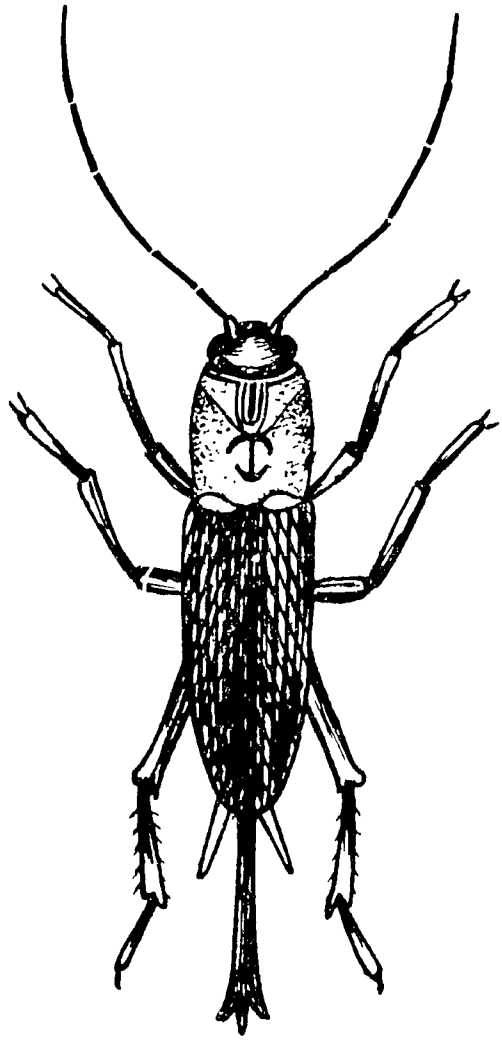
ADULT OVIPOSITING

SCHISTOCERCA GREGARIA (FORK.)



ADULT MALE

GRYLLUS BIMCULATUS **(DEGEER)**

Acheta hispanicus R. (Gryllidae: Orthoptera)
(Black-headed cricket)

DIAGNOSTICS

Medium sized cricket; body colour light brown; pronotum with dark brown patches.

Gryllus bimaculatus DeGeer (Gryllidae: Orthoptera)
(Field cricket)

DIAGNOSTICS

Adults well built, black coloured; head absolutely black; each fore wing black with a yellow spot at base; hind wings transparent.

DAMAGE BY ACRIDIDS AND GRYLLIDS

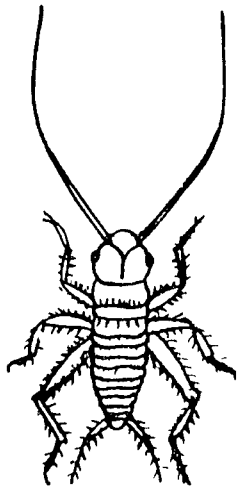
The damage caused by the acridids and gryllids is similar. The adults and nymphs cause serious damage to the young plants by cutting away the tender leaves, seedlings and stems. In case of heavy outbreaks most of the crop was damaged. Sometimes the leaves, buds, stems and the older plants were also damaged. The surface grasshoppers and gryllids are serious pests only during the early stages of the crop but their potential decreases as the crop is advanced.

Microtermes obesi Holm. (Termitidae: Isoptera)
(White ant)

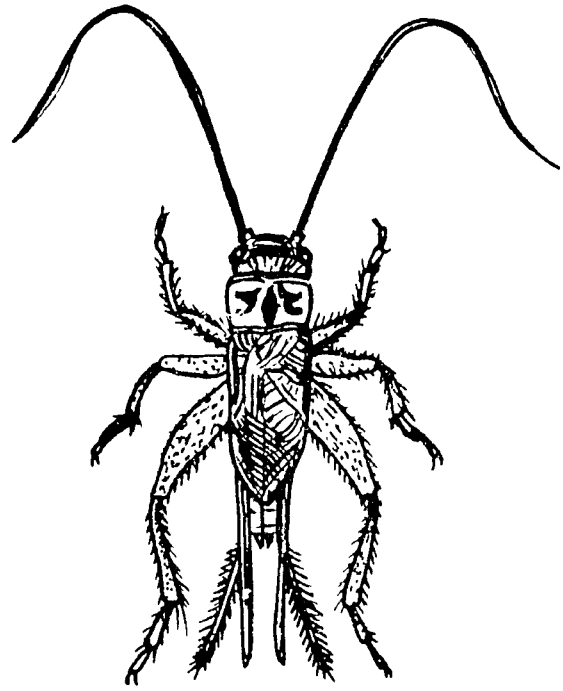
DIAGNOSTICS

Pronotum of workers and soldiers narrow, with a raised median anterior lobe.

Workers of *M. obesi* small, wingless, yellowish white; head oval, pale; cuticle thin and soft. Workers of *T. obesus* larger than *M. obesi*, wingless, soft bodied and greyish white.

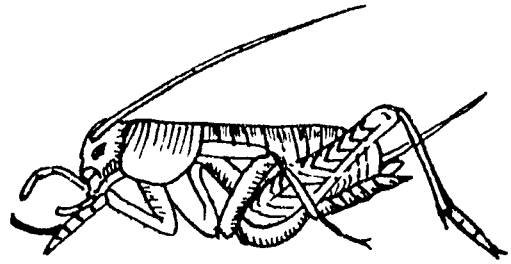


FRESHLY HATCHED CRICKET

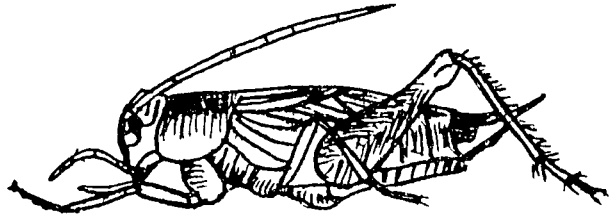


ADULT FEMALE
ACHETA DOMESTICUS (LINN.)

EGG



NYMPH



ACHETA HISPANICUS (R.)

MEASUREMENTS (IN MM.)

(Imagoes)

Length of head to side base of mandibles	0.92-1.04
Width of head	1.31-1.38
Long diameter of eye	0.36-0.40
Short diameter of eye	0.30-0.36
Length of ocellus	0.15-0.20
Width of ocellus	0.11-0.13
Ocellus from eye	0.05-0.07
Width of pronotum	1.19-1.30

(Soldiers)

Length of head to side base of mandibles	0.76-0.82
Maximum width of head	0.72-0.78
Length of left mandible	0.47-0.51
Length of pronotum	0.30-0.32
Width of pronotum	0.49-0.53

NATURE OF DAMAGE

It was commonly feeding on stumps, logs, twigs and roots of the plants.

The termite was found making irregular type of feeding galleries. The damage portions were replaced with mud. It was found approaching the host from their nests through underground tunnels. Considerable damage to crop is caused by this termite.

Odontotermes obesus (Ramb.) **(Termitidae: Isoptera)**

(White ant)

DIAGNOSTICS

Pronotum of workers narrow, head of soldier broader, with a raised median anterior lobe.

MEASUREMENTS (IN MM)

(Imagoes)

Length of head to side base of mandibles	1.93-2.15
Width of head	2.76-2.87
Long diameter of eye	0.80-0.90
Short diameter of eye	0.67-0.77
Length of ocellus	0.32-0.45
Width of ocellus	0.25-0.28
Ocellus from eye	0.09-0.12
Width of pronotum	2.51-2.60

(Soldiers)

Length of head to side base of mandibles	1.29-1.44
Maximum width of head	1.15-1.26
Length of left mandible	0.86-0.98
Tooth of left mandible from tip	0.30-0.35
Length of pronotum	0.51-0.57
Width of pronotum	0.80-0.94

NATURE OF DAMAGE

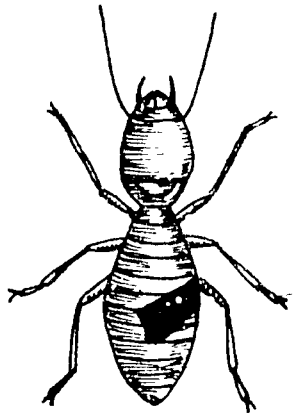
It damages young seedlings of wheat crop. It is a minor pest of wheat crop. Workers feed on cellulose which they obtain from roots of wheat plant. The attacked plant remains stunted, wilt and ultimately die. The attack is more severe during the early stages of crop.

Anaphothrips sundanensis Trybom **(Thripidae: Thysanoptera)**

(Thrips)

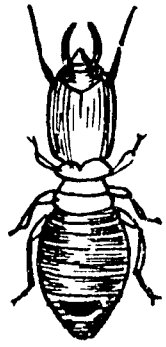
DIAGNOSTICS

Terminal antennal segments not long and thin; dorsum of body not polygonally reticulate.



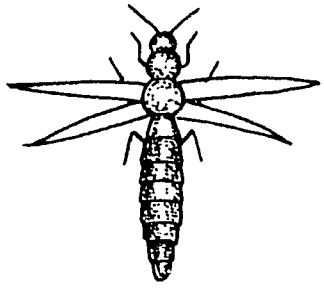
MICROTERMES OBESI (**HAL.**)

WORKER



SOLDIER

ODONTOTERMES OBESUS (**RAMB.**)



ANAPHOTHRIPS SUNDANENSIS (**TRYBOM**)

Bregmatothrips brachycephalus (Shansber) **(Thripidae: Thysanoptera)**
(Thrips)

DIAGNOSTICS

Adults amber yellow with bright orange thorax; body slender, 1.23 mm long.

Taeniothrips flavidulus (Begnall) **(Thripidae: Thysanoptera)**
(Thrips)

DIAGNOSTICS

Dark brown to almost black; antennae 8-jointed, seventh joint about twice as long as eighth; 1.26 mm long.

Haplothrips priesnerianus (Begnall) **(Phlaeothripidae: Thysanoptera)**
(Thrips)

DIAGNOSTICS

General body colour black, tips of legs and some middle antennal joints yellow; 1.5-1.8 mm long.

NATURE OF DAMAGE

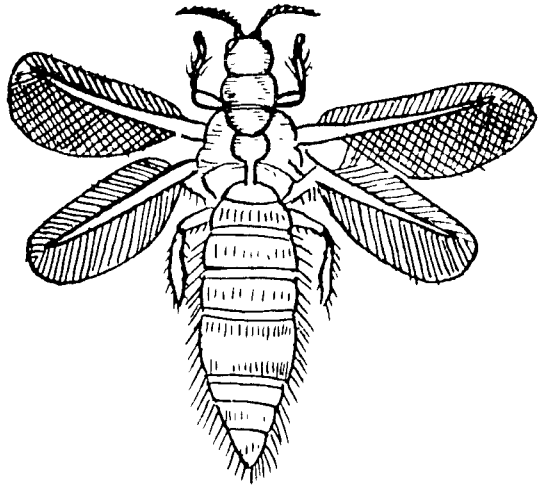
The affected plants show silvering or bleaching of the surface of leaves, fruits and stems. Growing tissues of terminal leaves and buds become deformed. The injury is first evidenced by small, scattered, dark greenish brown spots which after 2 or 3 days assume a characteristic silvery appearance. Their excrement on foliage, creates an unsightly residue. A number of virus diseases of plants are spread by thrips. Feeding on the lower side of leaf surface checks growth. This results in a curled and mis-shaped leaf which may split at several points and assume ragged appearance.

Bagrada cruciferarum (Kirkaldy) **(Pentatomidae: Hemiptera)**
(Painted bug)

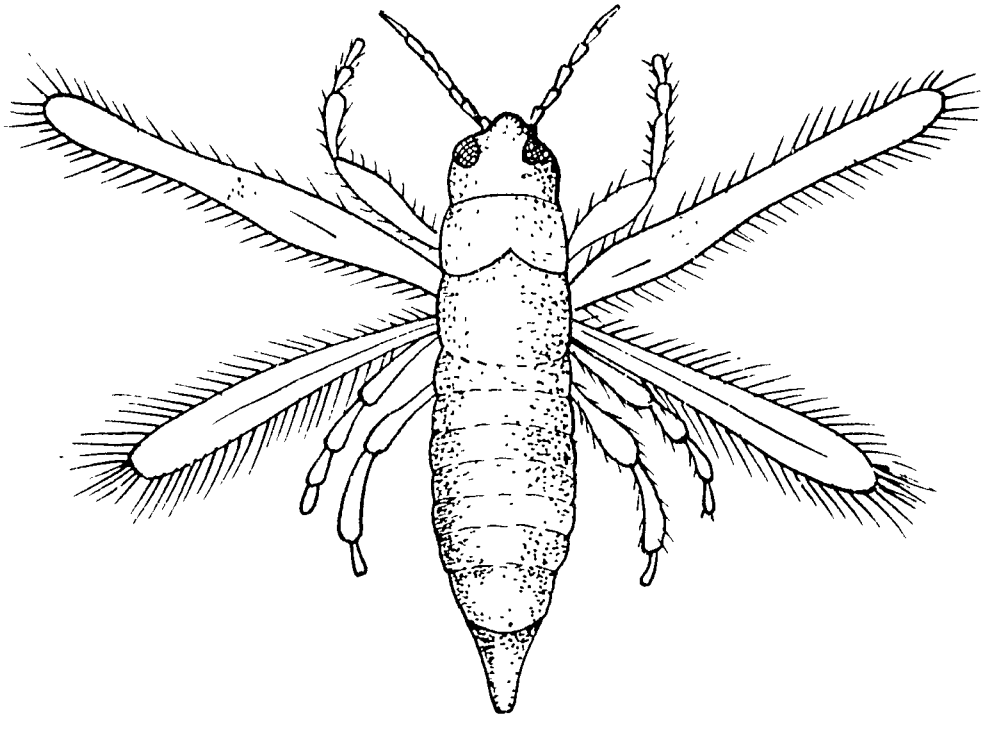
Synonym: *Bagrada picta* **Fabr.**

DIAGNOSTICS

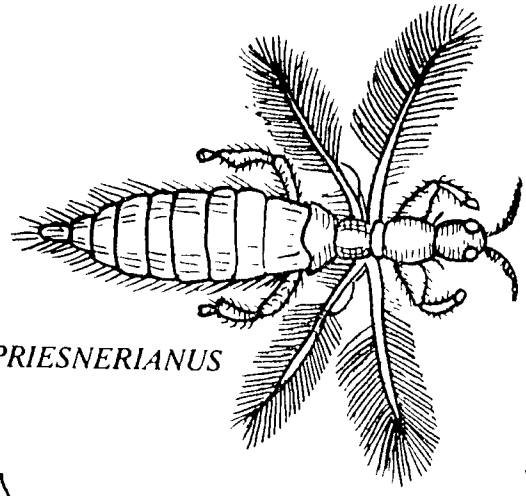
Shield-shaped; upper surface with a mixture of black, white and orange



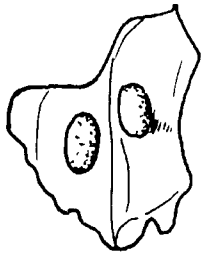
BREGMATOTHRIPS BRACHYCEPHALUS



TAENIOTHRIPS FLAVIDULUS (**BAGNALL**)



HAPLOTHRIPS PRIESNERIANUS



EGGS ON LEAVES

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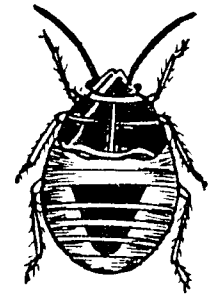

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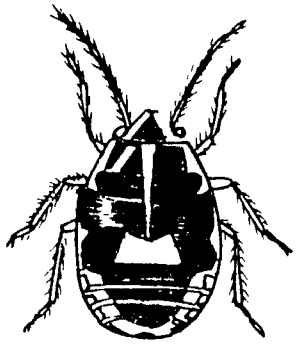

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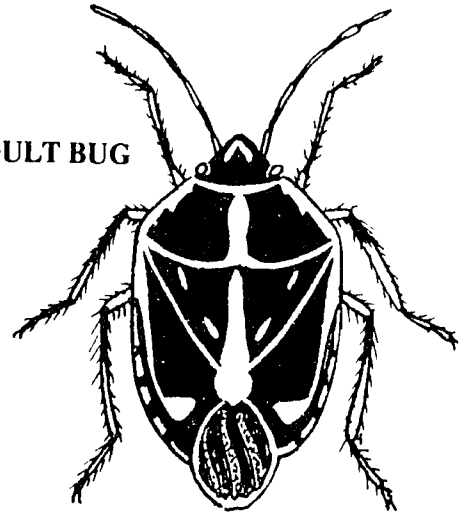
ADULT BUG



BAGRADA CRUCIFERARUM **KIRKALDY**

markings; 5-7 mm long and 3-4 mm broad. Full-grown nymphs sub-ovate, black, with a number of orange or brownish spots; about 4 mm long and 2.66 broad.

NATURE OF DAMAGE

This insect feeds on the kernels in the milky dough stage. It destroys the grains and leaves the kernels shriveled and shrunken. The punctures made by the bug manifest themselves as spots of various sizes and shapes. The colour of the affected plants also changes from light yellow, as if bleached, to black. The fungi may enter the punctures/wounds made by the bug, and thus affect the size of the spot as well as intensity of dis-colouration. The adult bugs also excrete a sort of resinous material which helps spoil the infested plants. Injury to the wheat grain also affects its milling and baking quality.

Cletus signatus Walk. **(Coreidae: Hemiptera)**
(Painted bug)

DIAGNOSTICS

Adults greenish yellow, body narrow and slender; apical antennal segment fusiform; lateral angles of pronotum acutely produced outwards; body length 8-9 mm.

NATURE OF DAMAGE

The nymphs and adults suck juice from the developing grains in the milky stage, causing incompletely filled spikelets or spikelets with empty grains. Black and brown spots appear around the holes made by the bugs on which a sooty mould may develop.

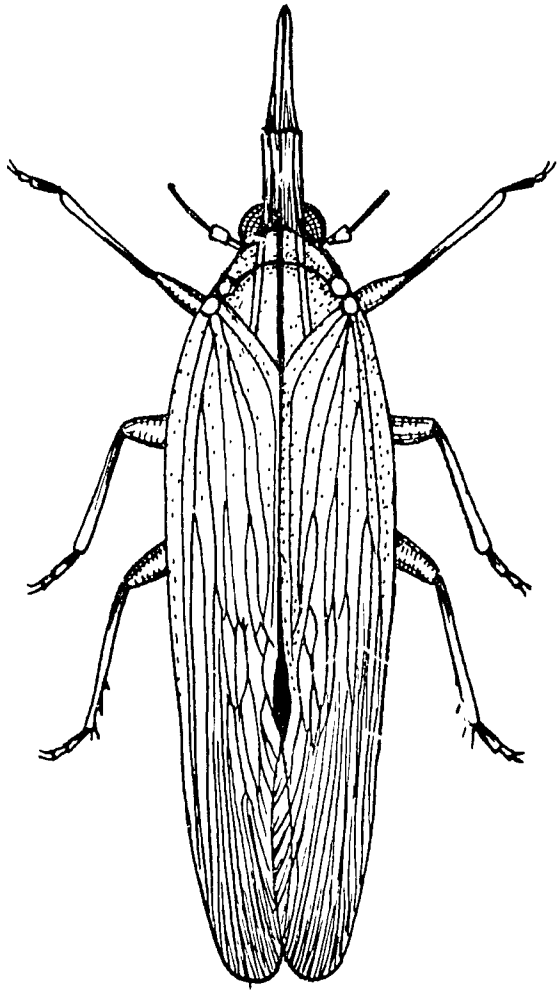
Pyrilla perpusilla Wlk. **(Fulgoridae: Hemiptera)**
(Sugarcane leafhopper)

DIAGNOSTICS

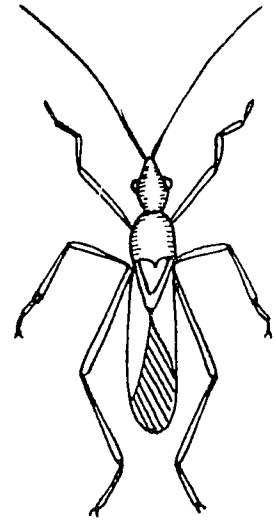
Body straw-coloured; eyes prominent, red on front end; dark patches on wings; a snout-like prolongation; length 20 mm.

NATURE OF DAMAGE

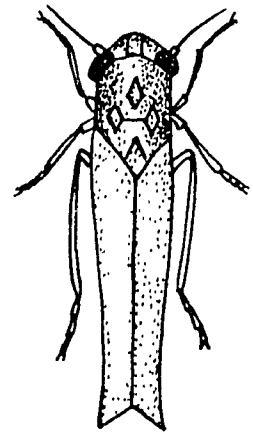
Both the nymphs and adults suck cell sap usually from the underside of



PYRILLA PERPUSILLA (**WLK.**)



CLETUS SIGNATUS (**DIST.**)



ZYGINA **SP.**

the leaves. Due to loss of cell sap leaves turn pale yellow and later on dry up. The insects excrete honey-dew - a thick transparent liquid, which falls on leaves and makes a good medium for the growth of a black mould. Thus leaves acquire a sickly black appearance and the attacked crop can be spotted even from a distance. Such a black coating is supposed to interfere with photosynthesis, and thus reduction in the food manufacturing of the plants takes place

Zygina sp./*(Zygina pallidifrons* **Edw.)**
(Cicadellidae: Hemiptera)
(Jassid)

DIAGNOSTICS

Approximately 2.8 mm in length, 0.5 mm in breadth; compound eyes black and very prominent; antennae setacious, and arising from basal angle of compound eyes: vertex, pronotum and scutellum light yellow, later with lighter shade in anterior part; vertex projecting forward angularly; sides of pronotum convex; scutellum with two triangular black spots on anterior margin and one triangular spot in apical angle; area around triangular spots on scutellum deep-yellow in colour. Style with a single apical extension, extreme posterior apex truncate. Legs well developed, mesoleg shorter than prolegs; metalegs longer and adopted for jumping. Fore wings transparent with yellowish appearance and visible veins; hind wings bluish. Abdomen light yellow and with a black transverse band on each segment, apparent through transparent wings; abdominal segments evident, first segment greatly reduced, eighth longer and narrow, 9th with anal tube and well developed; genitalia evident in both sexes.

Male and female apparently similar, of same length, male with darker muscular suffusion in centre of scutellum; female with triangular black spot and a darker transverse fascia above; scutellar spot triangular; ventral side or body light yellow except two prominent black spots between pro- an meso-thoracic legs.

Balclutha sp. **(Cicadellidae: Hemiptera)**
(Jassid)

Synonym: ***Cicadula* sp.**

DIAGNOSTICS

Small species, 3.5-4.0 mm long, yellowish green with four large black spots on margins of vertex; whitish or yellow spots on pronotum, a black transverse line on yellowish scutellum.

Amrasca sp. **(Cicadellidae: Hemiptera)**
(Jassid)

Synonym: *Empoasca* **sp.**

DIAGNOSTICS

Small insect of slender form, about one-eighth of an inch in length; adults winged, hind legs fitted for hopping; hind wing with sub-marginal vein present at wing apex; confluent with vein R + M; annal veins separate apically.

Macrosteles sp.**(Cicadellidae: Hemiptera)**
(Jassid)

DIAGNOSTICS

A small species, 3.5-5.0 mm long, yellow or yellowish green with six black spots on vertex; a vector of virus disease.

Cicadella sp. **(Cicadellidae: Hemiptera)**
(Jassid)

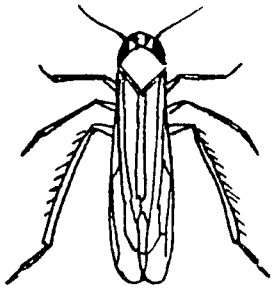
DIAGNOSTICS

Adults long, slender, bright green, with head, pronotum and scutellum yellow and legs green; length varies from 6.0-9.5 mm; head sharply pointed and marked with oblique brownish lines.

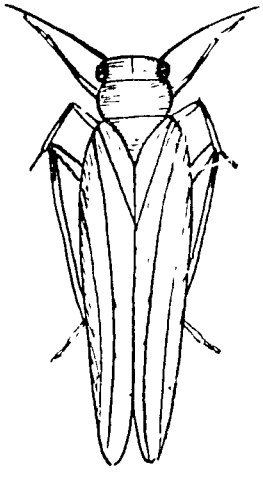
Orosius albicinctus Dist. **(Cicadellidae: Hemiptera)**
(Jassid)

DIAGNOSTICS

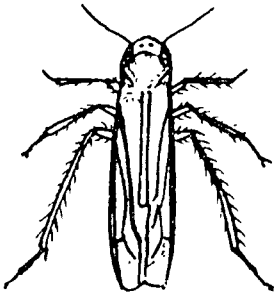
Small, elongate, tapering posteriorly, 13 mm in length; two ocelli,



BALCLUTHA **SP.**

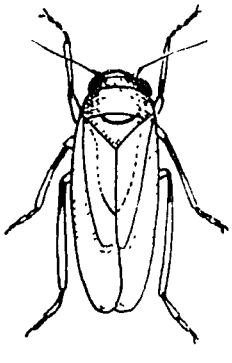


AMRASCA **SP.**

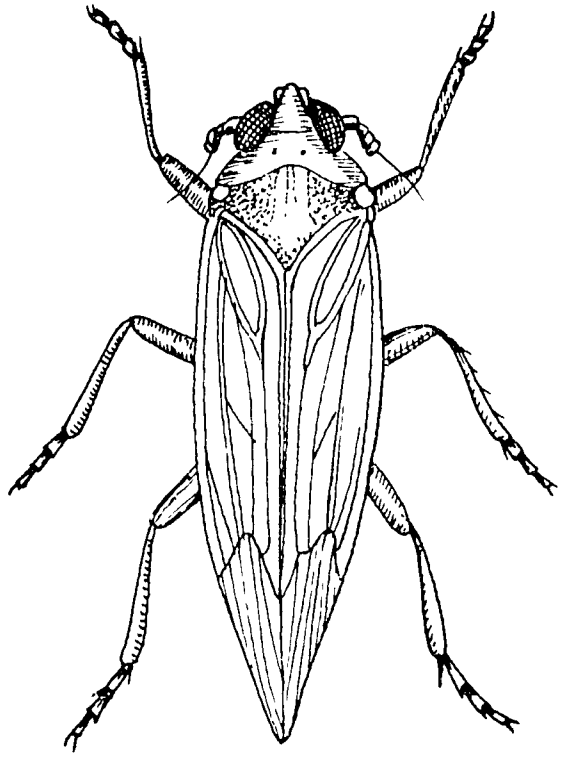


CICADELLA **SP.**

MACROSTELES **SP.**



OROSIUS ALBICINCTUS **(DIST.)**



SOGATELLA CATOPTRON (FENNAB)

antennae possess sensoria, apical part being long and setaceous; hind tibiae with double row of spines extending all over length; moveable tibial spur absent.

Psammotettix alienus Dahlb. **(Cicadellidae: Hemiptera)**
(Jassid)

DIAGNOSTICS

A small species, 3.0 mm to 3.5 mm long and variable in colour from pale green to dark brownish; whitish elytra with distinct brown nervures.

Exitianus **sp. (Cicadellidae: Hemiptera)**
(Jassid)

DIAGNOSTICS

Adult - a white hopper, long slender; head, pronotum gradually increase in size, turn brown, shrivel, and eventually become holes. When attack is severe the shoots may wither and die and so give the plant a distorted apperance. The necrotic spots result from the toxic salivary secretions injected into the plant during feeding.

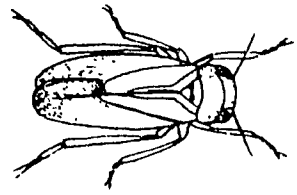
Sogatella sp./*Sogatella catoptron* **Fennah**
(Delphacidae: Hemiptera)
(Jassid)

DIAGNOSTICS

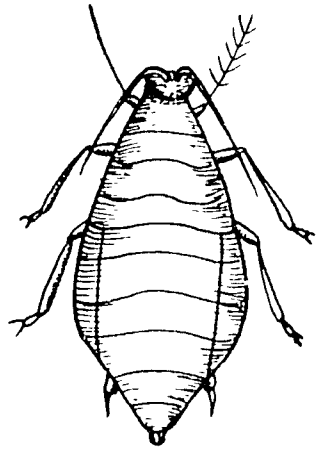
Adult small, green about 4 mm long; apical portion of fore wings pale black in males, pale brown in females; fore wings with a prominent black spot in males, female wings devoid of such markings.

NATURE OF DAMAGE

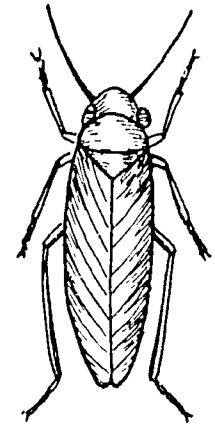
The nymphs and the adults suck cell-sap from the leaf surface and tend to congregate on the leaf sheath at the base of the plant. The leaves of attacked plants turn yellow and later on rust red. These symptoms start from the leaf tips and spread to rest of the plant. Numerous brownish spots also



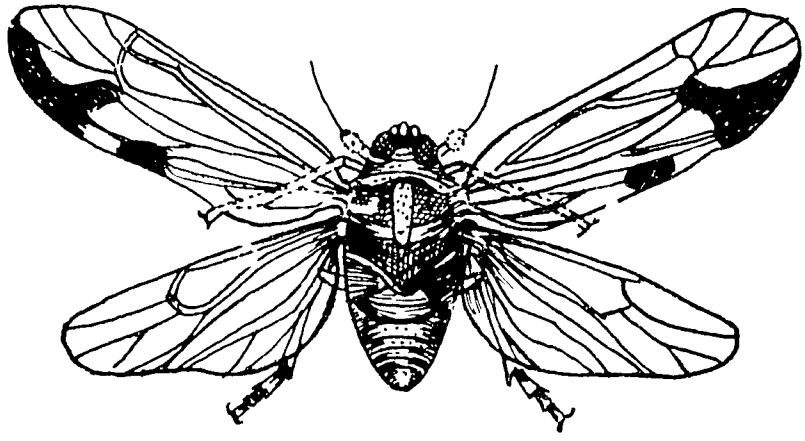
PSAMMOTETTIX ALIENUS (**DAHLB**)



MACROSIPHUM GRANARIUM **K.**



EXITIANUS **SP.**



SOGATELLA **SP.**

appear on the feeding sites. The attacked plants ultimately dry up without producing ears. The insect also excretes honey-dew on which a sooty mould appears, imparting a smoky hue to the wheat fields.

Macrosiphum avenae (F.) (**Aphididae: Hemiptera**)
(Wheat aphid)

Synonym: *Macrosiphum granarium* **(Kirby)**, *Siphocoryne avenae* **(Fabr.)**, *Hyadaphis avenae* **F.**, *Sitobion avenae* **(Fabr.)**, *Aphis avenae* **(Fabr.)** *Aphis padi* **(Linn)**, *Siphocryne padi* **(Fabr.)**

The above names have been synonymized in the interest of nomenclature. Since this is the first attempt, the available descriptions of those which are listed from Pakistan by Haq (1969) are given below, without assigning a sequential number, for comparison purposes by the future users.

Macrosiphum granarium (Kirby) (**Aphididae: Hemiptera**)
(Wheat aphid)

DIAGNOSTICS

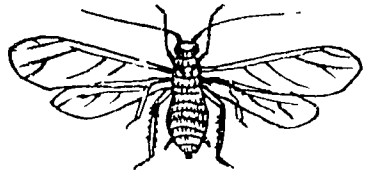
Body large sized and of green colour; antennae very long and black throughout, pits apart and swollen; eyes of body colour; legs very large; well developed, ends of femur, tibia and entire tarsi blackish, claws bifid; cauda long, stout and pointed at end, shorter than cornicles; cornicles black, well developed, large, base broader than tips; rostrum in between 2nd and 3rd coxae.

Body length	1.44 mm
Body width	0.67 mm
Antennae	2.06 mm
Cauda	0.32 mm
Cornicles	0.50 mm

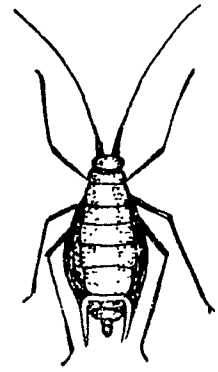
Siphocoryne avenae (Fabr.) (**Aphididae: Hemiptera**)
(Wheat aphid)

DIAGNOSTICS

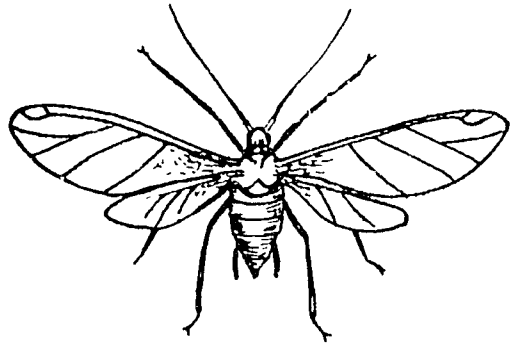
Size medium, colour dark, shape elongated; antennae longer than body,



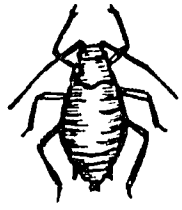
SIPHOCORYNE AVENAE (**FABR.**)



HYADAPHIS AVENAE (**F.**)



SITOBION AVENAE (**FABR.**)



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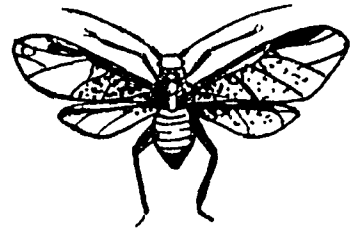


ADULT

SCHIZAPHIS GRAMINUM **ROND**

black throughout, pits apart; rostrum in between 2nd and 3rd coxae; eyes black; legs small and of smoky colour, claws bifid; cauda not well developed, rounded and shorter than cornicles; cornicles smoky, curved inside and slightly broader at tips; tip black, whole body with distinct linage.

Body length	1.44 mm
Body width	0.48 mm
Antennae	2.11 mm
Cornicles	0.29 mm
Cauda	0.10 mm
Wing length	3.168 mm

Hyadaphis avenae (F.) **(Aphididae: Hemiptera)**
(Wheat aphid)

DIAGNOSTICS

About 1/16 inch in length, body colour light to dark green; winged or wingless.

Sitobion avenae (Fabr.) **(Aphididae: Hemiptera)**
(Wheat aphid)

DIAGNOSTICS

Body medium, elongated and of green to reddish-brown colour with black siphunculi; head and thorax yellow, abdomen dark green; antennae twice as long as body, smoky and pits apart; legs very long, tarsi black and claws bifid; eyes shining red; cauda pale green or yellow, half of cornicles, length, well developed and too much pointed; cornicles of body colour; winged adults possessing cornicles and cauda similar to wingless forms; and tips black; rostrum exceeds 3rd coxae with black tip.

Body length	1.54 mm
Body width	0.62 mm
Antennal length	3.55 mm
Cauda	0.29 mm
Cornicles	1.20 mm

Schizaphis graminum Rond. **(Aphididae: Hemiptera)**
(Wheat aphid)

Synonym: *Toxoptera graminum* **(Rond.)**

DIAGNOSTICS

The chief distinguishing feature of the green bug is singly branched discoidal vein in the front wing. This being twice branched in the other species.

Rhopalosiphum rufiabdominalis (Sasaki) **(Aphididae: Hemiptera)**
(Wheat aphid)

Synonym: *Yamataphis oryzae* **Mats.,** *Cerosipha substerranea* **Mason.,** *R. padi* **(L.)**

DIAGNOSTICS

Body size medium, colour yellow; body shape elongated, abdominal area broader than rest; head smooth, rostrum reaching in between 3rd coxae; antennae of body length, tips smoky and apart, antennal hairs sparse; hind wings with two oblique veins; eyes brown; legs short, of body colour, tarsi smoky, claws bifid; hind wings with two oblique veins; cauda short and round at tip; cornicles well developed longer than cauda and of body colour; cornicles conical with a broad base, narrowing in middle, distal half-finger shaped; abdomen of apterous female dark green or brown.

Body length	1.37 mm
Body width	0.62 mm
Antennae	1.41 mm
Cauda	0.115 mm
Cornicles	0.39 mm

Rhopalosiphum maidis (Fitch.) **(Aphididae: Hemiptera)**
(Wheat aphid)

DIAGNOSTICS

Adults winged or apterous, body pear shaped, antennae long,

compound eyes prominent; rostrum several jointed; tarsi two segmented, with paired claws, nine pairs of lateral spiracles and a pair of cornicles or "honey tubes" at posterior end of abdomen arising from dorsal side of fifth or sixth abdominal segments. Wingless forms predominant in populations; in winged forms wings held vertically above body; cornicles secrete a waxy fluid which affords protection from predaceous insects; cauda pronounced with long conspicuous setae; dark purplish area around base of short siphunculi; about 2 mm long.

NATURE OF DAMAGE

The nymphs and adults suck the sap from plants preferably ears. The insects are green inert louse-like an ant and appear on young leaves or ears in large numbers during the cold and cloudy weather. The nymphs and the females look alike except that the latter are larger. The winged forms appear only in early summer. Aphids are amongst the most destructive of the plant infesting insects. Not only do they cause serious direct plant injury through their feeding, but many species transmit serious virus diseases of plants. The simplest injury is a wilting of the leaves and plants due to extraction of the sap by the insect. This is accompanied by yellowing which leads to the shedding of leaves from the plants. The introduction of toxins in the salivary secretion turns the leaves brown and causes them to wither or become curled and malformed. Heavy infestation on growing tips causes stunting, dwarfing and finally, in extreme cases death of the plants. It is believed that in feeding upon a plant, the setae of the proboscis may follow intercellular course until a vascular bundle is reached or the epidermal and parenchyma cells are pierced. Within the vascular bundles the tissue most commonly reached is the phloem, especially the sieve tubes.

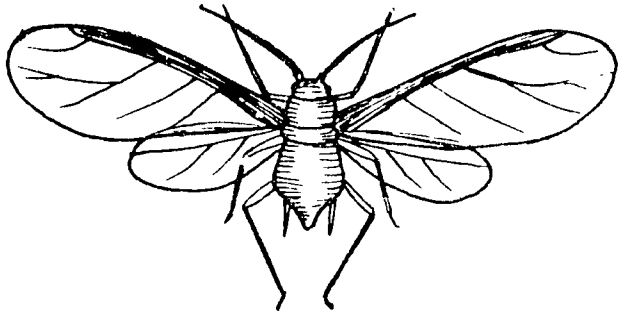
Aphids cause curling of leaves and young shoots resulting in the stunted growth or even the death of small wheat seedling. Very often the leaves become pale brown and crop dies prematurely which cause serious losses in the yield. These aphids are pests of minor importance.

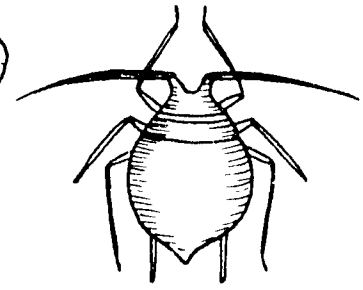
Agrotis flammatra Schiff **(Noctuidae: Lepidoptera)**

(Cutworm)

DIAGNOSTICS

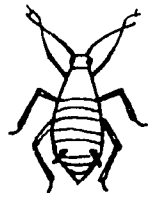
Adult heavy bodied, greyish-brown or wheat coloured, skin smooth with





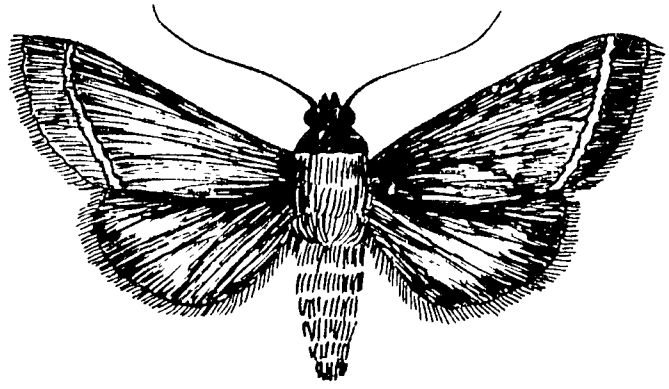
WINGED FEMALE **WINGLESS FEMALE**

RHOPHALOSIPHUM RUFIABDOMINALIS (**SESAKI.**)



NYMPH **ADULT**

RHOPHALOSIPHUM MAIDIS (**FITCH**)



AGROTIS FLAMMATRA (**SCHIFF.**)

small black spots; head and thorax grey brown, tinged with purplish-red, tegulae with semi-circular black-brown patch; fore wings grey-brown, with a characteristic marking and smoky patches, 2/3 of proximal/costal area pale, an elongated black streak at base, a kidney shaped spot slightly below pale costal area; a double wavy black line stretching from base of costal area to inner margin; hind wings ochraceous, white or yellow with a pair of dark brown longitudinal stripes in front; sometimes each wing with a semi-circular spot below pale area and a greyish-brown kidney shaped spot towards apical area; 50-62 mm in wing expanse.

NATURE OF DAMAGE

The caterpillars spend the day hiding near about the plant base. At night, they come out and become active, cutting down the young plants just above or slightly below the surface of the soil. They seem to be very voracious eaters and they fell more plants than they can consume

Agrotis ipsilon (Hufn.) **(Noctuidae:Lepidoptera)**
(Cutworm)

Synonym: *Agrotis ypsilon* **Rolt.**

DIAGNOSTICS

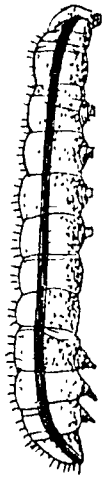
Body colour dark or blackish; fore wing being suffused with brown and with a black streak beyond reniform; sub-marginal line dentate with two black streaks on it below apex; hind wings with some greyish patches, more or less suffused with fuscuous brown; wing expanse 42-56 mm; body length from head to tip of abdomen 25 mm.

NATURE OF DAMAGE

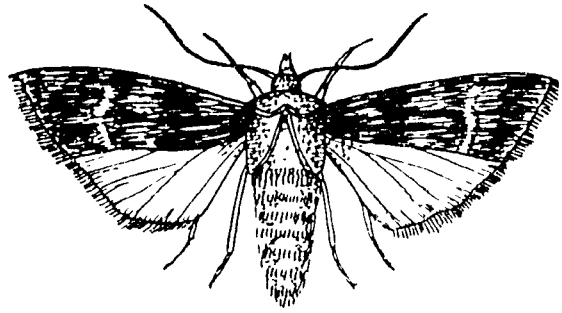
During the day time, they live in cracks and holes in the ground and come out at night and fell the plants by cutting their stems, either below the surface or above the ground.

Agrotis segetum (Schiff.) **(Noctuidae: Lepidoptera)**
(Surface caterpillar)

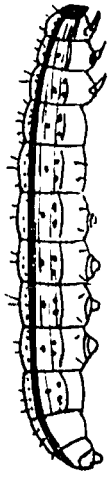
Synonym: *Euxoa segetis* **Schiff.**



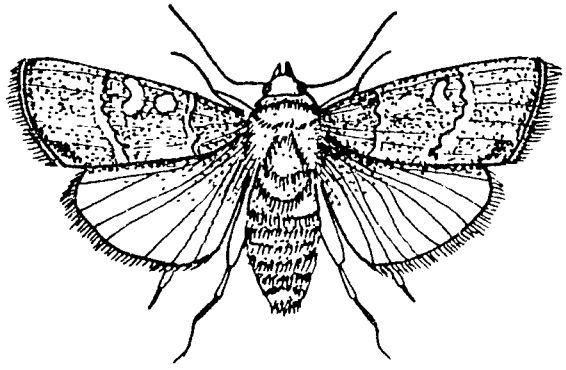
LARVA



AGROTIS IPSILON (HUFN.)



LARVA



ADULT

AGROTIS SEGETUM (SCHIFF)

DIAGNOSTICS

Head and thorax brownish, sparingly speckled with black; fore wing pale brownish with four blackish wavy lines, a black kidney shaped mark near centre and a marginal series of black spots; hind wings semi-hyaline, white, inner margin brownish; antennae brown, pectinate in male, simple in female.

Euxoa spinifera (Hb.) **(Noctuidae: Lepidoptera)**
(Surface caterpillar)

DIAGNOSTICS

Differs from *A. segetis* in having sub-basal ante-and post-medial lines of fore wings almost or quite obsolete; sub-marginal lines strongly dentate with dark streaks from lines, orbicular elongate with a dark streak from it to reniform; claviform very elongate and filled in with black, wing expanse 38 mm.

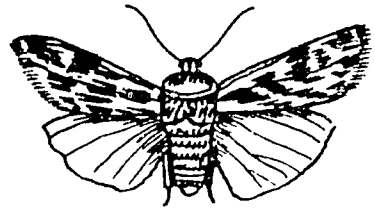
NATURE OF DAMAGE

The cutworms of *Euxoa* are polyphagous and occur virtually in all the cultivated regions. The damage, they inflict is great because they cut more young plants than they are able to eat. The nature of damage caused by *Agrotis* spp. and *Euxoa* spp. is the same. The damage of a mass occurrence is enhanced by the very high reproductive potential of the pests under favourable conditions.

According to Rehman (1940) 50 per cent of the gram crop was destroyed by *A. flammatra* in some years, particularly in South-east Punjab. The caterpillars spend the day in hiding about the base of the plants adjoining cut plants in the top 3-4" of the soil and waiting with their voracious appetite for the night, when they become active and cut down young plants of gram, peas, wheat, etc., mercilessly. They fell more plants indicating the activity of the pests in a field. Cutworms are generally considered as the major injurious pests of gram crop.

Heliothis armigera (Hubn.) **(Noctuidae: Lepidoptera)**
(Surface caterpillar)

Synonym: *Heliothis obsoleta*(**F.**), *Heliothis zea* **(Boddie)**

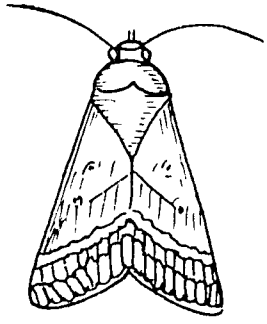


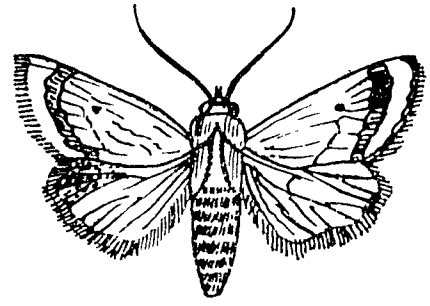
EUXOA SPINIFERA (**HB.**)

CATERPILLER

(FULL-GROWN)

PUPA





HELIOTHIS ARMIGERA (**HUBNER**)

DIAGNOSTICS

Adults usually dark brown with a reddish brown tinge; colour and markings variable, one form tan or buff coloured, another form with fore wings light greyish-brown; fore wings bearing a series of black dots, distinct wavy line towards apex and a dark speck near centre; sometimes dark grey irregular lines becoming olive green and a darker area near tip of wings; hind wings yellowish-brown with a broad blackish outer band, sometimes variable from white with smoky dark spots or irregular dark markings to mostly black with inner third lighter; veins of hind wings as dark lines, wing spread approximately 1.5 inch; underside of each wing with a black kidney shaped mark: wing trifid, with M_2 arising nearer to M_1 than M_3; hind tibiae spined.

NATURE OF DAMAGE

The small larvae feed on wheat seedlings in November-December. They are, however, seriously injurious to the developing wheat seeds during March-April. The larva gets at the seeds by biting a hole through the ear spikelets. It is estimated that one caterpillar can eat 3-6 wheat grains in 24 hours. It is a serious pest in the months of March and April.

Spodoptera exigua (Hubn.) **(Noctuidae: Lepidoptera)**
(Surface caterpillar)

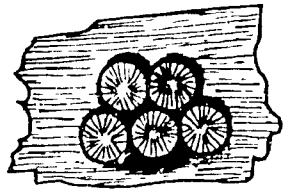
Synonym: *Laphygma exigua* **Hb.,** *Caradrina funceti* **Zell.**

DIAGNOSTICS

Pale, dark brown or ash-grey moths with a wing spread of about 1.5 inch; fore wings dark grey marked with light and dark areas and with an irregular white or light grey spot near tip, a kidney shaped mark with a dark centre and a marginal series of dark spots; hind wings semi-hyaline, white, with a pearly or pinkish luster, veins and outer margins tinged with fuscous brown.

NATURE OF DAMAGE

Caterpillars destroy seedlings in the months of December and January. They are injurious to developing wheat seeds during March. The young

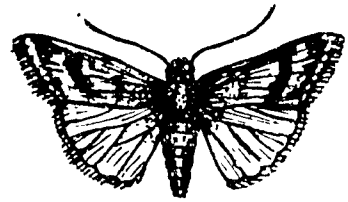


EGGS

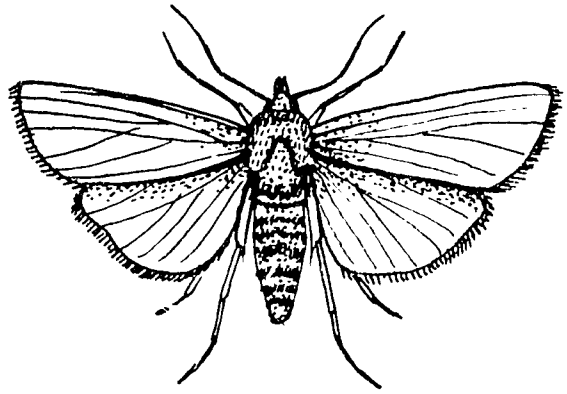
CATERPILLAR

(FINAL STAGE)

PUPA



SPODOPTERA EXIGUA (HB.)



MYTHIMNA SEPARATA (WALK.)

caterpillars in the earlier growth stages feed gregariously, but separate after a few days and attack new plants in small batches. The webbing together of small leaves with silken thread is a characteristic of the feeding habits of the catepillar. The damage is recognisible in the early stages of the attack by the bare veins which are left on the plant after it has been completely defoliated. It may be categorised as a serious pest of wheat.

Mythimna separata (Walk.) (Noctuidae: Lepidoptera)
(Army worm)

Synonym: *Cirphis unipuncta* **(Haw.)**, *Leucania unipuncta* **(Haw.)** *Pseudoletia separata* **(Walk.)** *Pseudoletia unipuncta* **(Haw.)**

DIAGNOSTICS

Pale brick-red, light brown to clay or very pale brown with dark specks and blotches, a pale central spot and a diagonal dark streak ending nearer body in a row of dots; fore wings fawn coloured and each marked with a conspicuous white dots near centre; white speck in cell minute, black speck on apical half of wing; hind wing pale suffused with fuscous brown, underside sometimes with cell spot and post-medial series of specks; wing spread of 45-50 mm, male genitalia with somewhat prominent claspers.

NATURE OF DAMAGE

The caterpillars damage the seedlings of wheat crop in the month of November. In the early stages, they feed on tender leaves in the central whorl of the plant. As they grow, they are able to feed on older leaves also and skeletonize them totally. In the case of a severe attack whole leaves including mid-rib are consumed. The pest may also eat away ears, including awns, and immature grains. Larvae feed on leaves. They are nocturnal in habit and remain hidden in leaves during day. It is considered as a miner pest of wheat crop.

The freshly emerged larvae spin threads from which they suspend themselves in the air and thus with the help of air currents reach from one plant to another. The grown up caterpillars throw out faecal pellets, which are quite prominent.

Sesamia inferens (Walk.) (Noctuidae: Lepidoptera)
(Pink stem borer)

Synonym: *Leucania inferens* **Walker.,** *Nonogria inferens* **Walker**

DIAGNOSTICS

Body stout, fawn or straw coloured; head and thorax whitish, without dark hairs; tegmen of fore wing distinctly and continuously dark brown; three black discal dots and an intermediate brown stripe, hind wing with Sc + R_1 fused with vein R_s for a short distance before middle of cell; harp of male genitalia with a strong furcated projection. At basal part of costa wing span 16-20 mm in male and 20-31 mm in female.

NATURE OF DAMAGE

Damage is done at the caterpillar stage. The attacked young plants show dead hearts and are killed together. The older plants are not killed but they produce white heads or few grains only. It has recently been recorded on wheat in rice tract and is a minor pest of wheat.

Euproctis fraterna Mo. (Lymantriidae: Lepidoptera)
(Hairy caterpillar)

DIAGNOSTICS

Small to moderate sized, white, yellow, brown, pale, yellow or orange moths; pale transverse lines on fore wings.

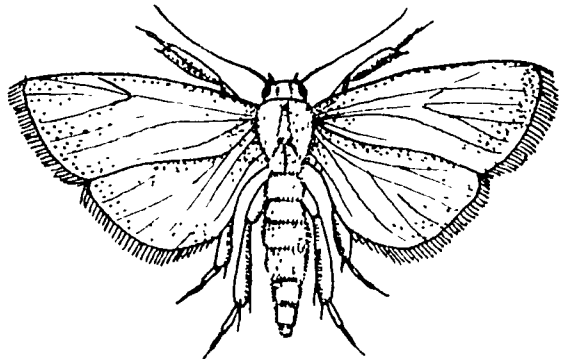
NATURE OF DAMAGE

The damage is caused by the larvae which feed on leaves and in case of severe infestation, they cause complete defoliation. The attacked plants remain stunted and produce very little seed.

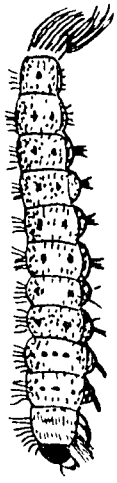
Chilo partellus Swin. (Pyralidae: Lepidoptera)
(Maize borer)

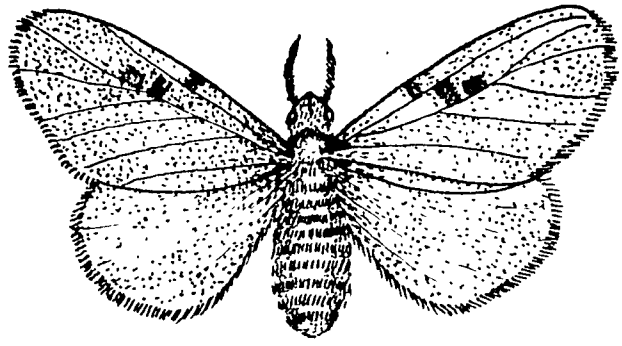
DIAGNOSTICS

Medium sized and straw coloured; frons projecting forward but not



SESAMIA INFERENS (**WLK.**)





EUPROCTIS FRATERNA **M.**

ADULT MOTH

HAIRY CATERPILLAR

sharply pointed, sometimes almost rounded; ventral margin of frons without such ridge; pale yellow wings of 26 mm expanse; fore wing with vein Sc free; hind wing with pecten of hairs on lower margin of cell towards base, Sc + R_1 never fused with vein R_S before middle of cell, sometimes approaching it, or briefly touching or fused for a short distance near angle of cell, M_1 arising from vein R_S before angle of cell; costal margin of harp of male genitalia with a blunt projection, sigmum of female genitalia small. Male smaller than female; average length 12 mm.

NATURE OF DAMAGE

The attacked leaf-sheaths first show transparent patches and later turn yellow-brown and eventually dry up. The caterpillars, as a result of their feeding inside the stem around the nodes, weaken the stem which easily breaks. Seedlings which have been attacked at the base show dead-hearts, i.e., the drying up of the central shoot. Attacked plants bear white heads, i.e., empty spikes or those with few filled grains.

Sitotroga cerealella Oliv. **(Gelechiidae: Lepidoptera)**
(Angoumois grain moth)

DIAGNOSTICS

Adults buff, grey, yellow, brown or straw coloured moths; a pecten or scape; fore wing with few darker markings, expanse 20-25 mm; hind wings narrow, pointed, fringed with long hairs, prominent along posterior margin.

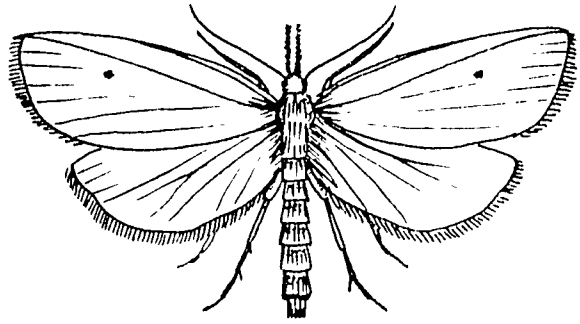
NATURE OF DAMAGE

The larva bores into the grain and feeds on its contents. As it grows, it extends the hole which partly gets filled with pellets of excreta usually, about 30-50% of the contents are consumed, but sometimes the larva finishes off the entire grain. When the infestation is severe, the grains give out an unpleasant smell and present sickly appearance, being covered with scales from the bodies of the moths. In a heap of grain, the upper layers are most severely affected.

Tanymecus indicus Fst. **(Curculionidae: Coleoptera)**
(Wheat weevil)

DIAGNOSTICS

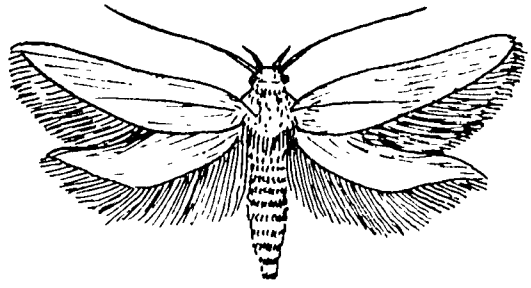
Body colour dark brown, brown scaling innervated with grey and a few



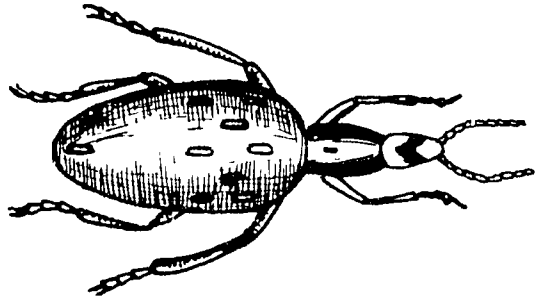
CHILO PARTELLUS (**SWINHOE**)

LARVA

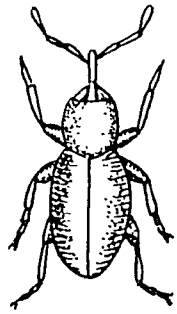
PUPA

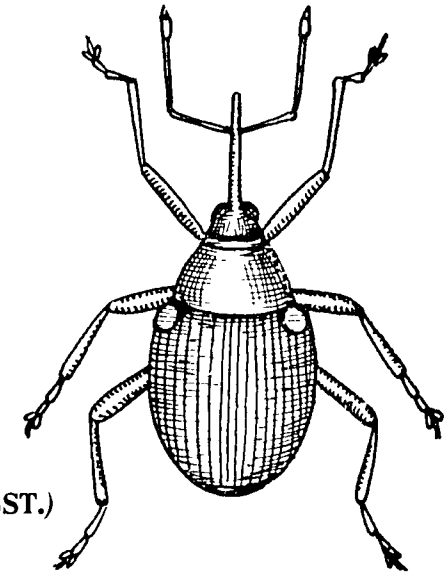


SITOTROGA CEREALELLA (**OL**)

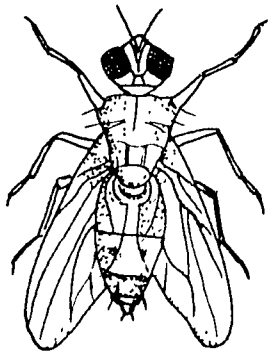


TANYMECUS INDICUS (**FIST.**)

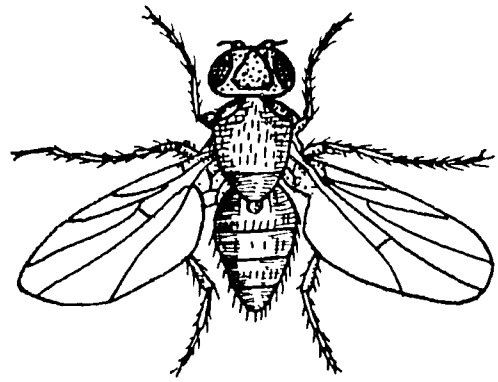




HYPERA VARIABILIS (**HBST.**)



ATHERIGONA **SP.**



OSCINELLA FRIT (**L.**)

green scales at apex of rostrum; eyes prominent, large, oval, almost as long as rostrum; rostrum as long as broad, shallowly sinuate at apex, with a distinct central carina, mandibles not prominent; antennal scape bisinuate, funicle with joint longer than 2; prothorax finely coriaceous and with a central carina in anterior half, longer than broad, rounded on sides, broad before middle, apex narrow, base broad. Elytra punctatostriate, striae shallow towards apex, punctures visible through scaling in basal half, stria 9 not impressed, posterior callus present, unpronounced; scaling fairly dense; scales narrow, setae very short and scarcely discernible among scales; legs black with fairly dense scaling, tibiae not denticulate internally; anal segments of female nearly twice as broad as long with a median longitudinal impression and rounded apex. Length 4.5-7.5 mm, breadth 1.75-2.75 mm.

Hypera veriabilis (Hbst.) **(Curculionidae: Coleoptera)**
(Lucerne weevil)

DIAGNOSTICS

Oval brown weevil, 0.36 long with a prominent snout projecting downward.

Pachnephorus sp. **(Chrysomelidae: Coleoptera)**
(Leaf-eating beetle)

DIAGNOSTICS

Adults with shining pale large irregular black blotches on elytra; blotches coalesce to cover nearly entire dorsum; 2.5-3.0 mm long.

NATURE OF DAMAGE

Weevils and beetles are destructive in January-March. They destroy the growing leaves and eat the green parts of other leaves; the attacked crop looks bleached. In addition to wheat, these weevils and beetles are serious pests of lucerne and gram and are widely distributed. It is a minor pest of wheat

Atherigona **sp. (Muscidae: Diptera)**
(Stem fly)

DIAGNOSTICS

Small, grey, about 3 mm long, with a yellow spotted abdomen and

yellow legs, head distinctly angular, antennae deep-set.

NATURE OF DAMAGE

This insect causes damage to the seedlings as well as to the early stages of wheat crop. The maggots bore into the stem and cut the main shoot.

It attacks the young crop when it is in the sixth leaf stage. Six weeks after planting, the crop is seldom attacked. As the maggots feed on the main shoot, the growing-point is destroyed and by the time they pupate, the plant is almost dead. The young plants show typical dead-heart's symptoms. When the attacked plants are somewhat older, tillers are produced, which mature later than the main crop.

Oscinella frit (L.) **(Chloropidae: Diptera)**
(Frit-fly)

DIAGNOSTICS

Body tagma, head, thorax and abdomen shiny globular; abdomen 5-segmented, covered with fine hairs; frons wider than eyes, frontal triangle shining black; antennal basal joint elongated, with a short hairy arista; dark hairs on thorax arranged in rows running length-wise, halteres yellow; trochanters and part of tibiae and tarsi yellow; claspers in male protruding from end of abdomen, on pointed end of female a pair of palp-like organs at tip of 3-jointed, retracted ovipositor; 1.5-2.0 mm long.

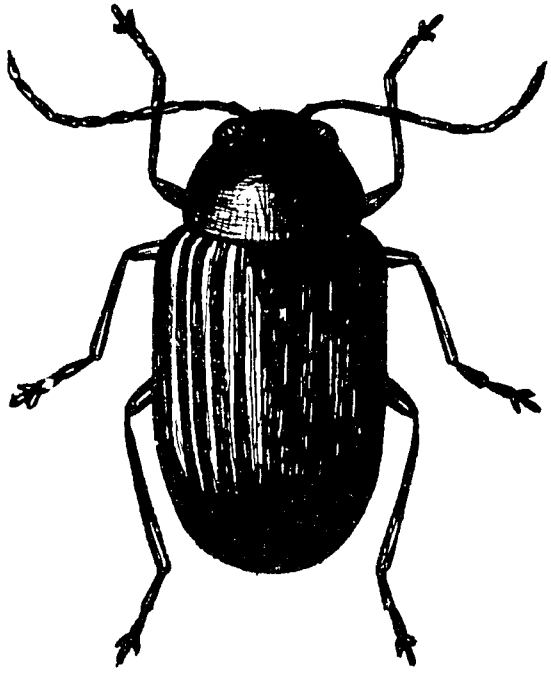
NATURE OF DAMAGE

The first generation larvae tunnel into the base of the wheat plant, turning the central shoot yellow and causing profuse tillering. The larvae of the second generation are found within the ears, when the grains are at a soft milky stage. Their feeding produces shrivelled grains, usually containing a brown puparium. Sometimes wheat is attacked while the ears are still within their sheaths, and the supper part of the rachis and grains become 'blind'. Such damage is usually caused by larvae from eggs laid by early-hatched flies of the first generation. In serious attacks as many as 90% of the grains may be affected, resulting in very serious losses.

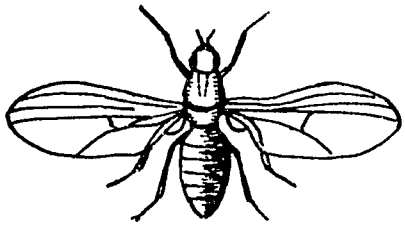
Cerodontha incisa Meigen **(Agromyzidae: Diptera)**
(Wheat leaf-miner)

DIAGNOSTICS

A minute black and yellowish fly, 2.0-2.5 mm long, with much of head,



PACHYNEPHORUS **sp.**



CERODONTHA INCISA **(MEIGEN)**

parts of thorax, legs, abdomen, halteres and scutellum yellow; mines almost straight and distinct.

NATURE OF DAMAGE

The larvae mine down the leaves towards the stalk, ending in the leaf sheath of the crown or the first node. From here they work up down the sheath or around the stalk causing it to wither and die. The mines are distinct and almost straight.

INSECT SUCCESSION AND POPULATION COUNTS

Periodic surveys revealed the occurrence of the following insects during the growing season of the crop.

1. During November, the following insects were found on the wheat crop.

   (i) Wheat weevil, *Tanymecus indicus* F.
   (ii) Wheat jassids, *Zygina* sp., *Balculutha* sp. and *Amrasca devastans* (Distant).
   (iii) Wheat beetle, *Pachniphorus* sp.
   (iv) Wheat aphid, *Rhopalosiphum maidis* (Fitch).
   (v) Wheat aphid, *Macrosiphum avenae* (Fab.)

2. During January no signs of thrips, cutworms and stemfly were found. However, aphids and jassids per leaf were 1.8 $\pm$ 0.9 and 1.5 + 0.8 respectively.

3. During February, the pests recorded comprised of:

   (i) Jassid, *Macrosteles* sp.
   (ii) Jassid, *Psammotettix aliemus* (Dahlb.)
   (iii) Plant hopper, *Sogatella* sp.
   (iv) Plant hopper, *Sogatella catoptron* Fennah
   (v) Wheat aphid, *Rhopalosiphum rufiabdominalis* (Sesaki)

4. During March, the insects collected were:

   (i) Cutworm, *Agrotis ipsilon* (Hufn.)
   (ii) Cutworm, *Spodoptera exigua* Hb.

(iii) Armyworm, *Mythimna separata* (Walk.)

5. During April, the insects caught on wheat included:

(i) Pink stem borer, *Sesamia inferens* Wlk.
(ii) Sugarcane pyrilla, *Pyrilla perpusilla* Wlk.
(iii) Wheat thrips, *Taeniothrips flavidulus* (Begnall)
(iv) Wheat thrips, *Haplothrips priesnerianus* (Begnall)
(v) Leaf miner, *Cerodontha incisa* Meigen

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Chapter 4

INSECT PESTS OF PULSES

Ali Asghar Hashmi*

The various kinds of pulses being grown in Pakistan are chickpea (gram), lentil, cowpea (kidney beans), mungbeans (green gram) and mashbeans (black gram). Pulses are grown on 1.4 million hectares producing 0.64 million tonnes.

Chickpea is our major pulse crop which occupies about 70-80% of the total pulses grown area. Our gross requirement of chickpea is 649 thousand tonnes at the rate of 4 kg. as adopted consumption against the projected population of 113.9 million in 1990-91. This target in chickpea could not be achieved in 1988-89 when total production of chickpea was 456 thousand tonnes. There is a big gap between actual and potential yield due to the incidence of diseases, insect pests and occasional drought stress years. Some of the significant insects damaging pulses are:

Heliothis armigera (Hubn.) (Chickpea pod borer)	Noctuidae: Lepidoptera
Diacrisia obliqua Wlk. (Mungbean and Mashbean hairy caterpillar)	Arctiidae: Lepidoptera
Spodoptera litura (Fb.) (Mungbean leaf caterpillar)	Noctuidae: Lepidoptera
Autographa (= Plusia) nigirsigna (Wlk.) (Chickpea semilooper/Cabbage semilooper)	Noctuidae: Lepidoptera
Eterusia (Etiella) zinckenella (Treit.) (Spiny lentil pod borer)	Pyralidae: Lepidoptera
Maruca testulalis Geyer (Spotted pod borer/Cowpea borer)	Pyralidae: Lepidoptera

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(Cont'd)

Melanagromyza obtusa (Malt.) (Pigeonpea pod fly)	Agromyzidae: Diptera
Bemisia tabaci G. (Mashbean and Mungbean white fly)	Aleyrodidae: Hemiptera
Nezara viridula (L.) (Mung, Mash and Pigeon-pea Greenbug)	Pentatomidae: Hemiptera
Acrosternum graminea (Fabr.) (Pigeon pea bug)	Pentatomidae: Hemiptera
Piezodorus rubrofasciatus (Fb.) (Pigeon pea bug)	Pentatomidae: Hemiptera
Cletus bipunctatus (Westw.) (Pigeon pea bug)	Coreidae: Hemiptera
Riptortus linearis Fab. (Pigeon pea bug/Brown bug)	Coreidae: Hemiptera
Stenozygum speciosum (Pigeon pea bug)	Coreidae: Hemiptera
Clavigralla gibbosa Spinola (Pigeon pea pod fly)	Coreidae: Hemiptera
Mylabris pustulata (Thunb.) (Blister beetle/Pigeon pea beetle)	Meloidae: Coleoptera
Callosobruchus analis Fab. (Cowpea, Mung, Gram stored grain beetle)	Bruchidae: Coleoptera
Callosobruchus sp. (Lentil seed beetle)	Bruchidae: Coleoptera

Heliothis armigera (Hubn.)(**Noctuidae: Lepidoptera**)
(Chickpea pod-borer)

DIAGNOSTICS

Egg: The eggs are cream coloured when freshly laid. Later on these change to dark brown and become blackish before hatching. A female can lay 100-200 eggs, singly or in batches on the under-surface of leaves, tender shoots and even flowers in one night. A maximum of 1400-1500 eggs may be laid by a single female in one or two weeks.

Larvae: The first instar larvae are blackish and crawl upto the tender shoots/leaves for their first feeding. The second and third stage larvae are brownish, and light brown or light green, respectively. The fourth stage larvae may be greyish, green or brownish but possess two lateral and one dorsal cream coloured, longitudinal bands on the body. The fifth stage larvae are bigger in size, but colour-wise could be greenish, brownish, greyish or greyish brown. The larvae are full-fed in the sixth stage and pupate to become adults.

Pupa: The fully fed sixth instar larva drops on the ground from the plant, digs 1-2.5 inch deep hole and then pupates. The pupa undergoes development for about 8-14 days,and then the adult emerges through an exit already made by the larvae for this purpose.

Adult: General body colour is brown. The forewing in both sexes with one distinct small dark spot. The distal portion of hind wing blackish. Pre-oviposition period 2 days.

PERIOD OF ACTIVITY

The first infestation starts during late November and early December, while the second severe attack can be observed from March onward.

NATURE OF DAMAGE

All larval stages feed on leaves, tender shoots, flowers and young pods. The fifth and sixth stage larvae are the most voracious feeders.

HOST PLANTS

It is a very serious pest of chickpea and virtually feeds on all the cultivated varieties. It also infests crops like maize, wheat, cabbage and cauliflower.

CONTROL METHODS

1. *Campoletis chlorideae* (Uchida) of Family Ichneumonidae is abundant during November-February, in the wheat & chickpea fields and is capable of parasitising about 40% of the second instar larvae of the pod-borer.
2. *Apanteles ruficrus* of Family Braconidae is quite abundant in the wheat fields at a late wheat stage and parasitises 2nd instar larvae.
3. Spray any one of the following insecticides at 6-10 days interval as soon as the small larvae become visible on leaves and tender shoots or adults are seen flying around.
   i) Nuvacron 40 SCW @ 1375 ml/ha
   ii) Nuvacron - Combi A-300 EC @ 2 lt/acre
   iii) Dimecron 100 EC @ 750 ml/ha
   iv) Nogos 100EC @ 750 ml/ha.
4. Spray Nexagan 80 EC @ 875 ml/ha with the appearance of the pest and repeat its application every 12-14 days, if necessary.
5. Spray Thiodan 350EC @ 2000 ml/ha at the time of initial pod formation stage and repeat after 14-18 days, if necessary.

Autographa (= *Plusia*) *nigrisigna* (Wlk.) **(Noctuidae:Lepidoptera)**
(Chickpea semilooper, Cabbage semilooper)

It is commonly known as cabbage semilooper and is primarily a pest of cabbage and cauliflower all over India (Atwal, 1976). Since these two are winter vegetables, its activity during summer was unknown. In 1981, this insect was recorded in gram crop near maturity, in the experimental area of University of Agriculture, Faisalabad.

DIAGNOSTICS

Egg: The fresh eggs are rounded, creamy (some say yellowish white) coloured and with sculptured chorion. One female can lay approximately 220-442, (Av. 247) eggs during her life. The eggs are laid singly as well in batches. During incubation period, the colour of eggs turns blackish. The eggs are laid on leaves, shoots and flowers of the host. Incubation period is variable depending upon the ambient temperature. At Faisalabad it was 3-6 (Av. 4) days.

Larva: The larva on emergence is straw coloured. It appears brownish black in the second stage, and yellowish green in the third instar. This greenish colour stays till the sixth stage, when greenish body colour also gets three prominent white longitudinal bands on dorsum. After the sixth stage, when the larva is full-fed, it falls on the ground and undergoes pupation. A detailed description is as under:

First instar: Head dark brown. Body; straw coloured later changing to yellowish-green with black hairs on the dorsal side. Body length; 2.9 - 3.0 mm at hatching.
Second instar: Head; light brown. Body;yellowish-green with no dorsal or lateral streaks and black spots all over the body. Body length; 5.8 - 6.0 mm on first day.
Third instar: Head; light brown. Body; yellowish-green with white longitudnal streaks on dorsal side. Ventral side; green. Spiracles with thin brown rings. Body length; 9.5-9.8 mm on first day.
Fourth instar: Head; green. Body; greenish-yellow with 3 white longitudnal streaks on dorsal side and 2 on lateral sides. Thoracic legs, green. Spiracles with thin brown rings. Body length;13.0 - 13.7 mm on first day.
Fifth instar: Head; green. Body; green with 3 white longitudnal streaks on dorsal and 2 white longitudnal streaks on dorsal and 2 white longitudnal streaks on lateral side. Posteriorly body is double in thickness to anterior part. Crochets biordinal meso-series. Body length; 18-20 mm on first day.
Sixth instar: No change in other characters. Body length, 23.5 - 24.5 mm on first day.

Prepupa: Body length; 28.5-29.5 mm before spinning the cocoon.

Pupa: Body size, 18.25 mm x 6.50 mm. Obtect, green to dark brown with cremaster at the end of abdomen.

Adult Male: Head and thorax covered with grey and blackscales, abdomen pale with dorsal tufts dark. Forewing fuscous with a cuperous tinge; ill-defined medial and sub-marginal patches;lower arm of the Y-mark being nearly straight and almost touching the antimedial line; a small bright chestnut patch just before the tail end. A wavy golden mark on outer edge of fore-wing. Hind wing pale at the base, the outer area suffused with fuscous. Some specimens are darker than the others. Body, 17.44 mm long, wing span 38.88 mm.

DURATION OF LIFE STAGES

The duration of different life stages depends upon the prevailing temperature.

Egg stage = 3-6 (Av. 4) days
First instar larva = 2-5 (Av. 3) days
Second instar larva = 3-5 (Av. 4) days
Third instar larva = 3-6 (Av. 4) days
Fourth instar larva = 2-5 (Av. 4) days
Fifth instar larva = 3-5 (Av. 4) days
Sixth instar larva = 3-5 (Av. 4) days
Prepupal stage = 1-3 (Av. 2) days
Pupal stage = 6-15 (Av. 9) days
Pre-oviposition period = 3-6 days
Oviposition period = 4-13 days
Post oviposition period = 1-2 days
Adult Life = 7-21 (Av. 14) days

ACTIVITY PERIOD

The insect was studied in the laboratory at Faisalabad, by Tariq *et al* (1985) by taking concurrent observations in the gram crop field. It is generally during November-December that one comes across greenish or dark brown larvae feeding on leaves and tender shoots of chickpea. The newly hatched larva consumed 1-2 leaves per day by biting small holes from December to February. Same mode of feeding was recorded by Atwal (1976) During this period under field conditions, the insect population and damage was so little that the incidence of its attack could not be easily detected. The feeding activity is slightly lowered during January-February due to low temperature. Feeding is enhanced near the flowering stage of the crop, i.e. in March. It is at this time that the pest multiplied in large numbers and built up a sizeable population and severe damage was inflicted to the crop which was near maturity in March-April. At this time, the fifth and sixth instar larvae fed upon leaflets leaving only veins and veinlets behind. The larvae were mostly confined to the top portion of the plant especially for boring the pods. Chaudhry *et al.* (1980) too reported similar damage from India.

When the larva was full-fed and about to stop feeding, it reached the top of the plant and enclosed itself in 3 to 4 leaflets stitching them together

with silken threads. The voracious activity of the larvae thus continues till harvesting time. Emergence of the adults began in the first week of February reaching its peak in March (when the temperature is moderate and the adults emerge from diapausing pupae) and continued till mid-May. Mating took place a day after emergence and lasted for 20-40 minutes. Three generations of this insect were recorded on gram during the season. The frequency of mating in the females was 1-2 (Av. 1.33).

NATURE OF DAMAGE

In the gram crop, the caterpillars were recorded feeding on leaves, buds, shoots, flowers and pods. The larvae can damage the crop or eat away the pods to the extent of 80%. As far as cabbage and cauliflower is concerned the freshly emerged larvae made holes of varying sizes.

HOST PLANTS

Cabbage, cauliflower and gram are the known host plants.

DISTRIBUTION

The insect appears to be widely distributed, but due to its being a minor pest, proper distribution records are not available

CONTROL

This pest can be controlled by applying the insecticides mentioned for the control of chickpea pod-borer.

Agrotis spp. (Noctuidae :Lepidoptera)

(Chickpea cutworm)

The larvae of these species are grey in colour and slim in shape. They cut the seedling at the ground level during night, while during the day-time they remain hidden in dark places and in the soil. The damage is usually more in low lying areas where water stays after the rainfall. Pupation takes place in the soil and the emerging moths are straw coloured with the hind wings being white. For controlling them, Dieldrin 20 EC @ 2 kg/ha is applied with irrigation water, or Heptachlor (granules) @ 2 kg/ha are sprinkled at the seedling time and repeated if the damage warrants so.

Eterusia (= *Etiella*) *zinckenella* (Treit.) **(Pyralidae: Lepidoptera).**
(Spiny pod borer)

DIAGNOSTICS

Egg: Eggs are laid singly on lentil pods and in a mass of 2-27 on flowers, pods, junction of calyx and twigs of peas. The incubation period is 4-7 days. A female can lay 45-175 eggs.

Larva: It is cream coloured in early stages and turns greenish in later stages. The larva feeds on the soft pods and seeds. The mature larva leaves the pod and crawls to the ground to pupate in the soil. The larval period is 10-20 days.

Pupa: Pupation takes place in the soil, and the pupal period lasts for about 4-6 days. The pupa is about 2.5 cm long.

Adult: Moth is small in size. The forewings are brownish with white anterior margin. The hind wings are light brownish. The moths pair 24-30 hours after emergence. In the Punjab, the moths appear after mid February.

ACTIVITY PERIOD

Infestation of this pest on lentil starts during the last week of February or in the first week of March and continues till the beginning of 4th week of March. The average hatching period is 5 days while the larval period varies with crop. It is 13-15 days on wildpeas and gram but 18-19 days on cowpeas and lentils. The total life cycle takes 35-45 days. The pest completes five generations in a year. The pest can reduce the yield from 10 to 40 percent, respectively in lentil & peas. Because of tiny size of larvae, it is often difficult to discern the damage.

NATURE OF DAMAGE

The larvae bore within the green pods and feed on the seeds. They can also web together 2-4 pods.

HOST PLANTS

This is a minor pest of red-gram, and green-gram, but important pest of lentil and peas.

CONTROL

Spray anyone of the following insecticides 5 or 6 days after flowering

and repeat it after 12-14 days, if necessary.

i) Nogos 100 EC @ 500 ml/ha

ii) Nexagan 80EC @ 550ml/ha

iii) Thiodan 35EC @ 750 ml/ha.

Maruca testulalis Geyer **(Pyralidae: Lepidoptera)**
(Spotted pod borer)

The larvae are pest of black-, green- and red-gram, cowpea, and lablab, in Indo-Pakistan.

The females lay eggs on or near the flower buds. On emergence the larvae enter the bud, the flower or the pod. When inside the pod, larvae feed on seeds, and the entrance hole is plugged with excreta. The infested pods and flowers are sometimes webbed together, and on accassions the tender stems are also bored by the larvae.

The full grown larva is 2 cm long and brownish-green in colour with black warts. The pupa is found in the debris near the surface of ground.

Melanagromyza obtusa (Malt) **(Agromyzidae: Diptera)**
(Pod fly)

This is distributed throughout the country and is a major pest of red-gram, soybean and cowpea. The adult is a small black fly.

Eggs are laid singly on pods or on flower buds. The fly pierces the pericarp with its ovipositor and lays a single egg. The eggs are seen like needles projecting inwards from the walls of the pod. One pod may contain 1-5 eggs. A female fly lays a total of 38-79 eggs. Egg period lasts about 3 days. The maggot first makes galeries just below the epidermis of the seeds, feeding deeper into the seeds later on. Larva pupates in the larval groove for 8-9 days. Adult life lasts for 3-6 days under laboratory conditions. Under abundant moisture conditions two broods are present in a year.

The maggot causes damage by mining the seeds. It is a major pest especially of redgram causing upto 60 percent damage to pods. The puparial stage is parasitised by *Euderus lividus* Ashm. and *Eurytoma* sp. and the pre-puparial stage by *Euderus agromyzae* Gang. Control of the pest can be obtained by spraying a contact insecticide in the early stages of the attack.

Piezodorus rubrofasciatus (Fb.) **(Pentatomidae: Hemiptera)**
(Pulses bug)

Both the adult and nymphs infest tender shoots.

Mylabris pustulata (Thunb.) **(Meloidae: Coleoptera)**
(Blister beetle)

It is a flower feeding beetle and damages flowers of cowpea, red-gram and black-gram.

Cletus bipunctatus (Westw.) **(Coreidea: Hempitera)**

It is a minor pest.

Riptortus linearis (L.) **(Coreidae: Hemiptera)**
(Brown bug)

It infests pulses as well as soybean. A female lays 4-8 eggs singly on the host-plants. The hatching period is 8 days and life history is completed in 24 days.

Clavigralla gibbosa Sninola **(Coreidae: Hempitera)**
(Pigeon pea pod bug)

Both the nymphs and adults feed on the pods which develop yellow patches and shrivel. In the damaged pods, grains are undersized. The female lays eggs in batches of 3-15 on pods or leaves. The total number of eggs per female may vary from 60 to 400. Hatching period is 4 and 20 days during May and December-January, respectively. These are 5 nymphal instars. Adult longevity is 2-5 months. It is also found on postures.

Callosobruchus analis **(Bruchidae : Coleoptera)**
(Lentil beetle)

This beetle infests the crop in the field during March-April. The adults come out of seeds kept in the store, at a later stage. This is a small, dark brown or black colour beetle.

Callosobruchus sp. **(Bruchidae: Coleoptera)**
(Lentil seed beetle)

This infests the stored seed of lentil from April-September. The female lays eggs on the outside of seed surface. The emerging larvae bore into the testa and feed inside the seed and pupate in the damaged seed.

CONTROL

1. Mixing of 10 ml of mustard oil per kg of grain helps protect the seed from beetle's infestation.
2. Fumigating the grains with phostoxin or detia or elphos (Aluminium phosphide) @ 3-4 tables per 1000 kg for 5-7 days at a stretch.

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Chapter 5

INSECT PESTS OF OILSEED CROPS

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The oilseed crops in Pakistan are categorised as conventional and non-conventional. The conventional crops include rape and mustard, groundnut, sesamum, linseed, while the non-conventional comprise sunflower, soybean, safflower and castor. The necessity to concentrate on oilseed crops has arisen during the last one decade because one third of the country's requirements for edible oils are met through domestic production, and the balance through imports. The requirements of edible oil increased from 82000 tonnes in 1970-71 to 710,000 tonnes in 1986-87 and are projected to be 1.7 million tonnes by the year 2000. The import bill which was only Rs. 15 million during 1970-71 increased to Rs. 4062 million during 1986-87. The gap between consumption and production of edible oils has widened to about 900 thousand tonnes in 1989-90.

A national effort in the form of crash programme is afoot to fit in the short duration early maturing varieties of sunflower, soybean and safflower besides the conventional crops into various established crop rotations. But very little information about the insect pest complex, nature and extent of damage to these crops is available. Some of the known or potential insect pests are listed below for each crop to serve as resoruce base to initiate further studies. Where possible, detailed information about some insect pests has also been provided.

CONVENTIONAL OILSEED CROPS

1. RAPE AND MUSTARD

A. Major Pests

Brevicoryne brassicae (Linn.) (Mustard aphid)	Aphididae: Hemiptera

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Rhopalosiphum (= Lipaphis) erysimi K. (Aphid)	Aphididae: Hemiptera
Myzus persicae Sulz. (Maize aphid)	Aphididae: Hemiptera
Phytomyza horticola Goureau (Pea leafminer)	Phytomyzidae: Diptera
Bagrada hilaris Fab. (Painted bug)	Pentatomidae: Hemiptera
Bagrada cruciferarum (Fb.) (Painted bug)	Pentatomidae: Hemiptera
Athalia proxima lugens Klug. (Mustard saw fly)	Tenthredinidae: Hymenoptera

B. **Minor Pests**

Agromyza sp. (Lantana seed fly)	Agromyzidae: Diptera
Nezara viridula L. (Green bug)	Pentatomidae: Hemiptera
Euproctis. sp. (Hairy caterpillar)	Lymantriidae: Lepidoptera
Pieris brassicae L. (Cabbage butterfly)	Pieridae: Lepidoptera
Plutella maculipennis Curt. (= *P. xylostella* (Linn.)) (Diamond back moth)	Plutellidae: Lepidoptera
Gryllus bimaculatus DeG. (Field cricket)	Gryllidae: Orthoptera
Acheta domesticus (L.) (Cricket)	Gryllidae: Orthoptera
Bemisia tabaci (Gennad.) (White fly)	Aleyrodidae: Hemiptera

II. **GROUNDNUT**

A. **Major Pests**

Microtermes obesi Holmg. (White ant)	Termitidae: Isoptera
Odontotermes obesus Ramb. (Scavenging termite)	Termitidae: Isoptera

Amsacta moorei Wlk. (Kutra moth)	Arctiidae: Lepidoptera
Amsacta albistriga (Kutra moth)	Arctiidae: Lepidoptera
Diacrisia obliqua Wlk. (Jute hairy caterpillar)	Arctidae: Lepidoptera
Aphis craccivora Koch. (Aphid)	Aphididae: Hemiptera
Heliothis armigera Hb. (Gram caterpillar)	Noctuidae: Lepidoptera

B. **Minor Pests**

Spodoptera litura (F.) (Tobacco caterpillar)	Noctuidae: Lepidoptera
Sphenoptera arachidis L. (Groundnut stem borer)	Buprestidae: Coleoptera
Sphenoptera perotetti G. (Stem borer)	Buprestidae: Coleoptera
Aphanus (= Elasmolomus) sordidus Fabr. (Groundnut chinch bug)	Lygaeidae: Hemiptera
Chrotogonus trachypterus Blanchard (Toka/surface grass hopper)	Acrididae: Orthoptera
Holotrichia spp. (White grub)	Melolonthidae: Coleoptera
Anisolabis (= Euborelli) stalli (Dohrn.) (Earwig pod borer)	Forficulidae: Dermaptera
Aproaerema modicella (Leaf minor)	Gelechiidae: Lepidoptera

III. **SESAMUM**

A. **Major Pests**

Diacrisia obliqua Wlk. (Jute hairy caterpillar)	Arctiidae: Lepidoptera

B. **Minor Pests**

Monolepta signata Oliv. (White spotted leaf beetle)	Galerucidae: Coleoptera

Spodoptera exigua Hubs. (Tobacco caterpillar)/(Army worm)	Noctuidae: Lepidoptera
Antigastra catalaunalis (Dup.) (Sesamum leaf webber)	Pyralidae: Lepidoptera
Acherontia styx Westood (Till hawk moth)	Sphingidae: Lepidoptera
Agrius (= Herse) convolvulii (L.) (Til hak moth)	Sphingidae: Lepidoptera

IV. **LINSEED**

A. **Major Pests**

Agrotis ipsilon (Hfn.) (Gram cutorm)	Noctuidae: Lepidoptera

B. **Minor Pests**

Diacrisia obliqua Wlk. (Jute hairy caterpillar)	Arctiidae: Lepidoptera
Euproctis scintillans Wlk. (Hairy caterpillar)	Lymantriidae: Lepidoptera
Heliothis armigera (Hb.) (Gram caterpillar)	Noctuidae: Lepidoptera

NON-CONVENTIONAL OILSEED CROPS

I. **SUNFLOWER**

A. **Major Pests**

Odontotermes obesus Ramb. (White ant)	Termitidae: Isoptera
Diacrisia obliqua Wlk. (Jute hairy caterpillar)	Arctiidae: Lepidoptera

B. **Minor Pests**

Myllocerus blandus Fst. (Cotton grey weevil)	Curculionidae: Coleoptera
Myllocerus maculosus Desb. (Cotton white weevil)	Curculionidae: Coleoptera
Tanymecus indicus Fst. (Wheat weevil)	Curculionidae: Coleoptera

Xanthochelus superciliosus Gyll. (Ber weevil)	Curculionidae: Coleoptera
Dolycoris indicus Stall. (Millets pentatomid bug)	Pentatomidae: Hemiptera
Heliothis armigera Hb. (Gram pod caterpillar)	Noctuidae: Lepidoptera
Oxycarenus lactus Kirby (Dusky cotton bug)	Lygaeidae: Hemiptera
Plusia spp. (Cabbage semilooper)	Noctuidae: Lepidoptera
Spodoptera (= Ciphis) unipuncta Haw. (Armyworm)	Noctuidae: Lepidoptera
Thrips tabaci Lind. (Onion thrips)	Thripidae: Thysanoptera
Phytomyza *horticola* Goureau (Pea leaf miner)	Phytomyzidae: Lepidoptera
Tetranychus spp. (Mite)	Tetranychidae: Acarina

II. SOYBEAN

A. Major pests

Bemisia tabaci G. (Cotton white fly)	Aleyrodidae: Hemiptera
Melanagromyza phaseoli (Tryon) (Pea stemfly)	Agromyzidae: Diptera
Amsacta moorei Butl. (Kutra moth)	Arctiidae: Lepidoptera
Empoasca spp. (Green leaf hopper)	Cicadellidae: Hemiptera

B. Minor Pests

Zygrita sp. (Lucern crown borer)	Cerambycidae: Coleoptera
Nezara viridula L. (Green stink bug)	Pentatomidae: Hemiptera
Heliothis armigera (Hb.) (Gram pod caterpillar)	Noctuidae: Lepidoptera

III. SAFFLOWER

A. Major Pests

Acanthiophilus helianthi (Rossi) (Safflower fly)	Tephritidae: Diptera
Macrosiphum sonchi L. (Thistle aphid)	Aphididae: Hemiptera
Odontotermes obesus Ramb. (Scavenging termite)	Termitidae: Isoptera
Spodoptera exigua Hubn. (Lucern caterpillar)	Noctuidae: Lepidoptera

B. Minor Pests

Tanymecus indicus Fst. (Wheat weevil)	Curculionidae. Coleoptera
Dolycoris indicus Stal. (Millets pentatomid bug)	Pentatomidae: Hemiptera
Heliothis armigera Hb. (Gram caterpillar)	Noctuidae: Lepidoptera
Perigaea (=Prospalta) capensis (Guen.) (Safflower caterpillar)	Noctuidae: Lepidoptera

IV. CASTOR

A. Major Pests

Euproctis fraterna Mo. (Hairy caterpillar)	Lymantriidae: Lepidoptera
Diacrisia obliqua Butl. (Jute hairy caterpillar)	Arctiidae: Lepidoptera
Euproctis abjecta Swinhoe (Hairy caterpillar)	Lymantriidae: Lepidoptera
Conogethes (=Dichocrocis) punctiferalis Guen. (Castor shoot and capsule borer)	Pyralidae: Lepidoptera
Spodoptera litura F. (Lucerne caterpillar)	Noctuidae: Lepidoptera
Achaea janata Linn. (Castor semilooper)	Noctuidae: Lepidoptera

B. **Minor Pests**

Amsacta moorei Butl. (Kutra moth)	Arctiidae: Lepidoptera
Euproctis lunatus Wlk. (Castor hairy caterpillar)	Lymantriidae: Lepidoptera
Empoasca flavescens Fab. (Castor leaf hopper)	Cicadellidae: Hemiptera
Nezara viridula L. (green bug)	Pentatomidae: Hemiptera
Xyleborus fornicatus Eichh. (Bark or Engraver beetle)	Scolytidae: Coleoptera

RAPE AND MUSTARD

The major insect pests of rape and mustard are aphids, mustard saw fly, pea leaf miner, painted bug, hairy caterpillar and the house cricket. At the seedling stage, the crop is damaged by saw fly and painted bug. The latter attacks the crop at pod formation stage as well. Aphids occur throughout the year but cause major losses from December to February. The leaf miner is more injurious towards pod formation while the house cricket is most destructive on threshing floor. Thus, one or another insect continues to damage the crop throughout its life cycle thereby necessitating an integrated control approach. The nature, biology and key identifying features of the major pests, as well as, the extent of the damage caused by some of them is described here.

Rhopalosiphum (=Lipaphis) erysimi Kalt., *Brevicoryne brassicae* L. and *Myzus persicae* Sulz. **(Aphididae: Hemiptera)**
(Mustard aphids)

All the three species attack rape and mustard in Pakistan. *R. erysimi* is by far the most abundant and widely distributed. Nymphs of *erysimi* are pear shaped, light yellow green in colour; adults are darker than nymphs. Both the nymphs and adults suck the sap from under surface of leaves. *B. brassicae* mostly attacks Cruciferous vegetables while *M. persicae* is restricted to plum, peaches and tobacco. Attack by these two species on rape and mustard is generally of a secondary nature. Besides causing direct damage, all the three species are known to be vectors of viruses. The number of such viral diseases recorded in case of *M. persicae* is more than one hundred.

Aphids are the most serious pest of rape and mustard crops in Pakistan. They can multiply rapidly under favourable conditions on leaves, stems and inflorescences where their clusters can be seen as soft, mealy, grey masses. Aphids suck the sap from plants causing serious distortion of plant parts and ultimately devitalizing them. The most active period of aphids is from December through February and coincides with the flowering stage. The attacked flowers fail to produce pods and those pods that are formed, produce very few seeds, most of which are shrivelled and of poor quality.

CONTROL METHODS

Cultural: 1. Since aphid attack on rape and mustard is more severe during December to February when the crop is in the flowering stage, early sowing in order to obtain early maturity may reduce the intensity of aphid attack to a certain extent. Early maturing varieties like "toria" and Poorbi Raya successfully escape the damage.

2. Use of varieties with glossy, dull, non-waxy and glabrous leaves.

Biological: 1. Release of predators like *Menochillus sexmaculatus, Coccinella septempunctata, C. undecipunctata* and *Adonia varigata.*

2. Release of parasites like *Diaereliella rapae, Aphchnus asychis* and *Aphidius matricariae.*

Chemical: The application of chemicals to control aphids or other insects should be avoided except as a last resort because the use of pesticides frequently results in the destruction of predators and parasites alongwith the pests. Furthermore, the use of chemicals poses a threat of residual toxicity. However, at times chemical control may be the only practical alternative. A number of chemicals, e.g., Formothion, Malathion, Metasystox, Methamidophos, Parathion etc. are recommended to control aphids. These aphidicides are generally effective but the addition of some extra-wetting agent is necessary in the case of the contact poisons to effectively wet the waxy bodies of the aphids. Systemic and granular insecticides provide more effective control.

It is desirable to develop a spray programme supplemented with suitable cultural practices, by developing natural enemies and by evolving resistant varieties.

Recommendations for doses of various insecticides are:

1. Apply Disyston or Solvirex, Themit, Temik Granules @ 22.50 kg/ha at the time of first or second irrigation if required.

2. Spray Folidol M-50 @ 813 cc/ha, Dimecron 100% @ 560g/ha, Malathion 57 EC @ 1626 cc/ha, Endrin 20 EC @ 1626 cc/ha, Phosdrin 24 EC @ 1626 cc/ha and Metasystox 50 @ 1-12 kg/ha in the late stages of growth.

Resistant Varieties: Insect resistant varieties have always been looked upon as the most economical method of reducing pest spread. Whereas complete resistance to aphids still remains beyond the grasp of breeders, tolerance of varying degrees has been found in *Brassica* species including *B. juncea.* The information that various *Bassica* species and cultivars are differently infested by aphids has shown that varieties with glossy, dull, non-waxy and glabrous leaf surface are relatively resistant to aphids as compared to those with waxy and hairy leaves. RL-16, a cultivar of *B. juncea,* and YSL-5, a cultivar of 'yellow sarson', possess these characters and are moderately resistant. Populations of aphids on these cultivars generally are comparatively less than on other more susceptible cultivars. Resistance based on low concentrations of a mustard oil glucoside known as sinigrin has also been identified. It has been noted that on rape and mustard plants that produce seed oil low in sinigrin content, the reproductive potential of aphids is reduced to a remarkable extent. In cultivars having higher concentration of this glucoside, aphids multiply more rapidly. Efforts can be made to impart this type of resistance to commercial cultivars of rape and mustard.

Phytomyza horticola Goureau **(Phytomyzidae: Diptera)**
(Pea leaf miner)

The adult is a small fly with one pair of wings and a black thorax. The newly-hatched, legless larva is white but changs its colour to greenish-yellow when fully grown. Mature larvae measure about 3 mm in length.

The insect is polyphagous and feeds on more than 100 plant species. It causes serious damage to peas, Crucifers, ornamentals and greenhouse plants. The pest appears in December and most of the damage to rape and mustard is done in January and February. The larvae feed by making serpentine mines in the leaves, resulting in disruption of photosynthesis.

Bagrada hilaris Fb. and *B. cruciferarum* L. **(Pentatomidae: Hemiptera)**
(Painted bug)

DIAGNOSTICS

This is a small pretty-looking insect with a black body conspicuously marked with beautiful red and yellow spots. The nymphs also have a number of pale brown and red markings on their body.

This bug is a major pest of rape and mustard crops but feeds on Cruciferous vegetables as well. It attacks the crop in the seedling stage and again at the time of pod formation. Both nymphs and adults damage the plants by sucking their sap. As a result the leaves turn yellow, wilt and dry. Meanwhile, white blotchy spots appear on the whole plant. On the mature crop the bugs feed on the seeds in the pods. High population becomes a nuisance on the threshing floors as well.

CONTROL METHODS

The bug can be controlled by the following methods:

Mechanical: Remove the produce from the field or threshing floor immediately after harvesting or threshing.

Cultural: Destroy the stubbles and all the dead plant material for destruction of eggs and nymphs.

Chemical: Dusting with DDT/BHC @ 0.56 kg a.i./ha or Sevin @ 2.24 kg a.i./ha.

Athalia proxima lugens K. **(Tenthridinidae: Hymenoptera)**
(Mustard sawfly)

DIAGNOSTICS

This insect is orange-yellow in colour, with smoky wings. The fully grown

larva is greensih-grey, having a black head and five stripes on the body. It measures about 17 mm in length.

The mustard sawfly is a serious pest of all Cruciferous crops although outbreaks are sporadic. The most serious damage is done from September to November when its young larvae bite holes in the leaves. Since rape and mustard are still in seedling stage at this time resowing may be necessary in cases of severe attack. Damage is most severe in those years when the winters are mild and the spring and summer are unreasonably hot.

CONTROL METHODS

Cultural: 1. Attack of sawfly could be avoided by adjusting the sowing date in accordance with climatic conditions and considering the history of previous crop and season.

2. Destruction of wild rape and mustard plants and other Cruciferous weeds in and around the field will also help in keeping the pest population under control.

Chemical: 1. Dusting with DDT/BHC @ 0.56 kg. a.i./ha or Sevin @ 2.24 kg a.i. per ha.

2. Spraying with Dimecron 100 @ 0.56 kg/ha.

Euproctis sp. **(Lymantriidae: Lepidoptera)**
(Hairy caterpillar)

DIAGNOSTICS

The abdomen of the moth is bright red with black spots. The forewings have a reddish tinge and the hind wings have dark brown spots. The newly-hatched larvae are light brown in colour and the fully grown ones are dark brown with numerous dark brown long hairs on the body.

The caterpillar is polyphagous and causes damage by feeding on the leaves. The young larvae are gregarious and feed on a few plants, but the grown-up caterpillars spread to the whole field and cause heavy damage to the crop.

CONTROL METHODS

Mechanical: 1. Use light traps to minimize the population of moths.
2. Remove gregarious larvae alongwith infested leaves and bury them in the soil.

Chemical: 1. Dust with BHC @ 0.56 kg a.i./ha.
2. Spray with Diazinon or Metasystox @ 0.56 kg a.i./ha.

Pieris brassicae L. **(Pieridae: Lepidoptera)**
(Cabbage butterfly)

Severe attack of cabbage butterfly caterpillers on rapeseed and mustard during some years has been observed. Late flowering rapeseed and mustard crop especially *B. carinata* and *B. napus* are mostly damaged. Its outbreak starts with the onset of the warm weather.

The adult, with white wings having one or two black dots, lays over hundred eggs underneath the leaf. After 7-9 days the eggs hatch and minute green caterpillars in large number come out of eggs. These larvae feed gregariously on the leaf in the beginning, later on these larvae spread and wipe out the whole plant by eating leaves, flower buds, young pods and skin of stem and pods. The size of caterpillar reaches to 5 cm in 14-17 days. In summer this pest takes 31-40 days to complete its life cycle.

Plutella maculipennis (Curtis)(=*P.xylostella*(Linn.))
(Plutellidae: Lepidoptera)
(Diamond back moth)

Yellowish green larvae with fine erect black hairs scattered over the body. Adult is small greyish brown moth with 3 pale whitish triangular markings on hind margins of each forewing. At rest 3 diamond shaped yellowish white spots visible by joining both the forewings. Symptoms of attack are typical whitish patches due to scrapping of epidermal leaf tissues by young larvae. Advanced stage larvae bite holes in the leaves.

Acheta domesticus (L.) (Gryllidae: Orthoptera) (Cricket)

DIAGNOSTICS

The pest is distributed all over the country but is most abundant in areas where the soils have a high clay content. It causes some damage in the seedling stages of rape and mustard crops but its attack is most serious on the threshing floors. Upon emergence from cracks in the harvested field or fallow lands, the pest converges in large numbers at night on the threshing floors where they feed on the seeds.

CONTROL METHODS

Mechanical: Remove the produce from the field or threshing floor immediately after harvesting or threshing.

Cultural: Plough the fallow fields to destroy the eggs in the hibernating places.

Chemical: Spray or dust the soil, on the bunds and around threshing floors with Aldrin, BHC or Basudin @ 0.56 kg a.i./ha.

Baiting with Dieldrin and rice husk (340 gms: 45 kg) around the standing crop and then irrigating the field to force the pest to come out of hibernating places.

Integrated Control in Rape and Mustard

A large number of insecticides are available in the market which provide effective control of insect pests attacking rape and mustard crops. However, the application of chemicals should not be looked upon as the only control measure, and an effort should be made to reduce the pest population by all available means. Chemical insecticides, when warranted by the seriousness of attack, should be applied judiciously. In addition, the following set of general recommendations will help in keeping the crop free of pests to a large extent:

The crop should be sown early in the season.

- Only a well decomposed farm yard manure should be applied to avoid termite attack.
- 'Raya' should be preferred over 'sarson' as the later is more susceptible to the attack of insects.
- From February onwards the population of predators and parasites becomes very high in some fields. Therefore, the decision to spray the crop during this period shold be made keeping in view the population of natural enemies in the field.
- Spray should be done in the late afternoon to avoid pollinators mortality.

GROUNDNUT

Groundnut is an important cash crop for barani farmers, but its use as a source of edible oil has not been exploited. Among the potential oilseed crops grown in Pakistan, this crop is grown on the second largest area in the country after rapeseed and mustard.

Of many insect pests attacking groundnut crop termites, aphids, armyworm and hairy caterpilalr are the most dangerous insects which inflict heavy losses to this crop. If proper control measures are not taken in time the crop yield is reduced to a considerable extent. Some of the important insect pests are listed below:

Odontotermes obesus Ramb. **(Termitidae: Isoptera)**
(Termite)

These are cream coloured tiny insects resembling ants with dark coloured head. These are subterranean pest. The symptoms of its attack are wilting of plants in patches. Usually tap roots of wilted plants can be seen as penetrated. In severe attack termites are hovering in and around plants.

Control: Apply Dieldrin 20 EC mixed with 88 kg of dry soil/ha as a soil treatment before planting.

Amsacta moorei Wlk. *Amsacta albistriga* **(Arctiidae: Lepidoptera)**
(Red hairy caterpillar)

Larvae are hairy, reddish brown with black bands on either end having long reddish brown hairs all over the body. They eat away all the leaves

leaving only the main stem. Adults are moths with white wings. In *A. albistriga* forewings are white with brownish streak all over and yellowish streak along the anterior margin and head; hindwings are white with black markings. In *A.moorei*, the anterior marginal streak on the forewing and head is red.

Control: 1. Organize campaigns to hand pick with tongs and destroy grown up caterpillars or pupae after (summer) ploughing.
2. Grow cowpea as intercrop which helps attract the female moths to lay eggs more on it and for early detection of its occurrence.
3. Set up light traps immediately after receipt of rains in the rainfed season to attract and kill the moths.
4. Dig a trench around the field to avoid immigration of the caterpillars.
5. Apply BHC dust @ 10 kg for young caterpillars.
6. Use Endosulfan, Fenitrothion, Dichlorvos and Chlorpyriphos per recommended doses.

Aphis craccivora Koch. **(Aphididae: Hemiptera)**
(Aphid)

These are reddish to dark brown in colour. Both the nymphs and adults suck the sap and lead to wilting of tender shoots during hot weather. Leaves are mottled with chlorotic or dark green spots and plants get stunted.

Control: Apply Dimecron 100 @ 1 kg/ha mixed with 50 gallons of water.

Spodoptera (Prodenia) litura (F.) **(Noctuidae: Lepidoptera)**
(Tobacco caterpillar)

Larvae are pale greensih, brown with dark markings. They are gregarious in the early stages. Moths are with wavy white markings on a brown forewing. Hindwings are white with a brown patch along the margin.

Control: 1. Set up light traps or use pheromone traps @ 5 per acre.
2. Collect the early instar gregarious larvae in clusters, and destroy them. During this condition larvae are easy to collect.

Sphenoptera perotetti G. **(Buprestidae: Coleoptera)**
(Groundnut stem borer)

The grubs are pale whitish with flattened anterior portion. The adults are dark brown shiny beetles. The symptoms are wilting of plants in patches. Stem just below the soil surface and main roots are tunnelled and tunnels contain elongate flat headed grubs. This is also a subterranean pest. The pest can be suppressed by cutting and destroying the infested branches, thus preventing the grubs from entering the tap-root.

Holotrichia spp. **(Melolonthidae: Coleoptera)**
(White grub)

Only the grubs do damage. The grubs are white, with brown head and prominent thoracic legs. The beetles are dull brown, 18 mm long, and 7 mm wide. Patches of wilted plants is the main symptom of attack. However, when the wilted plants are pulled out, these are without tap roots and rootlets(=fibrous roots). It can be controlled by BHC or Heptachlor or by mixing Phorate granules in the soil.

Anisolabis (Euborellia) stalli (Dohrn.) **(Forficulidae: Dermaptera)**
(Ear wig)

Nymphs are white in early stages but turn brown in the later instars. Adults are dark brown to black in colour with forceps like caudal cerci and white leg joints. Both the nymphs and adults cause damage. The main symptoms are that the young pods showing bore holes are plugged with excreta, sand particles or discoloured pulps and pods are without kernels.

SESAMUM

Monolepta signata Olive. **(Galerucidae: Coleoptera)**
(White spotted leaf beetle/Cucumber beetle)

Adults are soft bodied, yellowish in colour, bear white spots/stripes on their elyta. Antennae closely approximated, third tarsal segment deeply bilobed, fore-coxae globose, tibiae not grooved and meta-femora not swollen.

The larvae feed on the leaves of groundnut. Both the roots and leaves are attacked in the cucurbits.

Antigastra catalaunalis (Dup.) (Pyralidae: Lepidoptera)
(Sesamum leaf webber)

DIAGNOSTICS

Egg: Flat, shining, nearly 100 eggs are laid singly on the growing parts of plants. Incubation period is 4-5 days.

Larva: Full grown larva is pale green with black head and tubercles on the body bearing hairs. Larval period is 12-18 days. Meausres 17.5 mm in length.

Pupa: Pale whitish green, pupation takes place in the leaf fold in a thin transparent pale white silken cocoon. Pupal period is 5-7 days.

Adult: Small, brownish with pale yellowish brown elongate wings.

CONTROL METHODS

In nature it is parasitized by Ichneumonid, *Trathala flavoorbitalis* (?). In case of severe attack clipping the infested plant parts and destroying the larvae may be done. Dusting with DDT (10%) or spraying with Parathion methyl 0.025% can be effective.

Acherontia styx Westwood (Sphingidae: Lepidoptera)
(Till-hawk-moth, sphinx moth, Death,s head-moth)

This insect interests entomologists more for its peculiar characteristics, than its economic importance as a pest.

DIAGNOSTICS

Egg: These are 1 mm long .9 mm wide, globular and conspicuous in appearance, The micropyle is at the apex. They are greenish-white when freshly laid, but turn yellow later on. These are laid singly on the under-surface of the tender leaves of food plants. Hatching period is 2-5 days.

Larva: On hatching the young larva first eats up the egg-shell, and after resting on the underside of the leaves, it feeds on them. The freshly emerged larvae are pale-yellow. body of the full-grown larvae is plump and decorated with a mix of faded/soft colours. The hind end of abdomen bears horn-like

projections. A change in colour aids in the protective mimicry. The full-grown caterpillar measures about 5 cm in length and 1 cm in width. The larval period is long and may lost 2 months or more. The detailed description of different larval instars is as under:

First instar: Head and body pale yellow, horn black, straight, bifid.

Second instar: Head and body bluish green, dotted with white; seven oblique stripes; horn purple on dorsal surface, green on ventral.

Third instar: Head and abdominal segments 2-4 green, rest of body bluish green. The oblique stripes strongly marked and edged above with dark green.

Fourth instar: Head and abdominal segments 2-4 apple green, rest of body bluish green, yellowish green on lateral and ventral sides. The horn is green and is covered with pointed tubercles.

Fifth instar: Head square shaped, its basal angles rounded and tumid, false clypeus forming on broadly rounded arch over apex of true clypeus, reaching to one half length of head. Labrum is broad at base as clypeus, ligula kidney shaped, the lobes broadly rounded. Eyes 1-4 equidistant in gentle curve, surface of head shinning, body smooth and dull, nearly cylindrical, tapering slightly from segments 7 frontad. Horn, less stout at base, tapering evenly to a sharp point, basal half curved gently downward, and distal half gently upwards; distal 2/3 of anal flap shinning and set sparsely with minute tubercles. There are 3 types of colouration, green form is common.

Green form: Head dark green, a broad shinning blackstripe down the cheek; labrum whitish with a black spot in the middle of each half, ligula whitish, basal segments of antennae white, middle segments white with black base; mandibles pale green with tip broadly black. Segments 2-4 of body yellowish-green, rest of body grass green; horn corny yellow, legs black, prolegs and claspers green.

Yellow form: The green colour of the head and body replaced by canary yellow, markings remaining the same.

Brown form: Head ochreous with the stripe dark brown, body brown, on segments 2-4 broad black dorsal stripe and below it a broad ochreous stripe. The subspiracular area dotted and streaked with brown; a brown oval marking on each side of dorsum; horn ochreous, legs and prolegs black, clasper brown. Length 90 mm, breadth 12 mm. Horn 10 mm.

Pupa: Antennae of the pupae are longer than forelegs. Cremaster stout, triangular, the dorsal surface is rugose, tip ending in two teeth, each bearing a bristle. It is enclosed in a earthen chamber, without an external proboscis sheath. The fifth and sixth abdominal segments are free. Length 57 mm, breadth 14 mm. The pupal stage lasts 2-3 weeks in summer and 7 months in winter. Thus winter is usually passed in pupal stage in the soil.

Adult: It is a large reddish-brown, robust thick set, moth. Antennae slender and long, meso-tibiae equal in length to tarsal segments 1-3. In wing span it measures 10 cm. The forewings have a mixture of dark-brown and grey-patterns, with a dark or black wavy markings and a prominent yellow spot on each wing. The hind wings are yellow, with black lines. The thorax bears a prominent skull shaped mark (Death's head mark). The abdomen is yellow & possesses black bands.

There are 2-3 generations of this insect in a year. The active period being May-August. During active period the life cycle is completed in 45 days.

NATURE OF DAMAGE

The larvae feed voraciously on leaves and defoliate the plant. The insect can inflict heavy damage at times. It can cause serious losses in yield and quality of the produce of *Sesamum indicum*.

CONTROL METHODS

1. The pest can be controlled by hand picking the eggs and larvae in the initial stages and killing them in kerosine oil.
2. The soil containing the pupae can be ploughed up during the winter to expose pupae to the environmental stress.
3. The larvae can also be checked by mechanical means from going from one field to another.
4. The moths are attracted to light trap, hence these can be killed by use of light traps.

Agrius (= Herse) convolvulii (Linn.) **(Sphingidae: Lepidoptera)**

(Till hawk moth, Sweet potato moth, Convolvulus hawk moth.)

DIAGNOSTICS

Egg: Size of egg very small for a sphingid, surface smooth and shinning,

colour bright bluish green; ovoid in shape and with a smooth and shinning surface. Length 1mm, breadth 0.9 mm. They are laid singly on any part of the food plant.

Larva: There are five larval instars, each having a conspicuous posterior horn on the dorsum of 8th abdominal segment, which even gives the family its common name of "horn worms". The body colour is variable, usually either greenish or brownish. A brief description of each instar is given below:

First instar: Head small, body long and thin, horn straight, of medium length, tip bifid, head and body green, horn black.

Second instar: Same as first instar except that the body colour changes.

Third instar: Head small, body increasing gradually in diameter from 2 to 8 mm, nearly cylindrical, horn nearly vertical, thick at the base and tapering evenly to a sharp point. Surface of head and body is sharp and smooth. There are two colour forms of larvae. *In the green form,* the head and body are green and dotted with white. There are 7 narrow oblique stripes, whitish, edged above with dark green; horn green with the base brown. *In the dark coloured form,* body colour is brown dotted with yellow; head is brown with a yellow cheek stripe. There is a yellowish subdorsal stripe from segment 2 to base of horn; a narrow, waved yellow sub-spiracular stripe from segment 2-12, horn brown with a red stripe on each side.

Fourth instar: There is a little change. The dark coloured form is very variable in colour and markings.

Fifth instar: Head round, dorsal line of vertex slightly depressed; abdominal segment 2 of greater diameter than head, the segments increasing in diameter gradually to 7, rest of the body nearly cylindrical. Horn of medium length, sharply down curved, stout at the base but tapering evenly to a sharp point. Surface of head and body smooth and polished, slightly shinning, colour variable. Head pale yellow with a narrow black dorsal stripe dividing at the apex of the clypeus and running down on each side of it. There is a broad black subdorsal stripe and still a broader dorsolateral black stripe separating face from cheek, but not reaching vertex

or base of antennae; labrum and ligula dark brown. Antennae soiled whitish, mandibles and eyes black.

Dorsum of body smoky brown; horn black; legs, prolegs, claspers and venter smoky brown. Spiracles large, oval, flush, black in col our and lying in a round black patch.

In the green form, the head is grass-green, with a broad pale yellow stripe separating face from cheek; body grass green, the oblique stripes pale yellow, edged above with violet; horn orange with a black tip; legs, prolegs and claspers green. spiracles orange-red, edged narrowly with dark green. Length 95 mm, width 14 mm, height of head 5mm, horn 9 mm.

In the laboratory usually the larvae are recognized by (i) conspicuous spine (= horn) on the dorsal surface of the anal segment (= 8th segment) (ii) cryptic body colour, skin granulated but smooth (iii) horn is relatively longer in the first instars than in the later instars.

Pupa: Body slender, head small, fronts at right angles to the longitudinal veins of the body. Tongue reaching tip of wing base, in a free sheath which starts from the front of head at right angles to body,, curves backwards, till it comes parallel with the body and then forwards again to touch the ventral surface of the pupa, the slight bent being near the base of the eye. Antennae of male about 1.5 mm in length, longer than the female but shorter than foreleg. Abdomen finely pitted, the margins of the abdominal segments more coarsely pitted, sculpturing on segment 4, a pear shaped, raised polished area on each side of dorsal line, the broad ends ventral and reaching to about the dorsolateral line. Veins of wings slightly raised, antespiracular ridges on segments 9-11, three coarse ridges on each spiracle, oval, rising slightly from shallow depressions, covered by a short but wide lobe extending from the front margin of three. Cremaster conical, long and stout, Dorsal surface rugose, colour leather brown, spiracles and cremaster black. Length 47 mm, width 12 mm.

Imms (1965) summarised that pupa occurs free in a cell in the ground, or in a very loose cocoon on the surface between the leaves, etc. The 5th and 6th abdominal segments are free and there is always a cremaster.

Adult: The adult is large sized, stoutly built and swift flier. Its body colour is grey, wings are yellow/pale grey with black lines. The abdomen is with a narrow brown dorsal stripe, a broad grey stripe on each side of it, and

with a narrow white and broader pink and black sided patches (=incomplete pink bands on the abdomen). The antennae are thickened towards or beyond the middle and are pointed at the apices which are nearly always hooked. In the male the antennae are ciliated with partial whorls. The probosicis is developed to a length. The forewings are elongate, mottled with brown and grey, outer margin grey, many narrow whitish lonulate bands, nearly obsolescent in some specimens, black streak outwards from cell under R_1 and M_1; a white discoidal dot,with a black streak from it to apex of wing. Hind wings yellow/pale grey, with broad sub-basal, 2 median and post median fuscous (=black) transverse bands. Under side similar with a black discoidal spot. Expanse 80-120 mm; tongue upto 130mm. Adults emerge at dusk to fly and seek flowers for nectar.

Female: The mesal flap in front of vaginal aperture arises from an impression and is very thin; it belongs to the membrane connecting the 7th and 8th tergites; there is a tubercle at each end of the vaginal orifice and another behind it.

Male: Tenth tergite rounded-dilated before-end, apex compressed, pointed, higher than broad; ventral process of sharp, some what spatulate.

Imms (1965) reported that the adults can be easily recognized by the combination of following characters: elongate forewings and their very opaque outer margin; the antennae are thickened towards or beyond the middle and are pointed at the apices, which are nearly always hooked; in the males; the antennae are ciliated with partial whorls. The proboscis is developed to a great length, incomplete pink bands on abdomen.

LIFE HISTORY

The egg-stage lasts for 5-8 days. On hatching the young larva first eats up the egg-shell and after resting on the underside of the leaves, it starts feeding on them. The larvae are found on plants or in soil hiding among roots during the day. The larvae pass through five instars within 2 months time. At the end, the colour of the larvae is deep brown. At the feeding time the larval colour is green, which facilitates its hiding in the leaves, but at the end since it has to pupate, the colour turns brown to help camaflogue for hiding in the soil. The caterpillar feeds on the "Til" in the cold weather. The pupation takes place in the soil. The pupal stage lasts 2-3 months, 6 months or may even go to 1 year depending upon the prevailing environmental conditions. In the literature it is mentioned that the hibernation can take

place in all the stages. There being two generations in a year. The active period is from May to August. During this period the life cycle could be completed within 45 days under optimum conditions.

NATURE OF DAMAGE

The larvae defoliate the plants of cultivated pulses (beans, grams) and members of Convulvulaceae. The adults are crepuscular in habit and feed on flowers with a long tubular calyx e.g. *Hibiscus, Ipomoea, Begonia,* etc. The insect also attacks soybean, sunflower, tobacco, tomato, chilli and sweet potato plants in many countries and inflicts damage to the tune of 25-50%.

HOST PLANTS

Besides til, it has also been reported to occur on beans, gram, chilli, soybean, sunflower, sweet potato, tobacco and tomato

CONTROL METHODS

Physical: Farnseen (1939) obtained good results by filling ditches with water to prevent the migration of the larvae from one field to another field.

Cultural: Ayyar (1940) recommended to plough the fields to destroy the pupae and to put the light traps.

Chemical: i) Use of derris also gives good results; (ii) Use the same chemicals as for the other Hawk moth species.

SUNFLOWER

Sunflower as an oilseed crop helps a great deal in meeting the edible oil shortage in the country. It is grown twice a year i.e. in spring (March-June and Autumn (August-November). This is the time when climatic conditions are most ideal for insect pests and development of insect population is very rapid. About 17 insects and one mite species are known to attack this crop. The spring crop is generally attacked by aphid (*Myzus persicae* and *Rhopalosiphum erysimi*) during its early growth period in the month of March. Later on as the season becomes dry and hot this pest disappears. During April-May, army worm (*Cirphis unipuncta* and *Plusia* spp.) attack this crop.

The autumn crop is usually attacked by jassid *(Amrasca devastans)*. The leaves are found twisted, wrinkled and droop down. Pod borer (*Heliothis* spp.) attacks flower buds, heads and the young florets. It also makes tunnels

in the flower heads and remains partially hidden. The fungi attack the injured heads and cause decay of the tissue.These pests migrate from out going cotton crop to sunflower which is an alternate host for them.

The diagnostics, mode of damage and the control measures of different insect pests encountered in the literature are given below:

Chrotogonus trachypterus Blanchard, **(Acrididae: Orthoptera)**
(Surface grasshopper)

Small sized, with upper part of body rough and earthy coloured, under side white with black spots. Nymphs resemble adults in size but wings are not fully developed. Both nymphs and adults are destructive. They eat up young seedlings of the crop. In severe cases resowing has to be done.
Control: Apply BHC 10 percent @ 3 kg/acre.

Bagrada hilaris Burn (= *cruciferarum* Kirk)
(Pentatomidae: Hemiptera)
(Painted bug)

Adults black with conspicuous and beautiful markings of red and yellow in the centre of pronotum and lateral margins. Nymphs resemble adults with number of red markings. Both nymphs and adults suck sap from the plant; appears occasionally.
Control: Apply BHC 10 percent @ 3 kgs/acre.

Amrasca biguttula (Ishida) and *Empoasca devastans* (Dist.)
(Cicadellidae: Hempitera)
(Jassid)

Green coloured with a black spot on the head. Nymphs are transparent and yellowish green. Both nymphs and adults suck sap, leaves curled up, twisted and become yellowish red and droop down. This is usually termed stunting of the crop.
Control: Apply Temik 10 G. or Disyston 10 G @ 6 kg/acre.

Myzus persicae (Sulz.). **(Aphididae: Hemiptera)**
(Green peach aphid)

Apterous females, light green, head with slightly convergent antennal tubercle, abdomen without sclerotization. Adult females are reddish with a dark blotch on scleroitized abdomen. Both the adults and nymphs suck sap from underside of the leaves. Attack occurs in the early growth period of the plant.
Control: Apply Temik 10 G, Disyston 10 G @ 6 kg/acre, or spray Pirimor @ 0.2 kg/acre.

Rhopalosiphum erysimi (Kalt) **(Aphididae: Hemiptera)**
(Aphid)

Yellowish green with darker bands across the abdomen. Antennae, legs and cornicles are yellow except the extreme tips.
Control: same as *Myzus persicae*

Bemisia tabaci (Gennad) **(Aleyrodidae: Hemiptera)**
(Cotton white fly)

Body yellow, covered with mealy power. Wings white, vasiform. Nymphs ovoid and greatly flattened. It sucks sap from the lower part of leaves, lowers the vitality of the plant and produces honey dew which gives rise to soothy mould.
Control: Spray Metasystox 2- E.C. @ 0.5 lit/acre or Dimecron @ 0.225 lit/acre.

Oxycarenus loetus Kirby **(Lygaeidae: Hemiptera)**
(Dusky cotton bug)

Adult small, dark brown with transparent wings, nymphs brownish, rostrum large stretching from head to beyond middle of abdomen; suck sap from the floral part of the plant, found in great numbers on the flower heads.
Control: Spray Metasystox 25 E.C. @ 0.5 lit/acre or Dimecron @ 0.225 lit/acre.

Nezara viridula Linn. **(Pentatomidae: Hemiptera).**
(Green bug)

Adult dark green, nymphs smaller, blackish and wingless. Suck juices from leaves.
Control: Spray Metasystox 25 E.C. @ 0.5 lit/acre or Dimecron @ 0.225 lit/acre.

Agrotis spp. **(Noctuidae: Lepidoptera)**
(Cutworm)

In adults head and thorax grey brown. Forewings also grey brown, a kidney shaped spot slightly below the pale costal area; hind wings white or yellow, tinged brown. The caterpillars are dark brown, longitudinal stripes in front, skin smooth with small black spots.
Control: In small plots insect can be controlled by hand picking. Dust BHC 10% @ 3 kg/acre or apply Dieldrin 20% @ 2 lit/acre with irrigation water.

Heliothis spp. **(Noctuidae: Lepidoptera)**
(Pod borer)

Adults red brown, forewings with black dots, a kidney shaped mark on the under side, hind wings yellowish brown. Caterpillars green when newly hatched, becoming yellow brown later on. The caterpillars eat developing seed in the flower head and make tunnels. Large quantity of excreta on the floral parts indicates activity.
Control: Spray Folidol M 50 @ 0.5 lit/acre.

Spodoptera(=*Prodenia*)*litura* F. **(Noctuidae: Lepidoptera)**
(Tobacco caterpiller)

Adults pale brown. Forewings with some yellow streaks at base. Hind wings semi-hyaline. In caterpillars on each segment of abdomen a black patch above lateral yellow line. Caterpillars are gregarious and feed on leaves.
Control: Spray Nuvacron 40 or Azodrin 40 @ lit/acre.

Plusia spp. **(Noctuidae: Lepidoptera)**
(Cabbage semilooper)

These are shining gold coloured moths. Forewing fuscous. Hind wings pale at the base. The larvae are bluish green with a few short dorsal hairs. The larvae eat the leaves and are found in great numbers under the leaves.
Control: Spray BHC 12.5% W.P. @ 3 kg/acre or spray Dimecron @ 0.225 lit/acre.

Spodoptera(=*Cirphis*)*unipuncta* Haw **(Noctuidae: Lepidoptera)**
(Armyworm)

Adult pale brown with dark specks and blotches.Hind wings pale suffused with fuscous. Caterpillars grey brown, prothorax with dark shield and three light lines. Caterpillars feed on leaves, attack the crop in great numbers, migrate from adjoining wheat/berseem fields.
Control: Spray BHC 12.5% W.P. @ 3 kg/acre or spray Dimecron @ 0.225 lit/acre or Orthene S.P. 75 @ 0.5 kg/acre.

Euproctis spp. **(Lymantriidae:Lepidoptera):**
(Hairy caterpillar)

Adults deep yellow. Forewing with a black mark in the middle. Caterpillars dark reddish brown with black spots. Body very hairy.Caterpillars eat the leaves and are found on under side of the leaves in great numbers.
Control: Destroy the egg clusters in small plots. Spray Dimecron @ 0.225 lit/acre.

Amsacta moorei Butl. **(Arctiidae: Lepidoptera)**
(Kutra moth)

Adult white. Fore- and hind- wings marked with black dots. Caterpillars light yellow with dark head, very hairy. Caterpillars eat the leaves.
Control: Spray Dimecron @ 0.225 lit/acre.

Myllocerus maculosus (Fist.) **(Curculionidae: Coleoptera).**
(Cotton white weevil)

Whitish with brown spots on elytra, grubs are light yellow. Adults eat the leaves and make them perforated, the grubs damage the roots.
Control: Spray Folidol M 50 @ 0.5 lit/acre. Apply Hepatchlor 32 % 1.0 lit/acre with irrigation.

Thrips tabaci Lind **(Thripidae: Thysanoptera)**
(Onion thrips)

Adult yellowish, minute, wings long narrow, furnished with long fringes of hairs along margins. Suck cell sap, leaves become curled, wrinkled and twisted, dry and droop down.
Control: Apply Temik 10 G @ 6 kg/acre with first irrigation.

Phytomyza spp. **(Phytomyzidae: Lepidoptera)**
(Leaf miner)

Adults small to minute. Larvae are cylindrical, mouth parts conspicuous on account of their dark colour, on anal portion a small sucker like segment. Larvae tunnel into the leaves and stem.
Control: Generally need no plant protection.

Tetranychus spp. **(Tetranychidae: Acarina)**
(Mite)

Tiny with 4 pair of legs. Chelicerae stylet like, movable. In female genital portion with characteristic type of wrinkles. Found innumerable, and completely obscures the underside of the leaves.
Control: Spray Kelthane @ 1 lit/acre.

Chart for Chemical Control of Major Pests of Sunflower

Category	Name of Insecticide	Dose per acre
1. Sucking Insects	Dimecron	250 ml
(a) White fly	Folidol	250-400 ml

(Cont'd)

(Cont'd)

Category	Name of Insecticide	Dose per acre
(b) Aphids	Orthene	300-400 gr.
	Monitor	300-400 ml
	Roxion	400 ml
	Sumicidin	200-255 ml
	Kerate	300 ml
2. Leaf eating	Orthene	300-400 gr.
	Sumicidin	200-255 ml.
	Methyl parathion	500 ml
(a) Army worm	Monitor	300-400 ml
	Ambush	250 ml
(b) Cut worm	Dieldrin	2 lit.
	Heptachlor	2 lit.
(c) Hairy caterpillar	Dimecron	250 ml
	Sumicidin	225-300 ml.
	Ripcord	200-250 ml
	Kerate	300 ml
	Orthene	300-400 gr.
	Monitor	300-400 ml
3. Pod/Seed eater (*Heliothis*)	Thiodon	850 ml.
	Sumicidin	250 ml.
	Monitor	600 ml.

SOYBEAN

Melanagromyza (=Ophiomyia?) phaseoli (Tryon)
(Agromyzidae: Diptera)
(Pea stemfly)

It is a metallic blackly widely distributed, sporadic yet a major pest of soybean. The eggs are laid in elliptical cavities/slits under epidermis of leaves or stems made by the female. The fly also feeds on the sap exuding

from these punctures/wounds. Nearly 50-60 (elongate, oval, white) eggs are laid by a female. Incubation period is 2-4 days. Maggots can mine the leaves, or bore into the leaf petiole or tender stem by advancing through mining the leaves. As a result of maggot's burrowing the plants wither, droop and die.

Larval period is 10-15 days, and there are three instars before maggot is full grown. The pupation takes place within its gallery and lasts for 21 days. Adult females live for 21 days while males live 7 days. There are estimated 7-8 generations per annum. Over-wintering takes place in the larval or pupal stage.

Control: 1. Apply 10% BHC dust in the soil before sowing
2. Treat seed with 4% Carbofuran, Phorate or Disulfoton

SAFFLOWER

Acanthiophilus helianthi (Rossi) (Tephritidae: Diptera)
(Safflower fruit fly)

The adults are ash-coloured. The wing venation is unique in the sense that the subcostal bends apically at right angle and then fades out. The eggs are thrusted in clusters of 8 to 20, within the flower buds or flowers. The incubation period is one day. The larvae continue feeding within the flowers for a week, when they pupate for antoher week. The adults emerge from the bud through a hole made by pupating larva. There are three generations during a season of the crop.

The damage is done by the larvae to the floral parts including the thalamus. The symptoms are that the infested buds begin to rot and a foul-smelling liquid comes out at the apices of the buds, making the buds look like soaked.

Control: 1. Early maturing, spiny or non-felted varieties should not be cultivated, rather resistant varieties be encouraged.
2. Infested buds should be collected and destroyed.

Tanymecus indicus Faust. (Curculionidae: Coleoptera)
(Wheat weevil)

It is a polyphagous insect feeding on leaves of large number of crops in different parts of Indo-Pakistan. It has been recorded on rice, peas, red gram,

gram, mustard, sesamum, sunflower, cotton, wheat, jute, sugarcane, cruciferous vegetables, potato and indigo. It also sometimes damages seeds in the soil, which do not germinate.

The weevil is grey or greyish brown in colour. During the brighter part of the day the adults remain hidden in the loose soil and come out generally in the evenings and re-enter in the soil at night to reappear in the next morning. The life cycle of this weevil is very interesting. Adults come out of soil during Mid-June to Mid-July, soon after start of monsoon rains. These become sexually mature during the next 3-4 months. A female lays about 70-80 eggs, singly under clods of soil towards end of October. Eggs hatch within 2-3 weeks under optimum conditions. But then the larvae develop in soil in about 12 weeks. Pupae become visible during March-April and adults emergence is completed by the end of May. Since there is a very little greenary available, the adults continue staying in the soil, till the rains start in June-July.

The adults damage the seedlings upto 6 cm in height. Sometimes seeds sown in the soil may also be attacked by the weevils, which do not germinate, thus necessitating resowing.

Control: 1. Deep ploughing at the time of pupal stage.
2. Dusting the soil with 10 percent BHC or 5 percent Aldrin @ 22 kg/ha and raking it into the soil at the sowing time.

Perigaea (=Prospalta) capensis (Guen.) **(Noctuidae: Lepidoptera)**
(Safflower caterpillar)

The medium sized moth is dark-brown in colour with white wavy markings on the dark-brown forewings; hind wings are light brown. Female lays eggs singly or in small clusters on the leaves and stems. Hatching period is 3 days The larvae feed on leaves and are full grown in 15-22 days. Full grown larvae are smooth, greenish with purple markings, and a hump on the anal segment.

CASTOR

Euproctis fraterna **Moore (Lymantridae: Lepidoptera)**
(Castor hairy caterpillar)

It is a polyphagous insect and known to feed on a number of cultivated crops fruit trees, shade trees and ornamental plants.

DIAGNOSTICS

Egg: Freshly laid eggs are pale yellow with a greenish tinge (= creamy yellow). An egg is rounded, measures about .62 mm in diameter, is smooth in texture with a circular depression at the top. Before hatching the eggs turn completely brown or brownish yellow due to embryonic changes. These are laid by the female only once in a single cluster, on the underside of the leaf, generally along the midrib. The egg cluster is covered with a golden yellow hairs from anal tufts of the female. The cluster is 9-20 mm in length and 4-6 mm in width. It is linear, oval or irregular in shape according to the eggs arranged inside. The eggs below the tuft of hairs are not cemented but kept in position on a cushion of hairs with some hairs interspersed. The number of eggs in one cluster is 10-201. The incubation period is 3-8 days in summer and 6-15 days in winter.

Larva: Akhtar (1961) made a detailed study of the insect and reported that there are 5 larval instars. The details of which with some modifications are as under:

First instar: The body colour of the freshly hatched larva is light yellow or creamy which changes to orange yellowish before moulting. A dark spot appears on the first abdominal somite. Head bright orange/brown and the mouth parts are slightly lighter in shade. The larval body is covered with a number of outgrowths. Body length 1.9 mm to 2.1 mm, width 0.25-0.29 mm.

Second instar: Head and eyes bright orange brown, body greyish yellow. Paired brown dorsal protuberunces on 1st, 2nd and 8th abdominal somites are noticed. The dorsal and lateral verrucae of nearly all the abdominal segments bear very fine white spicules forming tufts. Ventral side slight yellow. Body length 5-5.4 mm.

Third instar: The general body colour is dark brown. First somite with long lateral tufts of black hair rising from prominent tubercles; the other somites with dorsal and lateral tufts of white hair; 9th and 10th somite with white dorsal spots; 11th somite with a dorsal black tuft. Body length 8 - 8.5 mm.

Fourth instar: Head crimson; body colour becomes brownish black. Hair grow thicker and longer. One white spot on the dorsum of each of 9th and 10th abdominal segments. Body length 16 mm - 17 mm.

Fifth instar: Similar to 4th instar, but body length 22-23.2 mm and width is 3-5 mm.

In Sindh, Siddiqui (1986-87) recorded five moults and six instars. The general body colour of full grown larvae is dark reddish brown/black, with black spots. Head is brown (some describe crimson), mouth parts and ventrum are dark, dorsum of thorax is dark brown, prothoracic shield bright orange red, abdomen is light yellow with greenish tinge.

The first somite with long lateral tufts of black hair rising from prominent tubercles,. The other somites with dorsal and lateral tufts of white hair, subdorsal pale lines; 9th and 10th somites with dorsal spots; 11th somite with a dorsal black tuft. Ayyar (1940) reported that the larva when full-grown is dark reddish brown, in addition to a covering of hairy tufts all over the body, it possesses a pair of long tufts directed forward on either side of the head and a single elongated tufts directed backward from the anal segment hence known as Tussock caterpillar. Siddiqui (1986-87) reported the larval period as 24-46 days in summer and 50-67 days in winter in Sindh.

Pupa: The general body colour is reddish-brown to dark brown. It is covered with a thin deep-yellow cocoon interwoven with larval hairs. Under laboratory conditions fullfed larva rolls the leaves of the food plant around itself to form a cocoon with the help of silken thread. It pupates inside this. In the field, pupation was found to take place on the leaves, on a branch, in a silken cocoon, under the fallen leaves or inside the crevices of the soil at a depth of 2-3 inches. A pupa is 9-10 mm long and 4-4.5 mm broad across the wing covers.

Adult: In general, head, thorax and forewings bright orange-yellow, abdomen tinged with fuscous, the anal tuft orange; forewing with ante- and postmedial curved pale lines, the space between them being slightly powdered with dark scales towards inner margin; black rounded dots along the apical margin.

Fronts rounded, maxillary palpi reduced; labial palp much longer than the length of head, 2nd segment 1.5 times the length of 3rd; forewings yellowish in colour, Sc + R_1 separate from R_s, R_3 and R_4 stalked, M_2 basally proximated to M_3, both stalked at bases, originating from lower angle of cell; hind wings pale white, veins with M_2 and M_3 wide apart, only M_3 originating from lower angle of cell.

Male: Antennae bipectinate, pectine twice as long as in the female. Wings yellowish, forewings being richer in pigmentation than hindwings. A large central area of the forewing is dark brown which is divided into smaller patches by faint lines. Two separate and two fused black dots are present near the apex and the anal angle. Three wavy transverse lines (white to creamy white)run across each forewing. Body 8.5 - 10.5 mm long and with wing expanse measures 20.5 - 27.5 mm.

Female: Antennae bipectinate, pectine half as long as in the male. Each forewing with a tiny orange yellow spot near the discoidal cell, which becomes faint in older specimens. Sometimes the yellow spot is enclosed by a faint whitish ring, three wavy transverse lines (of white or creamy white colour) are found running across the forewing in male, but are less prominent in the female. Two to four black spots are present on the forewing in fresh specimens. These are more prominent in female than in the male, but vary in position in the submarginal area of the forewing. Caudal extremity is provided with tuft of yellow coloured anal hairs. Body length, 11-12 mm, and with wing expanse it measures 31.5 - 40.8 mm.

ACTIVITY PERIOD

The egg are laid in batches on underside of the leaves of the host plant and covered with hairs of the parent female. The adults emerge from beginning of January to end of February. The eggs are laid in batches on host plants. The eggs hatch in 2-3 weeks. The larval period lasts for whole of the autumn and winter, and causes damage. The pupal stage lasts from mid October-November to January. The pest is active throughout the year. The adults from the pupae of last generation emerge towards the end of February and beginning of March and copulate 1-2 days after emergence. The copulation lasts for 1.5-3 hours. the preoviposition period is 2-4 days and the female lays eggs on the lowerside of the leaves of the available host plants. In Punjab it deposits 85-161 eggs in 1-3 clusters on underside of the leaves. Siddiqui (1986-87) observed only one egg cluster in Sindh.

The insect passes through 4-6 overlapping generations in the Punjab during a year. The duration of these generations is an under:

First generation	March-April
Second generation	May-mid June
Third generation	Mid June-Last week of August.

Fourth generation	End of August - End of October
Fifth generation	November-February

The insect is available in almost all its stages throughout the year except from December to mid February when only the larvae and pupae are found.

DURATION OF DIFFERENT LIFE STAGES

As reported by Siddiqui (1986-87) the incubation period is 3-8 days in summer and 49-67 days in winter in Sindh. In the Punjab the larval period is 35-50 days during March-October while it may extend upto 80 days in winter. The insect takes short time to pass through first three instars while the next two instars occupy long duration and the 6th being the longest. The pupal-period lasts 11-22.5 days in summer and 22-39 days in winter, in Sindh. In the Punjab the pupal period is 9-14 days during March-April to October and upto 26 days in winter. The female moth lives 1.3-3.00days while male moth has longevity of 1-2.6 days in Sindh. In the Punjab the adult stage lasts 2-5 days in male and 3-6 days in the female. The total life cycle of the pest losts 45-104 days. The pest passes through several generations in a year.

DISTRIBUTION AND FOOD PLANTS

The insect is widely distributed in India and Pakistan. Primarily it is polyphagous insect. Besides "ber" tree, this has been recorded on jaman, guara, pomegranate, pears, plums, 'falsa' grape-vine, castor and rose (Nath, 1941). In Pakistan it has been noted damaging tea, sunhemp, cotton, vegetables, fruit plants,shade trees, forest plantation and ornamental plants. Rahman (1940) reported that this insect has been found attacking castor,rose, cotton, citrus, ber, falsa, apple,loquat, peach, pear, berseen sheesham, kikar, sareen, rice, piazi, bathu, etc. Sometimes this even attacks fruits.

NATURE OF DAMAGE

The pest is more destructive during summer. The caterpillars feed gregariously on the epidermal tissues of the leaves from the lower side when young, but disperse later and feed singly. The attacked plant can be easily recognized by its parched appearance, sieve like look of dried leaves with jagged edges.

The caterpillars completely skeletonize the leaves and most of them drop off. Thus the food supply of plant is severely affected which invariably reduces the yield to a great extent. The hairs found on larval body cause severe irritation to human skin. In case of serious attack, picking of fruits from orchards or tillage operations in the field become rather impossible because the body hairs of larvae can cause severe itching and even blisters on the skin of field workers. Sometimes all agricultural practices have to be abandoned due to their presence in the field. Likewise, when larvae are present in large numbers these also cause considerable trouble and inconvenience to animals. Although a pest of economic significance and when comes in epidemic form causes serious damage and reduces the yield considerably. Very little or no work so far has been done on the biology of *Euproctis fraterna* except by Ayyar (1919) Krishanamurthy (1954)who reported the occurrence of larval parasites. Fletcher (1919) Hussain (1926) Janjua(1947), Pruthi and Battra (1938) Alam (1962) and others have mentioned the host plants of the pest. Pruthi and Battra (1938) further reported that the pest hibernated during winter in N.W.F.P. Rahman (1940) and Akhtar (1961) reported that the larvae of this insect are most destructive. They are mostly gregarious feeders in the early stages and may denude the vast areas of the crops and plantations in cases of severe attack. Siddiqui (1986-87) reported that usually copulation took place at night, but sometimes it occurred during the day time and it lasted from 74 to 350 minutes.

CONTROL METHODS

1. The population of the pest can be reduced to a considerable extent by collecting and destroying the egg masses when the plot size is small.

2. The young caterpillars can be killed by applying Malathion/Endosulphan 0.03%. When, they are grown up these can be killed with Methyl Parathion 0.05% as spray.

3. Spraying of Gusathion 20% @ 16-20 oz per 100 gallons of water/acre, Folidal M @ 8-16 oz per 100 gallons of water/acre, Dimecron 100 @ 6-8 oz per 100 gallons can also give effective results.

Diacrisia obliqua Wlk. (Arctiidae: Lepidoptera)

(Jute hairy caterpillar)

DIAGNOSTICS

Egg: Round, perfectly smooth, laid in clusters, pearly green when freshly laid, colour changed from brown to dull black before hatching. Incubation period 7-8 days, viability 94.9%.

Larva: Newly hatched, creamy white, eats away shell contents as food; feeds gregariously on lower epidermis of leaf, remains gregarious till the end of second instar. During third instar, the larvae gradually disperse and feed singly on the leaf. Full grown caterpillar has yellow coloured body, black head and inter segmental regions. Larva voracious feeder with enough potential to inflict collosal loss to foliage in a minimum possible time.

Six instars in all. Differences in size and duration of each instar have been given in Table 1.

Table 1. Larval stages of *D. obliqua* Wlk. on cotton with their durations and sizes

Instar	Duration (days)	Length (cm)	Breadth (cm)
First	3	0.47	0.08 - 0.15
Second	2-4	0.7 - 1.19	0.2 - 0.3
Third	2-3	1.15 - 1.75	0.34 - 0.42
Fourth	4-5	1.98 - 2.85	0.48 - 0.57
Fifth	6-7	3.25 - 3.96	0.64 - 0.68
Sixth	7-8	4.18 - 4.47	0.73 - 0.78

Pupa: Caterpillars pupate on the underside of leaves, in cocoons composed of dry hair and cast-off skins. Pupa exarate, reddish brown, shining and comparatively smooth. Pupae may be sexed by locating genital openings on ventrum of 9th and 10th abdominal segments in male and 8th segment in female.

Adult: Moth pale-brown, medium sized with black spots on wings, abdomen red. Male and female alike in appearance. Male and female antennae bipectinate and filiform, respectively. Male small, 17.05 mm long

4.55 mm wide and 38.65 mm wing spread. Female large, 19.8 mm long 6.33 mm wide, and 50.27 mm wing-spread. Soon after emergence, adults copulate. Female starts laying eggs in a day or two.

DURATION OF LIFE STAGES: Duration of different life stages of *D. obliqua* Wlk. is given in Table 2.

Table 2. Duration of different life stages of *D. obliqua* Wlk. on cotton.

S. No.	Life Stage	Duration + 95% confidence limits
1.	Incubation period (days)	7.4 + 0.271
2.	Egg viability (%age)	94.9 + 1.930
3.	Larval duration (days)	27.7 + 0.480
4.	Larval survival (%age)	82.0 + 7.044
5.	Pupal stage (days)	11.2 + 0.0218
6.	Longevity of male adult (days)	3.4 + 0.270
7.	Longevity of female adult (day .)	6.9 + 0.341
8.	Oviposition period (days)	2.5 + 0.276
9.	Number of eggs	650.0 + 235.05
10.	Total life (days) of male	49.6 + 0.748
11.	Total life (days) of female	53.3 + 0.965

NATURE OF DAMAGE

The young caterpillars feed gregariously on the lower surface of the leaf for 5-6 days and eat away the tender portion of the leaf. After this, the caterpillars disperse and devour the whole leaf except mid-rib.

HOST PLANTS

Jute hairy caterpillar is almost omnivorous so far as cultivated crops and low herbage are concerned. Lefroy (1906) recorded the infestation of this pest on jute (*Corchorus olitorius* L.) groundnut (*Arachis hypogaea*), brinjal (*Solanum melongena*), cabbage (*Brassica oleracea*), raddish (*Raphanus sativus*), peas (*Pisum sativum*) and many other leguminous crops. Bhowmik (1962) observed the infestation of *D. obliqua* on *Albizzia lebbeck, Artimisia vulgaris, Asparagus officinalis, butea monosperma, Cannabis sativa, Chenopodium ambrosoides, Cordia tremula, Hibiscus abelmoschus, H. rosasinensis, Mentha arvensis, M. longifolia, M. piperita, Tinospora cordifolia, Withania somnifera, Plutea tomentosa,* and *Chrysanthemum* spp. in India.

It has been observed feeding on cotton (*Gossypium hirsutum*), 'mung' (*Phaseolus mungo*), castor (*Ricinus communis*), 'toria' (*Brassica campestris*) and certain ornamentals like gardenia (*Clerodendron inerenus*)' 'gule-e-daudi' (*Chrysanthemum indicus*) and 'gul-e-khaira' (*Althaea rosea*), abundantly. Out of these host plants, cotton 'mung' castor, toria, gardenia and 'gul-e-khaira' have been observed to be its hosts for the first time. Ahmad *et al* (1988) reported it serious pest of mungbean (*Vigna radiata* L. wilczek), mashbean (*Vigna mungo* L.), sunflower (*Helianthus annus* L.), soybean (*Glycine max* L., *mess*) and groundnut (*Arachis hypogaea* L.).

CONTROL METHODS

Cultural Control

i) unless otherwise essential, the cultivation of crops other than cotton be discouraged, particularly in its immediate neighbourhood and

ii) if at all, the other crops are to be necessarily sown, they should be sown under extremely well protected conditions.

Euproctis lunata (Walker) **(Noctuidae/Lymantriidae: Lepidoptera)**

(Castor hairy caterpillar)

It is a serious pest of castor and oilseed crops. it also feeds on guara, grapevine, linseed and groundnut.

DIAGNOSTICS

Egg: The egg is creamy-yellow in colour, rounded in shape, laid in clusters underneath the leaves and then covered with hairs.

Larva: It is brown, with anterior, posterior and lateral tufts of long hairs; thoracic somites with dorsal quadrate white marks. The third somite with paired dorsal tubercles; fifth to anal somites with paired dorsal, quadrate white marks, spins a hairy cocoon on twigs. When full-grown it is dark reddish brown covered with numerous hairs on the body. The caterpillar passes through five instars. The body of the larva of first instar is slight yellow or creamy which changes to yellow before moulting and a dark spot appears on first abdominal somite. The larva of 2nd instar is of bright orange brown, body greyish yellow. The dorsal and lateral verrucae of nearly all the abdominal segments bear very fine white spicules forming tufts. Ventral side

slight yellow. In the third instar the body size increases from 8 - 8.5 mm. The general body colour is dark brown. In fourth instar the body length is 16-17 mm and in fifth instar the body length is 22-24 mm.

Pupa: It is reddish brown, with black spots. The body is very hairy, head and prothoracic shield bright orange. Pupal cocoon is thin deep yellow and interwoven by the larval hairs.

Adult: The moths are thick set, deep yellow (some say pale bright ochreous) and are seen sitting on castor and other plants during day. There is a large black lunate shaped (crescentric) mark in the middle of each forewing, on discocellular. Forewings in female are whitish ochreous, and the anal tuft is brownish ochreous (some say yellow hairs). Wing expanse 28-32 mm in male and 38-44 mm in the female.

ACTIVITY PERIOD

The moths appear in April. The copulation takes place after 1-2 days of emergence and continues for 1.5-3 hours. the previposition period is 2-4 days and the females lays eggs in clasters covered with the female anal tuft on the underside of the leaves of the host plant. Each female lays 200 eggs. After 4-5 days the eggs hatch and the young larvae come out. The larvae are gregarious in habit and at night time, they move from field to field. After 17-27 days the larva transforms itself into pupa in the active season but in winter it may take long time. The pupal stage is 9-17 days and the total life cycle is 1.5-2 month. The hibernation takes place in pupal stage in November-March, 2-3 generations have been reported in a year from April-October.

NATURE OF DAMAGE

This insect attacks tea, sunhemp, cotton, vegetables, fruit plants as ber, grape, etc; shade trees, forest plantations and ornamental plants. The larvae are gregarious feeders in the early stages and may denude the vast acrage of crops and plantations in cases of severe attack. They are also very troublesome for field workers as they cause severe itching and even blisters on the skin due to their coverage of poisonous hairs and sometimes all the agricultural practices are to be abandoned due to their presence in the field. When present in large number they cause a considerable trouble to animals. Janjua (1947) reported many deaths of cattle because the casterpillars were eaten by them in their food. According to Rahman (1940) generally it is a

leaf eating caterpillar, the newly hatched larvae feed on soft parts of the leaves, leaving a net work of veins and rendering a major portion of the foliage of the tree as skeletonized. In the advanced stage the caterpillars cut the whole leaf, if it is tender and soft. Sometimes the skin of the fruit is also nibbled and scratched by the larvae and although such injuries are only stem deep, the fruit is invariably exposed to the attack of fungi and scavanger beetle and is so most likely to be spoiled due to rotting. The hair coverings of the body of the larvae and those of the larval moults, pupal cases, egg clusters and anal tufts of female moth are poisonous and cause irritation and blisters on the human skin on contact.

CONTROL

Young caterpillars can be killed by applying 10 percent BHC dust to the crop. When they are grown up they can be killed with Endrin or Parathion 0.04% sprays.

Conogethes (= Dichocrocis) punctiferalis Guen.
(Pyralidae: Lepidoptera)
(Castor shoot and capsule borer)

This is quite an interesting pest of castor, wherever it is grown.

DIAGNOSTICS

Egg: Pink, oval, flat with rough surface, 0.5 mm in diameter. Eggs are laid at night singly or in batches of two, three or six on inflorescence (in between the warts or just below the style on the ovary of the flowers) and developing (half mature) capsules, as well as other tender parts of the plant. Nearly 20 eggs are laid on a single panicle. Eggs are seldom/rarely laid on unopened male flowers and leaf axil. The incubation period is 6-7 days.

Larva: A full grown larva measures 20-25 mm in length. Body pale green with a pinkish shade dorsally; head and prothoracic shield brown and body covered with numerous minute hairs arising on tubercles (warts). The larvae grow full in 12-16 days. There are five larval instars. Throughout its development larva remains in concealment under a cover of silk and frass or excreta which extends between capsules.

Pupa: Pupation takes place in cocoons of silk inside the stem or capsule. Pupal period is 7-10 days.

Adult: Size medium, colour bright orange-yellow; a number of small black dots/spots on wings. Total life cycle takes 25-35 days.

NATURE OF DAMAGE

The larvae bore into the terminal shoots of young plants and seed capsules of older plants. Occasionally the leaves are bored at the junction of the petiole with the leaf lamina. In broad leaved varieties even the thick midrib or vein of the leaf is attacked. In case of shoots, frass comes out from the holes of entry.

But when capsules are attacked, they are webbed together and galleries of silk and frass are made over them. Sometimes even the opening of the capsule is closed with a silken web. It is stated in the literature that at some places larvae overwinter within the hollowed out seeds. The faecal matter of the boring caterpillar emerging out of the bore holes presents a conspicuous indication of infestation.

HOST PLANTS

Besides castor, its larvae have been recorded infesting the several crops in India viz; (i) various parts of millets (ii) boring into green bolls of cotton (iii) boring into orange fruits in plains (iv) boring the young fruits of guava, which dry up and fall without ripening (v) flowers and tender shoots of mango (vi) boring into fruits of pomegranate, peaches, cocoa, (vii) infesting nursery plants and young green pods of cardamom (viii) boring the aerial stem of ginger and killing it (ix) boring the aerial stem of turmeric and killing the central shoot which appears as a "dead heart" (x) sporadic pest of sorghum ears, and sunflower as well.

CONTROL METHODS

1. Collecting and destroying the infested shoots and capsules.
2. Spraying with Quinalphos or Dimethoate.
3. Spraying of Malathion 0.1%, Carbaryl 0.1% at 21 days intervals from the time of formation of inflorescence minimizes damage.

Achaea janata (Linn.) **(Noctuidae: Lepidoptera)**
(Castor semilooper)

It is a specific pest of castor. Adult greyish brown, with wavy lines on the forewings and black and white blotches on the hing wings. Eggs are laid

singly on leaves and tender shoots. Hatching takes place within 4 days. The larvae feed on leaves voraciously causing considerable damage. The larvae are full grown in 15 days, possess smooth body, grey brown colour and pale-white stripes. They pupate in soil or leaf fold for 8-9 days and hibernate (Nov-Dec.) or aestivate in this stage. There are 5-6 generations in a year. The adults usually come out in June and have a pre-oviposition period of 1-3 weeks.

A female may lay upto 100-600 eggs at different places. The peak activity is July-August and the maximum damage is done by the second and third instar larvae. The caterpillars besides castor also attack leaves of cacao, pomegranate, ber trees, and leaves plus flowers of rose. The moth also pierces guava, grape wine, orange fruits and feeds on the juice.

Control: Mechanical collection and destruction of caterpillars and treatment with 5 percent BHC dust.

Empoasca flavescens Fab. **(Cicadellidae: Hemiptera)**
(Castor leaf hopper)

Adults small, yellowish green. Female lays eggs singly in veins and midribs of leaves, and in young stems. Incubation period is 1-2 weeks. There are five nymphal instars. Nymphal period is 20-21 days. Peak period is from July to August. The adults may live for 1-2 days. Both the adults and nymphs such the sap of the castor plant.

Xyleborus formicatus Eichh. **(Scolytidae: Coleoptera)**
(Bark or Engraver beetle)

It is a minute beetle measuring 3-4 mm in length. The female makes tunnels within the sap wood of the stems, which interfere with sap flow. The infested branches may break off at the slightest pressure. Weakened branches are liable to attack by wood-rotting fungus.

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Chapter 6

INSECT PESTS OF FIBRE CROPS

Heshamul Huque*

I. Insect-pests of cotton crop

Cotton is attacked by 1326 species of insect pests, of which 145 species of phytophagous insects of sucking and chewing habits have been recorded in Pakistan (Appendix). Among them more than a dozen insect pests keep their pressure on the crop and cause severe damage during its growing season. The major insect pests are listed below:

A) Insects attacking roots and seedlings

1. Surface Grass hopper *(Chrotogonus trachypterus)* Blanchard.
2. Black headed cricket (*Gryllus bimaculatus* Deg.)
3. Termites (*Microtermes obesi* Hol.)

B) Insects attacking leaves

a) Sucking Pests

4. White fly (*Bemisia tabaci*)
5. Jassid (*Amrasca devastans* Dist.)
6. Thrips (*Thrips tabaci* Linn.)
7. Aphids (*Aphis gossypii* Glov.)
8. Red cotton bug/cotton stainer, (*Dysdercus cingulatus* Fb.)
9. Mite (*Tetranychus cinnabarinus* Boise.)

b) Biting and chewing

10. Cotton grey weevil (*Myllocerus maculosus* Desb.)
11. Cotton leaf roller (*Sylepta derogata* Fb.)
12. Army worm (*Spodoptera litura* Hb.)

c) Insects attacking flowers, buds and bolls (Boll worms)

13. Pink bollworm (*Pectinophora gossypiella* Saund.)
14. American bollworm (*Heliothis armigera* Hub.)
15. Spotted bollworm (*Earias insulana* Boise./*E. vittella* Stoll.)

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In view of the significance of these pests for cotton crop, a brief account of their distribution, occurrence, host plants, life history and nature of damage is dealt with.

INSECTS ATTACKING ROOTS AND SEEDLINGS

Chrotogonus trachypterus Blanchard (Acrididae: Orthoptera)
(Surface grasshopper, Tiddi)

DIAGNOSTICS

Egg: Eggs are elongate — oval in shape

Nymph: Nymphs look like parents but are wingless and relatively smaller than adults

Adult: Dusky stout, stumpy and flattened. The tegmina wings are rudimentary. Dorsum of the body is rough.

LIFE HISTORY

A female usually lays 60 eggs in 3-4 clusters, by making holes in the soil. Eggs laid during winter remain in embryonic diapause for 3-5 months. Nymphs complete their development in 8-10 weeks and become adults. Eggs laid during summer, hatch out in about 11-26 days and nymphs take 30-186 days for becoming adults.

NATURE OF DAMAGE

Both adults and nymphs damage the seedlings of cotton and their attack continues till the cotton crop attains considerable height. As the surface grasshoppers prefer low vegetation, therefore, the crop in advanced stages escapes from their attack.

SEASONAL ACTIVITIES

Egg laying occurs twice a year; first oviposition during October-November and second during June-August. Population starts building up first in January-February and then in June-July. Eggs laid in October-November remain in embryonic diapause till April-May. Adults of this generation oviposit in June-August and nymphs which emerge in 23 days become adults in October-November.

Adults of grasshoppers migrate to cotton fields from nearby vegetations in April. Maximum damage has been noticed from May to August.

DISTRIBUTION

Surface grasshoppers are found throughout the plains of Pakistan. Usually they are considered as minor pests but in some particular years they have caused considerable damage to cotton crop in Punjab.

HOST PLANTS

Grasshoppers are polyphagous in nature and attack a number of cultivated plants including cotton, maize, vegetables, pulses, sorghum, gram, sanhemp, groundnut, castor, indigo, tobacco, millet, wheat, niger seed, etc. They also feed on a number of weeds.

CONTROL METHODS

Cultural: 1. To check the movement of pests from one field to another barriers (ditches filled with water) may be made around cotton field.

2. Insects may be collected with hand nets and destroyed.
3. Higher seed rates should be used and thinning should also be delayed.

Biological: It is preyed upon by over three dozen different species of birds, among which (*Acridotheres tristis-tristis*) commonly known as 'Myna' is the most important one.

Eggs of grasshoppers are also destroyed by the larvae of some unidentified blister beetles.

Chemical: In case of severe attack, dusting with BHC or DDT may be done.

Gryllus bimaculatus Deg. (Gryllidae: Orthoptera)
(Blackheaded cricket, Jheengar)

DIAGNOSTICS

Egg: Freshly laid eggs are yellow in colour which later on turn creamy white and become greyish before hatching. They are cylindrical in shape and about 1/12 inch in length.

Nymph: Nymphs are brown in colour with dark patches on head and thorax.

Adult: They are black coloured with brown patches on head and thorax. Head is narrower than pronotum. Fore wings are black with yellow spots while hind wings are transparent. Pronotum with dark brown or black patches. Measure 27 mm in length.

LIFE HISTORY

Black headed crickets are nocturnal in habit. During day time they hide in cracks and crevices of soil and under decaying matter. Feeding, mating and egg-laying takes place from late afternoon until the next day late morning.

Females lay 400-500 eggs, $^1/_4$ – 1-$^1/_2$ inch below the soil surface or underneath straw on threshing floor. Eggs hatch in 9-20 days during March-April and September-October, whereas during May-August it takes 6-10 days. Nymphal period is completed in 33 days during May-June and 128 days during September-March.

The adults and nymphs pass winter by hibernating in cracks and crevices of soil, under decaying leaves and other vegetative matter, etc.

NATURE OF DAMAGE

Both nymphs and adults of crickets are voracious feeders of seeds and seedlings of cotton. They destroy the seed kernal and the seed does not germinate. They cause heavy losses to cotton seedlings by cutting them off slightly above the ground or just below the apical bud. They also eat up young leaves of growing plants and nibble on the bark of their stems which leads to the death of plants. In case of severe infestation, replanting of cotton becomes necessary. In Dera Ghazi Khan district upto 70 percent cotton crop losses are attributed to this pest.

SEASONAL ACTIVITIES

During winter (mid-November – mid-January), both the adults and advanced stage nymphs hibernate. At the end of February and beginning of March, over-wintering forms become active and oviposition starts. Breeding continues till October and there are four generations in a year.

Seasonal activities of crickets may be divided into four phases:

i) **Mid-November to mid-January:** insect remains inactive in overwintering forms.

ii) **Mid-January to mid-April:** may be termed as the "Pre-outbreak period", when oviposition starts and small number of nymphs appear.

iii) **Mid-April to mid-July:** is the "Outbreak period" during which pest is in the nymphal and adult stages and causes maximum infestation to the cotton crop.

iv) The "Post-outbreak period" starts from mid-July to mid-November after which the activity is much decreased.

CLIMATIC RELATIONSHIP

Attack of crickets is severe in arid climatic conditions.

DISTRIBUTION

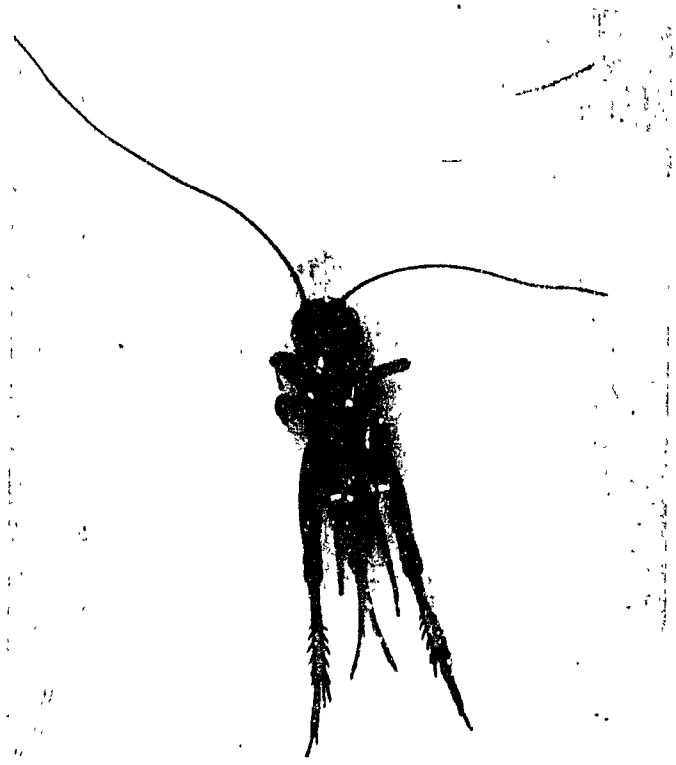
In Pakistan crickets are found in all cotton growing tracts having arid and semi-arid condition. Nangpal (1948) reported the existence of crickets in Dadu, Larkana, Sukkur and Jacobabad districts of Sindh. Recently, they have also been recorded in Muzaffar Garh and Dera Ghazi Khan districts of Punjab and Khirthar and Johi tracts of Sindh.

HOST PLANTS

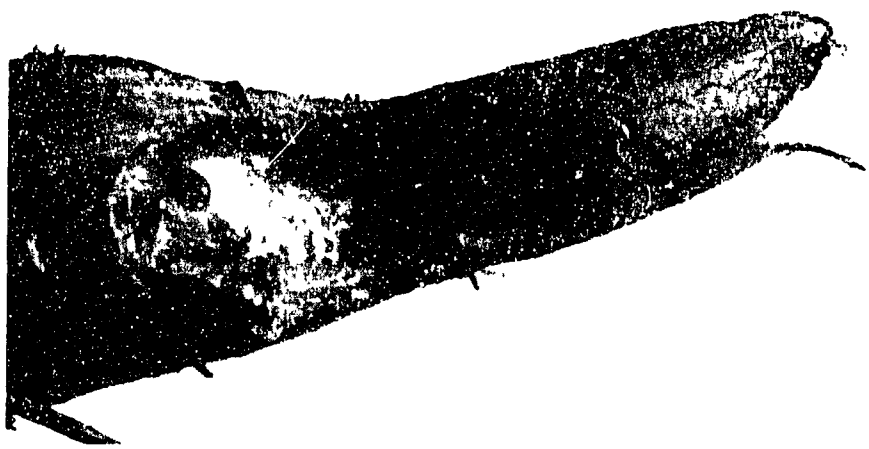
Crickets are polyphagous pests. Besides cotton, they are found on berseem, tobacco, maize, wheat, mustard and gourd. They also destroy seeds and stems of harvested "Taramira" and "Sweet turnip" during April.

CONTROL METHODS

Cultural: In cricket affected areas high seed rate (10-12 kg/ acre in Punjab and 12-15



BLACK HEADED CRICKET



TERMITES

kg/acre in Sindh) should be used. The crop should preferably be sown on ridges and thinning should be delayed.

Biological: A number of unidentified birds feed upon these insects.

Chemical: Population of crickets should be controlled at the initial stages, otherwise it spreads in the epidemic form, making it difficult to control. Therefore, spraying should either be done in the pre-outbreak period at the end of February to mid-March, just before the hatching starts or in the outbreak period (mid-April – mid-July) on all field bunds after irrigation, at 10-15 days interval. Baiting in the breeding places should be done in the evenings or at night especially from November to January, to control the hibernating population. Bait may be prepared by mixing 50 kg of rice husk with 250 ml of Dieldrin 20EC and 20 litre water. Seeds should also be treated with 1% solution of Dieldrin, Just before sowing.

Microtermes obesi Hol. (Termitidae: Isoptera)
(Termite, Deemak)

DIAGNOSTICS

Adults are pinkish white in colour. They live in the form of colony. Only the reproductive forms (known as king and queen) possess wings, whereas others (known as workers and soldiers) are wingless.

LIFE HISTORY

Males or king termites remain with the female or queen throughout life. Queen is the mother of the entire colony. She deposits eggs in the royal chamber of colony. In summer, after one week of incubation hatching takes place and nymphs appear which develop into adults. Adults distinguish into several groups, such as workers, soldiers, kings and queens. Workers and soldiers reach maturity in about six months while king and queen which are reproductive forms, takes 1-2 years for maturation.

NATURE OF DAMAGE

Termites attack the seedling of cotton. They damage the underground parts of the plant and roots resulting in plants death. When pulled, such plants easily come out with their broken underground stem. After completion of root feeding they start attacking stem of the plant.

SYMPTOMS

Leaves of the attacked plant get rolled and start dropping. Then wilting and drying of the attacked plant occurs.

CLIMATIC RELATIONSHIP

Attack of termites is closely related with dry climatic conditions, particularly from April to July

DISTRIBUTION

The termites are commonly found in Punjab, Sindh and NWFP. However, their attack on cotton crop is comparatively more in Multan, Bahawalpur, Rahim Yar Khan districts of the Punjab, and Sukkar and Nawabshah districts in Sindh particularly during hot and dry season.

HOST PLANTS

Besides cotton, termites feed on a number of vegetable products, wood, paper, fungi and dried animal materials.

CONTROL METHODS

Cultural: Following measures may be undertaken for cultural control of termites.

1. Seeds should be soaked in water for 6-8 hours before sowing.
2. High seed rate should be used in termite affected areas.
3. Flooding of cotton field is helpful in reducing termites infestation.
4. Thinning should be delayed.

Chemical: In hot spot areas, Dieldrin @ 2-1/2 lit/ acre should be applied with rouni as a soaking dose, before planting.

INSECTS ATTACKING LEAVES

a) Sucking Pests

Bemisia tabaci Genn. (Aleyrodidae: Hemiptera)

(White fly, Safead makhi)

DIAGNOSTICS

Egg: Eggs are sub-elliptical and stalked. Freshly laid eggs are light yellow in colour which later become dark brown. These are stuck on the lower side of leaves.

Nymph: *Ist instar nymphs* These are wingless, flattened, oval in outline and light yellow in colour with functional legs and 16 pairs of bristles on the margin of the body, usually called crawlers. The crawlers have beaks which they insert into the cotton leaves and begin sucking the sap. They adhere to the lower surface of leaves, and do not move, rather grow in size while sucking the plant sap in the same spot.

IInd & IIIrd instar nymphs: They are immobile, depressed and pale greenish yellow coloured with oval shaped body. After moulting they loose their legs and feed greedily.

WHITEFLY

IVth instar nymphs: The nymph ceases feeding.

Pupa: It is dark yellow in colour, sub-elliptical in shape with varying number of spines on the back. The reddish coloured eyes of the forming adult become visible through the transparent skin as two orange coloured spots. Puparia is on the under surface of leaves

Adult: They are yellow coloured, measuring about 1.5 mm in length having two pairs of white wings. Body yellowish and is covered with white fine powder/white waxy boom. Hind legs are relatively longer, than pre- and meso-legs.

LIFE HISTORY

About 12 overlapping broods are produced in a year. Therefore, all stages of the pest are met throughout the year. Female lays eggs on the lower surface of mostly lower and middle leaves. A female may lay upto 110 eggs. The suitable temperature for oviposition ranges from 33-37°C. Egg stage lasts 3-33 days depending upon the season From April to September, hatching period is 3-5 days. Nymphs, shortly after hatching, fix themselves on the underside of leaves and flourish by sucking the leaf sap Nymphal stage continues from 8 to 14 days from April to September in the cotton season and prolongs from 17 to 73 days in winter. Pupa takes 2-8 days to become adult April to September is the most active period for the pest during which life cycle is completed in 13-21 days Peak period of multiplication is June to August both in the Punjab and Sindh

NATURE OF DAMAGE

Both the nymphs and adults feed on the leaves of the plant and produce two types of effects: (i) lower the vitality of the plants by sucking the sap and (ii) affect the photosynthetic activity of leaves due to development of a sooty mould on the honey-dew, excreted by the pest on leaves. Severe infestation at the boll setting period causes considerable shedding of leaves and fruiting parts which together with bad opening of bolls results in loss of yield. In the field the diagnostic is the presence of chlorotic spots on the leaves which later coalesce to form irregular yellowing of leaf tissue This extends from veins to the outer edges of the leaves. These leaves later on dry up and are shed. If the plant is shaken, a cloud of tiny moth like insects flutter but rapidly resettle.

CLIMATIC RELATIONSHIP

Dry season with high temperature and scanty rainfall for the multiplication of white fly is a favourable milieu. Adults prefer temperature above 33°C for oviposition. Lowest infestation is found in the areas having temperate climate and high rainfall.

SEASONAL ACTIVITIES AND SEQUENCE OF INCIDENCE

At the end of cotton season the adults migrate to other alternate host plants like mustard, cauliflower, potato, etc. During winter, immature stages develop slowly.

The adults emerge in the month of January, multiply on weeds like lehli, from where they migrate to vegetables, such as cucurbits, bhindi, hollyhock and ratoon cotton. Till the end of March population is build up on these plants. Again in April -- May it migrates to cotton. Maximum infestation is found in the months of July and August.

DISTRIBUTION

It is widely distributed in the cotton growing areas of the Punjab particularly in the districts of Faisalabad, Jhang, Sargodha, Multan, Sahiwal, Rahim Yar Khan and Bahawalpúr. Its population in Sindh is comparatively low. In some years it has caused severe damage to cotton crop, especially in Khairpur, Sukkur and Nawabshah districts. It has been recorded even at the height of 4,900 feet.

HOST PLANTS

It is a polyphagous insect, infesting more than 50 plants of both wild and cultivated crops. The most favoured ones are "tori", lady's finger, cauliflower, melon, potato, peas, "alsi", "senji", "maina", "raya", tomato, reddish, brinjal, tobacco, cucumber, gourds, "sarsoon", water melon, chillies, "lehli", "dhaiik", "sonchal", hollyhock, etc.

CONTROL METHODS

Following cultural, biological and chemical control measures have proved effective for the control of white fly.

Cultural: 1. Avoiding cultivation of alternate hosts near the cotton fields.

2. Avoiding application of excessive amount of nitrogenous fertilizers in the cotton crop.
3. Avoiding over-irrigation of cotton field.
4. In case of severe infestation proper manuring of the cotton crop is also suggested for rapid recovery of plants.

Biological: Nymphs of the whitefly are parasitised to the extent of 23.6% by an unidentified chalcid during the month of September, when parasitism is at its peak. Among predators, grubs of *Chrysopa* sp., and a beetle (*Brumus* sp.) also feed on the adults and pupae of the whitefly.

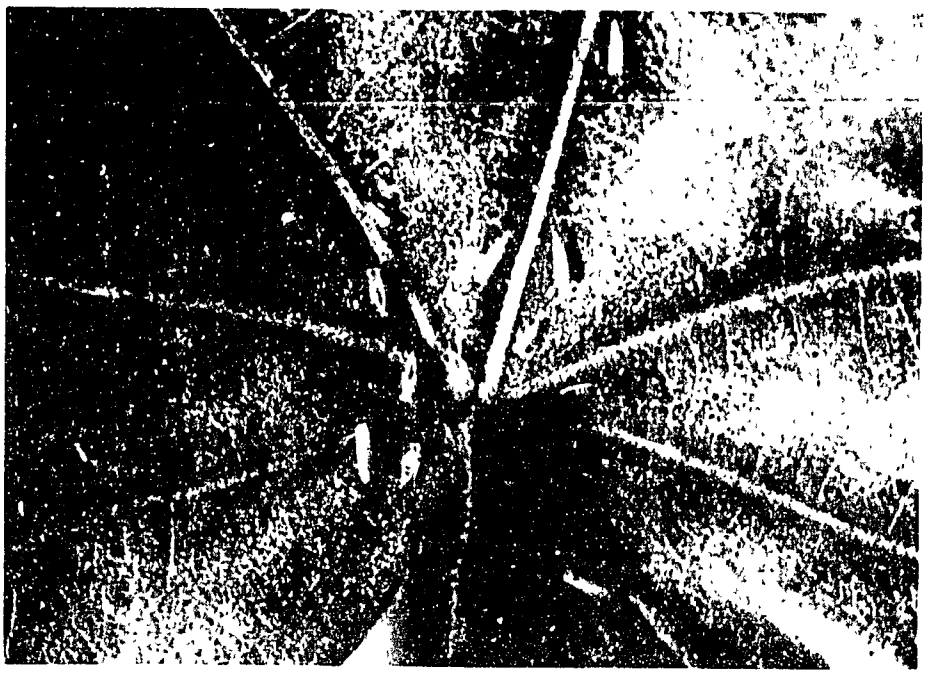
Chemical: Both granular and EC formulations are effective against whitefly. Granules are applied with first irrigation, if it is delayed then only foliar application should be given when the population has reached the economic threshold level.

Amrasca devastans Dist. (Cicadellidae/Jassidae: Hemiptera)

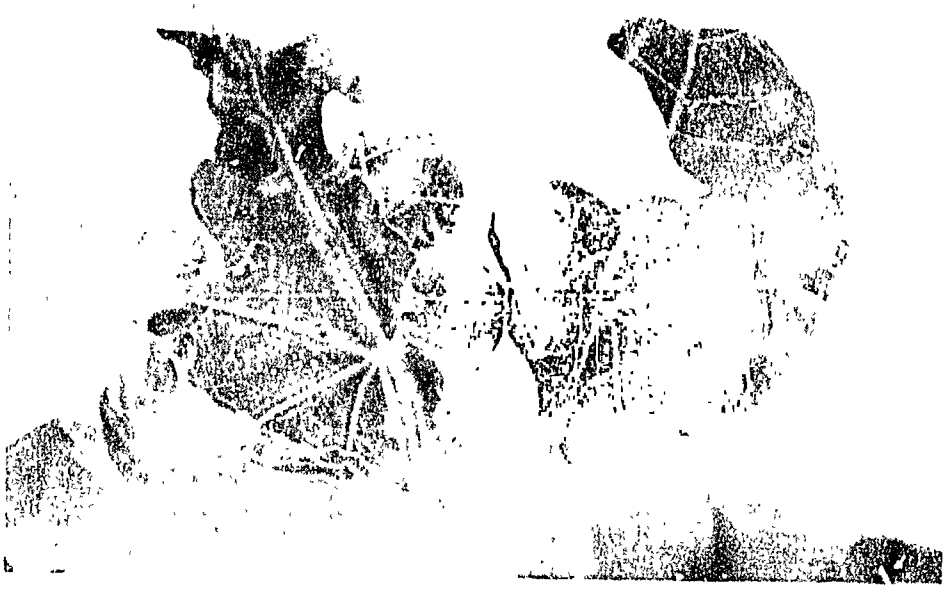
(Jassid, Sabaz tela)

DIAGNOSTICS

Egg: Eggs are translucent, elongated and yellowish white in colour. Anterior end is slightly hooked while broadly pointed towards the other end.



JASSID



SYMPTOMS OF JASSID ATTACK ON COTTON LEAF

Nymph: *Ist instar nymph:* Newly hatched Ist instar nymphs are wingless and transparent, which later attain greenish yellow colour with conspicuous oval reddish brown eyes. Six dorsal spines are present on head along the anterior margin. Thoracic segments are distinct. Abdomen is nine segmented. Measure 0.6 mm in length.

IInd instar Nymph They are with superficially white eyes but dark reddish underneath Rudimentary wing pads appear. Two single rows of spines are found on hind tibiae. Are 1.03 mm long.

IIIrd instar nymph: These are yellowish green in colour, wing pads are prominent, a small spine is present on tip of wings, males are 1.23 mm and females 1.33 mm in length

IVth instar nymph Head and thorax are greenish yellow whereas abdomen is bluish green in colour Head bears greyish purple eyes. Wing pads grow progressively. Length of male 1.50 mm and female 1.60 mm.

Vth instar nymph Body greenish yellow with bluish abdomen and legs. Minute spines are found at the anterior margin of the head. Wing pads grow further and spines get reduced. Males are 2.18 mm long and females 2.28 mm.

Adult: Adults are very active, winged and triangular in shape. Greenish yellow colour in summer changes to reddish in winter. A black spot is present on the tip of each forewing. Vertex of head shows two black spots. Are 3 mm long.

LIFE HISTORY

Jassid breeds throughout the year, except from the last week of January to late March Eleven generations have been recorded in a year. A female may lay 25-30 eggs preferably on mature leaves. Eggs are inserted singly in the prominent veins, at the underside of leaves. Hatching takes place after 3-4 days in summer. In winter this period extends to 10 days. Nymphs after passing through five stages become adults in 6-21 days after emergence. They are found on the undersides of leaves in the day time but during night they may be found on upper surface as well. The pest is serious on smooth leave varieties but does not damage varieties with hairy leaves, as the females can't lay eggs on latter kind of varieties.

NATURE OF DAMAGE

Jassids prefer American and smooth leave cotton varieties for their food. Nymphs as well as adults cause injury to their host but nymphs are more damaging. They cause severe damage known as "hopper burn". They suck the sap from underside of leaves and at the same time, inject saliva inside the plant tissue which is phytotoxic. This activity leads to un-even growth and the leaf becomes crinckled, and finally shedding of young squares, bolls and leaves takes place. The new as well as old (mature) leaves are less susceptible to this insect than the middle aged leaves.

SYMPTOMS

In the early stage of attack, edges of the leaves become pale green to yellow green. On resistant varieties, after wilting of leaves, apex and peripheral region become dry and turn brown and necrotic. On susceptible varieties, leaves curl up and necrotic patches brown in colour appear on the leaves. The leaves become cup-shaped in both cases and assume brick-red colour. Yellow green stripes appear along the periphery and edges of leaves and the leaves are shed prematurely.

CLIMATIC RELATIONSHIP

Highly humid conditions have been found favourable for the multiplication of jassid population.

SEASONAL ACTIVITIES AND SEQUENCE OF INCIDENCE

While lower populations of jassid have been found from February to April on brinjal, potato and hollyhock, the most active period of the insect is from June to August, when it occurs on cotton crop. The population on cotton is reduced rapidly from September to November and in January on alternate host plant, lady's finger, from where it migrates on to potato, brinjal and hollyhock. First generation breeds in April on hollyhock and brinjal. Maximum damage to cotton plants takes place during July — August.

DISTRIBUTION

Jassids are widely distributed throughout the cotton growing areas of Sindh and Punjab.

HOST PLANTS

Lady's finger is the most favoured host plant of jassids, from where it moves to cotton crop. Other important host plants among cultivated ones are potato, brinjal, french bean and cucurbits. Among uncultivated plants hollyhock "ban kapas" and "kangi" are important.

CONTROL METHODS

Cultural: 1. In order to escape from jassids attack, cotton crop should be sown earlier and excessive use of fertilizers should be avoided.

2. Clean cultivation and removal of weeds are found to be very effective in reducing the Jassids, infestation.
3. Cultivation of cotton varieties with hairy leaves also help in reducing the extent of damage.

Biological: Feeding on these insects by spiders (e.g. *Dictyna albida*) and ants (e.g., *Camponotus*) have been observed.

Chemical: Recommended insecticides, both granular and ECs., may help in arrest-

ing the jassid population. However, insecticides should be applied only if the number of jassids has reached to the level of 1-2 jassids per leaf.

Thrips tabaci Linn. **(Thripidae: Thysanoptera)**
(Thrips)

DIAGNOSTICS

Egg: Minute, kidney shaped, and are laid singly on the under side of tender leaves.

Nymph: Full-grown nymphs are similar to adults, but are paler in colour and wingless. They pass through four stages (3 instars and one pupal) to become an adult.

Pupa: This quiescent stage is passed in the soil. Wing pads are fully developed in this stage.

Adult: Adult thrips are minute, active, yellowish insects with slender bodies, pointed at both ends and measuring about 1 mm in length. Males are rare and wingless while females have four long and narrow wings each with marginal fringe of hairs. Veins of wings are either absent or even if present are only few in number. T' e diagnostics is "small, slender insects of varying colour from yellow to brown with fringed wings".

LIFE HISTORY

About 5-8 generations of thrips are found in a year. Females lay eggs on the lower side of tender leaves and stems. Hatching takes place after 5-10 days. Nymphs pass through four stages in 3 6 days to become adults. After passing 3 instars, the full-grown, 3rd instar nymphs descend to the ground for pupation and after passing a quiescent pupal stage they become adults. From nymphs to adult stage it takes 5-10 days and the whole life cycle is completed in 3-4 weeks under optimum conditions. The cotton crop is attacked from July to October and the insect is found in higher numbers during July-August on the crop.

NATURE OF DAMAGE

It is not a serious pest of cotton in the Punjab (except hot and dry areas) but in areas of Sindh it has an important status. Usually cotton seedlings are attacked by both adults and nymphs. They injure the cotyledonous leaves and terminal buds of seedlings by sucking and exuding sap from these parts by piercing the under-side of leaf tissue with their sharp cone like mouth parts. Ultimately they kill the shoots and cause withering and falling of leaves and opening of premature bolls.

SYMPTOMS

In the early stages of growth of the cotton plants, thrips attack produces malformation symptoms on the seedling. The lower leaves are the ones which are severely damaged during attack. The infested leaves become silvery white in the beginning, but later on turn dirty white and then crumple. Some have described it

as shrivelling of leaves due to scrapping of epidermis and desapping. The silvery white complexion of leaves and their cup-shaped appearance are the identification marks for thrips infestation. When leaves unfurl after attack on terminal buds, they will have ragged edges. Thrips infested plants show a dark olive colour with brownish motlings.

As a result of thrips attack, the cotton plant cannot manufacture its food, gets a severe set back in the initial stages of growth and thus remains stunted followed by defoliation and fall of flowers. Severe attack causes death of lower branches and premature boll opening. This lowers the cotton production.

DISTRIBUTION

Like other sucking pests, thrips are also widely distributed in all the cotton growing districts of Punjab and Sindh, especially in Nawabshah, Hyderabad and Sukkur districts.

HOST PLANTS

Thrips are found on a number of vegetables including onion, garlic, tobacco, cabbage, cauliflower, bitter gourd, lady's finger, tori, brinjal, til, groundnut, chillies, wheat plant, etc.

CONTROL METHODS

Cultural: 1. Avoid cultivation of Malvaceae and Solanaceae hosts near cotton fields.

2. Remove all weeds from the cotton field.

Biological: Eggs of thrips are parasitised by *Thripoctenus brui,* while *Thriphleps talihus* parasitises the nymphs. A mite (*Camspid* sp.) also feeds on thrips.

Chemical: Normally no control is required. However, in case of heavy infestation granular or other insecticides may be used after ascertaining that the population of the insect has reached the economic injury level.

Aphis gossypii Glov. **(Aphididae: Hemiptera)**
(Aphid, Black jassid)

DIAGNOSTICS

Egg: Freshly laid eggs are yellowish or greenish in colour which later on turn to black.

Nymph: Nymphs are brown to green in colour and similar to adult, however, they do not possess wings.

Adult: Wingless adults are yellowish green to greenish yellow in colour. They are small, soft bodied insects, measuring about 1.2-1.8 mm in length with two small black cornicals, present at the posterior end of the abdomen. Males may or may not be

THRIPS

winged. Oviparous females are wingless. In winged forms, fore wings two times the body length. Body colour in winged adults is either blackish green or greenish black.

LIFE HISTORY

Aphids' life history is complex. Two types of life cycle; oviparous or viviparous are found in other parts of the world; but in Pakistan it passes through viviparous cycle only. Oviparous females lay eggs while viviparous females give birth to living youngs or nymphs. Females lay eggs singly near the base of dormant buds or crackes and crevices of plants. Over-wintered eggs hatch early in the spring. The nymphs form colonies and grow by moulting four times. After 3-20 days, depending upon temperature, they attain maturity. These are wingless forms. When plants become over-crowded with aphids, wings are developed and they migrate to start fresh colonies on other plants.

NATURE OF DAMAGE

Both adults and nymphs mostly wingless/ apterous damage the plants by sucking sap from the under-side of leaves and shoots thereby reducing the plant vitality. They are often attended by ants, because they exude copious quantities of honey-dew on the under-side of leaves and shoots on which sooty mould grows. This results in reduced photosynthetic activities of leaves. Young cotton plants suffer much more from its attack than mature plants.

SYMPTOMS

The development of black fungus on the copious honey-dew secretions on leaves, results in blackening and dropping of leaves. Curling and crinkling of leaves, deformed & stunted plants and blighted appearance when infestation is severe are the common symptoms.

CLIMATIC RELATIONSHIP

Aphids develop and multiply rapidly in cool and humid weather with little rainfall.

DISTRIBUTION

Aphids are widely distributed throughout the cotton belt of the country.

HOST PLANTS

It feeds on cotton and a number of vegetables viz; brinjal, potato, lady's finger, water melon, tori, holly-hock and sunhemp also harbour this insect.

CONTROL METHODS

Cultural: 1. Destruction of stubbles in order to destroy the over-wintered eggs.

2. Destruction of alternate host plants near cotton fields.

Biological: Aphids bio-control agents are very active from August to November. Aphids are also eaten away by the birds viz., brown-willow warbler (*Phylloscopus tristis)* and rufons fan tail (*Cisticola cisitans*). An unidentified chalcid parasite also parasitises the nymphs. A number of predators also feed on nymphs and adults. These predators include (i) *Chilomenes sexmaculata* (Fab.). This beetle eats 100-200 insects a day (ii) *Coccinella septempunctata* (iii) *Scymnus* sp. (iv) *Chrysopa* sp. (v) *Syrphus confracter* (Wild.), (vi) *S derarius* (Wild), (vii) *S. balteatus* (De Geer). (viii) *Sphaegophoria javana* (ix) *Ischiodan scutallaris*, (x) *Leucopis griseola* and (xi) *Henviobius* sp. Eggs are also eaten by *Leucopis nigricornis.*

Chemical: Aphids usually require no chemical control measures as they appear at picking stage in the months of October and November when their natural enemies are very active. However, in the province of Sindh, aphids are observed in the months of May to August.

In case of severe infestation recommended insecticides may be used.

Dysdercus koenigii (Fb.) (Pyrrhocoridae: Hemiptera)
(Red cotton bug, Stainer)

DIAGNOSTICS

Egg: Eggs are bright yellow in colour and round in shape.

Nymph: These are similar to adults, red in colour and possess undeveloped wings. Abdomen has a row of black spots in the middle and a row of white spots on each side.

Adult: General appearance and wings red in colour; abdomen with white bands; wings with black tips and a black dot on each side. About 16 mm long.

LIFE HISTORY

Female lays about 80-100 eggs in a loose, irregular mass on the ground or under the loose leaves. In warm moist weather, which is favourable for hatching, eggs hatch in 7 days. Nymph passes through 5 instars in 4-6 weeks. Total developmental period is about 5-7 weeks. They infest the cotton crop during September – October.

NATURE OF DAMAGE

Both nymphs and adults suck the sap from the cotton seeds and thus bolls remain stunted and open badly. Seeds are rendered useless for sowing and oil extraction. The feeding of seeds also facilitates bacterial attack on bolls which help stain the fibre. In the field its attack can be diagnosed by red stained lint and rotting bolls. The inner boll wall is with warty growth or water soaked spots, the young bolls abort and turn dark brown.

CLIMATIC RELATIONSHIP

High humidity and low temperature during September – October favour the attack of cotton stainers.

DISTRIBUTION

Red cotton bug is a minor pest of cotton in the province of Punjab.

HOST PLANTS

It feeds on lady's finger (*Hibiscus esculentus*), wheat (*Triticum vulgare*), millet (*Pennisetum glaucum*), hollyhock (*Althea rosea*), sunhemp (*Crotalaria juncea*), Maize (*Zea mays*), silk cotton tree (*Bombyx malabaricum*) and a number of Malvaceous weeds.

CONTROL METHODS

Cultural: Cultivation of alternate host plants should be avoided near the cotton fields.

Chemical: Since the pest is not of an economic importance there is a rare need to apply any pesticide. However, in case of severe population build up, recommended pesticides may be applied on foliage.

Tetranychus cinnabarinus (Tetranychidae: Acarina)

(Mite, Joon)

DIAGNOSTICS

Egg: Eggs are very small, spherical and about 0.1 mm in diameter. Freshly laid eggs are translucent or creamy which become dark brown, later on.

Larva: Newly hatched larvae are orange in colour with 3 pair of legs. After feeding, the larvae change their colour from orange to green.

Nymph: (Protonymph and Deutonymph): Nymphs are yellowish to red in colour, small in size with four pairs of legs. They have two black spots on the dorsum and resemble adults.

Adult: These are very minute organisms usually invisible to the naked eye. They are oval in shape with 4 pairs of legs, reddish yellow in colour. Two black spots are present on the back. Body is sparsely covered with reddish spines.

Males are relatively shorter (0.3 mm.) than females (0.4-0.5), yellow in colour with a narrow body. The posterior part of the abdomen is pointed. Females are reddish brown with two reddish brown marks on each of the two sides of the anterior part of the body.

LIFE HISTORY

Pre-oviposition period is 24 hours, after which females start laying eggs on the under-side of leaves in the web which they spin themselves. They may lay 100-150

eggs singly in 20-30 days at a rate of 2-6 eggs in a day. After 3-5 days of incubation, hatching takes place and unfertilized (parthenogenetic) eggs, produce males while fertilized eggs produce females. Newly hatched mites pass through one larval and two nymphal (protonymphal and deutonymphal) stages. Larval development is completed in 2-3 days and they become adult after passing through 2-3 days of protonymphal and 2 days of deutonymphal stage. Thus, the life cycle is completed in 10-14 days.

Dry and hot weather is more favourable for their breeding, but usually breeding continues throughout the year. In favourable seasons, 6-8 generations are produced, in total up to 20 generations are produced in a year.

NATURE OF DAMAGE

Mites spin a delicate web on the lower surface of leaves because of which dust accumulates on the leaf surface, which interferes in the photosynthetic activities of leaf. All stages of life cycle of mites i.e. egg, larval, nymphal and adult are present in this web. The adults and young ones suck the sap from the under-side of leaves through their sucking mouth parts. Leaves surface become thickly dotted with whitish feeding punctures. Attacked leaves become reddish, wither and ultimately shed. Defoliation results under severe infestation.

SYMPTOMS

Silky web, spun by the mites, with the accumulation of dust is present on the lower surface of highly infested leaves. Lower surface of leaves become silvery due to the presence of numerous white marks, which are caused by the feeding punctures. Infested leaves become discoloured and show pale blotches in the earlier stages of infestation. With increase in infestation, either pale blotches turn reddish brown or this colour develops around the leaf edges. This is followed by drying, withering and shedding of leaves. In severe infestation, plants even defoliate and plants loose their general vigour and die off.

SEASONAL ACTIVITIES

Mites activity becomes slow during winter. During this period they feed on weeds and other alternate host plants, whereas in early summer they become active and move to cotton crop where they multiply rapidly and produce many generations. Maximum infestation is found in September and October when climatic conditions are most suitable for their attack.

CLIMATIC RELATIONSHIP

Continuously dry, hot weather, and absence of rains during August — September favours the mites infestation and results in rapid multiplication of their population. Fast blowing winds also help in extending the infestation by spreading the nymphs to a very large area.

MITES

DISTRIBUTION

Mites are found throughout the cotton belt in hotter and drier regions of the world. In Pakistan, it is found in all the cotton growing areas of the Punjab, especially in the districts of Multan, Vehari and Sahiwal. In Sindh, infestation of mites is comparatively low.

HOST PLANTS

In addition to cotton, mites are found on almost 200 types of plants, including many garden and field crops, ornamental plants as well as weeds.

CONTROL METHODS

Cultural: For cultural control of mites, destruction of weeds and other alternate host plants around the cotton field is necessary.

Biological: Redistribution of some local predators like *Stethorus* spp (Coccinellidae) and *Oligota* spp. (Staphylinidae) might reduce the infestation of mites. Besides, *Amblyseius* sp., lady bird beetle, *Chrysopa*, assassian bug and spiders are also effective biological control agents.

Chemical: Prudent use of chemicals is necessary to avoid the spread of mites. Spraying should be done only when 25% of the leaves become discoloured and there are 2-4 mites per leaf. Crop should be treated only with miticides, and fully covered with spray. Indiscriminate and continuous use of pesticides should be avoided, otherwise biological control agents are killed.

b) Biting and Chewing Insects

Myllocerus maculosus Desb. (Curculionidae: Coleoptera)

(Cotton grey weevil, Ash weevil)

DIAGNOSTICS

Egg: Yellowish in colour and oval in shape.

Grub: They are white, cylinderical in shape and without legs, fleshy and soft wrinkled bodies, about 8 mm long.

Pupa: Creamy white in colour and 4.3 – 5.7 mm long.

Adult: Whitish grey in colour with a number of dark brown spots/dark lines on greenish white elytra. Front wings hard, with black spots on them. Mouth is like a snout, measuring 8 mm in length.

LIFE HISTORY

Female lays about 360 eggs singly in soil. Oviposition may continue for 24 hours.

Hatching takes place after a week. Full-grown grubs take 4-5 weeks and pupate in the soil. The adults emerge out after 9-11 days.

NATURE OF DAMAGE

Both grubs and adults damage the cotton crop. Grubs attack the crop at an early stage of growth and damage the underground part i.e. the roots of the seedling. Adults are more destructive and voraciously feed on the foliage, buds, flowers and the young bolls of cotton. In the field diagnostics are: leaf margins are notched, wilting of plants can be noticed in patches. Plants come off easily when pulled, as roots are eaten away by grubs.

SEASONAL ACTIVITIES

The pest overwinters as grub in the soil and becomes active in April — May. It infests the cotton crop during July-September.

DISTRIBUTION

Cotton grey weevil is a minor pest of cotton. It is distributed throughout the province of Punjab.

HOST PLANTS

Myllocerus is polyphagous in nature, but "desi" cotton and "arhar" (*Cajanus indica*) are the preferred hosts. It also attacks on lady's finger (*Abelmoschus esculentus*), maize (*Zea mays*), sorghum (*Sorghum vulgare*), sugarcane (*Saccharum officinarum*), pomegranate (*Punica granatum*), pear (*Pyrus communis*), apple (*Pyrus mallus*), peach (*Prunus persica*), guava (*Psidium guava*), straw berry (*Fragaria chiloensis*), mango (*Mangifera indica*), deccan hemp (*Hibiscus cannabinus*) and "ber" (*Zizyphus jujuba*).

CONTROL METHODS

Cultural: To avoid spread of grey weevil alternate host plants should be destroyed. "Arhar" crop may be used as a trap crop as it is the preferred host. It should be sown earlier than cotton and pests collected from it should be destroyed.

Chemical: Normally no control is required. However, in case of high infestation crop can be sprayed with pesticides recommended against this pest.

Sylepta derogata F. **(Pyralidae: Lepidoptera)**

(Cotton leaf roller)

DIAGNOSTICS

Egg: Smooth, oval in shape and pale yellowish green in colour.

Larva: Newly hatched larva yellowish white; full-grown larva bright green (glisten-

ing) or greenish white with a smooky tinge which becomes pinkish before pupation. Head dark brown; pro-thoracic shield and thoracic feet black; a dirty white dorsal patch present on thoracic shield, thoracic feet with a white ring, about 25 mm long

Pupa: Reddish brown, possesses 8 straight spines with hooked tips at its extremity, measures 10-14 mm in length.

Adult: Yellowish white wing expanse 25.4 mm Wings have brown or black dots with a black border and greyish fringe. Numerous black or brown wavy lines traversed through wing imparting to it a greyish appearance. Length 12.7 mm. The diagnostic is, "moth with yellow wings having brown wavy markings".

LIFE HISTORY

Mating and egg laying takes place at night. Female lays eggs singly on the underside of leaves along thicker veins. A female usually deposits 74-759 eggs in 1-7 days. After 2-11 days of incubation larvae hatch out and start feeding continuously for 3-5 days. Firstly, the epidermis of lower surface of leaf is attacked by them, afterwards each caterpillar turns over the corners of the leaf towards the mid-rib and secures himself in position by means of silken threads. They live and feed in this trumpet-like rolled up leaf. Pupation takes place in this rolled up leaf on the plant or in debris during the active period. Larval period ranges from 8-18 days. Adults emerge out from pupa in 3-21 days. Duration of adult stage is 1-7 days. In summer at favourable temperature the life cycle is completed in 14-49 days, while during winter due to low temperature it takes 29-129 days.

NATURE OF DAMAGE

It is a mid-season pest of cotton and is most prevalent when plants are approaching their maximum size but their foliage is still young and tender. The young larvae feed on the lower side of leaves but they roll up the edges of the leaf towards the mid-rib as they become mature. Some times there are 3 rolls in a leaf. Leaves are rolled in the form of trumpets fastened by silken threads. Marginal portions of leaves are eaten away. Attached leaves are shed and in severe infestation even plant defoliation results.

SYMPTOMS

Leaves become rolled up by the larvae of the pest. Big holes are made in the leaf by the insects and in case of severe infestation plants are seen entirely denuded of leaves.

SEASONAL ACTIVITIES AND SEQUENCE OF INCIDENCE

Usually 6 generations of the pest are found in a year from April to March. Full-grown larvae of the last generation (October — March) undergo hibernation in the moist soil under green leaves to pass winter. This last generation is only found in the forest due to severe cold. These hibernating larvae pupate and

become active for breeding at the end of March. They start breeding in the forest and build up a high population and spread into the neighbouring cotton fields when the monsoon sets in. They produce maximum infestation on cotton from July to August.

CLIMATIC RELATIONSHIP

Cloudy weather conditions and the amount of rainfall affects very much its multiplication. Severe infestation is produced just after rains.

DISTRIBUTION

It is an important sporadic pest which is widely distributed in Asia and Africa. It causes heavy losses to cotton near forest plantations. In Punjab it is found in Chichawatni (district Sahiwal), Changamanga (district Lahore), Khanewal (district Multan) and Duffer plantation in tehsil Phalia (district Gujrat).

HOST PLANTS

American cotton is the preferred host of leaf roller. It is also found on lady's finger (*Abelmoschus esculentus*), hollyhock (*Althea rosea*), peali booti (*Abutilon indicum*), "sonchal" (*Malva parviflora*), kuchri (*Malvastrum tricuspidatum*), ban ochra (*Urena lobata*), *chorchorus* sp., *Sida* sp., and cholai (*Amaranthus spinosus*).

CONTROL METHODS

Cultural: Following measures may help in checking the spread of leaf rollers.

1. Destruction of alternate hosts.
2. Destruction of attacked rolled leaves from the plant and also from the ground.
3. Ploughing and watering of the infested fields with a furrow turning plough to bury the hibernating caterpillars.

Biological: For biological control of leaf roller eleven species of primary and seven of secondary parasites have been recorded from Pakistan. The primaries seem to be ineffective most probably because of hyperparasitism. Some 33 species of parasites are also known from other parts of the world (Africa, India, Sri Lanka, Burma, Korea, Malaysia, China, Fiji and the Philippines). Some of the African species, e.g. *Apanteles sagax* Walkn. (Braconidae), *A. diparopsidis* Lyle and *Elasmus syleptae* Ferr (Elasmidae), *Eurytoma syleptae* Ferr (Eurytomidae) and *Sturmia auratocauda* Curr (Tachinidae) appear to be suitable species for trial in Pakistan. Besides Braconids of Asiatic origin such as *Apanteles derogatae* Watan from China and Korea, *A. opacus* Ashmead from China, *A. stantoni* Ashmead from Malaysia, and *Benama hustsoni* Mixon from Sri Lanka could also be considered for introduction.

Chemical: Chemical control of leaf rollers is difficult at advanced stages mainly because the caterpillars roll-up the leaves and hide inside the leaves. However, at initial stages dusting with DDT 12% or Sevin 10% or any other suitable/recommended pesticide may be done to check the spread of this pest.

Spodoptera litura (Noctuidae: Lepidoptera)
(Army worm, Lashkari sundi)

DIAGNOSTICS

Egg: Greenish when freshly laid, later on turn black; rounded, flattened, and covered with frosty material.

Larva: Newly hatched larvae are pale green with a large black head; later on they become brownish green, grey or black with light coloured stripes. The skin is smooth. They have a cylindrical body which tapers towards the head. Two dark coloured spots are present on the anterior as well as posterior sides. Larvae are gregarious in the early stages. Full-grown larvae are about 30-35 mm long with white longitudinal stripes on both sides. Honey comb like spots are found on the head

Pupa: Brown in colour with a tapered tail and blunt head meaning about 18 20 mm in length.

Adult: Brown coloured wings with body covered with hairs and numerous black spots. Fore wings dark brown with a network of pale lines (=wavy white markings), hind wings light in colour and their edges tinged with brown colour (brown patch along the margin)

LIFE HISTORY

Female lays 2-3 masses of eggs on the underside of leaves Each mass contains 250-270 eggs. They hatch in 2-4 days and the young larvae, soon after hatching, gregariously feed on the cotton leaves. Third instar larval stage starts dispersing. Larvae are nocturnal in habit and during day time they hide themselves under soil clods and leaves. They are full-grown in 11-20 days and then pupate in the soil by burrowing a short distance into the soil or creep beneath stones. Pupation occurs during night. Pupal stage is completed in 7-8 days. The whole life cycle is completed in 24-35 days.

NATURE OF DAMAGE

Larvae feed on the leaves of the plants with amazing voracity and completely defoliate the plants. Hence, the immature bolls do not ripe properly and produce immature and weak lint.

SYMPTOMS

Due to heavy defoliation the infested fields give a look of standing sticks. When the larvae of this insect attack tobacco, leaves are reduced to papery structures initially which later become reddish brown patches; later on the leaves get riddled with large irregular holes.

SEASONAL ACTIVITIES

Armyworm may attack the cotton crop at any stage. During severe winter

season, the pest hiberr ıtes in the cotton debris, grasses and weeds along the water channels. However, berseem is the most suitable habitat. In mild winter they do not hibernate and the emergence of moth is continued. They pass the spring season on Maize crop from where they move to cotton and cause maximum infestation during August.

CLIMATIC RELATIONSHIP

The mild temperature and high humidity helps in the distribution and multiplication of armyworms.

DISTRIBUTION

Armyworm is distributed throughout the world. In Pakistan, it is found on cotton and other host plants in both the cotton growing provinces of Punjab and Sindh. Its attack is, however, more pronounced in Sahiwal, Multan and Vehari districts in Punjab. It has also been noticed that this pest spreads more in areas where indiscriminate use of pesticides has continued for sometime.

HOST PLANTS

Besides cotton, this insect is also found on tobacco, cabbage, cauliflower, maize, rice and wheat crops.

CONTROL METHODS

Cultural: The most effective method is the hand picking of egg-masses and their destruction. The host weed plants must be destroyed and field should be ploughed with furrow turning plough after harvesting the cotton crop. This helps in destroying the surviving larvae and pupae in the debris by exposing them to the predators.

Biological: *Apanteles* sp. is the major parasite which controls the population of armyworms. A number of bird predators also play an important role in reducing the spread of this pest. Further, Thuricide (*Bacillus thuringiensis*) is extremely effective bio-control agent against this pest.

Chemical: Since it is very difficult to control full-grown larvae, spraying should be done when pest is in the first and second larval instars. Further, the crop should be sprayed thoroughly otherwise the infestation will increase rapidly.

c) Insects attacking Flowers, Buds and Bolls

Pectinophora (Platydera) gossypiella Saund.

(Gelechiidae: Lepidoptera)

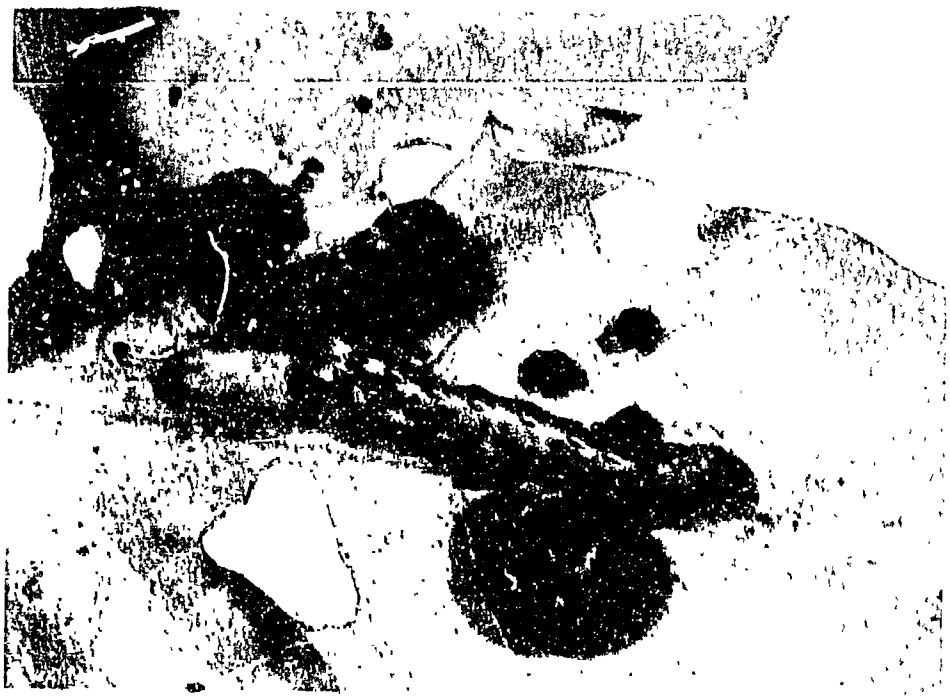
(Pink bollworm, Gulabi sundi)

DIAGNOSTICS

Egg: Oval with wrinkled surface. Newly laid eggs are pearly white in colour which

ROSSETTE FLOWER

YOUNG LARVAE OF ARMYWORM FEEDING ON COTTON LEAF



FULL GROWN ARMYWORM

LARVAE OF PINK BOLLWORM

later turn to brown on the third day and before hatching become deep brown in colour; approximately 0.5 mm long.

Larva: Four instars of the pink bollworm larvae are found.
Ist instar larva: Newly hatched larvae are glossy white with a prominent dark brown head and keep the same colour even when fully-grown. Prothoracic shield is greyish.
IInd instar larva: Body colour changes to creamy white with dark brown to chestnut brown head and distinctly lighter prothoracic plate and pale legs.
IIIrd instar larva: Body colour pinkish. Two pink transverse dorsal bands on each segment of the body. Anterior being broader than the posterior. These bands are interrupted by a median dorsal pale streak and two lateral streaks.
IVth instar larva: The full-grown larva with a distinct pink colour; brownish head and lighter brown pronotum. Skin is smooth and shiny with fine, pale hairs arising from minute colourless plates. It is about 12-15 mm long. Larva varies in general colour. Young larva white and late instar almost black, brown or green to pale or pink with several dark and light alternating bands running the entire length.

Pupa: Pupa is enclosed in a delicate, flimsy cocoon spun with the help of saliva excreted from its mouth. It is shiny brown in colour, measuring about 7-10 mm long. A minute projection with a dorsally directed hook, surrounded by a number of longer hooked setae is found at the end of the abdomen.

Adult: Moths are dark brown small insects, inconspicuously marked and with a wing expanse of about 12 mm. Fore wings are greyish yellow in colour with a blackish spot in the middle and a black strip from tip to the base of each fore wing. Hind wings are silvery gray in colour with curved outer margin. A deep fringe of hair like scales is present on the terminal part of the fore wing and the whole of the posterior edge of the hind wing. The legs, antennae and palps all bear a number of blackish rings. First segment of each antenna is furnished with 5-6 setae. Palps are long and curved upward. Some authors have described them as, "small moth, brown or dull yellow or olive grey with dark spots on the fore wing".

LIFE HISTORY

Two types of life cycles are found-short and long. The distinction between short and long cycles takes place at the end of the feeding period of 4th instar larvae when these become full-grown. From July to October-November they complete their generations. At the end of October or early November the larvae go into diapause. The short cycle larvae pupate immediately and continue to emerge throughout the year. The peak emergence from short life cycle is in March/ April. Most of them die due to the non availability of cotton plant as a host at this stage. The long life cycle larvae stay within the two seeds inside the open boll. In July-August when the fruiting parts of new crop are available, they pupate and moths emerge within few days.

Copulation is favoured at 60-90 ^{o}F. Mating takes place at night and after passing a 2-14 days of pre-oviposition period, females start laying eggs. Most

favourable temperature for egg laying is 75-81 ^{0}F with a relative humidity of 60-90%. Egg laying continues from 14 to 20 days. A female may deposit 100-250 eggs. Eggs are laid singly between the veins on the underside of leaves, bud, and flowers but most favoured sites are below the bracteoles, tip of the immature green bolls. Hatching takes place after 3-7 days. Young larvae, immediately after emergence enter into the susceptible boll within one hour. Generally larvae complete their development in the bud or boll. If the attacked buds are too small they are shed and then the larvae complete their feeding on the shed material. Feeding is completed in 8-16 days and full fed larvae at this stage either enter into a short cycle or a long cycle brood. The larvae, immediately after completion of feeding, pupate either on the ground or in the boll by spinning a loose cocoon around themselves. For pupation, on the ground they come out of the boll by boring a circular hole, 2 mm in diameter, fall to the ground and pupate in surface trash among shed leaves, flowers and lint. Emergence from the bolls starts from dawn and continues till dusk but considerably large number of larvae emerge from 11 p.m. to 2 a.m. Cool and humid conditions are favourable for pupation inside the bolls. Before pupation inside the bolls, larvae burrow a hole to the exterior of the boll wall. The cuticle remains intact as a transparent membrane covering the exit hole. At the time of emergence, the moth is able to break through the exit membrane and emerge out of the boll. Pupal development is completed in 6-7 days. Moth emergence depends upon the existing temperature of the field. Temperature ranging between 20-30 ^{0}C is found to be most favourable for moth emergence. There may be four broods from August to November. The adults live for 2-29 days and the short life cycle is completed in 20-30 days.

Cool weather, scant humidity and lack of food supply are some of the unfavourable conditions which force the larvae to hibernate inside the double seeds i.e., a pair of seeds in the mature boll that have been welded together. They construct a very tough, closely woven cocoon before pupation. At the end of diapause, pupation starts and after 6-17 days, moths emerge. Emergence of adults is dependent upon temperature and relative humidity. Range of 84-91 ^{0}F and relative humidity of 60% is found to be the most favourable for moth emergence. This condition is available during monsoon in the Punjab.

NATURE OF DAMAGE

Larval entery into the buds and flowers usually takes place by boring a very small hole which is invisible to the naked eye. In the beginning, infestation starts on the bud and flower. The bud is usually shed after the larvae are fully fed. After boll formation they attack the immature green bolls and by burrowing into the immature lint and seeds, they feed on the seeds and destroy the lint quality. Attacked bolls. are either shed prematurely or remain attached with the plants in a dry and hard condition. Oil contents of the seeds, spinning qualities of the fibres and ginning percentage are all badly affected. About 10-35% damage is caused to the seeds in the attacked bolls.

SYMPTOMS

Attacked buds wither and are shed before flower formation. Flowers show a characteristic rosette appearance due to twisting of petals. Infested bolls are either shed or remain attached with the plants in dry and hard condition. Lint becomes so stunted that it is unpickable and valueless. In sum rosetted flowers — interlocular burrowing, discoloured lint and burrowed seeds are common signs of larval attack.

CLIMATIC RELATIONSHIP

Pink boll worms' attack is closely related to climatic conditions. Cool and humid climate greatly favours the attack. Higher temperature accelerates the larval mortality. Only 1% or less infestation has been recorded from the areas where rainfall was 8" or less.

Temperature and relative humidity also affect the moth emergence. The temperature from 75 — 82 ^{0}F and relative humidity 60-80% provide the most suitable environment for the emergence of moths.

SEASONAL ACTIVITIES AND SEQUENCE OF INCIDENCE

Emergence of moths from short cycle larvae of pink bollworm continues from January to April. Long cycle larvae start from July and continue onward.

Moths emerging from January to June are unable to survive mainly due to the absence of food plants. However, July-August is the peak season of pest population because weather conditions during this period are suitable for larval development and moth emergence. They start attacking cotton at the end of July or beginning of August. The attack continues till November when it hibernates as a larva. The magnitude of infestation goes on increasing as the cotton growing season progresses. There may be 4 broods during the whole cotton season.

DISTRIBUTION

The pink bollworm is the most important pest of cotton, particularly in the province of Punjab, where it is widely distributed in the districts of Sialkot, Gujranwala, Rawalpindi, Multan, Bahawalpur and Rahim Yar Khan. This pest was earlier thought to be a native of South Asia sub-continent, but it is now considered to have originated in the area between N.W. Australia and Malaysia. It is a wide-spread insect in almost all the cotton producing countries of Asia and adjacent islands including Hawaii and the Philippines, in North east and North west Africa, Australia, Brazil, West Indies and in Mexico.

HOST PLANTS

About seventy plants are known as alternate hosts of pink bollworm, most of which are malvaceous plants; cotton is the most preferred host plant. Its infestation on lady's finger (*Abelmoschus esculentus*), khangi (*Abutilon indicum*), deccan

hemp (*Hibiscus cannabinus*, hollyhock (*Althea rosea*) and other malvaceous weeds is very common in different parts of the world.

CONTROL METHODS

Cultural: Pink bollworm can easily be controlled through cultural practices but it is difficult to control through chemical means. The main reason is that the larvae hatch from the eggs that are laid in protected sides on the fruiting forms of cotton and immediately after hatching they hide themselves into the buds, flowers and bolls, where chemicals may not reach.

Following cultural practices have been found to be very effective in protecting the crop from the pink bollworm attack.

A. Removal of crop residues (such as left over bolls and cotton sticks from the field) soon after harvest so as to check the carryover of the diapausing larvae.

a. Grazing by animals for 2 to 3 times in cotton fields after last picking and before cutting of sticks.

b. Cutting of cotton sticks and stacking them vertically in small heaps under sun for killing diapausing pink bollworm larvae by exposing them to vagaries of weather.

c. Ploughing of cotton fields with furrow turning plough to burry debris and bolls containing diapausing larvae.

d. Chopping or slashing of the cotton sticks in the field and burrying them with tractors to destroy pink bollworm and to increase organic matter and nutrients (especially potash) in the soil, followed by a heavy irrigation to kill the resting larvae in the soil.

B. Following seed treatments are recommended to eliminate the diapausing larval population in the seed.

a. Before sowing, all the seeds must be delinted and exposed to sun by spreading them on the hard floor at mid-day for about 4-5 hours and for 2-3 consecutive days.

b. All the double, triple and quadruple seeds, containing diapausing larvae, should be picked out and destroyed.

c. In case of early season attack, the infested flowers, which are distinguished by their characteristics rosetted forms, should be hand picked and destroyed.

d. To protect the next year crop from pink bollworm infestation, the ginning factories after the closing hours should be cleaned and all debris must be burnt or buried to destroy the diapausing larvae.

e. Considerably higher infestation is recorded in the crop which remains in the field for a long time. Hence, early maturing varieties should be used, picking should be done as early as possible and late irrigation should be avoided as it delays the maturity of crop. Besides, vegetative growth of the plant should also be checked by manipulating the fertilization and irrigation schedule.

Biological: Twenty eight species of parasites and 63 (including 50 arthropod species) predators are reported in Pakistan. Parasites are also reported from Europe, Africa, North and South America, Hawaii and Fiji. Some 147 parasites and predators were listed by Thompson (1964) and Herting (1975).

Reduction in Pink bollworm population was noted in Arizona (Bryan, *et al.*, 1973) as a result of releases of *Bracon kirkpatricki and Ceroplastes blackburni.* Similarly, Lenger and Medved (1979) reported an adjusted 69.6% infested boll reduction by inundative releases of *Chelonus* sp. nr., *currima culatus* Cam., in the Lower Colorado Desert of California and Arizona. As ecological conditions in the cotton growing areas of Pakistan are different, some of these may become permanently established and acclimatized here, without a need for annual inundative release.
Recently, *B.kirkpatricki* has been imported into Pakistan from India where it is established following its commercial production.

Among other parasites, *Bracon greeni* and *Bracon gelechiae* feed on the larvae. *Apanteles angaleti* is also a potent larval parasite. The pink bollworm population is also suppressed by a predator namely, *Chrysopa carnea.*

Chemical: Because of the obscure habit of pink bollworm larvae, chemical control is rather difficult. Larvae feed inside the bolls where chemicals do not reach. Therefore, control is effective, only at the first instar larval stage, exactly at the time, when larvae hatch from the eggs and enter into the bolls. Spraying is essential with recommended pesticides, at the peak period of boll setting when the infestation reaches up to 5%.

Heliothis armigera Hb. (Noctuidae: Lepidoptera)

(American bollworm, American sundi)

DIAGNOSTICS

Egg: Sub-spherical in shape, with a flattened base and smooth apical area surrounding the micropyle, rest of the surface is sculptured with several alternately short and long vertical ribs and numerous finer transverse ridges between them. Freshly laid eggs are yellowish white in colour which later on turn to dark brown. They measure 0.4-0.5 mm.

Larva: The larvae pass through 5-6 instars.
Ist instar larva: Newly hatched larvae are greyish in colour, with black to dark brown head, prothoracic shield and prothoracic legs. Prothorax has 11 pairs of long bristles while mesothorax and metathorax, each has nine pairs of such bristles. Abdomen 11 segmented. Prolegs on 3rd to 6th and 10th segments. The last two segments of abdomen are jointed. The first abdominal segment has a pairs of bristles, while second has 10 pairs and the third, fourth, fifth, sixth, ninth, tenth and eleventh segments have 6 pairs of bristles each, seventh and eighth segments have eight pairs of bristles. Larvae measure about 2.17+0.21 mm.

IInd instar larva: The greyish colour in the first instar changes to yellowish in second instar and larvae become 4.97+0.13 mm long.

IIIrd instar larva: It is greyish, five white longitudinal stripes are present on the dorsal and lateral sides. Bristles are distributed in the same way as in the Ist instar larvae. It measures 10.38+0.85 mm in length.

IVth instar larva: Body is greyish in colour. A single wide whitish band and continuous, narrow, whitish dorsal stripes are present on the body. Prothorax comprises 10 pairs of bristles while distribution of bristles on all other segments is the same as in the Ist three instars.

Vth instar larva: They are greyish or yellowish in colour, undergo a larval moult to attain the last instar. Several dark, narrow, longitudinal bands separated from one another by whitish lines, on the dorsal surface of the body and a broad, whitish band traversing the sides, is present.

Last instar larva: After 5th moult, larva enters the last instar. These full-grown larvae are greyish or yellowish in colour and with brown mottled head and pale brown prothoracic plate and legs. Skin shows a rough granular appearance with dark and pale bands on the surface. Ten pairs of bristles are present on the prothorax while mesothorax and metathorax each contains nine pairs of long bristles. They are 40.0+08 mm long. Broadly speaking larvae are green with dark broken grey lines and dark and pale bands. They show colour variation from greenish to brown.

Pupa: Pupa is coated within an earthen cell, dark brown in colour with smooth surface and both the posterior and anterior ends rounded. Posterior tip comprises of two tapering parallel spines. It measures about 25 mm in length.

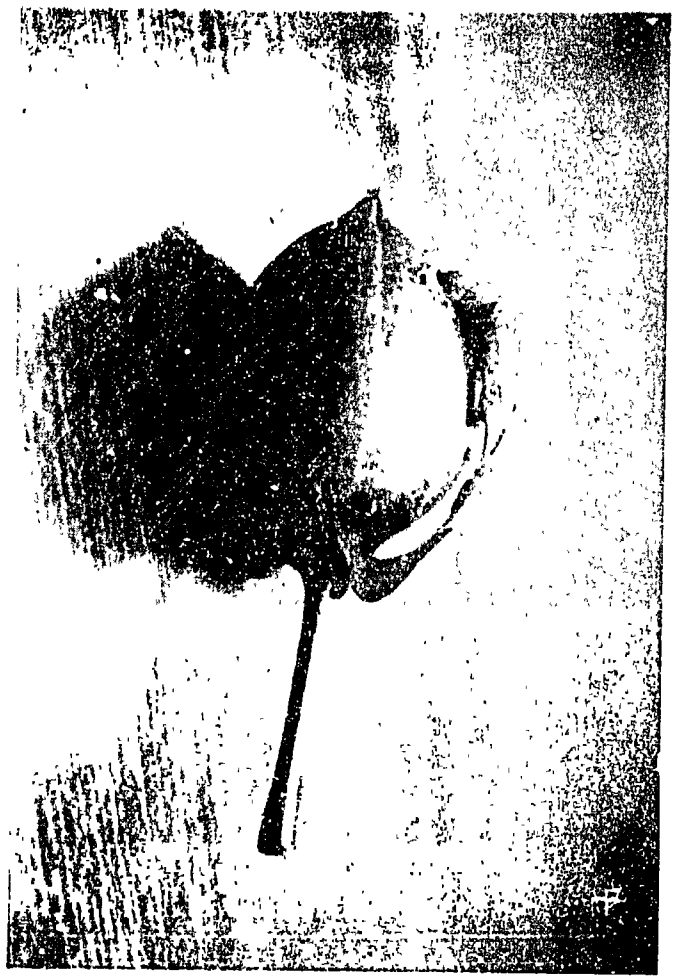
Adult: They are olive grey to brown, ochreceous insects of noctuid appearance with stout body, broad across the thorax and tend towards the tapering end. Wing span is 44 mm. Females have brownish wings while males have greyish wings. Hind wings are marked with dark veins with a broad, dark band on the outer margin with two lighter spots in it. Upper side of the fore wings is marked with greyish, wavy lines and black spots of varying sizes. While presence of a dark brown, kidney shaped mark on the underside of the fore wing is a characteristic feature of the insect. They are about 18 mm long. Some authors have given the diagnostic as, "Brown coloured with a "V" shaped speck on fore wing and dull black border on the hind wing".

LIFE HISTORY

The most active period for the moth is between sun down to dark, during which they feed on nectaries from their host leaves. Mating takes place within two to four days after emergence from the pupa, and females lay several hundred fertile eggs on the top tender leaves or on the bolls of the upper part of the plant. They also lay infertile eggs in the absence of mating but copulation increases the rate of oviposition. In almost all host plants of *H. armigera*, there is a close association between egg-laying and period of bud and flower production. Incubation period largely depends upon weather. It is longer during cold while shorter in the hot

AMERICAN BOLLWORM MOTH

COTTON SQUARE DAMAGED BY AMERICAN BOLLWORM



AMERICAN BOLLWORM LARVAE FEEDING ON COTTON BOLL

weather. In summer hatching takes place in 3-5 days while in winter incubation period increases to 6 days. The young larva usually grows by eating young bolls and flower buds and becomes fully-grown in about 15-24 days, then it drops to the ground and burrows into the soil to a depth of 1-7 inches for pupation. In cold weather pupae undergo a facultative diapause, during which development is suspended temporarily, resulting in a considerable extension of pupal period. Pupa requires a period of 8-15 days to become adult during April — October. After emergence from the pupa, moths with unexpanded wings crawl upward and break through the thin crust of the earth at the top and then wings are expanded.

NATURE OF DAMAGE

Foliage and fructriferous organs are severely damaged by the larvae. They are voracious feeders of the reproductive parts of the cotton plant i.e. buds, flowers and bolls. They usually prefer buds and small bolls by eating out the contents, leaving only a hollow shell and move about the plant to feed on the next boll.

If there are insufficient buds for eating, they start feeding on leaves. Usually they hollow out a boll incompletely. They eat the bolls very rapidly and cause considerable loss to the crop. Each larva damages up to twelve fruits. Finally, shedding of attacked buds, flowers and bolls takes place.

SYMPTOMS

For field identification one way is to locate if the larvae are feeding on the bolls by thrusting their heads alone inside; or bolls showing regular circular bore holes. Attacked buds and bolls usually show larval excrements (=granular faecal pellets) outside the bore hole or between the boll surface and the enclosing bracteoles. Boll formation and maturity is delayed in case of severe infestation.

DISTRIBUTION

American bollworm is widely distributed in Africa, South America, Australia and Madagascar. In Pakistan, it is found in Punjab, Sindh and NWFP. The magnitude of its spread, however, varies from year to year.

HOST PLANTS

American bollworm is a polyphagous pest. Besides cotton, which is not a preferred host, it attacks and develops on a wide range of cultivated plants. More important among these are maize, potato, and tomato, lady's finger, citrus, tobacco, carrot, onion, castor, oat, wheat, "bajra", berseem, lucerne, rice and sun hemp.

CONTROL METHODS

Cultural: 1. Proper preparation of land results in killing of pupae or exposing them to the environmental factors. Predators may also help in reducing the population of such exposed pupae.

2. Alternate host plants near the cotton field should also be removed.

Biological: About 161 species of parasites, 55 predators and 10 pathogens of *Heliothis* spp. are reported in the world. Most of these are incidental or general parasites. However, a few seem to be important in their areas of occurrence. For example, in Zimbabwe, the *Tachinids*, *Gonia* sp. and *Sturmia* sp. are reported to parasitise up to 94% larvae of *H. armigera*. Besides, *Sturmia angustifrons* Vill. and *S. munroi* Currow parasitise up to 85% larvae. Similarly, a sclionid *Phanurus* sp. (which parasitizes 50% eggs) is reported from South Africa, whereas in Tanzania *Drino imberis* (Wild) and *Goniophthalmus halli* are the important parasites.

Other biological control agents include a parasite namely *Trichogramma minutum* for eggs, while *Voria ruralis* (Meig) and *Ericarcelia kochhians*, the two *Tachinid* parasites and an un-identified *Ichneumonid* parasitises the caterpillars.

Chemical: Insecticides are applied only when 20 25 small larvae per 100 plants are found. For this purpose, a variety of insecticides, in the form of emulsifiable concentrates as well as sprayable powders, have been recommended and are available in the market.

Earias insulana Boisd. and *Earias vittella* Stoll.

(Noctuidae: Lepidoptera)

(Spotted bollworm, Chitkubri sundi or Spiny bollworm)

DIAGNOSTICS

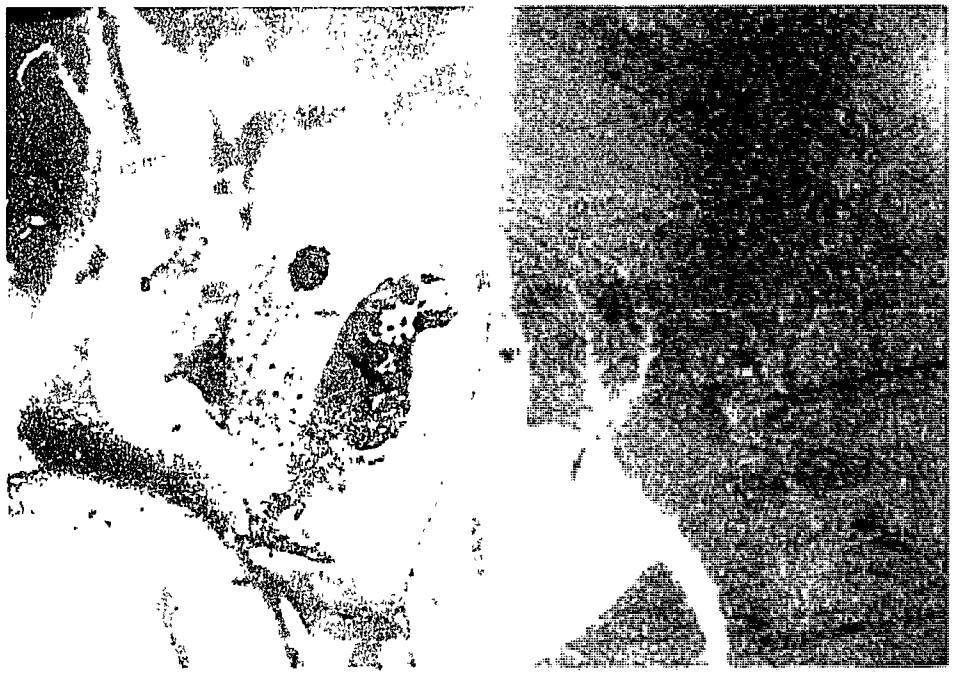
Egg: They are spherical in shape, light greenish blue in colour, a characteristic feature is the presence of about 30 parallel longitudinal ridges on the surface of the eggs of which alternate ones are pointed upward and form a crown. This feature gives the egg a resemblance to a miniature poppy fruit. They measure about 0.5 mm in diameter.

Larva: The newly hatched larva is brownish white in colour with a dark head, prothoracic shield. After four days of emergence, tubercles become prominent on the second and third thoracic and first abdominal segments. They measure about 1.3 mm in length.

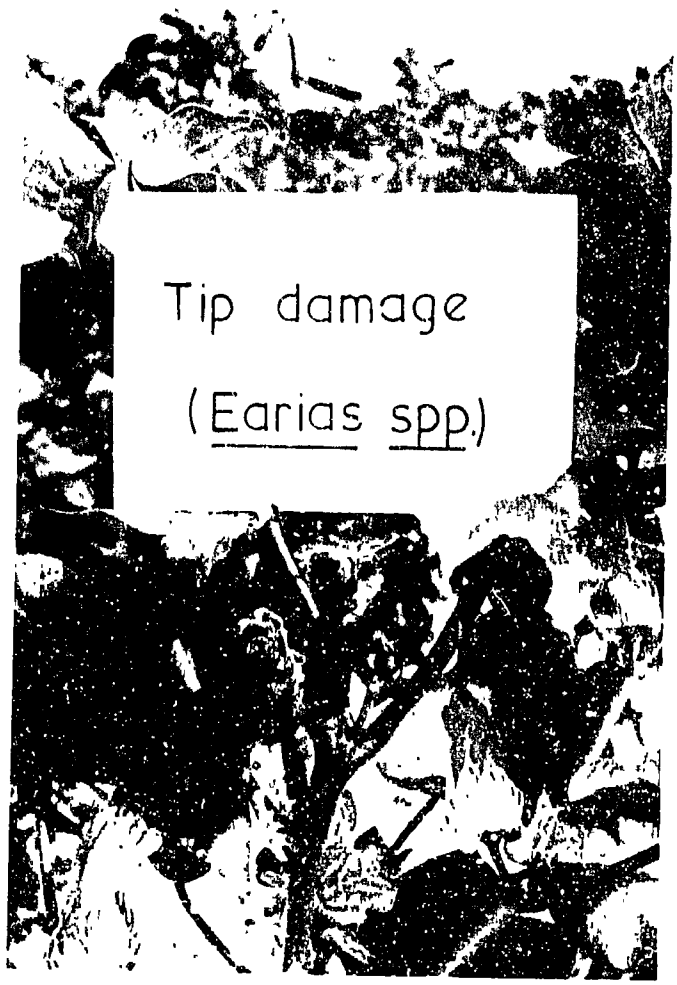
Full-grown larva is spindle shaped and stout structured. Each segment of the body bears a number of spine like hairs or setae. Two pairs of fleshy tubercles (finger shaped processes) are found on the last two thoracic and all the abdominal segments due to which insect is given the name spotted bollworm. One pair of tubercles is dorsal and the other is lateral. These tubercles may be long and slender or short and rounded and more prominent on the last two thoracic segments. On the last three abdominal segments, additional protuberances are found. They measure 18-20 mm in length.

Earias insulana larvae are dull greenish white in colour with a number of black marks on the body and orange dots on pre-thoracic segment, whereas *Earias*

ADULT OF SPOTTED BOLLWORM



SPOTTED BOLLWORM LARVA FEEDING ON COTTON SQUARE



TIP DAMAGE (*EARIAS* SPP.)

vittella larvae are brownish in colour with a white median longitudinal streak and ventrum is pale yellow or greenish. Tubercles are not much prominent particularly on the abdomen as compared to *Earias insulana* larvae.

Pupa: It is enclosed in a closely-woven, boat shaped cocoon which is made up of a felt like silk of dirty white or light brown colour. The pupa is purplish brown in colour with a distinct medium carina on the thorax. Surface is smooth or slightly rugose. Abdominal tip is bluntly rounded. A number of prominent projections are present on the fifth abdominal segment while three small teeth like projections are found on the terminal segment of the abdomen

Adult: The abdomen and hind wings are uniform and silvery or creamy white in colour. However, variation in the colour pattern of fore wing is found.

Earias insulana moths have grass-green to straw yellow fore wings, with three more or less distinguishable transverse lines of darker shade.

Earias vittella moths are small, buff coloured, have fore wings of creamy white colour with a pea-green, wedge shaped band (=green wedge) in the middle running from the base to the outer margin.

LIFE HISTORY

In summer, it requires a short period for completion of its life cycle, which prolongs considerably during winter. The pest remains active throughout the year and usually produces 6-8 generations.

Copulation usually takes place between 1 a.m. to 7 a.m. and is very much affected by the existing temperature of the area. Egg laying takes place only at night. Females of *Earias insulana* lay eggs between 7 p.m. to 10 p.m., while egg laying of *Earias vittella* continues throughout night. Temperature greatly influences the egg laying capacity of females. *Earias vittella* females are more prolific than *Earias insulana* ones. Each female deposits 163-420 eggs, singly on shoot tips, young bolls, buds, flowers and bracts.

Incubation period mostly depends upon the season in which eggs are laid. Hatching takes place in 3-4 days in summer while those laid in the end of October and November hatch in 7 to 9 days.

Soon after hatching larvae start feeding on the tender terminal buds, flowers and bolls and become full-fed after 7-18 days during August to October and 28-74 days during November — February. These full-fed/ full-grown larvae pupate either on the plants or on the ground depending upon the season in which they become mature. During August — September they pupate on the plants while during November — December on the ground. On the plants the pupae are found attached with the bracts, shoots, leaves and bolls. Pupal development is short i.e., 7-25 days during August — October and 41-87 days during December — March. The whole life cycle is completed in 18-34 days during summer whereas in winter it takes 26-136 days.

NATURE OF DAMAGE

In the pre-flowering stage the larvae bore into the top tender portions of the growing vegetative shoots (=terminal) and tunnel down the stem, which results in withering and drying of the attacked portions of the shoots. When flower buds and bolls appear, the pest attacks them by entering the bolls from below and feed inside the bolls; from where it moves to the other bolls. The infested bolls are often attacked by boll rot fungus. Thus during the boll formation stage, shedding of squares and young bolls, and flaring of bracts takes place. Holes on bolls and rotten bolls are also visible.

SYMPTOMS

Attacked portions of the shoots usually wither and dry up and ultimately drop off the plant. Bolls are either shed or open prematurely and badly.

SEASONAL ACTIVITIES AND SEQUENCE OF INCIDENCE

The pest has no resting or diapausing stage. It remains active throughout the year. The adults start emerging in winter. In March and April their number increases considerably on lady's finger and later on they attack cotton plants. Maximum attack is found from July to September. In October – November their number begins to decline and from December to March these are found in very small numbers. They feed on cotton up to the middle of January, till the green bolls are available and then moths appear during January – February, migrate to alternate host plants and cotton sprouts. From these hosts they move again in cotton.

CLIMATIC RELATIONSHIP

Earias insulana is mostly found in the arid regions of the cotton growing belt throughout the country. Humid climate in areas with greater rainfall, favours the existence of *Earias vittella*.

Temperature influences the egg laying capacity of moths and also the duration of life stages. Moths are short-lived in May-June as compared with November – December due to high temperature.

DISTRIBUTION

Earias insulana is widely distributed in the arid regions of the world including most of Africa, Madagascar, Mauritius and the Canary Isles. It extends northwards to the Mediterranean Islands and southern Europe, and eastwards through the Near and Middle East, including Southern Arabia, India and South East Asia.

Earias vittella, is distributed in the equatorial regions. It is recorded from Formosa to New Guinea. In Indo-Pak sub-continent both the species are found in all the cotton growing tracts as major pests of cotton.

E. insulana prefers the drier regions of Sindh and Punjab and predominates *Earias vittella* in both the provinces, while *Earias vittella* is found in areas having comparatively greater rainfall. It is not found elsewhere in Pakistan except, west of the arid zones of Indus and much of the Punjab. However, in moderate weather conditions both the species are found.

HOST PLANTS

The seasonal occurrence of alternate host plants in relation to cotton play a very important role in determining the severity of this pest. During off cotton season, it breeds on alternate hosts and remains active throughout the year. Lady's finger (*Abelmoschus esculentus*) is the most important cultivated crop while "khangi booti" (*Abutilon indicum*), "kuchri" (*Malvastrum tricuspidatum*), "gul khera" (*Althea rosea*), deccan hemp (*Hibiscus cannabinus*)., and "sonchal" (*Malva parviflora*) are important wild hosts.

CONTROL METHODS

Cultural: The control of spotted bollworm is largely affected by cultural practices and phytosanitary measures. The important measures are as under:

1. Destruction of wild host plants from and near the cotton field.
2. After the crop is picked, cotton sticks should be removed from the field by cutting them two inches below the ground level before mid-January in Southern zones and before mid-February in Central zones. Afterwards field should be ploughed with a furrow turning plough.
3. Eradication of "okra" (bhindi) before cotton sowing is also very important as it provides a good source of infestation to the coming cotton crop.
4. Late irrigation should be avoided.

Biological: Some 27 species of parasites have been reported in Pakistan. Of these, *Elasmus johnstoni, Bracon greeni, Rogas testaceus* (Braconidae) and *Goryphus nursei* (Ichneumonidae) are important.

Trichogramma sp. is the egg parasite while *Elasmus johnstoni* (Ferrier.) and *Bracon lefroyi* (D.& G) are larval parasites. First one is ectoparasite and the 2nd is an endoparasite. *Brachymeria tachardiae.* (Cameroon) and *Goryphus nursei* are internal and external pupal parasites, respectively.

The existing natural enemy complex can be strengthened by introducing some alien parasites and predators, such as *Agathis aciculata* from East Africa and Ivory Coast, *Netelia parvulas* from Malavi and *Strobliomyia nana* from Uganda.

Chemical: Spraying should be done only when the larvae are in the first stage of their development as it is difficult to kill larvae of the advanced stages. recommended insecticides should be applied when infestation in fruiting parts varies from 5-10%.

II. INSECT PESTS OF JUTE CROP

Jute is a new crop in Pakistan and hence no record of pest incidence is available. Review of literature, however, indicates that Jute suffers from the attack of various insect pests at different stages of its growth. But, these pests have not caused any serious damage so far. Observations on pest attack on experimental plots sown under Jute at the Sindh Agricultural University, Tandojam revealed the occurrence of following four pests.

1. *Chrotogonus trachypterus* Blanchard
2. *Laphygma exigua* Hb.
3. *Apion corchori*
4. *Tarsonemus latus*

In addition to the above mentioned insects following pests on Jute have also been documented in the literature.

1. *Anomis sabulifera*
2. *Diacrisia obliqua* Wlk
3. *Brachtrypes achatinus*
4. *Nupserha bicolor*

The common ones are described in the following pages.

Diacrisia obliqua Wlk. (Arctiidae: Lepidoptera)
(Jute hairy caterpillar)

DIAGNOSTICS

Egg: The freshly laid eggs are pearly green in colour, which later on turn to brown and then dull black before hatching.

Larva: *Ist instar larva*: The newly hatched larvae are creamy — white in colour. Ventral side is greenish while head is light brownish. There are moderately fine hairs on the intersegmental regions of the body.

IInd instar larva: Its colour is similar to the first instar larvae but when it is full-fed, its colour changes slightly to yellowish and head becomes brown.

IIIrd instar larva: On reaching third instar, the larvae change to yellowish white with greenish white ventral surface. Thorax and last two abdominal segments have black spots on the junction of dorso-lateral region with stout whitish hairs on the intersegmental region.

IVth instar larva: It is yellowish in colour with black spots on thorax and last two abdominal segments while head is black. Intersegmental regions of the body are well developed and possess black and white hairs.

Vth instar larva: Its colour is similar to fourth instar larvae. Intersegmental regions are black with well developed, stout white and black hairs.

VIth instar larva: It has yellowish colour with black head and well developed stout, black and white hairs on the intersegmental regions.

Pupa: It is reddish brown in colour, shining and comparatively smooth. It is enclosed in a cocoon which is composed of hairs and cast off skin.

Adult: Adult is medium sized moth, and is pale brown in colour. The intersegmental region of abdomen is red while wings have black spots on them. Males have bipectinate antennae while females have filiform antennae.

LIFE HISTORY

Copulation takes place immediately after the emergence of adults and continues till 2-12 hours. After 1-2 days of copulation, females start laying eggs. Each female may lay 300-1250 eggs in 3-4 days on the lower surface of leaves. Larvae hatch out after 7-8 days of incubation. They pass through six instars. First three instars are gregarious in feeding. First instar larvae feed on the lower epidermis of leaves and after 2-3 days they become full-fed and enter into second instar. They again become full-fed in 3-4 days and then enter into third instar. Their feeding rate increases in this instar and after 2-3 days they enter into the fourth instar. At this stage they very actively feed on both sides of tender and old leaves. They become full-fed in 4-5 days and then enter into fifth instar. They voraciously feed on whole leaf except mid-rib and veins. The duration of this instar is 6-7 days after which they enter into sixth and last larval instar which causes heavy losses to foliage. After 4-5 days they become full-grown and enter into prepupal stage. The larvae pupate on the lower surface of the leaves or in the plant debris in cocoons composed of hairs and cast off skin. Soon after emergence they start copulation.

NATURE OF DAMAGE

The larvae of hairy caterpillar are voracious feeders of leaves. In case of severe infestation, plants are completely defoliated. They also damage the young shoots. The first three larval instars are gregarious in habit. The leaves eaten by the fourth instar larvae are seen like grazed by sheeps and goats. After fifth instar whole leaf is eaten by the larvae except mid-rib and veins.

DISTRIBUTION

It is found on jute crop wherever it is grown.

HOST PLANTS

Besides jute it also attacks cotton, moong, maize, berseem and certain ornamental plants.

CONTROL METHODS

Cultural: The most effective method is hand picking of egg masses and their destruction. Planting of alternate hosts in the close vicinity of jute crop is also recommended. Fields should also be ploughed after harvest to burry the plant debris in the soil.

Laphygma exigua Hb. (Noctuidae: Lepidoptera)
(Indiago caterpillar)

DIAGNOSTICS

Egg: Eggs are dark brown in colour.

Larva: Full-grown larvae are green in colour with a white stripe down each side of its body which has a distinct pinkish tinge. It is over an inch in length.

Pupa: Its skin is dark brown and there are two spines at tip of its body.

Adult: Pale yellowish-brown in colour. Fore wings are dark with marginal series of dark spots mottled with small ochreceous spots and kidney shaped spot which has a dark centre. Hind wings are white in colour with dark veins and dark outer margin. They are about 19 mm long across the wings.

LIFE HISTORY

Copulation takes place at night. Each female may lay 200 eggs. After 2 days of incubation eggs hatch out. Larvae are gregarious in nature and feed for 2-3 days, then they disperse and each larva spins a web over the top leaves and feeds on the leaf tissue in the morning and evening, while rest of the day they remain hidden in the folded leaves. They pass through five instars. After 8-13 days of nymphal period during May-October and 15-24 days during November – April they become full-grown. Pupation takes place in the soil in a delicate cocoon formed by gluing of soil particles and trash with a sticky secretion. Pupal stage is completed in 3-4 days during May-October and 20-40 days during November – April. Normally there are 4 generations in a year.

NATURE OF DAMAGE

They destroy the leaves of the plants.

SEASONAL ACTIVITY

They appear on *Chorcharus capsularis* during last week of May and remain there up to the fourth week of August. While on *Chorchorus olitorius* there presence is found from first week of June to fourth week of August.

CLIMATIC RELATIONSHIP

Cool and wet weather conditions are very much favourable for pupal development of this pest.

DISTRIBUTION

It has been recorded in Tandojam (Sindh) from experimental jute fields.

HOST PLANTS

Along with jute following plants were also recorded as its hosts. Lucerne (*Medicago sativa*), indigo (*Indigofera* sp.), maize (*Zea mays*), cotton (*Gossypium hirsutum*), sugar-beet (*Beta vulgaris*), "til" (*Sesamum indicum*), linseed (*Linum usitatissimum*), onion (*Alium cepa*) lady's finger (*Abelmoschus esculentus*), pea (*Pisum sativum*), lettuce (*Lactuca sativa*), "senji" (*Melilotus parviflora*), berseem (*Trifolium alexandrinum*), "shaftal" (*Trifolium resupinatum*) and raddish (*Raphanus sativus*).

CONTROL METHODS

Cultural: Following measures are found helpful in reducing the infestation.

1. Cutting of plants close to the ground, which may be followed by a heavy irrigation. This practice helps in killing the larvae and pupae of the pest.
2. Destruction of egg clusters from the infested field.
3. Trenching the infested fields also helps in reducing the pest population.

Biological: Brown backed Indian Robbin, king crow and 'Myna' are the birds which prey upon this insect. Among parasites, *Chelonus rufus*, *Ascogaster* sp. and *Microplieits rufiventris* feed on the larvae of the pest.

Apion corchori Marsh. **(Curculionidae: Coleoptera)**

(Jute stem weevil)

DIAGNOSTICS

Adults are dull black in colour with a distinct snout and are about 1.7 mm long.

LIFE HISTORY

Female lays 400-600 eggs in holes made by it in the stem. The eggs hatch in 3-4 days and grubs emerge out. Pupation takes place after 15 days within the stem and adults emerge out after five days. They pass winter in protected places. Overlapping generations are very common.

NATURE OF DAMAGE

Grubs damage the stem by boring and also diminishing the length and quality of the fibre.

SEASONAL ACTIVITY

They appear on *Corchorus capsularis*, from second week of June and remain there up to third week of August. While on *Corchorus olitorius*, they occur in the third week of June and live up to first week of August.

DISTRIBUTION

Jute stem weevil is a minor pest of jute and is found in the areas wherever jute is grown.

CONTROL METHODS

Infested plants should be removed and in case of heavy infestation pesticidal treatment may also be given with recommended pesticides.

Cosmophila sabulifera Gn. (Noctuidae: Lepidoptera)
(Jute semi-looper)

DIAGNOSTICS

Egg: They are minute and greenish.

Larva: Green in colour with dark green wavy stripe along the sides. It has a characteristic semilooper movement. It is about 25 mm long.

Adult: It is medium sized moth of dull brown colour with dark spots and wavy lines on the fore wings.

LIFE HISTORY

Female lays 300-500 eggs on the lower surface of leaves. Larvae emerge out in 2-3 days and after 9-15 days of larval period, pupation takes place in the soil. Moths start emerging after 7 days. Three generations are found in a year. Second generation causing the heaviest damage.

NATURE OF DAMAGE

Larvae feed on the leaves, which results in reduction of yield.

DISTRIBUTION

It is found in all the jute growing regions of the world. However, this pest has not caused very serious damage so far.

CONTROL METHODS

For cultural control, the leaves containing eggs of semilooper, may be plucked and destroyed. Although this insect is not of much economic significance, but in case of serious infestation spraying with the recommended pesticides should be carried out.

Chemical Control: There are a large number of insecticides being used against cotton insect pests. Some of these are listed below.*

Insect(s)	Insecticide and dose per acre	Time of use	Method of application	Remarks
1	2	3	4	5
Cricket and Grasshoppers	B.H.C. 12.0% W.P. 225 gram	May-June	Mix the pesticide in the required dose with 10 kg of rice-husk/wheat bran and add water to make it moist but not wet. The bait should be applied around bunds in the evening or at night	1. These pesticides can stay in the soil for one year 2. These are harmful to honey bee and wild life 3. These insects occur when the cotton plant is too young. Therefore, application could be repeated after 8-10 days
White fly, Jassid and Thrips	Temik 1OG, 5 kg Thimet 1OG, 5 kg Solvirex 10G, 5 kg Disyston 1OG, 5kg	Apply with first irrigation	First apply granules along the lines of the crop and then irrigate the field	Contact with granules should be avoided
	Advantage 20EC, 500 ml	July-September	Spray	i. Only for sucking insects
	Fastac 10EC, 100 ml	"	"	ii. Good for caterpillars
	Danitol 10EC, 600 ml	"	"	iii. Use against sucking pests
	Larvin 80DF, 375gm	"	"	
	Baythroid 050SL, 330 ml	"	"	iv. For hand sprayer, use 120-150 litre of water
	Sherpa 5EC, 200-250ml	"	"	
	Pay off 100E. 200-250 ml	"	"	v. For power operated sprayer use 75-100 litre of water
	Sevin 85SP 150ml	"	"	
	Cymbush 10EC 250ml	"	"	

* *Added by Dr. A.A. Hashmi*

(Cont'd)

(Cont'd)

1	2	3	4	5
	*Thiodan 35EC, 1250ml	July-September	Spray	vi. Avoid the repeated spray of the same insecticide. Does not damage the application equipment
	Actellic 50EC 450-650ml	"	"	
	Anthio 25EC, 400-500ml	"	"	Has a long residue effect
	Azodrin 40WSC, 400-500ml	"	"	Harmful to birds
	Bidrin 86WSC, 200-300ml	"	"	Damages the iron, steel and bronze made equipment
	Celathion 50EC, 400-500ml	"	"	-do-
	Curacron 50 EC, 400-500ml	"	"	Besides insects also good for mites
	Cygon 400 EC, 300-400ml	"	"	Harmful for bees when used in higher doses
	Perfekthion 40EC, 300-400ml	"	"	
	Rogor 40EC, 300-400ml	"	"	
	Roxion 40EC, 300-400ml	"	"	
	Dimecron 100SCW, 200-250ml	"	"	Harmful for bees. Do not enter field till 24 hours after spray
	Hosdon, 1300-1500ml	"	"	-do-
	Lorsban 40EC 350-450ml	"	"	-do-
	Malathion 57EC 800-1000ml	"	"	Damages the iron made machinery Also harmful for bees
	Metasystox 25EC, 500-750ml	"	"	-do-

(Cont'd)

(Cont'd)

1	2	3	4	5
	Methyl-parathion 50EC, 500-750ml	July-September	Spray	Do not enter the field till 24 hours after spray
	Nexagon 80EC, 600-750ml	"	"	Harmful for birds and fish
	Ofonack 40EC, 450-600ml	"	"	
	Sumithion 50EC, 500-700ml	"	"	Has a long residual effect
	Folithion 50EC, 500-700ml	"	"	
	Accothion 50EC, 500-700ml	"	"	
	Agrothion, 500-700ml	"	"	
	Supracide 60EC, 600-700ml	"	"	
	Tamaron 600EC, 400-450ml	"	"	Do not enter the field after spraying
	Bathyroid 52.5EC, 400ml	"	"	
	Decis 2.5EC, 300-400ml	"	"	
	Karate 2.5EC, 325ml	"	"	
	Mavrik 2E, 175ml	"	"	
	Mikantop 40EC, 350ml	"	"	
	Nurelled 505EC, 400ml	"	"	
	Talstar 10EC, 250ml	"	"	
	Diapadrin 87EC, 250ml	"	"	
	Pillardin 40EC, 750ml	"	"	
	Modothion-Chemathion 40EC, 300-400ml	"	"	
	Dimetoxal 40EC, 300-400ml	"	"	

(Cont'd)

(Cont'd)

1	2	3	4	5
	Dimethoate-Systoate 40EC, 400ml	"	Spray	
	Amerthion 40EC, 400ml	"	"	
	Ameropa, 50EC, 400ml	"	"	
Army worm	Cidial 50 EC, 850ml	August-September	"	Harmful for bees, use at an early infestation stage
	Elsan 50EC , 850ml	"	"	
	Orthene 75SP, 500-750gm	"	"	Soon after spray, use Adrin or Heptachlor 3 and 2 litre per acre, respectively along with irrigation water to kill the larvae fallen on ground
	Lannate 90 WSP, 250-300gm	"	"	
	Nudrin 90 Liquid, 250-300gm	"	"	
American Pink and spotted bollworm	Azodrin 40 EC, 1000ml	August-Mid-October	"	Harmful for bees and birds Damages equipment made of steel and iron
	Nuvacron 40SCW, 1000ml	"	"	-do-
	Celathion 50EC, 1000ml	"	"	
	Cidial 50EC, 800ml	"	"	Harmful for bees
	Elsan 50EC, 800ml	"	"	
	Gusathion 20EC, 1000ml	"	"	Long residual effect
	Hostathion 40EC, 1000ml	"	"	
	Larsban 40EC 1000ml	"	Spray	

(Cont'd)

(Cont'd)

1	2	3	4	5
	Orthene 75SP, 750gm	"	"	Harmful for bees
American pink and spotted bollworm	Cidial 50EC, 800ml	August-Mid-October	"	Harmful for bees
	Elsan 50EC, 800ml	"	"	"
	Gusathion 20EC, 1000ml	"	"	Long residual effect
	Hostathion 40EC, 1000ml	"	"	Harmful for bees
	Lorsban 40EC, 1000ml	"	"	"
	Orthene 75SP, 750gm	"	"	"
	Supracide 40EC, 1000ml	"	"	Harmful for bees and wild life
	Lannate 90SWP liquid, 250-300ml	"	"	Harmful for bees
	Sevin 85WP, 1000-1250gm	"	"	Spray after Sevin and O/P insecticides
	Ambush 25EC, 200-250ml	"	"	Long residual effect
	Taicord 25EC, 200-250ml	"	"	
	Pounce 3.2EC, 200-250ml	"	"	
	Arrivo 10EC, 200-250ml	"	"	
	Cymbush 10EC, 200-250ml	"	"	
	Ripcord 10EC 200-250ml	"	"	
	Sumicidin 20EC, 300-350ml	"	"	
	Decis 2.5EC 200-250ml	"	"	
	Polytrin 440 EC, 500-600ml	"	Spray	

(Cont'd)

(Cont'd)

1	2	3	4	5
	Zolone - D.T. 41.25EC, 2000ml	"	"	
	Advantage 20EC, 1000ml	"	"	
	Fastac 10EC, 100ml	August-Mid-October	"	Equally effective for sucking insects as well as for lepidopterous larvae
	Larvin 80DF, 375gm	"	"	
	Danitol 10EC, 600ml	"	"	
	Nurelle 20EC 125-200ml	"	"	
	Baythroid 50EC, 250ml	"	"	
	Sherpa 50EC, 200-250ml	"	"	
	Pay off 10EC, 200-250ml	"	"	
	Sevin 3.4%, 1500ml	"	"	
	Cymbush 3%, 250ml	"	"	
	Bestox 5EC, 200ml	"	"	Good only for lepidopterous larvae
	Decis 2.5EC, 400ml	"	"	Useful for sucking insects as well as lepidopterous larvae
	Fenkill 20EC, 250ml	"	"	Good only for lepidopterous larvae
	Karate 12.5EC, 325ml	"	"	
	Mavrik 2EC, 175ml	"	"	"
	Mikantop 40EC, 350ml	"	"	"
	Nokout 400, 20 WSC, 1000ml	"	Spray	"
	Talstar 10EC, 250ml	"	"	"

(Cont'd)

(Cont'd)

1	2	3	4	5
	Diapadrin 87WSC, 250ml	"	"	"
	Pillardin 40WSC, 750ml	August-Mid-October	"	Equally effective against sucking insects and lepidopterous larvae
	Baythroid TM 525EC, 400ml	"	"	"
Mites	Akar 50EC, 650-750ml	On the appearance of mites	"	It is a good selective chemical to protect the predators and parasites but kills the mites. Repeated sprays required
	Ethion 46.5EC, 800-1000ml	"	"	"
	Kelthane 18.5EC, 1000-1200ml	"	"	"
	Omite 57E, 650-750ml	September-October	"	Do not spray when the temperature is above 35 C° Can damage younger cotton plants
	Mitac 20EC, 1000-1250ml	"	"	Harmful for fish
	Plictran 50WP 125-150gm	"	"	Equally effective for insects
	Talstar 10EC, 250ml	"	"	"

* *Used when lepidopterous caterpillars also occur along with sucking insects*

III. LIST OF INSECT PESTS OF COTTON CROP

Sr. No.	Name of pest	Family	Order
1	2	3	4
1.	*Attractomorpha crenulata* Fb.	Acrididae	Orthoptera
2.	*Attractomorpha psittacina* (Hann.)	Acrididae	Orthoptera
3.	*Aiolopus savignii* Kr.	Acrididae	Orthoptera
4.	*Aiolopus thalassinus* F.	Acrididae	Orthoptera
5.	*Aiolopus tamulus* F.	Acrididae	Orthoptera
6.	*Aiolopus affinis* Bol.	Acrididae	Orthoptera
7.	*Aiolopus strepens* Latr.	Acrididae	Orthoptera
8.	*Acrotylus humbertianus* Sauss.	Acrididae	Orthoptera
9.	*Truxalis nasuta* Linn.	Acrididae	Orthoptera
10.	*Acrida exaltata*, Walk.	Acrididae	Orthoptera
11.	*Catantops annexus* B.	Acrididae	Orthoptera
12.	*Catantops indicus* Bol	Acrididae	Orthoptera
13.	*Chrotogonus trachypterus trachypterus*	Acrididae	Orthoptera
14.	*Chrotogonus trachypterus robertsi* Kirby	Acrididae	Orthoptera
15.	*Chrotogonus lugubris* Bi.	Acrididae	Orthoptera
16.	*Cyrtacanthacris tatraica tatarica* Linn.	Acrididae	Orthoptera
17.	*Chrotogonus concavus* Kirby	Acrididae	Orthoptera
18.	*Chrotogonus saussurei* Bol.	Acrididae	Orthoptera
19.	*Eyprepacnemis alacres* Serv.	Acrididae	Orthoptera
20.	*Locusta migratoria* L.	Acrididae	Orthoptera
21.	*Oxya velox* Fb.	Acrididae	Orthoptera
22.	*Poecilocerus pictus* Fb.	Acrididae	Orthoptera
23.	*Schistocerca gregaria* Forsk.	Acrididae	Orthoptera
24.	*Acrida turrita* L.	Acrididae	Orthoptera
25.	*Acridella nasuta* L.	Acrididae	Orthoptera
26.	*Acrotylus insubricus* Scop.	Acrididae	Orthoptera
27.	*Acheta domesticus* Linn.	Gryllidae	Orthoptera
28.	*Brachytrypes portentosus* Licht.	Gryllidae	Orthoptera
29.	*Gryllodes melanocephalus* Serv.	Gryllidae	Orthoptera
30.	*Acheta viator* Kirby	Gryllidae	Orthoptera
31.	*Gryllus bimaculatus* DeG.	Gryllidae	Orthoptera

(Cont'd)

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Sl No	Name of pest	Family	Order
1	2	3	4
32.	*Gryllotalpa africana* Pal deB.	Gryllotalpidae	Orthoptera
33.	*Microtermes obesi* Hol.	Termitidae	Isoptera
34.	*Odontotermes obesus* Ramb.	Termitidae	Isoptera
35.	*Thrips tabaci* Lind.	Thripidae	Thysanoptera
36.	*Scirtothrips dorsalis* Hood	Thripidae	Thysanoptera
37.	*Leptocorisa* spp.	Coreidae	Heteroptera
38	*Leptoglossus* spp.	Coreidae	Heteroptera
39.	*Aganthocoris scaber* F.	Coreidae	Heteroptera
40.	*Glavigralla horrens* Dohrn.	Coreidae	Heteroptera
41.	*Oxycarenus loetus* Kirby	Lygaeidae	Heteroptera
42.	*Lygaeus pandurus* Scop	Lygaeidae	Heteroptera
43.	*Lygaeus hospes* F	Lygaeidae	Heteroptera
44.	*Ragmus importunita* Dist.	Miridae (Capsidae)	Heteroptera
45.	*Campylomma nicolasi* Put & Reut	Miridae (Capsidae)	Heteroptera
46.	*Ragmus flavomaculatus* Ballard	Miridae (Capsidae)	Heteroptera
47.	*Ragmus morosus* Ballard	Miridae (Capsidae)	Heteroptera
48.	*Dysdercus cingulatus* Fb.	Pyrrhocoridae	Heteroptera
49.	*Dysdercus koenigii* F.	Pyrrhocoridae	Heteroptera
50.	*Nezara viridula* L.	Pentatomidae	Heteroptera
51.	*Bemisia tabaci* Genn.	Aleurodidae	Homoptera
52.	*Aphis gossypii* Glov.	Aphididae	Homoptera
53.	*Machaerota planitiae* Dist.	Cercopidae	Homoptera
54.	*Pulvinaria maxima* Green	Coccidae	Homoptera
55.	*Cerococcus hibisci* Gr.	Coccidae	Homoptera
56.	*Saissetia nigra* Neitn	Coccidae	Homoptera
57.	*Phenacoccus hirsutus* Green	Coccidae	Homoptera
58.	*Phenacoccus iceryoides* Green	Coccidae	Homoptera
59.	*Dactylopius nipae* Mask.	Coccidae	Homoptera
60.	*Ferrisia virgata* (CKill.)	Coccidae	Homoptera
61.	*Chionaspis* spp.	Coccidae	Homoptera
62.	*Pseudococcus corymbatus* Green	Coccidae	Homoptera
63.	*Eurybrachys tomentosa* F.	Fulgoridae	Homoptera
64.	*Amrasca devastans* Dist.	Jassidae	Homoptera
65.	*Amrasca notata* Mel	Jassidae	Homoptera
66.	*Agrotis ypsilon* Hfn.	Noctuidae	Lepidoptera
67.	*Agrotis flammatrá* Denis & Schiff.	Noctuidae	Lepidoptera

(Cont'd)

Sr. No.	Name of pest	Family	Order
1	2	3	4
68.	*Acontia graellsi* Feist.	Noctuidae	Lepidoptera
69.	*Acontia malvae* Esp.	Noctuidae	Lepidoptera
70.	*Acontia intercepta* Geun.	Noctuidae	Lepidoptera
71.	*Cosmophila erosa* Hb.	Noctuidae	Lepidoptera
72.	*Earias insulana* Boisd.	Noctuidae	Lepidoptera
73.	*Earias cuprooviridis* Wlk.	Noctuidae	Lepidoptera
74.	*Earias vittella* Stoll.	Noctuidae	Lepidoptera
75.	*Euxoa segetum* Schiff.	Noctuidae	Lepidoptera
76.	*Euxoa spinifera* Hb.	Noctuidae	Lepidoptera
77.	*Heliothis armigera* Hb.	Noctuidae	Lepidoptera
78.	*Spodoptera exigua* Hb.	Noctuidae	Lepidoptera
79.	*Prodenia litura* Fb.	Noctuidae	Lepidoptera
80.	*Plusia nigrisigna* Wlk.	Noctuidae	Lepidoptera
81.	*Rabila* spp.	Noctuidae	Lepidoptera
82.	*Tarache notabilis* Wlk.	Noctuidae	Lepidoptera
83.	*Tarache nitidula* Fb.	Noctuidae	Lepidoptera
84.	*Tarache opalinoides* Guen.	Noctuidae	Lepidoptera
85.	*Cosmophila (Anomis) fulvida* Gn	Noctuidae	Lepidoptera
86.	*Anomis (Cosmophila) flava* F.	Noctuidae	Lepidoptera
87.	*Mocis (Pelamia) undata* F.	Noctuidae	Lepidoptera
88.	*Spodoptera pecten* Gn.	Noctuidae	Lepidoptera
89.	*Tarache basifera* Wl.	Noctuidae	Lepidoptera
90	*Tarache marmoralis* F.	Noctuidae	Lepidoptera
91.	*Amsacta moorei* Butl.	Arctiidae	Lepidoptera
92.	*Diacrisia obliqua* Wlk.	Arctiidae	Lepidoptera
93.	*Amsacta lactinea* Gr.	Arctiidae	Lepidoptera
94.	*Utethesia pulchella* Linn.	Arctiidae	Lepidoptera
95.	*Amsacta albistriga* Wlk.	Arctiidae	Lepidoptera
96.	*Pericallia ricini* F.	Arctiidae	Lepidoptera
97.	*Zeuzera coffeae* Nietn.	Cossidae	Lepidoptera
98.	*Pyroderces coriacella* Snel.	Cosmopterygidae	Lepidoptera
99.	*Pyroderces falcatella* Staint.	Cosmopterygidae	Lepidoptera
100.	*Pectinophora gossypiella* Saund.	Gelechiidae	Lepidoptera
101.	*Acrocercops zygonoma* Meyr.	Tineidae (Gracilariidae)	Lepidoptera
102.	*Lithocolletis triarcha* Meyr	Tineidae (Gracilariidae)	Lepidoptera

(Cont'd)

Sr No.	Name of pest	Family	Order
1	2	3	4
103.	*Bucculatrix* spp.	Lyonetiidae	Lepidoptera
104.	*Nygmia lunata* Wlk. (*Euproctis lunata* Wlk.)	Lyonetiidae	Lepidoptera
105.	*N. varians* Wlk	Lyonetiidae	Lepidoptera
106.	*Nygimia fraterna* Moore (*Euproctis fraterna* Moore)	Lyonetiidae	Lepidoptera
107.	*Nygmia xanthorrhoea* Wlk.	Lyonetiidae	Lepidoptera
108.	*Porthesia (Arctornis) proucta* Wlk.	Lyonetiidae	Lepidoptera
109.	*Nepticula* spp.	Tiniidae (Nepticulidae)	Lepidoptera Lepidoptera
110.	*Sylepta derogata* F.	Pyralidae	Lepidoptera
111.	*Phycita infusella* Meyr	Pyralidae	Lepidoptera
112.	*Corcyra cephalonica* Staint.	Pyralidae	Lepidoptera
113.	*Dichorcrocis punctiferalis* Gn.	Pyralidae	Lepidoptera
114.	*Acherontia styx* Westor	Sphingidae	Lepidoptera
115.	*Cacoecia* spp.	Tortricidae	Lepidoptera
116.	*Araecerus fasciculatus* Deg.	Tortricidae	Coleoptera
117.	*Alcides leoparidus* Ol.	Curculionidae	Coleoptera
118.	*Alcidodes affaber* Auriv.	Curculionidae	Coleoptera
119.	*Alcidodes fabricii* F.	Curculionidae	Coleoptera
120.	*Amorphoidea* spp.	Curculionidae	Coleoptera
121.	*Lepropus (Astycus) lateralis* F.	Curculionidae	Coleoptera
122.	*Atactogaster finitimus* F.	Curculionidae	Coleoptera
123.	*Myllocerus transmarinus* Hbst.	Curculionidae	Coleoptera
124	*Myllocerus undecimpustulatus* Faust var. *maculosus* Desh.	Curculionidae	Coleoptera
125.	*Myllocerus* discolor Boh.	Curculionidae	Coleoptera
126.	*Myllocerus sabulosus* Mshl.	Curculionidae	Coleoptera
127.	*Rhinoscapha* spp.	Curculionidae	Coleoptera
128.	*Tanymecus hispidus* Mshll.	Curculionidae	Coleoptera
129.	*Myllocerus blandus* Fst.	Curculionidae	Coleoptera
130.	*Myllocerus laetivirens* Mshl.	Curculionidae	Coleoptera
131.	*Pempher affinis* (Fst.)	Curculionidae	Coleoptera
132.	*Tanymecus indicus* Fst.	Curculionidae	Coleoptera
133.	*Tanymecus princeps* Fst.	Curculionidae	Coleoptera
134.	*Aulacophora (Raphidopalpa) foveicollis* (Lucas.)	Chrysomelidae	Coleoptera

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Sr. No.	Name of pest	Family	Order
1	2	3	4
135.	*Coelosterna spinator* Fb.	Cerambycidae	Coleoptera
136.	*Nisotra madurensis* Jacob.		
	Podagrica	Halticidae	Coleoptera
137.	*Coryna* spp.	Meloidae	Coleoptera
138.	*Epicauta* spp.	Meloidae	Coleoptera
139.	*Mylabris* spp.	Meloidae	Coleoptera
140.	*Zonabris pustulata* Thnb.	Meloidae	Coleoptera
141.	*Alphitobius laevigatus* F.	Tenebrionidae	Coleoptera
142.	*Colasposoma auripenne* Motsch.	Eumolpidae	Coleoptera
143.	*Solenopsis geminata* F.	Formicidae	Hymenoptera
144.	*Contarinia* spp.	Itonidae	Diptera
145.	*Tetranychus cinnabarium*	Tetranychidae	Acarina

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Chapter 7

INSECT PESTS OF SUGARCANE

Ali Asghar Hashmi*

Sugarcane is an important cash crop of Pakistan ranking fourth in the economy of country. The crop remains in the field for the whole year, it is therefore, twice as vulnerable as any other crop to insect damage. Insects feeding on sugarcane are diverse, numerous and characteristically of limited geographical distribution. At the global level 1300 insect species attack sugarcane while in Pakistan 61 species are on record. Variable statistics about the extent of damage by various species are quoted, which have negative impact on total cane production, but that is not properly documented.

The crop is grown in all the four provinces. The yields range from 37-50 tonnes per hectare. Some of the significant insect and mite pests are listed in Table 1.

Table 1. The annotated list of sugarcane insect pests

S. No.	Common Name	Technical Name	Family : Order
		A. BORERS	
1.	Sugarcane top borer	*Scirpophaga nivella* (Fabricius)	Pyralidae: Lepidoptera
2.	Sugarcane stem-borer	*Chilo infuscatellus* (Snellon)	Pyralidae: Lepidoptera
3.	Sugarcane stem-borer	*Chilo auricilius* Dudgeon	Pyralidae: Lepidoptera
4.	Sugarcane root-borer	*Emmalocera depressella* (Swinhoe)	Pyralidae: Lepidoptera
5.	Gurdaspur borer	*Acigona steniellus* (Hampson)	Pyralidae: Lepidoptera
6.	Maize borer	*Chilo partellus* (Swinhoe)	Pyralidae: Lepidoptera

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S. No	Common Name	Technical Name	Family : Order
7.	Pink graminaceous borer	*Sesamia inferens* (Walker)	Noctuidae: Lepidoptera
8.	Pink graminaceous borer	*Sesamia uniformis* Ddgn.	Noctuidae: Lepidoptera
	B. SUCKING INSECTS		
9.	Sugarcane leaf-hopper	*Pyrilla perpusilla* Walker	Fulgoridae: Hemiptera
10.	Sugarcane white fly	*Aleurolobus barodensis* (Maskell)	Aleyrodidae: Hemiptera
11.	Sugarcane mealy-bug	*Saccharicoccus sacchari* (Cockerell)	Coccidae: Hemiptera
12.	Sugarcane mealy-bug	*Kiritschenkella sacchari* (Green)	Coccidae: Hemiptera
13.	Sugarcane mealy-bug	*Phenacoccus saccharifolii* (Green)	Coccidae: Hemiptera
	Sugarcane mealy-bug	*Heterococcus rehi* (Lind.)	Coccidae: Hemiptera
14.	Sugarcane black-bug	*Cavelerius excavatus* (Distant)	Lygaeidae: Hemiptera
15.	Sugarcane aphis	*Melanaphis sacchari* (Zehnter)	Aphididae: Lepidoptera
	C. ATTACKING SETTS AND ROOTS		
16.	Mole cricket	*Gryllotalpa africana* Polissot de Beav.	Gryllotalpidae Orthoptera
17.	White ant	*Microtermes obesi* Holmgren	Termitidae: Isoptera
18.	White ant	*Termes obesus* (Ramb.)	Termitidae: Isoptera
	D. MITES		
19.	Sugarcane mite	*Oligonychus indicus* (Hirst)	Tetranychidae: Acarina
20.	Sugarcane mite	*Schizotetranychus andropogonii*	Tetranychidae: Acarina
21.	Sugarcane mite	*Tarsonemus spinipes*	Tetranychidae: Acarina

Scirpophaga nivella (Fabricius) **(Pyralidae: Lepidoptera)**
(Top borer of sugarcane)

DIAGNOSTICS

Egg: Oval, scale-like, covered with yellow or reddish brown hairs from the anal tuft of the female. Nearly 300 or more eggs are laid in clusters of 5-102 on the lower surface of the leaves.

Caterpillar: Creamy white, dorsal vessel prominent, thoracic region tapers towards head; longitudinal dark streak along the middle of dorsum.

Pupa: Brownish, abdominal tips broadly rounded.

Adult: Pure white, front wings long, narrow and triangular, hind wings shorter and wide; abdomen of female furnished with a brownish or reddish tuft of silken hairs. The males are smaller than the females.

DURATION OF LIFE STAGES

The durations of egg, larval, pupal and adult stages are 7-9, 28-35, 7-10 and 4-5 days, respectively.

PERIOD OF ACTIVITY

The pest is active from March to October, and overwinters as a full grown larva in the top portion of the attacked food plant from November to February. These caterpillars enter into the pupal stage about the second week of February and the moths begin to appear on wings towards the end of February or early March. During the day time these rest on sugarcane as well as on tall grasses, shrubs and trees growing near sugarcane fields where they can be easily caught with hand or hand nets. They become active at night when they fly, move about and mate. The females lay 300 or more eggs in clusters of 5-104 on the leaves of sugarcane plants. Egg laying is also done on other vegetation near the sugarcane field when the infestation is high. The eggs hatch in 7-9 days. The young caterpillars bore into the mid-rib of the leaf. More than one caterpillar may bore into the same mid-rib, but only one survives, which works its way towards the base of the whorl leaving a trail of whitish streak behind, which ultimately turns reddish due to fungus attack. In the case of resistant varieties some caterpillars perish near the base of the whorl. The factors that cause the death of the pest require to be investigated. After reaching the base of the leaf it bores into the top portion of the cane. The larvae are full fed in 4-5 weeks. Pupation takes place in a specially

prepared chamber which is usually located just above a node. The brownish pupae transform themsleves into adult within 7-10 days. The pest is active from March to October/November, when it passes through 5 broods, with caterpillars of 5th brood overwintering in the top portion of the infested cane.

NATURE OF DAMAGE

Damage is caused by the caterpillars which are generally found in the top portion of the cane. The first two broods of this pest attack young plants before the formation of the cane. In the subsequent broods, the pest attacks the terminal portions of the cane, causing bunchy tops. Damage by the third and fourth broods may result in more than 25% reduction in weight. The quality of juice is also affected adversely. The pest infestation extends from March to October and is very serious during July-August.

Month wise, the damage takes the following forms:

- The shoots attacked by the first two broods (April-June) are killed
- Cane affected by the third brood (July)remains stunted in growth and there is generally a decrease of 14 to 15 percent in height of such a cane. About 35 percent of the cane attacked in July gives out top branches (sprouting)
- Canes attacked by the fourth brood (August) grow slowly.
- By the time the 5th brood appears in September, the canes have almost attained their normal height. The height of attacked cane is only 1-2 percent less than that of the healthy cane. Only a few of the canes attacked in September give out top branching.

The following symptoms indicate the presence of top borer in the field:

- Dried up central most leaf roll
- Reddish or whitish streaks on the mid-rib of the one or more leaves.
- Bunchy tops
- Central leaves with ragged or jogged margins.

DISTRIBUTION

This pest occurs on sugarcane in Burmah, Cylon, China, Formusa, Indonesia, India, Japan, Pakistan, Philippines, Sri Lanka and Thailand.

FOOD PLANTS

The caterpillars have been collected from Kahi (*Saccharum spontaneum*), Sarkanda (*Saccharum sara*) *Eleusine covacana*, guinea grass (*Panicum maximum*). The pest however, shows a special preference for sugarcane. Nair *et al.* (1972) listed nine plant species in addition to sugarcane as host plants.

CONTROL METHODS

1. Remove the "dead heart" and kill the caterpillars with the help of a sharp spike.
2. The sugarcane tops should be cut in February and fed to the cattle to kill the hibernating larvae.
3. Mechanically destroy the eggs of the borers.

Chemical

Same as listed under stem borer

Chilo infuscatellus Snellon **(Pyralidae: Lepidoptera)**

(Shoot borer or Stem borer of sugarcane)

Synonym: In the literature this insect has been mentioned under different names, which should preferrably be called other names rather than synonyms. These are:

Argyria sticticraspis Hampson (1919)
Diatraea calumina Hampson (1919)
Diatraea shariinensis Eguchi (1933)
Chilo lavzhimiellus Gerusimor (1947)
Chilotraea infuscatella Kapur (1950)
Chilo infuscatella Bleszynski (1965)

DIAGNOSTICS

Egg: Flattened, scale-like, pale yellow (=creamy white) when freshly laid. A single female lays 300-450 eggs in clusters of 11-36 (average 30) on the lower surface of the leaves.

Caterpillar: Dirty-white or pale yellow, with five brownish (some call light violet) longitudinal stripes on dorsum; head and prothorax dark-brown. Crochets arranged in horse-shoe form, with the gap pointing towards outside. A full grown caterpillar measures about 25 mm in length.

Pupa: Reddish-brown, abdominal segments furnished with a zig-zag ridge, this ridge courses around the entire 7th abdominal segment.

Adult: Brownish pale-yellow, tinged with dark colouration; front wings brownish with dark spots along the longitudinal veins, one in the centre and a row of black spots along the outer margin, each spot being edged with white. Hind wings whitish.

DURATION OF LIFE STAGES

The egg, larval, pupal and adult life durations are, 5-7, 18-23, 7-12, and 2-4 days, respectively.

PERIOD OF ACTIVITY

The moths appear on wings from about 8th of March in the Punjab. They fly and pair only at night. The females lay eggs generally on the underside of the sugarcane leaves in batches. The young caterpillar on emergence leads a free life for a day or so when it feeds on the epidermis of leaves either by cutting holes or by eating in streaks. Afterwards it bores into the stem. On becoming a full grown caterpillar in about 18-23 days it measures upto one inch. A caterpillar is capable of making more than one hole/bore either in the same plant or on different ones to which it migrates. It pupates in the same tunnel in which it was feeding as a larva or in a specially constructed chamber by the larva. The pupa changes into adult in 7-9 days. The pest has 5-6 generations during its active period from March to October. It passes winter (November-February) as a hibernating larva in the stubbles of sugarcane. These larvae pupate sometimes in February and emerge as moths during March.

NATURE OF DAMAGE

This is a very injurious pest and its caterpillars destroy about 20% of the young shoots during April-June annually. The larvae, after hatching from the eggs, reach the plant base, bore into the shoot and feed there. In years of severe infestation, the damage may be as high as 67%. The caterpillars feed in the stem and cut off the growing point (central whorl of the leaves) causing

the later to wilt and dry. The central dead shoot is called "dead-heart". Such plants never grow further but the dormant buds sprout and produce side-shoots. After the formation of canes, its attack does not produce "dead-hearts" and damage is confined to a few internodes only. Even then, there is a considerable reduction in cane yield and sugar contents.

DISTRIBUTION

It has been recorded from Afghanistan, Central Asia, India, Korea, Formosa, Malaya and Phillipines. In Pakistan it is widely distributed in all the sugarcane growing areas of the country.

FOOD PLANTS

Sugarcane is the preferred host plant of this insect, but it also feeds on maize (*Zea mays*), bajra (*Pennisetum lyphoideum* Pich), Swank (*Rumicum colenum* Linn), guinae grass (*Penicum maximum* Facq.) dub grass (*Cynodon ductylon* Fers.), baru (*Sorghum halepanse* Pers.) Kahi and Sarkanda.

CONTROL METHODS

Cultural: The best way to prevent this insect from doing damage is to plough sugarcane stubbles anytime during November-February, when the caterpillars are hibernating in them. The uprooted stubbles should be collected and disposed of in a way that will ensure their destruction.

Mechanical: 1.Destroy egg-clusters by collecting them manually. 2. Destroy the moths by collecting them through light traps. 3. Remove the "dead-hearts" during April-May and introduce a sharp spike in a cavity and kill the caterpillars by moving the spike up and down.

Chemical: For stem borer, three chemical applications are involved:

First Application (Dusting)

1. Apply BHC 10% dust @ 3.50 kg mixed with DDT 10% dust @ 3.5 kg per acre from April to June. Dusting should be done in the morning. If BHC + DDT dust is not available, then

2. Apply Sevin 10% dust @ 5 kg per acre.
3. The second application is of an insecticide which can be sprayed.

Second Application (Spraying)

1. Spray any one of the following insecticides after 10-15 days interval during April-June, at the per acre rate indicated against each.

   i) Thiodon 35 EC. @ 1000-1200 ml
   ii) Carbicron 100 EC @ 300-500 ml
   iii) Bidrin 85 EC @ 300-500 ml
   iv) Methyl-Parathion 50 EC @ 500-750 ml
   v) Nuvacron 40 EC @ 1000 ml

Third Application (Granulars)

1. Apply Furadan 3% G @ 12-15 kg or Diazinon @ 7-9 kg per acre during May-June. The granules are applied through whorls and field is irrigated soon after application.

Emmalocera depressella Swinhoe (**Pyralidae: Lepidoptera**)

(Root borer of sugarcane)

Synonomy: The original name was *Melissoblaptes depressella* described by Swinhoe in 1885. Hampson (1896) described it under *Polyocha depressella.* According to him, a synonomy was created when Rag described *Polyocha variegatella* but later on *Polyocha variegatella* was considered a valid species (Hampson, 1918). Dudgeon (1905) created another synonomy by describing *Polyocha saccharella.* In 1977, *Polyocha depressella* was transferred to *Pupua* and later on to *Emmalocera* (Hampson, 1918).

DIAGNOSTICS

Egg: Scale-like, creamywhite, 277-355 eggs are laid singly on leaves, stems or on the ground by a single female.

Caterpillar: Pale-yellow with a yellow brown head when full grown; creamy white transverse grooves on the body segments, which give it a wrinkled appearance.

Pupa: Yellow-brown, tip of the abdomen knobbed on dorsum.

Adult: Pale or yellow brown, palpi long and brush like; outer aspects of mid and hind tibiae clothed with hairs; forewings pale or yellowish brown with rounded apices; a white costal band and a brownish band running from the base to the apical angle; hind wings whitish. Female has a wing expanse of 30-35 mm.

DURATION OF LIFE STAGES

The egg, larval, pupal and adult life stages last 3-5, 45-50, 10-18 and 5-7 days, respectively, during the period of high temperatures. However, with low temperatures the larval period may go up to 109 days.

PERIOD OF ACTIVITY

The pest is active from April to November and passes through five broods. During a year, four generations are completed and the caterpillars of the fifth brood enter into hibernation in the stubbles of sugarcane plant. The overwintered caterpillars pupate during the second fortnight of March and adults start emerging in the first week of April. A female on an average lays 184, 260, 222.5, 261.4 and 215.6 eggs during the first, second, third, fourth and fifth brood, respectively. During the early stages of plant growth, these are laid mostly on the underside of the first and second leaf along the midrib, but in the later stages on the sixth to tenth leaf, mostly on the eighth leaf though.

A freshly hatched caterpillar crawls to the base of the shoot at a distance of 9-11 inches. About 10-18 per cent of caterpillars bore successfully in the roots during the months of May and August, respectively. Pupation takes place at or below the surface of soil during the early stages of plant growth when full-fed caterpillar before pupation makes an exist hole 0.5" above the ground level. During later stages of plant growth a full-fed caterpillar before pupation constructs a silken tunnel and pupates at an average depth of 1.6" below the ground level. Emergence of moths takes place soon after dark. Males live for 3-5 days and 4-7 days, while females for 4-7 and 6-12 days during April-June and September-October, respectively.

NATURE OF DAMAGE

The larvae bore into stem below the soil surface. The central leaves of the attacked plants dry up, forming "dead-hearts" before the cane forming stage. The "dead-hearts" are not easily pulled out. As they feed, they cut right across the stem, reaching the adjoining tillers. The pest is primarily

destructive to the young plants and its attack is particularly severe from April to June. Plants attacked after formation of canes are not killed, although their weight and sugar contents are reduced. It is a minor pest of sugarcane. It is only in certain years that infestation exceeds 10-12%.

For comparing the population of different borers infesting sugarcane crop, a survey was conducted by the Entomologist, Ayub Agricultural Research Institute, Faisalabad during 1972 in Sheikhupura and Jaranwala. The per cent infestation of Gurdaspur borer, top borer, root borer and stem borer was 35, 25, 24 and 17, respectively. The cumulative infestation level in some fields was as high as 55%. When such a survey was extended to make an assessment of varietal resistance to infestation of borer species, the percentage infestation was 6.5, 7.5, 8.5, 9.5, 10.5 10.5, 12.0, 12.0, 13.0, 13.5 and 20.5 in COL. 54, L. 120, L. 113,, COL. 72, BL.4 L. 116, BL. 19, L. 112, COL. 44, C. 122 and L. 123, respectively.

Distribution: India, Pakistan

HOST PLANTS: Besides sugarcane, it has been found feeding on sarkanda, baru, sorghum and napier-grass.

CONTROL METHODS

Cultural/Mechanical: Destroy the stubbles after harvesting the crop to kill the hibernating larvae.

Chemical: Apply any one of the following granular insecticide at the per acre dose indicated against each:-

1.	Curater	3 G	@	12-15 kg
2.	Solvirex	8.8 G	@	07-09 kg
3.	Disyston	10 G	@	07-09 kg

Acigona (= Bissetia) steniellus (Hampson) **(Pyralidae: Lepidoptera)**

(New Pyralid or Gurdaspur borer)

This pest was first recorded in 1923 from Sialkot by Mian Afzal Hussain, the then Entomologist to the Government of Punjab, Lyallpur, who named it as "new Pyralid borer". Moths were bred in the laboratory and specimens sent to Imperial Research Institute, Pusa and British Museum

London for identification. But the pest remained un-named till 1939, when Mr. G.A. Bisset named it as *Chilo trypetes* sp. nov. The pest is now known as *Acigona (= Bissetia) steniellus* (Hampson). This is the most destructive pest of sugarcane in the Punjab province in some localities. In NWFP it is also serious in 5-6 years ratooned crops. Azhar (1978) reported its serious status in Lahore and Sargodha divisions of Punjab province during 1974-75.

DIAGNOSTICS

Egg: Flattened scale-like, glistening white to pale cream when freshly laid, changing to dark grey before hatching; 190-315 eggs are laid in clusters of 3-65 on the upper surface of the leaves along the mid-rib. An egg measures 0.65-0.88 mm in length and 0.42-0.53 mm in width.

Caterpillar: Body cylindrical, sparingly clothed with short setae. Head light orange or orange-brown, rest of the body creamy-white ornamented with four longitudinal reddish brown stripes situated along the spiracles and the dorsal vessel. The lateral stripes are very prominent particularly between 1st and 9th abdominal segments. A full-grown caterpillar measures 25-28 mm in length and 2.5-3.0 mm in breadth.

Pupa: Body more or less smooth, creamy-white when freshly formed, but later on changes to yellowish brown. Abdominal spiracles oval, slightly raised and deep brown in colour. Last abdominal segment terminating in a prominent broad ridge, distal margin of which is armed with three small spines. It is 14-19 mm in length and 2.3-3.0 mm in width.

Adult: The moth is dull brown. The hind wings are whiter than the forewings which have seven dark spots, between the veins along the outer margin. Female is similar to male but possesses fewer dusky brown scales on the forewings and have simple antennae. The antennae in male are serrate and finally ciliated. A male is 25-27 mm long, while a female is 29-32 mm in length.

DURATION OF LIFE STAGES

The egg, larval, pupal and adult life durations are 4-6, 48-64, 4-13 and 4-5 days, respectively.

PERIOD OF ACTIVITY

The adults from the overwintered larvae appear on wings during June-July. Resuming of activity is usually linked with on set of monsoon rains. If

rains are delayed emergence of adults may also be delayed. The adults become active at night when they mate, copulation lasts for 10-23 minutes. The moths in captivity lived for 2-6 days, the females surviving the males a day longer. A female could lay 190-315 eggs in clusters at night on the leaf-sheath near the upper nodal rings of the stem. They are arranged in rows and overlap each other like the scales on the legs of birds. One egg cluster may contain 3-65 eggs. The egg and larval stages occupy 4-6 and 48-64 days, respectively. Prior to entering into pupation a full grown caterpillar constructs a pupal cell in the burrow in which it was feeding. The cell is internally lined with silken threads. It also provides the cell with the exit hole by cutting out small circular piece from the rind of sugarcane and covering the hole thus made by a silken web. Afterwards it transforms itself into pupa. The pupal stage occupies 4-13 days. The life cycle of the insect is completed in 69-84 days, which is the longest among the sugarcane borers. During June-August the total development is completed in 44-74 days. There are three generations of this pest in a year and the pest is active from July to October. Hibernation takes place as caterpillar in the basal portion of the cane in November. Full fed larvae of 3rd generation migrate to the roots of healthy or attacked canes for hibernation. For this purpose they come out of the tunnel, crawl along the stem and bore into it 2-3" above the ground and thus enter the roots. If during migration they are blown off the plant by wind, etc., they bore into lower portion of any cane to enter the roots. Thus the full grown hibernating larvae pass winter and early part of summer (November-June) in the sugarcane stubbles. These larvae pupate sometime in June and start emerging as moths in the end of June or in the first week of July, to repeat the life cycle.

NATURE OF DAMAGE

The attack of this pest starts when internodes are well formed. The caterpillars after hatching feed for a while on the buds situated on the top first and second internodes and then they bore into it from near the buds. They feed on the tissue first below the rind boring their way upwards (from the point of entry) in a spiral manner. Externally this passage appears as a dark spiral streak, which on closer examination is found to be made of a series of punctures lying side by side like the beads in a rosary. When about 2/3rd of the internode is damaged in this manner, the caterpillar bores deeper into the softer tissue of the cane and feeds by making a single,

straight and central tunnel. The dark spiral streak renders the affected internode weak which breaks off when shaken by wind or passing animal. Upto the second moult the caterpillars feed gregariously when there may be 27-42 of them in a single bore. Afterwards they disperse and lead a solitary life. The attacked canes may loose weight by 54, 40 and 25% during July, August and September, respectively, and are poor in sucrose. Thus this pest adversely affects the quality and quantity of the cane.

It is usually after 7-10 days of attack, that the withering of the central leaves (notably 5th leaf) occurs, this is followed by the total drying up of the tops (1-4th leaves). The affected canes break at the point of attack with a slight jerk. It is at this stage of drying up of tops, that the larvae come out and enter the adjoining canes singly or in twos. They may again come out from these canes and attack more of the adjoining plants. The pest destroys 20-25 per cent of the crop in normal years. In case of severe infestation, the loss may be as high as 70-75 per cent. It is in this case that neither the dead heart can be pulled out nor any cavity left behind as against shoot borer. Midrib also remains unstreaked as against top borer in whose case the midrib of the leaf is rendered streaked.

DISTRIBUTION

According to Bleszynski (1969) it is distributed in Sourth West Asia and Indo-China. In Pakistan its occurrence has been on record in NWFP & Punjab province.

CONTROL METHODS

Cultural 1. This insect attacks the crop during June-July. At this time the crop has usually grown so high that it makes the insecticidal application quite difficult. The infested parts are therefore, cut and burnt or fed to the cattle, during July-August, for achieving encouraging results. The effect on the remaining shoots can lead to a reduction from 30% upto 10-16%.

2. Earthing up of ratoon crop checks the emergence of adults from the stubbles.
3. Ploughing up of stubbles and subsequent stirring of the soil after 10 days interval can also prove helpful in destroying the hibernating larvae.
4. A crop having 10% or more infestation should not be ratooned.
5. Removal of dead hearts also lowers infestation.

Mechanical: 1. Destruction of egg-clusters can lower the percentage of infestation.

2. Spike thrust method can be used for the affected stubbles.

3. Deep harvesting of cane though took more time yet increased millable cane by 10% but reduced the number of caterpillars to 28% as against 70% in case of stubbles left after cane cutting at ground level.

Chemical: 1. In the beginning of monsoon (June-July) apply 10% dust @ 5 kg per acre with a dusting machine.

2. If the need arises spray the crop with any one of the following insecticides at a per acre dose indicated against each:

(i) Thiodon	35 EC	@	1000-1200 ml
(ii) Carbicron	100 EC	@	300-500 ml
(iii) Nuvacron	40 EC	@	1000 ml
(iv) Methyl-parathion	50 EC	@	500-750 ml

Pyrilla perpusilla Walker (Fulgoridae: Hempitera)
(Sugarcane leaf-hopper)

DIAGNOSTICS

Egg: The eggs are laid in clusters on the underside of the leaves during the summer and within the leaf sheaths during the winter. The clusters are covered with a white fluffy material from the anal tufts of the females. As this tuft is removed, oval, pale-white eggs are seen in three to five longitudinal rows. Each egg is rounded at the extremity.

Nymph: Fifth stage nymphs are long, greyish brown, eyes greyish green with a central black spot. Tegmina reaching third abdominal segments, each with a black spot at outer posterior margin; two white prominent feather-like filaments at the end of the tail of its body.

Adult: Body and legs ochraceous (straw coloured), paler beneath than above, tegmina yellowish-white. Semi-opaque, apical area and outer claval margin speckled with minute black spots; wings pale hyaline. The dorsal ridge to cephalic process is much less prominent in front of central transverse ridge than behind it. Front of head extending into a bladder-like structure believed to be luminous. Eyes red and prominent, ocelli usually two.

DURATION OF LIFE STAGES

The egg-stage lasts 8-10 days during summer, 20-40 days in winter, i.e., November-December. Nymphal life is 8 weeks during summer, 5-6 months in winter. The adult lives for 27-52 days.

PERIOD OF ACTIVITY

The life cycle of this insect is completed in 36-41 days. Incubation period on the average is 8 days during autumn, when the insect pest is most active. During this active period the duration of five instars is 8.17, 6.20, 5.80, 7.60 and 9.50 days, respectively. From January to third week of March the pest is in the form of nymphs, and at that time they migrate to the wheat, where they assume adult form in March-April and these adults then migrate to sugarcane about the middle of April, when wheat is harvested. The females lay eggs on the underside of leaves in cold season. Sometimes they are laid on any part of food plant, on road sides, weeds and soil, etc. Each egg cluster is covered with whitish waxy threads. Each female lays 770 eggs. Eggs hatch out in 7-12 days in April-October, but during winter they take 20-40 days. Young ones turn into adults in 4-21 weeks depending upon the season. There are 3-5 generations in a year.

NATURE OF DAMAGE

The pest occurs throughout the year but is severe in April to October. Activity-wise it appears in April-May and again in August-September. The latest studies carried out by Kazi (1988) revealed that in Sind (Hyderabad, Nawab Shah and Tharparkar) the maximum population of nymphs is found from June through August. Both the adults and nymphs inflict damage by sucking juice of crop. The leaves become pale, wilted and ultimately growth is affected. Succulent varieties with broad leaves are preferred.

The insect excretes a thick transparent liquid known as honey-dew which falls on the leaves and provides a good medium for the growth of black mould. Owing to development of fungus, the crop turns black, which renders the tops unfit for feeding to cattle. The black mould/coating also interferes with photosynthesis, and very little food is manufactured by the plant. The worst affect is, the deterioration of juice. The existing sucrose in the canes is also used up and about 25% reduction in sugar yield is not uncommon. The cane juice becomes high in glucose, turns insipid and if used for making gur gives rise to a soggy mass which does not solidify properly.

DISTRIBUTION

It is widely distributed in sugarcane growing areas of Punjab, NWFP and Sind in Pakistan. It was first recorded in Indian Punjab in 1917 (Misra, 1917) and in 1922 from Lahore and then from Faisalabad (Rahman and Nath, 1940).

FOOD PLANTS

Besides, sugarcane, this insect is also found on wheat, barley, oats, maize, sorghum, baru, guinea grass, swank and sudan grass.

CONTROL METHODS

Cultural/Mechanical: 1. Destroy the eggs.

2. Destroy the pest through hand nets.

Chemical: Spray the crop with any one of the following insecticides (in required quantity of water) on the appearance of the pest at a per acre dose indicated against each:

(i)	Gusathion 20 EC	@	1000 ml
(ii)	Malathion 57 EC	@	1000 ml
(iii)	Methyl-parathion 50 EC	@	500-750 ml
(iv)	Diazinon 60 EC	@	500 ml
(v)	Roxion 40 EC	@	300-400 ml
(vi)	Cygon 40 EC	@	300-400 ml
(vii)	Perfekthion 40 EC	@	300-400 ml
(viii)	Rogor 40 EC	@	300-400 ml
(ix)	Basudin 90 SCO		400 ml
(x)	Perfekthion ULV		1000 ml
(xi)	Thiodon ULV		1000 ml
(xii)	Anthio 25 EC	@	500 ml

Recent studies by Kazi (1988) revealed that even after week of spray Perfekthion ULV and Thiodon ULV, gave 96.37% and 98.22% reduction in the nymphal population while initially Basudin 90 SCO, gave 96.10% reduction followed by Anthio 25 EC (93.70%).

Biological: Release of a parasite *Epipyrops melanoleuca* Fletcher has been found to be effective, for controlling nymphs. Kazi (1988) revealed that at some places in Sindh there was 60-70% nymphal parasitism.

Aleurolobus barodensis Maskell (Aleyrodidae: Hemiptera)
(Sugarcane whitefly)

This is not a serious pest. In the absence of sugarcane, it can also survive on sarkanda.

DIAGNOSTICS

Egg: The eggs are creamy-white, conical and are glued to the surface of the leaves. They are found in groups of 15-20, arranged in a single file. Egg stage lasts 8-10 days.

Nymph: The nymphs are about 3 mm long, oval in outline, flattened and scale-like in form. They remain sticking to the same spot on the leaf where eggs are laid. They are black and have a silvery-grey waxy coating on the body. Nymphal duration is 25-30 days.

Pupa: Dark-brown, elongated, elliptical with side nearly straight, abdominal segment indistinct. Pupal period lasts 10-11 days.

Adult: The adults are small delicate pale-yellow insects, about 3 mm long, and their wings have a white mealy appearance, mottled with black dots. They flutter about briskly, but because of their small size and brief life, they are not easily noticed in the fields. Adult life is 1-2 days.

PERIOD OF ACTIVITY

The pest breeds practically throughout the year except during the winter, when the nymphs and pupae are mostly present. Winged adults appear in the spring and soon after emergence, they copulate in an end-to-end position for 30-40 seconds. The insect completes nine generations in a year and in March-April, they migrate from the old to the new sugarcane plants. Their life cycle is prolonged in the autumn, when the nymphal and pupal stages are completed in three to four months. The complete life cycle normally takes 40 to 55 days. There are as many as 9 generation per year.

NATURE OF DAMAGE

Only the nymphs cause the damage by sucking the cell-sap. The general vitality of the plants is reduced and quality and quantity of gur produced is poor. The crystallization of sugar being sub-normal, sugar recovery is reduced by 15 to 25 per cent.

A black mould develops on the honey-dew excreted by the pest and it interferes with proper functioning of the leaves and renders them unfit as fodder.

Yellow streaks appear on the attacked leaves and the crop acquires a palish-green appearance. The leaves turn black owing to the development of a fugus. The underside of the leaves is full of nymphs and pupa.

Saccharicoccus sacchari Cock. **(Pseudococcidae: Hemiptera)**
(Cane mealy bug)

This is a minor pest of sugarcane. It is often present in very large numbers and the amount of honey dew secreted is substantial. It is probably toxicogenic. However, whether mealy bug really causes appreciable damage to sugarcane is debatable.

Mealy bugs are seen clustered at the basal nodes of the sugarcane and are exposed when a leaf sheath is removed. Sorghum, rice and various species of grasses have been found to be the alternate host plants of the pest.

DIAGNOSTICS

Egg: These are yellowish, smooth, cylindrical and rounded at both ends. The eggs are laid under the leaf sheath. Duration of egg-stage is 7-10 days.

Nymph: These are transparent, pink and are very active. The total nymphal duration is 14-21 days.

Adult: The female is pinkish and is elongate, oval to round in shape (sac-like segmented body,) covered all over with a white mealy powder. The males are sluggish, have one pair of wings, are short-lived and their only function is to fertilize the females. Full grown female lives 3-5 days.

PERIOD OF ACTIVITY

The pest practically breeds throughout the year. Hatching usually takes only 10-14 hours, for the eggs are retained in the genital tract of female until their development is well advanced. The pest completes several generations in a year. The life cycle takes about 30 days to complete.

NATURE OF DAMAGE

Mealy bugs are first noticed in appreciable number when the canes are four-month-old. Afterwards, they remain on the plants till harvest. Canes

having tight fitting sheath are more or less free from the attack, whereas a drought-affected crop is more severely damaged. Nymphs and wingless female adults cause damage by sucking the cell-sap from the canes and befoul them by their mealy secretions and honey dew on which a sooty mould develops. This makes canes appear blackish.

Cavelerius (= Macropes) excavatus Distant **(Lygaeidae: Hemiptera)**
(Sugarcane black bug)

The pest is widely distributed throughout the country and it is believed that the ratooning practice has helped its multiplication. The alternate host plants have been found to be rice *(Oryza sativa),* maize and a number of grasses.

DIAGNOSTICS

Egg: Eggs are creamy-white when freshly laid, becoming brownish before hatching. In summer, 55-478 eggs are laid in clusters of 16-17 on the inner surface of sheathing base of the side leaves. In the winter, they are laid singly or in pairs close to the roots in the soil at the depth of 5-7 cm. The egg stage lasts 9-17 days during May to September and 85-159 days during October-January.

Nymph: The nymphs have shape and colour similar to those of the adult but are smaller in size. There are five nymphal instars completed in 38-52 days during March to July, 26-42 days during July to October and 64-70 days during October to December.

Adult· The adults are 6-7 mm long, black with white patches on the wings which extend slightly beyond the abdomen. The males live upto 112 days in summer and 210 days in winter. The respective life duration for the females is 118 and 242 days.

PERIOD OF ACTIVITY

This pest actively breeds throughout the year but, during the winter (October to March), mostly (hibernating) adults and eggs are noticed around the sugarcane stumps, 5-7 cm deep, where they feed and oviposit. The insects complete appproximately three generations in a year. Eggs are laid in the soil at a depth of 5-7 cm during winter which hatch during the next season. Thus, in March-April, the new nymphs and the old adults are seen feeding side by

side. By May, all the adults die and only the nymphs remain alive and they mature by June. Afterwards, the generations overlap and all stages are found in the field. When the temperature is too high adults may also aestivate in June.

NATURE OF DAMAGE

Both the nymphs and adults cluster within the central leaf whorl and sheath bases of lower leaves of young plants to suck the sap. On the grown up plants they feed within the leaf sheaths.

The attacked leaves become pale, bear brown patches and dry up gradually. They also show holes after feeding. In severe cases, whole crop gives a scorched look.

The cane varieties with loose and large sheaths are more susceptible to this pest. The infestation is also higher on the ratooned crop. The damage interferes with the growth of the cane and affects both the quantity and quality of molasses.

CONTROL METHODS

Cultural: Burning of stubbles and spraying with recommended insecticides are the effective control measures.

Biological: Eggs are parasitised by *Nardo Cumaeus* Nixon and *N. Phaeax* Nixon.

Chemical: Spraying with Bidrin 24 EC, Anthio 25 EC, Orthene 75 WP or Methylparathion 50 EC @ 250 ml/acre

Spraying with Mikantop 40 EC or Roxion 40 EC @ 75 ml/acre. Any of the above chemical can give affective control upto 98%. The spray could be repeated as and when needed.

Microtermes obesi Hol. and *Termes obesus* Ramb.

(Termitidae: Isoptera)

(White ants)

This pest is very serious in sandy soils. It is present in almost every field.

The cultivation of sugarcane in some areas e.g. in Lieah and Bhakkar in the Punjab province is restricted. In NWFP about 70-80% termite damage to sugarcane is by *M. obesi* while *T. obesus* damage constitutes 20-30% only.

The termites are social insects and their colony organization is based on a caste system. In a colony, there are numerous workers, soldiers, a queen, a king and a good number of complementary or the colonising forms of true but young males and females. There are winged individuals of both sexes and are produced in large number during the rainy season.

Queen: This is the only perfect developed female in the colony. Its reproductive system occupies almost the entire abdomen and she is a sort of egg-laying machine, laying one egg per second or 70,000 to 80,000 eggs in a day. She lives 2-3 years. The egg stage lasts 7 days during summer.

King: The king emerges from an unfertilized egg and becomes fully developed by consuming better diet. He is the father of the colony and is a constant companion of the queen, living with her in the "royal" chamber.

Complementary Castes: These are short-winged or wingless creatures of both sexes and lead a subterranean life. In the event of untimely death in a colony, they replace the king or the queen and are thus, induced by the workers to undergo sexual development.

Workers: These are pale-bodied insects about 4 mm long with large, brown heads.

Soldiers: These are also pale, about 6 mm long and have very large heads with conspicuous pincer-like jaws.

LIFE CYCLE

The colony is established by a pair of day-flying winged reproductive forms. They shed their wings and make a cell underground from which the colony gradually expands. The mature colony is marked above ground level by a conical mound up to 1 m height. If the nest is dug out, the sponge-like fungus gardens can be found. The chewed up wood and pieces of vegetables are built up into the fungus gardens on which special species of fungus are cultivated. The termites then feed the fungal mycellium and bromatia. Eggs are hatched after about a week during summer. Within six months, the larvae develop to form soldiers or workers, as the case may be. The reproductive castes, when produced, mature in 1-2 years.

NATURE OF DAMAGE

Only workers are responsible for the damage. The damage causes the poor germination of sugarcane setts and the drying up of shoots. Mature cane is encrusted with earthen tunnels. The pest appears during April to June and again in October.

CONTROL METHODS

Cultural: Always use well-rotten farm yard manure.

- Avoid sugarcane sowing adjacent to poplar (*Populus nigra*) plantation or any other soft-word plantations (*Salix acmophylla*).

Chemical: 1. Sugarcane sets should be dipped in 5% solution of 0.5% Dieldrin per acre prior to planting them.

2. Apply 2-3 litres per acre of Dieldrin 20% EC at the time of rouni with irrigation.

3. Apply 2-3 litres per acre of Heptachlor 32% EC during April-June on the appearance of pest.

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Chapter 8

INSECT PESTS OF ORNAMENTAL PLANTS

Mohammad Shahid*

APHIDS

Aphids or plant lice belong to the family Aphidae (Aphididae) of order Hemiptera.

DIAGNOSTICS

Aphids are small, pear shape, often green in colour, sometimes yellow; brown or black. Head broad, antennae of varying length, 3-6 segmented, located on tubercles; 3 ocelli and a pair of large compound eyes. Mouthparts typically piercing and sucking type, rostrum (beak) 4 segmented, in few cases 5 segmented. In elates integument strongly sclerotized, in apterous soft and membranous. Metathorax strongly developed in winged forms to accommodate the flight muscles. Wings usually absent, when present 4 in number, and transparent; at rest held roof like over body. Hind wings smaller than fore wings. Wing venation greatly reduced, varying in genera and species. Abdomen 9 segmented, having a cauda (tail) as a projection of 9th segment. Fifth and sixth abdominal segments dorsally with a pair of cornicles which secrete a waxy fluid that gives protection against the predators. The honey dew is secreted through anus. The young ones are smaller in size and with incompletely developed cauda.

LIFE HISTORY

In active seasons the aphids are viviparous i.e. instead of eggs, adults lay young ones and the females are parthenogenetic i.e. reproduce without being fertilized by males. All the young ones so born are females. The number of young ones per female ranges from 40 to 120. The nymphs moult four times to become adults and requir 15-18 days. The mature females live

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for 15 days before they die. In active season mostly wingless females are found while in winter the females are winged. The winged form appears to help in migration of aphids to the alternate host plants since aphids are mostly polyphagous.

HOST PLANTS

The species of aphids which usually attack ornamental plants in Pakistan are listed vis-a-vis their host plants

Aphid species	Host Plant Technical name	Vernacular name
Aphus gossypii Glover	*Tagetes patula*	Mari Gold
	Celosia argentea	Cockscombs
	Rosa spp. *Delhia* sp.	Roses
	Tecona stans	
	Chrysanthemum spp.	Chrysanthemum
	Cineraria sp.	
Aphis fabae Scopoli	*Tagetes patula*	Mari gold
Aphis craccivora Koch.	*Rosa* sp.	Roses
Rhopalosiphum apsudobrasica Davis	*Brassica oleracea acephala*	Ornamental cabbage
Macrosiphonella sanborni	*Chrysanthemum* sp.	
Macrosiphum rosaeiformis Das	*Rosa* sp.	Roses
M. pisi	*Cestrum nocternum*	Lady of night
Acrythosiphon pisum	*Lathyrus odoratus*	Sweet pea
Myzus persicae Sulzer	*Antirrhinum majus*	Snap dragon
	Tagetes patula	
	Althea rosea	Holy hock
	Viola tricolor	Pansy
Aphis duranti Das	*Duranta plumeiri*	Duranta

The aphids are although small in size but very destructive because of the following characteristics:-

1. They have very high reproductive power because all are females and reproduce parthenogenetically.
2. The adults and nymphs suck huge amount of plant sap due to which the plants loose their vigour of growth.

3. Aphids secrete plenty of honey dew that becomes deposited on leaves which look waxy and lubricated. The honey dew is a sugary liquid on which the black sooty mould (fungus) very quickly develops. The respiration and photosysthesis of leaves is arrested because the stomata are blocked by honey dew. Leaves that are covered by black fungus do not receive sun light.
4. In numerous instances it has been proved that aphids transmit many fungal and viral diseases of plants.
5. Some plants also react to the attack of aphids by gall formation, which is in fact the abnormal growth of a certain attacked part of a plant.

CONTROL METHODS

Aphids can easily be controlled by using any one of a number of organophosphorus insecticides like Dimecron, DDVP, Decis, Methyl parathion, Diazinon, Perfecthion and Malathion in concentration of 0.025 to 0.05 per cent solution.

Phytomyza atricornis (Agromyzidae: Diptera)
(Pea leaf miner)

DIAGNOSTICS

The adults are small, two winged flies. The frons and orbits are yellow on dark ground, vertex yellowish brown, antennae brown, orbital bristles 5 pairs, mesonotum yellow, wings dusky with very fine hairs and brown veins. Abdomen and legs brown. Wings 2.38 mm long.

Larvae are very small, creamy white, slender and stay in the tunnels in the leaves. If the attacked leaves are held against bright light, the larvae can be seen feeding inside the tunnel.

LIFE HISTORY

The pest is active from January to May and it passes rest of the year in soil perhaps in the pupal stage. The adults appear in January and after mating the females start laying eggs singly in the leaf tissues. The eggs hatch in 2-3 days and the larvae feed on mesophyll between the upper and lower epidermis and make zigzag tunnels. The larval period is completed in about 5-8 days and pupation occurs within the tunnels or galleries. The adults emerge

after about 6-8 days of pupation. A life cycle is completed in 13 to 20 days. There are several generations during January to May.

HOST PLANTS

The leaf miner attacks a large number of cruciferous plants, *Antirrhinum majus, Pisum sativum, Linum usitatissimum, Tropaelium major,* and *Papaver somniferum.* Only larvae are destructive and they make prominent whitish tunnels in the leaves. The large number of tunnels made by the larvae interfere in photosynthesis and hence normal growth is affected. Also the attacked leaves make the plant unattractive.

CONTROL METHODS

The pea leaf miner can be controlled by spraying Sevin 0.1%, Dimecron, .05% or Dimethoate 0.02%, solution. The spray may be repeated if the infestation reappears. The application of systemic granules like Temik 10 G at the rate of 5 gm per square metre or Solverex 10% at the rate of 5 gm per square metre will also control the pests.

Drosicha stabbingi(Gr.) (Coccidae: Hemiptera)
(Mealy bug)

This is commonly called as mango mealy bug.

DIAGNOSTICS

Egg: Light crimson in colour and oval in shape. They are laid in soil in an enclosed sac at a depth of 2-5 inches.

Nymph: They resemble the females in shape but are very small in size. A female nymph passes through 3, while the male nymph passes through 4 nymphal instars.

Pupa (only in males): Oval or slightly oblong in shape and covered with white mealy powder. Mouthparts absent.

Adult: The species exhibits great sexual dimorphism i.e. males are entirely different from females in size and shape.

Males: Body small, about 5 mm long, front wings are present, hind wings are reduced to small knobs. Body and wings are deep crimson in colour. Antennae long, mouthparts atrophied. These flies are very sluggish.

Females: Much larger than males, upto 2 cm long, body is typically oval in shape and covered with white waxy powder. Antennae small and inconspicuous, wings absent, legs short. These flies walk very slowly.

LIFE HISTORY

The full-fed female enters into the soil and lays 400-500 eggs in cottony sac 2-5 inches deep in the soil in May or June. The eggs hatch in January or February (after 7-8 months) and give rise to very small brown nymphs. These nymphs come up to the surface of soil and then crawl up to their food plants. On the host plant these nymphs fix themselves on tender shoots in March and become mature in April when the winged males appear. After mating with females the males die. The females continue to feed for another 2-3 weeks. When they are full-fed they descend or drop to the ground in the end of May or early June. They enter into the soil to lay eggs, and die. The nymphs require 75 to 140 days to become adults. There is only one generation in a year.

HOST PLANTS

As it is a polyphagous insect, in addition to mango as its primary host, it also feeds on mulberry, citrus, peaches, plums, figs and guava, etc. In addition it infests a number of spring ornamental plants. The loss of plant sap results in the loss of vigour. The infested plants look very unattractive for bearing these bugs.

CONTROL METHODS

Spray Folidol, Diazinon, Metasystox or Lorsban in 0.05% solution on infested plants to kill the bug.

Bemesia tabaci (Aleyrodidae: Hemiptera)
(White fly of motia)

DIAGNOSTICS

This is a small insect which measures about 1 mm or less in length. It looks like a tiny fly. The wings are roundish and held loose and roof like on body. The body and wings are covered with white waxy powder. Normally the adults sit on the leaves but when disturbed they fly sluggishly for a few seconds and then resettle. The eggs are stalked and subelliptical in shape.

The nymphs are suboval in shape, having dentate margin, and vestigial legs. They are usually fixed on leaf surface. The pupae are convex having notches at both the ends. They are yellow with deep yellow patches on abdomen.

LIFE HISTORY

The white flies remain active on motia round the year and breed actively from January to September. It completes several generations (over 10) on it. The eggs are laid singly on leaves. A female may lay up to 100 eggs in her life time. The egg stage lasts from 3-5 days. The nymphal period is completed in 8-14 days. The pupal stage requires 2-8 days. The adults live for 5-12 days. A life cycle is completed in 15-30 days.

HOST PLANTS

It is a polyphagous insect. In general it attacks crops like cotton, tobacco and summer vegetables. Among ornamental plants white flies have been recorded only on motia *(Jasminum sambac)*.

The insect is although quite small but very harmful especially if the population is high. Both the adults and nymphs suck the plant sap with the result that the plants loose growth vigour. Also the adults and nymphs secrete a large amount of honey dew which is deposited on leaves. The leaves become greasy and black because of sooty moulds that grow on honey dew. The plants become weak showing yellow leaves which are covered with black fungus and produce no flowers.

CONTROL METHODS

White flies can be easily controlled by (a) spraying any one of the following insecticidal solutions:

Decis	...	0.012%
Dimercron	...	0.025%
Lorsban	...	0.025%
Malathion	...	0.05%
Perfecthion	...	0.05%

or any other contact insecticide or (b) by applying any one of the following granules:-

Temik 10 G @ 1 gm per sq. metre.

Thimet 10 G @ 1 gm per sq. metre.
Solverex 10 G @ 1 gm per sq. metre.

LEPIDOPTEROUS INSECTS

A large number of lepidopterous species attack numerous ornamental plants in the larval stage. Since they are polyphagous, so in addition to field crops and vegetables they also damage the ornamental plants. These have been discussed in a greater detail elsewhere in this book, only a brief reference is being made to them over here.

The following members of the family Noctuidae have been recorded damaging ornamental plants:-

1.	*Agrotis ypsilon*	} Cutworms
2.	*Agrotis flammatra*	}
3.	*Agrotis segetum*	}
4.	*Laphygma exigua*	Lucern caterpillar
5.	*Euxoa segetis*	Surface caterpillar
6.	*Heliothis armigera*	Army worm
7.	*Heliothis obsoleta*	Army worm

The cutworms attack almost all the ornamental plants in seedling stage in nurseries or soon after transplantation. These larvae live in soil and do their damage at night by cutting and then feeding on the young plants. The remaining noctuids damage the ornamental plants during day time by feeding on the foliage.

The following ornamental plants are being damaged in particular by the above mentioned noctuid insects:-

1.	*Calendula officinalis*	Post marigold
2.	*Rosa* spp.	Roses
3.	*Papaver somniferum*	Garden poppy
4.	*Petunia alba*	Petunia
5.	*Verbina hybrida*	Verbina
6.	*Viola tricolor*	Pansy

Some of the other lepidopterous insects that are pests are:-

1. *Pieris brassicae:* (The common cabbage butterfly attacking:-
   (a) *Brassica oleracea acephala*: (The ornamental cabbage)
   (b) *Tropaelium majus:* (Garden Nasturtium).

2. *Pectinophora gossypiella:* (The spotted boll worm of cotton attacking *Althea rosea,* Holy hock).

Bensonies jacquemonti (Garden snails)

DIAGNOSTICS

Snails are soft bodied animals, belonging to the Class Gastropoda; Phylum Mollusca. The body is asymmetrical and provided with soft boney shell which is in the form of spiral coil. Inside the shell is a fleshy body. Normally the shell is about 1.5-2 cm in diameter. In danger the body is contracted in the shell, but when active the fleshy body comes out of the shell. The head region has two long retractile thread like tentacles which bear the eyes and a posterior large and broad fleshy foot which is used for creeping. They are monoceous i.e., same individual has both male and female organs.

LIFE HISTORY

The snails breed actively in spring. The eggs are laid in loose masses of 50-90 eggs in the soil. The eggs hatch in 7-10 days and young snails emerging from the eggs start feeding up on tender plants. They grow slowly and become adults in about 2 years time. Normally snails are found at all times of a day but during mid-day when it is hot and dry, they hide themselves in plant debris or soil. In extreme summer and winter they undergo dispause, and remain active in large numbers on tree trunks, plant debris, understones and on wooden installations.

The snails feed at night in most places and destroy young shoots of a large number of summer vegetables, fodder crops and ornamental plants in spring. They are polyphagous and have a very broad range of host plants. When their population is high, they may cause serious damage. Also they come out to foot paths, roads and even enter into buildings specially toilets.

HOST PLANTS

They can damage almost all the spring ornamental plants.

CONTROL METHODS

The best and the cheapest method is to control them with sodium chloride (ordinary table salt). If otherwise not undesirable one can even dust dry salt around flower beds in a thin band. This will work as a barrier and the snails will not be able to cross this.

Similarly, cotton cloth impregnated with table salt (by dipping in salt solution and then drying up) may be spread around the flower beds to keep the snails off.

Spraying of Sevin in 0.25% solution or dusting with Sevin dust will kill the snails and help in the protection of plants. Ducks if maintained will actively feed on snails.

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Chapter 9

FOOD STORAGE INSECT PESTS

Umar Khan Baloch* and Mohammad Irshad**

INTRODUCTION

Agriculture is an important sector in the economy of Pakistan and efforts have been made to grow more cereals for food. In the past when food production was not enough, the problem in storage was minimal. The increased production has resulted in storage of grains for longer period. Thus losses became enormous and have attained much significance. Since cereals and pulses are the staple food of people of Pakistan, therefore these have to be stored in their homes by farmers and in big stores by traders, as well as Government agencies. Of various causes responsible for losses in storage, insect pests contribute major share. In Pakistan the storage entomology and other related subjects had mostly been neglected. Several insect species have been found to be associated with stored grains and milled cereals in Pakistan (Lefroy, 1906; Rahman, 1940, 1942a; Janjua and Nasir, 1948; Hamidullah, 1967; Qayyum 1977, 1982; Tahir, 1982; Ahmed, 1983 and Rustamani and Lohar, 1983). Many storage pests have originated in tropical and subtropical areas (Lefroy, 1906). The khapra beetle, *Trogoderma granarium* Everts and rice weevil. *Sitophilus oryzae* (L.) are believed to have originated from India and are now widely distributed in the world. Some of these pests damage the stored commodities severely and others are casual visitors. These species are either primary or secondary pests. Primary pests can destroy the undamaged commodity while secondary ones invade already damaged products. At harvest the grains are mostly free from these pests. the insects reach grain through infested receptacles or transfer of populations. All the important insect species of stored products belong to order Coleoptera or Lepidoptera. the important species are dealt with as below:

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BIOLOGY AND ECOLOGY OF IMPORTANT SPECIES

Sitophilus oryzae (L.) (Curculionidae: Coleoptera)

This is the most destructive primary insect pest of stored grain in the world and is commonly known as rice weevil. Its continuous breeding in stores may cause grain heating and mould formation. It was described for the first time infesting rice in India.

Distribution: It is cosmopolitan in distribution but is generally more injurious in warm humid conditions. It is native to South East Asian Subcontinent. It is distributed almost all over Pakistan

Food: Its hosts include wheat, rice, maize and sorghum. Both adults and larvae cause damage but the latter stage is more destructive.

Biology: Adults of *S. oryzae* are reddish brown and about 3 mm long. The head has a cylinder pointed snout like narrow projection with a pair of stout mandibular jaws at its extremity. The antennae are elbowed and held at right angle when in resting position. It is a strong flier and may move from godowns to the fields or vice versa where it begins to infest the grain by means of its powerful jaws. Afterwards a female lays between 300-400 eggs in her life time. The eggs are small enough to fit in the cavity made by the female who thereafter covers the eggs with a gelatinous fluid forming an egg plug. The tiny fleshy white legless grub after hatching bores into the grain; from where it comes out only as a adult weevil. Incubation period may range between 4-9 days depending on the temperature. The grubs feed voraciously inside the grain but leave the shell intact. A single grub can eat about one third of the grain during its developmental period. The full-grown larva pupates after 19-34 days within the grain. Pupal period may last 4-20 days. The adult bores its way out of grain. The life-span of the adult weevil is four to five months. The life cycle is normally completed in about four weeks. It is unable to breed in the grain when moisture content is below 90%.

Sitophilus granarius (L.)

It is a serious pest in Europe and America but is of little significance in Pakistan. It differs from *S. oryzae* in not having the four spots on wing covers. It is also incapable of flying. Biology is similar to *S. oryzae*.

Rhyzopertha dominica (F.) (Bostrychidae: Coleoptera)

Distribution: This pest is also cosmopolitan in distribution. It is commonly called as lesser grain borer and was first described by Fabricius in 1792 from a shipment of seed and roots carried from India to South America. Therefore, its original home is said to be India. Afterwards it has spread all over the world. It belongs to a family of wood-borers and has adapted to the stored grain after it came in contact with grain as an insect infesting the walls of containers made of wooden material.

Food: It is a serious pest of wheat, maize, rice, sorghum, barley, biscuits, dried potatoes, corn flour, etc. Both the larvae and adults destroy the grain by internal feeding. In some places it is considered to be next to *Sitophilus* but in others it is reported to be causing more damage.

Biology: In the adult stage it is small dark brown or black beetle about 3 mm long. Its body is cylindrical with head turned down under the thorax. The adult is strong flier. A female may lay about 300-500 eggs in batches or singly near the embryonic end of the grain or simply dropped in between the grains. After hatching in 5-10 days the larva enters the grain generally near the comparatively soft embryonic end. The newly hatched larva is white in colour and slightly yellowish towards the head. Some larvae may feed on the powdered starchy material without entering the grain. The larvae moult three times at 35°C and 75% R.H. and 6 times at 25°C and 75% R.H. (Qayyum, 1968). Afterwards these pupate inside the grain. As a result of larval feeding the whole grain gets reduced to a hollow, broken shell. The total life-duration from egg to emergence of adult is about a month. This period can be extended depending upon the temperature. Its developmental period was 59.75 and 27.31 days at 25°C and 52% R.H. and 35°C and 75% R.H, respectively. (Qayyum, 1968).

Trogoderma granarium Everts. (Dermestidae: Coleoptera)

Distribution: Although it is a cosmopolitan insect yet it is serious mostly in the warm dry regions. It is known as khapra beetle locally.

Food: It is a serious primary pest of wheat, maize, sorghum, gram and pulses, pistacho, walnut and other dried fruits. Unlike other beetles its adult is harmless and only larvae damage grains. The attack is generally at the embryonic point but later when infestation becomes severe, other parts of the

grain are also badly damaged. Its attack is serious in ill-ventilated and dark stores.

Biology: Its biology has been reported by Janjua and Nasir (1948) and Rahman *et al.*(1945). The adult female is small, oval, pale, red-brown or black, about 2.5 mm long with indistinct markings on the wing-covers. The elytra are highly clothed with fine hairs and are mild brown. Male is almost half the size of the female. A female may lay about 125 clylindrical eggs which hatch into very prominently hairy larvae. The hairs are reddish brown, movable and erectile and are grouped into a number of bundles along the body, forming a sort of tail at the hind end. The moults of the larvae may cover the surface of the infested ground. Larval development is completed in 27.4 days at 48°C and 49.6 at 20°C (Akbar and Qayyum 1969). The larvae are extremely resistant to insecticides, adverse temperature and humidity and starvation. Besides, in-built protection in the form of hairs and a hard waxy covering on the body surface, the larvae are in the habit of seeking refuge from adverse environment in cracks and crevices, concealed places and in meshes of jute bags. This species can remain alive in such places for several years without food. The resistance gets lost when the larvae change to the pupal stage. The pupal stage occupies one to three weeks and the adults are ready to start next generation soon after emergence. The whole life cycle may be completed under favourable conditions in four weeks but this period may be prolonged to even four years under unfavourable conditions. Its developmental period is shorter on wheat, maize, sorghum, millets and rice than barley, gram, walnut or pista. Larval survival is also higher on rice than sorghum.

As *T. granarium* is resistant to low humidity and moisture content of grain and unlike some other grain pests, this can breed in grains with low moisture content, therefore recommendation of drying of the grain as a control for other pests is of no avail for checking its infestation. Eggs, pupae and adults are highly susceptible to reduction in oxygen tension. Due to this it is generally a surface-feeder and is unable to breed beyond a particular depth below the grain surface. Its infestations are severe at about 75 cm depth and negligible at 2 m (Rahman *et al*, 1945). Therefore, any container is quite a dependable insurance against damage by this pest. As soon as the oxygen in an airtight container is partially consumed due to respiration by grain or insects and is reduced to 16%, the environment inside the airtight container becomes unfit for its breeding.

The larvae and adults of *T. granarium* react negatively to artificial and natural light (Rahman and Sohi, 1939) and behave the same way in nature (Rahman *et al*, 1947 and Sohi, 1947. Sabir et al., (1980) have also reported effect of light and darkness. Light accelerates development of all stages except the pupae but reduces oviposition.

Laethiticus oryzae Water. (Tenebrionidae: Coleoptera)

Distribution: It has world wide distribution. It is a serious pest of many stored grains. Its population is high in humid conditions. It mostly attacks those grains which are already damaged.

Biology: Its adult is light reddish. The eggs are opaque and ovoid and the immature stages complete their development in 29-79 days. Its development is completed in 35.3 and 38.1 days at 30°C and 27.8 and 32.1 days at 35°C on wheat and rice, respectively (Rana, 1982).

Tribolium castaneum (Hbst.) (Tenebrionidae: Coleoptera)

Distribution: The commonly called red flour beetle is cosmopolitan in distribution. It is more abundant during rainy season.

Food: It is a serious pest of wheat and its products. It also feeds on dry fruits, pulses and prepared cereal foods such as cornflakes.

Biology: Its adults are small reddish brown and about 3-4 mm in size. The female may lay about 350 minute, cylindrical and white eggs, which may measure 0.7 x 0.22 mm. The eggs are laid throughout the life of female. The egg stage lasts 5-12 days. The young larva is cylindrical and yellowish white, with hairs covering the body. Larval life ranges between 27-29 days and full grown larva is about 3.6 mm long. Complete mortality of larvae of *T. castaneum* occurs at 40°C and 0, 33.90 and 100% relative humidity while at the same temperature 79.9 and 68.1% mortality was recorded in combination with 52 and 75% relative humidity, respectively (Qamar and Qayyum, 1962). Pupal stage occupies 3-7 days. It may complete its generation in 26 days in summer and 3-4 months in winter.

Its infestation produces disagreeable odour and flavours due to production of benzoquinones from abdominal defence glands.

Oryzaephilus surinamensis (L.) (Silvindidae: Coleoptera)

Distribution: This cosmopolitan insect is not very serious pest.

Food: It feeds on wheat and also dried fruits.

Biology: Its adult is cylindrical and flat with dark brown colours; it measures 2-4 mm. Its thorax on each side contains sharp row of saw like teeth. A female may lay from 45-250 small whitish eggs, which may hatch in 5 days. Larvae are brown headed which become full grown in 12-21 days. Pupal period lasts 6-30 days. There may be 4-6 generations in a year.

Callosobruchus chinensis (L.) (Bruchidae: Coleoptera)

The pulse beetles belong to one family namely Brachidae. The majority of the bruchids attack the leguminous pods in the field from where they are carried to storage godowns. They are known locally as Dhora

Food: It is a serious pest of gram, moong, moth, peas, cowpeas, lentils, etc.

Biology: The adult bruchid, commonly exceed half a centimeter in size and is very characteristic which clearly distinguish it from other pests of storage. Its head is small with a blunt snout, the femur of the hind leg is thickened, elytra are truncate which do not cover the posterior portion of the abdomen. Antennae are serrate or pectinate. In the field, the eggs are laid on developing leguminous pods either on the outside or inside the pod.

Under storage conditions, the beetles often lay a number of eggs on each grain, depending on its size. These eggs are round and yellowish white. They hatch within a few days. Afterwards larva partially cuts a circular disc in the seed-coat which just remains in position and then the larva pupates inside the grain. The larvae after hatching bore into the soft, developing grain. Since the larvae are very tiny on emergence the entry hole is too small and is soon healed up The larvae inside the grain feed and moult. The pulse grain also matures earlier than the insect inside, with the result that the grain is harvested and stored in outwardly healthy condition, although the internal infestation may be quite high. The pupal period lasts only a few days after which the beetle emerges by further cutting out the circular disc into an emergence hole.

Sitotroga cerealella (Oliv.) (Gelechiidae: Lepidoptera)

Distribution: This pest is commonly known as Angoumois grain moth simply because it was first described from the French province Angoumois in 1736. It is cosmopolitan

Food: It feeds on wheat, maize and some other grains. Only the larvae cause damage by feeding on the grain kernel. High humidity and high moisture are important prerequisites for the development of this pest. It is also more serious when the grain is lying in open places. Its infestation generally does not exceed beyond a few inches below the surface of stores. In the surface layer the infestation is often very serious. In countries where moisture is generally high, this is a major pest

Its infestation starts when the crop is still in the field. Obviously during this period it is very easy for the moth to move from ear to ear and lay eggs. This movement gets restricted once the grain is cleaned and stored.

Biology: The adult is a small moth of 1.25 cm in wing span, yellowish-brown in colour and with very prominent wide fringes along the wing-margins. It can lay up to 400 eggs which are deposited indiscriminately on or in between the grains on the earheads in the field, on threshing-floor and in the store. The egg is about 0.5 mm in size, white and oval in shape but soon it turns bright red and hatches within a week. The young larva crawls about a little and soon finds out a comparatively weak spot, like crack or abrasion, through which it enters the grain. Inside the grain larva often turns about and practically closes the entry hole by a silken web. A full grown larva is about 5 mm. Its colour is white with yellowish head. Infested grain is practically hollowed, and its contents are replaced by faeces and other refuse. At this stage, the larva cuts out a circular exit hole, leaving over it just a sort of cap which the future moth can easily push off. Thereafter the larva spins a silken cocoon inside the grain and transforms itself into a brown pupa. The pupal period lasts for a week. It overwinters as a larva in cooler areas. There can be several generations in a year, depending on temperature and humidity. It is not generally easy to detect the infestation by means of the entry hole. The first indication of the infestation comes rather suddenly when adult moths emerge and exit-holes become prominently visible on individual grains.

The weakest spot in the life-history of this pest is its requirement of high moisture-content in the grain, hence its damage can be kept low by proper manipulation of the grain moisture content.

Corcyra cephalonica (Stn.) (Pyralidae: Lepidoptera)

This pest which is commonly called as rice moth is more severe in neglected old godowns.

Food: It damages rice, sorghum, maize, groundnut and cotton seed

Distribution: It is world wide in distribution but is more abundant in the humid conditions. Its biology is reported by Janjua and Nasir (1948) and Rahman and Mullick (1946). The adult female may lay 100-200 eggs which are white, elliptical, measuring 0.5 x 0.3 mm. Moths are active at night and lay eggs singly or in groups of 3-5 each on the grains, bags or other objects in the stores. Incubation period ranges between 4-5 days. The creamy white larva has a prominent head. The larva makes long galleries and feed under silken web like shellers. It prefers partially damaged grains. Larval life ranges between 23-50 days. The larvae feed on the surface of grain.

Ephestia cautella (Walk.) (Pyralidae: Lepidoptera)

It is a secondary pest of different cereals and is known as ware house moth.

Food: It is a serious pest of dried fruits like dates, berries, figs, almonds, walnuts, etc.

Distribution: According to Hussain and Ahmad (1953) this pest probably entered Pakistan alongwith dried fruits and wheat imported from other countries.

Biology: The inner one third of the forewing of newly emerged adult is pale yellow. The labial palps are long and held covered up in front of the head. The adult female may live for 7-14 days and does not feed. The female lays eggs loosely. The larvae move extensively through the commodity and spin webbing. Before pupation larvae wonder out of commodity and find a suitable site for pupation. Adults rest at night. Its total life cycle may be completed in 44-62, 65-82, 33-57 and 30-47 days on wheat flour, maida, whole rice and dates, respectively in summer.

In addition to above species, *Ahasverus advena* (Walt.), *Alphitobius laevigatus* (F.), *Attagenus megatoma* (F.), *Blattella germanica* L., *Callosobruchus annalis* (F.), *C. maculatus* (F.), *C. phaseoli* (Gyll.), *C. subinnotatus* Pic., *Cryptolestes ferrugineus* (Steph.), *C. pusillus* (Schon.), *Gibbium* sp., *Lae-*

theticus oryzae Waterh., *Laemopohaleus minutus* Oliv, *Lasioderma serricorne* (F.), *Lophocateres pusillus* (Klug.)., *Opatorides punctulatus* Brulle, *Oryzaephilus mercator* (Fauv.), *Palorus ratzeburgi* (Wissm.), *Periplanata americana* L., *Plodia interpunctella* (Hubn.), *Ptinus* sp., *Pyralis farinalis* L., *Saprinus* sp., *Scleron sulcatum* Baneh., *Tenebrio molitor* L., *Tenebriodes mauritanicus* (L.), and *Triboluim confusum* J., duvel. are also reported as minor pests of stored grain (Anon, 1953; Hussain and Aslam 1953; Anisa, 1971; Anisa and Anwar, 1971, Rustamani & Lohar, 1983 and Ahmed, 1983).

CONTROL METHODS

It is comparatively easy to protect the grains meant for seed but difficult to safely store grains for human consumption especially for a longer period. Temperature and humidity are important factors in the build of insect populations. A lot of attention is now being given to the construction of proper types of godowns for large scale storage. The aim of a successful storage is to avoid, damage by insects, deterioration of quality and to protect germinating power of grain. The following methods of control are practised.

Chemical

a. **Pesticides:** For the reduction of losses caused by insects chemical control is widely used. Control of these pests by mercury had been advocated by Rahman and Sohi (1946) and Nasir (1949). However, with the availability of organic insecticides, mercury is now being used at a lesser extent. Application of mercury in grains meant for human and cattle consumption does not seem to be advisable due to its lethal effect on them (Anon, 1983). The advent of modern insecticides for storage pest control has opened new horizons. A large number of chemicals like DDT, BHC, malathion, methyl parathion, bromophos, chlordane, lindane, reldane, ambush, sumithion, sumicidin, diazinon, fenitrothion, nogos, DDVP, gardona, actellic and petkolin have been tested in the laboratory against pests of stored grains (Ahmad, 1975, 1980; Ahmad *et al.*, 1976; Ahmed, 1973; Ahmed and Ausaf, 1978; Aijaz and Biag 1970; Aijaz *et al.*, 1971; Anwar, 1957, 1961; Ausaf and Ahmed, 1976; Baig and Aijaz, 1971; Butt, 1971; Din, 1971; Elhaj and Ahmad, 1979; Faizanuddin, 1973; Ghaffar and Haq, 1975; Huque *et al.*, 1969; Hussain and Anwar, 1956; Hussain and Fisk, 1955; Ishaque, 1976; Khan, 1981; Khattak; 1976; Khattak *et al.*, 1973; Mahmood, 1975; Masud, 1974; Nasir, 1946; Nasir and Khan, 1973; Nisa and Ahmed, 1970; Qayyum and Hussain, 1972, Qud-

dus, 1969; Siddique *et al.*, 1976 and Waheed, 1971). Some of the pesticides tested are not recommended against stored grain pests. Ahmad (1975, 1980) reported that fenitrothion @ 4 ppm can protect wheat from *Trogoderma* for 8-10 months while phoxim, gardona and malathion for 10, 7, and 5 months, in the field. Malathion and nogos have positive temperature co-efficient as against negative by DDT and BHC on *Rhyzopertha dominica* at 25, 30 and 35°C. Residual toxicity of diazinon, malathion, DEVP and BHC decreases when temperature increases from 25°C to 30 and 35°C (Butt, 1971). Lindane can give protection of grains against pests for 4 months. Methyl parathion has longer residual effect and food products treated with it could prove toxic to human beings (Din, 1971). It is also reported that fenitrothion and malathion can protect the stores from insects for 1 to 8 months, respectively, @ 1/8 gal of 50-57% malathion in 2-5 gallons of water per 100 tones (Ahmad, 1980). Derivatives from plants like *Pyrethrum*, *Calotropis*, *Gardonia*, neem, and turmeric have also been tested by Jilani (1973 & 1980), and Jilani & Malik (1973). Some of the compounds are reported to be quite effective. Present studies indicate that resistance has developed in many stored grain pests against malathion, lindane and some other pesticides, therefore these should not be used.

b. **Fumigation:** This is an important method of preventing pest population becoming serious in the stores at farm level, private sector or public sector storage. A lot of progress has been made elsewhere in the world in the recent past in this field. In Pakistan still a lot of fumigation work is needed.

Anonymous (1950 & 1951) reported successful fumigation by Dowfume EB5 of wheat grains in the open under tarpauline while Latif and Khan (1950a) reported 100% mortality of different pests with phosphine and EDCT. Effective fumigation with chlorosal, kilpoptera and Dowfume was obtained by Anonymous (1952) while Hussain (1953) did experiments with 12 lbs of Sodium cyanide per 5 bags under tarpauline and 4 per 550 maunds in Railway wagons. Ahmad and Hussain (1953) obtained satisfactory control of food grains in ships with EDCT. Ahmad and Shahzaman (1973) have published a guide for fumigation containing material on dosage, dose precautions, etc. Ahmad (1980) recommended EDCT @ 45 lb/1000 maunds or 2,000 cu ft. of air tight chamber or Aluminium phosphide as recommended by the manufacturer. Qayum (1982) found that phostoxin, EDCT & detia when applied at interval of 3, 7, 14 & 21 days did not affect the germination of some wheat varieties.

Studies by Alam *et al.* (1984) show that present system of fumigation is ineffective due to leakage of gas. Therefore, it is essential to make stores airtight. Most of the old stores in the public sector are unsuitable to be made airtight. Therefore, it is now recommended to fumigate under polythelene sheets. In the farm level storage the availability of fumigants and health hazards are important factors. Temperature is important in fumigation and very little work has been done on this in Pakistan. Recent studies show that stored grain pests have developed resistance to phosphine, therefore it must be used with great care to have economic control.

Biological

Biological control of insect pests is gaining more importance due to heavy losses incurred by pests. The chemical control being more expensive and hazardous need to be used to a lesser extent. Before any attempt on biological control of insect pests of stored grain is made, it is essential to know the fauna of beneficial species present. Some of the biotic agents have been recorded in Pakistan but detailed studies have not been undertaken.

Azim (1968) found *Bruchobius laticeps* (Ashm) and *Aplastomorpha calandrae* How. (Pteromalidae) from *Callasobruchus maculatus* and *Chaetospila elegans* W. (Spalangidae) from *C. maculatus* and *Lasioderma serricorne and Microbracon hebetor* Say. (Braconidae) from *Ephestia cautella.* Their biology on different temperatures has also been reported. Rahman (1942) reported *B. laticeps* and *Cephalonomia tarsalis* (Ashm) as parasites of stored grain pests while Anwarullah and Khan (1967) and Anwarullah *et al.*, (1966) found *Anisopteromalus calandrae* (How.), *C. elengens* and *Acarophenax tribolii* Newstead Duvell. as larval parasites of *Sitophilus oryzae* and *Rhizopertha dominica.* Hussain and Aslam (1953, 1970) found various stages of *Amphibolus venator* Klug. a reduviid feeding on larvae. These are voracious feeders. Zaman (1975) recorded the predatory mite *Pyemotes ventricosus* Newport from *Trogoderma granarium.* Pathogenicity of *Bacillus* to stored grain pest has been discussed by Naeem (1978) and Anonymous (1980).

Mechanical/Physical

It appears that some of the physical factors are important in regulating the population of pests. The most striking example is sun drying, cleaning and winowing practised by many farmers in the villages. It is evident if a good quality grain is stored then the losses are minimum.

Latif and Khan (1950) recorded good results of sun heating to control stored grain pests. Hafiz and Hussain (1961) and Ahmad (1963) recommended among others harvesting, threshing and drying of grains at proper time, cleaning and disinfection of premises as control measures. Hussain and Hussain (1970) reported 100% mortality of larvae of different ages of *Trogoderma granarium* by a vacuum of 10 mm pressure of 22 hours and released in 2 minutes at ordinary room temperature. Rahman & Sohi (1941) have discussed the role of superheating.

Radiation

Radio active materials have been tested in the past for the control of insect pests including those in the stored grain. This method shortens the life of an insect, stops its development and irridiated insects do not mostly develop resistance to radiation. Radiation studies in Pakistan have been mostly confined to the laboratory and no definite efforts have been made for their use in the field. However, its use in the store seems to be limited and for the same reason it could not be widely practised. The studies have been conducted in Pakistan on different doses against various stages of pests like *Triboluim castaneum, Rhyzopertha dominica, Lasioderma serricorne, Callosobruchus* spp, *Sitotroga cerealella, Ephestia cautella,* and *Corcyra cephalonica,* by Ahmed and Opal (1975), Ahmed *et al.,* (1976), Huque (1963, 1964, 1971), Huque and Anisa (1965), Huque and Kazmi (1965), Huque and Khan (1964, 1965, 1969), Huque and Malik (1965), Hussain (1975), Hussain *et al.,* (1967), Khattak and Jilani (1981), Khattak and Malik (1979) and Opal and Ahmed (1975). According to Huque (1963) higher doses of radioactive material give instant kill of pests but adversely affect the viability of grain, though the nutritive value of the grain is not affected. Gamma rays in all probability affect the activity of growth harmones of larvae of *Callosobruchus.*

Varietal Susceptibility

It is well known that varieties behave differently to insect species and this aspect is now being given importance in breeding programme. Variety to be developed should have characters making them less susceptible to pests and diseases. In Pakistan much attention has not been given to this aspect, and especially in storage the work is much neglected. Some work has been conducted to know susceptibility of different varieties of wheat, rice, maize and pulses by Hussain and Naqvi (1955, 1955a), Khan (1978), Shah (1969), Azeem *et al.,* (1976) (Khan 1978), and Shafique (1979).

The available information indicates that varieties of grains and pulses are either resistant or susceptible to different stored grain pests. However, some more detailed investigations are required to use this information in breeding programme of crops.

CONCLUSIONS

In Pakistan principles of store hygiene are not strictly followed and losses caused by insects can be prevented if a well coordinated programme of control is followed by the farmers, commercial grain dealers, mill owners and government food department agencies. Some of the important measures are proper harvesting, threshing, and drying the grain; cleaning and disinfestation of premises, application of residual sprays and fumigant; insect control in transport; application of grain protectant and regular inspection. In the public sector storage there are much defects in the designs, store maintainance and management. These factors allow the population of insects, rodents and birds to contaminate the stock. Spillage is also allowed to accumulate in the public sector storage. Ahmad (1980) is of the opinion that post harvest losses can be reduced to a considerable extent if protective cum remedial measures are strictly followed. Hafiz and Hussain (1961) have formulated some proposals for safe storage of seed due to its importance. Safe storage of wheat and other grains has been discussed by various workers (Jilani and Ahmed, 1982) and Makhdommi and Ulfat (1983), but detailed experiments have not been conducted to formulate these recommendations.

Anonymous (1951) reported fabrication of folding bins for farm storage and afterward no progress has been reported. A lot of laboratory work has been done on chemical control of pests but more of academic nature than field. Alternative methods for protection of stored grains are urgently needed.

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INSECT PEST MANAGEMENT

Horticultural and Forest Crops

Volume 2

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FOREWORD

One of the most difficult thing in the world is transforming ideas and scribbles into an organized format. The present book is a testimony to the fact that Pakistani scientists have the capability and capacity to do so. With our own brand of ideas, beliefs, social values and a tendency to doubt the veracity of obvious, the present effort is a courageous and laudable step towards self reliance in text books. It will help standardise and improve quality of education in plant protection and lessen dependency on foreign books. Although an onerous task, the book is based on the principle of inclusion of diverse experience and intellect in order to elicit a sense of national cohesion and identity-awaited for since the creation of Pakistan.

It is universally acknowledged that one of the factors that lead to the initiation and sustenance of the process of development is a sound footed education which is not possible without indigenous books.

The material presented is not a narration of the facts but a happening in which the real life situation about pest insects hitherto unrecognized has been subtly yet scholarly unfolded. There is a touch of futurism and a pinch of surrealism. The true aim is to achieve greater naturalism by exact analysis of diverse insect-plant interactions and available techniques to weaken this symbiosis.

After the publication of "Pests and Pesticides in Pakistan", this three volume book on Insect Pest Management is a breath taking sojourn into a realm of devotion and untiring stamina of Dr. Hashmi. The book symbolizes his perseverance, tenacity and insight about resolution of national issues.

It is a matter of great satisfaction to note that the book covers sufficient material to meet all the immediate and diverse demands of students, teachers, researchers, extension workers and above all progressive as well as small farmers and thus fulfills PARC mandate of dissemination of

knowledge. It is expected to bring a change in the style of thinking and acting of researchers and to facilitate wider practical application of the available knowledge to realities of life. This book will serve as a stimulus to further improvement of the principles and methods of integrated plant protection, and will further enhance the development of the new technologies for each and every crop and its zones of cultivation.

(Dr. Zafar Altaf)
Chairman
Pakistan Agricultural Research Council,
Islamabad

April, 1994

PREFACE

Global experience shows that even in the best managed agro-ecosystems where optimum levels of agro-chemicals and energy inputs are maintained the annual losses due to insects are as high as 20-30% of the total yield. These can be even higher for same crops in years of epidemic outbreaks.

Consequently one cannot seriously think of increasing the effectiveness and stability of agricultural production, unless the losses are reduced to minimum. Innumerable studies and practical experience has shown that adaptation of individual measures are insufficient to ensure long-term suppression of a number of harmful organisms. The great diversity of insect pests, the dynamics of their development and a whole range of susceptible commodities/crops, all make different demands on plant protection technologies.

During the last two decades three new concepts have entered the scenario of agricultural research in Pakistan. These are: Integrated Pest Management (IPM), Farming System Research (FSR) and National Coordinated Programmes (NCP) on various commodities.

There is also a group of researchers who have acquired specialized knowledge about different groups of organisms. Their knowledge and experience is equally useful for workers in IPM, FSR and NCP and it also sets a stage for inroads in research in the years to come.

All of these three themes require accurate, detailed and in-sequence information. For instance, for decision making in IPM, one needs proper diagnostics of all life stages of an insect, its life and seasonal history, host-plants and various options of control methods to subdue its population. For farming system research, the economic aspect of pre- & post-harvest pest control technology becomes a demanding element. And how the crops, and

animal husbandry technology should be meshed up for economically profitable, environmentally sound and socially acceptable endeavours? The commodity programmes for their successful optimization of yield aspect need a detailed information about the total insect pest complex of the crop and how the occurrence of various pest species is linked with the phenology of each crop. Is there any carry over of the pests on a commodity from one season to the other? What will be possible insect pest scenario under intensive agriculture?

In the educational institutions most of the teaching in entomology is carried along the taxonomic lines or individual pests are discussed as information communication unit. Thus, there are different groups of clients with different demands for information.

In this book, therefore, an effort has been made to meet the needs of all groups by apportioning the book into insect pests attacking agricultural crops, forests, stored grains, some special groups of insects and mites on which useful work at national level has been done. To these some material has also been added on the entomological industries e.g. apiculture, sericulture and lac culture.

The book tends to provide mostly the basic information and does not cover an extensive review of each and every insect. Part of this is that most research papers dealt with dose estimations of different insecticides, some of which never got into the recommendation domain. Thus, large number of research papers of this kind could not be utilized. The Fundamentals of General and Applied Entomology have been discussed in a separate book and it is expected that both books will be utilized simultaneously to reinforce the materials' utility.

March, 1994 Ali Asghar Hashmi

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Credit for initiating the idea of writing indigenous text and reference books in various disciplines of agriculture goes to Dr. Amir Muhammed, who always motivated and encouraged the scientists to make efforts in line with national needs and aspirations. This book also owes debt to his inspiring imagination. Dr. Zafar Altaf, who believes in originality, creativity, pragmatism and dynamism, immediately sanctioned the necessary funds as soon as three-volume manuscript was presented to him for publication. A deep sense of gratitude is expressed for the kindness of both of them.

During the preparation of this book Mrs. Afzala Tashfeen, (Scientific Officer) and Mr. Gul Zaman, (P.A) gave lot of their time for proof reading, correcting and retyping of the manuscript, respectively. Mr. Javed Iqbal, Senior Scientific Officer, assisted in preparation of species index. The book got into the presentable form due to help in editing by Ms. Sabira Hussain.

It would not have been possible to give final shape to the book and ultimately publish it without technical input of the Directorate of Publications, PARC. The staff of the Directorate finally edited the manuscript before and during composing in frequent consultation with the author. They also designed and determined the format of three volumes of this publication and finally read and checked the composed manuscript, besides technically supervising their printing. In this context, the input rendered by Malik Mushtaq Ahmad, Mr. Nassar Iqbal, Mr. Afzaal Haider and Mr. Abdul Ghaffar is respectfully acknowledged.

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Such a stupendous task of writing a book could not have been possible without the patience of my wife Munazza Hashmi and my little loving son Kamal Asghar Hashmi

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Chapter 10

INSECT PESTS OF PLAIN FRUITS

M. Rafiq Khan*

Eversince the appearance of man on earth, fruits have been his most relished and favoured food. Fruits are well-known as a comparatively cheap source of some health-giving and nutritional constituents, so essentially required for rationalising the dietary regime of our people.

In Pakistan, both soil and climatic conditions are conducive and encouraging for the cultivation of a large variety of fruits. The major fruits grown in the plains of Pakistan comprise citrus, mango, guava, date palm, banana, 'ber', pomegranate and grapes. About 68.1, 17.4, 9.0 and 5.5 per cent of the total fruit area lies under these crops in Punjab, Sindh, Baluchistan and N.W.F.P., provinces, respectively. Besides the major fruits, certain tropical fruits like peaches, plums, pears, apricot have gained popularity in the foot-hills of Baluchistan, N.W.F.P. and Punjab provinces. Among the other fruits, loquat, fig, 'chiku', 'litchi', 'falsa', papaya, coconut, persimmon, mulberry, avocado, 'jaman', etc. occupy 56.7, 23.0, 15.7 and 4.6 per cent of the total area under other fruits in the Punjab, Baluchistan, N.W.F.P. and Sindh province, respectively.

There are, a large number of local and exotic insect pests that take a heavy toll of fruit crops and deleteriously affect the further development of the fruit industry. Even at a very conservative estimate, the loss of yield caused by insect pests is no less than 10 to 15 per cent, although a total failure of bearing in or a complete drying up of certain fruit trees due to insect depredation is a matter of no uncommon observation in our country (Haq and Akmal, 1964). This situation is quite alarming and needs to be overcome through adopting extensive and thorough plant protection measures against insect pests, without which, it can be genuinely feared, that the fruit industry will not be in a position to occupy its rightful place in our agricultural economy. Bringing the fruit trees into bearing, producing high

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grade fruits and placing fruit gardens on a paying basis, call for skill, insight, knowledge, close observation and keen attention. There is no gainsaying the fact that this objective cannot be achieved successfully and expeditiously unless the fruit growers, extension workers and others concerned, who are to undertake plant protection measures, possess complete information about the identification, life-history, habits and control measures of these pests. This information pertaining to 233 major and minor pests of 23 fruit trees grown in the plains of Pakistan has been included herein in a consolidated form, for ease of reference, in time of need.

Citrus

Citrus psylla	*Diaphorina citri* Kuw.	(Psyllidae: Hemiptera)
Citrus whitefly	*Dialeurodes citri* Asham	(Aleyrodidae: Hemiptera)
Citrus whitefly	*Aleurocanthus woglumi* Ashleyd	(Aleyrodidae: Hemiptera)
Citrus whitefly	*Dialeurodes elongata* Dozier	(Aleyrodidae: Hemiptera)
Citrus whitefly	*Aleurocanthus husaini* Corbett	(Aleyrodidae: Hemiptera)
Citrus whitefly	*Aleurolobus citrifolii* (Corbett)	(Aleyrodidae: Hemiptera)
Citrus whitefly	*A. marlatti* (Quaint)	(Aleyrodidae: Hemiptera)
Citrus whitefly	*A. nilotucus* P&H	(Aleyrodidae: Hemiptera)
Citrus whitefly	*Aleurotuberculatus murrayae* (Singh)	(Aleyrodidae: Hemiptera)
Citrus whitefly	*A. jasmini* Tak	(Aleyrodidae: Hemiptera)
Citrus whitefly	*Acaudaleyrodes citri* P&H	(Aleyrodidae: Hemiptera)
Citrus whitefly	*Aleuronachelus* sp	(Aleyrodidae: Hemiptera)
Citrus scale	*Icerya aegyptiaca* (Dongl.)	(Margarodidae: Hemiptera)
Citrus scale	*Perissopneumon tamarindus* (Green)	(Margarodidae: Hemiptera)
Citrus scale	*Lepisma virgata* (Ckll.)	(Pseudococcidae: Hemipteraa)
Citrus scale	*Nipaecoccus vastator* (Msk)	(Pseudococcidae: Hemipteraa)
Citrus scale	*Planococcus citri* (Ris.)	(Pseudococcidae: Hemipteraa)
Citrus scale	*Spilococcus* sp	(Pseudococcidae: Hemipteraa)
Citrus scale	*Aonidiella aurantii* (Maskel)	(Diaspidae: Hemiptera)
Citrus scale	*Aonidiella citrina* (Coqvillet)	(Diaspidae: Hemiptera)
Citrus scale	*Chrysomphalus dictyospermum* Morgan	(Diaspidae: Hemiptera)
Citrus scale	*C. aonidum* (L.)	(Diaspidae: Hemiptera)
Citrus scale	*Parlatoria ziziphus* (Luc.)	(Diaspidae: Hemiptera)
Citrus scale	*P. oleae* (Clovee)	(Diaspidae: Hemiptera)
Citrus scale	*Lepidosaphes gloveri* (Pack)	(Diaspidae: Hemiptera)
Citrus scale	*L. conchiformis* (Gimelin)	(Diaspidae: Hemiptera)
Citrus scale	*Pinnaspis strachani* (Cooley)	(Diaspidae: Hemiptera)
Citrus mealy bug	*Pseudococcus filamentosus* Ckll	(Pseudococcidae: Hemiptera)
Citrus mealy bug	*P. citri* Ris	(Pseudococcidae: Hemiptera)
Citrus black aphi	*Aphis citricidus* Kirk	(Aphididae: Hemiptera)
Citrus black aphi	*Toxoptera aurantii* (Boy deF)	(Aphididae: Hemiptera)
Citrus thrip	*Astrothrips* sp.	(Thripidae: Physanoptera)
Citrus leaf miner	*Phyllocnistis citrella* (Staint)	(Phyllocnistidae: Lepidoptera)
Citrus butterfly	*Papilio demoleus* (Linn)	(Papilionidae: Lepidoptera)
Leaf eating caterpillar	*Indarbela tetraonis* (Moore)	(Arbelidae: Lepidoptera)
Fruit fly	*Dacus dorsalis* Hendel.	(Tephritidae. Diptera)
Fruit fly	*D. cucurbitae* Coquill	(Tephritidae: Diptera)

Fruit fly	*D. zonatus* (Saund)	(Tephritidae Diptera)
Fruit fly	*D. diversus* Coqvill	(Tephritidae Diptera)
Fruit fly	*D. cihatus* Lowe	(Tephritidae Diptera)
Citrus red mite	*Panonychus citri* (McGregor)	(Tetranychidae Acarina)
Citrus red mite	*Lotetranychus sexmaculatus* (Riley)	(Tetranychidae Acarina)
Citrus red mite	*Lutetranychus orientalis* (McGregor)	(Tetranychidae Acarina)
Citrus red mite	*T. telarius* L	(Tetranychidae Acarina)
Citrus red mite	*Brevipalpus amicus* Chaudhri	(Tenuipalpidae Acarina)
Citrus red mite	*Tenuipalpus masius* Chaudhri	(Tenuipalpidae Acarina)

Mango

Mango hopper	*Idioscopus clypealis* (Lethierry)	(Cicadellidae Hemiptera)
Mango hopper	*Amritodus atkinsoni* (Lethierry)	(Cicadellidae Hemiptera)
Mango gall Psyllid	*Apsylla cistellata* (Buckt)	(Cicadellidae Hemiptera)
Mango mealy bug	*Drosicha stebbingi* (Gr.)	(Monophlebidae Hemiptera)
Mango mealy bug	*Icerya aegyptiaca* (Dougl.)	(Monophlebidae Hemiptera)
Scale insect	*Lepidosaphes gigantea* (Ckll.)	(Pseudococcidae Hemiptera)
Scale insect	*Pseudococcus filamentosus* (Ckll.)	(Pseudococcidae Hemiptera)
Scale insect	*Spilococcus* sp	(Pseudococcidae Hemiptera)
Scale insect	*Rastrococcus spinosus* (Rob.)	(Pseudococcidae Hemiptera)
Scale insect	*Planococcoides robustus* Ezz, & McC.	(Pseudococcidae Hemiptera)
Scale insect	*Ceroplastes actiniformis* Green	(Coccidae Hemiptera)
Scale insect	*C. floridensis* Comst	(Coccidae Hemiptera)
Scale insect	*Coccus hesperidum* L	(Coccidae Hemiptera)
Scale insect	*C. mangiferae* (Green)	(Coccidae Hemiptera)
Scale insect	*Vinsonia stellifera* (Westw.)	(Coccidae Hemiptera)
Scale insect	*Pulvinaria psidii* Msk	(Coccidae Hemiptera)
Scale insect	*Lecanium formicarum* Green	(Coccidae Hemiptera)
Scale insect	*Aspidiotus destructor* Sign	(Diaspidae Hemiptera)
Scale insect	*Parlatoria crypta* (Mck.)	(Diaspidae Hemiptera)
Scale insect	*P. cinerea* Hadden	(Diaspidae Hemiptera)
Scale insect	*P. pseudopyri* Kuw	(Diaspidae Hemiptera)
Scale insect	*Lindingaspis ferrisi* Msc	(Diaspidae Hemiptera)
Scale insect	*L. floridana* Ferris	(Diaspidae. Hemiptera)
Scale insect	*Aonidiella orientalis* (Newst.)	(Diaspidae Hemiptera)
Scale insect	*A. citrina* (Coq.)	(Diaspidae Hemiptera)
Scale insect	*Aulacaspis tubercularis* Newst.	(Diaspidae Hemiptera)
Scale insect	*Hemiberlesia lataniae* (Sign.)	(Diaspidae Hemiptera)
Scale insect	*Chrysomphalus aonidum* (L.)	(Diaspidae Hemiptera)
Scale insect	*Genaparlatoria pseudaspidiotus* (Lind.)	(Diaspidae Hemiptera)
Scale insect	*Lepidosaphes pallida* Green	(Diaspidae Hemiptera)
Bark eating caterpillar	*Indarbela tetraonis* (Moore)	(Pseudarbellidae Arbelidae: Lepidoptera)
Mango fruit fly	*Dacus ferrugineus* Fb	(Tephritidae Diptera)
Mango fruit fly	*D. zonatus* Saund	(Tephritidae Diptera)
Mango fruit fly	*D. diversus* Coq	(Tephritidae Diptera)
Mango fruit fly	*D. dorsalis* Hendel	(Tephritidae Deptera)
Mango leaf gall insect	*Amiaemyia* Sp	(Cynipidae Cecidomyidae. Diptera)
Mango stem borer	*Batocera rufomaculata* (DeGeer)	(Gerambycidae. Coleoptera)
Mango stem borer	*Batocera rubus* L.	(Cerambycidae. Coleoptera)
Mango stone weevil	*Sternocheus mangiferae* F.	(Curculionidae Coleoptera)
Mango bud mite	*Aceria mangiferae* Sayed.	(Eriophydae Acarina))

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Guava

Scale insect	*Icerya aegyptiaca* (Dougl.)	(Margarodidae Hemiptera)
Scale insect	*Hemaspidoproctus cinereus* Green	(Margarodidae Hemiptera)
Scale insect	*Fernisia virgata* (Ckll.)	(Pseudococcidae Hemiptera)
Scale insect	*Pseudococcus filamentosus* Ckll	
Scale insect	*Spilococcus* sp	(Pseudococcidae Hemiptera)
Scale insect	*Ceroplastes acuminformis* Green	(Coccidae Hemiptera)
Scale insect	*C. floridensis* Comst	(Coccidae Hemiptera)
Scale insect	*Coccus hesperidum* L.	(Coccidae Hemiptera)
Scale insect	*Saissetia nigra* (Nieten)	(Coccidae Hemiptera)
Scale insect	*Pulvinaria psidii* Mask	(Coccidae Hemiptera)
Scale insect	*Aonidiella orientalis* (Newst.)	(Diaspidae Hemiptera)
Scale insect	*A. aurantii* (Mask.)	(Diaspidae Hemiptera)
Scale insect	*Chrysomphalus aonidum* (L.)	(Diaspidae Hemiptera)
Scale insect	*Hemiberlesia lataniae* Sign	(Diaspidae Hemiptera)
Scale insect	*Aspidiotus destructor* Sign	(Diaspidae Hemiptera)
Bark eating caterpillar	*Indarbela tetraonis* (Moore)	(Pseudarbelidae Lepidoptera)
Hairy caterpillar	*Euproctis lunata* Wlk	(Lymantriidae Lepidoptera)
Hairy caterpillar	*E. fraterna* Moore	(Lymantriidae Lepidoptera)
Fruit fly	*Dacus diversus* Coq	(Tephritidae Diptera)
Fruit fly	*D. zonatus* Saund	(Tephritidae Lepidoptera)
Fruit fly	*D. ferrugineus* F	(Tephritidae Lepidoptera)
Fruit fly	*D. dorsalis* Hndl	(Tephritidae Lepidoptera)
Fruit fly	*Carpomyia vesuviana* Costa	(Tephritidae Lepidoptera)

Date Palm

Scale insect	*Icerya aegyptiaca* (Dougl.)	(Margarodidae Hemiptera)
Scale insect	*Fernisia virgata* (Ckll.)	(Pseudococcidae Hemiptera)
Scale insect	*Parlatoria blanchardi* (Targ.)	(Diaspidae Hemiptera)
Scale insect	*Aspidiotus destructor* Sign	(Diaspidae Hemiptera)
Rhinoceros beetle	*Oryctes rhinoceros* (L.)	(Dynastidae Coleoptera)
Red palm weevil	*Rhynchophorus ferrugineus* (Oliv.)	(Curculionidae Coleoptera)
Date palm mite	*Raoiella indica* Hirst	(Tenuipalpidae Coleoptera)
Date palm mite	*Brevipalpus rica* Chaudhri	(Tenuipalpidae Coleoptera)
Date palm mite	*Colopalpus eriophyoides* (Baker)	(Tenuipalpidae Coleoptera)
Date palm mite	*Eutetranychus orientalis* (McGregor)	(Tetranychidae Coleoptera)

Banana

Banana aphis	*Pentalonia nigronervosa* Cock	(Aphididae Hemiptera)
Scale insect	*Aspidiotus destructor* Sign	(Diaspididae Hemiptera)
Scale insect	*Chrysomphalus aonidum* (L.)	(Diaspididae. Hemiptera)
Scale insect	*Parlatoria crypta* (Mck.)	(Diaspididae Hemiptera)
Scale insect	*Pulvinaria* sp	(Coccidae Hemiptera)
Scale insect	*Saissetia nigra* (Nieten.)	(Coccidae Hemiptera)
Meely bug	*Pseudococcus* sp	(Pseudococcidae Hemiptera)
Banana thrips	*Heliothrips* sp.	(Thripidae Thysanoptera)
Lead eating caterpillar	*Spodoptera litura* F.	(Noctuidae Lepidoptera)
Fruit fly	*Dacus ferrugineus* F	(Tephritidae Diptera)
Fruit fly	*D. tryoni* Frogg.	(Tephritidae Diptera)
Leaf eating beetle	*Nodostoma subcostatum* Jacoby	(Chrysomelidae Coleoptera)

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Banana weevil	*Cosmopolites sordidus* (Germer)	(Curculionidae Coleoptera)
Banana weevil	*Odoiporus longicollis* (Oliv.)	(Curculionidae Coleoptera)

Ber

Scale insect	*Icerya* sp	(Margarodidae Hemiptera)
Scale insect	*Pericoccus* sp	(Margarodidae Hemiptera)
Scale insect	*Nipaecoccus vastator* (Mask.)	(Pseudococcidae Hemiptera)
Scale insect	*Pseudococcus filamentosus* Chll	(Pseudococcidae Hemiptera)
Scale insect	*Maconellicoccus hirsutus* Green	(Pseudococcidae Hemiptera)
Scale insect	*Ceroplastodes cliton* Green	(Coccidae Hemiptera)
Scale insect	*Laccifer lacca* (Kerr.)	(Coccidae Hemiptera)
Scale insect	*Aonidiella aurantii* (Mask)	(Diaspidae Hemiptera)
Scale insect	*A. citrina* Coq	(Diaspidae Hemiptera)
Scale insect	*A. orientalis* (Newst.)	(Diaspidae Hemiptera)
Scale insect	*Aonidia zizyphi* R&A	(Diaspidae Hemiptera)
Scale insect	*Lemaspidiotus excisus* (Green)	(Diaspidae Hemiptera)
Hairy caterpillar	*Lupiocus fraterna* Moore	(Lymantriidae Lepidoptera)
Hairy caterpillar	*L. lunata* (Wlk.)	(Lymantriidae Lepidoptera)
Hairy caterpillar	*Daisychira mendosa* Hb	(Lymantriidae Lepidoptera)
Fruit fly	*Carpomyia vesuviana* Costa	(Tephritidae Diptera)
Fruit fly	*Dacus ferrugineus* F	(Tephritidae Diptera)
Fruit fly	*D. cilliatus* Lowe	(Tephritidae Diptera)
Ber beetle	*Sinoxylon anale* Lesne	(Bostrychidae Coleoptera)
Ber beetle	*Adoretus pallens* Arrow	(Scarabaeidae Coleoptera)
Ber beetle	*A. nudus* Arrow	(Scarabaeidae Coleoptera)
Ber beetle	*Monolepta khasiensis*	(Chrysomelidae Coleoptera)
Ber mite	*Phytoptipalpus* (= *Tarsacarus*) *transitans* Ewing	(Tenuipalpidae Acarina)

Pomegranate/Anar

Anar butterfly	*Virachola isocrates* F.	(Lycaenidae Lepidoptera)
Hairy caterpillar	*Lupiocus fraterna* Moore	(Lymantriidae Lepidoptera)
Hairy caterpillar	*L. lunata* (Wlk.)	(Lymantriidae Lepidoptera)
Fruit fly	*Dacus ferrugineus* F	(Tephritidae Diptera)
Fruit fly	*D. zonatus* Saund	(Tephritidae Diptera)
Nitidulid beetle	*Carpophilus dimidiatus* L.	(Nitidulidae Coleoptera)
Nitidulid beetle	*C. hemipterus* L	(Nitidulidae Coleoptera)
Pomegranate mite	*Tenuipalpus lustrabilis* Chaudhri	(Tenuipalpidae Acarina)
Pomegranate mite	*T. trisegmentis* Siddiqui & Chaudhri	(Tenuipalpidae Acarina)
Pomegranate mite	*T. homotunus* Chaudhri	(Tenuipalpidae Acarina)
Pomegranate mite	*T. polacatus* Chaudhri	(Tenuipalpidae Acarina)

Grape

Grapevine thrips	*Rhipiphorothrips cruentatus* Hood	(Thripidae, Thysanoptera)
Hawk moth	*Herse convolvuli* (L.)	(Sphingidae Lepidoptera)
Hawk moth	*Theretra alecto* (L.)	(Sphingidae Lepidoptera)
Hawk moth	*Celerio lineata* (Esp.)	(Sphingidae Lepidoptera)
Hawk moth	*Macroglossum stellatarum* L.	(Sphingidae Lepidoptera)
Grapevine leafroller	*Sylepta lunalis* Guenee	(Pyralidae Lepidoptera)
Fruit fly	*Dacus ferrugineus* F	(Tephritidae Diptera)
Wasp	*Polistes hebraeus* (F.)	(Vespidae Hymonoptera)
	Vespa orientalis (L.)	(Vespidae Hymonoptera)

Grapevine flea beetle	*Scelodonta strigicollis* Mols	(Chrysomelidae Coleoptera)
Defoliating beetle	*Anomala dimidiata* Hope	(Scarabaeidae Coleoptera)
Defoliating beetle	*Adoretus* sp	(Scarabaeidae Coleoptera)
Grapevine beetle	*Sinoxylon anale* Lesne	(Bostrychidae Coleoptera)
Grapevine girdler	*Stenias gisator* F	(Cerambycidae Coleoptera)
Red spider mite	*Tetranychus telarius* L	(Tetranychidae Acarina)

Papaya

	Empoasca papayae	(Jassidae Hemiptera)
	E. dilutara	(Jassidae Hemiptera)
	Dasyses rugosellus	(Tineidae Lepidoptera)

Pear

	Psylla pyricola Forst	(Psyllidae Hemiptera)
	Anaraphus helichrysi (Kalt)	(Aphididae Hemiptera)
	Pulvinaria lonalauensis Rao	(Coccidae Hemiptera)
	Parlatoria oleae (Colve)	(Diaspidae Hemiptera)
	P. cinerae Had	(Diaspidae Hemiptera)
	Quadraspidiotus perniciosus (Comstock)	(Diaspidae Hemiptera)
	Acrolita [illegible]	(Tortricidae Lepidoptera)
	Euproctis fraterna Moore	(Lymantriidae Lepidoptera)
	E. signata Blan	(Lymantriidae Lepidoptera)
	Dacus ferrugineus F	(Tephritidae Diptera)
	D. zonatus Saund	(Tephritidae Diptera)
	Vespa bicolor L	(Vespidae Hymenoptera)
	Adoretus brachypygus Burm	(Rutelidae Coleoptera)
	Carpophilus dimidiatus L	(Nitidulidae Coleoptera)
	C. hemipterus L	(Nitidulidae Coleoptera)
	Tenuipalpus tuisegmentus Siddiqui and Chaudhri	(Tenuipalpidae Acarina)
	Bryobia praetiosa Koch	(Tetranychidae Acarina)

Jaman

	Dialeurodes eugeniae	(Aleurodidae Hemiptera)
	Acrocercops phaeospora Meyr	(Gracillariidae Lepidoptera)
	Carea subtilis	(Noctuidae Lepidoptera)

Plum

	Anuraphis helichrysi (Kalt)	(Aphididae Hemiptera)
	Aphis arundinis F	(Aphididae Hemiptera)
	Pterochlorus persicae Cholodk	(Aphididae: Hemiptera)
	Myzus persicae (Sulz)	(Aphididae Hemiptera)
	Eulecanium coryli (L.)	Coccidae: Hemiptera)
	Parlatoria oleae (Colve)	Diaspidae Hemiptera
	Quadraspidiotus perniciosus (Comstock)	Diaspidae. Hemiptera
	Euproctus fraterna Moore	(Lymantriidae Lepidoptera)
	E. signata Blan	(Lymantriidae. Lepidoptera)
	Dacus ferrugineus F.	(Tephritidae. Diptera)
	D. incisus	(Tephritidae: Diptera)

Eurytoma samsonovi Vas	(Eurytomidae Hymenoptera)
V. orientalis I	(Vespidae Hymenoptera)
Adoretus brachypygus Burm	(Rynastidae Coleoptera)
Sphenoptera laferti Thoms	(Buprestidae Coleoptera)
Quettania coeruleipennis Schw	(Cerambycidae Coleoptera)
Scolytus amygdali Guer	(Scolytidae Coleoptera)
Bryobia praetiosa Koch	(Tetranychidae Acarina)

Litchi

Anuraphis helichrysi (Kalt)	(Aphididae Hemiptera)
Myzus persicae (Sulz)	(Aphididae Hemiptera)
P. pseudopyri Kuw	(Diaspidae Hemiptera)
Indarbela sp	(Pseudarbelidae Lepidoptera)
Lymantria sp	(Lymantriidae Lepidoptera)

Peach

Anuraphis helichrysi (Kalt)	(Aphididae Hemiptera)
Pterochlorus persicae Cholodk	(Aphididae Hemiptera)
Myzus persicae (Sulz)	(Aphididae Hemiptera)
Eulecanium coryli (L.)	(Coccidae Hemiptera)
Parlatoria oleae (Colve)	(Diaspidae Hemiptera)
P. cinerae Had	(Diaspidae Hemiptera)
Quadraspidiotus perniciosus (Comstock)	(Diaspidae Hemiptera)
Diaspis sp	(Diaspidae Hemiptera)
Euproctis fraterna Moore	(Lymantriidae Lepidoptera)
E. signata Blan	(Lymantriidae Lepidoptera)
Dacus ferrugineus I	(Tephritidae Diptera)
D. zonatus Saud	(Tephritidae Diptera)
Eurytoma samsonovi Vas	(Eurytomidae Hymenoptera)
V. orientalis I	(Vespidae Hymenoptera)
Protaetia impavida Jans	(Cetoniidae Coleoptera)
Sphenoptera laferti Thoms	(Buprestidae Coleoptera)
Aeolesthes sarta Solsky	(Cerambycidae Coleoptera)
Scolytus amygdali Guer	(Scolytidae Coleoptera)
Brevipalpus oersicanus Chaudhri	(Tenuipalpidae Acarina)
Eutetranychus orientalis (McGregor)	(Tetranychidae Acarina)

Apricot

Aphis arundinis F	(Aphididae Hemiptera)
Pterochlorus persicae Cholodk	(Aphididae. Hemiptera)
Myzus persicae (Sulz)	(Aphididae Hemiptera)
Eulecanium coryli (L.)	(Coccidae: Hemiptera)
Parlatoria oleae (Colve)	(Diaspidae Hemiptera)
Quadraspidiotus perniciosus (Comstock)	(Diaspidae Hemiptera)
Euproctis fraterna Moore	(Lymantriidae. Lepidoptera)
E. signata Blan	(Lymantriidae Lepidoptera)
Dacus ferrugineus F	(Tephritidae: Diptera)
Eurytoma samsonovi Vas.	(Eurytomidae: Hymenoptera)
Vespa bicolor F.	(Vespidae: Hymenoptera)

V. orientalis L	(Vespidae Hymenoptera)
Oryctes nasicornis L	(Dynastidae Coleoptera)
Sphenoptera lafertii Thoms	(Eupristidae Coleoptera)
Aeolesthes sarta Solsky	(Cerambycidae Coleoptera)
Quettania coeruleipennis Schw	(Cerambycidae Coleoptera)
Scolytus amygdali Guer	(Scolytidae Coleoptera)

Cherry

Eulecanium corvli (L.)	(Coccidae Hemiptera)
Quadraspidiotus perniciosus (Comstock)	(Diaspidae Hemiptera)
Protaetia impavida Jans	(Cetoniidae Coleoptera)
Quettania coeruleipennis Schw	(cerambycidae Coleoptera)
Scolytus amygdali Guer	(Scolytidae Coleoptera)

Fig

Phycodes minor Moore	(Glyphipterygidae Lepidoptera)
P. radiata Ochs	(Glyphipterygidae Lepidoptera)
Anjecrodiplosis peshawarensis Mani	(Cecidomyidae Diptera)

Mulberry

Batocera rufomaculata DeGeer	(Cerambycidae Coleoptera)
Bryobia praetiosa Koch	(Tetranychidae Acarina)
Lutenanychus orientalis (McGregor)	(Tetranychidae Acarina)
Indarbela sp	(Pseudarbelidae Lepidoptera)
Vespa orientalis L	(Vespidae Hymenoptera)
V. bicolor L	
Batocera rufomaculata DeGeer	(Cerambycidae Coleoptera)
Cenopalpus favosus Chaudhri	(Tenuipalpidae Acarina)
Brevipalpus plenus Chaudhri	(Tenuipalpidae Acarina)
B. amicus Chaudhri	(Tenuipalpidae Acarina)
Tenuipalpus trisegmentus Siddiqui & Chaudhri	(Tenuipalpidae Acarina)
T. ortus Chaudhri	(Tenuipalpidae Acarina)
T. mustus Chaudhri	(Tenuipalpidae Acarina)
Aponychus lupus Chaudhri	(Tetranychidae Acarina)
Lutenanychus orientalis (McGregor)	(Tetranychidae Acarina)
Haltica caerulescens	(Chrysomelidae Coleoptera)
Carpophilus dimidiatus L	(Nitidulidae Coleoptera)
C. hemipterus L.	(Nitidulidae Coleoptera)
Bryobia praetiosa Koch	(Tetranychidae Acarina)

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Diaphorina citri Kuwayama (Psyllidae: Hemiptera)
(Citrus psylla)

DIAGNOSTICS

Egg: Pale-yellow becoming orange before hatching; stalked, almond-shaped, thicker at the base and tapering towards the distal end where it is slightly curved, ends in a blunt point. The length of the egg without the stalk is 0.33 mm, the stalk measures 0.38 mm, and the greatest diameter of the egg is 0.13 mm.

Nymph: Five nymphal stages, characterized by fanwise arrangement of the wing-pads in the 2nd to 5th stages.

First Stage: Body length excluding lanceolate spines 0.022 mm; colouration orange; wing-pads cannot be made out; dorsal surface with a number of setae; two gold-club-shaped dorsal setae on each of the middle and hind legs and a single seta of each on the forelegs.

Second Stage Body length excluding lanceolate spines 0.43-0.56 mm; colouration orange, wing-pads small, triangular process projecting from the body; no lanceolate seta on the antennae and only one sensorium.

Third Stage: Body length without lanceolate spines 0.67-0.72 mm; colouration light-orange; general form of body triozine; wing-pads small, anterior edge of the meso-thoracic wing-pads reaching the eyes. Basal joint of antenna with two sensoria and a single lanceolate seta.

Fourth Stage: Body length without lanceolate spines 0.76-1.2 mm; general form of body triozine, characterized by the wing-pads produced cephalad at the humeral angle. General colour, light-yellow with an orange tinge in the region of the abdomen.

Fifth Stage: Body length without lanceolate spines 1.6-1.7 mm; general form of body triozine, wing-pads produced cephalad at the humeral angle. General colour light-yellow with an orange tinge in the region of the abdomen. Some nymphs, however, show a light bluish-green tinge. A full-grown nymph, with the antennae, tips of tarsal and tip of rostrum dark, and the eyes dark-red. Head well marked and separated from the thorax, eyes prominent but ocelli absent, antennae quite large, thicker at the base and tapering towards the tip, only basal two joints distinct.

Adult: Small-sized brown insect with antennae apically black; measuring about 2.5 mm in length. Front wings with medially discontinued brown band

along the outer margin of the apical half. Hind wings shorter and hyaline. The adult makes an angular posture with its tail end of the body raised upwards for embarking upon the plants.

LIFE CYCLE

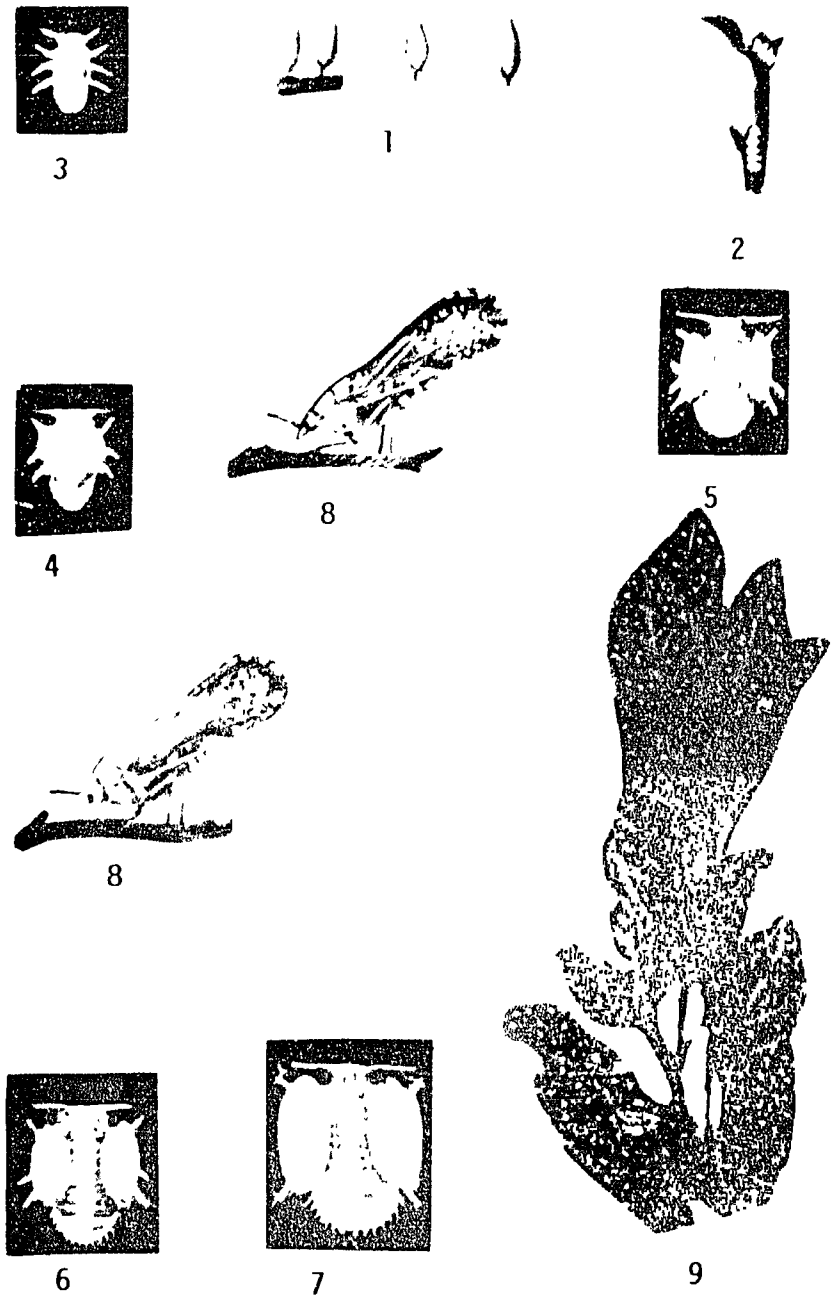
A single female may lay 379 to 897 eggs in her life time. The eggs are embedded on tender leaves and shoots of citrus trees through a stalk. Hatching takes place in 15 to 23 days in winter and in 4 to 6 days in summer months. The light yellow nymphs on emergence congregate on the young half-open leaves, but in the later stages of development they may migrate to the older leaves as well. There are five nymphal instars and the development is completed in 10 to 11 days during April to September, in 15 to 20 days in the spring and autumn, and in 34 to 36 days, in December-January. The full-grown nymphs migrate to the lower surface of the leaves where they change into adults. The females live longer than the males and the duration may be as long as 190 days in the winter and only 12 to 17 days in the summer but is much prolonged in winter. There are 8 to 9 overlapping generations in a year.

NATURE OF DAMAGE

It is the most destructive of all pests of citrus and remains active throughout the year. Overwintered adults resume breeding activity in February. Spring season fetches them the most favourable conditions for development and the pest is very active and abundant in March-April. The population declines considerably during May-June due to intense heat and only the adults are predominent although other stages may also be met. In July, the pest regains activity and a second peak of population is found in August-September. Towards the autumn, there is again a decline in the population and only the adults are found during cooler months.

The nymphs and adults cause damage by piercing their sharp stylets into the plant tissues and sucking the cell-sap. The damage is maximum in the spring season when the nymphs suck the cell-sap from young sprouts. The vitality of plants is affected and the young leaves and twigs stop growing further. The leaf-buds, the flower-buds and the leaves may wilt and die. Whatever little fruit is formed in the spring falls off prematurely.

The nymphs also produce honey-dew which develops black fungus, thus adversely affecting the photosynthesis. It is believed that this insect transmits a toxic substance in the plants rendering the fruit undersized, poor in juice



Diaphorina citri **Kuw.**

1.	**Eggs**	**8.**	**Adult**
2.	**Eggs**	**9.**	**Attack on leaves**
3-7	**Nymphal stages**		

contents and insipid (Husain & Nath, 1927). This insect is also responsible for spreading the greening virus. If the pest is not checked in time, the entire orchard may be lost after a year or two due to continued damage.

DISTRIBUTION AND HOST PLANTS

It is distributed throughout the orient and has been reported from Pakistan, India, China, Formosa, Japan, Burma, Sri Lanka, East Indies and New Guinea. In Pakistan, it has been reported on all species of citrus and members of the family Rutaceae.

CONTROL METHODS

Cultural: The plants receiving proper cultivation are better able to withstand the attack of this pest. It is, therefore, suggested that the plants should be given proper cultivation to make them healthy and vigorous.

Citrus hedges should not be grown around citrus orchards because these serve as reservoirs for fresh build up of the pest.

Biological: Natural enemies such as *Tetrastichus radiatus* W., a chalcid, parasitises the nymphs of the pest whereas larvae of *Chrysopa* sp., maggots of *Syrphis balteatus* D&G., lady bird beetles, certain mites and spiders feed on the adults and nymphs of the pest and, therefore, be encouraged.

Chemical: Spraying with Malathion/Phosphamidon/Methyl Parathion/ Dimethoate/Fenitrothion 0.05%, effectively controls the pest.

Pest Control Schedule

The adults of citrus psylla rest on plants in the winter. They become active and start laying eggs with the appearance of flower-buds and young leaves. It is, therefore, advisable to spray the trees with Malathion, Phosphamidon, Methyl demeton or Dimethoate in the autumn, i.e., September-October. A second spraying with Phosphamidon, Methyl demeton or Malathion should be carried out in February before the flowers open. As long as the flowers remain on the plants, no spraying should be carried out, otherwise the shedding of flowers is likely to be excessive. After the setting of fruits, if necessary, a third spray with any of the insecticides used for the first spraying is required to suppress citrus psylla.

During the monsoon again, there is a second flush on which a number of pests, like citrus psylla, white fly, citrus caterpillar, citrus leaf miner appear. In order to prevent the excessive shedding of fruits owing to the attack of these pests, one more spraying is desirable at this time.

Citrus White Flies: Citrus plants are attacked by about 11 different species of white flies, viz., *Dialeurodes citri* Ashm., *D. elongata* Doz., *Aleurocanthus woglumi* Ashby, *A. husaini* Corbett, *Aleurolobus citrifolli* (Corbett), *A. niloticus* P&F., *Aleurotuberculatus murrayae* (Singh), *A. jasmini* Tak., *Acaudaleyrodes citri* (P&H), *Aleurotrachelus* sp. Of these, seven species are more common The nature of injury caused by all the species of citrus flies listed here and methods for controlling them, have been discussed collectively for all these species.

Dialeurodes citri Ashm. (Aleyrodidae/Aleurodidae: Hemiptera)
(Citrus white fly)

DIAGNOSTICS

Egg: Sub-elliptical, pedunculated, pale-yellow, smooth and measures 0.23 mm without pedicel.

Nymph: There are three nymphal stages:-

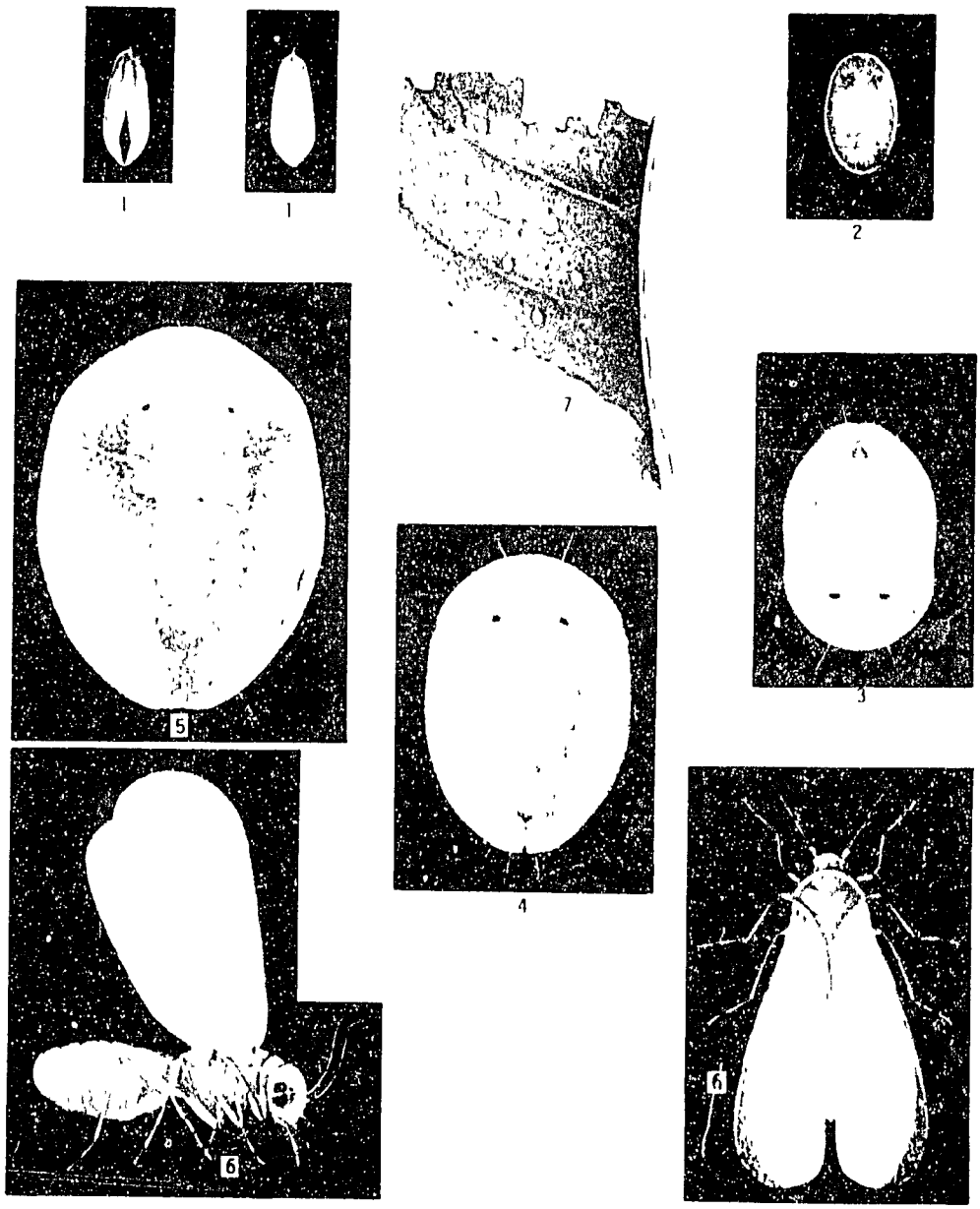
First Stage: Oval or elliptical; pale yellow; length 0.28 to 1.31 mm; greatest breadth 0.5 to 0.33 mm. Rostrum lies between fore legs; marginal bristles 30, being 15 on each side; eyes dark brown and divided; antennae situated on ventral surface and 3-segmented.

Second Stage: Oval or elliptical; length 0.18 mm, breadth 0.61 mm; pale yellow, margin very minutely crenulated, caudal margin somewhat emarginate. Eyes divided; antennae peg-shaped, 0.05 mm long and slender. Vasiform orifice rounded, cordate; operculum of nearly same shape as in first stage.

Third Stage: General form same as in second stage; length 0.70-0.75 mm, breadth 0.5-0.58 mm; colour pale yellow; dorsum covered all over with minute granulations; margin minutely crenulated, two tubercles with strong bristles on caudal margin. Antennae 0.05 mm long and hook shaped. Legs small, stumpy and unjointed.

Pupa: Broadly oval; pale yellow with an orange or yellow area in the middle of the body. Female pupa measures 1.5 mm x 0.76 mm.

Adult: A minute insect which measures about 1.02-1.52 mm; pale yellow in colour with dark red reniform eyes; head somewhat pointed; antennae six-jointed, the basal joint being thick and stout and the last segment ending in a sharp point; wings and body completely covered with a white waxy powder;



Dialeurodes citri (Ash.)

1.	Eggs	6.	Adult
2-5	Nymphal stages	7.	Attacked leaf

WHITE FLY

1.	Adult	4.	Nymph
2.	Nymph	5.	Adult
3.	Eggs	6.	Attacked leaf

legs pale yellow, claws bifid, ligula evident. Wings more than twice the length of body, extending beyond the tip of abdomen.

LIFE CYCLE

The pest has two generations in a year. The adults emerging from the over-wintering pupae of the second brood start laying eggs in February and continue doing so till the middle of April; the most active period of egg-laying being March. The second brood starts oviposition from the beginning of August and continues till about the end of November; the period of maximum activity being August-September. The eggs are laid singly, irregularly scattered on the lower surface of the young or soft leaves. They are inserted into the tissue of the leaf by means of a short peduncle. A single female lays more than 200 eggs in a short duration of 4 days and within 9 days of its emergence. A single leaf may have as many as 2000 eggs attached to it. The eggs of the first brood hatch out in 10 to 12 days and those of the second brood in 7 to 14 days. The emerging nymphs crawl about on the leaves for about 24 hours and, thereafter, they fix themselves to the leaf by inserting their beaks into the leaf tissue and suck the sap. They soon moult, losing their legs in the process, and have the appearance of minute, flattened, oval bodies. They moult thrice and become full-grown in 25 to 51 days in winter. The pupal stage varies from 125 to 154 days in summer and 114 to 159 days in winter. The adult life varies from 2 to 8 days in captivity.

NATURE OF DAMAGE

All stages of the pest are met with together during March-April. Only the nymphs and pupae are found in May. In June-July only pupal stage is present. All the stages are again met with in August-October. From October to the end of February only pupae are found.

Both the nymphs and adults cause damage by sucking the cell-sap from the leaves which curl over and fall off. The adults on emergence avoid bright sunlight and settle on the underside of the leaves, preferring the north side of a tree (Khan, 1942). The infested trees present a blackish appearance due to a sooty mould which develops on the honey-dew produced by the pest. Infested trees produce scanty blossom, most of which is shed and whatever little fruit is produced, it is undersized and of poor quality.

DISTRIBUTION AND HOST PLANTS

Out of the different species recorded, this species has a wide distribu-

tion and occurs in South and South-East Asia, India, Pakistan, West Indies and in South, Central and North America. In Pakistan, this species is found almost in all the citrus growing tracts, where it primarily feeds on citrus (Rehman, 1944, 1946).

Aleurocanthus woglumi Ashby. **(Aleurodidae: Hemiptera)**
(Woglum's black fly)

DIAGNOSTICS

Egg: Slightly reniform-elliptical; 0.26 x 0.01 mm; petiole yellowish brown; surface marked with polygonal or hexagonal markings; eggs laid in spirals of three whorls.

Nymph: The three nymphal stages are described below:-

First Stage: Oval or elliptical; 0.3 mm broad; dorsal surface armed with two ridges; brownish and highly chitinized; ventral surface pallid. Three small marginal bristles on each side of the head and 4th on the caphalo-lateral margin; two pairs of caudal bristles, the inner most pair being the longest. Dorsum with three pairs of highly chitinized brownish spines arising from whitish spots. Eyes divided, irregular in outline, and dark-red. Vasiform orifice dark brown, raised on a ridge, rounded anteriorly and pointed posteriorly.

Second Stage: Elliptical; 0.48 mm long, 0.28 mm broad; patches of dark colour all over the dorsal surface; margin minutely crenulated, caudal margin armed with two pairs of bristles. Dorsum considerably arched, highly chitinized with 10 pairs of long spines arising from whitish, circular spots. Vasiform orifice dark, somewhat circular, raised on a tubercle.

Third Stage: Elliptical; length 0.80 mm, breadth 0.45 mm; dark-brown to black in colour with irregular whitish-brown spots. Margin surrounded with short teeth; sub-marginal area covered all over with a row of wax pores. Dorsum covered with 13 pairs of long stiff spines arising from whitish spots. Vasiform orifice circular and raised on an elevation.

Pupa: Oval; length 1.4 mm, breadth 0.88 mm; dorsum considerably arched, jet black; margin with rounded black teeth, about 180 in number (number variable), dorsum with 29 pairs of long spines. A row of wax pores all around the sub-marginal area. Vasiform orifice circular and situated on an elevation.

Adult: A minute insect, measuring 1.3 mm in length; dark-orange in colour

with a greatly darkened head and thorax, wings slaty, each wing with whitish spots and reddish margin; the margins bear teeth which carry hairs.

LIFE CYCLE

The eggs are always laid in spirals of three whorls and can thus be easily differentiated from those of Husain's black fly in which case these are laid in a spiral of one whorl only (Rehman, 1940). The process of oviposition in this species is curious and interesting. A female when about to oviposit sits for hours together on a leaf, lays an egg and revolves a little, lays another egg and revolves a little more and, thus in this way, the eggs are laid one by one in a spiral. It usually takes 24 hours to lay a spiral of 15 to 22 eggs and a single female may lay 1 to 3 spirals in her life time. The maximum number of eggs found on a broad leaf of citrus has been 3000 in 150 spirals, overlapping each other. The egg stage lasts for 7 to 14 days in April, 7 to 9 days in August and 12 to 14 days in October. The emerging nymphs arrange themselves spirally or irregularly on the leaf surface near the egg shells. The duration of nymphal stages is very variable, the nymphs of the same egg spiral may pupate on different dates. The nymphal period is 45 to 60 days in May-June, 38 to 43 days in August-October and 48 to 60 days in October-December. Sometimes the nymphs overwinter and pupate in the third or fourth week of January. The pupal stage usually occupies 99 to 131 days, but in winter it varies from 147 to 161 days. The pest has two well-defined broods in a year. The spring brood of adults emerges in March-April and the winter brood of adults emerges from July to October and sometimes in November also.

DISTRIBUTION AND HOST PLANTS

This insect is widely distributed in the Orient, but it is only confined to Lahore, Gujranwala and Shahdara in the Punjab where it seriously attacks citrus (Husain and Khan, 1945).

Dialeurodes elongata Dozier **(Aleurodidae: Hemiptera)**
(Elongate white fly)

DIAGNOSTICS

Egg: Pale yellow; oval in shape; measures 0.25 mm in length and 0.08 mm in thickness.

Nymph: There are three nymphal stages:

First Stage: Elongate, oval, much flattened; 0.31 mm in length and 0.17 mm in breadth; pale yellow, mycelome light orange; possesses a narrow fringe of wax in the form of a frill all round the margin and the margin armed with 32 bristles; eyes dark red; antennae lash-like and 3-segmented.

Second Stage: Flat, scale-like, elongate, oval, symmetrical; 0.566 mm in length and 0.283 mm in breadth; pale yellow; margin minutely indented. Marginal spines of the first stage mostly disappear. Eyes divided and dark red. Two deep yellow areas visible on abdomen.

Third Stage: Asymmetrical, elongate, oval; 0.85 mm in length and 0.36 mm in breadth; margin minutely indented, one pair of minute bristles on cephalic end and two pairs on caudal end. Dorsum covered all over with minute pores which look like white globular dots. Legs small and stumpy, terminate in rounded discs.

Pupa: Yellow with orange coloured patches on the abdomen; elongate, elliptical and asymmetrical, 1.7 mm in length and 0.9 mm in breadth. Its dorsum is covered all over with minute whitish spots which are dorsal pores. The marginal area is almost transparent. Vasiform orifice elongate and more or less triangular.

Adult: A minute insect measures about 1.25 mm in length; deep yellow in colour (in other respects it resembles *D. citri).*

LIFE CYCLE

The eggs are laid singly and irregularly on the under surface of the young leaves. They are attached to the leaves by their curved stalks. The period of egg laying is concurrent with that of *D. citri.* The egg stage lasts for 6 to 9 days in April and for 12 to 14 days in October-November. On hatching, the nymphs crawl about for some time and then fix themselves along the leaf-veins. This is unlike the nymphs of citrus white fly which get fixed up indiscriminately. The duration of the nymphal stage varies from 24 to 40 days in case of summer brood and 102 to 114 days in the winter brood. There are two broods of this insect in a year and these are concurrent with those of citrus white fly. The adults of the first brood begin to emerge in March and continue emerging throughout April. From the eggs laid in March-April, the adults of the second brood develop by August-October. Like *D. citri,* this insect also passes the hotest period of summer and the coldest period of winter in the pupal stage.

DISTRIBUTION AND HOST PLANTS

Elongate white fly is commonly found in association with *D. citri* and *Aleurolobus citrifolii* Corbett and has been reported from Faisalabad, Lahore, Multan, Sheikhupura and Muzaffargarh districts attacking citrus varieties, particularly oranges and maltas (Haq and Akmal, 1964).

Aleurocanthus husaini Corbett (Aleurodidae: Hemiptera)
(Husain's blackfly)

DIAGNOSTICS

Egg: Reniform-elliptical, dorsally slightly concave; length 0.20 mm, greatest diameter 0.1 mm; chorion with hexagonal area. Colour uniformly pale-yellow. Eggs arranged in a spiral of only a single whorl.

Nymph: There are three nymphal stages:-

First Stage: Irregularly oblong-oval; 0.29 mm long and 0.17 mm broad; pale-yellow with a brownish tinge, margins entire; eyes divided, dark and irregular in shape. Vasiform orifice somewhat triangular in shape.

Second Stage: Elliptical; 0.38 mm long and 0.22 mm broad, dark at some regions and pale yellow at others; margins minutely crenulated, dorsum highly chitinized, considerably arched, with 10 pairs of long, chitinized, dorsal spines arising from whitish circular spots. Vasiform orifice on a raised portion and somewhat circular in form.

Third Stage: Elliptical; 0.63 mm long, 0.41 mm broad; colour dark-brown, margins indented, teeth small, roundish. Dorsum highly chitinized, greatly convex, with 14 pairs of spines arising from whitish spots. Vasiform orifice elevated on a tubercle, operculum of the same shape.

Pupa: Elliptical, female pupa 0.93 x 0.70 mm, male pupa 0.88 x 0.62 mm; black, with a slight bluish tinge in fresh specimens; dorsum greatly arched, highly chitinized, armed with spines. Margin indented, teeth long and rounded, number of teeth on an average 102. In a space of 0.01 mm there are four to five teeth. A series of minute wax pores round the pupa on sub-marginal area secrete whitish wax, sometimes forming a fringe around the pupal case. Dorsum arched, with 58 dark coloured spines. Vasiform orifice sub-ordinate, situated on a raised area; margins somewhat thickened. Operculum black, caudal margin somewhat concave.

Adult: Minute insect, measures 1.2 mm in length; body pale yellow with dark and yellow spots on thorax; eyes black and wings slaty and maculated.

LIFE CYCLE

The eggs are laid on the lower surface of the leaves in a spiral of a single whorl, comprising 9-17 eggs. Several egg spirals may be seen on the same leaf. Occasionally, the eggs may be laid in a cluster without any definite arrangement. Eggs are laid in March-April and again in July-October. These hatch in 9 to 12 days in April, 7 to 9 days in August and 8 to 12 days in October.

The emerging nymphs fix themselves near the egg spirals often assuming the same spiral arrangement. The nymphal period varies from 26 to 52 days and the pupal stage occupies 64 to 108 days. There are two broods of this insect in a year. The adults of the spring brood emerge in March-April, while those of the autumn brood come out in July-October.

DISTRIBUTION AND HOST PLANTS

This citrus fly is widely distributed in Punjab but is especially abundant in the south-eastern districts. It only feeds on citrus species (Qureshi, 1982).

Aleurolobus citrifolii Corbett (Aleurodidae: Hemiptera)
(Cloudy winged white fly)

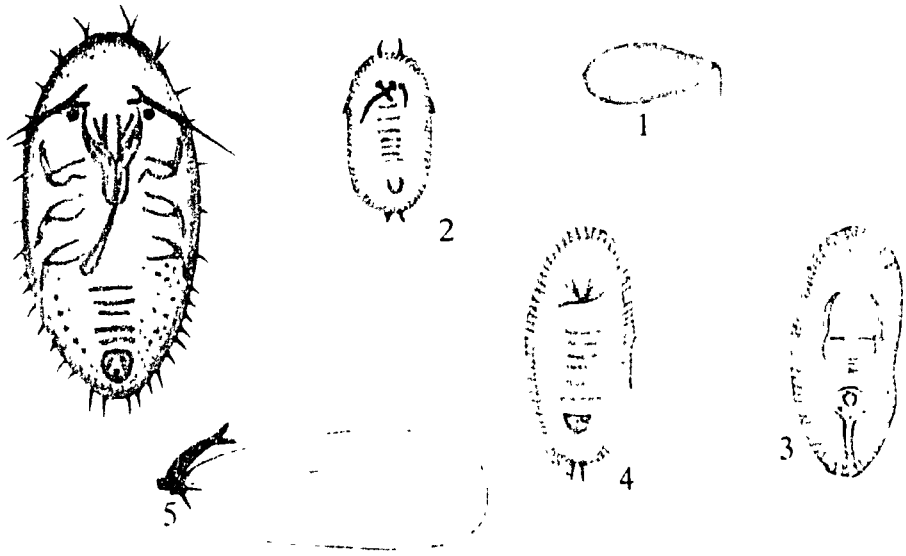
DIAGNOSTICS

Egg: Elliptical, stalked, pale-yellow; 0.18 mm long, 0.08 mm broad, stalk 0.04 mm long and bent near the egg so that the egg is held horizontal to the surface of the leaf. Egg surface smooth and polished.

Nymph: The three nymphal stages are described below:-

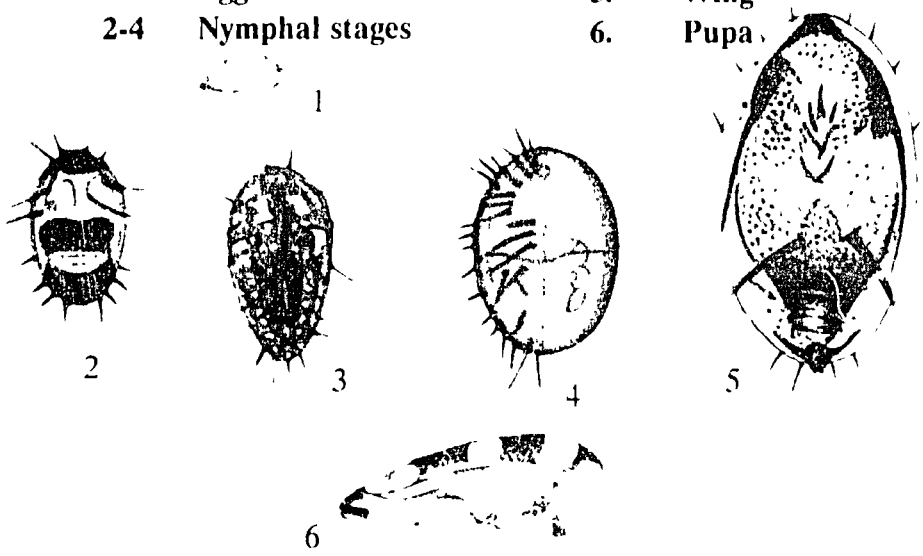
First Stage: Flattened, oval; 0.25 mm long and 0.15 mm broad; dark-yellow, a semi-circular ridge on the dorsal side of the cephalic region; margin armed with 36 bristles, vasiform orifice rhomboid with roundish corners.

Second Stage: Oval; 0.33 mm long and 0.22 mm broad; pale-yellow with brownish median streak on dorsum. Margin slightly indented and bears 3 pairs of marginal bristles. Three pairs of bristles on dorsal surface. Median region on the dorsal surface, from vasiform orifice to the head, brown. Vasiform orifice rhomboid, operculum sub-circular.



Dialeurodes elongata **(Doz.)**

1.	**Egg**	**5.**	**Wing**
2-4	**Nymphal stages**	**6.**	**Pupa**



Aleurocanthus husaini **Corbett.**

1.	**Egg**	**5.**	**Pupa**
2-4	**Nymphal stages**	**6.**	**Wing**

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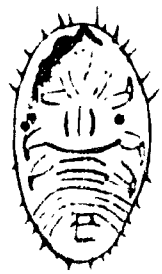

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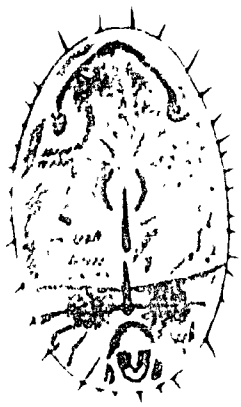
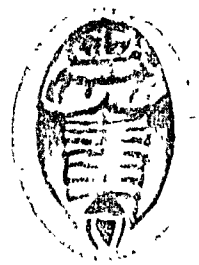
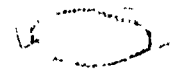
Aleurolobus citrifolii **Corbett.**







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Aleurolobus marlatti **Quaintance**

1.	**Egg**	**3.**	**Pupa**
2.	**Nymph**	**4.**	**Wing**

Third Stage: Oval; 0.50 mm long, 0.38 mm broad, pale-yellow. Margin minutely indented with suture-like markings. Vasiform orifice rhomboid, operculum occupies the entire space.

Pupa: Sub-elliptical, somewhat narrow at thoracic and abdominal regions; 0.58 mm long and 0.45 mm broad. Colour dark-brown to deep black. Margins entire in some specimens, very minutely indented in others. Tubercles all around the sub-marginal area. Each tubercle with a minute whitish wax pore at the top. There are minute wax pores, which look whitish spots all around the case on the dorsum along the encircling ridge. Three tracheal breathing folds evident.

Adult: A minute insect, 0.9 mm in length; uniformly pale-yellow; eyes dark-red and constricted in the middle; wings whitish, narrow, oblong, ovate and immaculate.

LIFE CYCLE

The eggs are laid singly and irregularly on the lower surface of the leaves. On account of their small size they are quite inconspicuous. The incubation period ranges from 10 to 12 days in April, 7 to 9 days in August and 13 to 14 days in October. On hatching, the nymphs crawl about on the leaf for about a day and then fix themselves on the upper or lower surfaces indiscriminately. It is because of this behaviour of the nymphs that the nymphs and pupae are found both on the upper and the lower surface, although the eggs are never laid on the upper surface of the leaf. The duration of the nymphal stage varies from 33 to 61 days, according to the season. The pupal stage occupies 39 days in September-October and 104 days in winter. All stages of the pest are met with from March to December, but only the pupal stage is met with from December to the end of February. There are no definite broods of this pest and the generations overlap.

DISTRIBUTION AND HOST PLANTS

This insect is widely distributed in Punjab but is particularly common and serious in Multan, Faisalabad, Lahore and Sahiwal districts. Besides citrus, it feeds on 'marhwa' *(Murraya exotical)* (Qureshi, 1981).

Aleurolobus marlatti Quaintance (Aleurodidae: Hemiptera)

DIAGNOSTICS

Egg: 0.19 mm long and 0.09 mm broad, with a short stalk 0.03 mm; elliptical,

thicker in the middle, one end thinner than the other; surface smooth; colour pale-yellow with a reddish spot in the yolk. Eggs are held on the leaf at about an angle of 80°.

Nymph: The three nymphal stages are described below:-

First Stage: Elliptical; 0.25 mm long, 0.17 mm broad; encircled with a fringe of glossy, waxen rods; pale-brown in colour. A prominent ridge-like structure on the head. Margin with 34 pairs of bristles arising from small tubercles. Two pairs of strong bristles on the dorsum; eyes purple and divided. Vasiform orifice somewhat triangular in shape.

Second Stage: Elliptical; 0.33 to 0.38 mm long and 0.25 to 0.28 mm broad, encircled with waxy fringe, dark-brown or black in colour. Margin distinctly crenulated. Eyes dark-brown and divided. Sub-marginal area surrounded by a circle of minute colourless wax pores. Three pairs of bristles arising from whitish spots on dorsum. Vasiform orifice triangular.

Third Stage: Elliptical, surrounded by a waxy fringe 0.61 mm long and 0.48 mm broad; colour dark-black, margin crenulated with suture-like markings running mesad from crenulations. Segmentation of the body distinct, 22 pores are present on the sub-marginal area and two pores on the caudal margin. Vasiform orifice triangular.

Pupa: Broad and elliptical; 0.95 x 0.73 mm in size; black, encircled with a fringe of glossy waxen rods. Margin crenulated and black lines running mesad so that minute lobes are formed on the sub-marginal area. The dorsum separated from the sub-marginal area by means of a yellowish and another blackish line, both running together around the dorsum. Eyes crescentic. Whitish wax is secreted on the dorsum and scattered along the various sutures and makes an outline on the main body of the insect. Vasiform orifice triangular in shape, surrounded by a trilobed figure.

Adult: Yellowish with reddish brown spots on dorsal side of thorax and abdomen; length 0.9 to 1.00 mm. Fore wings whitish and marked with rusty red spots, hind wings light smoky, slightly shaded at some places, a single thick vein running through, margin with reddish dentation.

LIFE CYCLE

The emergence of adults from the over-wintering pupae begins in early March. The eggs are laid singly and without any arrangement on the lower as well as the upper surface of the leaves. The egg stage lasts for 5 to 14 days, the nymphal stage occupies 12 to 35 days and the pupal stage 36 to 77 days,

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according to the season. The pest has no definite broods and is met with in all stages from March-December. In January and February, however, it is only present in the pupal stage.

DISTRIBUTION AND HOST PLANTS

This insect has a wide distribution in Punjab, but, in spite of this, it is a minor pest and does not cause any appreciable damage. Besides citrus, it attacks 'marhwa' *(Murraya exotica)* (Qureshi, 1980).

Aleurolobus niloticus P&H, *Aleurotuberculatus murrayae* (Singh), *A. jasmini* Tak., *Acaudaleyrodes citri* P&H and *Aleurotrachelus* sp. are rare species and have been collected from Faisalabad, Multan, Sahiwal and Sialkot in very small number. Being of minor importance, the details of these species are not being given here.

CONTROL METHODS

Cultural: The plants receiving proper cultivation are able to withstand the attack of this pest to a greater extent than those receiving improper cultivation. It is, therefore, suggested that the plants should be given proper cultivation to make them healthy and vigorous.

Citrus hedges should not be grown around the citrus orchards because these serve as reservoirs for fresh build up of the pest.

Biological: Four species of predaceous beetles, namely *Brumoides suturalis* (F), *Catana parcesetoa* (Sic.), *Menochilus sexmaculata* F. and *Scymnus* sp. have been found feeding gregariously on eggs and nymphs of various citrus flies *Chrysopa* sp. grubs have also been found to be predaceous upon nymphs. Spiders predate on adult flies.

Encarsia sp. and *Eretomocerus* sp. parasitise the nymphs and pupae of Husain's black fly, whereas *Comperiella* sp., *Amitus* sp. and *Prospaltella* sp. were found on the nymphs of *Dialeurodes citri* Ashm.

Chemical: As suggested for citrus psylla.

In the absence of the afore-mentioned synthetic insecticides, rosin compound, diluted with 6 parts of water, or rosin soap, dissolved in 50 parts of water, should be used as a spray.

The most appropriate time for carrying out spraying against these insects is the pre-blossoming period from December to the beginning of February. However, in case of severe infestation, spraying may also be done any time, except the flowering period.

Aonidiella aurantii (Maskel) **(Diapsidae: Hemiptera)**
(Citrus red scale)

DIAGNOSTICS

Egg: Minute, round; reddish in colour; covered with scale.

Nymph: The first stage nymphs or the crawlers have well-developed legs and antennae.

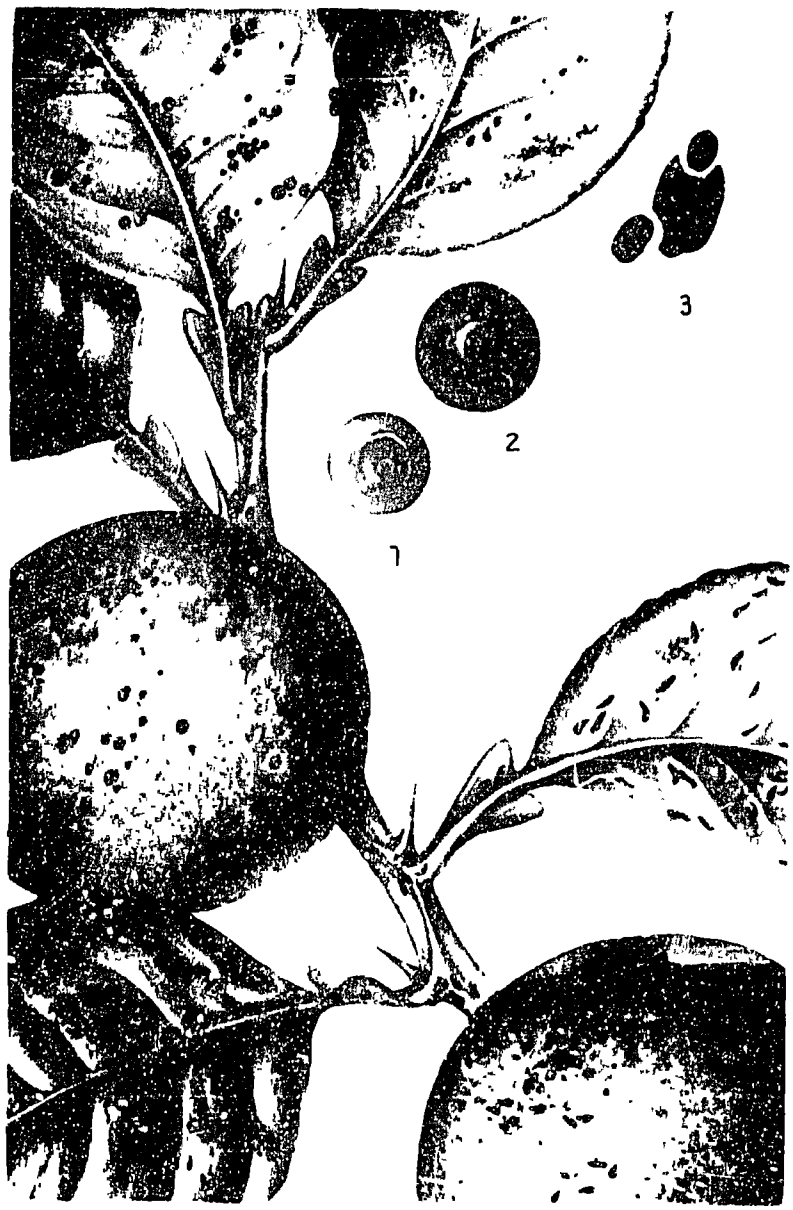
Adult: (Female): Denigrate, wingless, lies hidden under the scale; legs and antennae atrophied. The scale is circular in shape, depressed and measures 1.75 to 2 mm in diameter. (Male): Elongated and develops into winged adult.

LIFE CYCLE

The females, instead of laying eggs, give birth to young nymphs. As many as 150 or more young nymphs may be produced in two months by a single female. Upon emerging from beneath the female, the nymphs crawl actively for about an hour or two, then they settle. The crawler stage is easily dispersed by wind, by insects or by cultural practices, and therefore, is of special importance to the distribution of this pest. The young scales are chiefly found along the midrib and principal veins of the leaves or in depressions in the peel of the fruits. Soon after settling, the young scale begins to secrete a white, cottony covering. At this stage the young ones are called "white caps." The female is fully grown after two moults, whereas the male passes through two active larval stages and two diapauses before it reaches sexual maturity. The female moults for the first time 1 to 3 weeks after emergence, and the second moult takes place about 7 to 15 days later, lose their legs and antennae and incorporate their cast skin into waxy coverings. They reach sexual maturity in 10 to 15 weeks, do not acquire wings and may live for several months. The full-grown females are protected not only by the dorsal scale but also by a ventral membrane which adheres to the surface of the plant. The winged male adults develop in 1 to 2 months. They are very short lived, fly around and fertilize the sedentary females and consume no food after fertilization. The pest passes through a number of broods in a year.

NATURE OF DAMAGE

The pest is active throughout the year, but its attack is maximum during autumn. The population remains restricted due to intense heat in the summer months but regains momentum in July-August. The size and shape of the scales often differ most considerably according to the host plant and the part



Armoured scales

1. *Aonidiella aurantii* **(Maskel) (Scale)**
2. *Chrysomphalus dictyospermi* **Morgan (Scale)**
3. *Parlatoria ziziphi* **(Clovee) (Scale)**
4. **Scales on the leaves and fruits**

Pseudococcus citri **Risso**

1. **Adult (Female)**
2. **Injury and mealy bugs**

of the plant that is colonised.

The scale insects feed on the plant juice and devitalise the plant. Besides sap drainage, they inject a toxic substance into the plant sap. Yellow spots appear at the point of feeding (Rehman and Ansari, 1945). The scales infest all parts of the tree above ground. The leaves, branches and fruits may be covered with them. In case of severe infestation, the leaves may turn pale and twigs along with leaves get dried up.

DISTRIBUTION AND HOST PLANTS

The pest occurs in many countries of the world. It ranks as the most important citrus pest in California, Mexico, Central America, South Africa and in some parts of Australia. It causes serious damage in the citrus growing areas of South-East China and India. In Pakistan, it has been reported from Faisalabad, Gujranwala, Lahore, Sahiwal, Muzaffargarh and Multan districts. Besides citrus, it feeds on *Acacia, Eucalyptus,* Fig, grape-vine, guava, jaman, mulberry, oleander, rose, willow, shisham and many other plants.

CONTROL METHODS

Removing and burning the infested leaves and twigs; spraying infested trees with Metasystox/Phosphamidon 0.05 to 0.075%. Best results have been obtained when infested plants were sprayed with Phosphamidon/Ethion 225 ml. a.i. mixed with one gallon, summer oil in 100 gallons of water.

In case, summer oil is not available, the sprays have to be repeated a number of times.

Pseudococcus filamentosus Cockerell **(Pseudococcidae: Hemiptera)**
(Fluffy citrus mealy bug)

DIAGNOSTICS

Egg: Yellow; in clusters, under cottony masses.

Nymph: Amber coloured with a whitish waxy coating and filaments.

Pupa: (Only Male) enclosed in a waxy, tubular cocoon.

Adult: (Female): Wingless; body flattened having short, waxy filaments along the margins. (Male): Winged, midge-like; with long antennae and atrophied mouthparts.

LIFE CYCLE

The females lay 300 or more eggs in clusters on citrus plants, and are

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found in protective cottony masses. The eggs are deposited on all parts of the plant. The nymphs hatch out after 1 to 3 weeks. The male nymphs spin cottony cocoons, 2 to 3 weeks after hatching and pupate before transforming themselves into winged adults. The males are short lived and do not feed and die after fertilization. The females are full-grown in 6 to 8 weeks, and become wingless adults. There are 4 to 6 broods per year depending upon the climatic conditions.

The pest is most active during the winter months when conditions of their growth are optimum. The mealy bugs have a characteristic mealy white to yellowish covering which is composed of the last two larval skins cast by the insect and of waxy secretions. Since they multiply rapidly, all stages of development may be found in winter months on citrus. After hatching, the nymphs crawl out and start feeding by inserting their mouthparts in the plant tissue. The population declines during the summer months due to intensive heat.

NATURE OF DAMAGE

The nymphs and females of mealy bugs cause damage to all parts of the plants by extracting juice and excreting copious quantities of honey-dew which consequently develop fungus on it. Chlorotic spots about 2 to 3 mm long, are formed on the plant parts which interfere with the normal working of the plant. In case of severe infestation the citrus flowers do not set fruit or the fruits may drop prematurely.

DISTRIBUTION AND HOST PLANTS

The genus *Pseudococcus* has been recorded from citrus and many other crops from many countries of tropical and sub-tropical areas, viz., India, Pakistan, China, Malaysia, Indonesia and also some parts of USA.

Besides citrus, the mealy bug is found on *Cactus* spp., ferns, begonia, gardenia, poinsettla and many other flowers.

CONTROL METHODS

Spraying with Phosphamidon/Ethion 225 ml. a.i. mixed with one gallon summer oil in 100 gallons of water, effectively controls the pest.

Note: The citrus plant is attacked by a number of mealy bugs especially those belonging to the Genus *Pseudococcus*. Of these, *P. citri* Risso. and *P. filamentosus* Cockerll are most destructive. The distribution,

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seasonal history, nature of damage, life cycle and control of these species are identical and have been discussed collectively in the above species.

Phyllocnistis citrella Stainton
(Gracillariidae/Phylocnistidae: Lepidoptera))
(Citrus leaf miner)

DIAGNOSTICS

Egg: Very minute, rounded and transparent.

Larva: Small, pale yellow or pale green with a brownish head; legless. The full-grown larva measures 5.1 mm in length; mandibles brownish, well-developed.

Pupa: Small; brownish; head provided with a hook-like process.

Adult: A tiny moth; silvery white in colour; eyes black; about 4.2 mm in the wing expanse and 1.5 mm in length. The hind wings are pure white and the fore wings have brown stripes and a prominent black spot near the tips. Both pairs of wings being fringed with fine hair.

LIFE CYCLE

The females lay eggs singly, generally 2 to 3, on leaves and tender shoots usually on the lower surface, particularly near the midrib. The eggs hatch in 2 to 10 days. The legless larva makes tortuous silvery white galleries on the leaves and tender shoots and remains confined within for the rest of its immature life. Larvae are full-grown in 5 to 30 days. When mature, they settle down in enlargements of the galleries near the leaf margins and transform into pupae. The pupa is partly exposed through the gallery wall and has an acute spine on its head with the help of which it pierces through the wall as it emerges out as a moth. The pupal stage lasts for 5 to 25 days and the entire life cycle is completed in 12 to 65 days. It passes through 13 or more overlapping generations in a year (Yunus, 1967).

The pest is active throughout the year and breeds on young growth. The duration of various stages depends upon the prevailing temperature. Late in the spring or in summer, development may be five or six times as fast as in the autumn or early spring. All stages of the pest are met with all through the year except January and February when only the larval and pupal stages are present. Its population reaches the peak twice during the year; once during March to May and then again during September to October.

NATURE OF DAMAGE

The larvae cause damage by making zigzag mines in the young leaves between the upper and lower epidermal layers eating away the parenchymatic tissue. The injured epidermis takes the shape of twisted silvery galleries. On the older leaves, brownish patches are formed which serve as foci of infection for citrus canker. The attacked leaves get twisted or folded over but remain on the plants for a considerably long time and the damage gradually spreads to fresh leaves. Heavily attacked plants can be spotted out from a distance and young nurseries are most severely affected. The photosynthesis is hindered and the vitality of plants is lowered resulting in an appreciable decrease in yield.

DISTRIBUTION AND HOST PLANTS

This insect has a wide range of distribution in the oriental region and Northern Australia. In Pakistan, it has been recorded as a specific pest of citrus attacking rough lemon, mancarin orange, sweet orange, sour orange, sweet lime, sour lemon, European lemon, elephant lemon, grape fruit, pommelo and spaddock, etc. Practically all citrus orchards in Pakistan suffer from the attack of this pest to a lesser or greater extent (Latif and Yunus, 1961).

CONTROL METHODS

Minor infestations can be controlled simply by removing and burning the infested leaves and twigs. In cases of severe infestation, spray with Metasystox/Phosphamidon 0.05 to 0.075%. Best results have been obtained when infested plants were sprayed with Phosphamidon/Ethion 225 ml a.i. mixed with one gallon summer oil in 100 gallons of water.

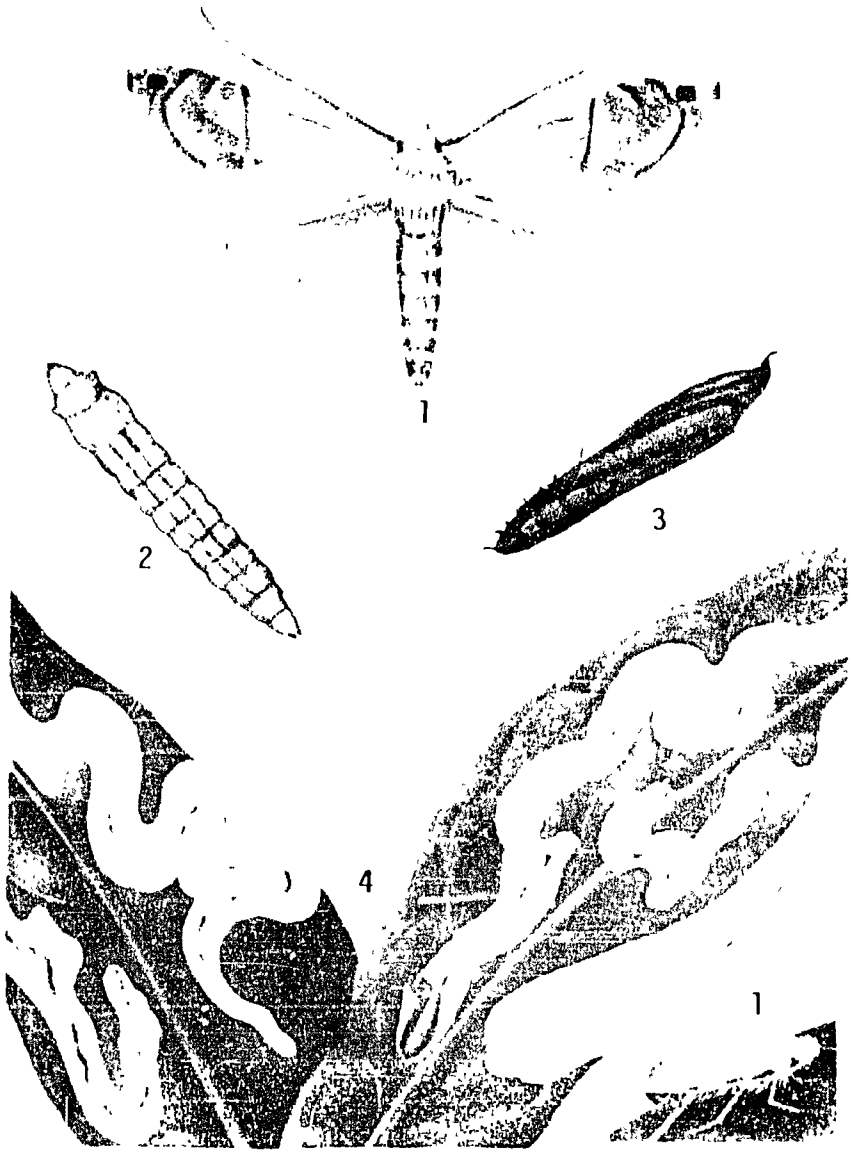
Papilio demoleus Linnaeus **(Papilionidae:Lepidoptera)**

(Citrus caterpillar)

DIAGNOSTICS

Egg: Round, smooth and pale or pale green when freshly laid becoming dark grey near maturity.

Larva: Young larva is a curious blend of black and white resembling a bird's droppings; when full-grown yellowish-green with a few oblique brownish stripes down the sides of its body. The caterpillar is equipped with two reddish sacs posterior to the head which discharge a pungent smelling fluid. It also has a horn-like outgrowth on the dorsum of last abdominal segment and



Phyllocnistis citrella **Stainton**

1.	**Adult**	**3.**	**Pupa**
2.	**Larva**	**4.**	**Silvery mines on the leaves**

Papilio demoleus L.

1. Adult (Butterfly)
2. Egg on young leaf
3-6. Larval stages
7. Larva suspended for pupation
8. Pupa

measures 40 mm in length and 6.5 mm in width.

Pupa: Greenish or straw-coloured with black spots, attached to twig with silken girdle.

Adult: Moderately large colourful butterfly, measuring 28 mm in length and 94 mm in wing expanse. It is bluish green in colour with its black front wings ornamented with numerous yellow spots. The hind wings (similarly coloured as fore wings) have a brick-red oval patch near the anal margin. The general colouration of the underside of the wings is slightly paler and the markings are also larger. Head and thorax black, there being a creamy yellow colouration on the underside of the abdomen. The antennae are black and have club-like structure at the ends.

LIFE CYCLE

The adults are active in March and lay eggs usually on the under surface of newly sprouted tender shoots and young leaves. The eggs are laid singly or in batches of 2 to 5. Sometimes the gravid females glue their eggs on thorns of citrus or on other parts of plants. The eggs hatch in 3 to 4 days in summer and 5 to 8 days in the winter. The young larva emerges by cutting a circular hole through the egg-shell, which serves as the first food of the larva. This scavenging habit persists throughout the larval life and the larvae eat their own exuviae after each moult. The pests pass through 5 larval instars within 8 to 16 days in summer and about 4 weeks during November-December. The mature larva becomes idle, stops feeding and spins a supporting girdle around its body and transforms into pupa. This stage is often referred to as Prepupa which lasts for ten days. The pupal stage lasts for about 8 days in summer; and up to 14 weeks in winter. The adults after emergence from pupae take to wings within 1 to 3 hours.

A female usually mates once and lays, on an average, 75 to 125 eggs within 2 to 3 days. The life span of adult male and female butterflies varies from 4 to 6 days and 6 to 7 days, respectively. The pest completes four to five overlapping generations in a year.

In the plains, this pest is active throughout the year, whereas in the sub-mountainous tract it hibernates as a pupa. The butterflies appear on wings in March with the advent of spring season and the population starts building up towards the end of April. The population remains restricted due to intense heat in the summer months but regains momentum in July and the pest is most active in September. The larvae pupate in November and may enter hibernation in autumn.

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NATURE OF DAMAGE

The damage is caused by the larvae which feed upon leaves and terminal shoots. The young larvae feed on tender shoots and fresh sprouts whereas in the later stages they feed even on mature leaves. Heavily attacked plants bear no fruits. The pest causes damage to the young plants in the nursery, sometimes by completely defoliating them. It is reckoned as the worst leaf-eating pest of citrus nursery plants (Haq, 1950).

DISTRIBUTION AND HOST PLANTS

The genus *Papilio* is cosmopolitan in occurrence. The citrus caterpillar, *P. demoleus* is found in the greater parts of Africa and Asia. It has been reported from all citrus growing areas of Pakistan. It causes severe damage to all varieties of cultivated or wild citrus and various other species of the family Rutaceae.

CONTROL METHODS

Spraying with Malathion/Methyl Parathion 0.05% effectively controls the pest.

Citrus fruit flies: The following five species of fruit flies have been reported attacking citrus plantations in Pakistan:-

1. *Dacus dorsalis* Hendl.
2. *D. cucurbitae* Coq.
3. *D. zonatus* Saund.
4. *D. diversus* Coq.
5. *D. ciliatus* Lowe.

Description of *Dacus dorsalis* and ***D. cururbitae,*** being more important pests of citrus, are included here.

Dacus dorsalis Hendel **(Tephritidae: Diptera)**

DIAGNOSTICS

Egg: White; cylindrical, narrow at both poles and slightly curved on one side with distinct micropyle at the anterior end; measures 0.1 to 0.2 mm.

Larva: Full-grown larva light yellow; long conico-cylindrical body, pointed at the head and composed of 12 visible segments; measures 8.97 x 1.74 mm.

Pupa: Barrel-shaped; light orange when freshly formed and light ochara-

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ceous at the time of emergence of the fly; narrow anteriorly, rounded posteriorly; measures 5.57 x 2.28 mm.

Adult: Body colour reddish brown; two longitudinal yellow stripes on thorax; ovipositor short and brown.

LIFE CYCLE

The female deposits 4 to 13 eggs in a single puncture, 1 to 2 mm below the skin of the fruit. The egg stage lasts for 2 to 4 days in summer season and 4 to 8 days in autumn and early winter. The duration of pupal stage varies from 6 to 12 days in summer and 12 to 30 days in winter. The adult flies live for 27 to 44 days. The pest completes its life cycle in 12 to 35 days in summer and 29 to 60 days in winter. It remains active from middle of March to October-November and passes through 7 generations in a year.

Dacus cucurbitae Coq.(**Tephritidae: Diptera**)

DIAGNOSTICS

Adult: Body colour yellowish-white with black spots on the thorax.

LIFE CYCLE

A female lays about 64 eggs, on an average. The egg, larval and pupal stages last for 2 to 5, 6 to 12 and 7 to 11 days in summer and 6 to 11, 18 to 28 and 15 to 48 days in winter, respectively. The adult life is 34 to 40 days. The pest remains active from the middle of March to October and passes through 6 generations in a year.

Panonychus citri (McGregor) (**Tetranchidae: Acarina**)
(Citrus red mite)

DIAGNOSTICS

Egg: Minute.

Larva: Light yellowish brown in colour; possesses three pairs of legs.

Proto-nymph: Orange brown; possesses four pairs of legs.

Deuto-nymph: Orange brown with a greenish tinge; possesses four pairs of legs.

Adult: Small, plump and orange with thick deep brown patches on the dorsal

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side of the body and measures 1/3 mm in length. Body covered with prominent bristles, each borne on a whitish tubercle. The antennae of female, three-segmented and bright pink in colour.

LIFE CYCLE

The female lays about 50 eggs, arranged singly along the large veins on the underside of the leaves. The eggs are minute, round and orange, and are embedded in the leaf tissue, with ornamentations o. thread which extend from the top outwards. The eggs hatch in about one week. Eggs laid parthenogenetically develop into males only. The first instar larva has three pairs of legs, and after feeding on the cell-sap for 3 to 4 days develops into a proto-nymph which has four pairs of legs. In 3 to 4 days, it develops further to form a deuto-nymph which also has four pairs of legs. It is full-fed in 4 to 5 days and after moulting transforms itself into an adult mite. The female mite lives for about 10 days. The life cycle in the summer is completed in 17 to 20 days and the pest passes through several overlapping generations in a year.

The pest is active throughout the year, but its breeding is rather slow in the winter. The mites are most active during May-June when they breed abundantly. This species lives in colonies on the underside of the leaves. The leaf becomes slightly raised in those parts where the mites harbour and the mites resting in this buldge are protected by a fine web.

NATURE OF DAMAGE

All the feeding stages cause damage by constantly sucking the cell sap from leaves, tender fruits and green bark. Because of loss of chlorophyll, the leaves present a speckled appearance. Heavy infestation may result in complete defoliation, especially of the young nursery plants. The affected fruit becomes yellow and remains undersized.

DISTRIBUTION AND HOST PLANT

This pest of citrus is of international importance and has been recorded in the USA, Indonesia, Philippines, Israel, Iraq, UAR, Sri Lanka, India and Pakistan. It feeds on sweet-orange, lemon, grape-fruit and lime. No alternate host other than citrus family is known.

CONTROL METHODS

Spraying the infested plants with a number of insecticides; lime sulphur

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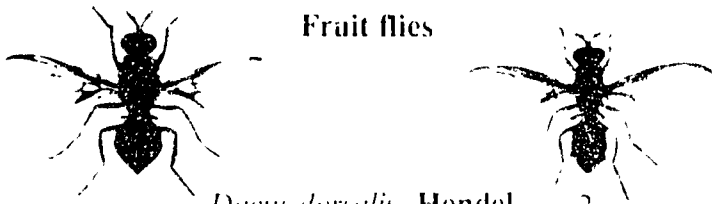
Fruit flies

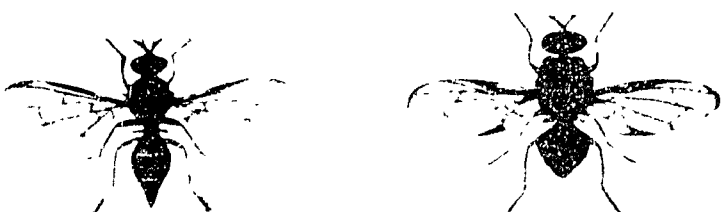


1 *Dacus dorsalis* Hendel 2

1. Adult (Female)
2. Adult (Male)

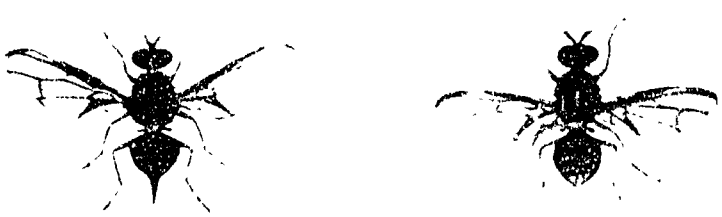
1 *Dacus cucurbitae* Coq. 2

1. Adult (Female)
2. Adult (Male)



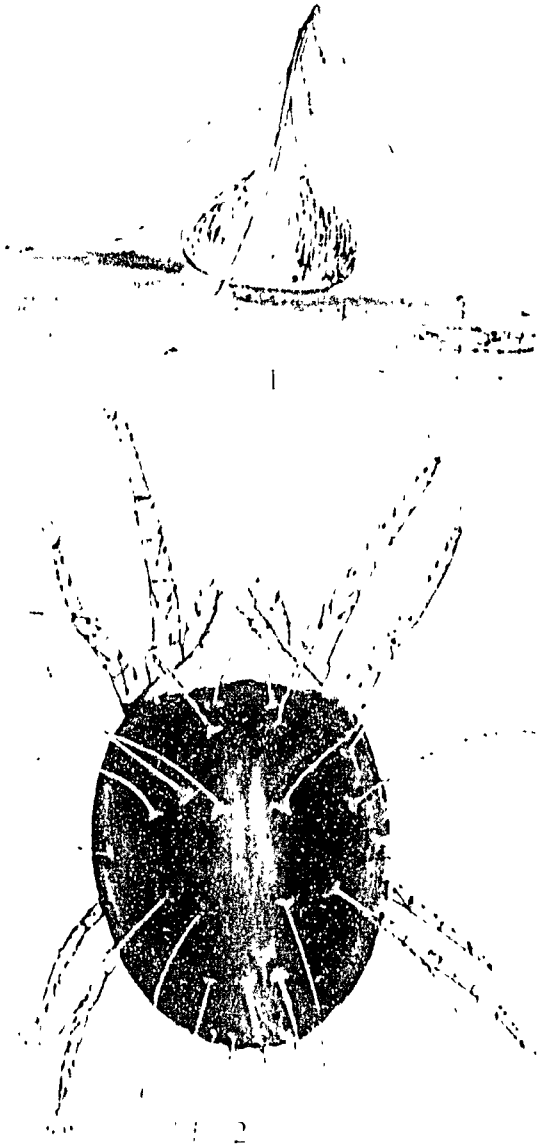
1 *Dacus zonatus* Saund. 2

1. Adult (Female)
2. Adult (Male)



1 *Dacus diversus* Coq. 2

1. Adult (Female)
2. Adult (Male)



Panonychus citri (McGregor)

1. Egg, greatly enlarged
2. Adult (Female)

wash (1:2:16); 1% wettable sulphur; Dimethoate 0.03%; Dicofol/Malathion 0.05% effectively controls this pest.

Several predatory mites viz., *Amblydromella plebius* Chaudhri, *Gnorimus tabella* Chaudhri and *Euselus mediocris* Chaudhri are also found on citrus along with the phytophagous species. These predatory mites should be encouraged.

In areas where the red scale or the mite is a major pest, repeated sprayings have to be carried out, as and when the pest appears.

MANGO

Amritodus atkinsoni (Lethierry) (Cicadellidae: Hemiptera)

(Mango leaf-hopper)

Nymph: Elongated, more active and pale-yellowish in colour.

Adult: 5 mm long; central longitudinal narrow dark streak on the scutellum absent.

LIFE CYCLE

The fertilized females insert 200 or more eggs singly in the tissue of the panicles, unopened flowers and young leaves. The eggs hatch in 8 to 10 days. The newly emerged nymphs feed on the inflorescence and suck the cell-sap and excrete honey-dew profusely. By the time the majority of nymphs are mature, the fruit has set. The nymphs then migrate to the stems and young leaves and are full-grown in three stages in 7 to 19 days. The full-fed nymphs develop into winged adults which are seen congregated on the lower portions of the branches and trunks. The adults are very agile and hop readily at the slightest disturbance. There are two generations of this pest in a year.

The pest is active practically throughout the year but during the hot months of May-June and the cold months of October through January, only the adults are found clustering on the underside of branches and amidst leaves to shun light and heat. The overwintering adults regain breeding activity in February-March when the tender shoots and panicles are available for their egg laying. The pest breeds twice a year, once during February-April and again in June-August.

NATURE OF DAMAGE

Injury is caused by the nymphs and adults by sucking cell-sap from the

inflorescence and tender shoots. The inflorescence is also injured in the process of egg laying by the females. The nymphs are particularly harmful as they are the voracious feeders. They cause the inflorescence to whither and turn brown, consequently flowers fall off prematurely without setting any fruit. The nymphs also produce honey-dew on which black mould develops giving the attacked plant a dull blackish look. Young fruits and dried inflorescence break-off at the axil and fall to the ground as the wind blows. The growth of the young trees is much retarded and the older trees do not bear much fruit.

DISTRIBUTION AND HOST PLANTS

They are widely distributed in Malaysia, Indonesia, Formusa, India and Pakistan. Mango is the only food plant of this pest so far known (Haq and Akmal, 1960).

CONTROL METHODS

Spraying the tree with Carbaryl 0.1% or Methyl Parathion/ Phosphamidon/ Endosulfan/ Dimethoate/ Malathion 0.05%, effectively controls the pest. Spraying should preferably be done during morning hours when the adults are under the benumbing influence of cold.

Idioscopus clypealis (Lethierry) **(Cicadellidae: Hemiptera)**
(Large mango hopper)

DIAGNOSTICS

Egg: Dull-white; pointed at one end and blunt at the other.

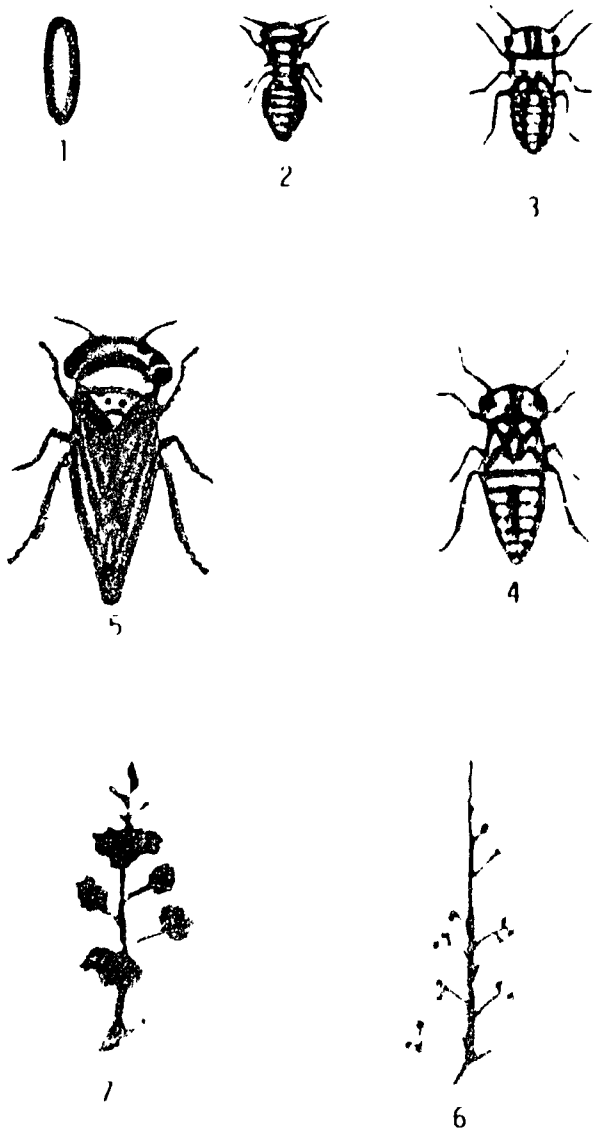
Nymph: Broad, less active and dull deep-yellow in colour.

Adult: Measures 6.3 mm in length; dull-yellow or greyish in colour with 3 dark-brown spots on the head, a median band and two black spots on the pronotum. The black triangular marking on scutellum and a central longitudinal dark streak dilated anteriorly and posteriorly.

Drosicha stebbingi (Green) **(Monophlebidae: Hemiptera)**
(Mango mealy bug)

DIAGNOSTICS

Egg: Oval, broad, pink becoming palish near maturity and measures about 1.0 x 0.7 mm.



Idioscopus clypealis (Leth.)

1. Egg
2-4. Nymphal stages
5. Adult
6-7. Attacked shoots

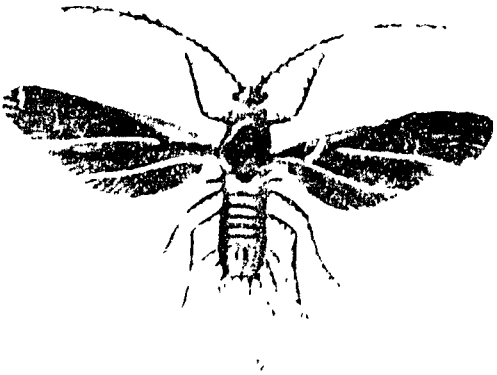
1

2

3

4

5



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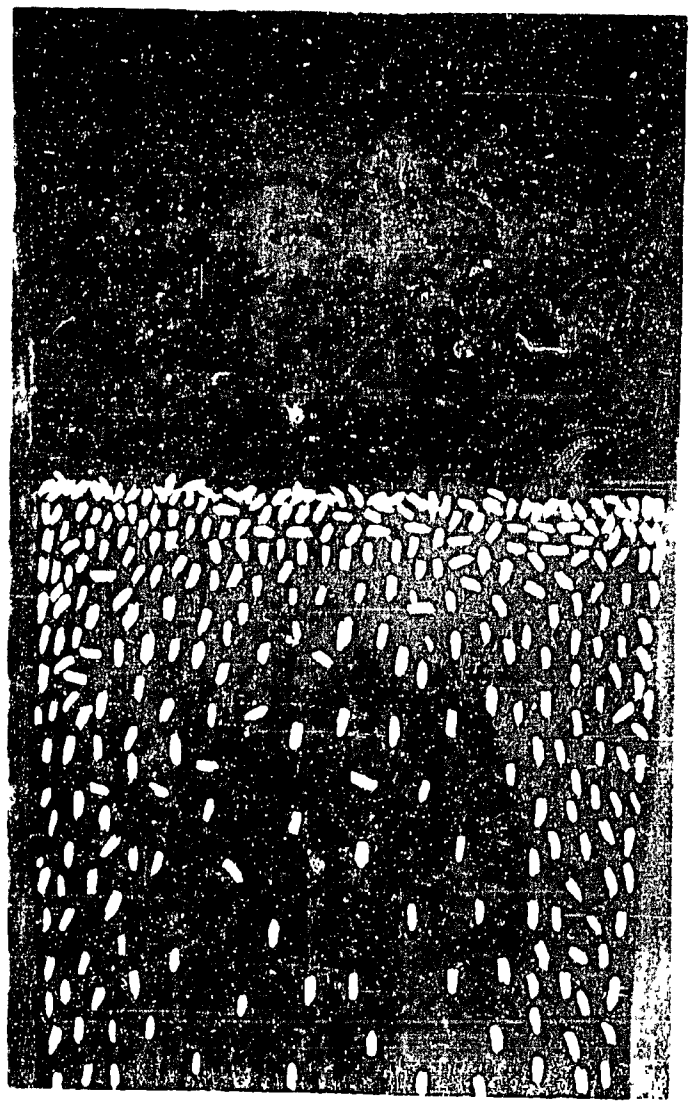
Drosicha stebbingi (Green)

1. Exuviae on leaf
2. Adult, female
3. Adult female with ovisac
4. Ovisac
5. Pupa, male
6. Adult (Male)



Attack of mango mealy bug

Emerging nymphs obstructed by Slippery band on mango tree trunk.

Nymph: There are three nymphal instars:-

First Instar: Elliptical; chestnut-brown in colour; antennae 5-segmented; measures 1.3 to 2.3 cm in length and 0.7 to 1.2 mm in greatest breadth.

Second Instar: Elliptical, reddish brown, covered with white mealy powder; antennae 6-segmented; measures 2.9 to 4.7 mm in length and 1.7 to 2.6 mm in breadth.

Third Instar (Female): Resembles second instar nymph in shape and colour; antennae 7-segmented; measures 4.55 to 7.7 mm in length and 2.5 to 3.7 mm in breadth.

Third Instar (Male): Prepupa: This instar nymph in male is also known as prepupa; general appearance resembling third instar female nymph; antennae 9-segmented; measures 4.5 to 4.9 mm in length and 2.2 mm in breadth.

Pupa: Occurs only in the male; enclosed in a cottony cocoon; antennae 10-segmented; measures 5.43 mm in length and 2 mm in breadth; mouthparts atrophied.

Adult: (Female): Wingless oval; flattened; body covered with a white mealy powder; measures about 18 mm in length; mouthparts suctorial. (Male): Dipterous, fore wings black, hind wings modified as hamulohalteres; body crimson; antennae 10-segmented, bushy and prominent; mouthparts atrophied.

LIFE CYCLE

The females lay up to 372 eggs which are enclosed in whitish cottony ovisacs, 5 to 15 cm below the soil. The diapausing eggs start hatching in December and continue till February. The nymphs ascend the mango trees and congregate on the fresh growth of flowers. There are 3 nymphal instars. The third nymphal instar in male is also known as Prepupa and is followed by the pupal instar which is missing in the female. The duration of nymphal instars in female and male lasts for 45 to 71, 18 to 38, 15 to 26 and 45 to 71, 18 to 38, 5 to 10 days, respectively. The pupal stage in male lasts for 9 to 15 days. Mating takes place soon after the emergence of the males, at a time when the females are not fully developed. The life span of male is 4 to 7 days and during this period they mate frequently. The adult females live from 22 to 47 days and die immediately after egg laying. The pest has only one generation a year.

The pest is active from December-January to May and spends the rest of the year in the egg stage. On hatching, the young nymphs wonder for some time and evidently crawl up the trees and cluster on the panicles. The fertilized females descend to the ground in April-May to lay eggs and die, their shrivelled bodies remaining attached to the egg-sac.

NATURE OF DAMAGE

Damage is caused by the nymphs and the wingless females. They suck plant juice, causing the tender shoots and flowers to dry up. The young fruits also become juiceless and drop off. In case of serious attack, the trees retain no fruit at all.

DISTRIBUTION AND HOST PLANTS

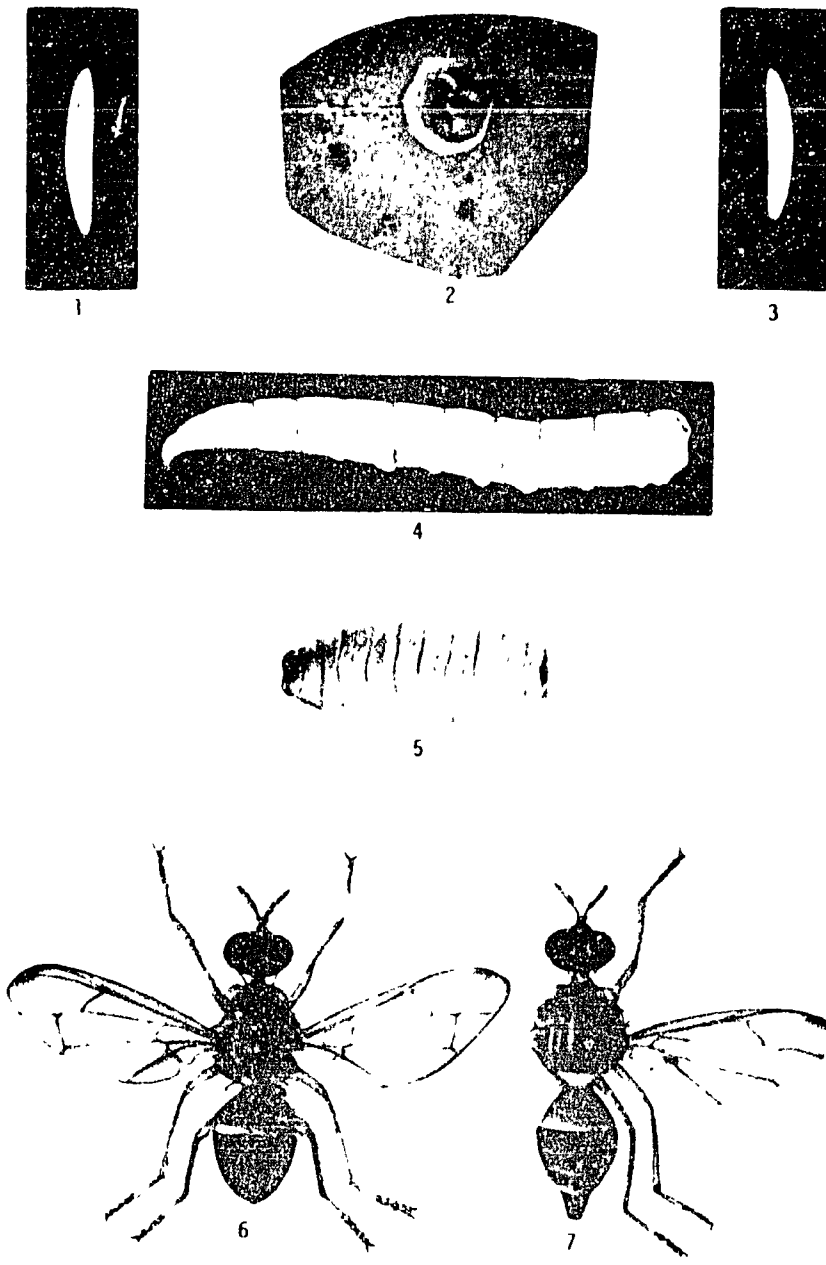
The mango mealy bug is widely distributed throughout the mango growing tract of Indo-Pakistan sub-continent. Besides mango, it attacks as many as 62 host plants including mulberry, jaman, citrus, plums, peaches, guava, fig, etc. (Rehman and Latif, 1944).

CONTROL METHODS

Scraping the soil to the depth of 15 cm to expose the eggs during summer, preventing nymphs from crawling up the trees by applying 8 cm wide sticky bands with greasy material (cotton band) or slippery bands with polythene or plastic sheets around the trunks at about one metre above the ground level during the second week of December prevents the trees from mealy bug damage. The nymphs congregated below the bands may be killed by spraying them with Methyl Parathion 0.05%. If the nymphs succeed in climbing up the trees, then these can be controlled by spraying with Methyl Parathion/Phosphamidon 0.1%. Full-grown females can be killed with 0.1-0.2% Methyl Parathion. The descending bugs on the tree trunk or soil can also be killed by spraying kerosene oil (Latif, 1941).

Dacus ferrugineus Fb. (Tephritidae: Diptera)
(Fruit fly)

The fruit flies are quite a serious pest of mango fruit. The damage caused is considerable since a fairly high percentage of the ripe mangoes goes to waste every year. Four species that attack mango in Pakistan, in order



Dacus ferrugineus F.

1.	Egg	5.	Pupa
2.	Maggots in fruit	6.	Adult (Male)
3-4.	Maggots	7.	Adult (Female)

of their importance, are: *Dacus ferrugineus* Fb., *D. zonatus* Saund., *D. diversus* Coq. and *D. dorsalis* Hendel.

The differentiating characters, distribution, seasonal prevalence, extent of damage and life cycle of *D. ferrugineus,* the most important species, is as follows:-

DIAGNOSTICS

Adult: Face brown with black spots at the base, a pair of rounded spots on cheeks; thorax, pleura and mesophragma reddish to brownish black. Abdomen with an interrupted or complete dark band on the third abdominal segment and a median stripe from third to fifth. Legs yellow with fore and hind tibiae dark.

LIFE CYCLE

The female deposits 4 to 13 eggs in a single puncture, 1 to 2 mm below the skin of the fruit. These eggs hatch in 2 to 4 days in summer and 4 to 8 days in autumn and early winter. The larvae (maggots) are full-fed in 5 to 9 days in summer and 9 to 20 days in autumn and early winter. The duration of pupal stage varies from 6 to 12 and 12 to 30 days in the summer and winter months, respectively. The adult flies live for 27 to 44 days. The pest completes its life cycle in 12 to 36 days in summer and 29 to 60 days in winter and passes through 7 overlapping generations in a year.

The pest remains active from middle of March to October-November and passes winter as hibernating pupa in the soil. The adults emerge in April and reach ripening fruits and vegetables of the season to breed. In spring, their population declines. During June, there is a dearth of fruits and flies resort to brinjal as the only food. During monsoon, however, they shift to mango and increase in number enormously. The autumn is another adverse season and the population of flies again declines.

NATURE OF DAMAGE

The attacked fruits get decayed due to the presence of maggots inside, which feed on the pulp, turn it into a semi-liquid mass and render it unfit for human consumption. The infested fruit in the beginning does not manifest any sign of attack. Later on, however, it can be made out by the presence of a brown spot which appears on its sickly and yielding surface. When such a fruit is cut open, numerous white maggots could be seen lacerating the pulp and wriggling about in it.

DISTRIBUTION AND HOST PLANTS

Fruit flies are widely distributed in the oriental region. This species has been recorded from all over Pakistan damaging mango, guava, mulberry, citrus fruits, peaches, persimon, plums, brinjal, pomegranate, apricot, 'ber', banana, apple, fig and loquat (Haq *et al.*, 1960).

CONTROL METHODS

Already included under general discussion on fruit flies.

Batocera rufomaculata DeGeer
(Cerambycidae/Curculionidae: Coleoptera)
(Mango stem borer)

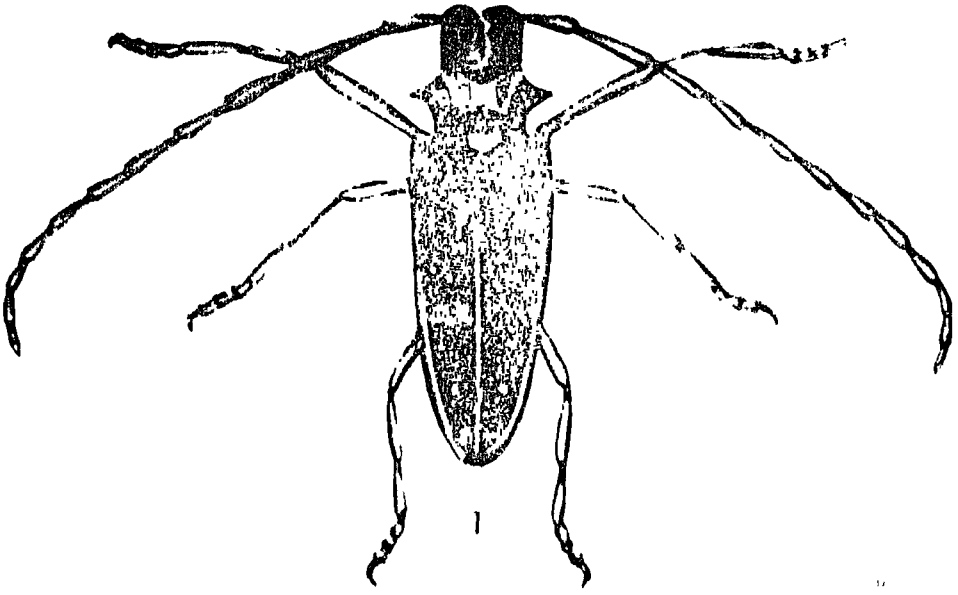
The two species of mango borers i.e., *Batocera rufomaculata* DeGeer and *B. rubus* Linnaeus closely resemble each other. Their distribution, nature of damage, life cycle and control being almost identical, however, adult characters differ which are given.

DIAGNOSTICS

Egg: Oval; dirty-white; measures 5.5 to 6.8 mm in length and 1.8 to 2.3 mm in maximum diameter.

Grub. Freshly hatched grub creamy-white with a dark brown head; slender, thickest in the thoracic region, gradually tapering posteriorly. Pronotum with numerous strongly chitinized, flattened denticles. Body covered all over with minute spines; measures 8.4 mm and 2.7 mm in length and breadth, respectively. Full-grown grub stout with strongly built mandibles; head black; measures about 8 cm long and 2.25 cm wide at the thorax; creamy-white, tapering towards, the 8th segment and cylindrical further on.

Pupa: Large, creamy-white when freshly formed, becoming pale brown near maturity. Head slightly deflected; antennae very long, terminally making a spiral over the respective meta leg. Pronotum shield-shaped and bearing one protuberance on each side. Abdominal tip tapering and curved with a sharp upward bend. It measures about 5 cm in length and 2.2 cm in breadth.



Batocera rufomaculata **DeGeer**

1. **Adult beetle**
2. **Full-grown larva**

Adult: Elongated and stoutly built with long legs and very long, 11-segmented antennae; dull brownish-yellow in colour with a number of dirty yellowish spots on elytra, a dirty-white band extending along the entire lateral aspect of the body; head distinct with large prominent eyes; cephalic region of elytra with numerous dark tubercles and one small sharp tooth on each shoulder; pronotum ornamented with two crescent orange-yellow spots. It measures about 5 cm in length and 2 cm in breadth.

LIFE CYCLE

The female lays up to 200 eggs singly, usually about the base of the stem in slits in the bark. The eggs hatch in 7 to 14 days, and the young grubs tunnel directly into the bark, penetrate into the stem or even the roots, making a circuitous tunnel in the wood. The grub is full-grown in 3 to 6 months. The grub either pupates before winter or remains in the resting stage without feeding. It pupates in a specially constructed elliptical chamber in its place of feeding in the stem, at a distance of about 5 cm from the surface. The duration of resting and pupal stages (inclusive of the resting period) occupies 4 to 7 months. The adult escapes by cutting through the space intervening between the chamber and the surface of the stem. The exit is made through a circular hole measuring about 2 cm in diameter. The life cycle may be completed in 1 to 2 years.

The adults appear on wing usually in the end of May, and the last of them coming out by the end of August. The emergence is at its maximum during July and August. The egg-laying period may extend from May to end of October or beginning of November. The grubs are equipped with a strong mandibulate mouthparts and feed inside the tunnel. The overwintering grubs regain feeding activity in the following spring when the season warms up. During the feeding process, they cut large galleries in the stem. It pupates during November in a specially constructed pupation cell in its place of feeding in the stem. The adults cut their way out of the pupation chamber and re-start the life cycle.

NATURE OF DAMAGE

The adults feed upon the bark of young twigs and petioles of leaves. Consequently, the damage done by them is not of great significance. It is, however, the borers (grubs) which do more damage and are really destructive. They do not kill the plant outright, for even a severely attacked plant may live for years. When the grubs feed in the heart-wood of the stem, the

plant usually does not dry up, but when they cut zigzag tunnels in the sappy wood, the plant always dries up and dies. In case of severe attack numerous large circular and conspicuous holes on the trunk or branches are a common sight

DISTRIBUTION AND HOST PLANTS

The mango borers better known as the fig-borers are widely distributed in Indo-Pakistan sub-continent, Sri Lanka, Malaysia, East Africa and Far East. Of the two species, *B. rufomaculata* is very common and more destructive. In Punjab, it has been recorded as a serious pest from Faisalabad and Sargodha. Besides mango, these species attack fig, apple and many other trees (Husain *et. al.*, 1940).

CONTROL METHODS

Plugging the borer holes with cotton soaked in kerosene, petroleum or EDCT mixture and then plastering them from outside with mud kills the borers. Injecting Methyl Parathion 0.2% in the holes and their subsequent plugging with mud will also effectively kill the borers inside.

Aspidiotus destructor Sign. (Coccidae: Hemiptera)
(Scale insect)

Mango Scales: There are about 25 species of scale insects attacking mango trees. Out of these only one species, *Aspidiotus destructor* Sign. has been reported of some significance.

DIAGNOSTICS

Egg: Yellow, tiny and circular.

Nymph: Yellowish; antennae and legs developed; measures 0.2 mm in length.

Adult: (Female): Bright yellow; circular in outline; covered with a flimsy, semitransparent, slightly convex scales; scales' diameter 1.5 to 2.0 mm. (Male): Reddish; oval in outline; winged; smaller than female.

LIFE CYCLE

The eggs are laid under the scale around the body of the female. Incubation takes 7 to 8 days. On hatching, the crawler leaves the maternal scale and takes up a position on the leaf and starts feeding. The nymphs remain on

this site throughout its nymphal life, and if it is a female it also stays there throughout its adult life. The female nymph moults three times, and the male twice. Larval development takes 24 days in the male, and longer in the female. The life cycle takes 31 to 35 days and there are about 10 generations per year. Dispersal of this scale is usually affected by both birds and bats, in their plumage and fur. The pest is active throughout the year.

NATURE OF DAMAGE

A severe infestation forms a continuous crust over the under surface of the leaves. The infested leaves become yellow and eventually die. The flower spikes and the fruits are also likely to be infested.

DISTRIBUTION AND HOST PLANTS

The pest is widely distributed in the Pantropical region; occurring up to Iran, Japan and California and southwards down to South Africa and Australia. In Pakistan, besides mango, it has been reported from citrus, banana, guava, sugarcane, date palm and many wild plants.

CONTROL METHODS

Minor infestation can be controlled simply by removing and burning the infested leaves and twigs. In case of severe infestation, spray with Metasystox/Phosphamidon 0.05 to 0.075%. Best results have been obtained when infested plants were sprayed with Phosphamidon/Ethion 225 ml a.i. with one gallon summer oil in 100 gallons of water.

Sternochetus mangiferae (F.)

(Chrysomelidae/Curculionidae: Coleoptera)

(Mango stone weevil, Mango nut weevil)

DIAGNOSTICS

Egg: White and oval.

Grub: White, legless, with a brown head.

Pupa: Pale-white, becoming dark-brown near maturity.

Adult: Short, stout weevil with a reduced head; broad; dark-brown in colour with paler patches on the elytra; body covered with papillate scales.

LIFE CYCLE

The female weevil with the help of her ovipositor makes small cuts in

the skin of young fruits and inserts a single egg through each cut. The cut normally heals over completely and becomes invisible to the unaided eye. The eggs hatch in 6 to 10 days and the young grub moves further inwards, cutting its way through the unripe tissue till it bores into the embryo of the mango stone. The grub is full-grown in 18 to 25 days and passes through 2 to 3 larval stages. It pupates inside a cell formed within the stone. The pupal stage lasts for 12 to 15 days. The adult weevil cuts its way through the stone and the pulp, and comes out. The pest usually has one generation in one year

The weevils are inactive from July to August onwards and remain concealed in the soil or underneath the bark of mango trees. Activity is regained in spring when the fruits have been set. The weevils lay eggs in March-April which develop inside the fruits and the adults emerge in May-June. The emerging adults become inactive and resume breeding during the next season (Fletcher, 1914)

NATURE OF DAMAGE

The pest attacks mango varieties with a relatively soft flesh. There are, however, no external symptoms of attack by this pest.

DISTRIBUTION AND HOST PLANTS

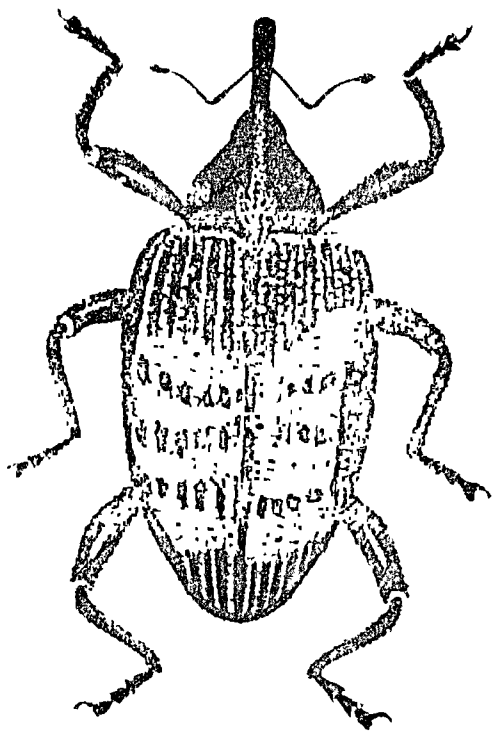
The pest is widely distributed in Africa (Gabon, East and South Africa, Madagascar, Mauritius), India, Bangladesh, Sri Lanka, Burma, Malaysia, South Vietnam, Philippines, East Australia, New Calendonia and Hawaii Island. No host other than mango has been recorded.

CONTROL METHODS

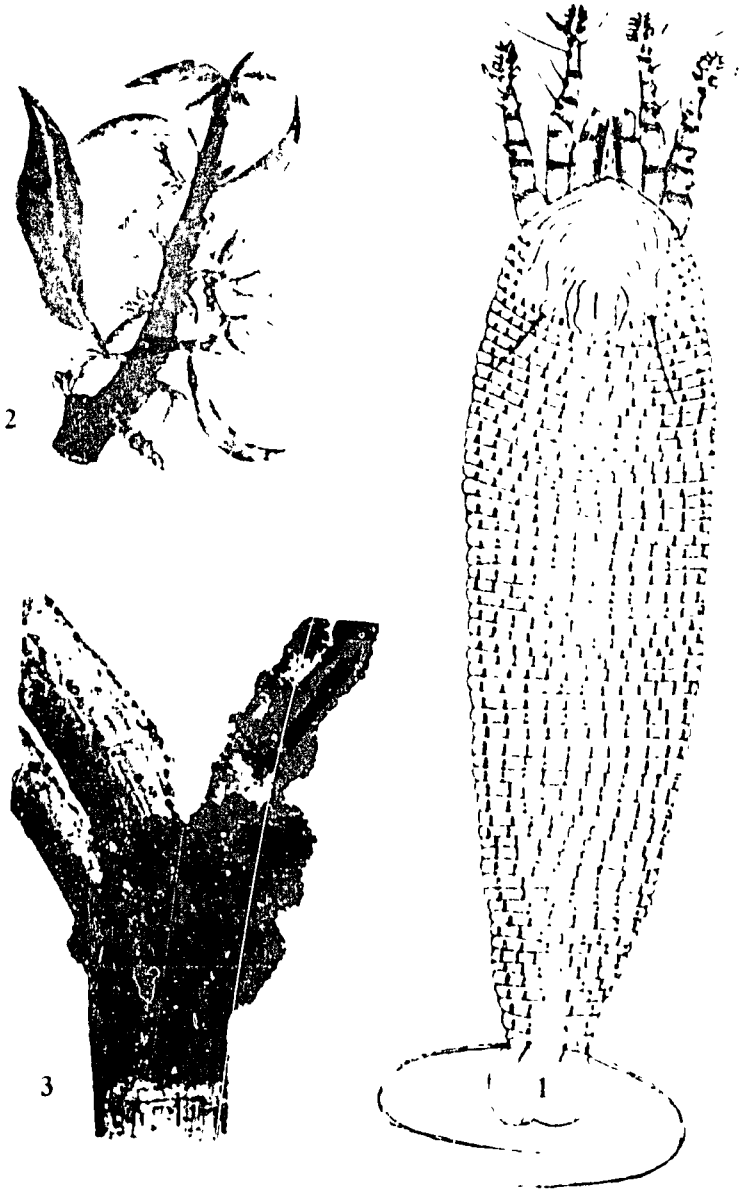
The pest can be suppressed by destroying all fallen fruits, weevilled mangoes, and by disposing of refuse, stones, debris, etc. The weevil being an internal feeder throughout its development is not easily controlled by the application of insecticides.

Aceria mangiferae Sayed **(Eriophyidae: Acarina)**
(Mango-bud mite)

The malformation of mango is a serious malady in Pakistan, especially in the Punjab. The etiology of this serious disease has received attention of physiologists, pathologists and entomologists during the last decade, but the



Sternochetus mangiferae (F.)
Adult beetle



Aceria mangifera Sayed

1. Adult, female mite
2. Malformed growth on young trees
3. Galls on the trunk of an old tree

information gathered so far leaves the mystery of the cause unsolved. The disease was attributed to nutritional deficiencies, and the application of balanced fertilizers was claimed to have reduced it. The constant association of the eriophid bud mite with the malformation, first recorded in 1954, gave an impression that the latter was either due to some toxin injected by the mite or was due to a virus transmitted by other agents, but the disease was not always controlled even when the bud-mite was completely under check. Yet another cause of the disease was claimed to be the fungus *Fusarium moniliforme* Sheld. While this complex problem continues receiving the attention of scientists, it is advisable for mango growers to pay attention to the control of bud-mite which is directly harmful to the mango inflorescence. Some other species of mites have also been recorded on the diseased inflorescence, but they all are probably predaceous, or they feed on dead and decaying matter (Chaudhri, 1965 & 1972). The bud mite is a pest of mangoes not only in Pakistan, but also in India and UAR.

DIAGNOSTICS

The mango bud mite is microscopically small, cigar-shaped and whitish in colour. The anterior pattern of the dorsal plate is indistinct, but between the 2 tubercles there is an interrupted portion of the admedian line. Distinct admedian lines that curve inward towards the posterior edge of the dorsal plate are visible, and a submedian line on each side of the admedian lines also curves inward to join posteriorly with the admedian line, the microtubercles are oval and to some extent elongated; the featherclaw is 6-rayed.

LIFE CYCLE

The detailed life history of this eriophid bud mite is unknown. Although the mite is present throughout the year on mango trees, yet studies on its population dynamics have revealed seasonal variation in its population. The first peak in population has been observed during February after which there is gradual decrease until it becomes very low in May. A second peak is usually observed in July. The population gradually declines until it becomes very low during October to December. The two peaks in the population of eriophyid bud mite synchronize perfectly with the new malformations; hence the suspicion that the two are related.

NATURE OF DAMAGE

There is a difference between various cultivars in resistance to the

damage that this mite can cause. The mites do most damage to young trees and attack the terminals of branches, where they feed amongst the bracts and cause brown to black patches. The symptoms that eventually develop are, the severely distorted new growth, which results from injury to the buds. If such an infestation continues for a few seasons, young trees become stunted and do not develop normally (Latif *et al.*, 1961).

There are 3 types of symptoms that can be attributed to these mites: a bushy appearance of the seedlings, vegetative distortion, and the distortion or die-back of blossoms. Sieralicht and Goldenburg (1976) are, however, of the opinion that distorted blossoms cannot be attributed to bud mite alone and that there are possibly other factors involved which can produce similar results. Some Indian mycologists are of the opinion that *A. mangiferae* is the vector of a fungus known as *Fusarium moniliforma* Subglutinans, but they do not have irrefutable evidence of this.

On older trees the bud mite can produce coarse galls in the forks of branches. These galls consist of a thick mass of abnormally developed growth points that accommodate large number of mites. Coarse galls are not common and the reason for their sporadic appearance is not known.

This pest can be of great economic importance, and may seriously jeopardize the mango industry.

CONTROL METHODS

Schwartz (1968) suggested the following safety measures for preventing the spread of this mite; on older trees on which galls have been produced, the galls should be cut out and burnt. Thereafter, the wound must be sealed to prevent infection by diseases. Budwood must be selected carefully so that wood from an infested mother tree is never used. If there is a danger that the presence of this microscopically small mite has been overlooked budwood should be dipped in a solution of Omite 0.04%. If, despite this precaution, symptoms develop on young trees, they must be immediately sprayed with Dicrotophos/Dimethoate/Formithion 0.1 to 0.2% emulsion. An effective full cover spray must be applied because the mites occur in the buds where they are well sheltered. If young trees have been extensively damaged, it would be wise to replace them with undamaged trees.

Pest Control Schedule for Mango Pests

The mango hoppers are the commonest and most destructive of all the

mango pests. Special attention may be given to the control of this pest during winter when they congregate in large number on the trunk of the tree and before the appearance of inflorescence in spring. At this stage, the pest can easily be controlled by spraying Methyl Parathion/ Phosphamidon/ Endosulfan/ Dimethoate/ Malathion, etc. During the period of end-December and the beginning of January, nymphs of the mango mealy bug ascend the trees, which have to be stopped by applying a band of grease or some other sticky substance or slippery band of polythene or plastic sheet around the tree trunk at about 1 metre above the ground level during the second week of December. The nymphs that gather below the bands can be killed by spraying with Methyl Parathion.

In areas where fruit flies are a serious problem, poison baits should be used throughout the orchards.

GUAVA

The guava is grown widely in tropical and subtropical regions and succeeds under a wide variety of climatic conditions. However, it produces more abundant crops of better quality in areas having a distinct winter than in more tropical areas. In Pakistan, guava ranks as the third major fruit crop, grown over 36.9 thousand hectares and comprising 9.5 of the total area under all fruit crops. The soil and climatic conditions of Punjab are very suitable for its growth and thus 87% of the total area under guava is located in this province.

The crop is attacked by a number of insect pests, the most notorious of these are the fruit flies (Batra, 1954). The rainy season crop is particularly susceptible to fruit fly attack. Two species of fruit flies which are important for guava crop are listed below:

Dacus diversus Coq. (Tephritidae: Diptera)

DIAGNOSTICS

Egg, Larva, Pupa: Similar to *D. ferrugineus.*

Adult: Greyish black; 3 longitudinal yellow stripes on thorax; ovipositor long and black.

LIFE CYCLE

The pest remains active from March to September. The eggs hatch in 3

to 5 days and maggots become full-grown in 8 to 12 days during summer. The pupal stage lasts for 8 days in summer and 20 to 44 days in winter. The adults live for 30 to 43 days. The life cycle is completed in 19 to 31 days.

Dacus zonatus Saund. (Tephritidae: Diptera)

DIAGNOSTICS

Egg, Larva, Pupa: Similar to *D. ferrugineus*.

Adult: Reddish-brown; yellow cross bands on abdomen but no longitudinal stripes on thorax; ovipositor short and brown.

LIFE CYCLE

A single female lays 44 to 55 eggs in all. The eggs give rise to maggots in 2 to 4 days in summer and 8 to 9 days in winter. The maggots are full-grown in 7 days in summer and 13 to 22 days in winter. The pupal stage lasts for 8 days in summer and 20 to 44 days in winter. The adults live for 37 to 41 days. The pest remains active throughout the year and passes through 8 to 9 generations during this period (Narayanan and Batra, 1961).

CONTROL METHODS

Already included under general discussion on fruit flies.

DATE-PALM

Oryctes rhinoceros (L.) (Dynastidae/Scarabaeidae: Coleoptera)

(Rhinoceros beetle)

DIAGNOSTICS

Egg: Whitish, globular/oval, measures about 3.5 mm in length.

Grub: Fat, soft bodied; yellowish-white; wrinkled, usually found curled up in a C-shaped position; measures up to 10 cm in length when full-grown.

Pupa: Large; dirty-white; naked; measuring about 4.5 cm in length.

Adult: Large; shining; head with a stout horn-like structure (= cephalic horn), conspicuously long in the male; tibiae with thorn-like spines; under surface of body reddish and clothed with short fine hairs; measures about 35 mm in length.

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Oryctes rhinoceros (L.)

1. Egg
2-3. Grubs
4. Pupa
5. Adult beetle
6. Head of female beetle
7. Head of male beetle

LIFE CYCLE

Each female lays about 60 eggs singly or in batches in the breeding material (damaged and decaying leaves, logs and stumps of dates and sometimes dung heaps). They hatch in about 11 to 12 days. The grub passes through 3 stages and is full-grown in 125 to 155 days and take another 185 to 215 days before they transform themselves into pupa. When ready to pupate the larva shrivels to form a Prepupa and leaves the foodstuff. It tunnels into the soil sometimes to a depth of about a foot and forms a hard earthen cell which is smooth internally. It pupates after about one week. The pupal stage lasts for about 3 to 4 weeks and the adult flies to the nearby palm trees on emergence. The adult lives for as much as 10 months. There is no definite sequence of generations in this species.

The pest is nocturnal in habit and remains active throughout the year but the incidence of attack is highest in the dry season, i.e., December to May. It is harmful only in the adult stage.

NATURE OF DAMAGE

The adults bore into the crowns (= central shoots) of healthy trees and eat through the un-opened young growing leaves, which later expand with a characteristic V-shaped cuts which are seen in the mature leaves. They feed on the sap, discarding the fibrous tissue, which often remains plugging the borings. Feeding is done in the early hours of the night, during the day the beetles are inactive and remain hidden.

DISTRIBUTION AND HOST PLANTS

This beetle is widely distributed in all date palm growing countries of the world. In Pakistan, it is particularly common and serious in Multan, Muzaffargarh, Dera Ghazi Khan and Khairpur districts. Besides date palm, it has been recorded on coconut and other palms. Rarely it attacks aloes, sugarcane and screw-pine stems (Haq and Akmal, 1960).

CONTROL METHODS

A single beetle is capable of flying long distances and attacking many different palms during its adult life; it is, therefore, essential to organise control measures simultaneously over a large area. The recommended methods of control are as follows:-

1. Plant palms at the same time, at a close regular spacing so that a

continuous canopy of foliage develops. Isolated palms and palms of irregular heights are particularly liable to be attacked.

2. All dead palms should be cut down leaving a stump of not more than 3 feet high. Stumps left of greater height than this should be dug out and burnt.
3. Dead palm trunks of all species should be burnt, after first splitting them into short lengths for drying.
4. All heaps of moist, rotting vegetable matter should be scattered and allowed to dry out thoroughly and then burnt, if possible.
5. The natural enemies of the pest, viz., *Scolia procer*, a grub parasite, be encouraged.
6. Chemical control can be effective with sprays of BHC and with DDT dust, the latter mixed with sand or saw dust and placed in the leaf axils.

Rhynchophorus ferrugineus (Oliv.) (Curculionidae: Coleoptera) (Red palm weevil)

DIAGNOSTICS

Egg: Oval; creamy white; measures about 2.25 x 1.25 mm.

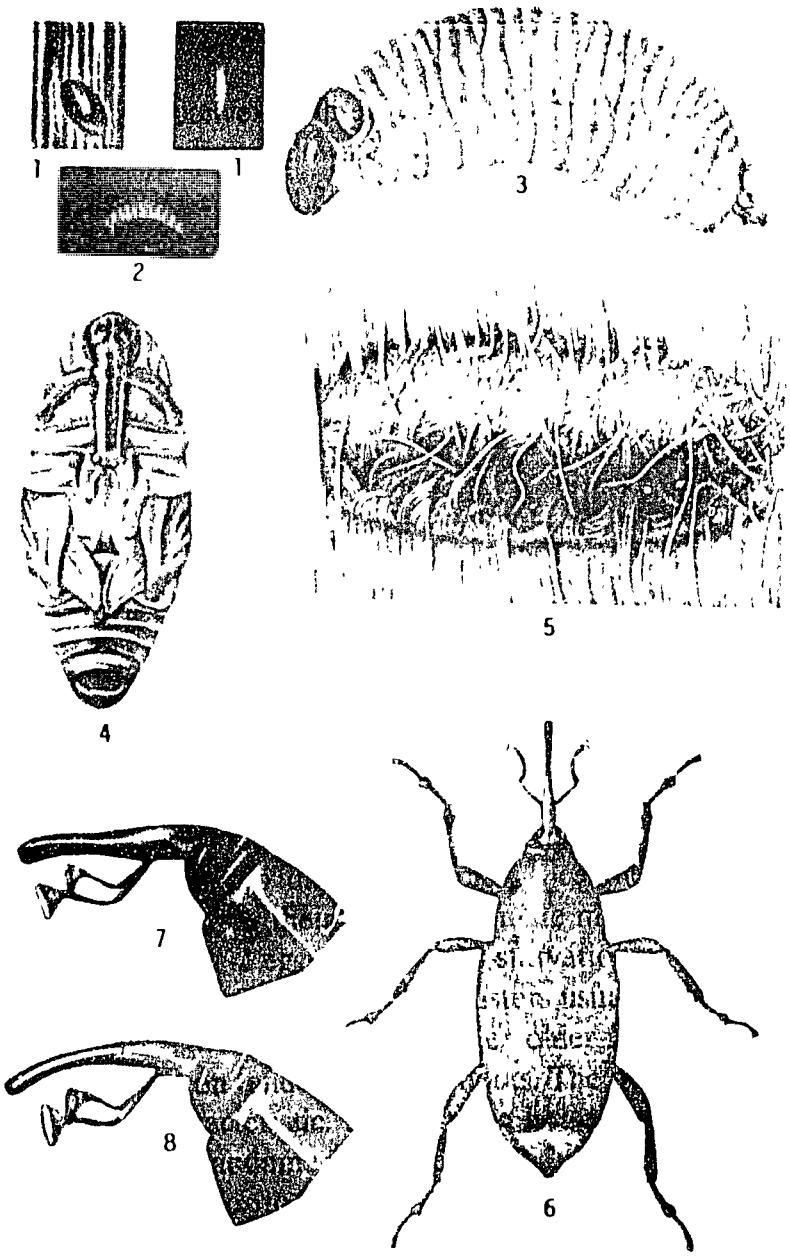
Grub: Thick, soft-bodied; legless; pale-yellow in colour with reddish brown head. When full-grown, measures 5 to 8 cm.

Pupa: Large; yellowish and enclosed in a fibrous cocoon.

Adult: Reddish brown; stoutly built with head produced into a downwardly bent snout which in male is furnished with a brush of brown hairs on the upper surface. Antennae elbowed and terminate in a funnel-shaped knob. It measures 2.5 to 4.0 cm in length.

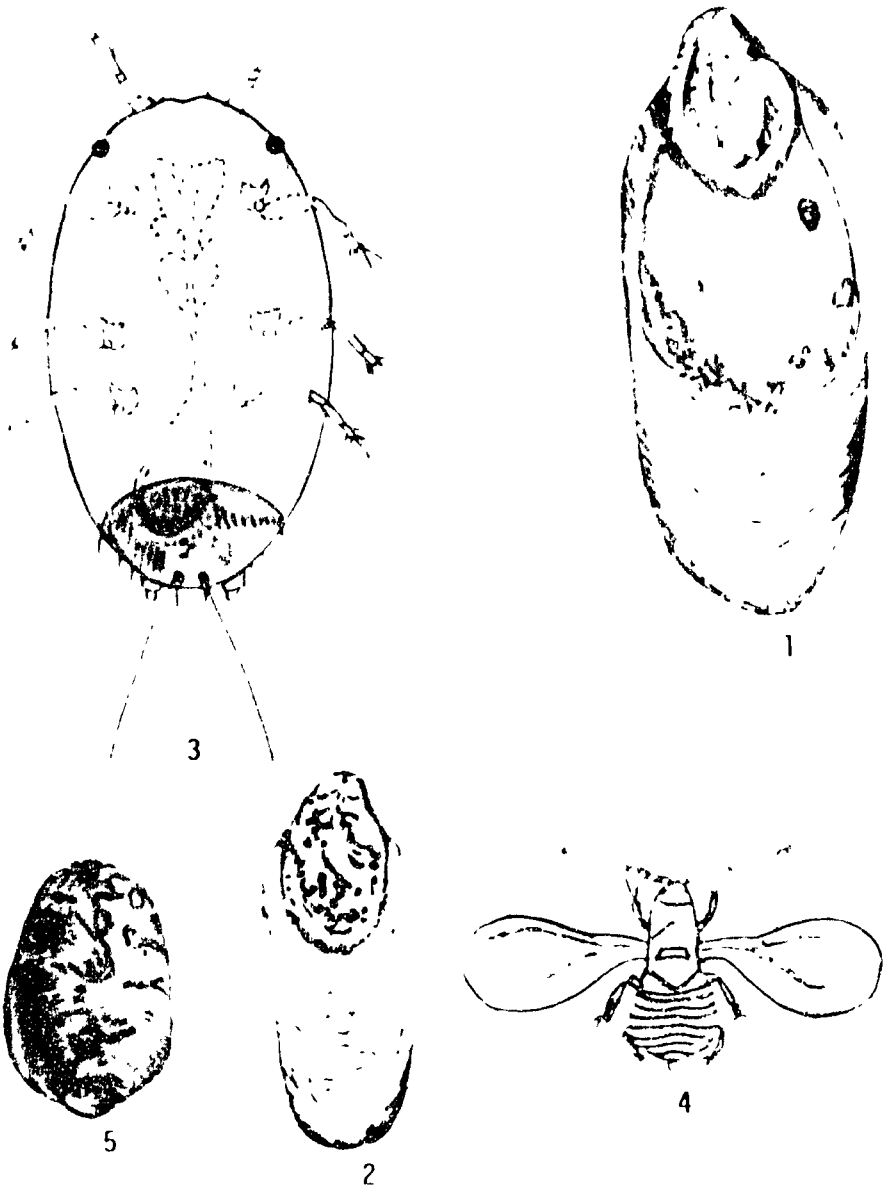
LIFE CYCLE

Adults are very active during night. Each female deposits about 300 eggs singly either in the holes cut by rhinoceros beetle or cut petioles or it scoopes out of a hole with its snout in the soft tissues of the tree 3 to 5 mm long for the purpose. The eggs hatch in about 4 days. The larva penetrates the crown initially and later on most parts of the upper trunk, making tunnels up to 1 metre in length. They are voracious feeders and the damaged tissue soon starts giving characteristic decaying unpleasant odour. As the galleries become more extensive, the trunk weakens and the tree may easily be de-



Rhynchophorus ferrugineus (Oliv.)

1. Eggs
2-3. Grubs
4. Pupa
5. Pupa enclosed in fibrous capsule
6. Adult weevil
7. Adult, male snout
8. Adult, female snout



Parlatoria blanchardii (Targ.)

1. Scale of mature female insect
2. Scale of adult male insect
3. Larva
4. Adult (Male)
5. Adult (Female)

capitated due to strong wind. The larval period lasts for 2 to 4 months. Pupation takes place either amongst leaf-basis or in the stem under the bark depending upon where the grub was feeding. Pupa is enclosed in a cocoon made of spirally arranged long fibres, the actual emergence hole being blocked with a fibrous plug. The pupal stage lasts for 14 to 28 days. The young adult stays in the cocoon for 8 to 14 days before emerging and starting to feed. Adults live for about two months. There are many generations in one year.

NATURE OF DAMAGE

The pest remains active throughout the year. Only the grubs are destructive which penetrate the crown and destroy it. Initially the outer leaves turn chlorotic and die, and this gradually spreads to the innermost leaves. Later, the trunk becomes tunnelled and riddled in all directions, weakened and ultimately may break, although the tree from outside looks to be quite healthy.

DISTRIBUTION AND HOST PLANTS

Like rhinoceros beetle, it is found in most coconut and oil-palm countries of the tropics. It has been recorded from Pakistan, India, Bangladesh, Sri Lanka, Burma, Malaysia, Thailand, Laos, Cambodia, Vietnam, Southern China, Taiwan, Philippines and New Guinea. In Pakistan, it is particularly common and serious in Multan, Muzaffargarh, Dera Ghazi Khan, Dera Ismail Khan and Khairpur districts.

Besides date palm, it has been reported attacking palmyra, coconut and sago palm in India.

CONTROL METHODS

Many cultural practices may be carefully applied, e.g., destruction of cut stumps and useless parts of the plant, plugging the cuts, wounds made by black beetle, etc.

Other control measures are similar to date palm beetle.

Parlatoria blanchardii (Targ.) **(Diaspidae: Hemiptera)**
(Date palm scale)

DIAGNOSTICS

Egg: Shining, light to dark purple coloured; oblong with one end rounded

and broader, the other bluntly pointed and measures 0.23 to 2.28 mm in length and 0.08 to 0.11 mm in breadth.

Larva: Oval; dark purplish, unconspicuous when freshly hatched, undergoes 2 to 3 moults. Female larva slightly bigger than male.

Pupa: Pupa is preceded by a short prepupal stage in both the sexes.

Adult: (Male): Minute, delicate; purplish in colouration; may or may not bear wings and measures 0.55 to 0.79 mm in length. Greatest breadth at wing expanse 1.26 to 1.29 mm. (Female): Dark purple; pyriform; plump, delicate, pygidial region more chitinised and measures 0.58 to 0.95 mm in length and 0.55 to 0.67 mm in breadth.

LIFE CYCLE

Oviposition starts at the end of March or beginning of April. The eggs hatch from 4 to 22 days depending upon the prevailing temperature. On hatching, the larva soon emerges out of the mother scale covering, wanders about in search of a suitable site to settle and soon starts secreting the scale covering from the dorsal body wall which later becomes dome-shaped. Larvae that hatch at the end of March complete their life cycle within 47 to 51 days and 73 to 75 days in case of male and female, respectively. This period is, however, shortened considerably during May-June when the temperature rises (but the mortality is high) and again prolonged in July-September, with the fall in temperature. Sexes can be differentiated after the second moult. The male scale is smaller than the female. Prepupal and pupal stages last for 1 to 4 and 3 to 11 days, respectively, depending on the prevailing temperature. A complete life cycle requires about 55 and 158 days during summer and winter, respectively and there are 4 to 5 overlapping generations in one year.

NATURE OF DAMAGE

The pest breeds actively during summer, slowing up in the mild season and completely hibernates during winter as first and second instar nymphs of both sexes and as mature females. The most favourable season for the multiplication of the pest is from July to September and March to April.

The larvae soon settle and pierce their stylets deep into the tissue and desap the plant. In cases of severe attack the leaves may be killed outright. The infested fruits look ugly and are thus rendered unmarketable.

DISTRIBUTION AND HOST PLANTS

The scale is widely distributed in the palm growing countries and has been recorded from Brazil, Africa and Asia. In Pakistan, it has gained entry with the imported date palm suckers from the Middle-East. It occurs throughout Punjab, NWFP and Lower Sindh areas. It is exclusively a pest of palm tree, particularly date palm. The Basra varieties of date palm, e.g., Hillawi, Zahidi, Khudrawi are attacked more severely than the local varieties. Other host plants are "doupalm", Canary Island palm and the California fan palm.

CONTROL METHODS

Spray infested trees with Metasystox/Phosphamidon 0.05 to 0.075%. Best results are obtained when infested plants are sprayed with Phosphamidon/Ethion 225 ml mixed with one gallon summer oil in 100 gallons of water.

BANANA

Cosmopolites sordidus (Germer) **(Curculionidae: Coleoptera)**
(Banana weevil)

LIFE CYCLE

The pest is active throughout the year. The female weevil bites a small hole in the corm, lays eggs singly. A single female is capable of laying 10 to 50 eggs during its entire life span. These eggs hatch out in about a week's time and the grubs bore into the corm, where they feed, making a tunnel. When full-grown in 2 to 6 weeks, these larvae pupate in the same tunnel. The pupal stage lasts for about a week. The adults, on emergence, remain in the soil for sometimes feeding on the under-ground parts of the plants. Later on, they visit the growing point for oviposition. The adults live for a few months. There may be many generations in one year.

NATURE OF DAMAGE

The weevil destroys the corm tissue. The seedlings are killed as a result of the borer attack, when the larvae approach the growing point. The tunnelled corms sometimes break, but since the weevils do not attack the roots they do not cause toppling over (Dutt and Maiti, 1970).

DISTRIBUTION AND HOST PLANTS

This pest is distributed in the tropical and South Africa, tropical America, South-East Asia, Australia, Hawaii Island, India and Pakistan. In

Pakistan, it has been reported to occur attacking rhizomes of banana in the major growing tract of Indus Valley (Sindh). No other host for the pest has been reported.

CONTROL METHODS

Cultural: Cultural methods of control are the most important and in many areas their use will be sufficient to keep the weevil population level down so that damage is insignificant. These methods include the use of clean suckers only; old stems should be cut off at ground level and the cut rhizome covered with impact soil; all old stems should be cut into small stripes and used for mulch. Old pseudostems can be cut and carefully placed in strategic positions with the cut surface downwards to trap the adult beetles, as they come and assemble under the trap from where they can be collected by hand, once a week.

Biological: Two predacious beetles, *Plaesius javanus* from Indonesia, and *Dacylosternum hydrophiloides* from Malaysia, have been introduced into various countries and are exerting a fair measure of control.

Chemical: The most successful insecticides for use against this pest are Aldrin and Dieldrin, applied as a dust around the bases of the pseudostems, and applied to the cut surfaces of the rhizomes before they are covered with soil. Planting suckers which are suspected of being infested should be dipped into Dieldrin solution.

FRUIT FLIES

The following species of fruit flies *(Tephritidae: Diptera)* have been recorded attacking different fruit plants in Pakistan:-

1. *Dacus dorsalis* Hndl.
2. *D. zonatus* Saund.
3. *D. diversus* Coq.
4. *D. cucurbitae* Coq.
5. *D. ciliatus* Lowe.
6. *D. ferrugineus* F.
7. *D. scutellaris* Bezzi.
8. *D. hageni* de Meiji.
9. *D. latifrons* (Hend.)
10. *D. longistylus* Wield.

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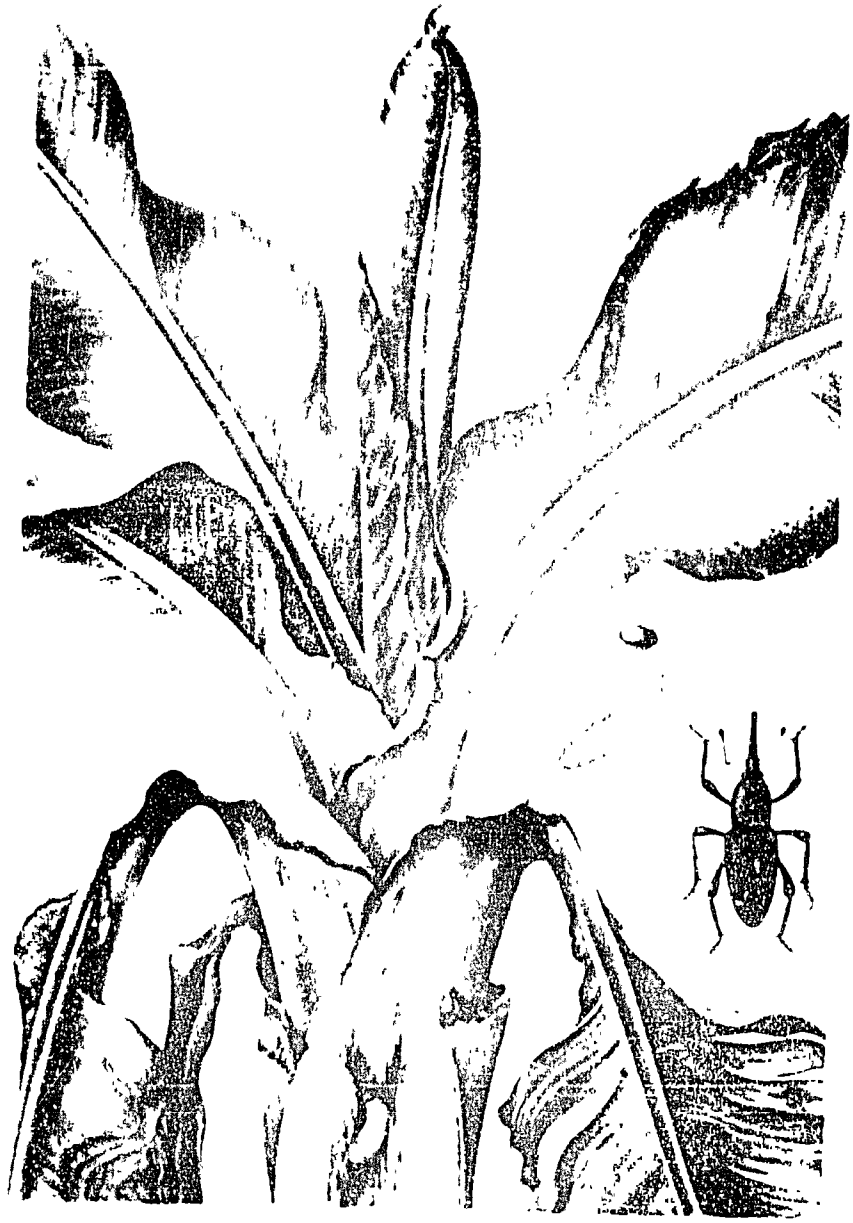


Cosmopolites sordidus (Germer)

1. Damage (dying heart leaf)
2. Larva
3. Adult, weevil

11. *Carpomyia vesuviana* Costa.

Since the morphological characters, life processes, nature of damage and the control measures recommended against all fruit flies are identical, therefore, these have been dealt with collectively for all the species. However, the differences in their diagnostic characters and life cycles, have been duly brought out under their respective host plant. *D. dorsalis* and *D. cucurbitae*, *D. ferrugineus*, *D. zonatus* and *D. diversus*; and *C. vesuviana* being serious pests of citrus, mango, guava and 'ber' respectively, have been dealt with in their relevant sections. *D. ciliatus*, *D. scutellaris*, *D. hageni*, *D. latifrons* and *D. longistylus* are allied species but are scarce and have a limited distribution.

DIAGNOSTICS

Adult: The adults of fruit flies are of the size of a housefly with variable-coloured bodies ranging from reddish brown to greyish black. The wings are transparent, each wing being ornamented with a brown spot about its tip. Although otherwise almost alike, these species can be differentiated as adults by comparing their general body colouration, the number and disposition of stripes on the thorax and colour and size of the ovipositor.

Immature stages, viz., egg, larva and pupa, are very similar in the fruit flies and, hence, the description of these stages given in case of *Dacus dorsalis* Hndl. will hold good for all practical purposes, for the remaining species as well.

LIFE CYCLE

As in morphological characters, these species are also allied in biological processes and life cycles. The females puncture the fruit with their needle-like extensile ovipositors and deposit the eggs, singly or in groups, under the skin of the fruit. The white legless, headless maggots which emerge from the eggs penetrate into the pulp, feed on it and cause decay in the fruit. The full grown larvae leave the fruit by making hole in the skin and drop on the ground. They enter the soil to a depth of 1 to 3 inches and pupate under the infested trees. The pupa is enclosed in a puparium from which adult flies emerge.

The duration of different stages of development differs only slightly in the fruit flies, but, in all cases, it varies significantly with the season.

HOST PLANTS

The hosts that are common to all the species are 'malta', orange,

'chakotra', grape-fruit, mango, gourds, vegetable marrow, muskmelon, bitter gourd, 'ghya tori' and fig. The fruits which serve as common hosts to *Dacus dorsalis*, *D. zonatus* and *D. diversus* are guava, mulberry and mango. The fruits which serve as common hosts to *D. dorsalis* and *D. zonatus* are peaches, pomegranate and 'ber'. *D. dorsalis* is also found on plums, loquat, 'nutha,' banana, persimmon, quince, crab-apple and tomato. The hosts that are common to both *D. cucurbitae* and *D. diversus* are longmelon, pumpkin and cucumber. The former species, i.e., *D. cucurbitae*, also attacks watermelon and 'tinda' in addition to its other hosts mentioned already (Haq *et al.*, 1960).

NATURE OF DAMAGE

The attack of fruit flies on citrus fruit starts in September, when the fruit is still green. The infested fruit does not betray any visible sign of attack in the beginning, but, later on, it can be made out easily by the presence of circular and depressed round patches on its skin. The attacked fruit turns orange in colour pre-maturely and gradually begins to fall. The maggots feed on and develop inside the pulp of the fruit. This sets up decay in the pulp and the fruit is rendered unfit for human consumption.

CONTROL METHODS

The following control measures which are applicable to all the species of fruit flies are recommended:-

1. **Sanitary:** (i) All fallen infested fruit should be carefully collected and buried 4' to 5' deep in the soil to kill the maggots contained therein. In no case should such fruit be thrown away carelessly or sent to the market.

   (ii) The soil under the infested trees should be kept frequently stirred by hoeing or ploughing to kill the pupae by exposing them to the inclemencies of weather.

   (iii) Applying irrigation to the soil, preferably by mixing some insecticide like sanitary fluid, BHC, Aldrin, etc., in the irrigation water, should prove further helpful in killing the pupae.

   (iv) Growing some cover crop on the infested soil also proves advantageous in this behalf. These operations should be a 'MUST', particularly during winter, when the pupae are hibernating in the soil.

2. **Biological:** *Spalangia grotiusi* Grirault (Pteromalidae) parasitises

immature stages of *D. dorsalis*, *D. cucurbitae* and *D. zonatus*. *Dirhinus giffardi* Silv. (Chalcididae) and *Opius longicaudatus* (Ashm.) (Braconidae) parasitise the pupae of *D. cucurbitae*, *D. ciliatus*, and *Carpomyia vesuviana*. These parasites should be encouraged (Mohyuddin, 1981).

3. **Chemical:** The chemical control of fruit flies comprises the use of cover sprays and bait sprays. Before taking up this control, it is preferable to determine the presence of the pest in the orchard by using bait traps which should be hung up on the trees. The trap bottles should be half-filled with cleansel diluted with water (1:2) or other attractants like amyl acetate, vanilla essence, melon pulp, malta, etc. As soon as the fruit flies start appearing on the bait material, spraying operations should be set afoot. In citrus orchards, the pest generally starts appearing by the end of August or in the beginning of September. As such, the control operations should coincide with this time.

   (a) *Cover Spray:* Citrus orchards should be sprayed at fortnightly intervals from September to December with Trichlorphon/ Dichlorvos 0.1% or Phosphamidon 0.057%.

Precautions: All these insecticides are deadly poisonous and care should be taken that the treated fruit is not consumed till after a fortnight of the final spraying.

   (b) *Bait Spray:* (i) Sodium fluosilicate or lead arsenate can be used as bait spray against the fruit flies according to the following formula:-

Sodium fluosilicate	=	10 oz.
or		
Lead arsenate	=	3 oz.
Molasses	=	2 to 5 lb.
Water	=	4 gallons

All these ingredients should be mixed to obtain a thin syrup. The bait solution be sprayed on small patches of the foliage here and there on the trees at weekly intervals during the fruit-bearing period. Instead of spraying, the bait can also be painted on the plants or on wooden boards which are hung on the trees under

shade. After rainfall, the bait spray or paint should be renewed promptly. Normally the paint may be renewed twice a week. It must be remembered that how effective the chemical control may be, it must be supplemented with the sanitary control to achieve better success.

(c) Spraying with a mixture containing 1% molasses and 0.1% Trichlorphon effectively controls fruit flies. Addition of 'Culture' for *D. cucurbitae* and Methyl-eugenol for *D. zonatus*, and *D. dorsalis* in the bait spray helps attracting the flies and increases its efficacy.

BER

Carpomyia vesuviana Costa. **(Tephritidae: Diptera)**

(Ber fruit fly)

DIAGNOSTICS

Egg: Whitish-yellow; spindle-shaped; measures about 1 mm in length.

Larva: (Maggot) Headless; apodous; creamy white in colour; tapering towards the anterior end.

Pupa: Yellowish-brown, oval in shape.

Adult: Brownish-yellow with shining black spots on the thorax and transverse yellow-brown streaks on the wing; measures 5 mm in length and 8 mm in wing expanse.

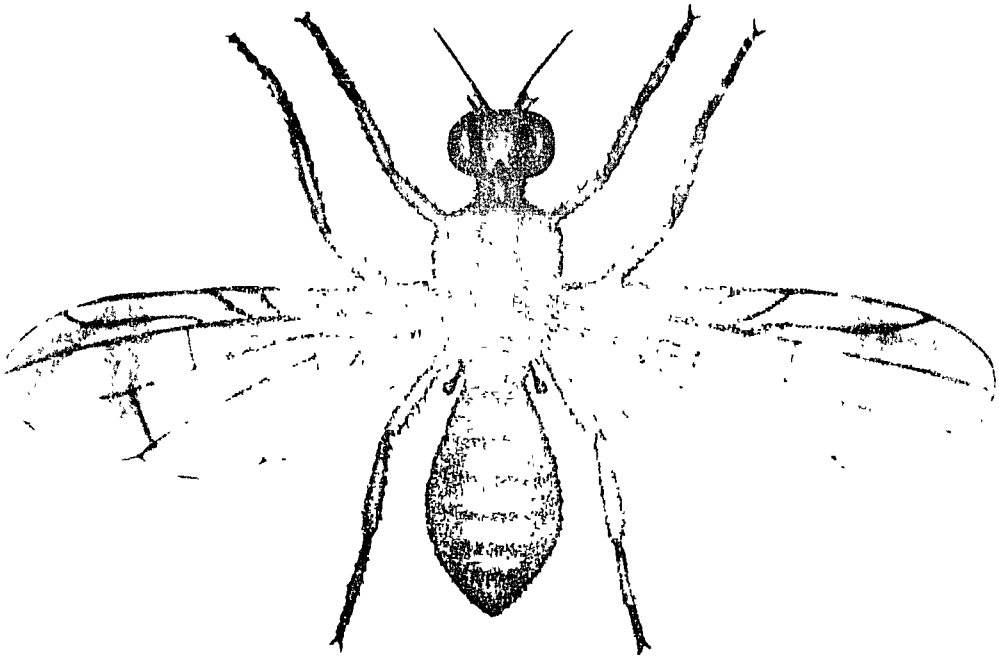
LIFE CYCLE

Adult flies make cavities in the skin of fruits and lay one or two eggs, 1 mm below the skin. These eggs hatch in 2 to 3 days. The maggots are full-grown in 7 to 10 days, jump out of the fruit by cutting exit hole and usually pupate 6 to 15 cm below the soil-surface. The pupal stage lasts 14 to 30 days. There are 2 to 3 broods in a year.

The pest becomes active in the autumn and builds up population during winter. It hibernates in the soil from April to August, in the pupal stage. The emergence of flies coincides with blossoming and fruit setting of 'ber' trees, i.e., during August to mid-November. The flies are very fast fliers.

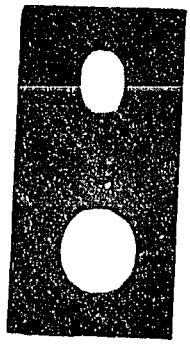
NATURE OF DAMAGE

For egg laying the flies make cavities in the skin of the fruit. As a result



Carpomyia vesuviana **Costa**

Adult fruit fly



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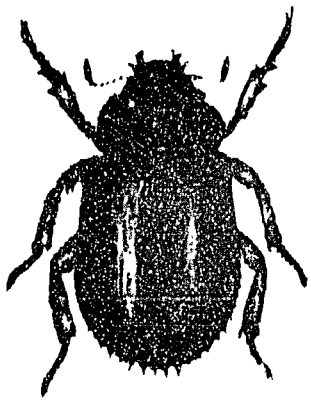

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3

Adoretus pallens **Arrow**

1. **Eggs**
2. **Grub**
3. **Pupa**
4. **Adult beetle**

of that the further growth of the fruit in the vicinity of puncture is checked and hence the fruit gets deformed. Fleshy varieties of 'ber' are more susceptible to its attack. The attacked fruits get rotten near the stones and emit a strong smell. Late-maturing fruits are found riddled with maggots almost entirely.

DISTRIBUTION AND HOST PLANTS

It occurs in India, Pakistan and southern Italy. Besides 'ber', the pest attacks guava fruits.

CONTROL METHODS

Already included under general account on fruit flies.

Adoretus nitidus Arrow and *Adoretus pallens* Har.

(Rutelidae/Scarabaeidae: Coleoptera)

(Ber beetles)

The two beetles closely resemble in their shape and structure. The details of *A. pallens* which is quite abundant and more frequently found has been included.

DIAGNOSTICS

Egg: Small, ovoid; white in colour.

Grub: Dirty-white; fleshy; crescentic with a brownish head; measures about 1.5 cm, when full-grown.

Pupa: Pale-yellowish, partly enclosed in the old larval skin; measures 1.2 to 1.4 cm in length.

Adult: Brownish, with a dark-brown head and characteristic antennae; measures about 10 cm in length and 4 to 5 mm in breadth; pygidium closely clothed with short hairs.

LIFE CYCLE

Females lay eggs singly in the soil near the host plants which hatch in 6 to 9 days. The grubs initially feed on soil humus, roots of grasses and other vegetable matter. When full-grown it measures about 1.5 cm in length and rests in earthen cells where it turns into pupa after overwintering. The pupal stage lasts for 11 to 13 days. There is a single brood of the pest in a year.

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The pest is active during summer (April-May) and starts breeding which may continue till August. The full-grown grubs make an earthen cell in the autumn and pass winter in this cell. Hibernating larvae pupate in next April before they become the adults and initiate the life cycle again.

NATURE OF DAMAGE

Damage is characterised by round holes cut in the leaves by adults during night. In case of severe infestation, the entire foliage may be eaten and such trees do not bear any fruits.

DISTRIBUTION AND HOST PLANTS

These two defoliating beetles are widely distributed in northern India and Pakistan and are polyphagous. Besides 'ber' tree it attacks grape-vine and many other trees (Rehman and Ghani, 1941).

CONTROL METHODS

The beetles can be controlled by spraying the trees with Malathion 0.1% during April-May. Their population can be suppressed by attracting the beetles to light and drowning them in kerosenized water.

Euproctis fraterna (Moore) *and Euproctis lunata* Walker

(Lymantriidae: Lepidoptera)

(Hairy caterpillar)

DIAGNOSTICS

Egg: Creamy-yellow, rounded; laid in clusters, covered with hairs.

Larva: Dark reddish-brown with black spots; body very hairy; head and prothoracic shield bright orange-red; when full-grown it measures 3.5 to 4 cm in length.

Pupa: Reddish-brown, covered with a thin deep-yellow cocoon interwoven with larval hairs.

Adult: Fore-wings deep yellow with black rounded spots along the apical margins. Female bigger than male and with an anal tuft of yellowish hair; measures 2 cm in wing expanse. *E. lunata* bears a conspicuous black crescentic mark in the middle of each fore-wing, otherwise similar to *E. fraterna* in colour and size.

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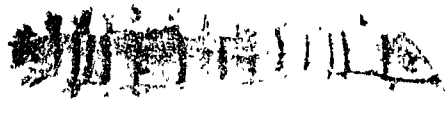

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Euproctis fraterna **Moore**

1. Adult
2. Larva

LIFE CYCLE

The female lays eggs in clusters, on the underside of the leaves of host plant. The eggs are covered with brown hair from the anal tuft of the female. Each female is capable of laying over 200 eggs. The eggs hatch in 3 to 8 days. The caterpillar is full fed in 17 to 28 days when it pupates on the leaves or on branch in a silken cocoon. The pupal stage lasts for 9 to 17 days. The pest passes through several generations in a year.

NATURE OF DAMAGE

The pest is more destructive during summer. The caterpillars feed gregariously on the epidermal tissues of the leaves from the lower side when young but disperse later and feed singly. The attacked plant can be easily recognized by its parched appearance, sieve-like look of dried leaves with jagged edges.

DISTRIBUTION AND HOST PLANTS

These are widely distributed in India and Pakistan. Primarily the hairy caterpillars are polyphagous insects. Besides 'ber' trees, these have been recorded on 'Jamun,' guava, pomegranate, pears, plums, 'falsa', grape-vine, castor and rose (Nath 1941).

CONTROL METHODS

The young caterpillars can be killed by applying Malathion/Endosulphan 0.03%. When they are grown up these can be killed with Methyl parathion 0.05% as spray.

Phytoptipalpus (= Larvacarus) transitans Ewing
(Tenuipalpidae: Acarina)
(Ber Mite)

DIAGNOSTICS

Egg: Oval, smooth; light reddish, transparent; measures 124.2 micron in length and 85 micron in breadth.

Larva: Body oval; light red in colour; possesses three pair of legs.

Adult: (Male): Body compressed and ovoid, light red, lustrous and transparent. Eyes intense red; legs three pairs; measures 249.9 micron in length and 118.8 micron in breadth.

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LIFE CYCLE

The emergence of adults takes place with the on-set of monsoon and continues during the rainy season. The mites on emergence, migrate to new sites and settle singly on the tender shoots and develop a scale over the body, after 10 to 15 days of emergence. During April, a slit appears on the side of the scale which provides exit for the emergence of mites. The oviposition takes place within the gall. The rate of oviposition and hatching is correlated with the prevailing temperatures. In winter (November-March), it is retarded due to low temperature; and is accelerated with the rise in temperature by the end of March. The minimum number of eggs laid was 6 per gall in November, whereas 397 eggs per gall were recorded in July. All stages of 'ber' mite (egg, larva and adult) are found within the gall throughout the year. There are many generations of 'ber' mite in one year.

NATURE OF DAMAGE

P. transitans causes considerable damage to the 'ber' trees, specially the grafted trees. The infestation appears, on any portion of the twig in the form of minute galls which grow in size with age, become hard and appear like scales. When full grown, the galls measure about 9 mm in length and 4.5 mm in breadth. The mite is enclosed in a gall, where it sucks cell sap from the tissue of the host plant with the help of chelicerae. This results in the development of undersized and crumpled fruits.

DISTRIBUTION AND HOST PLANTS

This mite has a fairly wide distribution in Pakistan. It has been recorded on 'ber' in Rawalpindi, Lahore, Multan, Khairpur and Hazara Divisions (Latif and Wali, 1961).

CONTROL METHODS

The 'ber' mite can best be controlled at the time when it migrates for resetting at new sites. Sprays with Dicrotophos/Dimethoate/Formothion 0.1 to 0.2% emulsion or Omite 0.04% effectively controls the pest.

POMEGRANATE

Virachola isocrates F. **(Lycaenidae: Lepidoptera)**

(Anar butterfly)

DIAGNOSTICS

Egg: Round; sculptured, shining pale-white in colour.

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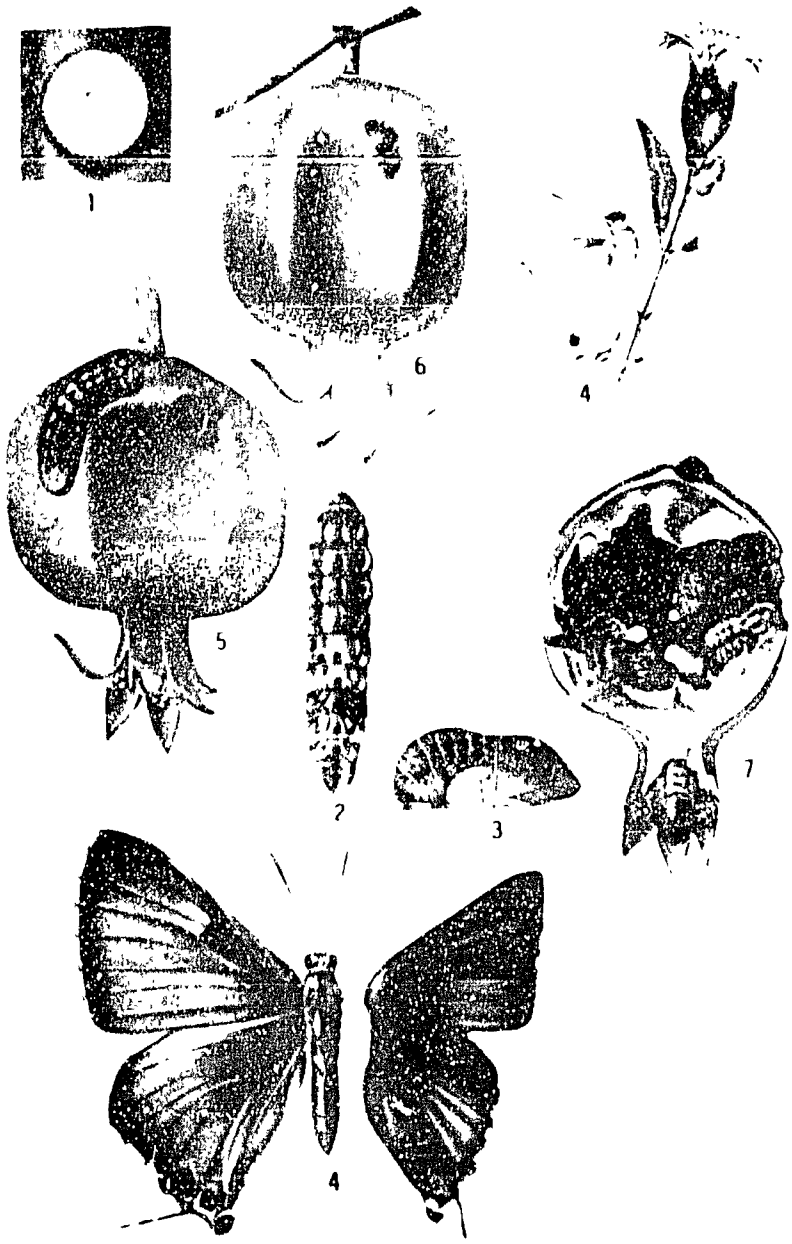

Virachola isocrates **F.**

1. **Egg**
2. **Larva**
3. **Pupa**
4. **Adult butterfly; also note egg laid on flower bud**
5. **Damaged fruit with an exit hole**
6. **Fruit laid with eggs, also showing entrance hole**
7. **Interior of the fruit damaged by larva**

Larva: 'Louse-like' in form, stoutly built; blackish brown with flesh coloured markings on the body; measures about 16 to 20 mm in length, when full-grown.

Pupa: Brown, rather squat in appearance and about 14 mm long.

Adult: Male glossy violet-blue above with an indistinct ochreous patch on the fore-wing and spots on the hind wings. Female is violet-brown above, ochreous spots more distinct; measures 3 to 4 cm in wing expanse. Both sexes have delicate, tail-like prolongations of the hind wings.

LIFE CYCLE

After mating, the females lay the eggs singly on flowers and young fruits. The eggs hatch in 4 to 6 days. The larvae are full fed in 20 to 70 days and the pupal stage lasts for 10 to 20 days. Life cycle is completed in about two to three months.

NATURE OF DAMAGE

The larva, on hatching, bores quickly into the fruit and feeds on the developing seed. The attacked fruit is rendered unfit for human consumption. The attacked fruit is recognized by a hole surrounded by a pale area. Larva when full-fed comes out of the hole and after binding the fruit with shoot by running silken threads across them, re-enters the fruit and pupates there in or on the stalk. Pupation takes place in the larval skin.

DISTRIBUTION AND HOST PLANTS

The pest occurs in India and Pakistan. Besides 'anar', the pest may be found attacking guava, loquat and tamarind.

CONTROL METHODS

Attacks are rarely reported until too late for effective action, so no insecticidal trials have been performed. Systematic destruction of infested fruits is a sure method of lessening the evil. In cases of heavy infestations, however, spraying twice with Methyl parathion 0.05% at ten to twelve days interval will effectively control the pest.

Tenuipalpus lustrabilis Chaudhri (**Tenuipalpidae: Acarina**)

(Anar mite)

Out of the four species of Tenuipalpid mites, viz., *Tenuipalpus lustrabilis*

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Chaudhri, *T. trisegmentis* Siddiqui and Chaudhri, *T. hornotinus* Chaudhri and *T. polacitus* Chaudhri, attacking pomegranate, *T. lustrabilis* is the most abundantly found species. The life history, other biological processes and control measures against them are almost identical, therefore, these have been dealt for one species.

DIAGNOSTICS

Egg: Freshly laid eggs blood red in colour.

Larva: Body colour deep red; with three pair of legs.

Nymph: Body colour red; with four pair of legs.

Adult: (Female). General body shining red; measures 265 micron in length and 184 micron in breadth. (Male): Not observed.

LIFE CYCLE

The mite remains active throughout the year. The immature stages and adults feed on the under surface of the leaves. The female lays eggs singly along the midrib which hatch in 6 to 7 days. The larvae feed on fresh and tender shoots and leaves, and are full-grown in 2 to 4 days after which they become sluggish and transform into Protonymph. The Protonymphs change into Deutonymphs in 5 to 7 days. The Deutonymphs develop into adults after 1 to 2 days and restart the life cycle. It takes about 17 to 22 days to complete the life cycle and there are about 12 overlapping generations in a year.

DISTRIBUTION AND HOST PLANTS

This mite is widely distributed on fruit trees in Pakistan. Besides pomegranate, it has been recorded on olive, mulberry, fig, peaches, plums, and pears.

CONTROL METHODS

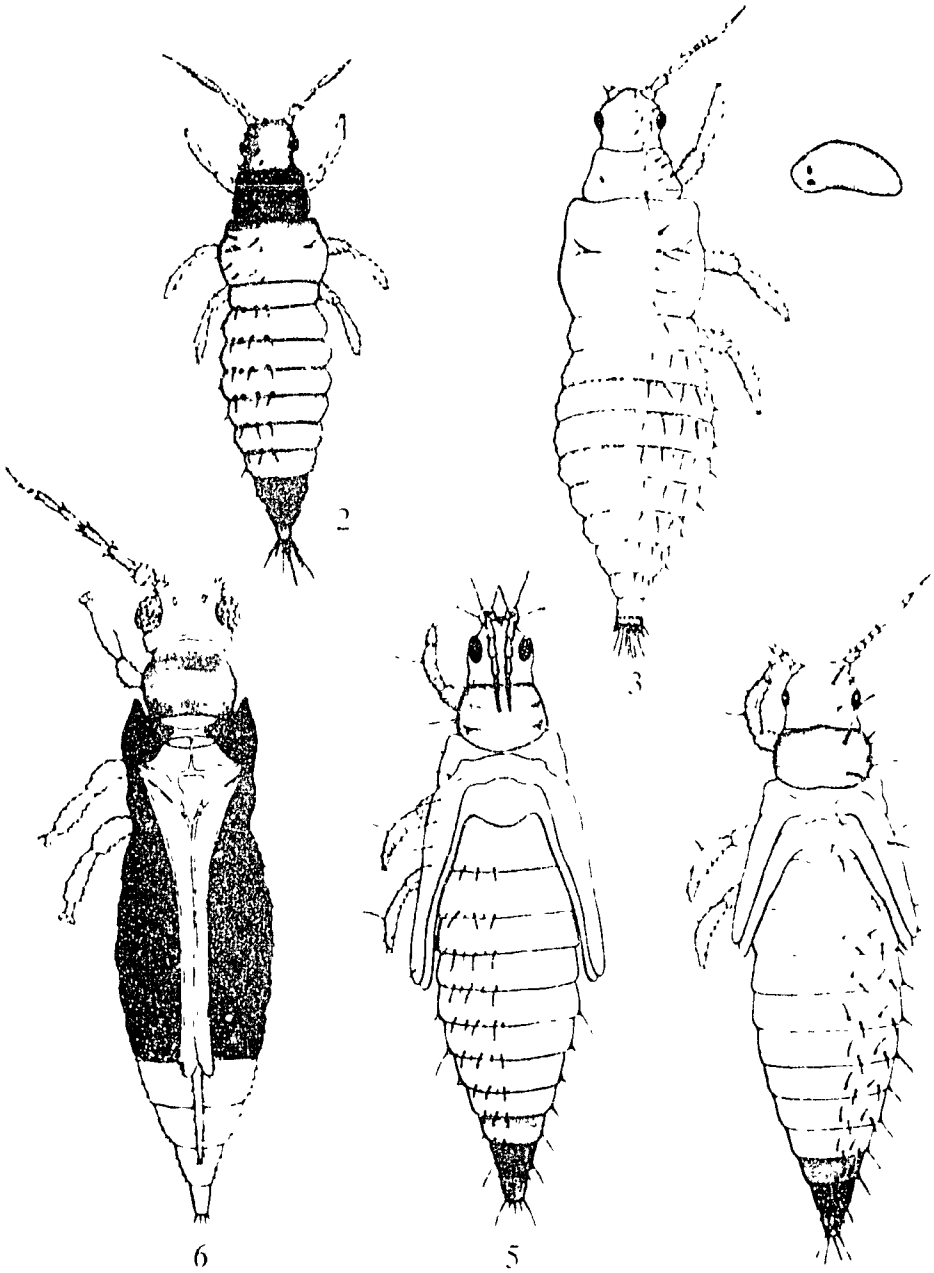
Removing and burning the infested leaves suppresses the mite populations. In cases of severe infestations, effective full cover spray with Dicrotophos/Dimethoate/Formothion 0.1 to 0.2% emulsion or Omite 0.04% may be carried out.

GRAPES

Rhipiphorothrips cruentatus Hood **(Thripidae: Thysanoptera)**
(Grape-vine thrips)

DIAGNOSTICS

Egg: Minute; reniform; pale-whitish.



Rhipiphorothrips cruentatus **Hood**

1. **Egg**
2-3. **Nymphal stages**
4. **Prepupa**
5. **Pupa**
6. **Adult**

Nymph: Very small, elongated; yellowish white with light orange spots. Setae arranged in a circular fashion at the tip of abdomen.

Prepupa: Brownish, similar to pupa, but antennae freely moveable.

Pupa: Brownish, with conspicuous wing-pads; antennae curved back over the head.

Adult: Minute, 1.4 mm long; blackish brown, with yellowish wings.

LIFE CYCLE

The females lay about 50 eggs on the underside of the leaf surface by marking small slits in the plant tissues and placing one egg in each slit. The eggs hatch in 3 to 8 days and the nymphs are full-grown in 9 to 20 days. During active breeding season, pupation takes place on the leaves and the pupae can make movement and crawl away when disturbed. Pupal stage lasts 2 to 5 days. The females are capable of reproducing parthenogenetically, the fertilized eggs giving rise to females and unfertilized ones to males. The insect hibernates as pupa in the soil. During the active period many generations are completed.

NATURE OF DAMAGE

The pest breeds throughout the year except in winter (December to February), when it is found as a pupa in the soil at a depth of 8 to 10 cm under the host plants. The adults appear in March and start breeding. Both the adults and nymphs cause damage by sucking cell-sap from the leaves. The pest usually feeds on the under surface of the leaves by rasping the leaf surface with their stylets and sucking the oozing cell sap. The attacked leaves show a whitish hue at first, acquiring a whithered appearance and then turning brown. The leaves ultimately curl up and drop off the plants. The yield from the attacked plants is adversely affected and whatever fruit is obtained is of poor quality.

DISTRIBUTION AND HOST PLANTS

This is the most destructive pest of grape-vine in Indo-Pakistan subcontinent. Besides grape-vine, it feeds on rose, terminalia, "jaman" and "ak" (Rehman and Bhardwaj, 1937).

CONTROL METHODS

Spraying with Dimethoate/Endosulfan/Phosphamidon 0.03% or Nico-

tine Sulphate 0.04% or Malathion 0.05%, effectively controls the pest.

Herse convolvuli (Linn.) (Sphingidae: Lepidoptera)
(Convolvulus hawk moth)

DIAGNOSTICS

Egg: Ovoid; bright-green in colour; measures about 1 x 0.9 mm.

Larva: (Young). Small with a straight black brown horn of medium length and bifid tip, head and body green. (Full-grown): Head pale-yellow with a narrow black dorsal stripe reaching the clypeus, a broad black, subdorsal stripe and another broader dorsal-lateral black stripe separating face from cheek; measures 9.5 cm in length and 1.4 cm in breadth.

Pupa: Slender; finely pitted; cremaster conical, long and stout, dorsal surface rugose, ending in two short conical teeth; leathery brown in colour; cremaster black, measures 4.7 cm in length and 1.2 cm in breadth.

Adult: Stoutly built moth; mottled grey in colour with pink markings on the body; measures about 8 to 12 cm across the wings.

LIFE CYCLE

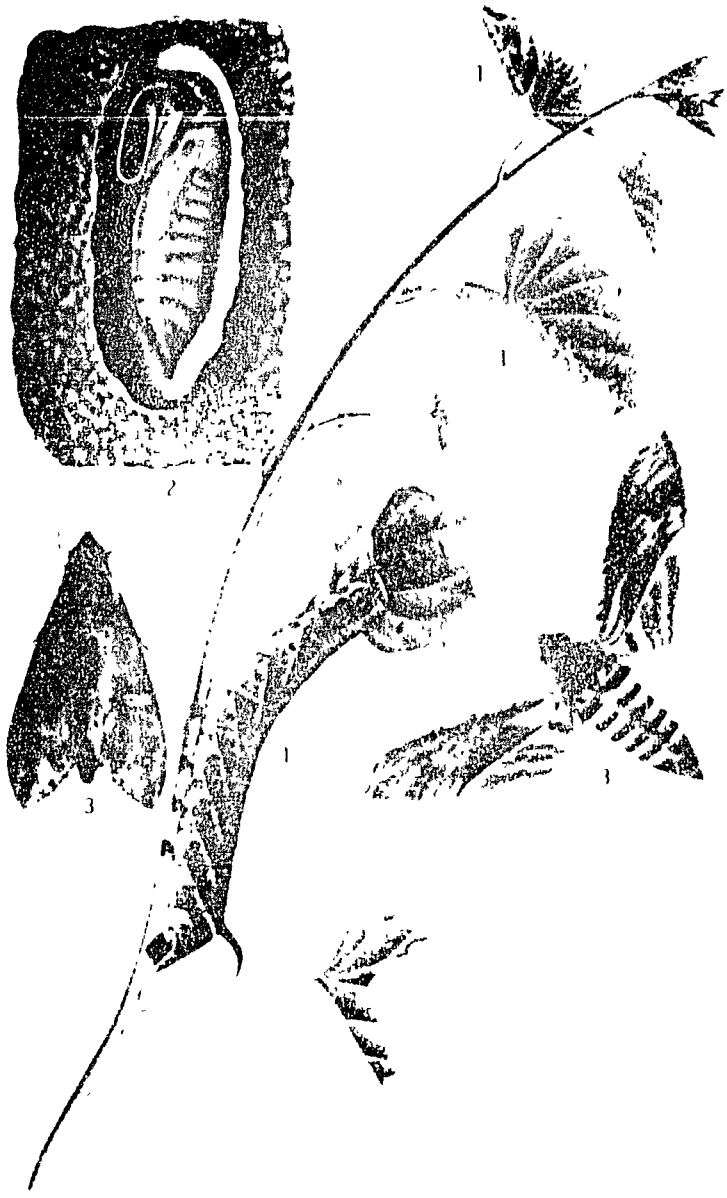
Eggs are laid singly or in batches of 10 to 20 on the under surface of leaves, firmly adhered, which hatch in 6 to 7 days. The larvae are full-grown in 30 to 40 days undergoing four moults. When about to pupate, the larva rests without feeding for 3 to 4 days. The pupal period varies from 18 to 251 days in summer. The pest passes through 2 generations in a year.

NATURE OF DAMAGE

Breeding activity begins in April, when the moths emerge from the overwintering pupae. Soon the population builds up. In June-July, the activity of the second brood begins and continues till September. The caterpillars are voracious feeders of grape-vine leaves. It has been estimated that one caterpillar eats from 10 to 20 leaves per day, resulting in a complete denudation of the attacked vines.

DISTRIBUTION AND HOST PLANTS

This species is widely distributed throughout the Eastern hemisphere except at higher altitudes. It is also found in Europe and occurs rarely in England. In Pakistan, it occurs in both wet and dry areas at elevations up to 7,000 feet.



Herse convolvuli **(L.)**

1. **Larval stages**
2. **Pupa in pupal case**
3. **Adult Moth**

It has been found damaging plants belonging to families Leguminosae and Convolvulaceae. In Pakistan, besides grape-vines it damages sweet potato, gram and pulses

CONTROL METHODS

Hand picking of the caterpillars is very effective in case of minor infestations. Use of light-traps for adults during night will also suppress the population. In cases of severe infestations, spray with Malathion 0.05%; Dimethoate/Endosultan 0.03%; or Carbaryl 0.1% effectively controls the pest.

Theretra alecto (Linn.) (Sphingidae: Lepidoptera)
(Hawk moth)

DIAGNOSTICS

Egg: Broadly ovoid, shining green in colour; measures 1.5 x 1.3 mm.

Larva: Pale-yellow; head dull and smooth, clypeus equilaterally triangular; body dull and smooth, with segments 4 and 5 considerably swollen; measures 80 mm in length and 11 mm in breadth

Pupa: Broad; measures about 6.9 cm in length and 1.3 cm in breadth.

Adult: Stout; head and thorax dark brown, abdomen and fore wings pale green, hind wings pink, antennae and thorax white; measures about 7.5 to 10.6 cm across the wings.

LIFE CYCLE

The eggs are laid on the underside of the leaves or the branches, in batches of 10 to 15 which hatch in about 6 to 7 days. The larva is full-grown in 40 to 48 days. When about to pupate, the larva enters the ground, spins a thin silken cocoon and pupates therein. The pupal period lasts for about 20 days in summer. Adults emerge in April and the breeding activity starts. Moths are powerful fliers and positively phototropic. Oviposition of the second brood takes place in June to July and the pupae of this brood overwinter. There are two generations of this pest in a year.

NATURE OF DAMAGE

The larvae of this moth have been found eating the grape-vine leaves. On an average, a single larva may eat 10 to 15 leaves in a day. In case of

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severe infestation, the entire vineyard may be completely defoliated (Atwal, 1976).

DISTRIBUTION AND HOST PLANTS

The pest has been reported from India, Burma, Formusa and Pakistan. In Pakistan, it occurs in the foot-hills and the adjacent areas, damaging grape-vines. The pest is known to feed on plants belonging to several families viz., Rubiaceae, Ampeliceae, Ternstroemiaceae and Dilleniaceae. However, in Pakistan, no host plant other than grape-vine has been recorded.

CONTROL METHODS

As for *Herse convolvuli*.

Sylepta lunalis Guenee (Pyralidae: Lepidoptera)
(Grape-vine leaf-roller)

DIAGNOSTICS

Egg: Oval, creamy-white; measures 1.4 mm across.

Larva: Full-grown caterpillar green in colour; cylindrical and measures 26 mm. Body covered with hairs; head brownish black.

Pupa: Reddish brown; abdomen terminating in a process bearing eight circular hairs.

Adult: Dirty-brown, with white spots on the fore and hind wings. Abdomen light brown, the terminal segment being dark brown. Male and female moths measure 22 to 24 mm and 25 to 28 mm, respectively, in wing expanse.

LIFE CYCLE

The moths lay 98 to 120 eggs, singly, on the underside of the leaves which hatch in 2 to 3 days. First, second, third, fourth and fifth larval instars last for 2, 2 to 3, 2 to 3, 2 to 3 and 3 to 4 days, respectively, and the larvae in body length measure 3.5, 6, 11, 18 and 24 mm, respectively. The pupation takes place inside the leaf-rolls. Later on, the pupa falls on the ground and gets underneath the fallen leaves and debris. The pupal stage lasts 6 to 7 days. The pest passes through 2 to 3 overlapping generations in a year.

NATURE OF DAMAGE

This pest remains active from August to October. Only the caterpillars

cause damage. The young caterpillars (1st to 3rd instars) feed gregariously on the lower epidermis of the leaves and skeletonize them. The grown up larvae (4th and 5th instars) roll up the leaf margins towards the mid-rib, there being one larva in each roll.

DISTRIBUTION AND HOST PLANTS

The leaf-roller is a serious pest of grape-vine in India. In Pakistan, besides grape-vine the pest has been recorded from other plants belonging to family Vitaceae (Hayes, 1960).

CONTROL METHODS

Spraying with Malathion/Dimethoate 0.05% Methyl parathion 0.04%, effectively controls the pest.

Sinoxylon anale Lesne **(Bostrychidae: Coleoptera)**
(Grape-vine beetle)

DIAGNOSTICS

Grubs: Thick, yellowish-white in colour; curved in shape; often feeding along with the adult in the infested vines.

Adult: Sturdy and very lively beetle that walks slowly and flies rarely; dark-brown in colour and measures 4.5 mm in length and 1.8 mm in breadth; antennae 3-bladed; pair of spines present on the posterior elytral extremity

LIFE CYCLE

The life cycle varies between very wide limits; its minimum may be about 3 months and the maximum being over 4 years. There is no regular sequence of generations and no regular correlation between the length of life cycle and the season of the year. The insect emerges as adult beetle throughout the year.

NATURE OF DAMAGE

The pest is active on dormant vines. After the winter sets in, the adult beetles bore into the living woody stems and branches. The activity of this pest is accompanied by a peculiar cracking noise followed by the ejection of dusty material from the exit of the feeding galleries. The multiplication of the pest continues in the dead vines throughout the year. The adult beetles con-

struct a circular hole, extending to the centre of the stem and then makes longitudinal galleries and forms a number of exits. The damage is always found about one foot above the ground level. Both the adults and grubs cause damage by feeding inside the vine stem. All the plant parts above the point of attack dry up completely.

DISTRIBUTION AND HOST PLANTS

It has been recorded from France, Italy, Australia, New Zealand, USSR, Japan, China, India and Pakistan. It is primarily a pest of grape-vine but also feeds on sal, teak, 'shisham,' 'kikar', fig, mango, almond and 'ber', etc., (Sohi and Bindra, 1969).

CONTROL METHODS

Pruning and destroying infested parts, removing loose bark and avoiding bamboo supports in the vineyard discourage the population growth of the beetle. Application of Dieldrin 0.04% as a cover spray to the dormant woody portion of the vines, effectively controls the pest.

Sthenias grisator **F. (Cerambycidae: Coleoptera)**
(Grape-vine girdler)

DIAGNOSTICS

Egg: Oval; enclosed in a white parchment like covering; measures 4 mm in length and 1 mm in width.

Grub: Thorax characteristically globular with a few chitinous spines; when full-grown it measures 10 to 12 mm long.

Pupa: Greyish brown; head deflected, antennae long; measures 6 to 8 mm in length.

Adult: Head dark brown in colour with a pair of prominent mandibles each with 2 teeth. Body greyish-brown with white and brown irregular markings (resembling bark colouration); elytra with an elliptical, greyish median spot and an eye-shaped patch in apical third; measures 24 mm in length.

LIFE CYCLE

In the spring, the adults become active at night when they mate. The female bites a transverse slit in the bark of the girdled shoots and stems and an egg is thrust in between the bark and the sapwood. The grub hatches in

about 7 to 10 days and bores tunnels directly into the wood. Pupation occurs in the elongate chamber and the adult escapes by cutting a circular exit hole. Emergence mostly occurs during the months of July-August. The pest requires five months or even a year to complete its life cycle. It hibernates as an adult during winter (Sanjeeva Raj, 1955).

NATURE OF DAMAGE

Damage is done both by the adults and the grubs. Girdling of the green branches is an essential event before egg laying. The vines dry up above the point of girdling. The bark and wood are cut right up to the centre and at times, the branches are cut into two bits. Girdling is done at any place from 15 cm to 3 metres above the ground. Branches varying from 1.25 to 2.50 cm in thickness are preferred.

DISTRIBUTION AND HOST PLANTS

The pest has been recorded from Pakistan, India and Sri Lanka. Besides grapes, it feeds on mulberry, various garden shrubs, rose bushes, mango, almond, bougainvillaea and yellow oleander.

CONTROL METHODS

Hand-picking of the adults, from affected plants especially at night with torches and collecting the girdled branches suppresses the pest population. Spraying infested plants at ground level with Dieldrin 0.04% or with BHC 0.2%, effectively controls the pest.

Tetranychus telarius L. (Tetranychidae: Acarina)
(Red spider mite)

DIAGNOSTICS

Egg: Spherical; translucent, becoming dark stray coloured before hatching, with carmine eyes visible through the chorion.

Larva: Oval; light amber when freshly hatched and becoming greenish near maturity; possessing 6 legs; bright carmine eyes; measures 0.148 to 0.189 mm in length and 0.131 to 149 mm in breadth

Proto-Nymph: Oval; darker; possesses 8 legs; lateral pigments more prominent; abdomen spherical in female and pointed in case of male protonymph. Male and female proto-nymph measure 0.218 to 0.297 mm and 0.212 to 0.278

mm, respectively, in length and 0.170 to 0.184 mm in breadth.

Deuto-Nymph: Larger much elongated; amber in colour. Male deuto-nymph comparatively more slender and smaller than female and measures 0.235 to 0.298 mm and 0.318 to 0.285 mm, respectively, in length and 0.178 to 0.189 mm in breadth.

Adult: *(Male):* Body cuneate, ovate; cephalothorax rounded; amber yellow in colour, lateral spots located near the front of abdomen. Eyes crimson, conspicuous; measures 0.256 mm in length and 0.142 mm in breadth. *(Female):* Body pyriform; colour varies from dull yellow to greenish amber, usually brick-red; body bears two large dark spots laterally; measures 0.278 mm in length and 0.424 mm in breadth.

LIFE CYCLE

The eggs are laid singly on the underside of the leaves. Each female is capable by laying 60 to 80 eggs which hatch in 2 to 6 days. The larval, protonymphal and deuto-nymphal stages last for 5 to 7, 3 to 4 and 2 to 3 days, respectively. The adults live from 10 to 20 days. The pest passes through 16 overlapping generations from April to September and 4 generations during the rest of the year.

NATURE OF DAMAGE

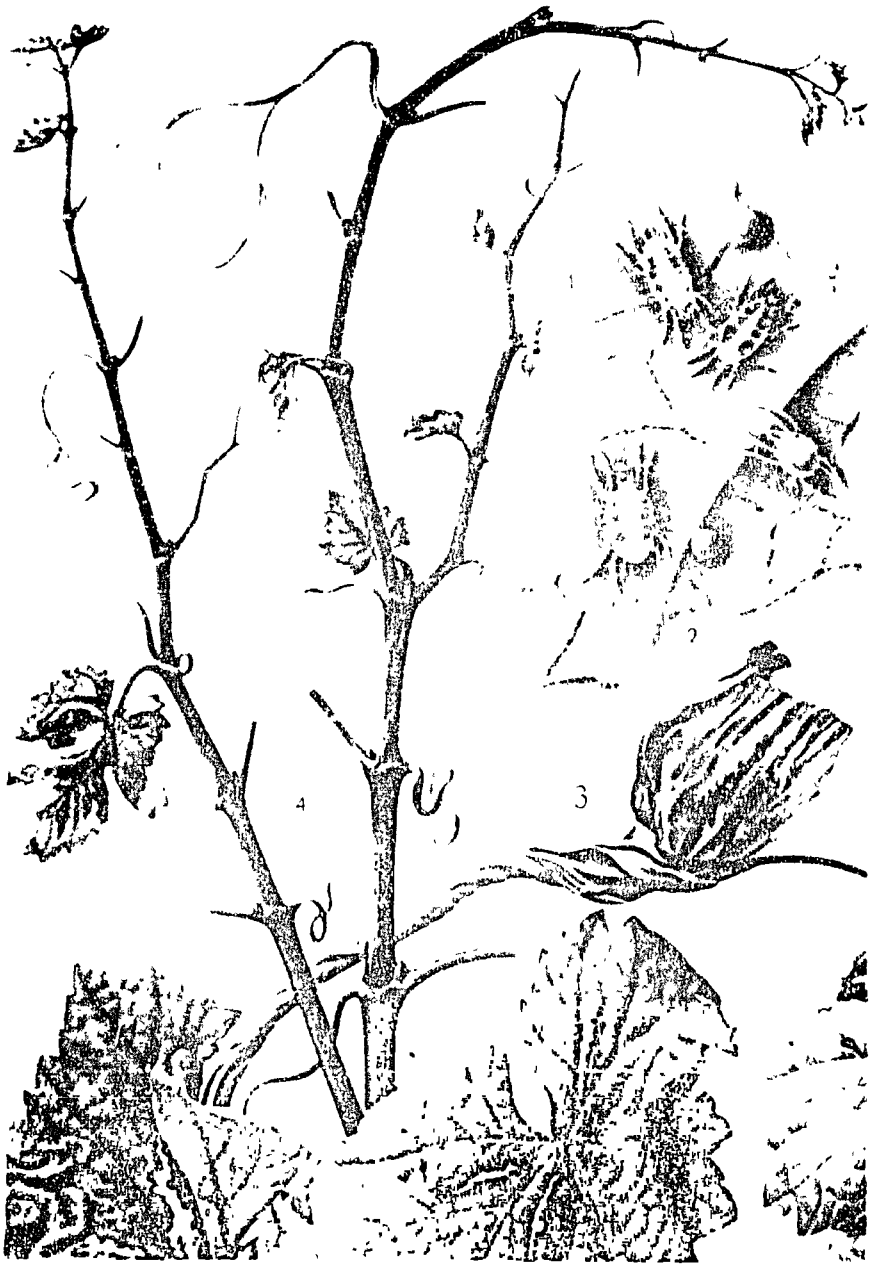
The mite is active from March to October and passes the winter as gravid female. Breeding activities start as soon as the season warms up. It spins web on the under surface of the leaves. All the active stages usually feed on the underside of the leaves. The infested leaves dry up gradually, and webbing interferes with plant growth. There is a poor setting of the fruits and the yield is considerably reduced.

DISTRIBUTION AND HOST PLANTS

It is a polyphagous mite and is widely distributed all over the world. In Pakistan, it has been recorded from a wide range of plants, including field crops, fruit trees, ornamental plants and weeds of economic importance.

CONTROL METHODS

The red spider mite can be controlled by spraying the crop with Lime Sulphur wash (1:2:16); Dimethoate 0.02%; Malathion or Dicofol 0.05% or Omite 0.03%.



Tetranychus telarius L.

1. Females, male and larva (enlarged)
2. Summer eggs (enlarged)
3. Overwintering females
4. Damage
5. Injary on leaves

PEACH

Anuraphis (= Brachycaudus) helichrysi (Kalt.)

(Aphididae: Hemiptera)

(Peach leaf curl aphis)

DIAGNOSTICS

Nymph: Small; wingless; resembles the adult.

Adult: Yellowish green with one or more dark green streaks on the back; cauda not seen from above. Winged forms with a big black spot on dorsum and 3 or 4 black spots laterally.

LIFE CYCLE

The pest overwinters as an egg near the bases of the buds and most commonly between the buds and the twigs. The eggs hatch in spring, shortly after the buds begin to swell and transform into flowers. The nymphs move on to the primordial leaves and start sucking cell sap. When the fruit is set and the leaves have developed, these aphids migrate to the leaves and after about 15 days grow into apterous, viviparous stem-mothers which breed parthenogenetically. Each female produces about 50 young ones in her reproductive life span of 13 days. The young ones mature in 10 days. During this period of activity, the pest undergoes 7 to 8 generations. Winged forms appear with the warming up of the season (March-April). They migrate to other alternative host plants, such as weeds and grasses and once again start reproducing asexually. Several generations (3 to 4) are completed during late summer and beginning of autumn (June to September). During late September and throughout October, winged forms are produced on the secondary host which fly back to the primary host plants. In November, true sexuals are produced which lay eggs at the base of the buds. Egg laying is completed by the middle of December when the females die.

NATURE OF DAMAGE

The nymphs and the females suck the sap from young leaves and cause them to curl. The severely attacked plants have only small crumpled or twisted leaves and bear very little fruit.

DISTRIBUTION AND HOST PLANTS

This aphid has been recorded from Europe, South and North America; Japan and Egypt. In the Indo-Pakistan sub-continent, it is widely distributed

up to an altitude of 2200 metres and feeds on a number of fruits, like peaches plums, pears and 'litchi'.

CONTROL METHODS

1. **Biological:** Several species of *Coccinella*, *Adalia decempunctata* L. *Menochilus sexmaculatus* (F.), larvae of *Syrphus* sp., larvae and adults of *Chrysopa* sp. have been recorded feeding on this aphid. These predatory insects should be encouraged.
2. **Chemical:** The best time to kill this aphid is early spring when the aphids hatch out from overwintering eggs. Spraying with Phosphamidon or Metasystox 0.03% effectively controls the pest.

Myzus persicae (Sulzer) (Aphididae: Hemiptera)
(Green peach aphid)

DIAGNOSTICS

Egg: Pale-green, becoming darker towards maturity; ovoid and measures 0.6 mm in length and 0.3 mm in breadth.

Nymph: Similar to apterous female in colouration.

Adult: *(Alate-viviparous female):* Green or pink-green; head, pronotum and thoracic lobes black; abdomen with a black dorsal patch in front and between the cornicles; four pairs of lateral black spots on the abdomen; antennae dark, almost equal in length to the body; measures about 2 mm in length. *(Apterous-oviparous female):* Pink or red; antennae extending slightly beyond the middle; measures about 1.7 mm in length.

(Male): Winged; similar to alate female but smaller and darker.

LIFE CYCLE

The green peach aphid passes the winter in the egg stage in the axils of buds or on the bark of the host plants. Hatching starts about the time, the blossom-buds begin to show colour. The nymphs first settle on the developing fruit buds, establish themselves on the green sepals of flower as they appear and finally establish on the peduncles of the future flowers. These stem-mothers become full-grown in about 15 days. As soon as they settle on the leaves they multiply parthenogenetically at a rapid rate and several generations are completed. The alate, viviparous females are produced by about the middle of April and the infestation is carried to other host plants, where

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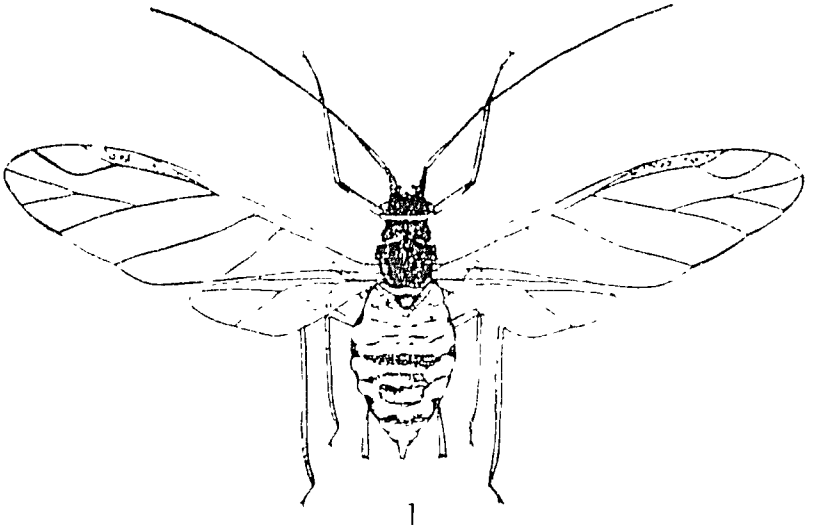
PLATE XXX



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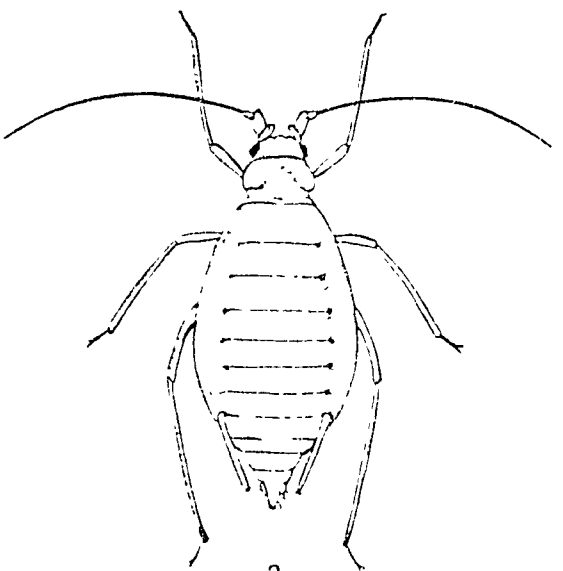

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Myzus persicae (Sulz.)

1. Alate, Adult female
2. Apterous, Adult female

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several generations are completed. About the end of May, these aphids leave the fruit trees and migrate to their alternate host plants. In September, alate forms are again produced on the alternate host plants which return to the fruit trees and establish colonies breeding parthenogenetically. A few generations of apterous, viviparous females are produced when oviparous females and winged males make their appearance by about the middle of October. The number of males is much less than that of the females. They mate and the females lay eggs about the end of October or beginning of November.

In the plains winged adults appear in October to November on peach trees and on nursery stock. In November, when the grown up trees shed their leaves, the viviparous females migrate to the tender foliage of young host plants or the nursery stock where they breed parthenogenetically till mid-February. When leaves of the nursery plants begin to fall, the aphid either lives on the swelling buds or migrates to other host plants. In March, the winged females are seen settled in the axils of the leaf buds and producing young aphids. After April, the aphids migrate to cooler places and return to the primary host plants in autumn. It is capable of breeding asexually throughout the winter in the plains (Janjua and Chaudhry, 1965).

NATURE OF DAMAGE

The nymphs and adults suck cell sap through the petioles and mid-ribs of the tender apical leaves. The attacked leaves become twisted and reduced in size and eventually become compact and controlled to form pseudo galls. The growth of the young shoots is very much stunted as the tender leaves produced at the top are always attacked first by these aphids. The attacked trees are devitalized. The young setting fruits shrivel up and drop. The trees then do not bear fruit during the next one or two years even though the aphid may be absent.

DISTRIBUTION AND HOST PLANTS

It is a cosmopolitan species found in Europe, USA, China, Japan, Australia, Africa and Asia. In Pakistan, it has been recorded in the plains as well as in the hills. The aphid is a polyphagous species and has numerous host plants both wild and cultivated. Of the deciduous fruits it causes considerable damage to peaches, apricot and plums (Hill, 1975).

CONTROL METHODS

As recommended for *Anuraphis helichrysi* (Kalt.).

Quadraspidiotus perniciosus (Comst.) (Diaspidae: Hemiptera)
(San Jose scale)

DIAGNOSTICS

Nymph: Small; yellowish; with a pair of antennae, three pairs of legs and a long proboscis.

Scale: *(Female):* Flattened; nearly circular, with a raised central nipple; grey in colour; measures 1 to 2 mm in diameter.

(Male): Oval; grey in colour; measures 1.0 to 1.5 mm in length.

Adult: *(Male):* Minute; antennae long; compound eyes well-developed; wings two, hyaline, halteres present; aedeagus elongated, strongly chitinized. *(Female):* Degenerate; wingless; lies hidden under a scale of the size of a pin-head; legs and antennae atrophied, mouthparts piercing sucking.

LIFE CYCLE

The San Jose scale passes the winter in nymphal stage on the bark of its host plant. It remains in resting condition until about the beginning of March, when the suspended activities of the plant begin to revive. The nymphs then actively begin to suck the sap from the tree and increase in size until they become full-grown. About the middle of March, the scales become enlarged considerably. At this stage, male and female scales can be differentiated. The winged males emerge about the end of March and fertilize the wingless females. These females after being fertilized produce 200 to 300 young larvae; the eggs hatching within the body of the female. These young ones are produced during the second half of April and beginning of May and after crawling for some time they establish themselves on the tree by inserting their mouthparts deep into the developing plant tissue. After some time they begin to secrete a mass of cottony and waxy fibres which soon form a covering scale over the body of the insect. The nymphs take a month to reach maturity and about the middle of June another swarm of nymphs is produced. In this manner about 5 generations are completed during summer and autumn. At the approach of winter the nymphs enter the dormant condition.

NATURE OF DAMAGE

Tiny, circular scales, just visible to the unaided eyes, can be seen on the bark of lightly infested tree. If the trees are heavily infested then the bark may be completely covered by overlapping scales. All parts of the plant

above the ground may be attacked. The nymphs and adults suck the cell sap and deprive the plants of its nutrient material. As a result, the plant becomes weak, the bark may crack and exude gum, and the twigs die back; infested tree often die. The nursery and newly planted trees succumb to the attack much more than the older trees.

DISTRIBUTION AND HOST PLANTS

This pest has a wide distribution throughout the warmer parts of the world. It has been recorded from South Europe, Algeria, South Africa, Rhodesia, Congo, Iraq, Turkey, India, Pakistan, China, Korea, Japan, Australia, New Zealand, USA, South America and Mexico.

Primarily, it is a pest of deciduous fruit trees like apple, peaches, plums, pears, and currants, but has also been recorded from a wide range of trees and shrubs.

CONTROL METHODS

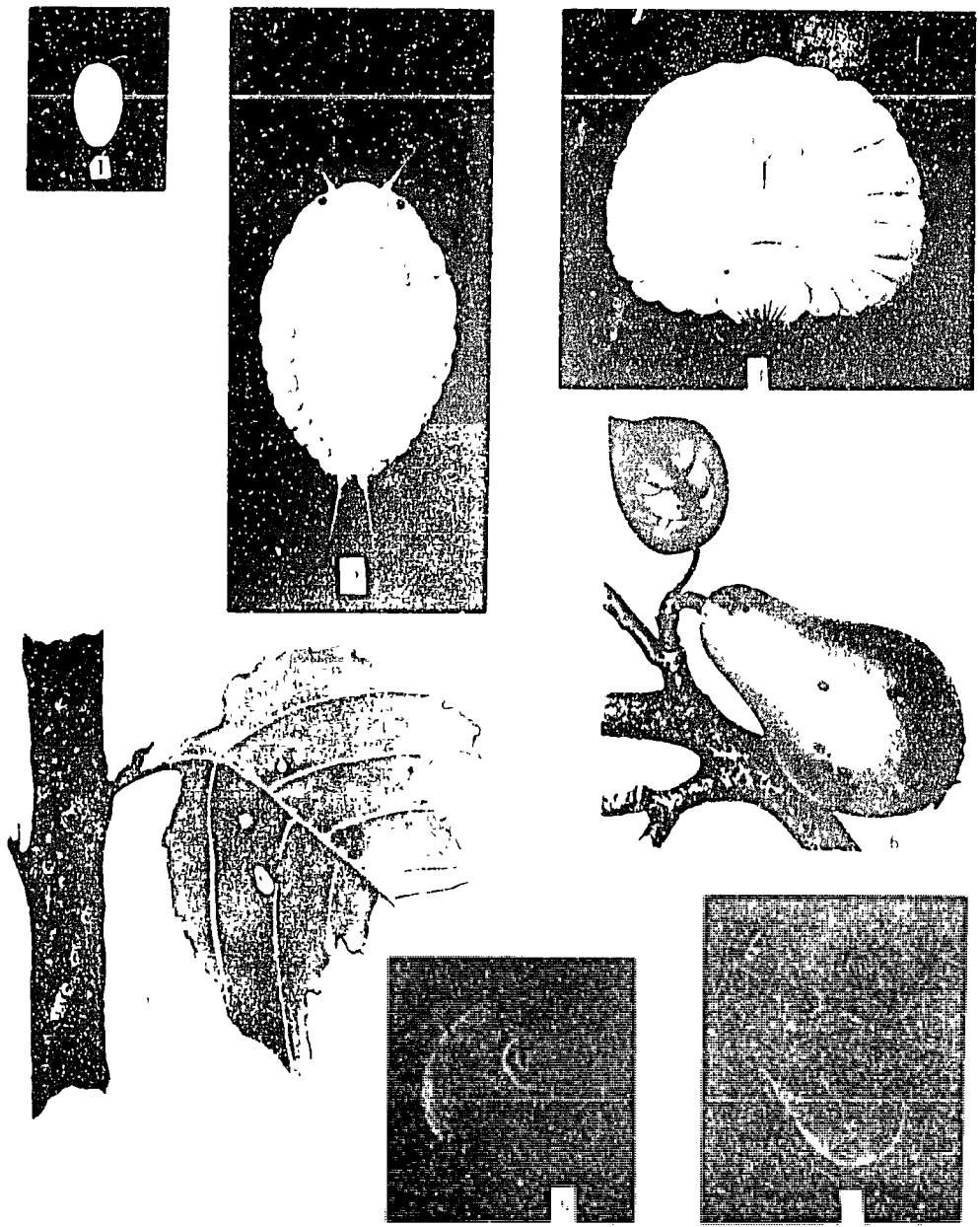
1. **Biological:** *Prospaltella perniciosus* Tow. (Aphelinidae) has established itself on this pest. Some Coccinellid predators viz., *Chilocorous bipustulatus* (L.), *Coccinella* sp. have been observed voraciously feeding on this scale. These parasites and predators can be encouraged.
2. **Chemical:** The best time for the control of this pest is during winter when the trees are in dormant condition. A thorough spraying with Diesel oil-Bordeaux mixture or Lime-Sulphur wash should be given as soon as the buds show slight swelling. During spring and summer specially when swarming of nymphs occur, spraying Metasystox/Phosphamidon 0.05 to 0.075% brings the pest under control. Best results have been obtained when infested plants are sprayed with Phosphamidon/Ethion 225 ml mixed with one gallon summer oil in 100 gallons of water.

Sphenoptera lafertei Thomson (Buprestidae: Coleoptera)

(Buprestid borer)

DIAGNOSTICS

Egg: White, spherical, pin-head size when freshly laid and becoming black and oval near maturity.



Quadraspidiotus perniciosus Comstock

1. Egg
2. Nymph
3. Adult (Female)
4. Scale (Male)
5. Scale (Female)

Larva: Dull-white in colour; anterior margin of head brown and sculptured dorsally; prothorax broader than long with a prominent inverted V-shaped marking on dorsum; mandibles brown and well-developed; measures 18.25 mm in length and 4.0 mm in breadth, when full-grown

Pupa: Black and measures 11 mm x 4 mm.

Adult: Bronze coloured; metasternum with transverse suture; antennae short, serrate; fore coxae small, rounded; female, slightly bigger than male and measures 8.5 x 4.0 mm.

LIFE CYCLE

The beetles begin emerging about the middle of March and feed on leaves. The female lays eggs, singly, on the bark of tree trunk and branches which hatch in about 20 days in spring. The larva bores into the bark and feeds beneath it. The larva is full fed in about 60 days in summer and 180 days in winter. Before pupation, the larva prepares a sub-cylindrical chamber 4 to 6 mm long, 2 to 4 mm broad and about 1 cm deep in the wood, where it pupates. The pupal stage lasts for 10 days in summer. The winter is passed in the larval or prepupal stage and there are 3 generations of the pest in one year.

NATURE OF DAMAGE

The young larva enters the trunk of the tree and as a result of feeding activity, gum globule appears at the point of entrance on the bark. It soon prepares a minute irregular gallery, converting the sap wood (phloem and cambium) into a powdery mass. As several larvae feed together in close proximity, the outer bark is loosened and sometimes it splits showing the brownish frass or "Saw-dust" beneath. The growth of the tree is arrested as the wood is riddled with the burrows of the full-grown larvae. The leaves become pale and turn brown at their tips and along the margins. Detachment of the inner bark in the form of a ring causes the death of the limb above it. When a branch that is gumming heavily is scraped, numerous larvae boring into the wood are exposed. Oval holes are noticeable on the surface of the bark after the beetles have emerged. Badly riddled bark becomes loose after some time, exposing the wood with the oval holes in it. This phenomenon is more frequently observed on the southern or sunlit side of the tree. In case of severe infestation the tree dies. The attacked branches are easily broken off by wind. Both young and full-grown trees are attacked, even a young nursery plant is liable to be attacked.

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DISTRIBUTION AND HOST PLANTS

This pest has been recorded in Afghanistan, India and Pakistan. In Pakistan, it is widely distributed in the Peshawar valley where it causes considerable damage to peach. The borer has also been recorded heavily attacking plum, apricot, pear, loquat, apple and cherry.

CONTROL METHODS

1. As the grubs mostly feed inside the branches the mechanical methods can be employed to reduce their population to a reasonable extent. Prompt removal and destruction of the infested branches should be carried out.
2. Plugging the borer holes with cotton soaked in kerosene, petroleum or ECDT mixture and then plastering them from outside with mud or injecting Methyl parathion 0.2% in the holes and their subsequent plugging with mud will kill the borers inside.

CHERRY

Quettania coeruleipennis **Schwarzer (Cerambycidae: Coleoptera)**

(Cherry tip-borer)

DIAGNOSTICS

Egg: Elongate; convex with widely flattened base; whitish with dark yellow contents visible through chorion.

Larva: Bright yellow when newly hatched and dirty creamy white when full-grown; head brownish; with short, strong, brown mandibles.

Pupa: Creamy white; resembles adult; antennae long, recurved near the 7th abdominal segment, the apical joint reaching near the head in male.

Adult: Metallic blue; antennae long; elytra punctured; measures 2.5 cm in length and about 5.0 mm in breadth.

LIFE CYCLE

The pest resumes breeding activity in May when the eggs are laid singly on the branches. Each egg is covered on the exposed surface with an opaque, whitish, cement-like substance. A female is capable of laying about 75 eggs. The eggs hatch out in 2 to 3 weeks. The newly hatched grub bore into the sides of the shoots by about the middle of June and when they reach the core, they take a downward course. The grubs remain active throughout the year and become full-grown in March next. When about to pupate, the grub con-

structs a wide chamber made at the end of the tunnel which is closed on all sides by saw-dust packing. The prepupal period lasts for about a week or 10 days. Pupation takes place in the beginning of April. Pupal period lasts for 30 to 40 days. When about to emerge, the adults cut holes directly to the outside from where they crawl out and emerge in May. The adults pair soon after emergence and oviposition starts two days after mating. The pest completes only one generation in a year.

NATURE OF DAMAGE

The grubs enter the shoot or a branch from one side after making a small hole which is marked by having a gum globule exuding from it. The grub works in the core of the shoot and tunnels down. As it works its way downwards, it leaves a watery fluid, which oozes out of the occasional holes made by the grub on the sides of the branches. Thus, the place where the larva is at work can be easily detected. The attacked portions of the shoots and branches ultimately become hollow and dry up, the dried leaves remaining attached to such shoots even during the winter months. The attacked branches and shoots may fall off with strong wind. Old trees are most susceptible to its attack (Janjua and Chaudhry, 1965).

DISTRIBUTION AND HOST PLANTS

The genus *Quettania* which is reported to be represented by one species, i.e., *coerupleipennis* occurs in the Indo-Pakistan sub-continent. In Pakistan, this species is abundantly found in the Balochistan valley at an elevation of 4500 to 6000 feet above sea level. Besides cherry, it attacks plum, quince, apricot, almond and pomegranate.

CONTROL METHODS

1. The attacked shoots and branches harbouring the grubs should be removed and destroyed.
2. Plugging the borer holes with cotton soaked in kerosene, petroleum or EDCT mixture and then plastering them from outside with mud or injecting Methyl parathion 0.2% in the holes and their subsequent plugging with mud will kill the borers inside.
3. Spraying with Malathion 0.05% or Dimethoate/Endosulfan 0.03% or Carbaryl 0.1% as soon as the beetles emerge in May, at 3 to 4 weeks interval, effectively controls the pest.

Pest Control Schedule

The useful practice of spraying the dormant trees with diesel-oil emulsion mixed with Bordeaux mixture is still very effective, particularly against scale insects and aphids. At the flowering stage, no chemical should be applied to the trees, because the flowers are likely to be damaged and the honey bees and other pollinators are likely to be killed.

Repeated sprayings of the fruit trees for keeping the leaf-curl aphis under check are essential; otherwise, the leaves become crumpled, the vitality of the plants is lowered and there is a heavy dropping of immature fruits.

TERMITES OR WHITE ANTS

Termites or white ants (Termitidae-Isoptera) are among the commoner insect pests attacking living and dead plant parts, faecal matter, exuviae and dead members of their colony and are thus omnivorous. There are about 22 species of termites recorded from Pakistan and the more abundant are, *Microtermes obesi* Holmgren, and *Odontotermes obesus* (Ramber). Other species which are relatively less important include *Odontotermes bellahunusensis* Holmgren, *O. gurdaspurensis* Holmgren, *O. horai* (Roonwal and Chhottani), *Microtermes mycophagus* (Desneux), *M. unicolor* (Snyder), *Microcerotermes heimi* (Wasmann), *M. sakesarensis* (Ahmad), *M. longignathus* (Ahmad), *M. baluchistanicus* (Ahmad), *M. championi* (Snyder), *Amitermes belli* (Silvestri), *A. dentatus* (Haviland), *A. paradentatus* (Ahmad), *Eremotermes paradoxalis* Holmgren, *E. neoparadoxalis* Ahmad, *E. fletcheri* (Holmgren), *E. dehraduni* (Roonwal and Sensarma), *Angulitermes dehraensis* (Gardner), *A. hussaini* (Ahmad), *Angulitermes* sp. (Ullah & Ahmad, 1969).

They are social insects; polymorphic, living in large communities, sometimes in elaborate nests both above and below ground, containing workers, soldiers, and reproductive forms; they have biting mouthparts; two pairs of equal size wings, with a fracture line near the base where the wings break off; the cerci are very small; metamorphosis is slight or absent; some genera have symbiotic bacteria in the gut which break the cellulose (wood) eaten by the insects; others use the cellulose to cultivate fungi which are then eaten.

A. REPRODUCTIVE CASTES:

1. **Colonising individuals:** These are winged individuals of both

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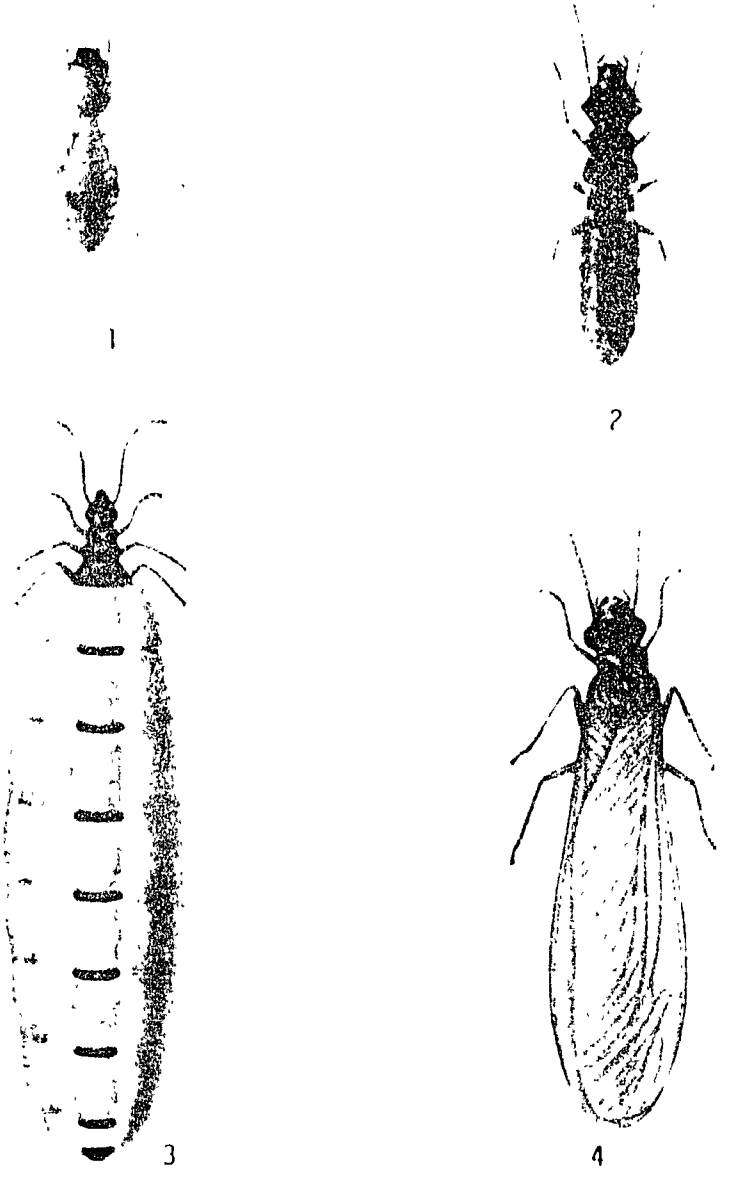

Odontotermes obesus **(Ramb.)**

1. **Worker**
2. **Soldier**
3. **Queen**
4. **King**

sexes and are produced in large number during the rainy season. When the temperature and moisture conditions are optimum they emerge from the parent colony and hover over street lamps early in the evening, usually after a shower of rain. The wings are meant for nuptial flight only and when they have mated, the wings usually drop off. Most of the winged insects are eaten up by frogs, lizards and snakes. A pair that happens to escape may start a new colony in a crevice in the soil as the queen and the king of a colony. To start with, they themselves attend to the foraging and other duties which, later on, are performed by the workers.

2. **Queen:** This is the only perfectly developed female in the colony. She develops either from the colonizing individuals described above or from the wingless forms (complementals) present in an established colony. It attains a much larger size, when developed from the former caste. The queen of *M. obesi* measures 5 to 7.5 cm in length, has creamy-white abdomen which is marked with transverse dark-brown stripes. Its reproductive system occupies almost the entire abdomen and she is a sort of egg-laying machine, laying one egg per second or 70,000 to 80,000 eggs in 24 hours. There is only one queen in a colony and normally it lives from 5 to 10 years, but the cases in which queens lived for 20 years are on record. The queen is fed by workers on the choicest food, and is housed in a special place known as the 'royal chamber' which is situated in the centre of the nest at a depth of about 0.5 metre below the ground surface.

3. **King:** A king develops from an unfertilized egg and becomes fully developed by consuming superior diet. He is the father of the colony and is a constant companion of the queen, living with her in the 'royal chamber.' It is much smaller than the queen and is slightly bigger than the colonizing individuals and mates with the queen time to time and, thus aids her in laying fertilized eggs from which the colonizing forms, and the workers develop. Its life is much shorter than that of the queen and, when dead is replaced by a new one.

4. **Complementary castes:** They are short-winged or wingless creatures of both sexes and lead a subterranean life. In the event of untimely death in a colony, they replace the king or the queen and

are, thus, induced by the workers to undergo sexual development.

B. **STERILE CASTES**

5. **Workers:** The workers develop from the fertilized eggs but remain stunted as they are reared on ordinary food. Numerically they are the most abundant in a colony, but are smaller than the soldiers. Their mandibles are well developed and are adapted to the gnawing of wood. The workers shun light and need high humidity for their survival. These conditions are maintained inside the tunnels in which they move about in search of food. Often those earthen galleries are above ground and run for long distance. The food of the termites consists of timber, wood, and dry stems of plants, sugarcane sets sown in the field, paper, books or any other article that contains cellulose. Except for the reproduction and defence of the community, particularly all other duties are performed by the workers. They take care of the eggs and the young ones and remove them to safe places at the time of danger. They also tend and feed the queen, collect food and cultivate a fungus food (ambrosia) in underground gardens.

   When a new colony is established, the earlier broods of workers construct a hemispherical chamber for the queen and it is connected with innumerable galleries. In certain species, the workers also construct a high mound above the ground which is known as the termitarium. Since the workers have to collect all provisions for the colony, they are notoriously destructive.

6. **Soldiers:** Soldiers develop from unfertilized eggs and remain comparatively under-developed. They are the most specialized members of the community and can be readily recognized by the large head and strongly chitinized sickle-shaped mandibles. In a colony, two well-defined types of soldiers can be distinguished:-

   (a) The mandibulate type with large and powerful jaws, but with no frontal rostrum.

   (b) The nasute type in which there is a median frontal rostrum, but the jaws are small or vestigeal.

The former type of soldiers defend the colony by fighting the intruders and the latter type repels them by spraying through rostrum a fluid secretion that has an obnoxious smell.

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LIFE CYCLE

In the rainy season, when atmospheric conditions are favourable, the colonizing forms leave their parent colony. As they are weak fliers, they do not travel a long distance unless aided by wind. As a rule, a particular species swarms at about the same time of the season. The members of the swarm comprise individuals of both sexes. They are attracted to light, where they mix with individuals of the neighbouring swarm. A great majority of them fall a prey to many types of predators and only a few individuals survive in the end. The survivors sooner or later fall down and cast their wings and mate before or after shedding them. Both the male and the female participate in the early operations of forming a nest by excavating small burrows or galleries or the nuptial chambers. The eggs laid at first are only a few and are looked after by them and the newly hatched nymphs are fed by the parents themselves which then take over all the brooding, feeding, cleaning and other duties. During the first season, the reproductive castes are usually not produced and the queen gradually grows in size, and the number of eggs laid also increases.

Eggs hatch after about one week during the summer and within 6 months the larvae develop to form soldiers or workers, as the case may be. The reproductive castes, when produced, mature in 1 to 2 years. The queen is capable of laying many millions of eggs during her life, which is very difficult to estimate, but probably 6 to 9 years is the approximate span.

Nests of many termites grow fungus gardens in the centre, near about the 'royal chamber.' The fungus grows into a comb-like structure and is fed to the royal pair and the larvae.

In addition to the various castes in a termite nest, there live such insects as beetles, flies, thrips, some species of Collembola, Acarina, Diplopoda and Chilopoda. A termite mound may also afford shelter to lizards, snakes, scorpions and certain birds. All these creatures live either as symbionts for mutual benefits or as guests.

NATURE OF DAMAGE

The termites live on cellulose which they obtain from dead and living vegetable matter. To obtain their food, they destroy woodwork, articles of household, fences, wooden poles that come into contact with the soil. They also damage fruit and shade-trees, crops like sugarcane, chillies, wheat and peas.

CONTROL METHODS

1. When a colony is established, it is not so easy to eradicate the pest. The only sure method is to reach the centre of the nest and kill the queen and the complementary forms. Since the termite tunnels run for hundreds of metres, it is often difficult to locate the royal chamber. However, in the mound-forming species of termites, it is much easier to locate the centre which lies in the mound or just below it.

2. To avoid the attack of white ants in the cultivated fields, care should be taken not to use green manure or raw farmyard manure.

3. In the case of new plantations, the pit should be treated with 0.2% Dieldrin emulsion or crude oil emulsion before planting the trees. This is done by thoroughly mixing 1/4 kg of crude oil emulsion and a little Arsenic in about 4 baskets of subsoil taken from the pit. The treated soil is returned to the pit.

To protect the tree trunks, spraying them with 1% Dieldrin is effective. To protect the roots, 0.5% Dieldrin or 3% sanitary fluid in the irrigation basin should be applied.

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Chapter 11

INSECT PESTS OF HILL FRUITS

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The soil and climatic conditions prevailing in the hilly tract of Pakistan are excellent for deciduous fruit cultivation. Therefore, fruit cultivation is the main industry involving more than eighty percent population directly or indirectly in this region. The hilly areas which are falling in North- and Northwest of Pakistan, comprise Azad Kashmir, North Western Frontier Province, Kurram and Gilgit Agencies, and Northern hilly areas of the Punjab and Balochistan provinces.

Several notorious pests of palaearctic region have already got introduced in this tract due to the unrestricted movement of plants and plant products, both from neighbouring countries and from one region to another within the country. All these imported insect pests alongwith certain native forms are taking a heavy toll of fruits and fruit trees in this region. These pest species are of great economic significance as the future of the development of the deciduous fruit industry depends on the successful management and control of these.

Although there exists a long list of insect pests of deciduous fruits found in this area, only a few of very important economic species are discussed in detail in this chapter. Minor and occasional pest species are not accounted, for which a separate tretise is required. Pest species in this chapter are considered in the order of their significance.

Cydia pomonella Linn.(**Eucosmidae: Lepidoptera**)
(Codling moth)

This lepidopterous insect is the most important pest of apples. This insect possesses a disputed and confusing synonymic record. Still being notorious worldover, it is commonly known to almost all entomologists. Different

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authorities have proposed different synonyms not only to species level but to generic levels as well. Even the insect has been classified into various families of the Order Lepidoptera. Various synonyms observed in literature are listed below:

Species: *Pomonella, pomonana, pomonoella, pomella*

Genera: *Laspeyresia, Carpocapsa, Cydia, Enarmonia, Tinea, Phalaena*

Family: Tortricidae, Olethreutidae, Eucosmidae

Codling moth has extreme ecological plasticity as a particular characteristic and may be considered unique in various aspects. This is the only pest which is widespread alongwith apple cultivation and has adopted itself universally to diverse climatic conditions.

DISTRIBUTION

Codling moth is distributed to almost all continents with varying degrees. Its original habitat itself is in doubt and comprises almost all Southern Europe. Its rapid migration with its major host (apples) suggests that its original distribution range is determined by food plants rather than by climatic factors.

HOST PLANTS

This moth possesses a wide host range. Despite considerable polyphagy, the insect has adopted itself to apples and its distribution is quite parallel to the apple plantation in the world. The caterpillars of this insect are regularly transported in apple fruits and sometimes in seedlings. The moth seems to possess little capacity of migratory flight. The recorded host plants besides apple include pears, quinces, plumes, peaches, walnuts, apricots, chestnuts, and cherries. Unusual damage to the fruits of almonds, medlars, pomegranates, figs, and oranges has also been recorded in various parts of the world.

NATURE OF DAMAGE

The newly hatched larva of the first brood of codling moth nibbles green leaf tissues and flower stalks and finally crawls into flower clusters. Before entering a newly setting fruit they may nibble a few more flowers and

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may damage the pericarp. Mostly the larva of the first generation enters the fruit through the calyx end. Only a few larvae (less than 5%) may enter through stalk end. Usually one larva enters a fruit. Occasionally two or three larvae may enter a fruit from different ends. Canabalism has never been observed in this pest.

The larvae of second generation mostly enter through the sides of the fruit or stem end. The point of contact of two fruits in a cluster is usually preferred as the caterpillars are aided by getting a foothold for penetration. In such cases both the fruits are damaged at the point of contact.

The infested fruit presents a stunted and shrivelled appearance and often falls to the ground by moderately strong winds. The tunnels made by the caterpillars provide exposition for the entry and attack of fungi to which the healthy fruit is normally resistant. A less familiar 'sting injury' is also caused by the habit of nibbling fruits by the caterpillars before selecting and entering the apple fruit. Some larvae die after entering the fruit and cause a deep sting. These injuries usually cause the damage as dry spot by the fruit graders. These stings also sometimes provide enterance to scavanger fungus, which is termed as wet spot and rot.

Caterpillars of codling moth cause considerable damage to apples. If wind dropped apples are also accounted, the loss may rise sometimes to 80 percent. The old orchards aging more than 20 years are more extensively damaged as compared to new and younger plantations.

LIFE AND SEASONAL HISTORY

The full grown caterpillars of this insect overwinter in diapausing state in thick, elliptical, silken cocoon spun under loose bark or crevices of tree. With the approach of the spring the caterpillars transform into chrysalid inside the cocoon. After about two weeks spring brood moths emerge. The emerged moths go into sexual union usually at dusk and start laying after about three days of emergence. Under favourable climatic conditions the moth lays about 80 eggs in 20 days. The young larvae of first brood hatch after 7 to 15 days depending on the temperature. The newly hatched larvae wonder over leaves and clusters of newly set fruits for about 60 to 72 hours. The caterpillar passes most of its life inside the infested fruit and usually leaves it upon gaining full maturity. Occasionally it may leave one fruit and enter the other.

The feeding period of first brood lasts from 20 to 45 days, averaging a month depending on temperature. Mature larvae abandon the attacked

apple fruit and crawl down to limbs and trunk in order to pupate. Some larvae drop to ground with the help of string spun from their salivary glands. Numerous larvae fall within the premature dropped fruits and leave them for seeking a suitable hiding place.

Caterpillars find a suitable protected place, usually between limb crochets, crevices, borer holes, or under loose bark of the tree. The caterpillar first finds a place sufficient to accommodate its body and then spins a cocoon. The pre-pupation period lasts for about six to ten days and pupal period for about ten days. Few larvae of this brood enter in a long diapause which lasts a year or so.

The pupa upon maturity wriggles out of the cocoon. The pupal case opens from the sutures provided in the head region and the adult moths struggle out. Moths stretch their wings for a considerable time before taking normal flight. These summer brood moths usually start emerging from the last week of June but most of them emerge in the second week of July every year. The caterpillars of this brood are responsible for extensive fruit damage. Mating flight usually takes place at dusk hours.

The oviposition period of second brood is six to ten days and the length of feeding period is 40 to 60 days. Most caterpillars of this generation enter into diapause after spinning a tough cocoon. The diapausing period normally lasts for 200 to 250 days. Some of the caterpillars enter in an unusual diapause lasting one or more years. Although normal diapause is governed by the photoperiod conditions, the unusual diapause may take place on any day length and is responsible for the survival of the species under extreme pressure of destruction.

PARASITES AND PREDATORS

Janjua and Chaudhry (1964) have reported the following parasites from hilly areas of Balochistan.

i) *Paralitomastix variicornis* Nees (Encyrtidae: Hymenoptera) a larval parasite.
ii) *Dibrachys clavus* Walker (Pteromelidae: Hymenoptera) a larval and pupal parasite.
iii) *Trichogramma minutum* Riley (Chalcidoidea: Hymenoptera) an egg parasite. The same authors have reported the following predators on hibernating larvae of codling moth.

iv) *Reduvis pallipes* Klug (Reduviidae: Hemiptera).
v) *Rhaphidosoma tuberculatum* Dist. (Reduviidae: Hemiptera).
vi) *Acanthaspis quinquespinosa* F. (Reduviidae: Hemiptera)

But all these predators and parasites leave no significant effect on the overall codling moth population because of high fecundity and protective adaptations. Indian house sparrow, *Passer domesticus indicus* is also reported preying upon overwintering caterpillars probably due to food pressure in those days.

CONTROL AND POPULATION MANAGEMENT

Codling moth is considered a difficult to control pest as it passes most of its life inside the apple fruit as a caterpillar. Mature larvae and pupae are also less vulnerable due to the selection of protected hibernating sites. Due to its great economic importance this insect has remained the main target of insecticides. There exists a complex of arthropods in all the apple orchards. If specific insecticides are not used, many non-target species are affected and the special balance is disturbed. Destruction of carnivorous species, which are always less fecundative, results in the flareup of phytophagous species. In order to reduce the hazards of non-specific chemical applications other non-chemical pest control strategies are also accommodated in the programme against codling moth. Therefore, a population approach comprising of limited but timely pesticidal applications, orchard cleanliness, and other mechanical techniques is considered.

For a successful management programme a complex of climatological studies, pest behaviour, and study of other existing arthropods is required. Newly hatched larvae before entering the fruit have been found as the most vulnerable stage of codling moth. While mature larvae seeking a hiding place are considered for mechanical destruction.

Among climatic factors affecting the development of codling moth, temperature and day length hours are the most important. The lower threshold of development of all preimaginal stages is around 10 + 1 degree centrigrade. The optimum required temperature is 20°C and upper temperature limit is 33°C. A temperature above 14°C at dusk time is required for moth activity and oviposition. A sum of effective temperature required for the completion of one generation is 650 degree-days. The oviposition begins at about 100 degree-days and incubation of egg requires about 85 degree-days. In calculating effective degree-days, days with the maximum temperature of

10°C are not accounted. Average daily temperature minus 10°C is taken as the daily sum of effective degrees. An effective forecast of larval emergence and best time of pesticidal application may be based on this information.

Since, the individual variability in behaving against climate is very high, and micro-climate of individual orchard is highly variable, forecast based solely on the study of climatograph of an area is usually inefficient. Moreover the programme is very complicate, requiring skilled technicians and probably the help of a computer; it seems little practical for the orchard owners with limited means.

Due to high individual variability, moths are found constantly flying from mid of May to the end of September. But real danger to apple fruits is in the period when the peak activity of this moth takes place. The peak moth emergence occurs twice and is termed as 'spring peak' and 'summer peak'. Both peaks may be determined by bait trapping, light trapping, rearing the insects in cages and observing them, or by recording and assessing from the sum of degree-days.

Effective daily temperatures above a base of 10°C are added, from the beginning of the year. Following formulae are considered.

If maximum is less than 10°C, A = 0

If minimum is greater than 10, $A = \frac{max + min}{2} - 10$

If maximum is above 10 and minimum is less than 10, then the following is taken

If $\frac{max + min}{2}$ is more than 10, $A = \frac{max}{2} + \frac{min}{4} - 7.5$

If $\frac{max + min}{2}$ is less than 10, $A = \frac{max}{4} - 2.5$

Where A = the daily sum of degrees in centigrade scale.

In bait trapping method of determining the peak moth activity, food as well as sex attractants are used. The bait is placed in the center of a sticky card board which is installed in the apple orchard. Synthetic pheromones as sex attractant are now available in the market. A trap installed in an apple orchard is specific to male codling moths only. The male moths trapped are recorded and removed at frequent intervals. The method is so simple that a common grower finds the peaks and schedules the sprays against this insect.

Male and exhausted females are also attracted to the light. A 15 watt florescent lamp is considered a powerful attractant. Incandescent lamp is less attractive, instead 150 watt mercury vapour lamp can be used with success. These lights may attract any moth including codling moth. Separation of the later from others requires expertise, the light traps are less sensitive where the population of codling moth is low.

Talhouk (1969) recommended direct rearing of overwintering larvae, in orchard and examining of trees for the presence of pupae, eggs, and moths for obtaining correct information for timely application of pesticides. Rearing starts with the collection of overwintering larvae in burlap, gunnies, or carrogated paper bands placed around trunk and limbs of trees in summer. The caterpillars collected are kept in fly screen cage (3 x 3 x 3 feet) placed in the orchard. As soon as moths start emerging in cages (in April for spring brood, and June for summer brood) field observations must be taken for egg hatch and fruit penetration. The spraying must be scheduled accordingly before fruit entry.

Only pheromone trapping or rearing in orchard, is practical and feasible for the determination of peak moth flights under our conditions. Both employed simultaneously may be more useful and informative.

For the control of codling moth, contact insecticides are best applied after 10 days of male peak flight for spring brood and after 7 days for summer brood. This will allow enough time for laying and hatching. Thus the young sensitive caterpillars will be exposed to the action of deadly poisons. Due to pest growth rate and increasing temperatures the duration of action of the insecticides is limited, hence, more than one cover sprays may be applied. At least one more cover spray after 10 to 15 days must be applied after first spray for each generation.

Lead arsenate and DDT employed in the past are replaced with organophosphates in codling moth control programmes due to their questionable residues and their adverse effects on other biotic factors. Azinphos methyle and synthetic pyrethroids are proving best to control the pest. Anyhow care for the phytophagous mite species should be considered as some of these chemicals are deadly to most useful predatory mites. Use of suitable acaricides will be effective in reducing phytophagous mites.

Biological control agents have not shown promise, because the pest in its larval stage is mostly concealed inside the fruit. Any how *Bacillus thuringiensis* preparations can be utilized in pest management programmes,

where resurgence of mite species is expected due to application of other chemicals.

Planococcus citri Risso (Pseudococcidae: Hemiptera)
(Citrus and grape mealy bug)

The mealy bug is a fairly polyphagous insect. Among its important hosts are citrus, grapevines, bananas, loquats, and several ornamental shrubs and trees. It has a wide distribution in tropical and subtropical areas. In Balochistan it has established in Pishin and Quetta district.

NATURE OF DAMAGE

The insect is a voracious sap feeder. It secretes tremendous quantity of honey-dew. The infested vines could easily be recognized due to visitor ants, bees, flies, and wasps attracted to honey-dew. The infested trees are weakened and bear less fruits. Besides this direct injury, the infested grape branches become sticky, and glutinous and get smeared with honey-dew and insects. Thus infested grape bunches become unmarketable and unfit for consumption. The excessive secretion of honey-dew follows the attack of sooty molds. The grape bunches from attacked trees loose their sweetness and flavour.

LIFE AND SEASONAL HISTORY

The mealy bugs are provided with soft and segmented body and are characterized by the mealy wax covering the body. The insect overwinters as gravid female on the host bark under loose flaxes. The overwintering females settle, in group of six or seven, slightly under ground at irrigation level mark, of the vineyard. The female lays eggs between tangles of wax threads, like cottony masses, underneath her body. Normally she lays from one to three hundred eggs depending on weather and food quality. The egg laying continues over several weeks. Laying female may be found in one place along with her eggs and maturing larvae. The young nymphs crawl upward and can be first noticed, late in spring. They first settle on the junction of new and old growth. Subsequent generations move further upward and settle in leaf axils, on midribs and grape bunches.

The adult female is light cream-coloured, ovate and covered with white wax secretions. The margins of body are surrounded by 17 pairs of waxy processes of equal length except for caudal pair which is usually longer. The in-

sect passes through three larval instars during which functional legs and antennae are maintained. The male emerges from an elongated, dark brown to blackish puparia. The insect is small and very tender provided with one pair of wings. There are probably four to six overlapping generations per year. Ants are found much helping by the cleaning of colonies and carrying and fixing females on suitable sites in return of honeydews.

MANAGEMENT AND CONTROL

The system of trench cultivation of grapes favours this, otherwise it is a least motile insect. The trench provides special ecosystem in which the survival of the pest becomes easy. It holds high humidities favouring the insect and efficient proper shelter for the survival of the pest. In this type of cultivation proper pesticidal coverage also provides great hinderance. Almost half of the plant remained unsprayed. There is great need to modify the present system, and of instead training, prostrate vines should be prepared. The grape vines may also be trained on trellises but this system is expensive.

Certain toxicants are effective against this pest but none is most efficient. Methyl parathion and synthetic pyrethroids may suppress this insect but it escapes total control due to her habits, wax covered body and difficulty in proper coverage. As the insect is in habit of passing winter on lower portion of plant stem, it may easily be killed by applying polyethylene sheet around main trunk during winter months. Under such sheeting the humidity rises above 75% and the insect is suffocated in situ. This method is found very economical and most effective in vineyards and may possibly be adopted in other situations, and against certain other insects of similar habit.

Khalchini a local variety of grapes grown in Balochistan always escapes invasions of grape mealy bug. Haitha variety suffers to a great extent because of its late maturity.

PREDATORS AND PARASITES

Angyrus sp. an endo-parasite of the pest has been found in reducing the pest population in great numbers from June to September in Balochistan. Similarly, a coccinelid predator has also been found on young nymphs of mealy bugs. Manipulation of these natural enemies in a pest management programme can be effective in controlling the pest.

Scolytus amygdali Guer. (Scolytidae: Coleoptera)
(Almond bark beetle)

This shoot hole borer insect is a serious pest of almond, cherry and peaches. Other stone fruits are also attacked. It is circum-Mediterranean in distribution. This borer is a pest of cambium layer of bark and almost exclusively attacks weak trees. Therefore, the insect is considered a secondary pest.

NATURE AND EXTENT OF DAMAGE

The damage caused by this insect is due to feeding in bark cambium by both adult and larvae. The adults cause two types of injury: the twig injury and the limb bark injury. In case of twig injury the adult bores holes in the new wood at the base of buds and fruit spurs. A considerable amount of gum exudes from such punctures resulting in drying up of most of new growth. Limb bark injury is caused by adult females which tunnel the bark to the base and sapwood for making brood chamber at main gallery. Heavily infested trees are weakened and are rendered more susceptible to further attacks of the same and other wood borers.

LIFE AND SEASONAL HISTORY

Shoot hole borer passes winter as a mature larva living at the end of its gallery in the bast layer. These overwintering larvae pupate in spring and after about two weeks the adults emerge, and cut their way out of the bark. During premature period these insects eat on the soft bark of new growth. Upon attaining sexual maturity the female prepares a tunnel in the direction of sap flow. At first a perpendicular or slanting entrance, the "Vestibule" is bored into the rind or bark until the cambium is reached. Once the vestibule is completed the beetle starts to dig out the maternal tunnel or brood chamber about 5 cm long. The gallery is cleaned and all debris is removed completely. The female waits at the entrance of the vestibule to attract visiting males for copulation. The males pay visit to many females while searching them for sexual union. Similarly, a female may copulate with more than one male. After fertilization she lays from 70 to 100 eggs regularly spaced on both sides of the brood chamber. When egg laying is completed, she returns to the entrance and sits there till her death. Thus she plugs the gallery and provides protection to her progeny from intrusion by ants and other predators.

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Hatching takes place after about three days and grubs excavate their galleries individually parallel to each other and perpendicular to the maternal tunnel. The larval galleries are small in the beginning but gradually become enlarged with increasing larval size and in the end an appropriate sized pupal chamber is cut. The grubs become full grown in about four weeks and pupal stage lasts for about 10 days. This insect passes through overlapping four generations in a year.

CONTROL AND MANAGEMENT

The pest prefers weak and unhealthy trees for attack and vigorous trees are avoided. The female possesses great search ability to find out weak trees for the survival of her progeny. The exuded sap in voluminous quantity from a healthy tree may be fatal to survival of tiny grubs. Therefore, the general recommendations for maintaining vigorous growth, are pruning, soil fertilization, fruit-thinning, and proper irrigation which require first attention and correction. Orchard sanitation especially cutting and burning of the infested wood as soon as it is observed is absolutely necessary. Wound sealing, removal of broken branches and damaged limbs, and reducing competition by removing shrubs and unwanted suckers will add to the tree vigour.

Severely infested trees may be corrected by rejuvination of excessive pruning. Gama BHC formed into paste in linseed oil when applied as paint on stems, limbs and big branches will save the tree from further invasion. Fewer trees in an orchard can also be treated with BHC and sticking mud with 1: 2 ratio. The material is prepared in the form of paste with water and painted over infested limbs. Males visiting females come in contact with pesticide residue and are killed. This will result in unfertilized eggs of females. Thus further breeding of the pest is checked.

Emergence of adults normally occurs in May, June, August and October. Pesticidal applications with fairly good persistance at peak emergence of each generation, can also be effective in controlling the pest. There exists great overlapping of shoot hole borer generations. Therefore spray of insecticides does not show much promise in all cases.

Biological control with virulent viruses and pathogens have been used in the control of borers in forest plantation with success, but the same is still to be tested in hilly tracts of Pakistan in future.

Myiopardalis pardalina Biggot. (Trypetidae: Diptera)
(Balochistan melonfly)

The Balochistan melonfly is the most serious pest of cantaloups and musk melons. It has been reported from the Middle East countries, Egypt, Pakistan, Lebanon, Syria, Turkey Caucasia, Iraq, Iran, Afghanistan and North-west India. It is fairly distributed in Balochistan and some areas of North west Frontier Province and Punjab The pest is obligophagous and members of cucurbitacae other than various melons are rarely attacked. It infests cherries, apricots and peaches. Late variety peaches are severely attacked. During heavy infestations apples and pomegranates have been found severely infested.

NATURE OF DAMAGE

The fly lays eggs by puncturing the tender and young developing fruits with her sharp ovipositor and places eggs in the flesh of the fruit. Often exudate comes out of the oviposition hole on which other scavanger flies feed. The newly hatched maggots feed on the pulp and tunnel into the flesh. The surface of feeding tunnels usually acquire brownish colour. When ever fruit contains several larvae, its shape is degenerated and when seeds are damaged the growth of the fruit is arrested. Finally the larvae leave the fruit after gaining full maturity by cutting holes into the rind. These openings provide a passage to various micro-organisms to establish and rot the fruit completely. Infested fruits become unmarketable and unfit for consumption.

LIFE AND SEASONAL HISTORY

The insect diapauses during winter in a hard skinned puparia formed in the soil at a depth of more than two inches. Adult flies come out of these pupae when the soil temperature rises above 20°C. This corresponds to the middle of May. The male fly is slightly smaller than female. They are yellow in colour. The thorax bears six dark patches on dorsal surface. The abdomen is brownish and wings are stripped yellow. The adult female after pairing lays eggs in the early hours of morning. She walks over the entire surface of the fruit and selects a suitable laying site.

The incubation period is 3 to 5 days and about 100 eggs are laid in an extended period. The maggot is white translucent, apodous and pointed at head. They cut tunnels in the pulp and feed on juicy pulp and seeds. The feeding period extends to two weeks. The mature larvae cut their way out

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and usually pupate in the soil. Summer pupae are formed not very deep in the soil. The pupal period lasts for about three weeks, after which flies emerge out and repeat the cycle. About three broods are developed in the entire active season and maggots of last brood diapause by pupation in late September.

CONTROL AND MANAGEMENT

Diapausing pupae may be exposed by ploughing the field as soon as the crop is over. The ploughing is very essential as the pupae are relished by birds. Many maggots pupate just below the fruit or even inside it. They may be carefully collected and destroyed.

Adult flies feed on sweet and fermenting substances before acquiring sexual maturity. It is the particular period when they can be poisoned and controlled. Various sweet poisoned baits are used, protein hydrolyzate bait is preferred. In the absence of protein hydrolyzate a pollard bait is proposed.

Ferment one pound of wheat bran in a gallon of water for 24 hours. Add one table spoonful of Sodium metabisulphide to arrest further fermentation. Obtain clear fluid by swifting through double fold muslin cloth. Take two lbs of pollar, 5 lbs of sugar and one lb of any one poison from Dimethoate, Phenthoate or Malathion and add to it 100 gallons of water. This mixture should be sprayed on melon crop and other nearby vegetation especially broad leaf bushes. Weekly spraying will be sufficient to attract and kill adult flies.

There are other economically important fruit flies found in Hilly tract of Balochistan. Among these *Dacus zonatus* and *Dacus cucurbitae* are fairly common. Both the species are major pest of fruits and vegetables in plains through out the country. *Dacus zonatus* is a serious pest on late variety peaches in Balochistan. *Dacus cucurbitae* attacks apricots, cherries, pomegranates and occasionally apples.

Myzus persicae Sulzer **(Aphididae: Hemiptera)**
(Green peach aphid)

This insect is widely distributed in the palaearctic region and from there it has already spread in almost all continents. It is considered a cosmopolitan insect in distribution. It is a highly polyphagous pest and is considered a potential vector of many virus diseases in cultivated plants. The most important virus transmitted by this insect is the leaf roll virus of potato caus-

ing detrimental effect on the seed potato management. Pakistan is compelled to import seed potato every year from abroad due to this insect and disease complex.

DIAGNOSTICS

M. persicae is characterized by the presence of highly developed double antinary tubercles forming a deep furrow in frontal of head. The pale green parthenogenic wingless female, commonly found on leaves, measures 1.7. to 2.3 mm. The last antennal segment, the cornicles, and the cauda are darker than body colour. The cornicles are comparatively long. The antennae are short. The cauda bears three pairs of setae on its posterior end. The winged (alate) parthenogenic female is 2 to 2.3 mm long. Its head, pronotum and thoracic lobes are shiny black. Its abdomen is olive green with a central dark patch on the 3rd to 6th segments. There are two dark cross streaks and few scattered spots on the dorsal side. There are also four pairs of lateral black spots on the abdomen. The cornicles are shorter than wingless forms but antennae are longer, almost equal to body length and dark in colour.

The oviparous females produced in the last season are apterous, pink coloured and measure about 1.7 mm. The males are alate similar to alate females but smaller and darker in colour.

NATURE OF DAMAGE

The nymphs hatch out in spring and settle on tender petioles. Their development is rapid and exuviae are seen scattered on leaves of host plant. It is known as carrier of about 21 different virus diseases to its host plant complex. This importance have been attained due to the following habits of this insect.

(a) It is highly polyphagous insect and is recorded from more than 150 different plants, belonging to at least 8 different plant families.

(b) It is an active insect. The apterous forms move around on plant surface to select a succulent and attractive site, to establish.

(c) It leaves the host immediately by producing winged females when the feeding tissues indicate slight change in their succulence.

(d) It feeds from the phloem tissues a large quantity of sap and produces copious amounts of honeydew. While sucking sap it injects large amount of saliva which can hold virus particles.

(e) It is highly prolephic and migratory in habit.

(f) It retains virulance for a longer period.

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The direct leaf feeding is not very important as it is a selective feeder. Anyhow the trees are known to be devitalised in case of severe infestation. Poor fruit setting and fruit drop in early stages has resulted due to heavy sap sucking.

LIFE AND SEASONAL HISTORY

As the threshold of development of this insect is at 11°C, the winter is passed diapausing in egg stage where there are freezing temperatures. In holocyclic pattern the returning winged viviparous females stay on peaches and certain other prune species to pass few generations for establishing active colonies of apterous forms. With the first cold spell in autumn, the population of winged males and virginogenous females is triggered. The virginogenous females give birth to sexual oviparous females that mate and lay the fertilized winter eggs in the bud axils of host trees.

In regions where winter temperatures do not fall to freezing, insect follows an holocyclic pattern and does not go in winter diapause. Parthenogenic viviparous reproduction continues indefinitely and frequently. Alate forms appear and continue flying to newer hosts wherever required. Species maintain itself by very few individuals on the great majority of susceptable plants.

PREDATORS AND PARASITES

Like many other aphids this insect is attacked by many predatory insect species but none produces any significant destruction.

Larvae of Syrphid flies and green lace-wings are active aphid predators. Adults and larvae of various coccinellids especially *Coccinella septempunctata* Linn., *Coccinella undecimpunctata* Linn., and *Chilocorus bipustulatus* Linn.; prey on adults and nymphs. There are certain braconid and chalcid wasps known to parasitise this aphid species and other aphids.

Though aphids are heavily attacked by predators and parasities but their reproduction rate is so high that it outstrips to all their natural enemies collectively. Management of natural enemies must be considered, to keep the aphid population below economic threshold.

CONTROL AND MANAGEMENT

This aphid is hardly important for any chemical control. Only some times peaches and plums require spot application of insecticides. Since the

insect is visited by many predators and parasites, it is proposed that only selective chemicals be employed. Pirimicarb is an aphidicide successful at the rate of half pound per acre to control this and other aphids. Certain systemic insecticides give partial selectivity after their absorption in plant tissues. Methyl demeton, Oxydemeton, Phosphamidon, Mevinphos, and Dimethoate are good insecticides for sucking pests. In field crops Phorate, Disulfoton, Quinalphos and others in the granular form are effective and economical. Dichlorvos and Mevinphos being of short residual effect may be used in edible fruits & vegetables, even at harvest.

POTATO DEGENERATION

It was recognized in the eighteenth century that potatoes sown year after year with same seed result in severe yield losses due to a phenomenon called degeneration. At first this was wrongly considered as the loss of vigour due to repeated vegetative propagation. A Dutch scientist, Quanjer, through careful scientific work in 1913 concluded that the degeneration is caused by a virus infection called leaf roll. Twenty virus diseases are known as occurring in potatoes. Of these it is generally accepted that leaf roll is responsible for the largest reduction in yield. Leaf roll and many other potato viruses are perpetuated through the planting of infected tubers. The foliage of plants grown from such tubers indicate leaf roll symptoms after a month on lower leaves initially.

This disease is considered aphid transmitted. Yet there exists considerable uncertainity as to the exact role of certain insects. No one has been able to transmit leaf roll virus by artificial sap inoculation although it is readily transmitted by grafting. It has ben demonstrated that there is an incubation period in the vectors. It takes a fortnight after sap sucking from a diseased plant when the aphid becomes viruliferous. Now when viruliferous aphids feed on a healthy plant they infect through their saliva. This infection takes about 12 days to reach to the tuber and another 20 days elapse before the symptoms appear in the newer young growth in infected plant.

The way in which the virus affects the foliage as well as the yield has been studied. The main physiological effect of the virus is to prevent normal translocation of the carbohydrates manufactured in the potato leaves. In normal leaf the starch prepared during day is converted into sugar at night and moved to other parts of plants including tubers where it is reconverted to starch. In diseased leaves most of the starch remains accumulated in the spongy parenchyma cells. This results the underside of leaf to expand and

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curl the leaf slightly upward. The resulting small supply of sugars in infected plants limits the number of tubers and hence reduces the crop yield.

The farming practice of using healthy seed potatoes is still the main method of preventing crop losses due to the virus diseases. The discovery of role which the aphid plays in disseminating the diseases has led to a wider choice of sites for growing seed potatoes. Seed potatoes are now grown in localities with low flight aphid. But in many countries, like Holland, aphids are universal, and consequently other methods have to be used to obtain virus free potatoes. The Dutch research workers soon came to the conclusion that it is possible to harvest virus free seed potatoes, if they are harvested prior to reaching the virus to tubers. To do this considerable scientific expertise is required with close collaboration of farmers, scientists and legislative authorities.

At the beginning of the season, the growers are given a forecast of probable date to remove winter solanaceous and cruciferous crops. The crop of potato is then inspected during the growing season for freedom from virus diseases. At the same time entomologists keep a watch on aphid populations and when it reaches to the edge and migration has begun,a warning is issued that destruction of potatoes crop must be completed within 10 days time. When this period has elapsed the fields are reinspected and if any foliage is present, the potatoes are down graded and no certificate for seed is granted. Wide range of chemical defoliants are available such as Calcium cynamide, Sodium chlorate, DNOC, Copper sulphate, Pantachlorophenol and Diaquate. Use of Calcium cynamide on freshly cut tops is fairly common. Diaquate is getting popular for early and mid varieties of potatoes.

Pterochlorus (Lachnus) persica Choldak **(Aphididae: Hemiptera)**
(Black peach aphid)

This is of a big size and most conspicuous aphid. It is found in Middle East, Turkey, USSR, Iran, Afghanistan, Pakistan, and India. It is probably common throughout the hilly tract of central area. The insect is a serious pest of peaches, plums, almonds, and apricot trees. Apple trees situated in the vicinity of peaches are also attacked. Certain forest trees like willows and soft poplars are infested to varying degrees.

NATURE OF DAMAGE

The insect is a heavy sap feeder and therefore prefers to establish on big branches and stems of trees. Drastic amounts of sap is sucked through stylets thrusted into the bark of host plant. From infested branches the honey-dews drop like a gentle shower, also trickling along lower plant parts and giving them oily appearance. Due to prolificacy and short life cycle, infested trees suffer from sap depletion. Only very few fruits mature and fruiting is decreased due to devitalization of infested trees. Such trees also become subject to the attack of borers and their life is reduced.

LIFE AND SEASONAL HISTORY

The winter is passed in hibernation in the form of black shiny and oblong shaped eggs, laid in large masses or clusters on lower side of scaffol branches, and on the trunks of young trees. These eggs hatch out with the warming of the season in early spring and on emergence nymphs settle near their egg shells. They insert their stylets into the bark and suck the cell sap of host. These apterous viviparous females are dark grey in colour with ovate or pear shaped body and thick large cornicles, multiply parthenogenetically. In the month of May alate females are developed which soon leave the host and cause infection to new tree and then give rise to viviparous reproduction.

The pest is also seen on scaffol branches of its host during winter months at freezing temperatures. The colonies can stay alive, during winter on branches opposing to the direction of chilly winds.

The reproduction rate is considerably reduced during July, and August, but is regained in September. Several parthenogenic breeds are produced till about mid of November when sexual morphs are given birth. The sexual apterous oviparous females are similar to viviparous females but the alate males are smaller in size. The female lays about 10 eggs in a week's time and die later on. The aphids in general live into a slightly closed mass, touching each other in almost all cases.

The aphid being conspicuous attracts many predators but its high rate of reproduction saves it from any serious threat to the progeny of the species. The biological agents enlisted in case of green peach aphid also attack this like many other aphids.

CONTROL AND MANAGEMENT

Its control must be considered immediately at the initial stage as the drastic sap sucking will cause irrevocable damage. The colonies and egg

masses may be destroyed by rubbing and crushing them with rags tied in sticks. In case of serious infestation spraying with contact insecticides like Pirimicarb, Malathion and Dichlorvos should be considered whenever required. Reapplication may be done if necessary. Persistent pesticides like Aldrin and DDT should be avoided because of biological reasons. Conspicuous egg masses during winter may be crushed, or winter oil @ 2.5 gallons per 100 gallons of water per acre applied before the appearance of green tip of buds. It will obstruct the embryonic respiration and kill them.

There exist many economically important species of aphids in the hilly tract of Balochistan. Some of them are common in plains as well. Their control and management is not different than the aphid species described above. A few of them are enlisted below:

1. The melon or cotton aphid; *Aphis gossypii* Glover
2. The black bean aphid, *Aphis fabae* Scop.
3. The alfalfa aphid, *Therioaphis trifoli* Monell.
4. The corn leaf aphid, *Rhopalosiphum maidis* Fitch.
5. The green apple aphid, *Aphis pomi* DeGree
6. The leaf curling plum aphid, *Brachycaudus helichrysi* Kalt.
7. The Cabbage aphid, *Brevicoryne brassicae* (L) and *Hyalopterus pruni* Geogg
8. The Mealy plum aphid, *Hyalopterus arundinis* Fabr.
9. The rosy apple aphid *Sapaphis mali* Ferr.
10. The green cereal aphid, *Macrosiphum granariun* (Kirby) *Sitobion avenae* F.)

Parlatoria oleae Calv. (Coccidae : Hemiptera)
(Olive scale)

The native home of this insect is considered Italy. From there it has spread in almost all Europe, Mediteranian countries,North America, Iraq, Afghanistan, India, China, and hilly tracts of Pakistan. It is a polyphagous Diaspid scale and recorded from more than thirty five different host plants. It is a serious pest of plums, pears, appricots, almonds, apple, peaches, and roses.

NATURE OF DAMAGE

Olive scale becomes an important pest if allowed to get established in an orchard. Dessication of small wood is caused due to toxicogenic saliva in-

jected while sap sucking. Stems, branches, leaves and fruits all are attacked simultaneously. Badly infested branch seems covered with whitish grey coating. The scale nymphs settle on midrib of leaves and fruits and develope circular pinkish spots on their surface. The plants become very weak and dry ultimately. The fruit remains undersized, undernourished and shrivelled. Therefore the market value is greatly reduced.

LIFE AND SEASONAL HISTORY

The winter is passed in nymphal stage on the bark of host tree. With the beginning of spring season the sap sucking is started and their size is increased. It is in the first week of April that the insect reaches to a stage where sexes become distinct and separable. The adult female is wine red, oval shape and convex. It bears a dark olive green to black excentric exuvium. Male puparia are smaller and elongate with anterior end slightly dark in colour. Following copulation, the sedentary females begin laying eggs under their own scale cover. The laying extends over several weeks and mother scale shrivels and dies in a week after the laying is completed. The nymphs hatch out and creep from below the scale cover. After a short roaming period the crawlers settle on twigs, fruits and leaves. Once settled, they follow the usual course of metamorphosis. The insect has three to four overlapping generations in hilly areas of Balochistan.

CONTROL AND MANAGEMENT

The insect can best be controlled with winter oil applied in winter. Methyl-parathion and synthetic pyrethroids should be used during active season. Early season applications are considered best for control.

Aphytis maculicornis was imported and tried for the control of Olive scale in California and it proved successful. An *Aphytis* species found in Balochistan regulates the pest to some extent. Proper pest management programmes can encourage the parasites for better control of the pest.

Eriosoma lanigerum Hausm. (Aphididae :Hemiptera)
(Woolly apple aphid)

The woolly aphid which is also, called the American blight is practically distributed wherever apples are grown. Despite its cosmopolitan distribution this is occasionally a serious pest. The insect is host specific and is seldom

found on other rosacae but could not thrive. This insect can become a serious problem if ecosystem is disturbed by using pesticides without preplanning.

NATURE OF DAMAGE

As a result of sap sucking by this aphid, the fruit from heavily attacked plants are undersized, malformed, of poor quality and flavourless. Damage to the aerial parts of the attacked tree is more pronounced and young nursery trees scumb due to this pest.

LIFE AND SEASONAL HISTORY

This insect solely multiplies parthenogenetically and winter is passed on shallow apple roots or in perennial suckers. These overwintering females become active in March. The pest multiplies rapidly in summer on aerial parts of plant as well as on shallow roots. The aphids are reddish brown and produce abundant waxy secretions of light flufy nature. Its saliva stimulates adjoining cells to develope gall like tumers of different sizes. Partial movement takes place in May to aerial parts of plant and in July winged females start appearing. These winged forms migrate to other plants and nursery stocks during August and September. The activity is reduced and partial migration to roots and other hiding places starts in October. From December to February production activities are completely stopped. Wind is an effective dispersal agent. The pest is considered to be spread unnoticed through propagation by man himself.

CONTROL AND MANAGEMENT

Nursery stocks should be carefully examined and fumigated before transplantation. Pruning and other wounds must be sealed on trees. Application of systemic granules and spraying aerial parts with contact pesticides like Pirimicarb, Dimethoate, and Dichlorvos are effective control measures.

Tetraynchus urticae Koch. (**Tetraynchidae: Acarina**)
(Spotted spider mite)

This mite is polyphagous and cosmopolitan in distribution. Besides deciduous fruits, of which it is considered a major pest, it also attacks variety of crops, vegetables, ornamentals, forest trees and weed plants. It is fairly common in Balochistan, N.W.F.P., Punjab and Azad Jammu and Kashmir. Apples and plums suffer great devastations due to this pest.

NATURE OF DAMAGE

This mite is recognized by its characteristic spinning of fine webs on all attacked leaves. These webs later on hold dust and become more conspicuous. This results in obstruction in normal physiological processes of leaves like transpiration and photosynthesis. This together with direct injury to the leaf by reposing and sucking results in mottled and sickly appearance of foliage. The apple leaves often turn rust red and dry. Badly infested leaves may fall premature and canopy of the affected trees is severely thinned. The buds are also attacked and badly affected trees fail to produce normal flowers in next season. Besides the direct damage caused by mites, the weakened trees attract bark beetles and borers, which results in great destruction in neglected orchards.

LIFE AND SEASONAL HISTORY

The winter is passed as obligatory diapause on weeds particularly on orchard floors. Only the fertilized females are able to survive low temperatures of winter at which males and nymphs die. In spring the first few generations are passed on weeds and migration to apple and other trees occurs in summer. The adult female is brown green and winter female is orange to brick red in colour. The body is ovoid and non-segmented. There is a single circular furrow running around the body below the second pair of legs. On its back the mite carries six transverse rows of setae. It bears dark markings on each side of the body. The egg is spherical and does not bear a strip. It is yellow in colour and assumes dark orange yellow colour after embryonic development.

During its development, the mite passes through three active stages termed larva, protonymph and deutonymph. Each stage is followed by resting or quiescent stage. This form of development is termed " epimorphosis". The larval stage is characterized by the presence of the first three pairs of legs and absence of colouration. As it comes out of the nymphochrysalis, the protonymph becomes equipped with four pairs of legs which are retained in subsequent stages. After feeding for a few days the protonymphs go into a second resting stage, which ends by moulting. The resulting deutonymphs possess six differentiation characters. The male deutonymphs are shorter and narrower than females. Its posterior of abdomen is conical, while that of female is ovoid. These characters are also retained subsequently. The deutonymphal stage of the mite is shorter, resulting in earlier appearance of the same from teleiochrysalis These males wait until females emergence and

then copulate with her immediately. Parthenogenic reproduction exists and unfertilized eggs produce males only. This arrhenotoky is important for special survival.

The fertilized females spin their webs on the underside of leaves before oviposition. She lays from 9 to 90 eggs depending on the host and prevailing temperatures. This mite passes through about 20 generations per year depending on climatic conditions and day length.

CONTROL AND MANAGEMENT

The management of this mite requires great consideration of placement of right type of chemicals even for the control of insects and pathogens. Populations of phytophagous spider mites are universally regulated to be of very low level by various species of predatory mites and insect predators of different groups. Non-damaging pesticidal application programme can save this valuable biological agent complex and guarantee the orchard cleanliness from mite pest. Various groups of chemicals employed in mite control are listed below:

(i) Miticides which are useful against eggs and early mite stages; hence recommended for early season applications are: Chlorbenside, Chlorfenson, Tetradifon, and Terasul.
(ii) Miticides which are effective against all stages including the eggs and are recommended for active season applications are: Dicofol, Chlorbenzilate, Binapycryl
(iii) Systemic insecticides which have some miticidal activity are: Dimethoate, Demeton-s-methyl, Phosphamidon, Thiometon.

If any mite control operation is to be done, the orchard floor must be considered most important and all vegetation should be sprayed thoroughly. Most of the mites stay on grasses beneath the trees. They become source of infestaion later on.

There are certain insecticides which are used for other pest complex of fruit trees. These contact insecticides disrupt mite population by killing predaceous as well as phytophagous mites. Therefore, such pesticides must be used carefully.

Paninychus ulmi Koch. (Tetranychidae: Acarina)
(Fruit tree red spider mite)

This web forming spider mite is of European origin and has spread to many circum-Mediteranean, Asiatic, Australian and African countries. This is the most serious mite pest of fruit trees in cold climates. All pome and stone fruit trees, vines, ornamental and forest trees of the temperate regions are important hosts of this mite. It is considered as a best example of man made pest connected to chemical control. This mite species hardly occurs in pest status on unsprayed fruit trees.

NATURE OF DAMAGE

The European red mite unlike other web forming mites prefers young unfolding leaves and buds of the tree for its development and thus causes more damage. The mite pierces the leaf epidermis with its stylets and sucks the contents of mesophyll cells. It feeds on both sides of the leaf but prefers lower side of the leaf during development of stages. The damage appears as speckling followed by bronzing of leaves. Thus photosynthesis is greatly reduced. This has more severe effects on fruit trees if occurred in early season. It affects fruit bud formation and reduces fruit size. Late season attack causes poor colour of the fruit. Moderate foliar damage in late summer may cause little harm but attacks tend to debilitate trees.

LIFE AND SEASONAL HISTORY

This mite passes the winter in the egg stage. These eggs are laid any where on spurs, bud axils, at the junction of old and new growth, at the bases of forked branches on the underside of twigs and other places on the tree. These diapausing eggs require a cold shock, prevailing to about 100 to 150 days at temperatures between -1°C to 10°C, in order to break diapause. Hatching continues over several weeks. The egg of *Paninychus ulmi* is onion shaped and somewhat flattened at its vegetal pole. It is slightly angular at its animal pole and bears a long central hair known as stips. Upon magnification very fine rows of radial ridges may clearly be seen on egg surface. These eggs vary in colour between deep red to pale yellow.

The larva is six legged and almost circular. The colour of larvae emerging from winter eggs is orange red while those of summer eggs hatched are light red or yellowish. Colour changes to various shades of red, according to ingested chlorophyll. The larvae pass into a resting stage, then emerge as

an eight legged protonymph. The protonymph after feeding and resting re-emerges as deutonymph. It is the stage when male and female mites may be morphologically differentiated. The spider mite also exhibits an arrhenotokous parthenogenesis. The females develop from fertilized diploid eggs whereas males develop from unfertilized haploid eggs. Newly emerged male searches for a female teliochrysalid and sits quietly by its side and sometimes puts his forelegs over it to pass it. As soon as the emerging female begins to free herself, the male helps to tear the chrysalid skin. Most often male mite copulates with her as soon as her posterior part is visible even though her head is still ensheathed. The complete life cycle takes few days to four weeks depending on climatic conditions. There are four to nine generations per year depending on climatic conditions, food type and day length.

CONTROL AND MANAGEMENT

Winter eggs of red spider mite are virtually water proof and very resistant to dessication and low temperatures. Genetic variation, in diapause intensity, results in variable hatching period and makes chemical control a difficult task. Higher than average temperatures increase the likelihood of early season foliar damage. These mites are kept low in population by various predators among which the phytoseiid mites are most important. Other mites may provide attractive food to predators, enabling them to survive when spider mites are absent. Studies have indicated that various pesticides can stimulate mite outbreaks regardless of direct natural enemy destruction. They may increase the fecundity directly or by modifying the nutritional quality or physiology of host plant. They may also affect the behaviour in a way leading to rapid population increase. The complexity of such effects render experimental analysis difficult and for this reason quite conflicting results have been reported to various pesticides in literature.

For a good spray programme it is desirable to know whether the pesticide is stimulant or suppressant to mite population or at least neutral. Their harmless-ness to predatory mites, and other insects should also be known. Most of the orchard aphids must be controlled with Pirimicarb which is not effective against woolly aphids where as Demeton-s-methyle is effective, against woolly aphid. Codling moth and other torticids, have been found controlled with Diflurobenzuron and Azinphos-methyle. But these chemicals should be used after proper monitoring in individual orchards. Carbaryl should be employed for apple thinning. For controlling spider mites Tetradifon, Triadimeton and Cyheatin should be applied, where as Decofal,

Amitraz, Primiphos methyl and Binapacryl be avoided. Mildews may be controlled best by using Buprimate instead of Benomyl, Dinocap, Binapacryl and sulphur. This approach will encourage biological control of this mite which is so far considered sufficient to keep population of red spider mite well below economic threshold.

Quettania coeruleipennis Schwarzar (Cerambycidae : Coleoptera) (Cherry tip borer)

This insect is a native pest of hilly tract of Balochistan. Elevations upto 4500 feet above Sea level are considered as the home range of this insect. Almonds, pomegranates, plums, apricots are most important hosts of this beetle. Apples and pears are also attacked.

NATURE OF DAMAGE

Grubs of this insect attack the small branches, spurs and top shoots of its host. The grub works in the core of the infested branch and tunnels downward. The larva opens occasional holes on the side of the gallery to throw the large masses of frass and fiberous excreta. Often gum exudes from such holes. The attacked portions become hollow and dry. The dried leaves remain intact to infested shoots even during winter months. The portion where larva is at work can be located by watching fresh frass regularly thrown outside. The attacked branches and limbs often fall with the strong winds.

LIFE AND SEASONAL HISTORY

The grub of this insect remains active throughout summer and winter. Usual activities are slightly reduced in winter but the growth of the larvae is completed in March. The full grown grub is dirty white and creamy in colour with brown head and strong mandibles, measuring about 4 cm in length. The grub constructs a wide pupal chamber at the end of feeding gallary and remains there as prepupa for a week. Pupation takes place in the beginning of April. Exarate pupa is pale to creamy in colour. The pupal period lasts for more than a month and the adults usually appear in May. An emergence hole is cut out with strong mandibles from which the insect comes out and stays on branches and twigs facing sun. Copulation follows shortly after emergence. The female starts laying eggs two days after mating.

The eggs are laid singly as a plastic mass on pencil thick branches. The egg is covered with an opaque whitish cement like substance which soon hardens. Eggs are elongate, convex, possessing widely flattened base. Laying continues in May. The incubation period is three weeks. The newly hatched grub directly bores in the shoot below the egg covering and eats inside the shoot. There is one complete generation in a year.

CONTROL AND MANAGEMENT

Adults may be hand picked and light collected. Branches should be cut carefully carrying the grubs in cut portions and destroyed. Branches bearing leaves during winter should also be cut alongwith grubs and destroyed. Maintenance of fertility in orchard distracts the laying adults.

Adults can be easily seen in May on young plants. They can be destroyed by hand picking. Adults are attracted to light. Light traps can also be used for its control.

All deciduous trees shed their leaves in winter. The branches attacked by tip borer can be seen from a distance because of intact dried leaves. Such branches must be clipped along with grubs and burnt immediately.

Chemical Control with pesticides is not effective because the eggs are not permeable. The larvae that hatch from the eggs directly penetrate the twigs, therefore these are not exposed to insecticides.

Clipping of infested twigs is easy and economical if carefully done.

Aeolesthes sarta Solsky (Quetta borer)

This species is distributed in mountainous region of Balochistan, and N.W.F.P. It is also found as a serious borer in the forests of Afghanistan, Turkistan and Tibet.

NATURE OF DAMAGE

Seriously infested trees can be easily seen by stunted growth, dirty looking bark with linings of frass fallen on the tree and on the ground. Attacked branches break at the point of infestation due to wind storms. Some of the galleries made by borers can be seen filled with frass and fiberous excreta. Codling moth larvae generally prefer to hibernate in the galleries and frass of this pest. At attacked parts the bark becomes loose and can be pealed off easily. The grubs feed on sap wood and then reach the crown of

the tree. Due to this injury the tree ultimately dies. The galleries and tunnels formed by the grown up grub are irregular and numerous.

ALTERNATE HOST PLANTS

Although it is a pest of shade trees like poplars, willows, chinars and elms, yet it has become serious pest of apples, apricots, almonds, cherries, quinces, walnuts, peaches and many other fruit trees.

LIFE AND SEASONAL HISTORY

The eggs are light grey in colour and are laid in groups of 5-10 eggs on broken limbs, cracks and crevices of the tree. Tiney larvae hatch out from the eggs in two weeks time. Initially they feed on soft wood till their mouthparts develop stronger. Feeding continues through out the summer. It hibernates during winter. During spring it bores another tunnel opposite to the former one and prepares a pupal chamber. Grubs transform into pupae inside the pupal cells prepared with bits of soft wood by the end of summer of second year. Pupal period lasts for 4-5 months. In the meanwhile imagine parts of the beetle are acquired. Beetle stays in the pupal chamber till the parts are hardened and cold weather of winter ends. Now it eats its way out for emergence as adult in May or June. It lays 50 eggs in batches. The life-cycle is thus completed in two years.

CONTROL

Attack of this borer generally occurs in abandoned and old orchards. The insect is always concealed deep in the wood. Therefore, chemical control with sprays is not practicable.

The following mechanical method of control has been found more effective. Galleries must be located 1st in the orchard. Each gallery must be cleaned with a long non flexible wire. Most of the time the grub is injured and killed while cleaning the tunnel.

Long persistent insecticides are soaked in a piece of cotton and pushed inside the gallery. The mouth of the gallery is plugged with mud in order to check escape of any fumes of pesticide.

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Chapter 12

INSECT PESTS OF VEGETABLES

by

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Vegetable crops play a significant role as an important supplementary source of food and nutrition as well as income.

Because of their wide adaptability they can fit into varying cropping systems under diversified agro-ecological conditions, thus there are several constraints to improved production and quality of vegetables. A common one is the high incidence of insect pests and disease, which may inflict losses upto 30-40%

The research work on insects of vegetables in Pakistan is primarily limited to some of the significant pests and there are not any detailed studies on insect pest complex carried out successively over a number of years. Listing of the known insect pests is provided below and subsequently the significant ones are discussed in details.

Cucurbits (Pumpkin, Cucumber, Gourds)

MAJOR PESTS

Melon aphid, *Aphis gossypii* Glov	Aphididae: Hemiptera
Red pumpkin beetle, *Aulacophora africana* Weise	Chrysomelidae (= Galerucidae): Coleoptera
Red pumpkin beetle, *Raphidopalpa* (= *Aulacophora*) *foveicollis* (Lucas.) *Raphidopalpa* (= *Aulacophora*) *atripennis*	Chrysomelidae (= Galerucidae): Coleoptera
Hadda beetle, *Epilachna dodecastigma* (Wied)	Coccinellidae. Coleoptera
Melon fruit fly, *Dacus cucurbitae* Coq.	Tephritidae: Diptera

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Melon fruit fly, *Dacus ciliatus* Loew.	Tephritidae: Diptera
Cutworm, *Agrotis ipsilon* (Hfn.)	Noctuidae: Lepidoptera

MINOR PESTS

Balochistan fruit fly, *Myopardalis pardalina* Bigot	Tephritidae: Diptera
Fruit fly, *Dacus zonatus* (Saund.)	Tephritidae: Diptera
Hadda beetle, *Epilachna demurili* Muls.	Coccinellidae: Coleoptera
Blue pumpkin beetle, *Aulacophora atripenis* Fabr.	Chrysomelidae: Coleoptera
Pumpkin weevil, *Myllocerus blandus* Fst.	Curculionidae Coleoptera
Black bug, *Aspongopus janus* F.	Pentatomidae: Hemiptera
Cotton whitefly, *Bemisia tabaci* (Genn.)	Aleyrodidae: Hemiptera

Okra or Lady's finger

MAJOR PESTS

Shoot and fruit borer, *Earias insulana* (Boisd)	Noctuidae: Lepidoptera
Shoot and fruit borer, *E. vitella* (Fb.)	Noctuidae: Lepidoptera
Shoot and fruit borer, *E. fabea* Stap.	Noctuidae: Lepidoptera
Semi looper, *Agrotis ipsilon* (Hfn.)	Noctuidae: Lepidoptera
Cotton whitefly, *Bemisia tabaci* (Genn)	Aleyrodidae: Hemiptera
Cotton aphid, *Aphis gossypii* Glov.	Aphididae: Hemiptera
Cotton leaf hopper, *Amrasca devastans* (Dist.)	Cicadellidae: Hemiptera

MINOR PESTS

Fruit borer, *Heliothis armigera* (Hb.)	Noctuidae: Lepidoptera
Tobacco caterpillar, *Spodoptera (Prodenia) litura* (F.)	Noctuidae: Lepidoptera

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Cotton leaf roller, *Sylepta derogata* F.	Pyralidae: Lepidoptera
Red cotton bug, *Dysdercus koenigii* (F.)	Pyrrhocoridae: Hemiptera
Dusky cotton bug, *Oxycarenus loetus*	Lygaeidae: Hemiptera

Brinjal or Eggplant

MAJOR PESTS

Brinjal lace-wing bug, *Urentius echinus* Dist.	Tingidae: Hemiptera
Brinjal lace-wing bug, *Urentius sentis* Dist.	Tingidae: Hemiptera
Hadda beetles, *Henosepilachna* (= *Epilachna*) *vigintioctopunctata* (F.) and *Epilachna dodecastigma* (Wied.)	Coccinellidae: Coleoptera
Epilachna demurili	Coccinellidae: Coleoptera
Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee	Pyralidae: Lepidoptera
Brinjal stem borer, *Euzophera perticella* (Rag.)	Pyralidae: Lepidoptera
Cutworm, *Agrotis ipsilon* Hfn.	Noctuidae: Lepidoptera
Cotton leaf hopper, *Amrasca devastans* (Dist)	Cicadellidae: Hemiptera

MINOR PESTS

Grasshopper, *Attractomorpha crenulata* Fab.	Acrididae: Orthoptera
Cotton whitefly, *Bemisia tabaci* (Genn.)	Aleyrodidae: Hemiptera
Mite, *Tetranychus urticae* Koch.	Tetranychidae: Acarina

Chillies and Green Pepper

MAJOR PESTS

Cotton Whitefly, *Bemisia tabaci* (Genn.)	Aleyrodidae: Hemiptera

Cutworm, *Agrotis ipsilon* (Hfn.)	Noctuidae· Lepidoptera
MINOR PESTS	
Cotton aphid, *Aphis gossypii* Glov.	Aphididae: Hemiptera
Tobacco caterpillar, *Spodoptera (= Prodenia) litura* F	Noctuidae: Lepidoptera
Fruit borer, *Heliothis armigera* (Hb.)	Noctuidae: Lepidoptera

Taro or Calocasia

MAJOR PESTS	
Cotton whitefly, *Bemisia tabaci* (Genn.)	Aleyrodidae: Hemiptera
Tobacco caterpillar, *Spodoptera (= Prodenia) litura* F.	Noctuidae: Lepidoptera
Cutworm, *Agrotis ipsilon* (Hfn.)	Noctuidae: Lepidoptera
MINOR PESTS	
Potato tuber moth, *Phthorimaea operculella* (Zell.)	Gelechiidae: Lepidoptera

Onions and Garlic

MAJOR PESTS	
Onion thrips, *Thrips tabaci* Lind.	Thripidae: Thysanoptera
Cutworm, *Spodoptera exigua* Hubn.	Noctuidae: Lepidoptera
Cutworm, *Agrotis ipsilon* (Hfn.)	Noctuidae: Lepidoptera
Cutworm, *Spodoptera litura* (F.)	Noctuidae: Lepidoptera
MINOR PESTS	
Onion bulb fly, *Hylemya antiqua* Meign	Anthomyiidae: Diptera

Potato

MAJOR PESTS	
Green peach aphid, *Myzus persicae* (Sulz.)	Aphididae: Hemiptera

Potato tuber moth, *Phthorimaea (= Gnorimoschema) operculella* (Zell.)	Gelechiidae: Lepidoptera
Cotton white fly, *Bemisia tabaci* (Genn.)	Aleyrodidae: Hemiptera
Cutworm, *Agrotis ipsilon* (Hfn.)	Noctuidae: Lepidoptera
Tobacco caterpillar, *Spodoptera litura* (F.)	Noctuidae: Lepidoptera
Lucern caterpillar *Agrotis exigua* (Bb.)	Noctuidae: Lepidoptera

MINOR PESTS

Mole cricket, *Gryllotalpa orientalis* (= *africana* P de B)	Gryllotalpidae: Orthoptera
Termite, *Odontotermes obesus* (Ramb.)	Termitidae: Isoptera
Green stink bug, *Nezara viridula* (L.)	Pentatomidae: Hemiptera
Painted bug, *Bagrada hilaris* (Burm.) (= *cruciferarum* Kirk)	Pentatomidae: Hemiptera
Henosepilachna sparsa Hbst. *Henosepilachna (= Epilachna) vigintioctopunctata* Fab.	Coccinellidae: Coleoptera
Cucumber beetle, *Monolepta orientalis* Jac.	Galerucidae: Coleoptera
Colorado potato beetle, *Leptinotarsa decemlineata* Say.	Coccinellidae: Coleoptera

Peas and Beans

MAJOR PESTS

Cow pea aphid, *Aphis craccivora* Koch.	Aphididae: Hemiptera
Pea leaf minor *Liriomyza chinensis* (Kato)	Agromyzidae: Diptera
Pea Stemfly, *Ophiomyia (Melanagromyza) phaseoli* (Trayon)	Agromyzidae: Diptera

MINOR PESTS

Green pea aphid, *Acyrthosiphon pisum*	Aphididae: Hemiptera
Pea leafminer, *Phytomyza horticola (= atricornis* Meigen)	Agromyzidae: Diptera

Cutworm, *Agrotis* sp.	Noctuidae: Lepidoptera

Tomato

MAJOR PESTS

Cotton whitefly, *Bemisia tabaci* (Genn.)	Aleyrodidae: Hemiptera
Fruit borer, *Heliothis armigera* (Fb.)	Noctuidae: Lepidoptera
Cutworm, *Agrotis ipsilon* (Hfn.)	Noctuidae: Lepidoptera
Tomato aphid, *Aphis craccivora* Koch.	Aphididae: Hemiptera

MINOR PESTS

Ak-Grasshopper, *Poecilocerus pictus* (Fab.)	Acrididae: Orthoptera
Cotton leaf hopper, *Amrasca devastans* (Dist).	Cicadellidae: Hemiptera
Tomato mealy bug, *Ferrisia virgata* Ckll.	Pseudococcidae: Hemiptera
Hadda beetle, *Henosepilachna sparsa* (Hbst)	Coccinellidae: Coleoptera
Thrips, *Thrips tabaci* Lind	Thripidae: Thysanoptera

Turnip, Radish, Mustard and Spinach

MAJOR PESTS

Mustard sawfly, *Athalia lugens proxima* (Klug)	Tenthredinidae: Hymenoptera
Mealy cabbage aphid, *Brevicoryne brassicae* (L.)	Aphididae: Hemiptera

MINOR PESTS

False cabbage aphid, *Lipaphis erysimi* (Kalt.)	Aphididae: Hemiptera

Cruciferous Vegetables (Cabbage, Cauliflower, Radish)

MAJOR PESTS

Cotton whitefly, *Bemisia tabaci* (Genn.)	Aleyrodidae: Hemiptera
Cabbage butterfly, *Pieris brassicae* Linn.	Pieridae: Lepidoptera

Cutworm, *Agrotis ipsilon* (Hfn.)	Noctuidae: Lepidoptera
Diamond back moth, *Plutella xylostella* (L.)	Plutellidae: Lepidoptera
(= *P. maculipennis* Curt.)	Yponomeutidae: Lepidoptera
Cabbage borer, *Hellula undalis* Fab.	Pyralidae: Lepidoptera
MINOR PESTS	
Grasshopper, *Attractomorpha crenulata* F.	Acrididae: Orthoptera
Termite, *Microtermes obesi* Holm.	Termitidae: Isoptera
Cabbage semi-looper, *Diachrysia (Plusia) orichalcea* (Fab.)	Noctuidae: Lepidoptera
Cabbage semi-looper caterpillar, *Autographa* (= *Plusia) nigrisigna* (Wlk.)	Noctuidae: Lep' loptera
Cabbage looper, *Trichoplusia ni*	Noctuidae: Lepidoptera
Cabbage caterpillar, *Plusia signata* Fab.	Noctuidae: Lepidoptera
Mustard aphid, False cabbage aphid, *Lipaphis erysimi* (Kalt.)	Aphididae· Hemiptera
Mealy cabbage aphid, *Brevicoryne brassicae* Linn.	Aphididae: Hemiptera
Tabacco caterpillar, *Spodoptera (Prodenia) litura* F.	Noctuidae· Lepidoptera
Mustard sawfly, *Athalia lugens proxima* Klug.	Tenthredinidae. Hymenoptera

The important pests of vegetables are described below in detail.

Aphis gossypii Glov. (Aphididae: Hemiptera)
(Melon aphid, Cotton aphid, tela)

Synonyms: *Aphis cucumeris, A. cucurbiti, A. frangulae, A. solanina, Doralis frangulae, Cerosipha gossypii.*

DIAGNOSTICS

Aphids are small, soft bodied, pear shaped insects usually found in

large number on the lower side of the leaves or on tender stems sucking the sap of the plants. Such aphid colonies often include individuals in all stages of development. Both winged and wingless forms are met within the same colony at times.

Egg: Eggs white, obloag and laid only under temperate climatic conditions.

Nymph: Similar to adult in shape but lighter in colour and smaller in size than adult.

Adult: Colour variable usually light green mottled with dark green. Large specimen however dark green to black. Adults produced on over crowded leaves at high temperature may be less than one mm long, pale yellow to almost white. Siphunculi dark and cauda pale.

Distinguishing characters of *A. gossypii* are its short femoral hairs except for a few along the posterior margin, the 8th abdominal tergite bears only 2 and the cauda only 5-8 hairs.

LIFE HISTORY

Life cycle of this aphid like many other aphid species is rather unusual and complex depending upon the climatic zone in which the pest in found.

In temperate climates after mating, the females lay eggs and do so only at the beginning of winter. These eggs overwinter on *Rhamnus* and on plants of Bigoniaceae family. These eggs hatch in the spring into females that reproduce parthenogenetically (without mating) and viviparously (give birth to living youngs instead of eggs). Several generations are produced during the summer in this way with only females being produced and the young being born alive. The first 1-2 generations usually consist of wingless individuals, but eventually upon crowding winged individuals also appear. which migrate to different host plants. In the later part of the active season, the aphids migrate back to the winter host plants where again both males and females are produced. Here the mating takes place, the females lay eggs which overwinter. In areas with tropical climate *A. gossypii* do not overwinter, rather reproduction is continuous throughout the year. However, the pest population is very low during winter months. The aphids reproduce parthenogenetically and viviparously. Winged individuals also appear and keep on migrating between plants of dicotyledenous families and on flower stems of many monocotyledons but seldom Graminae. One female may produce 20-140 young ones in its life time at a rate of 2-9 young ones per day depending on the climate. The females mature and start reproduction after

4-20 days of their birth. Thus exact number of generations per year can not be worked out certainly. Both nymphs and adults excrete sufficient amounts of honey-dew and the colonies of the aphids are visited by ants.

HOST PLANTS

The range of host plants in this aphid is very wide. However, main damage is done to cucurbits, cotton, citrus, brinjal, peppers, potato, lady's finger, cocoa, coffee and many other ornamental plants. The pest seldom attacks plants of the family Graminae.

DISTRIBUTION

The pest is widely distributed and found in all countries of the world with tropical, subtropical and temperate climates. In Pakistan, the pest is found throughout the country and attacks its various host plants where ever they are grown

NATURE OF DAMAGE

Symptoms of attack are rarely conspicuous specially when the pest is in low population density. However, the presence of the pest on the plant can be easily recognized by the ants which move around on the plants visiting the aphid colonies for feeding on honey-dew. Shiny and grassy appearance of the upper surface of certain leaves due to the deposition of honey-dew also locates the presence of aphids. When plants are attacked specially in younger stage they remain stunted and distorted. The attacked leaves become pale-green to yellowish-green and drop prematurely. *A. gossypii* can transmit over 50 different kinds of viruses and very often symptoms of attack by these viruses are mistaken to be the result of direct feeding activities of the aphids.

CONTROL METHODS

Cultural: Since this pest feeds by sucking the cell sap thus very high doses of nitrogen fertilizer should not be applied otherwise the pest population would increase rapidly due to lush vegetative plant growth

Biological: A number of predatory insects feed on the aphid in its all developing stages in a larger part of the season. Important among these predators are larvae of green lace wing (Chrysopidae), larvae of syrphid flies (Syrphidae) and larvae and adult of lady bird beetle (Coccinellidae). Effectiveness of Coccinellid larvae as biological agent, however, depends upon the characteristics of the leaf surface e.g. hairy (tomato), waxy

(cabbage) with respect to suitability as walking substratum for the prey searching larvae. Among the parasitic insects important ones are *Aphidius* sp. (Braconidae) and *Aphelinus* sp. (Chalcidoidae). Parasitic fungi *Entomophthora exitialis* and *Verticillium lecanii* also attack this species.

Chemical: An emulsion prepared from 1 oz. of 40% of Dimethoate per 4 gallons of water or 1 oz. of 20% Endrin in 2 gallons of water gives good control of the pest on brinjal. Similarly, 0.25-0.05% spray of Basudin gives good control of the pest on various vegetable crops or spray of 20 gm of Folidol E 605 when mixed with 100 litres of water also gives good control of the pest. Malathion (57% EC) or Methyl-parathion (57% EC) @ 0.45 litre per acre is also recommended.

Aulacophora africana Weish. (Chrysomelidae: Coleoptera)
(Red pumpkin beetle)

Synonyms: *Aulacophora foveicollis, Raphidopalpa foveicollis*

DIAGNOSTICS

Egg: Single egg oval, freshly laid eggs yellow, later on orange coloured. The eggs are laid singly or in batches of 8-9 in moist soil near the base of plants.

Larva: Larva creamy yellow or white, with a slightly dark oval shield at the back, measures 12 mm in length when fully-grown, head and prothorax brownish. Last abdominal segment dark coloured and provided with a "Pro - leg".

Pupa: Pupa creamy white and pupation takes place in an oval thick walled earthen chamber in the soil up to a depth of 20-25 cm.

Adult: The adult beetles are usually seen visiting flowers of the host plant or flying from one plant to another. Adult medium sized, elongate, oblong, 5-8 mm long. Its dorsal surface brilliant orange red and ventral surface entirely black with soft, short and whitish hairs. Compound eyes conspicuous on the head.

LIFE HISTORY

The beetles are found concealed in groups, under dry weeds, bushes and plant remains in crevices of soil. They become active in March-May as soon as the season warms up. After mating the females lay eggs on moist soil under the cover of fallen leaves or plant debris near the base of the host

plants. The eggs are laid singly or in small clusters of 8-9 eggs each. Each female may lay up to 300 eggs. The larvae which hatch after 6-15 days remain below the surface of soil, feed by boring into the roots, stems of creepers and fruits of the host plant lying in contact with the soil surface. Larval stage is completed in 13-25 days. Before pupating, the larva constructs an oval chamber in the soil up to a maximum depth of 20-25 cm where it turns into pupa. The pupal stage lasts for 7-17 days. Upon emergence the adults mate and again start laying eggs to start new generation. In this way several generations are completed on various cucurbit species grown during summer. Before the onset of winter (November) the adults stop laying eggs and start hibernating singly or in groups among the dried up cucurbit creepers, weeds, grasses, bushes, and even in cracks in the soil. The beetles remain inactive hibernating from November up to March-May next year.

HOST PLANTS

The pest attacks almost all the plants of cucurbitae family (both wild and cultivated). Cultivated cucurbit host plants grown in Pakistan, include gourd (kaddu) *Lagenaria vulgaris*, bitter gourd (karela) *Momordica charantia*, (tinda) *Citrullus vulgaris* var. *fistulosus*, (ghiatori) *Luffa aegyptiaca*, cucumber (kheera) *Cucumis sativus*, pumpkin (petha) *Cucurbita* spp. Musk melon (kharboozah) *Cucumis melo*, water melon (tarbooz) *Citrullus vulgaris* and squash or vegetable marrow *Cucurbita pepo*.

DISTRIBUTION

This species is widely distributed in the countries around the mediterranean sea and throughout Africa, Asia, Australia and Southern Europe. In Pakistan, the pest is distributed in all areas where the host plants are grown. It is, however, serious in areas with longer cucurbits growing season.

NATURE OF DAMAGE

This is one of the serious pests of cucurbits in this country. Both adults and grubs cause damage to cucurbitaceous vegetables, particularly when the creepers are very young. The grubs bore into the roots and stems of the plants causing their death. Roots and stems of attacked plants contain burrows with larvae present inside. The grubs also bore into the fruits touching the soil surface. Severely attacked fruits contain holes and can be recognized by the presence of openings on their outer surface. Adults on the

other hand, eat holes in the leaves, feed and destroy the developing ovaries in the flowers, causing appreciable damage. Withered flowers as a result of the damage to the ovaries is an important symptom of adult attack. Crop is seriously damaged, particularly in the seedling stage due to the grubs' feeding on roots.

CONTROL METHODS

Sanitary Measures: The beetles are found concealed under dry weeds, bushes and plant remnants during winter. These should be burnt. Adults lay eggs on the soil under the cover of plant debris. Removal of all such plant debris during the growing season of crop is important to discourage egg laying. Regular hoeing, removal and destruction of all dead and dried up plants are recommended to destroy pupae and larvae present therein. Clean-up of the field is also important after the harvest of the crop.

Cultural: Early sowing of the crops and early maturing varieties are recommended so that by the time adults appear in the spring, the roots and stems of the plants are well developed and can better withstand the attack. Deep ploughing of the field in winter is important to expose the hibernating adults which would be either killed by the cold temperatures or eaten up by the predatory birds.

Mechanical: Adult bettles present on the leaves or in the flowers can be collected easily with hand or hand nets in the morning hours and destroyed.

Chemical: Adults can be effectively controlled from attacking leaves of young plants by dusting the plant with ashes, particularly cow dung ash. Addition of a little kerosene oil to the ash greatly improves its repellent quality. Similarly, Sevin and other dusts as stomach and contact insecticides are also effective against the adults. Dusting should preferably be done in the morning hours and all the plant parts should be thoroughly covered. Spraying the crop with Methyl Parathion/Dimethoate 0.01% or Malathion 0.05% is effective against the pest. The Punjab government has recommended the same insecticides for this pest as for brinjal lace-wing bug, brinjal fruit and stem borers.

Aulacophora foveicollis Lucas (Chrysomelidae: Coleoptera)
(Red pumpkin beetle)

It is the most destructive pest of all cucurbitaceous vegetable crops, and

occurs throughout the country. The red-coloured beetle lays eggs singly or in batches in the moist soil around the base of the food plants. As many as 300 eggs are laid by a female. Egg period lasts for 6 to 15 days, larval period for 13 to 25 days and pupal period for 7 to 17 days under different climatic conditions. The grub bores into the roots and stems and later into the leaves and fruits lying on the ground. It undergoes four instars entering soil each time to moult. The mature larva enters soil and pupates within a water-proof cocoon 1.3-25.4 cm deep. Five generations are completed yearly. The adults hibernate in November and reappear by the end of April and the broods overlap thereafter. The adults live for more than one month. They hibernate under old cucurbitaceous creepers, grasses, weeds and in soil. Mortality among the hibernating adults is high.

It is a major pest of lucerne, the adult biting holes in the leaves. The grub bores into the roots and stem of berseem. It also attacks shoots and leaves of brinjal and sometimes leaves of fruit trees such as mangoes.

The damage is caused mainly by the adult beetles which feed extensively on the leaves, flowers and fruits making holes and causing death or retardation of growth. The seedlings when infested, are totally destroyed. The damage done by the grub to the seedlings also is serious. The hibernating beetles are the most destructive and so prompt control measures have to be taken against them. Field sanitation, clean cultivation, collection and destruction of the beetles and the use of contact insecticides are the control measures.

The allied species found together with *A. foveicollis* are *A. lewesi* Baly which is blue in colour and *A. stevensi* B. which is grey; both of these are less abundant than *A. foveicollis*. The biology of all the three species is similar (Hussain, 1924; Hussain and Shah, 1926; Anonymous, 1930; Lall, 1964).

Dacus cucurbitae Coq. (Tephritidae/Trypetidae: Diptera)
(Melon fruit fly)

Synonyms: *Batrocera cucurbitae, Chaetodacus cucurbitae, Strumeta cucurbitae*

DIAGNOSTICS

Egg: Whitish-yellow, spindle-shaped, approximately 1.2 mm long and 0.3 mm wide. Laid under the skin of the fruit, in a cavity made by a female.

Larva: Maggot dirty white, without legs, pointed anteriorly "appears as head-

less" and broader posteriorly (apodous). Young larvae are white and 2.4 mm long; full-grown larvae are yellowish and about 10 mm long.

Pupa: Pupa coarctate, enclosed in the last larval skin (puparium). Puparium barrel shaped, initially light yellow but later on becomes dark brown. Pupation is underground. The pest passes winter (December-February) as pupa. The adults appear in March.

Adult: The adult fly is about the size or a little bigger than common housefly. In an infested field the flies are usually seen hovering on the fruits and other parts of the host plants with their both wings stretched. The flies are reddish with yellowish (= lemon yellow) patchs on thorax and black bands on abdomen. Wings with radiomedial veins having black bands, lower front orbital bristles present, vibrissae and ocelli absent, spines present on middle tarsi. Ovipositor three segmented.

LIFE HISTORY

The adults become active in spring or early summer and start ovipositing after mating. For oviposition the female punctures the soft skin of the young fruit with the help of its long, needle like, horny ovipositor and deposites eggs just under the skin of the fruit. Since these oviposition punctures are very small, these are usually invisible to the nacked eyes. During each oviposition act, 5-10 or more eggs are laid. Flies preferably lay eggs in young fruits with soft and tender skin than in older fruits with harder epidermis. Total number of eggs laid by one female ranges from 60-120 in its life time. The eggs hatch in 2-9 days and the young maggots start tunnelling deep into the fruit where they continue to feed on the pulp 13 days during summer and 3 weeks during winter till they become full-grown. The larvae are full-grown in about 15 days after which they leave the fruit by making an exit hole and drop on the ground. Although the exit holes are bigger in size than the oviposition punctures, yet these wounds become healed in a growing fruit leaving characteristic scars. Such scars are usual symptoms on an attacked fruit. The mature larvae after falling on the ground move away in jumps of 12-20 cm. The movement is made possible by folding and unfolding the two ends of its elongated body. Upon reaching a suitable place the maggot burrows 2-5 cm deep in the soil and pupates. The pupal stage lasts for 6-10 days. Adult life lasts for 14-54 days. The total duration of one generation varies between 23-34 days depending upon the prevailing weather conditions. There are 4-10 overlapping generations each year according to the geographical location of the area. Th pest is serious and the period of its

maximum activity is during July and August. In plains with mild winter temperatures the pest overwinters in the adults stage during November-December under the leaves of guava, loquat or other plants. In mountainous areas the fly, however, overwinters as pupa in the soil from November till May.

HOST PLANTS

Gourd (*Lagenaria vulgaris),* bitter gourd, tinda, ghia tori, cucumber, pumpkin, musk melon, water melon and squash. Besides cucurbitaceous vegetables, it has been reported to attack tomato, guava, papaya, citrus, mango, date palm, peach, green pepper, etc.

DISTRIBUTION

The origin of this pest has been reported as northern India. Now the pest is widely distributed in tropical and temperate regions of the world and reported from India, Pakistan, Burma, Philippines, Sri Lanka, Taiwan, Okinawa, Kenya, Mauritius, Guam, Japan, Hawai, Australia, Java, U.S.A. (California) and Malaysia. In Pakistan the pest is widely distributed in coastal areas, plains, sub-mountainous and mountaneous areas, where ever the host plants are grown.

NATURE OF DAMAGE

Little damage is done due to oviposition behaviour of the fly which punctures the fruit and lays eggs under the epidermal layers, in a cavity made by the sharp ovipositor. After laying eggs, the female releases a gummy secretion which cements the tissue surrounding the puncture and makes the entrance water-proof. The secretion solidifies to form a shiny brown resinous material. Mostly such oviposition punctures can heal up quickly and leave no visible symptoms of attack. Most of the damage results from the feeding of pulp by the larvae. Infestation of the fruit by maggots is usually followed by its decomposition due to invasion of secondary organisms. The larval feeding on the pulp and subsequent decomposition render the fruits unfit for human consumption. Such heavily attacked fruits usually loose their grip from the plant and drop down by themselves. These dropped fruits are the most important symptoms of attack. Some of the fruits, however, remain on the plant but show small scars on their skin. Such scars are actually healed up exit holes made by the larvae. Mostly such scars are recognisable only by a thorough and close examination of the skin. Another symptom of attack is

the smaller size and yellow colour of infested fruits.

CONTROL METHODS

Sanitary: Regular collection and destruction of the infested fruits fallen on the ground help to avoid spreading of the pest by killing the inside larvae. Burying the infested fruits under the soil to a depth of 2-3 feet or burning them are methods suggested for the destruction of the fruits.

Cultural: Cultural control is mainly done for the destruction of pupae in the soil. Thus surface ploughing after the crop harvest is recommended in order to expose pupae to the attack of natural enemies or the extremes of temperatures. Another method to destroy pupae in the soil is to irrigate the infested field heavily. Sowing of early or late cucurbit varieties also help in escaping the damage.

Resistant Varieties: Crops resistance is one of the most important, economical and easy method of insect control. Different varieties of cucurbits are reported to be resistant to the attack of insect pests e.g in India "Improved long green" variety of cucumber, "Soft green" variety of bitter gourd, "Sultan's long green" of bottle-gourd and "Smaller sugar" of pumpkin are resistant to the attack of fly.

Biological: In India *Opius fletcheri* Silv. (Hymenoptera: Braconidae) is the most effective pupal parasitoid for controlling the fruit fly. In Pakistan, however, its parasitism is very low.

Sterile Male Technique: Utilization of sterile male technique either by irradiation or by chemosterilant is useful against this species.

Chemical: Chemical control which is mainly directed against the adult stage of the pest can be applied in two ways.

(1) Insecticide sprays e.g. Endrin (0.3%) or Parathion (0.25%) are effective.

(2) Bait spray e g. wettable Malathion 50% 2 lbs+1 lb of protein hydrolysate dissolved in 100 gallons of water used as spray at weekly intervals gives excellent control. Similarly, combination of Parathion with Methyl-eugenol also gives good results. Time of spray is very important for the effective control. Best time of first spray is just after the fruits are set. Early spray at the flowering would kill the pollinators while too late would be ineffective as the flies would have already laid their eggs.

The Punjab government has recommended any one of the following insecticides, as spray during May to September.

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Insecticide	Formulation	Dose/acre
Dipterex	80% Powder	0.90 kilogram
Nogos	100 EC	0.45 litre
Malathion	57 EC	0.45 litre
Labaycid	50 EC	0.22 litre

Agrotis spp. **(Noctuidae: Lepidoptera)**
(Cutworms)

It is a polyphagous pest and has a wide range of host plants. It is found all over the world. It causes considerable damage to potatoes. Besides potato it caused damage to gram, tobacco, peas, wheat, lentil, mustard, linseed and cucurbits, vegetable seedlings and several weeds.

DIAGNOSTICS

Egg: Eggs are creamy-white, dome-shaped.

Larva: A caterpillar on emergence measures 1.5 mm with a shiny black head and a black shield on the prothorax and is slightly yellowish. The full-grown larva is about 42-45 mm long and is dark or dark brown with a plump and greasy body.

Pupa: Makes earthen chamber in the soil and pupates underground.

Adult: The moth, measures about 25 mm from the head to the tip of abdomen and looks dark or blackish with some greyish patches on the back and dark streaks on the fore wings.

LIFE HISTORY

The pest is active from October to April and probably migrates to the mountains for further breeding during summer. The moths appear in the plains, in October and come out at dusk, flying about until darkness sets in. They oviposit at night and lay eggs in clusters of about 30 each on the under surface of the leaves of plants or in the soil. The duration of different life stages is as under:

Egg stage	=	2 days in summer 8-13 days in winter
Larval stage	=	30-34 days in February-April
Pupal stage	=	10 days in summer 30 days in winter

The moths usually emerge at night. The life cycle is completed in 48-77 days and generally three generations are completed in a year.

NATURE OF DAMAGE

Only the caterpillars do the damage. The young larvae feed on the epidermis of the leaves. As they grow, their habit changes. During the day time they live in cracks and holes in the ground and come out at night and fell the plants by cutting their stems, either below the surface or above the ground. The cut branches are sometimes seen to have been dragged into the holes where the leaves are eaten at leisure. Larvae may also bore into cabbage. The larvae/caterpillars curl up into a tight "C" shape when disturbed.

CONTROL METHODS

Cultural/Mechanical/Physical : 1. Instal light traps for collection and then destruction of moths

2. The weeds should be removed from the field
3. Frequent hoeing should be done
4. Irrigate the field

Chemical : Same as for grasshoppers.

Myopardalis pardalina Bigot (Tephritidae: Diptera)

(Melon fruit fly)

This is an important pest of muskmelon, watermelon and cucumbers. Eggs are laid in tender fruits only. Up to 130 eggs are laid in a fruit. They hatch in about four days. The maggots feed on the seeds and on the pulp surrounding them. They may get drowned if they go deep into the juicy pulp. Larval period lasts a fortnight. Pupation occurs in soil or under the fruit for about 13 days in summer and for over six months in winter. The pupa can

survive immersion in water for two to three weeks. Adult life lasts for three to four weeks when fed on fruit juice. Overwintering takes place in the pupal stage from September to April. The adults emerging in April subsist on the honey-dew of aphids. The most active period of the pest is in July when the life-cycle is completed in the shortest period of one month. Two or three generations are passed before overwintering starts. Damage is caused by the adult fly puncturing the fruits and by the maggot tunnelling within fruit pulp. Egg laying takes place in tender fruits and even in just fertilized ovaries; they may rot due to the oviposition punctures alone. Though the maggots may not cause much injury to the pulp of the melons, fermentation and rotting of the fruits take place consequent to their boring out of the fruits for pupation. Up to 20 percent loss to the fruit yield may occur in the peak infestation period in July. Covering the fruits with earth and using late ripening varieties will help in reducing the degree of infestation. Other control measures are similar to those described for other fruit flies.

Bemisia tabaci (Genn). (Aleyrodidae: Hemiptera)

(Whitefly, cotton whitefly)

Synonyms: *Bemisia gossypiperda, B. longispiea, B. goldingi, B. nigeriensis*

DIAGNOSTICS

The most characteristic organ in whiteflies is the vasiform orifice, a conspicuous opening, which is present on the dorsal side of the last abdominal segment. This opening is provided with an operculum (flap or lidlike structure). Within the orifice and beneath the operculum is a tongue or strap-shaped organ known as ligula. Vasiform orifice is present both in larval and adult stages. The anus opens within the orifice at the base of the ligula. Honey-dew excreted through the anus accumulates on the ligula, and this fact gives rise to the view that ligula secretes the honey-dew.

Egg: Surface smooth, sub-elliptical, stalk very short, light yellow when laid yet before hatching turns dark brown. The egg is inserted singly into the plant tissue by the female while ovipositing.

Nymph: Nymph louse-like greenish yellow to light yellow, oval in outline, (elliptical) with notches at either end; abdomen with a pair of deep yellow patches. They are sluggish creatures, clustered together on the under surface

of the leaves.

Pupa: Deep yellow, convex, sub-elliptical with notches at either end, abdomen with a pair of deep yellow patches.

Adult: Small in size, measures 1.3 - 1.7 mm in length, males smaller in size than females. Body whitish to yellowish, dusted with a white waxy powder (= white waxy bloom). Two pairs of pure white wings, hind wings prominently long. Vasiform orifice elliptical, operculum sub-triangular, ligula exposed and reaches anterior end of claspers. Third antennal joint considerably larger than other segments of antennae.

LIFE HISTORY

The pest is active throughout the year and all stages of its development are found on different host plants. In the cold season the adults are prominent. From January to April the attack is severe on crucifer and cucurbit vegetables, and from April to August on cotton. Again in September-October attack decreases on cotton and increases on cruciferous vegetables. The adult spreads wings immediately after emergence, soon afterwards, the adult males and females start to powder themselves with white wax secretion by the ventral wax glands on first and second abdominal segments of the male and on the third and fourth abdominal segments of the female. Twelve hours to two days after emergence the adults mate, they copulate several times during their life. One female may lay 110-160 eggs, in its life time at the rate of 1-2 eggs per day. On starvation, females stop laying eggs. Eggs are laid only on living plants in clusters usually on the under side of the leaves. Young leaves are preferred over older leaves for oviposition thus the attack is severe on tender growing shoots. The position of the female while laying is very characteristic. She stations herself with stylets inserted into the plant tissue. The abdomen is moved slightly up and down and finally the sharp tip of the ovipositor pierces the epidermis. The egg is guided gently, with its stalk coming out first, into the very fine slit made by female on the leaf surface. The ovipositor is raised leaving the egg standing perpendicular to the leaf surface. From same position, several eggs are laid by the female in an arc, if she is not disturbed. The extent of the arc is determined by the nature of leaf surface i.e. whether smooth or hairy. The eggs hatch in 3-5 days in summer and 6-33 days in winter. The development of the egg stops if temperature falls below 16°C.

Shortly after hatching, the nymph (free juvenile stage) crawls about on the leaf surface for some time before settling and fixes permanently itself on

the lower surface by inserting its stylets for sucking food. It starts sucking and excretes tiny wax filaments from the edges of its body. Nymphal period is 8-14 days in summer and 17-74 days in winter. Pupal stage is 2-8 days. The longevity of the adults varies widely and depends on environmental and other factors. The males are always short lived. They live for an average of 9-18 days and females for 37-75 days. There are 12 generations in a year depending upon the location. The duration of life stages in different months is as under:

Egg stage:	April - September	=	3-5 days
	October-November	=	5-17 days
	December-January	=	33 days
Nymphal stage:	April-September	=	9-14 days
	October-March	=	17-81 days
Pupal stage:		=	2-8 days

ECOLOGY

Attempts have been made to correlate whitefly infestation with weather conditions. There is sharp increase in the whitefly population when relative humidity varies from 80-90% and the temperature from 36-38°C among the plants in the field. These conditions favour the development of nymphal stages by shortening each stage. Low temperature and low humidity in winter causes decrease in the population. A relative humidity less than 10-16% and temperature of below 9°C deceases population sharply and is lethal for free juvenile stages.

HOST PLANTS

The host plant range of this insect is very large. It attacks a number of plants belonging to different families. Important host plants, which are severely damaged are cotton, lady's finger, tomato, chillies, peas, beans, gram, tobacco, groundnut, lucerne, potato, cucurbit vegetables, and many other plant species.

DISTRIBUTION

It is widely distributed in India and Pakistan. It has also been recorded from north and south Africa, i.e. Sudan, Somalia, Egypt, Libya, Morocco, southern Italy, U.S.A. central America, Israel, Malaysia, Japan, Taiwan and a number of other countries.

NATURE OF DAMAGE

Owing to the multifold damage caused by the pest, different symptoms of attack appear. The nymphs and adults remove plant nutrients through sucking cell sap and result in loss in vitality of plant. Numerous chlorotic spots appear on an infested leaf, later on these spots enlarge and cause irregular yellowing of the leaf which extends from the veins to the outer edges of the leaf. The attacked leaf becomes dry and eventually shed. All free juvenile stages excrete honey-dew, on which sooty mould grows and interferes in photosynthesis of the plant. From a distance, an infested plant surface gives sickly black appearance. This insect is also an important vector of viruses including leaf curl diseases of tobacco, vein clearing disease of lady's finger and the leaf curl of sesame.

CONTROL METHODS

Cultural: The weeds should be removed.

Biological: Few Hymenopterous parasites of the family Aphelinidae e.g. *Encarsia lutea* and *Eretmocerus mundus* attack whiteflies in various parts of the world. Similarly, phytosiid mites, *Amblyseius aleyrodis* and *Typhlodromus sudanicus* also prey on eggs and young larvae of the whiteflies. Also, entomopathogenic fungi, *Aschersonia aleyrodis* and *Verticillium lecanii* are known to infect the larvae of this pest.

Chemical: Many insecticides have been tested against this insect in different countries. Effective chemicals are e.g. Basudin 0.1-0.5%, Sevin 0.45-0.90 kg a.i./acre, Dimecron 100, @ 30 cc/100 litre water.

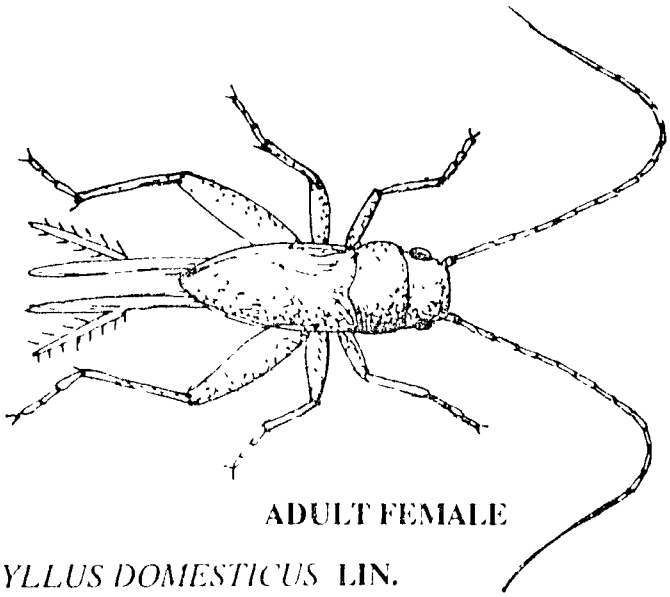
The Punjab government has recommended the same insecticides for this pest as for jassid during its activity period (April to October).

Amrasca devastans Distant (Cicadellidae: Hemiptera) (Jassid)

DIAGNOSTICS

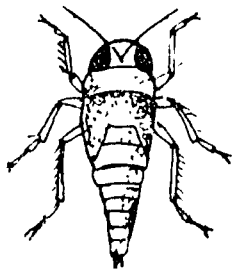
Egg: Elongate yellowish-white when freshly laid, become greyish-yellow before hatching. The eggs are embedded/deposited in the veins on the underside of the leaves.

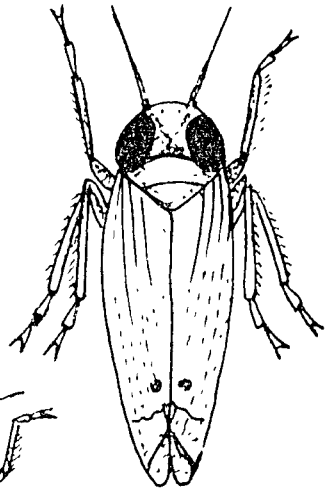
Nymph: The nymphs are wedge-shaped, are active, resemble adults, but have no wings. They pass through six nymphal stages.

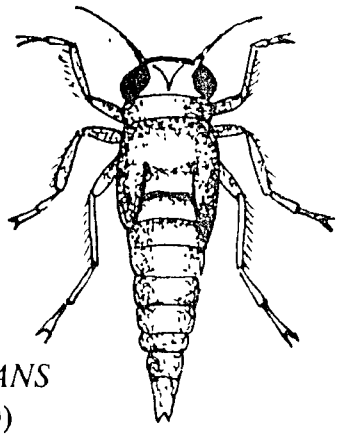


ADULT FEMALE

GRYLLUS DOMESTICUS LIN.







AMRASCA DEVASTANS
(COTTON JASSID)

Adult: The adults are greenish yellow during summer, acquiring a reddish tinge in the winter. The winged adults jump or fly away at the slightest disturbance. They are also attracted to light at night. They measure about 3mm in length.

HOST PLANTS

Cotton, okra, lady's finger, potato, brinjal and some wild plants, like hollyhock, kangi buti (*Abutilon indicum*), etc.

LIFE HISTORY

The pest completes seven generations in a year. Breeding takes place throughout the year but during the winter months, only adults are found on plants such as potato, brinjal, and tomato, etc. In spring, they migrate to lady's finger and start breeding. The female inserts about 15 eggs in the veins of the leaves. They hatch in 4-11 days. The nymphal stage lasts for 7-21 days. The winged adults live for 5-7 weeks.

NATURE OF DAMAGE

Damage to the crop is caused both by the adults and nymphs. They suck the sap from the underside of leaves and inject toxins. The edges of the leaves in lady's finger turn upward, while in cotton the edges of leaves turn downward. The attacked leaves first turn pale, ultimately become rust red and droop off the plants. The reduced vitality of the cotton plant also leads to fall of cotton bolls.

Earias insulana (Boisd) and *Earias vitella* (Fb.)

(Noctuidae: Lepidoptera)

(Spotted boll-worms)

DIAGNOSTICS

Egg: The eggs are spherical and bluish green. They are laid singly on flower-buds, brackets and tender leaves of lady's finger or cotton plants. Hairy parts of the plants are preferred for oviposition.

Larva: White, with a black head when newly hatched. Th full-grown larvae are dull green and have tiny, stout and a series of longitudinal black spots on the body.

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Pupa: Enclosed in a tough yellowish, silken cocoon. The pupation takes place either on the plants or on the ground among fallen leaves.

Adult: There are two species of this insect.

1. *Earias insulana*
   The head and thorax of moths are grass green, fore wings green, yellow brown or greyish brown, hind wings semi-transparent.
2. *Earias vittella*
   The moths are of the same size as of *E. insulana* and have a narrow light longitudinal green band in the middle of fore wing.

HOST PLANTS

American cotton, lady's finger, sonchal, gulkhaira and some other malvaceous plants.

LIFE HISTORY

Several overlapping generations are completed in a year. The roots of cotton plants sprouting in early spring and the fruits of lady's finger left neglected in the field are the two important sources of an early infestation and multiplication of this pest. The insect breeds practically throughout the year, but during the winter only the pupae are found hiding in plant debris. The moths appear in April, live for 8-22 days. A female is capable of laying 200-400 eggs at night It takes 17-29 days to complete a life cycle during summer. The duration of life stages is as under:

Egg stage	=	3-4 days (one week during winter)
Larval stage	=	10-16 days
Pupal stage	=	4-9 days (6-12 weeks during winter)

NATURE OF DAMAGE

Only the larvae (caterpillars) cause damage. They bore into the growing shoots, the flower-buds, flowers and fruits of cotton and lady's finger, either killing plants or causing heavy shedding of the fruiting bodies. In the attacked bolls, lint is spoiled by larval feeding. The fruits of lady's finger become distorted and are rendered unfit for human consumption.

Urentius sentis Dist. (Tingidae: Hemiptera)
(Brinjal lace-wing bug)

DIAGNOSTICS

Egg: Egg shining, white and nipple-shaped, laid singly in the plant tissue on the underside of the leaves.

Nymph: Nymph oval shaped, greenish yellow (=straw coloured), stoutly built, measures 2 mm x 1.35 mm in size. Body covered with long branching prominent spines or tubercles.

Adult: Adults small about 3 mm long, dorsally straw and ventrally black or dark brown in colour. Pronotum and wings with a network of markings and veins. (reticulated lace-like). The name "lace-wing" indicates this feature. Head partially covered with pronotum. Body fringed with small spines.

LIFE HISTORY

During winter (November-March) the pest is found as adult, hiding in cracks and crevices of the soil near the brinjal plants or other protected places in the field. The overwintered adults resume activity in spring. After mating (which takes place generally in the morning hours) the bugs insert their whitish eggs singly in the plant tissue on the underside of the leaves. One female lays 3-4 eggs daily and may lay up to 35-44 eggs during its life. The incubation period varies from 4 to 12 days depending upon the climatic conditions of the area during April to November. Upon emergence, the young nymphs start sucking the cell sap gregariously and prefer to stay on the underside of the same leaves, where their hatching took place. Older nymphs and adults, however, become scattered and are found moving and feeding individually on both sides of the leaves. The nymphal period lasts for 10-12 days and a nymph moults 4-5 times. The adults live for 30-40 days during which they oviposit and the new generation starts. In this way upto eight generations are completed in a year depending upon the locality. The pest is active from April to October, but it is most abundant in August-September.

ECOLOGY

Low temperatures during the winter months kill the overwintering adults to a large extent. The pest is serious in those summers before which mild winter and warm spring have lapsed. Such favourable conditions lead to epidemic and in such years damage is greatest specially when population builds up in August-September.

HOST PLANTS

This is a monophagous insect which feeds only on brinjal.

DISTRIBUTION

This insect is widely distributed in Pakistan and India. It is a common pest of brinjal specially in the plains.

NATURE OF DAMAGE

Both the adults and nymphs suck the cell sap from the leaves as a result of which yellowish spots appear. These yellowish feeding spots together with scale like excereta deposited by the insect, gives a characteristic mottled appearance to the infested leaves. Heavily infested leaves become pale-yellowish, shrivel, dry up and fall down. In this way severely attacked plants of brinjal may be completely defoliated and the plants ultimately die.

CONTROL METHODS

Cultural: Uproot and burn the withered plants.

Chemical: The pest can be brought under control by spraying the crop with Diazinon 0.02%, or Dimethoate 0.05%. The Punjab government has recommended the use of any of the following insecticides, during the activity period of the pest (April-October).

Insecticide	Formulation	Dose/acre
Sevin	85% SP	0.90 kilogram
Thiodan	35 EC	0.45 litre
Methyl parathion	50 EC	0.45 litre
Dimecron	100 EC	0.22 litre

Henosepilachna vigintioctopunctata Fabricius (Coccinellidae: Coleoptera), *Epilachna dodecastigma* Wied (Coccinellidae: Coleoptera) and *Epilachna demurili* (Hadda beetles)

DIAGNOSTICS

Egg: Cigar shaped, shining yellowish, laid in clusters or batches of 4-50 each

on all exposed parts of the plant particularly on the underside of the leaves. The female while laying, glues one end of each cigar shaped egg on the substratum. Eggs in a cluster appear like small pillars standing side by side.

Larva/Grub: Sluggish, slow moving, yellowish and oval. Bears long, branching, yellowish black-tipped spines of varying sizes in 6 rows on the body; length 6 mm.

Pupa: Pale or yellow in colour. Pupation takes place often in groups usually on underside of the leaves on the host plants. Before pupation the larva cements its anal end to the substratum and then pushes back its skin to the tip of its abdomen. Thus the anal end remains covered with this spiny wrinkled skin and the rest of the pupa remains bare. When disturbed the pupa swings its head with an articulating movement. After the emergence of the adult, the pupal cast remains attached to the plant.

Adult: Adults of all the species resemble each other in general appearance and colour, and apparently resemble commoner predatory lady bird beetles. They measure 8-9 mm in length and 5-6 mm in width. Elytra red brown to rust red, with copper sheen. Each elytron bears a number of black rounded small spots. Number of spots, however, varies with species. Out of the three species *E. vigintioctopunctata* is more abundant and also more important economically. The life-cycle being almost similar in all the three species. The differential diagnostics of all the three species are given below.

Epilachna dodecastigma: Beetles are deep copper-coloured and have six black spots on each elytron whose tip is more rounded, than in *E. vigintioctopunctata.*

Epilachna vigintioctopunctata: Beetles are deep red and usually have -14 black spots on each elytron whose tip is somewhat pointed (some say rounded)

Epilachna domurili: Beetles have a dull appearance and are light copper-coloured. Each of their elytron bears six black spots which are surrounded by yellowish rings.

Epilachna dodecastigma (Wied) and *Epilachna vigintioctopunctata* (Fabricius) attack Solanaceous vegetables like brinjal, tomato and potato while *Epilachna demurili* attacks cucurbitaceous vegetables, exclusively.

LIFE HISTORY

The life cycles of both the species are more or less similar. They hibernate in adult stage during winter months in the heaps of plant debris, in

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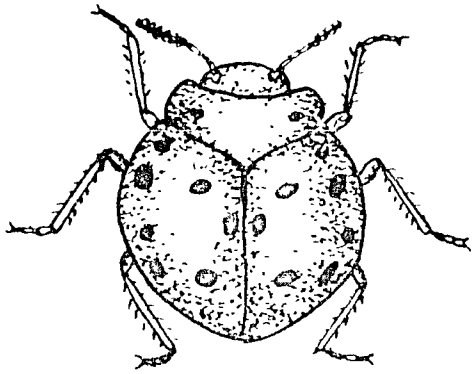
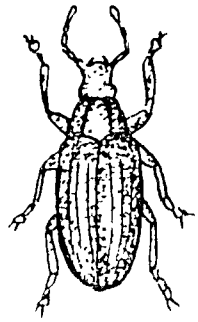
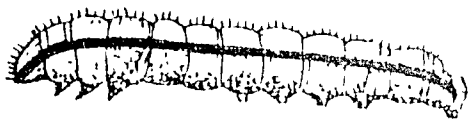


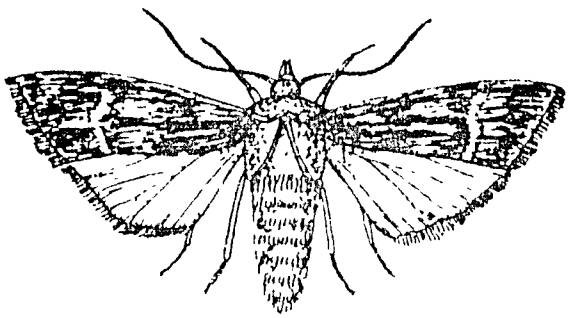
HUDDA BEETLE
EPILACHNA VIGINTIOCTOPUNCTATA



MYLOCERUS SUPERFASCIATUS



LARVA



AGROTIS IPSILON **(ROLT.)**

the field in soil, under stones or similar protected places. The hibernated adults start activities in the spring and remain active throughout summer but they cause greatest damage during May-June. After mating, the female lays eggs on the under side of the leaves of its host plant. Eggs are laid in clusters of 15-65 eggs each One female may lay up to 450 eggs in its life time. The egg hatches in 3-5 days depending upon the temperature. Upon hatching, the young larvae initially feed aggregated on lower side of tender leaves leaving the upper surface more or less intact. Older larvae, however, make feeding holes in the leaves Larval instars are completed in 10-25 days according to the weather of the area Pupation takes place on the plants The anal end of the pupa is fixed to the substratum Pupal period is 4-15 days Adults upon emergence also feed on leaves making holes After mating the adults lay eggs and the next generation starts There are several generations in a year depending upon the latitude and prevailing climatic condition of the area. During the active season the pest attacks different types of cucurbits grown in the area. The adults of the last generation do not lay eggs rather go into hibernation at the start of winter.

NATURE OF DAMAGE

Young larvae feed on the underside of the leaves leaving the upper surface intact and an attacked leaf present lace like and ragged in appearance Older larvae and adults feed irregular holes in the leaves. Both adult and larval feeding appreciably reduce the leaf area thus demolishing the photosynthesis.

HOST PLANTS

H. vigintioctopunctata and *E. dodecastigma* are oligophagous in their feeding habit. They feed on all plants of the family Solanaceae (tomato, potato, tobacco). Brinjal is specially a preferred host plant on which they are very serious pests.

DISTRIBUTION

All three species are widely distributed in India and Pakistan. The populations of these species are usually found mixed with each other. In Pakistan, these pests are present with varying degree of population densities in all the areas where the host plants are grown.

CONTROL METHODS

Sanitary: Clean cultivation, regular hoeing and proper disposal of the plant debris after the harvest of crops are recommended for the control of hibernating adults.

Mechanical: In small plots hand picking of adults, egg clusters, larvae and pupae is an effective method of control.

Chemical: Spray of 0.10 lb a.i. of Carbaryl/acre, or Methyl-parathion 0.20-0.25 lb a.i./acre or a mixture of Toxaphene and Methyl-parathion 0.4-0.20 and 0.50-0.25 lbs a.i. respectively/acre gave 80% mortality of the adults and grubs within 48 hours after the treatments. No spraying schedules are generally recommended, rather the crops should be preferably surveyed periodically and the treatments shall be made only when the damage reaches economic injury level.

The Punjab government has recommended use of any one of the following insecticides during the activity period (April to October) of the pest.

Insecticides	Formulation	Dose/acre
Malathion	57 EC	0.45 litre
Methyl-parathion	50 EC	0.45 litre
Thiodan	35 EC	0.45 litre

Biological: Laboratory tests on the pathogenecity of the entomopathogenic fungus *Verticillium lecanii* have shown that larva, particularly third instar larvae, and pupae are attacked by the fungus.

Leucinodes orbonalis Guenee (Pyralidae: Lepidoptera)
(Brinjal fruit borer)

DIAGNOSTICS

Egg: Elongate, freshly laid egg creamy white, yet before hatching the colour changes to reddish brown or dark. Eggs are laid singly or in clusters, on the underside of leaves, green stems, flower buds or calyxes of fruits.

Larva: Newly hatched larva creamy white but later on its dorsal side turns pinkish. Full-fed larvae measure 18-23 mm in length with brown head, and body sparingly covered with minute hairs.

Pupa: Pupa reddish brown, enclosed in dirty brown, tough, boat shaped silken cocoon, bearing four black coloured spines at the tip of the abdomen. Pupae are found attached to the fallen leaves from the plants or in cracks in the soil.

Adult: Adult medium sized, measuring 20-22 mm in wingspan. Body white with pale brown or black spots on the dorsal side of thorax and abdomen. Wings white with apical and anal margins fringed with small hairs. Fore wings bear a number of black, pale and light brownish markings/spots. Hind wings opalescent with black dots.

LIFE HISTORY

The pest is active during the spring and summer months. During the winter months it is found as full-grown larva hibernating in silken cocoons among the plant debris or soil cracks. In the early spring with rise in temperature the hibernating larvae turn into pupae and after a fortnight the moths appear in March-April depending upon the climate of the area. The adults are short lived, they live only for 2-5 days during which the females, after mating lay 80-120 eggs either singly or in clusters of 2-4 eggs on the underside of the leaves, stems, flower buds or calyxes of the fruits. Incubation period is 3-6 days and may be prolonged into 9 days depending upon the temperature. Upon hatching, the early generation larvae bore into the tender growing shoots or the flower buds. The later generation larvae, however, preferably bore into the fruits. A larva after boring and feeding upon one fruit may come out and attack another one. In this way 4-6 fruits may be destroyed by one larva. The larval period is 9-28 days during which it passes through 5 larval instars. After the larvae are full-fed they come out from the feeding tunnels and pupate in a silken cocoon either among the plant debris or on the plant or even in the cracks of the soil. The pupal period lasts for 6-17 days. The moths upon emergence mate and oviposit to start the next generation. One generation is completed in 20-43 days. There may be 4-5 overlapping generations from March-April till October November. But the severe damage has been observed from August to October.

HOST PLANTS

This insect feeds mainly on brinjal, but it has been found attacking a number of other plants of the family Solanaceae.

DISTRIBUTION

The pest is widely distributed and has been reported from a number of countries in Asia and Africa. In Pakistan, it causes serious damage to brinjal in all areas where this vegetable is intensively cultivated.

NATURE OF DAMAGE

The damage is done only by the larvae. Early generation larvae bore into the growing shoots but as the flowering and setting of the fruits start, the later generation larvae preferably bore into the flower buds and fruits. When the terminal shoots are attacked, the growing points are killed. Attacked shoots die off and hang down. Drying of leaves due to boring of petioles by larvae also occurs. Attack on flower buds hinders fruit setting by shedding of flower buds and hence reduction in the yield. The bored fruits show conspicuous holes on their surface plugged with excreta. Such fruits although do not cause significant reduction in the yield yet bring very little price in the market

CONTROL METHODS

Mechanical: In small plots the infested fruits both fallen and hanging on the plants along with dead shoots should be cut, collected and properly disposed off to destroy the larvae contained in them.

Sanitary: Clean cultivation and regular removal of the plant debris from the fields are recommended to destroy pupae in such debris.

Cultural: After the harvest of the crop the plants should be pulled out and properly destroyed. A deep ploughing would destroy the pest in various developmental stages, if any, present in the soil.

Chemical: A large number of insecticides are recommended against this pest, some of these are listed in tabulated form below: Anyone of these can be used depending upon its availability during April to October.

Insecticide	Formulation	Dose/acre (gm/ml)
Sevin	85% SP	1000-1200
Malathion	57 EC	800-1000
Nogos/Vapona	100 EC	200-300

(Cont'd)

(Cont'd)

Insecticide	Formulation	Dose/acre (gm/ml)
DDVP or Dipterex	80% powder	800-1000
Decis/Cymbush/ Sumicidin/Ripcord/ Arrivo	25 EC	200-250

Euzophera perticella Rag. **(Pyralidae: Lepidoptera)**
(Brinjal shoot borer)

DIAGNOSTICS

Egg: Eggs creamy white, scale like and oval or rounded in shape. Eggs may be laid singly or in clusters, on the underside of the young leaves or in axils of young branches.

Larva: Larva yellowish, pale-whitish or light brown with an orange brown or red head; few bristle like hairs on the body. Full-grown larvae measure 20-22 mm in length with body tapering posteriorly.

Pupa: Pupa light brown enclosed in a silken cocoon. Pupation takes place within the feeding tunnels or in cracks and crevices of the soil.

Adult: Moth pale yellow to grey brown, head and thorax greyish, abdomen pale yellow, fore wings scaly and straw coloured (some say greyish brown) hind wings membranous and whitish. There is a W-shaped mark about the basal half of the fore wing and a dentate line near the apical half (some say fore wings have transverse lines). Wing span 32 mm.

LIFE HISTORY

In winter the activities of the pest are ceased and it is found only as full-grown hibernating larvae in the feeding tunnels in the stems of plants standing in the field after the harvest of the fruits. With rise in temperature the overwintered larvae pupate in the beginning of March and the moths emerge on wings in the second half of month. The moths are nocturnal in habit, they are active at night: feeding, mating and ovipositing. The eggs are laid in clusters or singly on the underside of the young leaves or in the axil of the branches. A female during its week long life may lay up to 104-363 eggs.

Incubation period of the egg is 3-10 days depending on the temperature. Upon hatching the young larvae first feed on tender leaves and in the later instars they bore into the stem making longitudinal tunnels. The larval instars last, for 26-58 days depending upon environmental conditions. The full grown larva, before pupation, spins a silken cocoon in which it pupates. Pupation takes place either inside the feeding tunnels, exposed on the plant or in the cracks and crevices of the soil. Pupal period lasts for 6-8 days. Upon emergence they mate and oviposite with which new generation starts. One generation is completed in 35-76 days and there may be 5-6 overlapping generations per year

HOST PLANTS

The insect feeds primarily on brinjal, especially during seedling stage in the nursery and on young plants in the field. It also attacks chillies, potato, tomato, etc.

DISTRIBUTION

This insect is widely distributed in Pakistan and India.

NATURE OF DAMAGE

The damage is caused by the larvae which feed for a few minutes on exposed parts of the plants before they bore (their early developmental stages) into the tender stems. They feed on the pitch of stem by making longitudinal tunnels. As a result, apical shoots die out and hang down giving a characteristic symptoms of attack. During the advanced stage of their development larvae bore into the main stem near the ground level resulting in death of the whole plant. All the host plants including tomato, potato, chillies, etc., show similar symptoms of attack. The caterpillars feed exclusively in the main stem and have never been observed boring into the fruits. As a result of their attack in the field, stray plants are seen withering and drying up. Stunted growth, withering and wilting of plants; stem and leaf axils covered with excreta indicating the bore holes are the field identification symptoms.

CONTROL METHODS

Cultural: Ratooning of the crop is not recommended since previous year's plants serve as a main source of infestation in which larvae seek protection for overwintering. All attacked plants from the nursery and the field should

be removed and properly disposed. After the harvest of the fruits all the plants should be uprooted, collected and properly disposed. These plants may harbour pest and serve as source of infestation for the next year.

Chemical: Spray Carbaryl 1.15% or Malathion 0.1% or Endrin 0.02% after every two weeks upon appearance of the pest. Following insecticides are also recommended by the Punjab government during March to October.

Insecticide	Formulation	Dose/acre (gm/ml)
Sevin	85% SP	1000-1200
Malathion	57 EC	800-1000
Elsan	50 EC	200-250
Dimecron	100 EC	200-250
Decis/Cymbush/Arrivo	2.5 EC	200-250

Thrips tabaci Lind. (Thripidae: Thysanoptera)

(Onion thrips)

DIAGNOSTICS

Egg: Egg minute, kidney shaped (reniform). Eggs laid singly inside the plant tissue. Female cuts a slit in the plant tissue with the help of its saw like ovipositor and deposites one egg in each slit.

Larva (Nymph): Larva is yellowish and resembles adult in general features and feeding habits, yet without wing pads and with fewer antennal segments. There are 2 larval instars, second larval instar without spiracles on the second abdominal segment.

Prepupa and Pupa: Before actual pupal stage there is a more or less similar stage called as prepupal stage. In both, the prepupal and the pupal stages the insect has conspicuous wing pads but do not feed. These stages can be, however, differentiated from the larval and adult stages by absence of the characteristic protrusible vesicles, on their pre-tarsi. Moreover the antennae in pupal stage are bent over the head whereas in the larval stages they are directed forward. The prepupal and pupal stages although inactive yet are capable of slow movement when stimulated. Pupation takes place in the soil and apparently no pupal cell is formed in the soil.

Adult: Adult minute, slender bodied, measures 1.0 mm in length. Colour variable from pale yellow to brown. Sometimes they also appear as dark coloured. At lower temperatures the colour turns darker but never blackish brown or with striped wings. Head bears compound eyes and three ocelli but ocular pigments never bright red. Antennae seven segmented with a forked sense cone on 3rd and 4th segments. Pronotum bears 2 pairs of long posteroangular setae but without long setae on the anterior margin. Wings two pairs, long and narrow. Each wing with 2 longitudinal veins fringed with a row of long setae and the anterior vein with 4 setae in the distal half. The wings are used for flight, yet the adults cannot fly readily. They exhibit the habit of curving to flight. Eight abdominal tergite with a complete comb of microtrachia along the posterior border. Ninth abdominal tergite with only one (and not two) pairs of dorsal pores. Pleurotergites with several transverse rows of fine pointed microtrachia.

LIFE HISTORY

In temperate climates the pest overwinters as adult during the winter months. The overwintering adults resume activity in spring whereas in tropical and subtropical climates the insect continuously breeds throughout the year. From November to May it breeds on onion and garlic. In summer up to September it breeds on cotton. In late summer it is found on cabbage and cauliflower. Since the males of this insect are extremely rare thus it seems that the females reproduce parthenogenetically. The females lay egg singly on the underside of the leaves in the plant tissue. For this purpose the female makes a slit in the plant tissue with the help of its saw like ovipositor. In each slit one egg is laid, one female may lay up to 50-60 eggs in its life time. If an infested leaf is dehydrated and cleared in clove oil, the eggs would appear as transluscent spots in the plant tissue. The eggs hatch in 3-9 days depending upon the prevailing temperature. Upon hatching, the larvae start actively sucking the plant sap from the leaves. There are two larval stages which take 4-6 days to complete. The full-fed larvae descent to the ground for pupation. Before the true pupal stage there is a prepupal stage. The prepupal stage lasts for 1-2 years and the pupal stage for 2-4 additional days. The adults live from 3 weeks to 4 months or more, depending upon weather, during which eggs are laid and new generation starts. There may be several generations in a year depending upon climatic zones.

ECOLOGY

The prevailing weather conditions and nutritional status of the host

plant are important factors which decide the population density of the insect. The population build up is maximum in hot and dry weather. Heavy rain affects the population negatively by washing it out.

NATURE OF DAMAGE

Since this is a small insect it usually escapes the notice of the farmer. On onion and garlic they are congregated usually at the leaf base or in the flowers. On cabbage, cauliflower and cotton they are found feeding on lower side of the leaves. Its presence is, however, at once recognized by the characteristic symptoms of attack. The adults and the larvae feed usually on the leaves penetrating the plant tissue with their piercing mouthparts and imbibing the sap. The contents of the lower mesophyll are removed and as a result air space develops; hence the characteristic symptoms appear namely "white blast", "white blight" or "silvery top." The leaves may bear small spots of faecal matter. These symptoms of attack usually appear on onion and garlic. On cabbage, however, feeding damage may lead to resetting or bronzing of leaves. In addition to the feeding damage the insect damages the plant tissue by injuring it for oviposition purpose. In tomato, laceration of tissues and sucking of sap takes place. Tender foliage becomes spotted and pale, and silvery sheen appears on affected leaves. Feeding on flowers results in premature drop of flowers. Thrips are also known vectors of tomato spotted wilt virus which they transmit to various other crops. Virus infected onion leaves are first curled, wrinkled and even twisted and ultimately die off.

HOST PLANTS

This insect feeds on a large number of host plants but the most preferred are onion and garlic. It has also been reported attacking various plants of the family Compositae, and Cruciferae in the temperate regions whereas in tropical and subtropical climates it usually feeds on cotton, tomato, tobacco, cucurbits and some weeds of the family Compositae.

DISTRIBUTION

The pest is consmopolitan in distribution. In Pakistan, the pest is found in all the four provinces. It is particularly serious and abundant in hot dry climates.

CONTROL METHODS

Biological: Five hymenopterous parasitoids of the family Eulophidae are

reported on *T.tabaci* in various parts of the world but no definite work on them has been done in Pakistan so far. Few Anthocorids, Coccinellids and Arachnids as predator on *T. tabaci* are of significance.

Cultural: Ploughing and harrowing of the field after the harvest of the crop is recommended to expose the pupae which would be killed by extreme weather conditions.

Flood irrigation in the standing crop helps to keep the pest under control, by killing the pupa in the soil.

Early growing and rapid maturing varieties are suggested because the most susceptible "seedling stage" would either escape the attack before the insect becomes active or the period during which a variety is most susceptible is reduced due to the rapid growth. By altering the plant to plant distance the thrips population can be reduced. Optimum plant distance varies from crop to crop.

Sanitary: Removal and proper disposal of plant debris after the harvest of the crop is important to destroy the adults sheltering in them, which serve as potential source of infestation for the next crop. Weed eradication is of great significance especially those weeds which serve as food for the pest and are known to harbour viruses causing tomato spotted wilt.

Chemical: In the early stages of the plant development the pest can be effectively controlled by spraying 0.1% BHC. When bulb formation starts the insecticidal spray recommended are Lindane 0.1% or Malathion 0.05%.

The Punjab government has recommended the use of any one of the following insecticides during the activity period (throughout the year) of the pest:

Insecticide	Formulation	Dose/acre
Malathion	57 EC	800-1000 ml
Nogos/Vapona/DDVP	100 EC	200-300 ml

Spodoptera litura (F.) **(Noctuidae: Lepidoptera)**
(Tobacco caterpillar)

Synonym: *Prodenia litura*

DIAGNOSTICS

Egg: Eggs are laid in buff coloured clusters, usually on the lower side of the

leaves of the host plants. Egg clusters are covered with brown hairs. Upon removal of these hairs, the eggs in a cluster are found to be beautifully arranged; individual egg is round, pearly white when freshly laid, may change from creamy-yellow to greenish, 0.5 mm in diameter. Egg shell sculptured with ridges converging towards the apex.

Larva: Young larvae are greenish with black lunate patches above the lateral yellow line on each segment of the abdomen. Grown up larva dirty brown dorsally and dull grey-green ventrally, plump, heavy bodied, measuring 30-40 mm in length and 5-7 mm in diameter. Dorsally with five longitudinal thin orange lines, one in mid dorsal position and two on each side. The most important diagnostic character of the larva is one black rounded small spot laterally and a triangular or "D" shaped small patch dorsolaterally on each body segment. Some authors have given the diagnostic as "pale greenish brown with dark markings: yellow and purplish spots in the submarginal areas."

Pupa: Pupa light brown at first, but later on it changes to dark brown. Length of male pupa is 16.0 mm and that of female 10.5 mm. The larvae pupate in the soil.

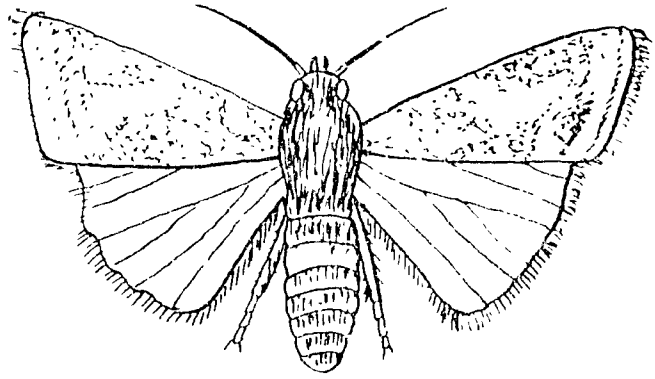
Adult: Medium sized stout moth, 22 mm long with 32-38 mm wingspan. Fore wings have beautiful golden and grey brown patterns. Males differ from females in appearance. In males, fore wings and thorax brownish having 5 light brown strips. In female, however, fore wings and thorax bears streaks of light brown scales. Patches of light brown scales in males are comparatively brighter than in females. Hind wings in both the sexes membranous white with brown margins.

LIFE HISTORY

In plains, the pest remains active throughout the year except that its development is considerably retarded during the winter due to mild temperature and the availability of one or the other host plant. In mountainous areas, however, the pest hibernates, as pupae in the soil up to 2"-4" deep during the winter months. With rise in temperature, the moths emerge from the hibernated pupae in the spring. They mate and the females lay eggs in clusters of 50-300 usually on the underside of the leaves of the host plants. The adult is usually active at night and one female may lay from 15-2500 eggs in its life time. Incubation period is 3-5 days. Upon hatching, the young larvae remain aggregated and feed on the leaves, devouring the

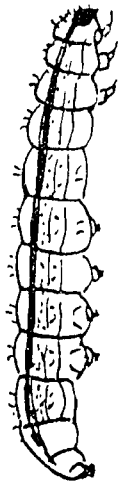
LARVA

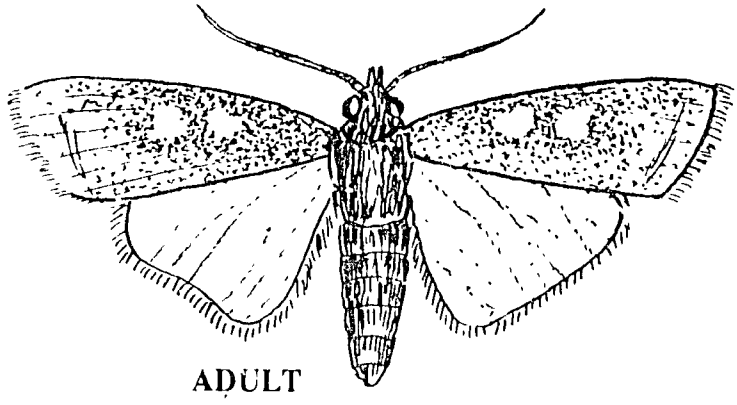
PUPA



ADULT

SPODOPTERA LITURA
(TOBACCO CATERPILLAR)





ADULT

AGROTIS FLAMMATRA
(GRAM CUTWORM)

LARVA

green matter from lower side leaving the upper side intact. In the latter instars the larvae become solitary and distributed on the other leaves and plants. Older larvae feed holes into the leaves and are usually active during night while during the day time they generally remain hidden in the plant parts. Six larval instars are completed in 15-30 days depending upon the temperature. Before pupation, the larva enters the soil and prepares an earthen cell in which it pupates. The pupal duration lasts from 7-15 days according to the climate. Adult stage lasts for 7-10 days during which it oviposits and next generation starts. One life cycle is completed in 32-60 days. There may be 3-4 generations from June to September depending upon the area.

HOST PLANTS

This is a polyphagous insect and has been reported to attack many crops. In Pakistan, important crops attacked are cauliflower, tomato, tobacco, castor, lucerne, taro. This insect, as a minor pest, has also been reported on potato, eggplant, okra, lettuce, sweet-potato, pepper, onion, watermelon, banana, beans, groundnut, turmeric, etc. It also attacks a number of weeds such as *Eclipta alba*, *Amaranthus spinosus*, *Portulaca quadrifida*, *Zinnia elegans* and *Chenopodium amaranticolor*.

DISTRIBUTION

The insect is widely distributed in almost all countries of Asia including Pakistan, India, Sri Lanka, Thailand, Burma, China, Philippines, Japan, Korea. In Pakistan the pest is found in all the climatic zones where any one of its hosts is grown.

NATURE OF DAMAGE

Symptoms of attack vary on different host plant species depending on the size and texture of the leaves. Moreover, mode of feeding by young and older larvae also differ on the same plant species. The young larvae feed aggregated usually on the lower surface of the leave blade of fleshy leaves like that of cauliflower, taro and tobacco etc., consuming the green matter from one side and leaving the other side intact. This type of feeding by a number of larvae on different spots of a leaf results in characteristic symptoms of attack giving the leaf lace like appearance. Later on, such attacked areas dry up giving the leaves a patchy appearance. The older leaves are defoliated altogether leaving only the hard and thicker midrib resulting in

the death of the plant. On plants with thinner leaves like lucerne, the early instars nibble holes in the leaves and the late instars defoliate the plant altogether. Also the older caterpillars cause damage like a cutworm, *Agrotis* sp. by cutting the tender host plants at ground level and hiding during the day in soil near the plant. This means that young larvae feed by scrapping the leaves from ventral surface, while older larvae feed voraciously at night on the foliage. Larvae can also feed on young fruits.

ECOLOGY

The pest breeds and remains active throughout the year if the host is available and winter temperatures are not very low as in the plains. After the harvest of one type of the host plant, the pest attacks the other type in the nearby field. However, in the plains, the pest is present very sporadically during the hot summer months due to high temperature and lack of host plants.

CONTROL METHODS

Mechanical: In small plots, hand collection of older larvae and collection of adults by hand nets are recommended. Infested leaves with masses of younger stage larvae should be collected and destroyed.

Cultural: Deep ploughing of the soil to expose hibernating pupae helps to keep the pest under control.

Biological: Although there is no cannibalism in this species during the early larval instars, yet, in the later instars cannibalism is common if there is shortage of food. The older larvae devour the younger ones. Various micro organisms like protozoa, viruses, fungi, and bacteria attack the larvae and kill them. Attack by these micro organisms, is specially high during wet conditions. A number of predators and ectoparasite *Telenomus remus* Nixon (Scelionidae: Hymenoptera) also attack the larvae but non of them has been used in the biological control of this pest so far.

Chemical: A number of insecticides are used effectively against this pest. However, Endosulfan 0.05%, Carbaryl 0.22%, Phosphamidon 0.03% and Parathion methyl 0.025% gave very good results.

The Punjab government has recommended the use of any one of the following insecticides during the activity period of the pest (throughout the year).

Insecticide	Formulation	Dose/acre
Malathion	57 EC	800-1000 ml
Sevin	85 SP	1000-1200 ml
Nogos/Vapona/DDVP	100 EC	200-300 ml
Decis/Cymbush	2.5 EC	200-250 ml
Dimecron	100 EC	200-250 ml

Phthorimaea operculella (Zell.) (Gelechiidae: Lepidoptera)
(Potato tuber moth)

Synonym: *Gnorimoschema operculella*

DIAGNOSTICS

Egg: Egg oval, 0.5 x 0.4 mm in size. Freshly laid eggs pearly white; before hatching turn reddish brown to dark.

Larva: Newly hatched larva nearly 1 mm long; larva moults four times; when fully-grown measures about 11 x 1.5 mm. Body colour yellowish, pale green, with pink markings. Head is brown and on its each side there are six stemmata, mouthparts with spinneret. A cervical and an anal plate present. Body bears 9 pairs of spiracles. Abdomen bears 5 pairs of prolegs one pair each on 3, 4, 5, 6 and 10th segment. Before pupation larva spinns a white cocoon.

Pupa: Pupa 6 mm long, dark brown. Male and female pupae can be distinguished from each other by the presence of genital aperture on 9th abdominal segment in male and on 8th in female. Pupa enclosed in a white or greyish silken dirt-coloured cocoon which is about 13 mm in length. Pupation takes place in the infested tubers in the stores and in the field it takes place on the leaves, stems or even on the ground.

Adult: Adult is greyish, brown to dark brown. Body size, very small, 6-10 mm in length and 13-17 mm in wingspan. Wings narrow, mottled and fringed with hairs. Abdominal end cone shaped in females and bears 2 apical claspers in males. Moths are nocturnal in habit.

Similarities to other pests: The larva of potato tuber moth resembles, to a great extent, the larva of pink bollworm of cotton *(Pectinophora gossypiella).*

LIFE HISTORY

If food is available and the climatic conditions are favourable, the insect may breed throughout the year. In the cold weather the life cycle is much prolonged. Wherever insect passes winter in stored tubers, the infested stores serve as a source of infestation for the next year. In the early spring the moths from the storehouses escape and lay eggs chiefly on the underside of the potato leaves in the field or on exposed tubers if available. The eggs are laid singly and one female may lay up to 150-200 eggs. Incubation period is 3-4 days at 26.5°C. Early instar larvae make mines in the leaves producing blotches, but later instar larvae bore into the stems. Late in the growing season when the foliage becomes scarce, the larvae attack tubers in the soil by working their way through cracks in the soil. Swelling of the tubers causes the hard soils to crack providing access to the larvae. The larval development is completed in 67 days in winter (11°C) and 9-12 days in summer (25-32°C). Before pupation the larva spins a white silken cocoon in which it pupates. These cocoons are entangled in the dead leaves or among debris on the ground. The pupal stage lasts for 5-18 days depending upon temperature. The adults are active only at night. Adults live for 13 days at 25°C+65% R.H. One generation is completed in a month or so during summer. There may be 5-6 generations per year.

ECOLOGY

The moths are poor fliers yet they disperse in the direction of the winds with short flights at ground level. The pest is carried to the new areas usually through infested tubers used as seed. Swelling of the tubers in harder soils causes the soil to crack providing access to the larvae, thus crops in hard soils are more attacked than in light soils. Humidity does not seem to play role in the pest development.

HOST PLANTS

The pest attacks a number of cultivated and wild plants. Among the cultivated plants the most important is potato whereas tobacco, tomato and brinjal are also attacked to a varying degree. Some wild species of plants in the genera *Solanum, Datura, Nicotiana,* also serve as alternate hosts.

DISTRIBUTION

The insect is widely distributed in all continents of the world where its host plants occur. In Pakistan, it is found attacking potato and other host plants throughout the country.

NATURE OF DAMAGE

Potatoes both in the fields and storages are attacked. In the early stages of plant development, leaves and stems of potato are mined or bored by caterpillars resulting in leaf blotches and death of the shoots. The premature withering away of the leaves and the presence of excreta on the axil of leaves, as well as on tubers are signs of the presence of this insect. In the later stages of plant development, the larvae leave the foliage and come down to the soil for attacking tubers. The larvae make many burrows into the tubers and leave accumulations of excrements near the entrance holes. The burrows made by the larvae are slender, dirty looking and lined with silk. Similar symptoms of damage also appear on the tubers in the storages.

CONTROL METHODS

Sanitary: The harvested tubers should not be left overnight in the field as moths are attracted towards them for oviposition. Since such eggs would be carried along the tubers to the storages, in this way pest easily gets entry into the stores, moreover such infested stores also serve as an infestation reservoir for the next season.

Before storing the tubers, stores should be thoroughly cleaned and sprayed with 1% Malathion or 0.6% Diazinon.

Always use healthy and infestation free tubers as seed. To avoid the caterpillar migrating from wilting vines to the tubers at the time of harvest infested vines should be cut and burnt.

Cultural: Damage to the tubers can be avoided effectively by planting seed tubers deep in the soil up to a depth of 20 cm or more and covering them with about 25 cm of fine and loose soil. This would keep the larvae away from attacking tubers to a greater extent.

Biological: There are a number of non-specific parasitoids which occur abundantly in most of the areas where potatoes are grown. They do not contribute a lot to suppress the pest. A number of specific parasitoids are also very effective e.g. *Copidosoma hochleri* and *Apanteles subandinus* if established.

Mechanical: Potatoes stored in bags are less infested than those stored simply in heaps. Sacks used for storing potatoes treated with 1% DDT solution give additional protection.

Chemical: Chemicals should only be used when other methods of pest control could not suppress the pest and 10% of the plants become heavily

infested. Dust the plants with 0.5-1 lb of Thiodan or spray 0.4% of Endrin. The applications should be repeated after 10 days if necessary. Table potatoes when stored should be protected by 2.5% Diazinon or 2% Malathion dust. For seed tubers use only 5% DDT dust.

Gryllotalpa africana Pde B. **(Gryllotalpidae: Orthoptera)**
(Mole cricket)

DIAGNOSTICS

Egg: The eggs are oval, in shape and brown in colour, and measure 1.5 mm in length. They are laid 10-15 cm below the soil surface in chambers at the end of burrows. A female usually constructs three chambers and lays about 100 eggs in loose clusters of 30-50 each in them. Hatching takes 2-3 weeks. Eggs are usually laid in the rainy season.

Nymph: The first stage nymphs are fed by the mother while in the egg-chamber. Subsequent instars stay in the burrows during the day and come out at night to forge for food on the soil surface. There may be 9-11 instars and the nymphal period may extend from 4.5 to 7 months, depending upon environmental conditions.

Adult: The adults are brown, velvety in appearance due to short setae over the body. The fore legs are adapted for digging. The wings are folded and do not cover the full length of the abdomen. The adults also live in burrows or hide themselves under trash during day time and come out at night for feeding. Adults mate after about 10 days of the final nymphal moult and egg-laying begins 1-2 weeks later. The life-cycle is completed in 5.5 to 10 months, hence apparently there are two overlapping generations in a year. Adult life is 2-3 months.

NATURE OF DAMAGE

It is a sporadic pest attacking herbaceous crops at the seedling stage. In cultivated fields the insect lives in underground tunnels 2-3 feet deep. It usually eats away the buds at their point of junction with sugarcane sets and sometimes the small seedlings of other crops. When the roots are attacked, the plants wilt. Sometimes the tender base of the heart-leaf may be eaten up resulting in a dead-heart. A 10-15 per cent damage is caused to the seedlings.

Heaps of soil in the cropped field are indicators of the burrows of this insect. The entrance to the burrow is usually on the side of the heap. Primarily it is found in warm climate, at lower altitude and in moist soils.

HOST PLANTS

Many of the herbaceous crops in the seedling stage, sugarcane buds, roots of newly planted crops, fresh potato tubers, etc., are eaten up by this pest.

DISTRIBUTION

It is cosmopolitan insect, found in warm regions of Africa, Asia and Australia. It occurs at low altitudes and in moist soils.

Nezara viridula L.(**Pentatomidae: Hemiptera**)
(Green sting bug)

The type locality 'in Indiis' (Linnaeus 1758) has been commonly interpreted as being India. The distribution of the bug, will probably never be known. However, an analysis of genetic colour variants and specific parasites led to the conclusion that original home of green vegetable bug was in the Ethiopian. Africa is considered to be the centre of origin of the genus *Nezara.*

The entirely green colour form *smaragdula* of *N. viridula* is the one that occurs widely in the Pacific area. In other area of the world it is accompanied by several other colour forms (Yukawa and Kiritani, 1965). This reflects that there could be several forms of this insect in Indo-Pakistan sub-continent.

DIAGNOSTICS

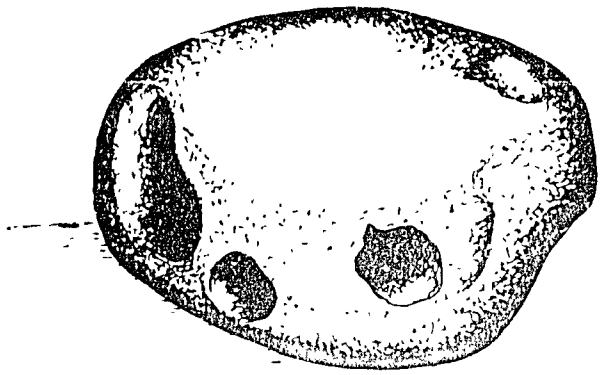
Egg: Barrel-shaped.

Nymph: Small, blackish and wingless.

Adult: Approximately 0.5 inch long and has a triangular-shaped scutellum that extends from just back of the "shoulders" narrowing posteriorly to a point. Front wings are thickened and stiff at the base, but the distal half is much thinner and membranous. These membranous areas of the wing overlap over the back when not in use. The adults are dark-green.

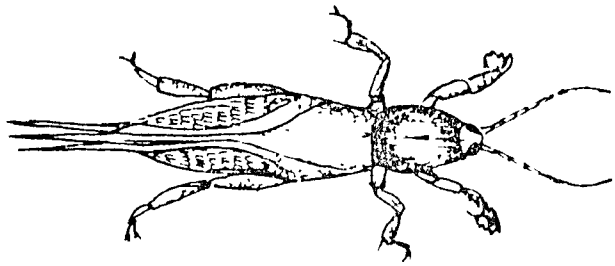
LIFE HISTORY

The barrel-shaped eggs are laid at night in neat rafts (=clustors), usually of 40 to 80 or more and they are cemented firmly to one another and

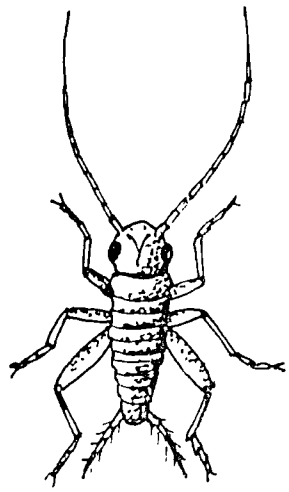


POTATO TUBER DAMAGED BY

GRYLLOTALPA AFRICANA



GRYLLOTALPA AFRICANA **PAL. BEAAV.**



FRESHLY HATCHED CRICKET

are deposited on the underside of the foliage or on to the sheltered surface of a leaf. The eggs are often beautifully coloured and ornamented. These hatch in 4 to 9 days, and the newly emerged nymphs remain together near the egg shells for a day or two, a degree of gregariousness persisting also in the next instar or two. There are five nymphal stages before the adult emerges, 24 to 60 days after hatching, depending on temperature. The nymphal stages are multicoloured, but the adults are a uniform green in the form *smaragdula*. The adults can fly strongly. There may be one to three or perhaps four generations in a year, and perhaps more in areas with no perceptible winter.

The adult bugs live up to 3 weeks in hot weather. In regions with a cold winter those of the autumn generation may live much longer, hibernating in debris, under bark, or in buildings, inactive and non-reproductive. Such overwintering or hibernating adult bugs change colour from green to brown. In areas with a less severe winter the still-green adults may remain active, although non-reproductive. Waite (1980) showed that the adults and nymphs tend to bask exposed on the surface of the plant canopy in the early day light hours behaviour that can be availed of in applying chemical control measures.

HOST PLANTS

The host plant range of *Nezara viridula* is so broad that it is impracticable to list here all associated pests, the spectrum of which varies widely from crop to crop and from place to place. However, legume seed crops are important hosts in a great many countries. In Pakistan lady's finger, potatoes, beans and tomatoes are the hosts in vegetable crops.

NATURE OF DAMAGE

Damage is caused both by nymphs and adults by sucking sap primarily from pods, buds, blossoms and seeds. Removal of liquid contents of developing seed makes them flattened and shrivelled. If the pods are attacked at an early stage of development, "catfacing" or pitted holes will occur on bean pods.

When not controlled by chemicals or natural enemies, this bug can be a serious pest of a very wide range of crops and ornamental plants. The attack of the bugs is concentrated chiefly on fruits and fruiting bodies, which, through the removal of sap and the injection of saliva, show discolouration, malformation, stunting and shrivelling. Heavily attacked tomatoes, for instance, are repulsive and inedible and even lightly attacked ones are

unmarketable. On soybean in Brazil, green vegetable bug attack affected pod development, increased pod fall, and reduced the number of seeds per pod.

The bug has been shown to carry spores of fungal diseases from plant to plant and to transmit plant pathogens during feeding.

CONTROL METHODS

Crops sanitation is advised to help control this pest. The insect can be controlled by spraying with any of a range of carbamates and organophosphorus compounds. Most of these persist on the plant for only a relatively brief period, so that crops soon become liable to reinfestation by bugs flying from other areas.

In many places, biological control by introduced parasites is so effective that chemical control is seldom necessary. Some cultivars are less damaged by *Nezara* than others and a strain of soybean that appears to have a high level of resistance has been selected.

Bagrada cruciferarum (=picta) **(Pentatomidae: Hemiptera)**
(Painted bug)

DIAGNOSTICS

Egg: The eggs are oval and pale yellow. They are laid singly or in groups of 2-3 on the leaves, stalks, pods and sometimes on the soil.

Nymph: The nymphs are black with a number of brown markings.

Adult: The bugs are sub-ovate, black and have a number of orange or brownish spots.

HOST PLANTS

It is distributed world-wide and attacks toria, sarson, mustard, rape, cabbage, cauliflower and turnips, etc.

LIFE HISTORY

The painted bug is active from March to December during which period all the stages can be seen. It passes the winter months of January and February in the adult stage under the heap of dried oilseed plants lying in the fields. The female can lay 37-102 eggs in its life span of 3-4 weeks. The

incubation period lasts for 3-5 days and 20 days during summer and winter, respectively. The nymphs fully develop in five stages and transform themselves into adults in 16-22 days and 25-34 days during summer and winter, respectively. The insect completes 9 generations in a year. The duration of a completed life cycle is 19-54 days.

NATURE OF DAMAGE

Both the nymphs and adults are responsible for damage. They suck cell-sap from the leaves and the developing pods, which gradually wilt and dry up. They also excrete a sort of resinous material which spoils the pods.

Leptinotarsa decemlineata Say **(Chrysomelidae: Coleoptera)** (Colorado potato beetle)

Egg: Eggs are laid in batches.

Larva: Reddish, humped and with two rows of black spots on each side of the body.

Adult: Robust, yellow and black striped beetle about 3/4 inch long.

Pupa: Pupation takes place in the soil.

HOST PLANTS

Potatoes, tomatoes and brinjal.

LIFE HISTORY

About 500 eggs are deposited in batches of about 24 each on the underside of leaves. Eggs hatch in 4 to 9 days and larvae become full-grown in 2-3 weeks by consuming the leaves. Pupation occurs in the soil and requires 5-10 days to become adult. There are 2-3 generations in a year.

NATURE OF DAMAGE

Both larvae and adults are responsible for damage. They devour foliage.

Aphis craccivora Koch. (Aphididae: Hemiptera)
(Cow pea aphid)

Synonyms: *Aphis laburni* Part., *A. medicaginis* Part.,*A. robiniae, A. leguminosae, A. papilionacearum*

DIAGNOSTICS

These are small, reddish to dark brown, soft bodied insects found usually in colonies on all the aerial parts of the host plant including fruits. In an aphid colony individuals in all developmental stages and both winged and wingless forms are met at different seasons of the year. Both winged and wingless individuals reproduce parthenogenetically and viviparously.

Adult: *Wingless form :* 1.5-2 mm long, shining black, antennae shorter than body and bear small hairs. Abdomen dorsally provided with a large, dark and solid plate. Segments II-V without marginal tubercles. Base of segment VI about 1/3 to 1/2 as long as processes terminalis. Siphunculi black, scaly 1-2/5 to 1-4/5 as long as cauda. Cauda dark, slightly pointed and has 5-6 bristles.

Winged parthenogenetic female: 1.5-1.8 mm long, antennae blackish with short hairs, III antennal segment with 3-8 rhinaria (rhinaria absent on joint IV & V). Dark and large dorsal abdominal plate dissolved into cross markings of varying number. Very exceptionally segments II-V contain marginal tubercles. Siphunculi and cauda blackish. Siphunculi 1-1/3 to 1-3/4 as long as cauda.

Nymph: Resembles to a great extent wingless adults in general morphology except small in size, brownish in colour and faintly dusted with wax.

LIFE HISTORY

Under tropical and subtropical climatic conditions the pest breeds on different host plants (leguminosae) throughout the year with varying population density.

In the absence of cultivated host plants it breeds on the wild ones, but as soon as they are available it migrates from the later to the cultivated. In drought periods the pest can take refuge on weeds or may also withdraw into cracks in the soil. With the onset of rains they are driven out and they once more colonise aerial portions of the host plants. The summer morph of *A. craccivora* is fairly susceptible to low temperatures, thus it cannot tolerate and die out in the frost of the cold regions. Reproduction is parthenogenetic

(females reproduce without mating) and viviparous (females give birth to living youngs instead of laying eggs). Both winged (alatae) wingless (apterae) females reproduce. Under reasonably suitable climatic conditions one virginaptera may produce 97-112 young ones in its life time (27-33 days) at the rate of 2-3 youngs/day. Alatae produce only half the progeny produced by apterae. The young ones moult four times and become adult in 20 days (3-19°C) and 7 days (11-28°C). The mortality of the nymphs is relatively high. One generation is completed in 6-8 days.

ECOLOGY

The size of the aphid differs greatly from one host to another and the colour varies from season to season. On summer crops adults are smaller and reddish brown while on winter crops they are larger and black. *A. craccivora* has the ability to migrate over wide distances. In drought period irrigated plants are more heavily infested than non-irrigated plants. As soon as drought period is over plants which grow normally without irrigation, are again preferred. *A. craccivora* attack on densely planted parts of the field is slight than on sparcely planted parts. Ants consistantly visit colonies of this aphid.

HOST PLANTS

Preferably all members of the family Leguminosae e.g. lucerne, groundnut, broad beans, pea, etc. are attacked. Some members of the family Malvaceae, Chenopodiaceae, Cucurbitaceae, Compositae, Solanaceae, etc. also serve as host of this aphid.

DISTRIBUTION

This aphid is widely distributed in tropical countries e.g. in Asia, Africa, Australia and South America and Pacific Islands. In the temperate zone of Europe and North America it is represented by races or sub species. In Pakistan, it occurs through out the country.

NATURE OF DAMAGE

Both the nymphs and adults are sap feeders. Black colour of the aphids in colonies can be seen usually on the apical portions of the plants from a distance. The aphids secrete honey-dew and the surface of attacked plants gives greasy or oily appearance. On the infested plants ants are seen running here and there visiting aphid colonies for collecting honey-dew. Young plants

when attacked remain stunted. Likewise, wilting of tender shoots occurs during hot weather. Leaves are mottled with chlorotic or dark green spots and plants remain stunted, even in crops like groundnut. Heavy attacks at the time of flowering and seed formation on leguminaceous plants negatively affect the yield and the plants may wilt. The aphid is a known vector of about 30 phytopathogenic viruses e.g. "rosette virus complex". The damage by viruses is not only confined to the legumes but may also spread over to non-leguminous crops i.e. cotton etc. Virus attacked plants show abnormalities e.g. rosetting, stunting, mosaic, mottle, etc. Usually virus attack is confined in patches to the edges and corners of the field, a sign that virulent aphids are present very early in the season.

CONTROL METHODS

Biological: A number of parasites attack this aphid in Pakistan. Important among them are *Aphidius absinthii* Marshall, *Aphelinus basalis* Westwood, *Aphidencyrtus aphidivora* (Magr.), *Ephedrus* sp. nr. *Cerasicola* Stary, *Trioxys* sp. *Sinensis* Mackauer and *Lysiphlebus fabarum* Marshall. Among the predators two anthocorids, one chamaemyiid, one chrysopid and nine coccinellids and nine syrphid species are recorded in Pakistan.

Cultural: Densely planted lucerne, groundnuts, etc. in the field discourage colonisation by aphids. The sooner the crop has grown and closer the plants before the aphids migrate from wild plants, the lesser the attack.

Chemical : Comparatively large number of preparations with effective action against, *A. craccivora* are available. Some of these are Dimecron, Malathion, Trichlorphon, Menazon, Monocrotophos, Diazinon, Dimethoate, etc. In hot regions chemical control with Nicotine, Pyrethrum and or Rotenon is decidedly advantageous despite their short term effect which permits reinfestation within 1-3 days after application. Residue problems may arise if granular or similar preparation for soil application (Phorate, Disulfoton) are used.

Phytomyza atricornis Meigen (Agromyzidae: Diptera)
(Pea leaf miner)

DIAGNOSTICS

Larva: Maggot is white, legless, wedge-shaped and about 1/8 inch long.

Pupa: Pupae are light brown, oval and ringed with ridges.

Adult: Small fly, about 1/8 inch long with a yellow and black thorax and black head. Adults fly quickly for short distances when disturbed.

HOST PLANTS

Peppers, all cucurbit crops, beans, peas, tomatoes, potatoes, brinjal and spinach.

LIFE HISTORY

About 10-20 generations are completed in a year. Adults deposit small eggs into leaf tissue. Under optimum conditions eggs hatch in 4 days. Larvae feed in leaf tissue for 14 days, pupate in the soil, remain there for 5 days and then emerge as adults. The life cycle under optimum conditions is completed in 23 days.

NATURE OF DAMAGE

Maggots live by eating leaf tissue between the upper and lower surfaces leaving slender, white, tortuous trails through the leaf's interior.

Chrotogonus trachypterus Blanchard **(Acrididae : Orthoptera)**
(Surface grasshopper)

Many species of grasshoppers cause damage to vegetable crops. This pest is polyphagous and is widely distributed throughout the world.

DIAGNOSTICS

Egg: Elongated-oval.

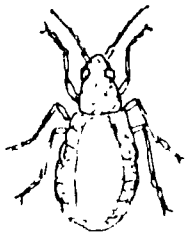
Nymph: Resembles adults, but is smaller in size and lack fully developed wings.

Heliothis armigera (Hb) **(Noctuidae: Lepidoptera)**
(Tobacco bud worm, Gram caterpillar, Gram pod borer)

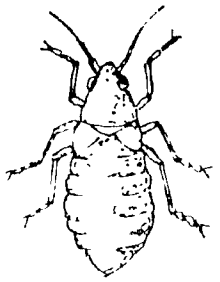
Synonyms: *Heliothis obsoleta, Helicoverpa armigera*

DIAGNOSTICS

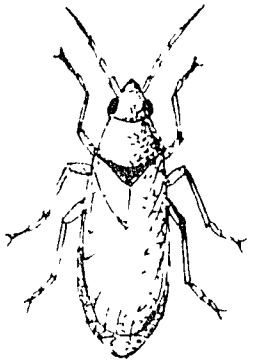
Egg: The eggs are 0.4-0.5 mm in diameter. They are spherical with a



NYMPH

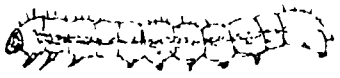


GROWN UP NYMPH



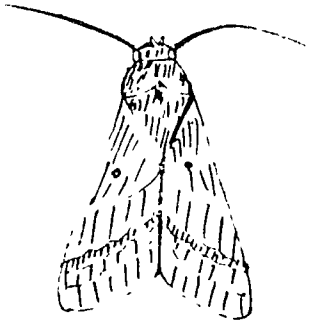
ADULT

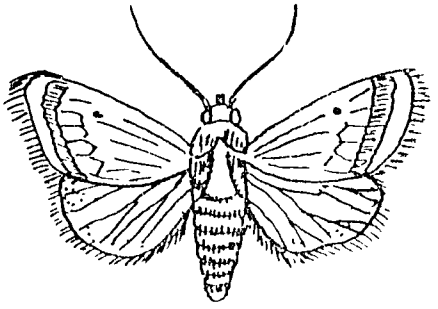
OXYCARYNUS LOETUS
(DUSKY COTTON BUG)



CATERPILLAR

PUPA





ADULT

HELIOTHIS ARMIGERA **(HUBNER)**

flattened base, which serves as a surface of attachment and are ribbed. Upon magnifying, the egg surface shows 24 ribs, alternate one being slightly shorter than transverse ridges between them. They are shiny white when first laid, changing through greenish yellow to dark brown before hatching.

Larva: The newly hatched larva is translucent and whitish in colour. The number of instars in nature is, generally six, although seven instar populations are known in southern Zimbabwe, where development is prolonged. Advanced larvae are very variable in colour and pattern. They may be black, brown, or green to pale yellow or pink in colour and measuring about 40 mm in length. They often feed with only the front portion of the body inside the hole they have bored in the fruit, boll or other part of the plant. Larvae often move about a plant from one fruit or pod to another, or even from one plant to another of a different species. They attack other larvae of their own kind they encounter and in some circumstances cannibalism is a population regulator, for example in closed-head varieties of sorghum where larvae come into close contact. Duration of larval development is also affected by the type of food, feeding on sunflower, for example, resulting in much longer developmental periods than on chickpea or maize. Distinguishing characters are conspicuous body hairs on prominent tubercles, skin rough and a dark band along the back on each side of which there is a pale band, followed by another dark band and then a very thin light band.

When fully grown the *H. armigera* larva ceases feeding and crawls or drops to the ground, where it burrows to a depth averaging about 10 cm, but varying from 2.5 cm, deeper burrows being associated with lighter soils. If the soil is very hard the larva may avail itself of a crevice. When it comes to rest, the larva forms an earthern cell and, after a day or so in a prepupal stage, it turns into a pupa.

Pupa: Pupa brown, pupation takes place in soil, thus one very seldom encounters pupae in an infested field unless soil is dug to expose them. In areas with a marked cool season, some or all of the pupae may enter diapause in autumn, which adds a safety factor to the overwintering of the species. Emergence from the pupa may be delayed by drought, as well as cold.

Adult: Adult stoutly built, ochraceous moth, wingspan 40 mm. General colour variable ranging from dull yellow or olive grey to brown. Fore wings marked with greyish wavy lines and black spots of varying sizes on the upper-

side and black kidney shaped mark and a black rounded spot on the underside. Hind wings white with dark veins and with a broad blackish band along the outer margin. Since the moths are noctural they are seldom seen during the day. When conditions are most favourable, the adults emerge 12 to 14 days after pupation.

LIFE HISTORY

The pest hibernates in pupal stage in the soil. The moths start emerging in spring. The moths are nocturnal in habit, thus they feed, mate and oviposit only at night. The moths feed on plant nectors and start laying eggs within 4 days of emergence. The eggs are laid singly, mostly between 2100 hours and mid-night, the preferred site for oviposition is different in different crop plants.

On cotton, oviposition is heaviest on the upper surface of the leaves in the upper parts of the plant and lightest on the lower surface of the leaves in the lower parts of the plant in some African countries. On some host plants they are laid on the lower surface of the leaves along the midrib, but they may also be laid on buds, flowers, between the calyx and young fruit and on tender foliage at the top of the plant. On tomato and tobacco the eggs are laid preferably on the underside of the leaves whereas in gram the moth prefers to lay eggs on leaf-lets. Incubation period is 2-8 days depending upon the temperature. But under cool conditions they may take up to 17 days to hatch. Upon hatching at first the young larvae usually feed on their egg shells before starting to feed on the tender foliage of their host plants. Although the larvae feed for a few days on the leaves but preferably they bore into the fruits, flowers and buds of their host plants which they hollow out. After boring into the fruit or bud the larva commonly feeds the inside contents with much of its body lie outside the hole on the surface of the fruit. In laboratory cultures the number of larval instars can range from five to nine, depending upon the vigour of the strain, the temperature experienced and the type of food. The number of instars in nature is, however, generally six, although seven instar populations are known in Southern Zimbabwe, where development is prolonged. In the field the larva before reaching maturity passes through 6 instars which may take from 15-35 days or even up to 40 days. The time spent in the larval stage (developmental limits being betwen 11 and 34°C) is stated to be as brief as 8 days in the Punjab in India and as long as 51 days in Southern Zimbabwe, but seems to average between 14 to 18 days in the hot season in most places. For pupation the larva enters deep

into the soil up to a depth of 25-175 mm where it constructs an earthen cell in which it pupates. On maize plant, however, pupation take place in the tip of the cob and before doing so it spins a silken cocoon. The pupal period is 8-15 days. After emergence the moths mate and start ovipositing thus a new generation starts. There may be several generations during the active season depending upon the climatic conditions and the availability of the host plant of the area. The pupal period of the generation which occurs at the start of winter season is prolonged and such pupae hibernate in the soil. The moths from them would emerge in the next spring for new infestation.

HOST PLANTS

The insect feeds on a wide range of host plants around the world including cotton, tobacco, maize, sorghum, sunflower, legumes i.e. (grams, peas), citrus, tomatoes, okra, and other fruit crops.

In Pakistan, the pest is serious besides other crops on tomato in hills and gram in the plains. Some of the wild plants which serve as alternate host of this insect are in the plant families Euphorbiaceae, Amarantanceae, Malvaceae, Solanaceae, Compositae, Convolvulaceae, etc.

DISTRIBUTION

The insect is widely distributed in whole of Asia, Africa, Eastern Australia, and Southern Europe. In Pakistan, the insect is found in all climatic zones where its host plants are found.

NATURE OF DAMAGE

Severe attack of *H. armigera* occurs at the time when flowering and fruiting takes place on its host plants. During the active season of the pest there may be a succession of attacks on various crops as they come into flowering and fruiting stage. The larvae although feed on leaves but preferably attack floral parts of the plant including buds, flowers and fruits. Symptoms of attack by the larva vary on different host plants. On tomato, peas, okra, etc. the larvae partially bore into the fruits to feed on the contents and hollow them. On cotton and gram the larvae bore into the bolls and pods.

CONTROL METHODS

Cultural: With a highly mobile, opportunistic pest like *H. armigera,* cultural

control practices have limited applicability. There seems to be good sense in eliminating weeds from which *H. armigera* larvae might migrate directly on to crop plants. In the literature possible value of uncultivated marginal areas in the survival, buildup, and subsequent of predators and parasites of *H. armigera* have been stressed.

Thus most important sanitary control method is to destroy alternative host plants and crop remains after the harvest to avoid any ratoon growth supporting an early generation of the pest. After the harvest of the crop deep ploughing is recommended to destroy the overwintering pupae in the soil.

In areas where the pest is very serious the dates of sowing of different crops should be such that period of flowering in various crops should be as short as possible. This is to avoid a successive buildup of the pest population from one crop to another. For example, an early sown maize followed by late sown cotton will encourage a heavy incidence of the pest on the later crop.

Diversionary crops or trap crops are good means of attracting the pest where it is killed by spraying, etc.

Biological: Of the listed 37 species of parasites from *H. armigera* in India, only 8 were rated as important, on the basis of achieving over 3% parasitisation of available hosts.

A number of egg and larval parasites and predators are recorded attacking the pest but these are not very effective. A polyhedral virus also attacks the pest. The scope of using this virus is great in future.

Chemical: In sudden onsets of attack, chemical control is the only effective method of control. Effective insecticides are Carbaryl 0.1% or Endrin 0.025% or Endosulfan 0.25-0.5% ULV spray. Carbaryl is specially effective in areas with low rain fall. For the effective control proper time of insecticidal application is important. The crops should be sprayed if 1-1/2 to 2 eggs are found per plant.

Note: The wide host range of *H. armigera* involves many associated pests. The following are likely to be important:

Hemiptera: *Acyrthosiphon pisum, Bemisia tabaci, Nezara viridula* and *Rhophalosiphum maidis;*

Thysanoptera: *Thrips palmi, T. tabaci*

Diptera: *Contarinia sorghicola, Delia platura* and *Ophiomyia phaseoli*

Lepidoptera: *Agrotis* spp. (including *A. ipsilon), Etiella* spp. *Maruca testulalis, Mythimna separata* and *Spodoptera litura*

Acarina: *Tetranychus* spp.

Of the above pests, chemical control would be most likely to be applied against thrips, flies, some caterpillars and mites.

Athalia lugens proxima (Klug) **(Tenthredinidae: Hymenoptera)** (Mustard sawfly)

Synonym: *Athalia proxima*

DIAGNOSTICS

Egg: Eggs are elongate, yellow-white, small and are laid singly in slits made by the female with its saw like ovipositor in the leaf tissues on its underside along the margins.

Larva: Full-grown larva is oily black or dark green with black head, wrinkled appearance, and cylindrical body measuring 16-18 mm in length. Therefore, five black strips on the body. Larva has 8 pairs of abdominal prolegs and 3 pairs of thoracic legs. They resemble lepidopterous larvae but can be distinguished by abdominal prolegs.

Pupa: Pupa yellowish to green, enclosed in a water proof oval silken cocoon. Pupation takes place in soil up to a depth of 25-30 mm. Measures 7 mm in length along the black dorsal line.

Adult: Adult small, orange yellow body (abdomen) with black markings on it. Wings translucent, smoky with black veins. Antennae long, head and thorax black. Adults are sluggish and do not fly much.

LIFE HISTORY

During the summer months (April-September) when none of its host plant is available the pest remains inactive and it is found only as larvae enclosed in silken cocoons in the soil. In October these larvae pupate and the flies appear on wings, which actively breed on various host plants till March. Thus by March all stages are found in the field. The adults live only for 2-8 days during which each fly lays 30-35 eggs singly on the underside of the leaves. For oviposition the female makes a slit with the help of its saw like ovipositor in the tissues of the leaf along the margin and deposits an egg. Incubation period is 4-8 days. Upon hatching the young larvae feed holes gregariously on the leaves. The larvae are active during morning and evening hours whereas they hide themselves in the plant parts during the day. The

larvae are full-fed in 11-37 days during which they pass through 7 larval instars. Full-grown larva enters the soil up to a depth of 25-30 mm and after spining a silken cocoon pupates in it. Several larvae may lie together in a lump. Pupal stage lasts for 4-8 days or may extend up to a month depending upon weather. It takes 31-47 days to complete one generation and there may be 2-3 generations from October till March.

HOST PLANTS

The pest feeds on various plants of the family Cruciferae like turnips, raddish, cabbage, cauliflower, mustard, etc. It has also been recorded on toria and rapeseed.

DISTRIBUTION

The pest is widely distributed in South-east Asian countries. It has been reported from Pakistan, India, Burma, Formusa, Indonesia, etc. In Pakistan, it is found in all parts where its host plants are cultivated.

NATURE OF DAMAGE

The larvae damage the plants by feeding holes in the leaves, or even nibbling the margins of the leaves. Leaves are skeletonised and the seedlings succumb to the attack. The young plants are altogether defoliated leaving only thicker veins. The older plants when attacked do not bear seeds. In severe cases of infestation even epidermis of the shoots is also eaten up.

CONTROL METHODS

Chemical: A number of insecticides have been tried against this pest in various places. Dimethoate 0.03% spray gave good control of the pest. The Punjab government has recommended the use of any one of the following insecticides during the activity period (October to May) of the pest.

Insecticide	Formulation	Dose/acre
Malathion	57 EC	800-1000 ml
Perfekthion	40 EC	300-400 ml
Roxion/Cygon	40 EC	300-400 ml
Rogor	40 EC	300-400 ml
Curacron	50 EC	400-500 ml

Rhopalosiphum (Lipaphis) erysimi Kaltenback
(Aphididae: Hemiptera)
(Mustard aphid)

It is world-wide in distribution and is a serious pest of cruciferous oilseeds (toria, sarson, raya, taramira), brassica vegetables (cabbage, cauliflower, knol-khol, etc.), potato and amaranthus.

DIAGNOSTICS

The adults and nymphs are louse like and are pale-greenish in colour. They are seen feeding in large numbers, often covering the entire surface of flower-buds, shoots, pods, etc.

LIFE HISTORY

This insect is most abundant from December to March when it infests various cruciferous, oilseeds and vegetables. During the summer, it is believed to migrate to the hills and there is some evidence that aphids also survive on abandoned stray plants of cabbage and on cruciferous weeds in the plains. The pest breeds parthenogenetically and the females give birth to 26-133 nymphs. They grow very fast and are full-fed in 7-10 days. About 45 generations are completed in a year. Cloudy and cold weather is very favourable for the multiplication of this pest. The winged forms are produced in autumn and spring and they spread from field to field and locality to locality.

NATURE OF DAMAGE

Both the nymphs and the adults suck cell-sap from leaves, stems, inflorescence or the developing pods. Owing to the very high population of the pest, vitality of the plants is greatly reduced. Leaves acquire a curly appearance, the flowers fail to form pods and the developing pods do not produce healthy seeds. The yield of the infested crop is reduced to one-fourth or one-fifth.

CONTROL METHODS

Since vegetables are consumable commodities, soft insecticides like Malathion 0.05% or Nogos are recommended. For oilseeds pollinators are involved at flowering stage, for which advice of Agricultural Department should be sought.

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Pieris brassicae Linn. (Pieridae: Lepidoptera)
(Cabbage butterfly)

Synonyms: *Pontia brassicae, Mancipium brassicae, Ascia brassicae*

DIAGNOSTICS

Egg: Eggs are laid singly or in cluster usually on the underside of leaves. Individual egg, pale white or yellowish, long, rounded or flask shaped, with many longitudinal ridges on its surface running from the top to the base. These are deposited on the upper or the lower side of the leaves, and are 1.20-1.22 mm long and 0.20-0.25 mm wide.

Larva: Young larvae pale-yellow, later on turn greenish yellow. Body covered with many small black dots of varying sizes and small short hairs. Head capsule black with white strips. Mahmood and Alam (1986) studied the life history in the laboratory. The following description of different larval instars has been taken from their paper:

1st stage larva: The body was dirty white in the beginning and changed to light yellow. Small black spots appeared on dorsal surface. Head and eyes were black. Body length was 1.00-1.10 mm (X = 1.05 mm)

2nd stage larva: The body became pale yellow with prominent black spots on dorsal side. All body was covered with white hair, black head and eyes. Body length on the first day after moulting was 6.00-7.00 mm (X = 6.75 mm).

3rd stage larva: The body was greenish yellow with prominent black spots on dorsal side and covered with white hair. Head and eyes' colour was same as in the previous instars. Body length on the first day after moulting was 13.50-15.00 mm (X = 14.20 mm).

4th stage larva: All characteristics were same as in previous instar. Body length on the first day after moulting was 24.00-26.00 mm (X = 24.50 mm).

5th stage larva: The body was greenish yellow with prominent black spots on dorsal side. All body still covered with white hair, head black with a small white spot in the centre on the front side. Eyes were dirty white with many minute black spots on its surface. Body length on the first day after moulting was 32-34 mm (X = 33.60 mm) while 40-44 mm (X = 42.10 mm) before entering into prepupal condition.

In the field, the young larvae (1st, 2nd and 3rd stages) fed gregariously and made small feeding holes of irregular shape usually in the tender leaves.

Later, larval stages separated from each other but remained on the same plant. They only moved to other plant when the first plant was completely defoliated. In cabbage, the head remained smaller in size due to heavy attack of the insect and market value was drastically reduced. Total larval period of 16-22 days under laboratory conditions was closer to the results of Atwal (1976) but, Edward and Heath (1964) claimed larval period as 28-42 days. This difference may be attributed to different environmental conditions under which the studies were made.

Prepupal stage: Under laboratory conditions, the full-grown larva left the host and attached itself to muslin cloth or the side of beaker and assumed prepupal condition. In the field, the full-grown larva assumed prepupal stage on the upper or lower surface of the leaves, branches/twigs of other plants present in the field, trees or the walls near the field. The prepupal period was 1-2 days.

Pupal stage: Pupa was greenish yellow with many small black dots of different sizes on the body. Body naked, with a silken girdle. Pupation takes place on plants or any other high place like wall, etc. The tail of the pupa was attached to the substrate with a button of silk in such a way that the body was kept hanging (50-100 angle) with the support of a single loop of silk that encircled the body near its middle. The length was 23.00-24.00 mm (X = 23.40) while width was 6.50-8.00 mm (X = 7.05). Pupal period was 9.12 days.

Adult: Adults medium sized, body black, wings white to yellowish white. Fore wing with a large black patch on apical angle, hind wing with rounded black spot on anterior margin. Male easily distinguishable from female by its smaller size and two black rounded spots in the centre of each fore wing (visible only on the underside). In females, however, these spots are visible on both the sides i.e. upper and lower side of fore wing. A female measures 6.5 cm across the spread wings. The males are smaller than the females.

LIFE HISTORY

The adult butterflies are good fliers. To avoid extremes of weather and in search of food plants they regularly migrate from hill to plains and then back to hills so that winter is passed in plains and summer in hills. In Pakistan, the butterflies migrate from the hills towards the plains in November where they breed till April. Migration from the plains towards hills starts in April-May and there the pest remains active till November. The adults lay eggs usually on the underside of the leaves. The eggs are laid singly or in clusters of 50-90, on the upper or lower side of a leaf. One female may

lay 190-390 eggs in its life time. Incubation period is 11-17 days from November to February and 3-7 days during March-May. Upon hatching the young larvae feed gregariously on the leaves and make holes of irregular shape. Older larvae disperse and feed on the leaves in such a way that only major veins are left and at times the whole plant is defoliated. The larval period is completed in 15-22 days during March-April and in 30-40 days during November-February. They pass through 5 instars. Pupation usually takes place on a higher place like plant or wall etc. away from the food plants. The pupal stage lasts for 7-14 days in March-April and 20-28 days during November-February. The adults upon emergence feed on plant nectors and may live for 3-13 days. They are usually seen flying and visiting ornamental flowers. The adults after mating lay eggs and next generation starts. There may be 4-6 generations per year. Information about duration of various life stage as reported by Mahmood and Alam (1988) is reproduced:

Table 1: Duration of different life stages of *Pieris brassicae* L. at Islamabad

Stage	Range	Average
No. of eggs per female	190-390	273.80
Incubation period (days)	3-8	5.07
Duration of 1st instar larva (days)	3-4	3.53
Duration of 2nd instar larva (days)	3-5	3.86
Duration of 3rd instar larva (days)	3-4	3.53
Duration of 4th instar larva (days)	3-4	3.26
Duration of 5th instar larva (days)	4-5	4.40
Total larval duration (days)	16-22	18.90
Prepupal period (days)	1-2	1.20
Pupal period (days)	9-12	10.53
Adult male life (days)	3-4	3.13
Adult female life (days)	6-8	7.50
Generation period (days)	32-52	41.50

HOST PLANTS

All plant species of the family Cruciferae are attacked, but most preferred host plants are cabbage, cauliflower, cole, collard, and *Brassica* spp. It may also attack turnip, raddish, sarson, toria and other cruciferous plants.

DISTRIBUTION

The pest is widely distributed in all regions of the world with

temperate, subtropical and tropical climates. In Pakistan, this insect is found in all climatic zones including coastal and subcoastal areas, plains, sub-mountainous and mountainous areas wherever the host plants are present.

NATURE OF DAMAGE

The damage is caused by caterpillars only. The first instar larvae just scrape the leaf-surface and occur gregariously. Later instars make small feeding holes of irregular shape usually in the tender leaves. Older larvae, however, separate from each other but may remain on the same plant. They feed from the margin inwards, on all parts of the leaf, leaving only the harder veins intact. In severe infestation the plants are altogether defoliated. Heads of the attacked cabbage and cauliflower remain smaller in size and their market value is drastically reduced.

CONTROL METHODS

Mechanical: In small plots the pest can be controlled by collecting the egg masses, larvae and pupae with hand and butterflies with hand nets. The collected insects can be killed in kerosenized water. The larvae occurring on leaves can be shaken and dropped in kerosenized water.

Biological: *Apanteles glomeratus* a hymenopterous parasitoid is common on the larvae of the pest.

Chemical: The pest can be effectively controlled by spraying the crop with different insecticides, important among them are Malathion 0.05% or Diazinon 0.02% or Carbaryl 0.2%.

The Punjab government has recommended the use of any one of the following insecticides during the activity period (October to April) of the pest.

Insecticide	Formulation	Dose/acre
Malathion	57 EC	800-1000 ml
Sevin	85 SP	1000-1200 ml
Nogos/Vapona/DDVP	100 EC	200-300 ml
Decis/Gymbush	2.5 EC	200-500 ml
Dimecron	100 EC	200-250 ml

Plutella xylostella (Linnaeus) (= *maculipennis* Curtis)

(Plutellidae: Lepidoptera)

(Diamond back-moth

Synonym: *Plutella maculipennis* Curtis

DIAGNOSTICS

Egg: Minute, yellowish-white, pin-head sized, oval, somewhat flatened eggs are laid singly or glued in groups of two up to eight, mainly on the underside of the leaf. The egg hatches in 4 to 8 days.

Larva: The full-fed caterpillar measures about 8 mm in length and is pale-yellowish green in colour with fine scattered erect black hairs over the body.

Pupa: Pupal cocoon is a beautiful gauzy sac, but so thin and loosely spun that it hardly conceals the pupa. It is usually fastened to the underside of a leaf.

Adult: The moths are small, slender, greyish-brown and measure about 8-12 mm in length. At rest, the fore wings lie close to the sides of the body and in profile present a slightly upturned posterior end. In resting moths a creamy-yellow dorsal band on fore wings has three distinct constrictions (= conspicuous white spots) which appear like diamond patterns while the wings lie flat over the body.

HOST PLANTS

It is distributed throughout the world. It attacks cauliflower and cabbage seriously. Many other curciferous, solanaceous and liliaceous plants may also come under the attack of this insect.

DISTRIBUTION

The diamond back cabbage moth is now cosmopolitan and occurs over most of Africa, North and South America, Australia, China, India, Japan. New Zealand, South-east Asia and USSR.

NATURE OF DAMAGE

Only the caterpillars cause damage. The newly hatched caterpillars bore into the tissues from the underside of the leaves and feed in the tunnels so formed. At first, their presence is detected only from the blackish excreta that appears at the mouth of each tunnel, but in the second instar the mines become more prominent. In the third instar, the caterpillars usually feed

outside the tunnels i.e. on the exposed leaf surface. The larvae of the fourth instar feed from the underside of the leaves, leaving intact a parchment-like transparent cuticular layer on the dorsal surface. The larvae are very sensitive to touch, wind, or other physical disturbances and readily feign death.

The caterpillars damage leaves of cauliflower, cabbage and rapeseed, particularly in the head or in the heart. Central leaves of cabbage or cauliflower may be riddled and the vegetables rendered unfit for human consumption. The pest is most serious when it appears on the early crop in August-September.

LIFE HISTORY

The newly hatched larva crawls to the lower surface of the leaf and bores through the epidermis to mine the leaf tissues. After the first or second instar it usually feeds from the lower surface, chewing irregular patches in the leaves and consuming all except the veins and upper epidermis, producing a characteristic window effect. When disturbed, the larva wriggles backwards very rapidly or drops from the leaf on a fine silken thread, to remain suspended temporarily, or to land on a lower leaf. The final (fourth) instar larva, which causes most of the injury to the plant, often appears green, due to food in the gut. The mature larva usually spins its fine, open network cocoon on the host plant, generally on the lower leaves, but it may migrate short distances from its host plant in search of a suitable pupation site.

The adults are inactive during the day unless disturbed, when they spiral upwards in narrow circles above the plant, moving swiftly in search of other shelter. They may crawl and fly short distances alternately, giving the impression of jumping. Although they are weak fliers they are readily carried by the wind, sometimes over hundreds of miles in mass displacement movements. They become active just before dusk when they seek nectar from the flowers of Brassicaceae. Females mate only once and this occurs at dusk on the day of emergence; oviposition begins shortly after. The insect remains active through the year and there are many overlapping generations in a year.

The female is capable of laying 18-356 eggs in her life time. The duration of different stages of this pest are as under:

Egg stage	3-9 days

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Larval stage	9-17 days
Pupal stage	4-5 days
Adult stage	The moth may live for 20 days

CONTROL METHODS

Physical/Cultural: Mass releases of laboratory reared *Trichogramma* wasps belonging to species (e.g. *T. evanescens, T. pretiosa* (= *T. cacoeciae)* that attack the eggs of a wide range of lepidopterous species, have produced reductions in cabbage moth abdundance.

When cabbage and tomato were interplanted in the Cameron Highlands of Malaysia the infestation of cabbage by *P. xylostella* was reduced by about 36% and similar results were obtained in the Philippines. Interplanting with a wide variety of crops reduced damage to cabbage in Taiwan.

Larvae, especially when young, are very susceptible to drowning during periods of rainy weather and more than half the larvae of the first three instars may perish in this way. In humid weather early instar larvae may drown if trapped in a droplet of dew. Larvae are greatly disturbed by rainfall and if they crawl or are washed into leaf axils, they drown in the water that accumulates there. Those that spin threads and drop to the ground may perish in small accumulations of surface water. It would seem, therefore, that pressure spraying of water, perhaps with a detergent, might be a valuable control measure. Where irrigation by means of overhead sprinklers is possible this is also a useful control measure in the orchards. The highly adverse effects of heavy rainfall may explain why *P. xylostella* occurs more abundantly in the dry part of the year and why it becomes a more serious pest in drier years.

Biological: A major factor in relation to the biological control of *P. xylostella* is that it is almost always associated on cultivated crops with other pests that require insecticidel control unless they too are under effective biological control. The necessity to use insecticides against any member of the pest complex may seriously reduce the effectiveness of biological control of all the others. Common associates of *P. xylostella* include: Hemiptera: *Brevicoryne brassicae, Myzus persicae;* Lepidoptera: *Agrotis* spp., *Crocidolomia binotalis, Heliothis* spp. *Pieris rapae* and many others. More than 90 parasites of *P. xylostella* have been recorded from various parts of the world.

Plusia orichalcea Fabricius and *P. Nigrisigna* Walker
(Noctuidae: Lepidoptera)
(Cabbage semi-loopers)

Both species are polyphagous and attack almost all kinds of cruciferous crops (viz. mustard, cabbage). They also occur on potato, pea, cowpea, lin-seed and groundnut, etc. As the caterpillars walk, they form characteristic half-loops and are often seen mixed with cabbage caterpillars, *Pieris brassicae L.*

DIAGNOSTICS

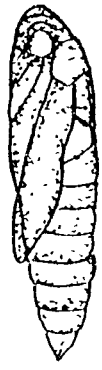
Comparison of the two species is as under:-

Stage	Name of species	
	Plusia orichalcea	*Plusia nigrisigna*
Egg	Laid in batches on leaves of the food plants	Laid in batches on the leaves of the food plants.
Caterpillars	Full-grown caterpillar is slender about 25mm long. Bluish-green with a few short dorsal hairs, dorsal white lines and a prominent lateral line.	Leaf eating semi-looper, green with lateral and a dorsal white line, and short hairs.
Pupa	Found in folded leaves lying as debris on the ground	Found in folded leaves lying as debris on the ground
Adults	The adults of this species are light palish brown, with a large golden patch on each fore wing, 42 mm at wing span	The adults of this species are darker and have dark brown and dirty-white patches on the fore wings, 40 mm at wing span

LIFE HISTORY

These insects are active during winter, and it is not known how they survive the heat of the summer. The females lay eggs on the leaves of the

LARVA



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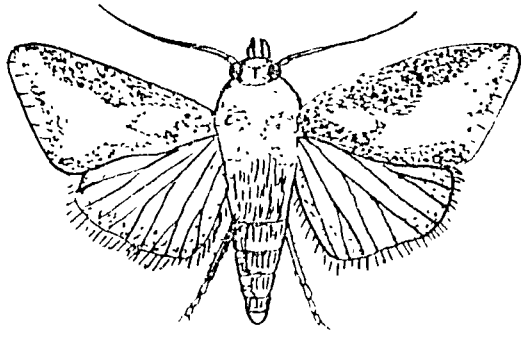

ADULT

THE CABBAGE SEMI-LOOPER

PLUSIA ORICHALCEA

host plants, during the active period. After few days the caterpillars emerge from the eggs and feed individually. Full-grown caterpillars pupate in the debris lying on the ground. The moths are very active at dusk on flowers in the gardens and public parks, where they are seen in hundreds during the spring season.

NATURE OF DAMAGE

The damage is caused by the caterpillars only. They feed individually, biting holes of varying sizes according to the stage of their development.

CONTROL METHODS

Same as for cabbage caterpillar.

Trichoplusia ni. **(Noctuidae: Lepidoptera)**
(Cabbage looper, Cabbage green semi-looper)

DIAGNOSTICS

Egg: Greenish white, spherical, sculptured. Laid singly on the under surface of leaves.

Larva: The caterpillars are slender, greenish with white wavy lines along the back and a heavy thick/broad lateral stripe on either side of the body. The head is narrower than thorax (= attenuated anteriorly).

Pupa: Larvae pupate in a flimsy lace-like cocoon (= transparent cocoon) on the under surfaces of leaves.

Adult: Stout, head and thorax grey in colour; abdomen white with basal tufts ferruginous; general body colour light greyish brown with a small (slender "y" mark) light coloured spot near centre of each fore wing. In wingspread measure about 1-1/2 inches.

HOST PLANTS

Cabbage, cauliflower, knol-khol, lettuce and spinach.

LIFE HISTORY

The females lay greenish white eggs on the upper surface of the leaves. The caterpillars attain a size of 1-1/2 inches when full-grown. They move in a "looping" motion, thus the name cabbage looper. The caterpillars go into a resting or pupal stage in a flimsy lace-like cocoon on their host plant. The

Table 1. Some important vegetables

S.No.	Name of vegetables	Time of sowing	Time of transplanting	Time of harvesting
A.	**Winter Vegetables**			
1	Potato			
	(a) Autumn (Plains)	15th Sept-15th Oct.		Jan.
	(b) Spring	Jan.	-	May
	(c) (Hills)	Apr.	-	Sept-Oct.
2.	Peas			
	(a) Early	20th Sept-10th Oct.		Nov.-Dec.
	(b) Late	20th Oct. to 30th Oct.	-	Feb.-Mar.
3.	Radish			
	(a) Early	Jul. Aug.	-	Sept.-Oct.
	(b) Medium	Sept.-Oct	-	Nov.-Dec.
	(c) Late	Nov.-Jan.	-	Jan.-Mar.
4.	Turnip	Aug.-Nov.	-	Oct. Mar.
5.	Carrot	15th Sept. to 15th Oct.	-	Dec. Mar.
6.	Spinach	Jul.-Oct.	-	Sept. Mar.
7.	Sugar Beet	Sept.-Nov	-	Nov. Mar.
8.	Garlic	Oct.	-	May
9.	Onion	15th Oct. to Nov.	Jan.	May-Jun.
10.	Tomato			
	(a) Early	Sept. to Oct.	Oct. Nov.	Apr.-Jun.
	(b) Late	15th Nov.	Feb.	May-Jun.
11.	Cauliflower:			
	(a) Early	Beginning Jun. to Jul.	Jul.-Aug.	Sept. Nov.
	(b) Medium	Aug.	Sept.	Dec. Jan.
	(c) Late	Sept.-Oct.	Oct. Nov.	Jan. Mar.
12.	Cabbage	Aug.-Oct.	Sept. Nov.	Dec. Apr.

(Cont'd)

(Cont'd)

S.No.	Name of vegetables	Time of sowing	Time of transplant-ing	Time of harvesting
13.	Khol-Khol	Aug.-Oct.	Sept. Nov.	Dec. Apr.
B.	**Summer Vegetables**			
1.	Brinjal	Feb. Jun.-Jul. and Oct.	Apr.-Aug. and Feb.	Jun. Nov. Oct. Dec. Apr.-Sept.
2.	Lady's finger	Feb.-Mar.	-	Apr.-Nov.
3.	Sponage gourd (Ghia tori)	Feb.-Mar. Jun.-Jul.	-	May-Aug. Sept. Dec.
4.	Gourd	Last Oct. to early Nov.	-	Mar.-May
	(Ghia kaddu)	Feb.-Mar.	-	Mar.-May
5.	Vegetable marrow (Chappan Kaddu)	Jan.-Feb.	-	Mar.-May
6.	Halwa kaddu	Feb.	-	May-Jun.
7.	Balsum apple (Tinda)	Mar.-Apr. Jun-Jul	-	Apr.-Aug. Aug.-Nov.
8.	Bitter gourd	Last Feb. to Apr.	-	May-Aug. Sept.-Nov.
9.	Cucumber	Feb-Mar.	-	Apr.-Jul.
10.	Long melon	Feb-Apr.	-	Apr.-Jul.
11.	Musk melon	Feb-Mar.-Jun.	-	May-Jun.-Aug.-Sept.
12.	Water melon	Feb-Mar.-Jun.-Jul.	-	May-Jun.-Oct.
13.	Cow peas	Jul.-Feb.	-	Oct. Nov. May Jun.
14.	Chillies	Oct. Feb-Mar.	Feb. Mar. Apr.	Aug. to Dec. Aug to Dec.
15.	Arum	Feb. Mar.	-	Sept.-Nov.

(Cont'd)

(Cont'd)

S.No.	Name of vegetables	Time of sowing	Time of transplant-ing	Time of harvesting
16.	Turmeric	15th Mar. 15th Apr.	-	Jan-Feb.
17.	Ginger	15th Mar.- 15th Apr	-	Jan.-Feb.

insect is prevalent in large numbers from October to April. There may be 3 or more generations per year.

NATURE OF DAMAGE

Only the caterpiliars/larvae do the damage. They feed on cabbage and other host plants. The larvae eat away the leaves of cabbage plants in the nursery and in the mainfield, leaving only veins and midribs of leaves on the plants; this is reflected as leaves with holes or severe damage by skeletonization. Complete defoliation can also take place.

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Chapter 13

INSECT PESTS OF FORESTS

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INTRODUCTION

With the rising human population and increasing daily demands of wood, exploitation of forest resources for timber, firewood and industrial use is resulting in premature felling, decreasing regeneration and diminishing wood resources throughout the world. In Pakistan the situation i. getting worse because tree cover disappearing in the hills and foot-hills due to human pressure is not being replenished and the denuded soil is moving down with the rains to leave behind bare rocks, unfit for any plant growth. The devastations of deforestation and erosion of wildlands is widening the ever-increasing gap of supply and demand of wood in the country.

In order to improve the situation there is an immediate need to start corrective measures and to embark upon developmental plans for the propagation of forest resources. Undoubtedly the important steps to increase wood productivity are reafforestation of plains with fast growing tree species, introduction of management systems safeguarding regeneration and watersheds and proper management of most valuable water resource for sustained supply and judicious use of irrigation water to reap richer harvest of forest and agriculture crops. But one of the most important factors influencing wood yield in our natural as well as man-made forests can be protection of losses due to insect pests.

In the recent years multifarious human activities disturbed the natural biological balance and the insect pests have become major threat to forestry crops and forest produce. Some soil dewelling insects damage nurseries, a few bark beetles kill weak trees, aphids, scales and gall midges hamper tree growth but the most devastating are the defoliators and tree borers which produce serious deleterious effect on tree health and cause mortality. The felled wood borers take a heavy toli of the valuable forest produce.

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Severe damage to foliage by insects has been especially noticeable in the irrigated plantations and natural stands of pines. A noctuid caterpillar, *Plecoptera reflexa* Guen. on shisham, a notodontid, *Ichthyura anastomosis* on poplars, a geometrid looper, *Ascotis imparata* Walk. on bakain and a pyralid, *Margaronia pyloalis* on mulberries and hairy caterpillars of *Euproctis* spp. on babul are serious leaf pests of deciduous trees in the plains. A large geometrid, *Biston regalis* Moore on blue pine, a bagworm, *Cryptothelea crameri* Westwood and a hairy caterpillar, *Elkneria (Dasychira)* sp. on chir pine are noxious defoliators of conifers. Broad-leaf trees lose 60% annual growth if defoliated once and hardly put up any growth if denuded 2-3 times in a year. But the coniferous trees rarely survive if there is complete leaf loss even once. Out-break of these defoliators every other year at one place or the other is not an unusual occurrence by which 30-40% loss in wood yield occurs, in a rotation, besides the dead loss due to outright mortality of trees.

Stem and shoot borers are more damaging as they bring about canker formation, deformity, stunted growth and mortality in trees. Scolytid beetles of *Ips*, *Polygraphus* and *Pityogenes* genera on pines, flat-headed grub, *Melanophila picta* Pall on poplars, *Buprestis geometrica* on pines and *Agrilus dalbergiae* on shisham are serious bark borers which usually cause tree mortality by girdling and strangulation. Long horn beetles, *Apriona cinerea*, *Aeolesthes sarta* and *Stromatium barbatum* are very dangerous sapwood and heartwood borers of poplars, chinar, fruit trees and shisham which apart from killing the trees destroy the wood by network of galleries made in the stem. There are numerous other insects which live in our forests and damage plant life from seeds and seedlings to twigs and trees. Even the wood in storage and in use is not safe from their ravages.

Following is an effort to bring out a detailed account of important pest insects of our forests with the object to protect our forest wealth from their ravages by proper pest management.

DEFOLIATORS

Eupoctis spp. (Lymantriidae: Lepidoptera)

(Babul defoliator)

DIAGNOSTICS

Euproctis lunata Walk: Moth: Male light ochreous, with large black discocellular spot. Female whitish ochreous with ochreous brown anal tuft, male 34, female 38 mm.

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Larva: Brown with long tufts of hair anteriorly, posteriorly and laterally, and with square white dorsal spots on the thoracic segments and on segment 5 and the following.

E. scintillans subnotata **Walk:** Moth: Forewing reddish brown suffused with mauve and with indications of blackish smears, costal and distal margins sulphur yellow, but not reaching the base costally, at the outer margin three yellow spots, incurved on the inner side and bear silvery spots at this margin. Hindwing yellow. Head and collar orange. Pectinations of antennae brownish yellow, like the abdomen, while thorax is brown. Underside light yellow, forewing with darker subcostal stripe. Anal tuft orange. Male 20 to 26 female 32 to 38 mm.

DISTRIBUTION AND HOST PLANTS

Euproctis lunata **Walk. and** *E. scintillans subnotata* **Walk:** Occur throughout Pakistan but serious defoliations occur in Babul plantations and riverian forests in Sindh. They are also reported on *Aesculus indica, Cassia fistula, Ficus bengalensis, F. glometrata, Lagerstroemia indica, Lantana aculeata, Shorea robusta,* bamboo and many agricultural crops.

NATURE OF DAMAGE

Very low population occurs in March, the pest becomes active in September and enough population can be found in October and November. Young plantations are attacked seriously while bigger trees are less affected. The defoliated trees suffer growth losses but the young plants and seedlings succumb to death.

LIFE HISTORY

The young larvae feed on the newly formed (fresh) foliage of babul but as they grow in size the entire leaves are destroyed. When disturbed they fall down through a silken thread. The larvae feed for 10-12 days during July-September. Pupation occurs 2.5-5 cm below the ground in soil or plant debris, without constructing any cocoon. The pupal period is 4, 5 and 7 days in July, August and September, respectively. The pest is active from September to December in riverian and block plantations in Sindh, causing whole sale defoliation of new plantings and young plantations during November-December. Most of the new plantings fail due to the damage.

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CONTROL METHODS

Spraying of 1 kg Bactospiene, a bacterial insecticide, or 400 g of Dimilin or any other antimoultants per hectare on the young plantations will kill the larvae.

Tephrina disputaria (Geometridae: Lepidoptera)
(Babul looper)

DIAGNOSTICS

Moth is marked with brown and white. Wing expanse 2.5 cm.

Larva: Dark green colour with anal segments lighter when young; in later stages anal segments become dark green mottled with black. Full grown looper measures 2.5 cm.

DISTRIBUTION AND HOST PLANTS

The species is an important defoliator of *Acacia nilotica* where ever the tree occurs.

NATURE OF DAMAGE

The young larvae feed on the newly formed tender foliage of babul but as they grow in size the entire leaflets except the main stalk and a few ragged shreds are consumed. When abundant it completely strips the trees causing clear defoliations, sometimes death of young plants. Even when partially damaged the trees usually shed the remaining foliage.

LIFE HISTORY

The overwintering pupae give rise to adult moths in March-April depending upon the seasonal variation of the locality. The newly hatched loopers feed on the foliage for about 10-12 days before descending to the ground for pupation. The pupation occurs among the dried leaves on the ground or in loose soil with in 2.5 cm of the surface. Moths emerge in about 4 to 7 days. There are 6 to 8 generations of the pest in a year in various localities and climatic conditions.

CONTROL METHODS

One kg of Dipel or Bactospiene, the bacterial insecticides or 400-500 grams of Dimilin in 1000 litres of water per hectare when sprayed on the

larval stage on the plants, kills the pest without harming the natural enemies of the pest.

Ascotis imparata Walk. (Geometridae: Lepidoptera)
(Bakain defoliator)

DIAGNOSTICS

Egg: Slightly oval, shining-green, changing to pale-green before hatching, egg-shell furnished with ridges and furrows, size 0.78 x 0.35 mm.

Larva: Entirely black on hatching, measures 3.5 to 4 mm long, changes to reddish-brown or green with black head and black lines and patches on nota; measures 56 to 73 mm in length when full-grown.

Pupa: Reddish-brown, smooth, cylindrical tapering posteriorly, with dark spiracles, 18.2 mm long.

Moth: Irrorated with dark brown on a whitish-grey or pale-fuscous ground, abdomen with paired dark dorsal specks, wing expanse 5 cm, forewings with indistinct curved and slightly wavy medial line, becoming straight and antimedial on hind wing, underside pale with large black cell spots.

DISTRIBUTION AND HOST PLANTS

It is well distributed in Europe, Amur, Japan, China, Nepal, Congo, South Africa and N.W. Himalayas. *Melia azedarach* is the principal host but the pest can live on *Dalbergia sissoo*, *Vitex negundo* and *Acacia farnesiana*. In Pakistan this pest has been recorded in Swat, Peshawar and plains of Punjab. It is in abundance in irrigated plantations of the Punjab where it causes serious defoliation of Bakain, *Melia azedarach*.

NATURE OF DAMAGE

A plain defoliator, occasionally appearing in epidemic form in the irrigated plantations. Whole sale defoliation of trees causes severe growth losses resulting in reduced wood yield.

LIFE HISTORY

The overwintering pupae produce adult moths in March which mate and start laying eggs in about 2 to 4 days in masses of 30 to 165 or singly on the upper surface of leaves and shoots. A female lays up to 1200 eggs in 3 to 7 days which hatch in 3 to 10 days in different seasons. Larvae, the full

looper. on hatching feed on tender leaves by making small holes. The second and third instar larvae eat away the entire leaves leaving only mid-ribs. The full-grown caterpillars devour even the mid-ribs and tender shoots when leaves are not available. The larval stage spread over 5 instars is completed in 15 to 30 days in different seasons after which the full-grown larvae descend from trees through silken threads and burrow down 5-8 cm deep in the soil where they remain in prepupal stage for 2-3 days. The pupation takes place naked in the soil and lasts for 9 to 19 days after which adult moths emerge and start new generation. Thus a life cycle is completed in 33 to 61 days. There are six generations of the pest from March to November with hibernation in the soil in pupal stage from December to February.

CONTROL METHODS

Spraying of Dimilin 25% W.P. or such antimeultant at the rate of 250 grams in 1000 litres of water per hectare kills the feeding caterpillars. If the pest is in pupal stage spraying of Sevin, BHC, Orthene or Malathion 1.5 kg in 500 litres of water per hectare, on the ground will kill the emerging moths by contact with sprayed surface.

Ectropis deodarae (Geometridae: Lepidoptera)
(Deodar defoliator)

DIAGNOSTICS

Moth: The male moth has broad wide wings with mottled black markings but the female has incomplete wings and is unable to fly. In order to lay eggs on the needles of deodar the moths climb up the trunk of the tree.

DISTRIBUTION AND HOST PLANTS

It occurs in the outer ranges of the Himalayas in Pakistan and India in *Cedrus deodara* pure stands.

LIFE HISTORY

The eggs are laid on the needles of the tree. The green white-lined caterpillars hatch in March and feed until the end of hot weather, completely denuding the trees. They descend from the top of the tree through a silken thread for pupation under the plant debris without forming cocoon before the rains begin, at the end of June. The rest of the year is passed in pupal stage thus the life cycle is annual.

DISTRIBUTION AND HOST PLANTS

The pest is a defoliator of *Cedrus deodara*. It is most injurious in pure deodar forests of Pakistan. Epidemics occur at intervals of about 10 years. The defoliations may cause death of 1/3 of growing stock particularly in younger trees.

CONTROL METHODS

As the moths cannot fly and have to climb through the trunk of the trees to reach the needles for egg laying, sticky bands can very safely be applied on the stem of the trees to prevent their climbing. These bands should be applied in February before the emergence of moths and renewed when needed. The moths gathering below the band should be crushed or sprayed with any synthetic insecticide.

Cerura wiseri Swinhoe (Notodontidae: Lepidoptera)
(Double tail caterpillar)

DIAGNOSTICS

Egg: Round 1.6 mm in diameter, dome shaped, flat at bottom. Red when laid, turn brownish before hatching.

Larva: Bright-green, dorsal surface waxy bordered with whitish longitudinal line on either side of body upto anal end. Head retractile into square thorax provided with pinkish rectangular band on pronotum encircling the head with a whitish marginal band. Two long filaments at the tip of abdomen, pinkish, 35-40 mm, serve as organs of defence.

Pupa: Chocolate, 25 x 9 mm enclosed in a hard cocoon made of chewed bits of wood and silken threads, dome-like oval.

Moth: White-grey, underside whitish, wing expanse 55-63 mm, body length 22-23 mm. Head large, antennae large, pectinate. Frons, thorax and abdomen densely covered with woolly hairs. Forewing triangular, veins prominent, golden grey, 6-10 black dots on basal portion and on outer margin of hind wing.

DISTRIBUTION AND HOST PLANTS

Commonly distributed in China, Sikkum, Assam, India, Sri Lanka and Pakistan, attacking poplars and willows.

NATURE OF DAMAGE

Young caterpillars nibble at the leaf edges, later eating out larger portions and finally consuming whole leaf, leaving only the mid-rib and small parts along the mid-rib. In severe attacks even the tender shoots are eaten and the trees are denuded completely. Partial defoliations are usual and wide spread, complete defoliation not very common.

LIFE HISTORY

The moths emerging from the hibernating pupae in hard cocoons in early spring, mate and lay eggs with in a week or so, depositing upto 250 eggs per female, singly on newly sprouting leaves, shoots and stems. Greenish-black caterpillars hatch in 9-12 days in March-April and start feeding on foliage. After a feeding period of about 53 to 60 days, the caterpillars mature and change from bright green to dirty brown before digging in a trough like cavity in the bark of the tree trunk or large branches where they spin hard cocoons around their bodies. Pupation occurs in the end of May which lasts for 283 to 293 days to give rise to adult moths in the following spring. The life cycle is annual.

CONTROL METHODS

Mechanical: During its long pupal period of 9-10 months the pupae can be removed from the tree trunks and destroyed. Hand picking and destruction of large sized caterpillars is also possible in young plants in small areas.

Chemical: Spraying of Dimilin 25% W.P. or such antimoultantat the rate of 400 grams in 1,000 litres of water per hectare can control large populations.

Biston regalis Moore (Geometridae: Lepidoptera)
(Kail defoliator)

DIAGNOSTICS

Egg: Green, oblong measures 0.01 x 0.006 mm.

Larva: Full looper, rough bodied, light grey, having two distinct horns on the head, measures 10 cm when full-grown.

Pupa: Dark-orown, measuring 2.5-3 cm.

Moth: Brownish-grey, wings with small basal brown patch and a large brown area alongside distal margin, both patches bound by irrregular black line, remaining middle area lighter with strong suffusion. Antennae bipectinate in male and filiform in female.

DISTRIBUTION AND HOST PLANTS

Pinus wallichiana (Kail) is its principal host out the insect has also been found defoliating *Xylosma longifolium* (Char, Ba ti). The other plants partially damaged are *Quercus incana* (Oak), *Nerium odorum* (Kaner) *Salix* sp. (Willow), *Viburnum*, *Berberis lycium* (Sumbloo). *Juglans regia* (Walnut), *Prunus cornuta* (Kalakat), *Rosa macrophylla* (Wild rose) and *Malus pumila* (apple). It is distributed in Himalayas but appeared in epidemic form in Patriata (Murree) and Jhelum Valley Forest Division in Azad Kashmir during 1980 for the first time

NATURE OF DAMAGE

As a foliage feeder, it cuts the needle about an inch from the base which falls down to the ground after a few bites thus causing defoliation of trees. Completely defoliated trees rarely survive.

LIFE HISTORY

This insect hibernates in pupal stage from October to May in the loose soil around tree bases or on slopes, 10 to 15 cm deep. The moths start emerging from the over wintering pupae in end of May/early June and continue upto July when the day temperature reaches 25-27 C. Pairing and mating takes place within few hours of emergence and lasts for 10 to 18 hours, mostly on the tree trunks. The eggs are laid soon after mating, in the cracks of bark on stems, branches and also on the needles. A female lays 570 to 2700 eggs with an average number of 1500. Blackish tiny caterpillars hatch out from eggs in 8 to 12 days and start feeding on young needles, later switching over to old ones. The needle is cut at about one inch from the base and after few bites thrown to the ground thus stripping the trees off their foliage. This activity continues from June to October. The mature caterpillars attain a full length of 10 cm, descend to the ground through the trunk or silken threads and locate suitable pupation sites for burrowing themselves into the soil where they transform into pupae and pass winter.

CONTROL METHODS

Chemical: Use of poisonous insecticides is not advisable in the natural environment for fear of pollution and damage to useful insect, bird and wildlife fauna. Commercially available insecticides based on *Bacillus thuringiensis* if sprayed at the rate of 2.5 kg per hectare kill the larvae. Dimilin and or any other antimoultants if sprayed on foliage at the rate of 500 grams per hectare can kill the larvae in a fortnight.

Mechanico-Biological: Hibernating pupae in loose soil around defoliated tree bases can be collected by motivating the local people to sell the pupal collection to the Forest Department. The pupae so collected and purchased should be put in wooden-wiregauze-cages to release the emerging parasites and predators and hold back the large sized moths of the pest. This method was adopted in Murree and Azad Kashmir in 1981 and 1982 and proved very effective as well as economical to subdue the epidemic of the pest.

Maugaronia pyloalis Walk. (Pyralidae: Lepidoptera)
(Mulberry leaf roller)

DIAGNOSTICS

Larva: Body bluish green, head brown and sparse long hairs on the body, size 2.5 cm long.

Pupa: Light-brown, about 2 cm long.

Moth: Pure white with golden-yellow marginal bands on both pairs of wings, forewing with rectangular golden bands in the middle.

DISTRIBUTION AND HOST PLANTS

It is a widespread defoliator of mulberries, *Morus alba* and *M. indica.*

NATURE OF DAMAGE

It becomes serious in the irrigated plantations, quite often defoliating trees in patches. Since sericulture in the Punjab depends on mulberry trees in the forest plantations this pest sometimes also causes set back in silkworm industry.

LIFE HISTORY

Moths emerge from the overwintering pupae in March and lay eggs on mulberry leaves in 3-5 days. The newly hatched caterpillars either roll the

leaves by stitching them with silken threads or web two leaves together. In the beginning, the larva feeds inside the web, on surface tissues only, later the mature larva consumes the entire leaf leaving only viens, midribs and small portions of uneaten leaf. The feeding continues for 8 to 20 days depending on season after which the larva spins a cocoon around it and pupates in between the leaves on the trees or among fallen leaves on the ground. The adult moths emerge after a pupal period of 7-12 days thus completing 10 to 14 generations from March to December with pupal hibernation from December to February.

CONTROL METHODS

As the mulberry leaves are also used for silkworm rearing, no insecticidal sprays is desirable against this pest. Whenever large populations of the pest are noticed large scale collections of pupae from the dried leaves should be caged to hold back the moths of the pest. Adults of the known parasites to enforce biological control should also be released.

Cryptothelea crameri Westwood (Psychidae: Lepidoptera)
(Pine bagworm)

DIAGNOSTICS

Egg: Smooth, spherical, creamy-yellow, becomes blackish in 10 to 15 days.

Larva: Brownish-black with reddish head, measures 25 to 38 mm when full-grown, lives in a bag measuring 30 to 46 mm long made up of bits of bark and silk.

Pupa: Male, elliptical, brown, measures 13 to 16.5 mm, female pupa oval, measuring 21 to 31 mm.

Moth: Male reddish-brown, wings with black streaks, body clothed with dark-brown hairs, wing expanse 26 to 32.5 mm. Female, wingless, apodous, vermiform, elliptical, creamy-white having a band of yellow hairs at the anal end, does not leave the pupal shell, 24-26 mm long.

DISTRIBUTION AND HOST PLANTS

It is well distributed in Pakistan, India and Sri Lanka, and has been reported feeding on chirpine, *Pinus roxburghii* and a number of broad-leaved trees and plants such as *Acacia nilotica, Albizzia* spp., *Bombax ceiba,*

Lagerstroemina indica, Clerodendron inerme, Tamarindus indica, Terminalia chebula, cotton, caster, rose and pomegranate.

NATURE OF DAMAGE

It appeared in epidemic form and defoliated *Pinus roxburghii* over 9 square kilometres in Mirpur forests of Azad Kashmir during 1970-71. *Brachyconiphus nursei* Cam. (Ichneumonidae), *Strumia inconspicuella* and *Podomyia* sp. (Tachinidae) were found parasitizing the bagworm which overtook the pest population in a couple of years. The pest appeared again during 1982 and caused serious defoliations.

LIFE HISTORY

Emergence of moths takes place from mid May to July. The winged males emerging from their pupae fly and locate female bags hanging on the shoots and twigs of the tree. They copulate with the sedentary females through the posterior aperture of the female bags. The impregnated females lay 600 to 3900 eggs per female within their bags, packing them tightly in two-third of the pupal shell and squeezing themselves to 11 - 12 mm in size. They either wriggle out or adhere to the opening of the bag and die after a life span of 3-10 days.

On hatching the larvae stay for a day within the pupal shell in the motherbag and then crawl out in groups through the posterior opening of the bag, keeping their abdomens lifted up and walking on thoracic legs, very actively. Soon after dispersal, larvae construct their bags with silk and tiny bits of bark of twigs. First of all a ring around the thorax is made by uniting the bark bits with silk and then more pieces are added to the ring on the anterior side and slowly the ring is pushed backward till the whole body is covered. This process takes about 40 minutes. Young worms carry their bags upright but in latter instars the bags are carried in appendant position as the size of the larva and bag increases from 2 to 40 mm.

Newly hatched larvae feed for 12-14 days on green soft bark by making small holes but the second instar larvae shift to foliage and feed on pine needles. Larvae pass through 4 moults to mature. A grown-up larva during feeding ties its bag to a twig and protrudes its head and thoracic legs from the bag, holds a needle with thoracic legs and eats it completely, starting from tip to base. Full-grown larva, 25-38 mm long in a 30-46 mm long bag, consumes 3 to 12 needles (average 5) a day in 3-4 intervals. Larval period, consisting of 5

instars, lasts for 10.5 to 11 months from June-July to next May-June, with 5 months of hibernation from November to March. The caterpillar remains inside the bag throughout its life, taking out its head and thoracic legs only for walking and feeding while the abdominal legs keep the bag gripped in hooks for dragging behind. When at rest, during hibernation and while pupating it attaches the rim of the bag to a twig or branch by means of a silken thread so as to hang in the air and close the mouth of the bag from inside. Female and male larvae can be distinguished from their size as female larvae and bags are bigger than those of males.

Hibernating larvae become active and start feeding again in March and pupate in last week of April to end of June in the bags tightly closed from both sides, fastened securely to the twigs. Females emerge after 7-15 days while males come out after a pupal period of 15-30 days.

CONTROL METHODS

Insecticidal spray is not economical but when required the caterpillars can be killed by spraying Dimilin 25% W.P. or other antimoultant at the rate of 250 grams per hectare. Formulations of *Bacilus thuringiensis* can also prove effective against the pest when sprayed on the trees.

Augmentation of parasites at the time of epidemic can be helpful. By its style the pest always remains in bags on the trees but the parasitised worms fall down on the forest floor. Only the fallen down individuals are adversely affected by forest fires. Large scale forest fires broke during 1970 and 1982 and were the main cause for parasite destruction and free multiplication of the pest. Forest fires should be avoided as far as possible.

Elkneria (Dasychira) mulleri Ebert **(Lymantriidae: Lepidoptera)**
(Pine defoliator)

Dasychira sp. the caterpillars of which have long dorsal yellowish-brown tufts of hair and black pencils of hair on 1st and 11th segments is a serious pest of forest trees. Some species have been reported defoliating pines in U.S.A. and West Germany. In Pakistan it has not been reported as a pest of pine trees before it appeared in epidemic form in 1977 in chirpine forest in Swat.

A vast area covering dense to open crop consisting of pole to middle aged trees, was defoliated seriously at elevations of 1,000 to 1,700 metres

above sea level. In an overall outbreak heavy defoliation occurred in patches.

The biological studies of the pest revealed that it has two generations in a year, one from April to June-July and the second from July to September-October with hibernation in winter in pupal stage during November to March. Pupation occurs in hard cocoons made on the stem, branches and among leaves.

A hymenopterous parasite, *Monodontomerus dentipes* Boheman (Family : Torymidae) naturally exists in the area. The outbreak was controlled by the parasite within the same year.

CONTROL METHODS

In case of an epidemic of the pest, extent of the parasitism by the parasite should be studied. If the parasitisation is less than 50% at the end of second generation, large population of the pest be collected and caged to recover and release the parasite in next spring and to hold back the pest moths to reduce its population.

Ichthyura anastomosis Steph. **(Notodontidae: Lepidoptera)**
(Poplar defoliator)

DIAGNOSTICS

Egg: Semi-globular, moderately convex, hemispherical, 0.6-0.7 mm , light green becoming dark brown and translucent before hatching.

Larva: Light yellowish dorsally, hairy caterpillar, 2-2.4 mm on hatching, 33-36 mm long when full-grown.

Pupa: Strongly glossy, head and thorax portion black, wingcases and abdomen reddish-brown, tapering posteriorly with small hooks, 12.3-13.1 mm long.

Moth: Body greyish-brown, vertex and centre of thorax deep blackish-brown, velvety; antennae pectinate, branches longer in male, thorax densely hairy, abdomen slender, pointed in male with forked anal tuft, forewings rust-brown, with 3 narrow dark-edged transverse bands below the apex. Length 14-18 mm in male, 20-30 mm in female, wing expanse 22-28 mm in male and 30-35 mm in female.

DISTRIBUTION AND HOST PLANTS

The insect is widely distributed in North America, Europe and Asia. In Pakistan and India it is a serious defoliator of poplars and willows.

NATURE OF DAMAGE

It skeletonizes the leaves in the 1st instar but eats out entire leaf in the later stages to cause complete defoliations of willows and poplars resulting in losses of growth and wood yield.

LIFE HISTORY

It remains active throughout the year except the hibernation period from middle of December to middle of February. The hibernating larvae crawl out of cracks and start feeding on bark of poplars and willows in the 3rd week of February. By the end of February they pupate in loose cocoons normally attached to leaves, sometimes between two or more tied leaves or on the ground without any silken webs. The moths emerge in the month of March in about 1-2 weeks and mate within 10-16 hours. A female lays eggs along the midrib on the underside of the leaves, in batches of 15 to 280, with a maximum of 1500 in 5 to 13 days.

The newly hatched larvae feed gregariously on leaves by scraping the epidermis and skeletonizing the leaves after an incubation period of 3 to 10 days. On second and third day they make small holes in the leaves, thereafter they start eating out leaves in patches. Half-grown larvae disperse on the tree and eat away leaves thus completely defoliating the willow and poplar plantations.

The full-grown caterpillars after feeding for 13 to 28 days transform to pupae and emerge as adult moths after 1-2 weeks. Thus a generation is completed in about 25 to 60 days. There are 8-9 successive generations of the pest in the plains from February to December and only 6 generations in the hills from April to November. The young larvae of the last generation hibernate in larval stage but the mature larvae pupate before hibernation thus both larval and pupal stages pass winter to start fresh generation in the next spring.

CONTROL METHODS

Larval stages of the pest can be killed by spraying Bectospiene or Dipel (Bacterial insecticides) at the rate of one kg in 1000 litres of water per

hectare. Dimilin or any other Antimoultants if sprayed on foliage at the rate of 250 grams per 1000 litres of water per hectare can also control the pest completely.

Gyposonoma hapalosarca Meyr. (Tortricidae: Lepidoptera)
(Poplar leaf stitcher)

DIAGNOSTICS

Egg: Oval, flattened, shining, creamy white when laid, changes to reddish light-brown when about to hatch, egg-shell transparent, 0.5 to 0.6 mm.

Moth: Small, buff-coloured to ashy-grey having light transverse bands in the middle of forewings, body length 4.5 mm, wing expanse 13-15 mm.

DISTRIBUTION AND HOST PLANTS

Populus nigra, P. X-euramericana, P. deltoides, P. euphratica and *P. alba* are the common hosts of *Gypsonoma hapalosarca* but degree of infestation varies in different localities. *P. alba* in Peshawar and Kohat, *P. nigra* in Hazara hills, *P. X-euramericana* in Multan and all poplar species in Quetta remain safe from this pest where as all these species are subject to heavy infestation in other localities. The pest is, however, well distributed throughout the country.

NATURE OF DAMAGE

A serious leaf stitcher of poplars causing complete destruction of foliage in the growing season, resulting in serious growth losses.

LIFE HISTORY

Moths from the overwintering generation emerge between first week of March and first week of April and start mating within 10-20 hours, usually at night. Oviposition commences within 12 hours of mating and the eggs are laid along the midrib, singly as well as in batches of 30 eggs with a maximum of 260 eggs per female, in about a week's time.

Hatching of eggs takes place in 2 to 9 days and the young larvae start nibbling at the leaf tissue. The caterpillars stitch two leaves together with loosely spun silken threads and feed in between. After skeletonizing both the stitched leaves from within, the larva either stitches the adjoining leaves with

the old ones or stitches two more leaves separately. In this way passing through six larval instars it spoils upto 33 leaves in a larval duration of 9 to 24 days after which it pupates among stitched leaves or in the cracks and crevices of the bark for 6 to 14 days. Thus the pest completes six generations up to November and the larvae of the 7th generation pupate among skeletonized and dried leaves in the middle of December for hibernation during winter.

CONTROL METHODS

Spraying of phosphatic insecticides like Ekalux, Dimecron, Carbicron can kill the leaf stitchers feeding in between two webbed leaves but natural enemies of the pest and other useful fauna in the poplar plantations are liable to be adversely affected. Spraying the dried fallen leaves on the ground in the end of February or early March can kill the emerging moths of the pest and the plantation can be protected from fresh infestation.

Burning of plant debris during winter before February will also kill the hibernating pest population.

Plecoptera reflexa Guen. (Noctuidae: Lepidoptera) (Shisham defoliator)

DIAGNOSTICS

Egg: Circular, dome shaped, 0.75 mm, pale green when laid, turning brownish-red when about to hatch.

Larva: A semi-looper, smooth, cylindrical, green with 8 white longitudinal lines on the dorsal side, the mature caterpillar one inch long, changes to pinkish before pupation.

Pupa: Dark-brown, about 2 cm long.

Moth: Forewings greyish-brown with oblique irregular bands, underside greyish-white, wing expanse 3.5 cm.

DISTRIBUTION AND HOST PLANTS

Distributed in Pakistan and India. It is a serious pest of shisham in the irrigated plantations of Punjab, Sindh and N.W.F.P. It has also been reported as a pest of *Dalbergia latifolia* and *Pterocarpus marsupium.*

NATURE OF DAMAGE

A serious defoliator of shisham in the compact and linear plantations. With one complete defoliation the trees suffer a loss of 60% in annual growth and with two or three defoliations in a year hardly 20% of the annual growth takes place. Five-six defoliation years occur in a rotation of 20 years which reduce wood yield by 25%.

LIFE HISTORY

With the warming up of the season the greyish-brown moths emerge from pupae hibernating under plant debris on the ground. The moths being nocturnal hide in shady places in weeds, low vegetation and plant debris, becoming active at dusk. After coupling and mating in about 1-4 days the eggs are laid singly on newly sprouted tender shisham leaves up to a maximum of 400 eggs per female. Depending on temperature the larvae hatch out of eggs in 1-5 days and start feeding on tender leaves of the leading shoots. As the larvae moult in 2nd and 3rd instar they start denuding the tree-tops and in the 4th and 5th instars switch over to older leaves defoliating the trees partially in the first generation but completely (many times) in the subsequent generations. Larval feeding period is 8-18 days after which they descend to the ground through silken threads and pupate under dried leaves and plant debris for 7-10 days.

From the time of emergence of moths in spring in the month of March to the start of hibernation in December the insect passes through eleven overlapping generations. Higher rate of survival of overwintering pupae and favourable weather conditions in early spring are the two main reasons for shisham defoliator epidemics during April-May. Dry hot weather in June and July suppresses the pest population but if enough population survives the hot summer outbreaks also occur in September.

CONTROL METHODS

Biological: There are a number of parasites belonging to families Tachinidae, Chalcididae, Eulophidae, etc; which individually do a little to check the multiplication of the pest but collectively exercise a good control particularly in the old irrigated plantations of shisham where rich complex of these parasites exists. The newly started plantations suffer heavy losses due to successive defoliations up to 5-6 years when the complex of natural enemies is developed. Due to natural fluctuations in the populations of pest

and parasites, insect epidemics do occur 5-6 times during 20 years rotation of shisham trees even in the old plantations.

Silvicultural: The shisham nurseries which are maintained over an area of 20-40 hectares in a plantation of 4000-8000 hectares are well looked after for raising planting stock every year and hence possess green and tender leaves during late fall and early spring when the big trees do not possess good foliage. The last and the first generation of the pest prefer to feed on the nurseries and with the coming up of new flush of leaves the pest switches over to regeneration areas and big plantations.

It is, therefore, necessary to monitor the development of pest population in the nurseries in February-March and spray against, if needed, to stop spread of the pest to whole plantation.

Chemical: In case, there is pest infestations in nurseries, regeneration areas or the large compact linear plantations along roads, canals, etc., spraying of Dimilin 25% W.P. at the rate of 250 grams in 1000 litres of water per hectare kills the caterpillars within couple of days. The chemical being antimoultant inhibits moulting when this is ingested alongwith foliage. Since this is neither poisonous nor toxic, no non-target insect is hit by contact. Only phytophagous insects are affected. The useful organisms like insect parasites and predators remain unaffected.

Leucoptera sphenograpta Meyr. (Lyonetiidae: Lepidoptera)
(Shisham leaf-miner)

DIAGNOSTICS

Egg: Oblong-oval, reticulated, white, 0.31 mm.

Larva: Light green with light brown head, constricted between segments, tapering, 5 mm.

Pupa: Spindle-shaped, light brown anteriorly, blackish posteriorly, size 3.5 mm.

Moth: Shining white, forewing narrow, tipped with brownish-yellow and black apical spot and fuscous bars, expanse 0.8-1 cm.

DISTRIBUTION AND HOST PLANTS

A specific pest of shisham, *Dalbergia sissoo* in the irrigated plantations of Pakistan and Northern India.

NATURE OF DAMAGE

The species is a leaf miner and destroys young plants and fresh foliage by causing premature leaf shedding which stunts growth. Heavily infested trees show up with brown spotted foliage which later curl up and drop. The glistening webs for pupation also hamper photosynthesis and give a bad look to the plants.

LIFE HISTORY

With the warming-up of the season and sprouting of the leaves in March the hibernating moths become active and oviposit on the lower surface of the young leaf near the edge. The caterpillar hatches in 2-5 days, mines into the leaf, forming a tortuous line which ultimately expands into an irregular blotch about 15 to 25 mm across. The palisade tissue and large veins are destroyed between the lower and upper epidermis and the leaf dries up. After a feeding period of 11-28 days in March to May, 7-9 days in the hottest months (June-August) and 15-30 days during September to November the full-grown caterpillar leaves the mine and spins a white glistening web with broad X shaped cross cables on the upper surface of a green leaf under which the pupation cocoon is formed. The pupation continues for 10 days in March-April, 5-9 days from May to October and 11-22 days in November.

The emerging adults pass winter as inactive moths in the dried leaves on the ground. They become active during the next spring and oviposit. This pest thus has only one generation in a year, which starts with ovipositing adults and ends with freshly emerged, and ready to hibernate adults.

CONTROL METHODS

Spraying of organophosphatic insecticides with systemic action can wipe out the pest, particularly on nurseries and regeneration areas.

Dichomeris eridantis Meyr **(Gelechiidae: Lepidoptera)**
(Shisham leaf roller)

DIAGNOSTICS

Egg: Elliptical, sculptured, dull-white, 0.7 mm.

Larva: Greenish-yellow, green or dark-grey with two faint sub-median lines, smooth body, slightly flattened, head and pronotum black, full-grown 2.5 cm.

Pupa: Dark-brown, the anal segment with curved hairs, size 9 mm x 2 mm.

Moth: Brown or tawny-brown with narrow oblong forewings, hind wings ashy or brownish-yellow slightly speckled with black, expanse 1.7 cm.

DISTRIBUTION AND HOST PLANTS

It is a specific pest of shisham and is distributed in Pakistan and Northern India.

NATURE OF DAMAGE

The incidence is light to moderate during April and May. The damage is more conspicuous from June to August. It is a minor pest of shisham trees in the irrigated plantations where it may destroy half the canopy in a season, but it causes significant damage to nurseries and young plantations.

LIFE HISTORY

The moths of the overwintering generation emerge in March and lay eggs on the underside of the newly sprouting leaves, usually singly, sometimes in twos and threes. The young ones hatch in 5 days in March and October and in 2-3 days from May to September. The newly hatched caterpillars make their shelter by rolling single leaf or stitching together two leaves with silk. Feeding commences within the shelter on the inner leaf surface by abrading or eating small holes in the leaf edges and blade, mainly at night. The shelter is often abandoned when inner leaf surface is consumed or on disturbance and a new one is constructed. The caterpillar moves about the foliage by using silken thread. The feeding period spread over four moults, is completed in two to four weeks. Pupation occurs in white silken cocoons formed between leaves on the trees or between dead leaves on the ground. The moths emerge after 5-10 days from pupae, hide in plant debris during the day and become active at dusk.

The pest passes through seven generations from March-April to October. The 7th generation caterpillars continue feeding slowly as the cold weather approaches and then hibernate in their leaf-shelters for about 5 months, completing this generation in 160 to 190 days.

CONTROL METHODS

Measures adopted against the principal defoliator, *Plecoptera reflexa* Guen., usually take care of this pest well, particularly in the nurseries and regeneration areas.

Apoderus sissu Marshl. (Curculionidae: Coleoptera)
(Shisham leaf weevil)

DIAGNOSTICS

Egg: Smooth, creamy-white, oblong, 1 mm.

Grub: Wrinkled, curved, white or yellowish, full size 5 mm.

Pupa: White to dark-brown, sparse bristles on body, 2 spines at abdominal apex, size 4.8 mm x 2.7 mm.

Adults: Bright golden-yellow, head, thorax and elytra with black edges, snout, eyes and forehead black, elytra channelled and possess three black patches situated triangularly on their upper halves, female 6 mm, male 4 mm.

DISTRIBUTION AND HOST PLANTS

Widely distributed in Pakistan and India as a serious defoliator of shisham, *Dalbergia sissoo*

NATURE OF DAMAGE

Female weevils construct leaf rolls by biting across the leaf-blade near the base from the opposite edges up the midrib thus dividing the blade in two halves which are folded longitudinally along the midrib. The upper surface is turned inward and the tips tucked in. A cavity is bitten in the midrib and after inserting an egg inside, the leaf is rolled upto the end to form a compact cylindrical packet. It takes 3/4 hour to make one roll which remains suspended from the petiole or falls to the ground. The population is usually abundant enough to destroy the entire flush of new leaves particularly in the nurseries and regeneration areas, in March-April and again in monsoon season.

LIFE HISTORY

The female weevils emerging in March start constructing leaf rolls after laying an egg in each, up to 20 rolls per female. The grubs hatch in 3-6 days during March to September and in 5 to 8 days in October and feed on the inner leaf roll for 10 to 15 days during March-April, 4-7 days during May to October and 20-30 days in November-December. The pupation occurs in a cavity within the roll and the weevil emerges in 3 to 6 days during March to October and 5 to 9 days in November-December. There are eight generations of the pest in a year. The larvae of the last generation overwinter

inside the leaf roll and pupate in the following spring to give rise to weevils in March. The weevils of the last generation maturing early and emerging during or before the winter sets in, do not survive the cold weather.

CONTROL METHODS

Burning of dried leaves and plant debris on the forest floor particularly in the nurseries and regeneration areas before March, will kill all hibernating population of the pest. During the active season spraying of Dimilin at the rate of 400 grams in 1000 litres of water per hectare before the adult emergence will wipe out the larval population feeding on sprayed leaves to protect the crop from further damage by the subsequent generation of the pest.

Melasoma populi L. (Chrysomelidae: Coleoptera)
(Willow leaf beetle)

DIAGNOSTICS

Grub: Plump bodied when grown up, whitish with rows of black spots and black head, size 13 mm.

Pupa: Remains partially enclosed in the larval skin, hangs from the tip on underside of leaf.

Adult: Bright yellow or red, elytra, thorax, legs and underside blue, length 1 mm.

DISTRIBUTION AND HOST PLANTS

Widely distributed in Indo-Pakistan, China, Japan and North Africa as a pest of willows and poplars. At higher elevations in Himalayas it defoliates *Salix babylonica, S. denticutata, S. elegans, S. tetrasperma* and *Populus ciliata.*

NATURE OF DAMAGE

Casually it appears in epidemic form and defoliates the trees completely. In poplar plantations in the plains and foot hills its infestation is rarely severe.

LIFE HISTORY

The beetles pass winter in the soil or humus, where from they emerge in spring and become active with the appearance of new foliage. Eggs are

laid in clusters of 20-30 on the underside of the leaves. On hatching the grubs start feeding by abrading the green part of the leaves. During the larval life of about 3 weeks most of the foliage is skeletonized leaving the veins intact. Just before pupation the grub hangs on the underside of the leaf and pupation occurs as such partly enclosed in the larval skin. Beetles appear in 7 to 10 days to start new generation. There are 2 generations of the pest on the higher elevation and it may pass through 3 generations at the lower altitudes.

CONTROL METHODS

The willows and poplars are rarely found in large patches. Being scattered all over the hills the infestation is not so serious throughout and application of control measures, other than augmentation of natural enemies, is also quite cumbersome. Dipterous parasite *Meigenia bisignata* takes care of the pest. Its augmentation can keep it under control. Spraying of Dimilin 250 grams per 1000 litres of water will kill the grubs.

SHOOT, BARK AND STEM FEEDERS

Indarbela quadrinotata Walk. **(Pseudarbelidae: Lepidoptera)**
(Carpenter worm of poplars)

DIAGNOSTICS

Egg: Flattened oval, light greyish when laid, becomes reddish-brown with embryo development and turns black before hatching.

Larva: Newly hatched black, 2 days old deep red, half-brown yellowish red, full-grown dull and just before pupation light-brown. Mature larva smooth and naked, measuring 35-46 mm.

Moth: Female, forewings light, outer margin with black and white spots; hind wings uniformly light grey with spots and numerous lines. Female dull and larger, male shiny and smaller with conspicuous yellow margins on hind wings. Size, female 30-32 mm, male 25-26 mm.

Pupa: Dark-brown provided with 2-3 rows of saw-like teeth and projections on the abdominal segments which help the pupa to wriggle out of its chamber before emergence of adult. Size 30-35 mm long.

DISTRIBUTION AND HOST PLANTS

A widely distributed lepidopterous borer, very common on *Populus*

nigra, P. X-euramericana in Faisalabad, Lahore, Changa Manga, Sialkot, Attock, Gujrat, Jhelum and Rawalpindi (Punjab), Abbottabad (Hazara) and Muzaffarabad in Azad Kashmir. It also feeds on *Albizzia* spp. *Cassia fistula, Acacia* spp. *Morus alba, Terminalia arjuna, Bauhinia variegata, Pterospermum acerfolium, Prunus bokhariensis, Pyrus* spp, *Greveillia robusta, Lagerstroemia indica,* eucalypts and willows.

NATURE OF DAMAGE

The larva makes an irregular tunnel 2.5 to 6 mm deep in the stem and branches for resting and hiding usually near the base of a branch or in a knot. For feeding on the outer bark it comes out and constructs a very loose cover made of wood fibers and excreta tied with silken threads. Brownish fluid keeps oozing out of larval tunnel which causes rotting of wood around and inside the tunnel. The tree does not suffer serious growth losses but the felled logs fetch less price or are altogether rejected by the match industry due to the presence of numerous holes in it. *Albizzia, Cassia fistula, Terminalia arjuna* and willows are severely attacked but the damage neither kills the tree nor seriously undermines growth or yield.

LIFE HISTORY

The emergence of moths is spread over May to July with majority appearing in June. Within hours of emergence the moths pair, mate and start laying eggs on the depresssions and crevices of the bark on the main stem and branches, mostly in clusters of 10 to 44 eggs. During the life time of 7-9 days a female lays an average of 365 eggs with a maximum of 1330 eggs.

Hatching is completed in 12 to 16 days. The caterpillars start feeding on superficial layers of the bark under a cover made up of bits of wood fibers and excreta tied together with silken threads. On removal of this loose cover small patches of nibbling on the green bark are exposed. After 3-4 months of feeding under the loose cover the caterpillars make a hole into the stem or a branch to make an irregular tunnel (2.5 to 6 cm deep), from which a brownish fluid keeps flowing.

In the young and thinner trees the gallery is shallow and slanting, while in thicker branches and biggar stems the hole is deeper and vertical. The caterpillars mostly come out of their tunnels at night for feeding on bark. After leaving the enterance they loosely close it with frass but a continuous flow of the brownish liquid shows the location of the hole. The larval life

extends up to 10-11 months with about 70 days of hibernation from middle of December to last week of February.

Full-grown larva broadens the tunnel after becoming active in spring to make it a smooth and straight gallery for pupation in the month of April. Pupation takes place in a silken shell at the end of the tunnel from where they wriggle out after a pupal period of 18-25 days to the mouth of the tunnel where emergence of moths takes place. Life cycle is completed in one year.

CONTROL METHODS

Biological: Spraying of pathogenic fungus, *Beauveria bassiana* on the infested tree trunks and branches at the rate of two infected larvae in one litre of water kills the carpenter worm as the fungus comes in contact and develops on these worms.

Chemical: Spraying of Dimilin 25% W.P. or other antimoultants at the rate of 300 grams per 1000 litres of water on infested tree trunks, can give encouraging results.

Ageria Sp. (Aegeriidae: Lepidoptera)
(Clear wing moth of poplar)

DIAGNOSTICS

Larva: Head black, body brownish-black in the beginning, creamy-white with deep-red head when half-grown, full-grown yellowish-creamy with light-brown head. Five pairs of prolegs, each bearing two transverse rows of crochets. Size 22-31 mm long.

Pupa: Light-brown, smooth, shiny, 18-23 mm long with thoracic shield dark brownish, having three rows of spines on the abdominal segments.

Moth: Both sexes shining brown, antennae spindle shaped, wings clear with less veins, wing margins clothed with hairs, forewing narrow with anal area greatly reduced, hindwing with widely expanded anal area, frenulum consolidated in both sexes, hook-like in male and more specialized in female. Size: female 35-40 mm, male 25-32 mm.

DISTRIBUTION AND HOST PLANTS

The borer is distributed in Afghanistan, Iran and Pakistan. It has been found [illegible]cking *Populus nigra, P. alba, P. X-euramericana* and *P. deltoides* in

Parachinar, Dir, Swat, Chitral, Quetta and Rawalakot. It may also be present in other hilly areas of the country particularly drier areas.

NATURE OF DAMAGE

Caterpillars on hatching bore into the bark and make irregular galleries on the stem and branches, sometimes on the base of small trees. The tunnels are widened by feeding which result into knot formation on the branches ultimately causing girdling and rotting of the affected spots through which frass and fluid flow out making the sites easily detectable from a distance. The branch or whole tree snaps off from the infestation site. Drying of shoots and branches cause heavy growth losses. In drier areas like Parachinar and Quetta the infestation is so severe that hardly any tree of 4-5 years age escapes its attack. In other areas the infestation from 25 to 75% trees is quite common. The infested trees get weak and become suitable for the attack of *Melanophila picta* which ultimately kills these trees.

LIFE HISTORY

Emergence of moths from the pupae which had just wriggled out of their chambers takes place in the second half of October and soon after pairing and mating occurs during the day. Females start egg-laying in a couple of days and during their life time of 4-15 days deposite 60 to 560 eggs per female usually in clusters on the stem and branches of the hosts.

Hatching of caterpillars takes place in 18-20 days and they bore into the bark making tiny tunnels upward and downward. Some of the late laid eggs stay in diapause in their oviposition sites, firmly glued in the cracks of the bark. These hatch in February. Larvae from the early laid eggs hibernate in the tunnels upto March. Newly hatched and overwintering larvae bore in the bark and keep widening the tunnels by feeding to form knots and thus produce deformity in the branches and stem portion. After a life of 10-11 months, the larvae mature and make vertical tunnel ending into a pupal chamber made up of compact wood fibers. They pupate in hard silken spun cocoons in September and wriggle out of their pupal chambers after 17-19 days as moths in October. The life cycle is thus annual.

CONTROL METHODS

Silvicultural: Pruning of attacked branches and burning them before September reduces pest population and protects the plantations if carried out as a routine.

Chemical: Application of Temik, Furadan or Disyston granules at the rate of 30 grams per plant of 1-2 years age and 100 grams per plant of 5-6 years of age, in the month of March-April kills all caterpillars feeding in the bark.

Scolytus major Stebbing (Scolytidae: Coleoptera)
(Deodar bark beetle)

DIAGNOSTICS

Egg: Spherial, yellow and shining, 0.8 mm in diameter.

Grub: Curved, legless, white, 5 to 8 mm long, head-end broader, tapering towards abdomen.

Pupa: White, resembling adult in shape but legs, antennae and wings presssed against the breast.

Adult: Shining black; front of head impressed over mouth with tubercles in the middle of forehead; prothorax constricted and impressed on anterior lateral margin; elytra red-brown or black impressed medially at base, striate, punctate, not very conspicuous at apices which are rounded; abdomen with anterior margin of first segment prominent and produced forward and thickened; legs brown to blackish; antennae and tarsi rufous brown. Size 4.25 to 4.5 mm long.

DISTRIBUTION AND HOST PLANTS

Bark beetle of *Cedrus deodara* distributed throughout deodar forests.

NATURE OF DAMAGE

It is a typical bark beetle and most dangerous pest of deodar stands. It usually confines its attack to sickly trees and trees broken by snow or other causes in which vitality has been reduced and upward flow of sap decreased. Newly felled and wind-fallen trees are also attacked.

Long droughts and warm winters followed by early springs help this beetle to build up its population which is bound to attack even the green healthy trees. In such situations the trees growing on exposed aspects, dry southern aspects, poor soil and in open forests fall easy prey to the enormous population of bark beetles. Once a centre of attack is established the insect through successive generations multiply and spreads outwards from the centre in concentric rings, each generation attacking trees nearest to their breeding site.

LIFE HISTORY

The overwintering grubs pupate in early spring and emerge as beetles after seven to ten days but the hibernating beetle population emerge earlier. Both lots of beetles pair and bore into the bark for egg-laying. An oblique enterance tunnel starting under the concealment of a bark flake is made which leads to lower end of a single axial sinuous mother-gallery, about 5 to 8 cm long, partially engraved in the sapwood. The length of the mother or egg-gallery varies according to the thickness of stem or branch attacked. In the boles or large trees these galleries are shorter than those made in saplings, poles and branches. The female after completing the egg/mother-gallery, clears off any frass or wood dust, lays 50 to 85 eggs in egg-niches made in both sides of the gallery.

The larvae on hatching bore their larval galleries in the bast and sapwood, in serpentine fashion, usually at right angle from the central portion and at angles moving away from right angle on both ends of the egg-gallery thus occupying most space around the egg-gallery. The female beetle keeps living in the mother-gallery even up till the grubs mature and pupate probably protecting its young ones from the predaceous insects which would otherwise easily enter the open enterance tunnel and oviposit or destroy the larvae. The larval galleries increase in size with growth of the grubs and in about 4 weeks of larval life 6 to 8 cm long tunnel is eaten out which ends up in a broadened pupal chamber.

The beetle passes through several generations in a year, the actual number depending upon the environmental conditions of the early and late part of the season. In ordinary years there are three complete and a partial fourth generation in a year. Various stages of the pest in different generations appear as follows:-

Generation	Appearance of various stages			
	Egg	Larvae	Pupa	Beetles
1.	April	May-June	June	June-July
2.	June-July	July-August	August	August
3.	August	August-Sept.	Sept.-Oct.	October
4.	October	Oct.-Nov.	Nov and April*	Nov. and April*

*Early maturing grubs pupate and become beetles in November while late brood hibernates as grubs and pupate in April.

CONTROL METHODS

Same as described under *Ips longifolia.*

Ips longifolia Stebb. (Scolytidae: Coleoptera)
(Pine bark beetle)

DIAGNOSTICS

Larva: Whitish-yellow, curved, corrugated and legless. Head well developed, yellow, shining; first prothoracic segment with a dorsal horny plate to it. Size 6 mm long.

Pupa: Yellowish-white, large and thick, prothorax shows a well marked horny shield on the dosal surface. Wings bent on the breast beneath, as also the legs and antennae. Length 6 mm.

Adult: Chestnut brown to almost black, with long brown hairs scattered over thorax and elytra; head smooth, moderately shining, finely punctate; elytral declivity excavate, its sides thickened and toothed, 4-5 teeth, 1st small and sharp, 2nd and 3rd close together usually the largest and knobbed, 4th smaller. Size 4 to 5.5 mm long.

DISTRIBUTION AND HOST PLANTS

Distributed throughout chirpine forests of the North West Himalaya on *Pinus roxburghii.*

NATURE OF DAMAGE

This beetle normally breeds in dead and felled trees and is not a regular primary pest of large standing trees nor does it frequently occur in extensive epidemics as experienced in North America. Usually the outbreaks originate from the felling areas where the insect multiplies on felled material and finding no more suitable food is forced to attack the healthy living trees in regeneration areas. The advance growth and young poles offer best resistance. Similarly primary attacks appear in association with thinnings. The centre of fatal attack is usually surrounded by patch of failed attacks marked by trees displaying many dead beetles entangled in resinous bark.

LIFE HISTORY

The male beetle bores through the thick bark down to the bast and eats

out a squarish pairing chamber in the sapwood below the bark, 2.5 x 2 cm in size. The female enters by the same hole and after pairing bores away from the pairing chamber in an upward direction parallel to the long axis of the tree to make one or more mother galleries running for 5 to 8 cm. Three mother galleries in a Y-shape are the commonest pattern. The egg-galleries are kept free of frass, excreta and other wood particles and one or two aeration holes are eaten out to the outside bark in each gallery. Throughout the length of egg galleries small recesses or notches are drilled and 30 to 60 eggs are laid, one in each.

On hatching, the small grubs eat out galleries, which are very winding often being inclined at an acute angle to the egg gallery and occasionally curving back. The larval tunnels chiefly grooved in the inner bark are tightly packed with frass and excreta. When heavy infestation occurs the main egg-galleries and a mass of intersecting larval galleries almost entirely remove the bast layer.

When full-grown the larva enlarges the end of its gallery in the inner bark into a squarish irregular pupal chamber, clears it of frass and excreta and pupates in it. On maturing the beetle bores straight through the bark to the outside and escapes.

Duration of a life cycle varies according to the climate and elevation. In warmest localities at altitudes of 750 metres there are 4 generations of the pest in a year. The wintering-over generation starting from oviposition in October-November matures in March-April. The other generations give rise to adults in the end of May, end of July and end of September. At the highest elevations there is only one full or two overlapping generations.

CONTROL METHODS

Silvicultural: (i) Sickly dying, dead and wind-fallen trees heavily infested by the bark beetles should be felled and debarked well before the maturity of the beetles and exposed to sun or burnt to kill the developing grub population.

(ii) The green standing trees found infested by bark beetles should not be felled till these are very heavily infested because in their presence healthy trees will not be attacked even if there is heavy population of the insect.

(iii) In case heavy population of these beetles exists in a forest, green trees should be chosen and felled at suitable positions to cover most of the affected area, to serve as trap trees. These trees when heavily infested should

be removed or debarked to kill the grubs before their transformation to pupae and beetles.

Polygraphus longifolia Stebbing (Scolytidae: Coleoptera)
(Pine bark beetle)

DIAGNOSTICS

Larva: White, curved and corrugated with small, yellow shining head; length 2.75 mm.

Pupa: White with yellowish tinge, constricted posteriorly with small flaps; the wing outgrowths on the dorsal surface; short legs and antennae on lower surface.

Adult: Oblong; head black; prothorax and elytra dark, chestnut brown; antennae and legs yellow, slightly chestnut tinge on legs except tarsi. Head with a circular brush of hair on front; prothorax punctate, about a fourth as broad as long with transverse channel in anterior fourth; elytra less than twice as long as prothorax, slightly dilated towards apex, striate, rugose. Size 2.75 to 3 mm long, male smaller.

DISTRIBUTION AND HOST PLANTS

Bark beetle of chir pine, *Pinus roxburghii* in the Himalayas.

NATURE OF DAMAGE

Same as that of *Ips longifolia*.

LIFE HISTORY AND CONTROL METHODS

About the same as that for *Ips longifolia*.

Melanophila picta Pall. (Buprestidae: Coleoptera)
(Poplar bark and sapwood borer)

DIAGNOSTICS

Grub: Newly hatched creamy white with V-shaped wrinkle on pronotum, head invaginated into large prothorax, apodous. Full-grown size 20 mm.

Pupa: Ovate, yellowish in colour, antennae, legs and wings pressed against the chest; size 13-15 mm.

Adult: Black with metallic shine; head short, vertical, deeply sunk into thorax; elytra with 7 irregular light yellow spots; antennae short, serrated; tarsi 5-jointed; size 14 x 5 mm.

DISTRIBUTION AND HOST PLANTS

Melanophila picta Pall is well distributed in India, Pakistan, Afghanistan, Iran and Turkey. In Pakistan it is found infesting *Populus nigra*, *P. alba*, *P. euphratica*, *P. X euramericana*, *P. deltoides* and *Salix* spp. in Peshawar, Rawalpindi, Chitral and Baluchistan.

NATURE OF DAMAGE

On hatching the grubs bore into the green bark. They make galleries below the bark by feeding on wood in patches. They detach the bark from the stem and bore into the sapwood where the grubs pupate. In severe attack the bark on all sides of stem is damaged and the tree dies of strangulation. The attacked trees also break off from the point of infestation even with mild wind. In water-deficient areas almost all poplar trees are attacked, out of which 10 to 30% trees die.

LIFE HISTORY

The emergence of beetles takes place from early May to end of July with majority emerging in June. Pairing and mating occurs in about a week's time and the eggs are laid in cracks and crevices of the bark throughout the female life of 3-4 weeks. Tiny grubs hatching from the eggs bore into the bark and feed on inner phloem and cambial layer just beneath the upper bark eating out patches. One month old grubs measuring 2-3 mm make irregular galleries in the bark but a month later the grubs move deeper touching the sapwood. The full-grown grubs bore into the sapwood and make pupal chambers after feeding for 6 months or more. Grubs hibernate in pupal chambers for 3-4 months from December to February.

After a larval duration of 9-10 months the grubs pupate in their hibernation chambers for 3-4 months (February to May-June). Life cycle is thus completed in a year.

CONTROL METHODS

Silvicultural: Poplars and willows should not be grown in water deficient and poor soils as this pest rarely attacks healthy plants with copious flow of cell sap.

Chemical: In the event of infestation granular insecticides like Temik, Furadan, Disyston should be applied in the soil around the stem of infested trees at the rate of 30 grams per plant of one year age and 100 grams per tree of 5-6 years age.

Biological: Spraying of pathogenic fungus *Beauveria bassiana* on the infested tree trunks and branches at the rate of two infected larvae in one litre of water can control the pest

Aeolesthes sarta Solsky (Cerambycidae: Coleoptera)
(Poplar sapwood borer)

DIAGNOSTICS

Egg: White, elliptical with pointed ends, slightly swollen at one end, measures 3.1 to 4.9 mm

Larva: Newly hatched grub yellowish-white with brown head and black mandibles, half-grown and mature grubs shining yellow, 4 segments following the head larger than the rest 8 segments which are constricted having slit like dark brown spiracles; full-grown larvae measure 5 to 6.5 mm.

Pupa: Yellow, soft bodied, legs tightly pressed on to sterna, bear complete resemblance to future beetle, size 3.6 x 1.6 cm.

Adult: Large, elongate, cylindrical, steel-grey, elytra with thick pubescence, shining-white on emergence, disappearing with age, antennae more than double the body length in male and shorter than body length in female, size 22 to 42.2 mm in male and 29.2 to 43 mm in female.

DISTRIBUTION AND HOST PLANTS

Except for the coastlands and Indus plains the borer is well distributed in Pakistan. It is also found in Afghanistan, Turkestan, Western Tibet and Iran. It has been recorded from *Acer cultratum, Aesculus indica, Corylus colurna, Juglans regia, Malus pumila, Platanus orientalis, Pupulus alba, P. ciliata, P. euphratica, P. X-euramericana, P. nigra, Prunus amygdalis, P. armenica, P. communis, P. racemosa, Pyrus malus, Salix alba* and *S. babylonica.*

NATURE OF DAMAGE

Larvae bore into bark and sapwood of fruit, shade and forest trees. The attacked portion of bark gets detached and falls down exposing the wood

beneath, riddled with network of larval galleries, some still filled with frass The infestation holes surrounded by rotting areas on the bark of attacked trees are visible from a distance. As the grubs grow in size they bore deeper in the bast and sapwood, cutting off the flow of sap and finally killing the trees. Poplars, willows, chinar and elms are attacked the most. Among the fruits, apple, quince, apricot and walnut trees are severely damaged. Almonds and peaches are attacked to a lesser degree

LIFE HISTORY

Beetles appear in the middle of March in Peshawar and early May in Quetta areas with peak emergence from 25th March to 7th April at Peshawar and during May-June at higher elevations Pairing and mating takes place within two days of emergence and eggs are laid within a week, in wound scars or bark depressions usually on the main stem, in small clusters of 7-13 eggs. Beetles are seen feeding on bark and later laying eggs in the feeding scars preferably on the healthy trees which continue for three weeks. A maximum of 231 eggs have been recorded laid by a female. Hatching of grubs occurs in 10 to 22 days. They bore into the bark of the trees and continue feeding in the bark and sapwood for 17-18 months. The hibernation takes place from December to March inside their tunnels which are usually made deeper in the sapwood for this purpose. The full-grown grubs make their pupal chamber during September-October and pupate for 3-4 months. The formation of beetles takes place in January-February and the immature beetles remain lying in their chambers waiting for outside weather to become suitable for emergence.

CONTROL METHODS

Silvicultural: All heavily infested, dead and dying trees, trunks and branches should be cut during October-December and burnt before March to kill the grubs, pupae and immature beetles.

Chemical: Spraying of tree trunks and branches with BHC twice during March and April in the plains and during May and June in the hilly areas will give considerable protection from fresh attack.

Apriona cinerea Chev. (Lamiidae: Coleoptera)
(Poplar stem borer)

DIAGNOSTICS

Egg: Large creamy-white, blunt and rounded on one end, slightly pointed on the other, egg shell thick, white, size 6 to 8.5 x 3.2 to 4 mm.

Grub: Yellowish-white, apodous, with well developed head, powerful and large mandibles, swollen thoracic segments. Body length on hatching 7.5 to 9.1 mm, full-grown 55 to 65 mm long.

Pupa: Whitish-yellow, head wedged into thorax, legs and rudimentary wings folded, six visible sterna, size 25 to 40 mm long.

Adult: Large, elongate, greyish-yellow, under surface golden, elytra with thick coating of pubescence, head with longitudinal median suture. First antennal joint swollen long, 2nd very short, 3rd longer than 1st and 2nd, 4th equal in length of first two joints. Antennae in both sexes equal and slightly longer than the body. Elytra with shoulders produced into spines, basal 1/5th of surface studded with number of small raised shining black points. Apex terminated in three small spines placed some what close together, 3 to 4.5 cm long.

DISTRIBUTION AND HOST PLANTS

Distributed in Gilgit, Dir, Chitral, Swat, Hazara, Parachinar and Muzaffarabad in hills and in Lahore and Sialkot in the plains. The trees attacked are *Morus alba, Morus indica, Populus nigra, P. alba, P. euramericana, P. deltoides, Ficus* spp. and *Debregeasia salicifolia.*

NATURE OF DAMAGE

It is a very serious borer of poplars and mulberries in hilly areas of Pakistan where almost every tree is infested. In the plains (Lahore and Sialkot) every third tree of hybrid poplars is seen infested. The trees are hollowed out by numerous tunnels and usually break from the middle with wind.

LIFE HISTORY

The emergence of adult beetles commences in June and continues upto the second half of August, majority appearing in July. Beetles feed on bark and leaves of host plants and start pairing and mating within 3 to 10 days.

Oviposition starts soon in the eye-shaped slits made by females on young shoots and continues for seven to ten days. During a life time of 1-4 weeks a female lays upto 20 eggs which hatch in 3-4 weeks. The grubs bore into the shoot usually from the oviposition sites and penetrate into the heart of the shoot within 2-3 days from where they make tunnels downwards. For keeping the tunnels clean they make ejection holes to throw the frass and excreta out. The first ejection hole is made within 2 to 6 cm. Later on the interval increases to 15-22 cm, i.e., it becomes bigger with an increase in size of the grubs. The flow of liquid from the holes and accumulation of frass dropped from these holes at the base of the trees is the conspicuous indication of infestation by the borer.

The grubs continue feeding and boring downwards from the top of the shoot to the main stem in case of big trees and reaching the root portion in young plants during a larval period of 8 to 20 months. The grubs on maturity prepare their pupal chambers by plugging tightly their galleries with powder and wood fibers from both ends and pupate for a period of 94 to 112 days (average 3.5 months). The life cycle is thus completed in two years.

CONTROL METHODS

Chemical: After plugging the lower most live ejection hole any dilute insecticide (0.0001%) or even kerosene oil may be injected with ordinary ear washing syringe into the second lowest hole to kill the grub. To achieve good results this measure should be applied in September every year particularly in compact plantations to reduce the incidence and cost of operation in every successive year.

Biological: Spraying of *Beauveria bassiana* fungus on the infested trees at the rate of two infected larvae crushed in 100 litres of water.

Propagation and release of predatory mite, *Proctolaelaps* sp. in the infested plantation to achieve effective biological control of the pest.

Tonica niviferana Walk (Oecophoridae: Lepidoptera)
(Semul shoot borer)

DIAGNOSTICS

Larva: Brownish-yellow when young and orange-yellow with black dots above and greyish or black along the sides and under surface, 25 mm long.

Pupa: Brownish-grey, roughened, usually attached by cremastral hooks to a network of silk, measures 12 mm x 6 mm.

Adult: Forewings white with dark patches, hindwings yellow, resembling a birds droppings when resting with closed wings, wing expanse 37.5 mm.

DISTRIBUTION AND HOST PLANTS

It is a borer of young shoots of semul, *Bombax ceiba* and a serious pest in semul plantations throughout India and Pakistan.

NATURE OF DAMAGE

The larva bores into the tender shoot at leaf axil near the growing tip under the cover of silken web and excavates a tunnel down to the centre of the shoot and may completely hollow out and kill a thick stem down to the old wood of the previous year. The infestation, sometimes, is so severe that hardly any shoot remains uninfested.

LIFE HISTORY

The egg is laid in the leaf axil near the top shoots and the caterpillar just after hatching bores into the new shoot. As the larva grows, it excavates a tunnel down to the centre of the shoot and hollows out the stem. The tunnel is filled with black larval excrement, gum etc. which extrude through the boring hole to remain visible from distance as a blackish mass. The caterpillars continue feeding in the shoot and come out after 18-20 days during May to August, 20-25 days in September and 25-30 days in October to November for pupation on the leaves or on the stem in the open. The moths emerge in 8-10 days during May to August, 15-20 days during September to November.

There are 6-7 generations of the pest in a year. The larvae of the last generation leave their tunnels in November, crawl down to the base of the stem and bore into thick bark of the tree where they form individual chambers for passing winter. During spring these caterpillars become active and emerge from the tunnel towards end of March to pupate exposed on the surface of the stem.

CONTROL METHODS

Collection and distribution of pupae from the base of the trees during early March reduces the pest population considerably. Spraying of the tree bases with any safer contact poison can kill the emerging moths. Spraying of

Malathion at the rate of half a kg/litre per hectare on young plants can kill larvae and protect the saplings.

Agrilus dalbergiae Thery (Buprestidae: Coleoptera)
(Shisham bark borer)

DIAGNOSTICS

Larva: Creamy white grub with head and prothoracic segments flattened, full grown size 2 cm.

Pupa: Yellowish white, 10 mm.

Adult: Elongate, narrow, black with sternal region dull purple, elytron with two white spots, head deeply furrowed its entire length and covered with small transverse ridges, legs very finely punctate, size 9 mm x 2 mm.

DISTRIBUTION AND HOST PLANTS

Agrilus dalbergiae is well distributed in the shisham growing areas of Pakistan and Northern India. It is a specific bark borer of shisham, *Dalbergia sissoo.*

NATURE OF DAMAGE

The grubs boring in the living green bark make zigzag galleries, cutting off sap-flow and ultimately resulting in complete girdling and strangulation of the branch or stem attacked. The branch or whole tree beyond the point of girdling dries up thus killing the growing stock. It is basically a weak and dying tree borer and is not a pest of healthy trees having copious flow of sap. Shisham plantation in the capital territory of Islamabad is entirely dependent on rains. It faces drought from April to June, which causes great set back to the tree health, hence attack of these bark beetles. The pest flourished well on drought striken trees and caused mortality of 10-30% to the growing stock during mid-seventies.

LIFE HISTORY

The emergence of beetles starts in early July and continues upto the end of August or early September. During a normal life of 7-10 days the females mate and lay eggs at night on the bark of tree trunk and branches, usually under the bark flakes (in niches and depressions on the bark). The

flat-headed tiny grubs hatch out, bore into the superficial layers of green bark, make irregular zigzag tunnels, go deeper and deeper as they grow in size. They moult 4-5 times and during this period the grubs continue girdling of the tree trunks and branches for about 11 months and pupate at end points of their tunnels during July to August for 7-12 days. The adult beetles eat out their exit holes from their pupation sites.

CONTROL METHODS

Silvicultural: Shisham is a riverian bed-side tree and can be successfully grown in compact and linear plantations having regular and adequate water supply. It should not be raised in water deficient areas and on poor soils. Pruning and felling of heavily attacked trees and burning them before June will reduce pest incidence to a large extent.

Biological: Place heavily infested material in cages of 300-400 mesh per square inch before June in the infested areas to hold back the bark beetle adults and release the smaller sized adults of *Tetrastichus* sp. which parasitize 30-40% population of the pest.

Chemical: Spraying 1% BHC on tree trunks and main branches of shisham during June prevents oviposition of the pest. Spraying of Folidol or Methyl parathion in 1.5% concentration kills all borer grubs, if conducted before September otherwise the grubs go deep and become out of reach of insecticides so applied.

Hypsipyia robusta Moore (Pyralidae: Lepidoptera)
(Toon shoot borer)

DIAGNOSTICS

Egg: White oval, 0.9 x 0.75 mm.

Larva: Colour varies from pale straw through brown, pink, green to blue with a series of black setiferous spots in 5 longitudinal rows on each side of body, the spots of the 1st and 3rd row being larger. Newly moulted 4th instar larva is reddish-brown which gradually changes to pinkish, purple or reddish-blue and finally to light blue which is characteristic of mature larva, length 19-29 mm.

Pupa: Brown, 10.5-15.7 mm.

Adult: Pale rufous brown mixed with grey and black; forewing veins streaked with black and crossed with zigzag black lines and patches; hindwing whitish, semi-transparent, margin and costal zone darker; wing expanse 26-32 mm in male, 28-42 mm in female.

DISTRIBUTION AND HOST PLANTS

It is a serious pest of plantations of cedars and mahoganies in sub-tropical and tropical forests of South Asian Region, Australia, Africa, West Indies and South America. In Pakistan, it attacks toon, *Cedrela toona* wherever it is grown. In India cedars and mahoganies are heavily attacked.

NATURE OF DAMAGE

Basically a shoot borer but in case of *Cedrela toona* the flowers, fruits and seeds are also attacked, destroying most of the seed crop. As a result of boring the leader and lateral shoots of the current year are killed and branching of the growing tips spoils the quality of wood produced. The pest, although very serious, is not of primary importance because none of its host plants are commercially grown in Pakistan.

LIFE HISTORY

In the first generation 400-600 eggs per female are laid on the flowering shoots of *Cedrela toona*, early in March. Caterpillars hatching in 4-5 days feed gregariously on all parts of paniculate inflorescence, binding together groups of flowers with loose network of silken threads. Each caterpillar prepares a cell of more densely woven silk, inside the network, and moults in it. After a feeding period of 12 days the caterpillars descend to the main stem, locate sheltered places for pupation in cracks and crevices and form silken cocoons to pupate inside. The cocoons are tightly packed in masses, 2 and 3 layers deep, amounting to more than 1000 to a square inch. The second generation lives on fruit and seed of the crop and pupates on the stem in cracks and crevices.

The larvae of the 3rd, 4th and 5th generation feed as borers in the soft shoots. The shoot above the boring hole dies or shrivels, eventually falling over or breaking off. Below the site of entry of larva in the shoot, the buds and the lateral shoots dry up as far downwards as the tunnel extends.

For population the larvae of 3rd, 4th and 5th generations construct silken partitions in the tunnel for protection against natural enemies and rain

water. Pupation takes place in these protected sites in silken cocoons. Fifth generation larvae hibernate in silken hibernaculae constructed in their tunnels.

The incubation period in all the generations remain 4-5 days but other durations differ depending upon weather and feeding sites as follows:-

Duration in days				Parts attacked
Generation	Larva	Pupa	Generation	
1	12	8-10	24-29	Flowers
2	12	8-10	24-29	Fruit & seed
3	49-59	13-14	66-78	Shoot
4	47-60	13-14	64-79	Shoot
5	130-150	13-15	147-170	Shoot

CONTROL METHODS

Since toon is mainly grown as avenue and ornamental tree, cultural methods can easily be applied. Pruning off the attacked shoots containing borers and burning or burying deep in the soil can reduce pest population. Spraying of a pyrethroid or Dimilin 25% W.P. during the first two generations attacking flowers and fruits can wipe out the pest and avoid infestation on shoots.

FRUIT AND CONE BORERS

Dioryctria abietella Denis and Schiff **(Pyralidae: Lepidoptera)**
(Chalgoza cone borer)

DIAGNOSTICS

Egg: Creamy white, oval shaped.

Larva: Reddish to greenish with black head, 25 mm long when mature.

Pupa: Light brown to dark brown, about 2 cm long.

Adult: Forewings grey, mottled with black, wing expanse 25 to 35 mm.

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DISTRIBUTION AND HOST PLANTS

Cosmopolitan in distribution, well known in Europe, widely distributed in USA, Canada, Japan, Northern India and Pakistan, throughout the range of Pinus. In Pakistan it is a serious pest of coniferous trees in Baluchistan, Kurrum Valley, Kaghan Valley, Swat, Hazara, Murree and Azad Kashmir.

Abies pindrow, *A. spectabilis*, *Cedrus deodara*, *Picea morinda*, *Pinus roxburghii*, *P. wallichiana* and *P. gerardiana* are the host plants but damage to chalgoza cones is of great economic importance.

NATURE OF DAMAGE

Young caterpillars bore into the one-year-old green cones, cut the hard shell of the seeds and feed on its edible portion. When one seed is eaten the larva moves to the adjacent seed and feeds on it, by cutting a circular hole near the broad end of the seed shell. Thus the caterpillars destroy many seeds inside and the cones cripple and shrivel showing brownish frass oozing out from the enterance holes which later accumulate as resinous material. The most infested cones fall premature and even the hanging ones do not possess many seeds inside. In case of chalgoza pine the crop on which livelihood of the tribal people depends is destroyed to a large extent. In other conifers destruction of seed crop affects adversely the natural regeneration of crop in the hill forests.

LIFE HISTORY

The female moths lay eggs on one-year-old cones, a few days after mating, singly or in groups of two, three or four upto a maximum of 172 eggs during a whole life of 6-18 days of a female. The eggs hatch in 7 to 10 days in May and 5 to 9 days in August.

The young larva bores into the scales of the green cone, locating the seed, cutting a circular hole near the broad end of seed-shell and feeds on the kernel. After finishing the first seed, grub attacks the adjoining seed and still bores further to approach the seeds in the next scale. In this way the larvae continue feeding on the seeds inside the cones. The full-grown larvae stop feeding after 27 to 38 days in May-June move about in search of suitable pupation site. Generally the central axis of the cone is preferred but some larvae wandering about fall to the ground and pupate in debris and soft sand on the ground. In both cases a silken cocoon is spun around the body in which pupation lasts for 34 to 44 days in June-July.

The moths emerging towards the end of July, mate and lay eggs for the second generation on the green cones of the previous year in early August upto a maximum of 86 eggs per female, average being 43 in August and 22 in September for late layers. The larvae hatch in a week's time and bore into the cones. The larvae from the early layings mature in 5 weeks and pupate in September while the rest hibernate alongwith these pupae inside heavily damaged cones mostly hanging on the trees. Some larvae are dropped on the ground with the opening of cones for dispersal of seeds.

The hibernating population of the pest becomes active in April. The moths emerge from pupae, full-grown larvae pupate and the immature larvae start feeding on seeds.

CONTROL METHODS

Chemical control of the pest is impracticable.

Mechanical: The heavily infested cones of chalgoza carrying 95% population of the pest are left unpicked at the time of harvest of the crop because hardly any edible seed in these cones are left undamaged by larvae. If these cones are also plucked and burnt or buried deep, 95% of the larvae/pupae hibernating in these cones can be destroyed and the pest can be wiped out in 2-3 years.

Alcidodes porrectirostris Marshall (Curculionidae: Coleoptera)
(Walnut fruit borer weevil)

DIAGNOSTICS

Larva: Fat white grub, more or less curved with 12 segments, the middle ones thicker than those at either end; head small, bright yellow-brown. Full-grown 19 mm.

Pupa: Ordinary curculionid shape.

Adult: Black without scaling, legs clothed with yellowish-brown hairs; head closely punctate; rostrum straight and porrect, antennae medium sized fairly thick, funiculus ending in a thick oval knob; elytra much broader than prothorax; body pubescent; front legs longer than others; size 8 to 9.5 mm long, 3.75 to 4 mm broad.

DISTRIBUTION AND HOST PLANTS

Walnut *(Juglans regia)* is found in most hilly areas of Indo-Pakistan, hence this weevil is found wherever walnut is grown.

NATURE OF DAMAGE

The grubs bore into green fruit and feed on endocarp and kernel. The attacked fruit is deformed and fall premature. The weevil destroys 50 to 100% fruit.

LIFE HISTORY

The adult beetles appear in early August and continue to emerge upto September. They hibernate under stones and crevices in the ground until the appearance of the young fruits in spring. Egg laying takes place in incisions in the pericarp of the young developing walnut fruit during the month of April. The grubs hatching from the eggs bore into the centre of the green fruit and feed on endocarp and the kernel, hollowing out the whole inside. Four to five grubs with a maximum of 13 grubs develop inside one fruit. The attacked fruits wither, deform and drop from the tree prematurely in June-July. The grubs on maturity may leave the fruit and pupate in the soil or inside the fruit for 15-20 days.

CONTROL METHODS

Cultural: Collection and burning or burying deep of infested and fallen fruits can reduce the pest population.

FELLED WOOD BORERS

Sinoxylon anale Lesne and *S. Crassum* Lesne
(Bostrychidae: Coleoptera)
(Powder post beetle, Felled wood borer)

DIAGNOSTICS

Grub: White, curved anterior segments enlarged, median dark line running down the back; three pairs of legs present. It is active in movement, wriggling about when disturbed. Length 5.5 to 6.5 mm.

Pupa: White, beetle-like form, gradually assuming shape of mature insect; head, legs and wings pressed on to the underside.

Adult: Oblong slightly dilated behind, black with elytra anteriorly rufous chestnut, more or less dusky, antennae and palpi testaceous, femur paler and

abdomen reddish at the apex; antennae club-shaped; prothorax convex; elytra truncate, size 4 to 5.5 mm long.

DISTRIBUTION AND FOOD PLANTS

It is the commonest bostrychid found in forests, timber depots, sawmills and factories, primarily attacking firewood and sapwood of logs of almost all broadleaf tree species particularly of Family Leguminosae. It is widely distributed in the Oriental Region and has also been introduced in Australia and New Zealand through transport of the infested goods.

NATURE OF DAMAGE

It is a serious borer of firewood, sapwood of logs and materials manufactured with timbers possessing sapwood portions. The grubs work through the wood repeatedly to reduce it to powder. The firewood produced in the forest plantations is heavily infested to cause at least 30% loss of wood produced every year

The adult beetles sometimes bore into green shoots and twigs for the purpose of feeding in scarcity of food or for hibernation, making axial tunnels as a result of which leader shoots of seedlings or young saplings may be girdled or killed. Similarly, sickly and dying trees are also attacked and a black gum exuding from the stem is a clear indication.

LIFE HISTORY

Life cycle varies a great deal, the minimum being 3 months and the maximum goes upto 4 years. Emergence of beetles in the plains continues throughout the year except the coldest months of November to January. As soon as the trees are felled the adult beetles are attracted to the sapwood. The female with the help of the male makes a short gallery, an inch or so in length along the circumference. Mating takes place in this chamber and the female lays 50-100 eggs in niches. The grubs on hatching start feeding and tunnelling along the vertical axis. They make very widening galleries and the sapwood is converted into powder which is packed in the galleries. The grubs assimilate certain sugars and starch, passing out rest of the wood particles undigested, some of which is thrown out of the wood as a powder.

After about 2-3 months the grubs become full-grown and pupate at the end of the galleries. The adult beetles emerge after a month or so by cutting circular holes straight to the outside. They usually fly away to attack other

logs or billets but may attack the same pieces if there is enough moisture and food left in there. In the plantations there are three overlapping generations of the beetles in a year and the peak emergence of beetles is noticed in February-March, June-July and August-September. By far the maximum infestation occurs during these periods. Under unfavourable conditions of food, weather and high density of population the life cycle may be completed in several years

CONTROL METHODS

Silvicultural: Felling of plantation should be restricted to winter months when the activity of the powder post beetles is at its lowest ebb.

Chemical: Spray firewood soon after felling with 8 litres of Dieldrin 20 percent E.C. in 320 litres of water per 100 metre square of stacked firewood. Brush painting, spraying or dipping of sapwood portion of timber in the above dilution of Dieldrin can also make the wood resistant to powder post beetle attack, if done before infestation. Application of the same insecticide with the help of ordinary syringe in the borer holes made in furniture or other valuable wooden articles can kill the borer grubs if well soaked to reach the grubs inside the galleries.

Buprestis geometrica Cast and Gory **(Buprestidae: Coleoptera)**

(Flat-headed borer of pines)

DIAGNOSTICS

Grub: Thorax moderately depressed; abdomen nearly cylindrical; exposed part of head testaceous, slightly darker along the anterior margin. Length 38-40 mm.

Adult: Elongate, finely granulose, dull bronze or black with yellow or yellowish-red spots on elytra; under surface and legs coppery-bronze, head yellow in front with two small black spots, one on each side of the middle line, a small depression on vertex behind the yellow patch. Prothorax broader than long with yellow spots on lateral edges and lateral halves of anterior margin. Length 17-20 mm, breadth 6-6.5 mm.

DISTRIBUTION AND HOST PLANTS

Widely distributed in Pakistan and India almost throghout the hilly tracts as borer of *Pinus roxburghii* and *P. wallichiana.*

NATURE OF DAMAGE

The larva is a borer of dry wood of pines which is repeatedly worked through and reduced to fine powdery dust.

LIFE HISTORY

The beetles appearing on wings during May and June, lay eggs in cracks and crevices on the bark of dead trees and felled logs of chir and kail. The grubs on hatching bore into the bark making irregular tunnels and feed on bark for sometime, later entering the sapwood portion which is repeatedly worked through and reduced to fine powdery dust, during a larval period of 17 to 20 months with 4-5 months of hibernation. Pupation takes place at the end of larval tunnel in a pupal chamber made for the purpose at the end of summer. The beetles emerge from the overwintering pupae in spring and remain in the pupal chambers till suitable environment approaches in April-May. The life cycle is, therefore, completed in two years.

CONTROL METHODS

Mechanical: Early debarking of felled logs prohibits egg-laying. Debarking of logs before hatching of eggs or penetration of grubs into sapwood also protects the timber.

Chemical: Spray one litre of Dieldrin in 40 litres of water on freshly felled logs if debarking is not done.

Stromatium barbatum F. **(Cerambycidae: Coleoptera)**
(Longhorn felled-wood borer)

DIAGNOSTICS

Egg: Elongate ovoid, one end slightly, the other end distinctly blunt, white, granulate; size 2.1 x 0.8 mm.

Grub: Nearly white, head capsule slightly pigmented; body-form robust, anterior segments subquadrate in cross-section; with extremely sparse, moderately long, body hairs. Length 35 mm.

Pupa: Yellowish white, exerate.

Adult: Brownish-black to reddish-brown covered with a tawny pubescence; antennae much longer than body in male, not so in female; prothorax very

densely covered with strong coarse punctures; elytra punctate; size 12-29 mm long, 4-7.5 mm wide.

DISTRIBUTION AND HOST PLANTS

It is a well distributed pest of felled wood of *Acacia catechu, Dalbergia sissoo, Dendrocalamus* spp. and *Mangifera indica,* in Pakistan and India.

NATURE OF DAMAGE

It is an important pest of sapwood portion of many common woods usually used for packing cases, woodworks in buildings, furniture, plywood, panels and firewood.

LIFE HISTORY

Eggs are deposited in small holes, crevices or fissures in wood, singly or in groups during June-July. A female lays 60 to 100 eggs during a period of 7 to 16 days. After an incubation period of 5 to 13 days the tiny whitish grubs hatch out and start boring into the wood of any kind, even through the surfaces treated with varnish, resin, oil, or any antiseptic materials

The grub makes irregular tunnels and the sound produced by abrading action of the mandibles is quite audible. The tunnels are loosely packed with powdery frass and excreta. The grub matures usually in 10-11 months and pupates at the end of its tunnel at various depths from the surface without making any pupal chamber. After about 2 weeks of pupal duration beetles appear on wings in the month of June.

The life cycle is usually annual but depending on the suitability of the wood, infestation continues for several years. The longest life cycle recorded is 10 years.

CONTROL METHODS

Chemical: 1. The timber and firewood sprayed soon after felling or in May-June with Dieldrin 20 E.C. at the rate of one litre in 40 litres of water will remain protected.

2. Spraying of logs and dimensioned timber in the saw-mills and factories dealing with wooden materials in May-June can avoid fresh infestation by killing the emerging beetles.

3. Drilling the infested parts of furniture or other valuable wooden articles and injecting insecticide even kerosene oil till saturation of the frass and powder has reached in the galleries, will kill all feeding grubs.

NURSERY PESTS

1. COCK-CHAFER BEETLES, *(Anomala polita, A. grandis)*

A number of species of the families, Cetonidae, Dynastidae, Melolonthidae and Rutelidae are cock chafers. More important are the members of genera, *Anomala*, *Adoretus*, *Melolontha*, *Oryctes* and *Popillia*. The beetles, both day-flying and night-flying, are abundantly found in the hills. Brightly coloured, testaceous, brown or green beetles usually swarm first in May after the earliest shower of rain. Pairing and oviposition takes place throughout the rainy season. Eggs are laid at night in soil at a depth of 5-8 cm, singly. The eggs 3-5 mm increase visibly in size and become more spherical as they mature.

On hatching the grubs tunnel through the soil, eating out the rootlets of plants and rotted vegetable matter. Seed beds having well-worked soil, are preferred for oviposition. The grubs continue feeding under ground from June to March when they pupate in their tunnel inside their split larval skin. Pupation is completed in about 10 days to two weeks but the beetles keep lying in the soil waiting for the outside weather to improve with the first shower of rain. The life cycle is completed in a year.

The beetles swarm at dusk and settle on broad-leaf trees, mostly hill fruits and shade trees such as Alder, Ficus, Chinar, Walnut, etc. The entire foliage is destroyed by feeding holes in them. The grubs destroy seedlings in seed beds making nursery raising difficult in hills.

CONTROL METHODS

Mixing of one kg of Sevin SP in well rotten organic manure in an acre of nursery beds kills the grubs.

Placing of a lamp over a basin containing poisoned or kerosinized water about 50 yards away from the fruit orchard or trees to be protected will attract all beetle swarms to the light at dusk. The beetles falling in kerosinized water will die.

2. CUTWORMS

Larvae of the genera *Agrotis*, *Euxoa*, etc., of the family Noctuidae are cutworms or surface caterpillars and serious pests of nurseries and regeneration in forests. There are several species of cutworms but *Agrotis ypsilon*, *A. segetum*, *Euxoa segetis* and *E. spinifera* are more commonly found.

As polyphagous pest of agricultural and garden crops and of nurseries

and regeneration in forests the cutworms appear in early spring as moths which oviposit in the soil laying upto 2,000 eggs per female mostly in humus, weeds and sowings. The cutworms on hatching within 3-6 days feed on foliage or humus or dried leaves if fresh foliage is not available. They are also carnivorous living on larvae even cutworms. Being nocturnal they hide during the day in burrows 1-3 inch deep in soil. Young seedlings are cut through the stem at ground level They destroy more than they eat, thus large patches in seed beds and regeneration are destroyed.

After 20 to 35 days feeding period it pupates in the soil for 10-30 days in a smooth earthen cell. The life cycle is passed in 5 to 8 weeks having a number of generations in a year depending upon weather of the area.

CONTROL METHODS

Dust BHC or Sevin in seed beds and regeneration areas. Light trap in the early season will reduce cutworm population considerably. Flood irrigation and application of Malathion or BHC will kill the cutworms.

3. FIELD CRICKETS AND GRASSHOPPERS

Brachytrypes portentosus, Gymnogryllus erythocephalus and *Gryllotalpa africana* are important field crickets attacking nurseries and regeneration crops in hills and plains. A number of grass hoppers exist in our forests living on vegetation of all types. Besides true locusts, *(Schistocerca gregaria* and *Locusta migratoria), Chrotogonus* spp. and *Poecilocerus pictus* are serious pests of sowings in the seed beds. Large patches of seedlings and regeneration areas are cleared at a stretch and repeated resowings are to be done.

The crickets cut seedlings or low shoots at night and drag the pieces to to their tunnels in the soil for feeding. Eggs are laid in the tunnels at the bottom in September-October. Young crickets appear in spring when peak damage is noticed.

Grasshoppers lay eggs in soil in masses of 100 or so from June to August. A portion of brood hatches in 7-8 weeks the rest overwinter and hatch in spring. These are 7-9 moults before adult stage is reached. The life cycle is annual.

CONTROL METHODS

Eggs can be destroyed by ploughing or digging the fields and exposing them to sun and predators. Poison baits spread in nurseries and

regenerations can control cricket and grasshopper populations. Application of BHC or Sevin with irrigation will kill the crickets in nurseries.

4. LAND SNAILS

Land snails and slugs *(Gastropoda, Oullusca)* are most active at night and in damp weather. They glide slowly and smoothly by waves of muscular action on the ventral side of foot over a 'slim track' of mucus secreted by large pedal glands below the mouth.

NATURE OF DAMAGE

Snails cause damage in kitchen gardens, fruit orchards, green houses, nurseries and agricultural fields by nibbling on the leaves and cutting young plants close to the soil surface or gnawing on roots or other subterranean parts of plants which result in complete destruction of plants. Occurrence of large population of snails in coniferous nurseries in hilly areas has seriously threatened planting programmes.

Snails become active in spring after remaining inactive during cold winter. The population subsides during hot dry weather in May-June and builds up again in rainy season in the plains. In the humid hills they remain active throughout summer but damage is severe during monsoons.

Reproduction is preceded by mating between two snails during which a dart from each is discharged into the body of the other. Snails being hermaphrodite and copulation is reciprocal by which both end up pregnant. Each later deposit one or more batches of gelatinous covered mass of eggs in damp places or shallow slanting burrows. Hatching eggs give birth to young snails.

Being nocturnal the snails hide by day beneath objects on the ground, in crevices or in burrows and the soft head and foot are drawn into the shell. In dry hot weather a temporary covering of mucus and lime is secreted to cover the shell aperture and avoid desiccation. In winter they bury themselves deep in soil to protect from cold.

CONTROL METHODS

Put Temik or Furadan granules about 100 grams on each 30 x 30 cm plastic sheets and place them all over the nursery area, vegetable garden or any affected field at 10 metres distance from each other to kill all snails by attraction and contact poisoning.

5. PORCUPINE

The Indian porcupine, *Hystrix indica* Kerr (Rodentia, Mammalia) is

common nocturnal rodent abundantly found throughout the country.

It is a cosmopolitan pest of trees and crops. There are three species of sub-genus, *Hystrix indica* occurring in southern and western Asia, *H. cristata* found in Italy, North, West and part of East Africa and *H. africaeaustralis* in Central and Southern Africa. All species are similar in appearance.

It is a pest of seedlings, saplings and poles of forest trees and agricultural crops, such as gram, maize, sugarcane, tubers and vegetables. Among the forest trees Mulberry, Semul, Shisham, Bakain, Siris, *Cedrela toona*, *Terminalia arjuna*, *Acacia modesta* and *Pinus roxburghii* are usually debarked, cut or uprooted. The animal has preference for different trees in different localities where one or two of these trees are damaged and rest are not touched. Agave planting in scrub forest has completely been wiped out several times while other host plants remained safe. In irrigated plantations mulberry and bakain are preferred.

Porcupine breeds twice a year, in March and September and usually two young ones are produced in the main chamber of the burrow. The young ones live on mothers milk initially but soon start feeding on tender bark. Porcupine burrows are long and deep in loamy soil and short and shallow in stony area. The opening of 30-35 cm diameter leads to a short tunnel (60-80 cm) which opens into main chamber of 50-100 cm dia. in hilly areas. From the main chamber 2 to 4 tunnels of 2 to 5 m originate, depending on the population. In plain areas the opening leads to a long tunnel which is sloping downward turning 2-3 times at sharp angles, making 3-4 slanting tunnels of 2.5 to 5 m each having small chambers at each turn, the deepest being 7-8 metres from ground level.

CONTROL METHODS

Placing Phostoxin, Agtoxin or Detia tablets in porcupine inhabited burrow, 3 in hills and 5 in the plains and closing the opening tight with earth will kill all the inhabitants.

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Chapter 14

APICULTURE

Manzoor-ul-Haq*

The honey bee due to its industrious habits for the production of honey has attracted the attention of the human race since the dawn of civilization. It serves man in a variety of ways. For example, it pollinates most of the agricultural and horticultural crops and thus helps in setting their seed and fruit. The wax produced by it is used in the preparation of cosmetics, polishes, electric insulating apparatus, candles, etc. The honey produced by it is used for medicinal purposes as well as food. However, its value as a pollinator is estimated much higher than as a producer of honey and wax.

Beekeeping in indigenous hives in Indo-Pakistan sub-continent is being practised since ages but the credit for initiating any attempt in modern beekeeping goes to Sir Louis Dane who kept eastern honey bee, *Apis indica* F. (*A. cerana F.*) in movable hives in 1883-84 at Kulu (India). It was he who as Lieut Governor of the Punjab tried to arouse interest in this industry in 1908 and continued thereafter up to 1917 but all his efforts did not bear fruit (Rehman, 1941). The efforts made by a few more persons to establish western bee, *Apis mellifera* also ended in futile (Rehman and Singh, 1940b). However, beekeeping on scientific lines remained a neglected industry till 1934 when the Entomologist, Department of Agriculture, Punjab, started investigations on *Apis cerana* F., the domesticated species at the Punjab Agricultural College and Research Institute, Lyallpur (Faisalabad). Since then a considerable knowledge on the domestication of this beneficial insect in the plains has been accumulated (Rehman, 1943). The work on beekeeping was extended by one of his descendants in 1973 with the import of a few colonies of the western bee, *Apis mellifera* L. which showed good progress in the northern region of the Punjab (Pakistan).

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Pakistan Agricultural Research Council (PARC), Islamabad took initiative in 1977 and imported a few colonies of *A. mellifera* and aroused interest in the private sector for taking up this industry on commercial lines. PARC is making every effort to develop this industry at the national level. An Entomologist (Beekeeping) with his headquarters at Rawalpindi has been appointed by the Government of Punjab exclusively for the development of this industry in the province. The University of Agriculture, Faisalabad and Ayub Agricultural Research Institute, Faisalabad, are also maintaining small apiaries for teaching and research at their premises. Economics of beekeeping has also been worked out in Pakistan (Ahmad, 1985).

This chapter contains information about research investigations conducted mostly on *Apis cerana* F. and *Apis mellifera* L. in the part now constituting, Pakistan.

SPECIES OF HONEY BEES

Four species of honey bees, three native and one exotic, are found in different parts of Pakistan. A brief description of these species is given as under:-

Apis dorsata F. (Giant or Rock honey bee)

It is commonly known as *Doomna'* and is found in the plains and submontane tracts specially of the northern region of the country. It is migratory in habit and is prone to excessive swarming. Its migration depends upon climate and bee plants. It usually visits plains in March-April and leaves them in June.

It builds a single large comb, measuring 2 metre in length and 3/4 metre in breadth, generally suspended on the branches of tall trees and occasionally from rocks. The worker and drone cells are similar in size but can be differentiated from their cappings which are smooth in worker cells and rough and raised in drone cells (Qayyum and Ahmad, 1967). There are 18.7635 of these cells per 4 linear inches. The brood comb is 1.5 to 1-5/8 inches thick, but the honey portion may be up to 9 inches thick. The workers measure 16 to 18 mm in length and weigh about 3,000 pound (Rehman and Singh, 1940a). The average tongue length of the worker bee is 6.68 mm (Rehman, 1941). Drones are stout and shorter in length.

It is an industrious species, builds up rapidly and yields up to 80 lb. honey per colony per year (Rehman and Singh, 1940). It is very easily provoked and attacks en masse humans and animals often with fatal results

(Rehman, 1941). Although it responds to smoke very well but on account of its migratory behaviour, wild habits and feroecious temperament it is not fit for domestication (Ahmad, *et. al.,* 1978).

Apis florea **F. (Little honey bee)**

It is commonly known as 'Chhoti makhi' and is restricted to the plains of the country. It is also wild in nature, migratory in habit and prone to swarming. It builds a single comb in bushes, hedges, twigs, stacked cotton sticks, etc. A single comb measures up to 30 cm in length and 15 cm in breadth. It is gentle in temperament but is poor yielder, i.e., a colony may yield .5 to 1 kg of honey in a year. It is not suitable for domestication. The average tongue length of the worker bee is 3.441 mm (Rehman, 1941) and there are 32.8849 cells per 4 linear inches and workers brood comb is 19.23 mm thick (Rehman and Singh, 1946).

Apis cerana **F. (Eastern honey bee)**

It is commonly known as 'Pahari makhi' as in nature it is found in the hilly tracts of the northern region of the country viz, Murree, Hazara and Swat hills, etc. However, Swat strain has produced better results.

It builds parallel combs in the cavities of tree trunks, hollows of rocks and in the wall recesses of the houses specially prepared by their dwellers (Ahmad, 1983). It is prone to excessive swarming, robbing and absconding. It is industrious and docile and is fit for keeping in the modern hives. The average honey yield per colony in nature is 4.00 kg in a year as against 10.00 kg in modern hives.

The average tongue length of the worker bee is 5.525 mm (Rehman, 1941) and there are 21.2576 worker cells per 4 linear inches and the worker brood is 22.64 mm thick (Rehman and Singh, 1946).

Apis mellifera **L. (Western honey bee)**

It is also a domesticated honey bee. Although it closely resembles to *A. cerana* in body structure, habits and behaviour yet it surely is a separate species (Ruttner, 1966), because all efforts to have a cross between these two species have failed. It is a good temperament bee and besides being a high yielder it is an efficient pollinator and on this very account its services for honey production and pollination are being utilized in most of the countries species have failed. It is a good temperament bee and besides being a high yielder it is an efficient pollinator and on this very account its services for

honey production and pollination are being utilized in most of the countries of the world. It is less prone to swarming, absconding and robbing. The average yield of honey per colony per annum is 25 kg. The average tongue length of the worker bee is 6.438 mm (Rehman, 1941).

It was successfully introduced in the Punjab province in 1973 through the efforts of the Entomologist, Ayub Agricultural Research Institute, Faisalabad. Pakistan Agricultural Research Council has now introduced it in the other provinces of Pakistan including Balochistan (Ahmad, 1985) both in the public and private sectors. There is a great demand for this bee from the people at large but due to limited breeding programme in the country their demands are not being fully met.

Comparative studies on the three races of *Apis mellifera* L. viz., Italian (*A.m. ligustica* Spin.), Carniolan (*A.m. carnica* Pollmann) and Caucasian (*A.m. caucasica* Grub.) revealed that all the three races flourished well in the northern region of the Punjab. However, the caucasian race proved better. It was also found that some of the bee colonies of different races fell an easy prey to wasp, *Vespa velutina sureria* Smith and a bird, *Merops orientalis* Latham and they were also robbed by *Apis indica* F. (Makhdoomi, *et al.*, 1977).

HONEY BEE COLONY

The honey bee being a social insect leads a colonial life. A colony comprises of three different castes, a queen, thousands of workers and a few hundreds of drones, but none of these can survive an independent life (Muzaffar, 1983). Thus it is the relationship between these components of a colony which collectively make colony life possible and hence beekeeping a practicable enterprise. The characteristics and activities of the different castes in a bee colony are described as under:-

Honey Bee Castes

Queen: A colony of honey bee usually obtains a fertilized queen (sexually developed female) which is readily distinguishable from both workers and drones by shining colour and long tapering abdomen that extends far behind her wings. A virgin queen mates, once in her life, with about 8-10 drones in the air and the sperms that are stored in her spermatheca during her nuptial flight remain viable during her entire reproductive life. This behaviour of queen mating avoids inbreeding which is detrimental for colony vigour.

The mated queen lays two types of eggs, fertilized and unfertilized. Queens and workers are produced from fertilized eggs while drones emerge from unfertilized ones. The difference between queen and workers emerging from fertilized eggs is due to nutritional variation i.e. the developing queens during whole of their larval life are fed by the nurse bees on royal jelly, the secretion of their hypopharyngeal glands, while the worker larvae are fed on this diet for three days only. The larvae to be formed as queens are reared in special large sized cells called "queen cells" that usually hang at the bottom or sides of the brood comb and the developed queens emerge out of these cells, one queen per cell, within about 16 days. The queen leaves the colony only for mating and with her swarming or absconding colony. She possesses a well-developed sting having a few barbs and is usually for fighting out her rival queens.

Although the queen can live for 2 to 3 years or even more but her efficient productive life is usually for about a year and, therefore, one-year old queens should be replaced by young vigorous mated queens (Gondal and Hashmi, 1976; Rehman and Singh, 1946b).

Besides egg laying, queen produces in her mandibular glands pheromones (scents), one of which attracts the workers of her colony and helps keep cohesion among the inmates of the hive. Another pheromone (inhibitory scent) of these glands in combination with 9-oxodecenoic acid called ' queen substance' inhibits queen rearing by the workers of her colony and also prevents the development of the ovaries of the workers. This substance is licked off her body by the young workers of courting the queen and is supplied by them mixed with the regurgitated food to the workers so that they remain aware about the presence of their queen. The older queens have been found to produce this substance in smaller quantities which consequently results in swarming or queen supersedure and when a queen meets an accidental death the workers begin to rear new queens within a few hours of queenlessness (Chaudhry and Johanson, 1971).

Workers: The workers (sexually immature females) constitute the major population of the colony which may number from 10,000 to 80,000. They are the product of fertilized eggs but they remain small-sized sterile females due to nutritional deficiency occurring during their larval period. Since their ovaries remain under-developed they do not lay eggs except the laying workers which start laying eggs only when their colony becomes queenless and they fail to raise another queen. The progeny of the laying workers comprises of only drones, however, such colonies perish sooner or later.

The workers perform all the indoor and outdoor duties for the colony. The indoor duties, usually up to three weeks of their adult life, include regulation of colony temperature, brood rearing, feeding of queen and drones, comb-building, maintenance of sanitary conditions, colony defence, nectar and pollen storage, ripening of honey, etc. The outdoor duties include nectar and pollen collection, bringing in water for colony during summer and collection of propolis. The propolis is a sticky gummy substance collected by workers from the exudations of certain trees, and used for holding the frames together and for closing the cracks and crevices of the hive through which cool air can enter. Their tongue enables them to collect nectar from the nectaries of flowers and their modified hind legs and hairy body helps them to collect pollen. The ovipositor has been modified into sting, which is used as an organ of defence.

Royal jelly, a product of their hypopharyngeal glands, is a food for developing larvae and queen bees. The wax is produced in glands located on the underside of the abdomen.

Drones: They are sexually developed male members of the colony and their number is restricted up to a few hundreds. They are the product of unfertilized eggs. They are readily recognized by their stout body, bluntly rounded abdomen and large eyes meeting on the head. The cells in which they are reared are larger in diameter and are usually located in the corners at the bottom of the comb. The cappings of their cells are bulging out while those of the worker cells are flat. They are without sting and possess underdeveloped mouthparts and are usually fed by the workers. Their only duty is to fertilize the virgin queens at the cost of their life which, of course, ensures the continuation of their generation.

They normally live for about 2 to 3 months but usually are killed by the workers before the commencement of monsoon or winter season as they are then considered a burden on colony food reserves.

Life Cycle

All castes of the honey bee pass through three developmental stages viz., egg, larva and pupa before they emerge as winged individuals. This chain of events from egg to adult constitutes the life cycle of the individual. These

stages of different honey bee castes (*Apis mellifera* L.) are completed in varying durations as given below:-

Caste	Duration of developmental stages (days)			Total duration (days)
	Egg	Larva	Pupa	
Queen	3	5.50	7.50	16
Workers	3	6.00	12.00	21
Drones	3	6.50	14.50	24

The above-mentioned durations with slight variations also hold good in *A. cerana*. However, the total developmental period in queen, worker and drone of *A. dorsata* was completed in 13 to 13.5 days, 16 to 20 days and 20 to 23.5 days, respectively (Qayyum and Ahmad, 1967).

Seasonal Cycle

A wide variation in the environmental conditions and bee plantation is found in the different geographical regions viz., plains, sub-montaneous tracts and hilly areas of Pakistan. The suitability for beekeeping in the different season also varies, accordingly. In the plains, honey bee of a colony remains active throughout the year but high temperature and dearth of honey plants during summer (June-September) slow down their activity. The bees stay in their hive most of the time and there is considerable decline in brood rearing activity. The aging bees face the natural death but in the absence of their replacement by the younger bees the colony strength dwindles drastically. The attack of bee enemies, viz., wax moth, wasps, mites and bee eaters during this season further worsens the situation. This results in uneconomical units or the most affected colonies abscond. However, with the availability of food source particularly *Brassica* sp. ('toria' and 'sarson') and decrease in the intensity of temperature in October, the bees of the surviving units resume field and brood rearing activities and then the colonies continue to build up their strength though at a slower pace, throughout the winter (November-February). Some stronger colonies yield surplus honey with the onset of spring season (March) when the temperature becomes normal and the citrus flow becomes available which stimulates the bees for increased foraging activity and intensive brood rearing. Consequently, the colonies become

crowded and the bees divide through swarming. In this way their strength is again affected but prevalence of optimum environmental conditions and availability of bee flora in plenty enable them to make good of the loss within April, so that the dividing units are capable of collecting surplus honey from Egyptian clover during April-May.

The sub-montaneous tracts (up to 1500 metres) are ideal for bee-keeping as plenty of bee flora is available and suitable environmental conditions for the honey bees prevail there almost throughout the year. The honey bees thrive well on shain *(Plectranthus rugosus)* during September-October and yield surplus honey. The bees utilize loquat and *Eucalyptus* flowers from October to March for building up their lost nutritional strength and surplus honey collection. It is followed by 'Baikar' and 'Granda' flowers during March-April. 'Asl-i-amir' as a good source of nectar from May to September, is a defensive stay against the mishap in beekeeping industry during this period.

In the higher hills the period from April to September is suitable for beekeeping but later on the bees abscond or migrate to the lower hills. Moreover, severe winter (December-February) and lack of bee flora work against the well-being of the colonies. Therefore, shifting of the bees to the lower hills is a feasible, economical and practical proposition to safeguard the bees against severity of the cold at the higher hills.

Bee Flora

The flora includes a variety of wild and cultivated plants which yield nectar and pollen accessible to bees. Nectar is a principal source of carbohydrates on which the adult bees thrive while the pollen is the sole source of proteins, fatty substances, minerals and vitamins essentially required by the nurse bees for the production of larval food and for the development of newly emerged bees. The brood cannot be reared in the absence of protein and the adults cannot survive in the absence of carbohydrates. Thus, nectar and pollen yielding plants supply the raw material for colony development and production of honey which is converted form of nectar. However, honey yield depends upon weather conditions and nature of honey-flow (Rehman, 1944).

In order to manage bee colonies for honey production the beekeeper must have the knowledge about the availability of nectar and pollen sources in the vicinity of his apiary. In Indo-Pakistan sub-continent a large number of nectar and pollen plants are on record which are useful for honey bees

(Ahmad, 1981, 1984; Ahmad and Munawar, 1985; Latif *et al.*, 1958; Makhdoomi *et al.*, 1977; Qayyum and Shahid, 1975; Rehman, 1960; Rehman, 1945; Rehman and Sharma, 1947; Rehman & Singh, 1940a; Rehman and Singh, 1941a) but only a few are major sources of nectar and pollen while others are minor or supporting sources. Although it is not practicable to grow crops or plants exclusively for beekeeping, yet there are agricultural and horticultural crops that provide nectar and pollen to the bees and can very well fit in the cropping patterns of the respective regions.

There are also many ways in which plantings made for other purposes can benefit bees. For example, shrubs and trees grown in the recreation areas can provide beauty and pleasure for people and nectar and pollen for honey bees. Forest plantations, roadside plants and those on the banks of the canals can also provide forage to the bees.

Ornamental flowers in orchards and gardens are considered enough by a layman to make them suitable for beekeeping but in reality all good looking flowers do not provide honey to the honey bees. Some flowers e.g., butter cup and daisies yield so little nectar and pollen, that they are frequently ignored by the bees. *Ipomoea* and *Naustursium*, because of tubular construction of the flowers, have nectar so deeply located, that it is not within the reach of honey bees. Similarly, there are many flowers e.g., some varieties of roses and marigold in which pollen remains concealed because of double corolla, and cannot be utilized by the bees (Rehman and Sharma, 1947). However, there are some ornamental flowers, viz., antigonon, bottle brush, portulaca, anchusa, etc. which are eagerly visited by the honey bees for nectar or pollen or both.

A list of major and some supporting sources of nectar and pollen and the flora that can help tide over period of food dearth (June-September) in the plains and sub-montane tracts is given below:-

the flora that can help tide over period of food dearth (June-September) in the plains and sub-montane tracts is given below:-

Table No. 1. Plants useful for nectar and pollen for honey bees

Local or English Name	Botanical Name	Status	Distribution	Blooming Period	Source of Supply
a) *Major Sources*					
Citrus	*Citrus* spp	Fruit trees	Plains	March	Nectar and Pollen
Shisham	*Dalbergia sissoo*	Tree	Plains	April-May	Nectar

(Cont'd)

(Cont'd)

Local or English Name	Botanical Name	Status	Distribution	Blooming Period	Source of Supply
Berseem	*Trifolium alexandrinum*	Fodder seed crop	Plains	April-June	Nectar and Pollen
Phulai	*Acacia modesta*	Tree	Plains, sub-montane tracts	April-May	Nectar and Pollen
Mesquite	*Prosopis Jubiflora*	Tree	Plains, sub-montane tracts	April-May	Nectar and Pollen
Shain	*Plectranthus rugosus*	Shrub	Sub-montane tracts	September-October	Nectar
Loquat	*Eriobotrya japonica*	Fruit tree	Sub-montane tracts	October-February	Nectar and Pollen
Toria & Sarson	*Brassica* spp	Crop	Plains	November-March	Nectar and Pollen
Sufaida	*Eucalyptus* spp	Tree	Plains, sub-montane tracts	November-April	Nectar and Pollen
b) *Supporting Sources*					
Deciduous fruits	*Malus* spp. *Prunus* spp *Pyrus* spp	Fruit trees	Sub-montane tracts	February-April	Nectar and Pollen
Antigonon	*Antigonon leptopus*	Creeper	Plains	March-October	Nectar and Pollen
Litchi	*Nephalium litchi*	Fruit crops	Plains	March-April	Nectar
Radish	*Raphanus sativus*	Vegetable seed crop	Plains, sub-montane tracts	March-April	Nectar and Pollen
Onion	*Allium cepa*	Vegetable seed crop	Plains, sub-montane	April-May	Nectar and Pollen
Grunda	*Carissa opaca*	Shrub	Sub-montane tracts	April-May	Nectar and Pollen
Bottle brush	*Calistemon lanceolatus*	Trees	Sub-montane tracts	September-October	Nectar and Pollen
Date-palm	*Phoenix dactylifera*	Fruit tree	Plains tree	April	Nectar and Pollen

(Cont'd)

(Cont'd)

Local or English Name	Botanical Name	Status	Distribution	Blooming Period	Source of Supply
c) *Dearth Period Sources*					
Portulaca	*Portulaca oleracea*	Ornamental plant	Plains tree	June	Pollen
Lucerne	*Medicago sativa*	Fodder crop	Plains tree	July-August	Nectar
Asl-i-amir	*Vitex negundo*	Shrub	Sub-montane tracts	July-September	Nectar
Maize	*Zea mays*	Fodder and seed crop	Plains and sub-montane tracts	July-September	Pollen
Hars ngar	*Lagerstroemia indica*	Ornamental plant	Plains and sub-montane tracts	July August	Pollen
Sunflower	*Helianthus annuus*	Crop	Plains and sub-montane tracts	August-September	Pollen

It is evident (of the bee flora,) that there are five major honey-flows in a year from different sources viz., 'toria', 'sarson' and 'loquat' (November-February); citrus (March); 'shisham', 'mesquite' and 'phulai' (April-May); 'berseem' (April-June) and 'shain' (September-October) which are utilized by stronger colonies for surplus honey collection. The weaker colonies on the other hand make use of these flows for building-up their strength besides accumulating food stores for their maintenance during food scarcity periods. Since good nectar and pollen plants are not available in any one locality all the year round, maximum benefit has been derived by practising migratory beekeeping (Makhdoomi and Chohan, 1980).

Studies on the effect of fertilizers on nectar secretion have revealed that the application of ammonium sulphate to 'sarson' *(Brassica campestris* var. *sarson*) and 'toria' *(Brassica napus)* produce more than 100% nectar as compared to crops grown in untreated plots (Gondal and Hashmi, 1977).

Beekeeping Equipment

Modern methods of beekeeping aim at protecting bees against abnormal weather, facilitating their capacity for gathering and storing large quanti-

ties of honey and obtaining pure honey without hampering their activities. Most of the essential equipment which helps in achieving the aforesaid objectives is being manufactured locally and the same is described below.-

Bee Hives. A standard 10-frame movable Langstroth bee hive invented by an American Reverend Lorenzo Lorraine Langstroth in 1851 has been found suitable under our conditions for domesticated honey bees (Rehman and Singh, 1942) It has, therefore, been adopted as a standard bee hive both in the public and private sectors. A two-storey bee hive consists of stand, bottom board, brood chamber, super, inner cover and top cover.

Hive frame is rectangular in shape and consists of one top bar, two side bars and one bottom bar A space of 3/8" called 'bee space' by L.L. Langstroth should be available to the bees in between and around the frames inside the brood chamber or super as the narrow space obstructs the movement of the honey bees and wider space stimulates the bees to fill it with extra combs resulting in the waste of their labour and material used for the preparation of this comb

Wiring Board: This is used to wire the hive frame.

Comb Foundation It is a sheet of pure beeswax with the bases of worker brood cells embossed with the help of a comb foundation mill. It stimulates the bees to raise worker cells which are used by the bees for rearing worker brood, storing honey as well as pollen It is the invention of a German, Johannes Mehring, in 1857.

The comb foundation mill for preparing comb foundation for *Apis cerana* was got manufactured in 1939 from an American Firm, Messrs A.I. Root Company according to the measurements of the cell size of the worker honey bee - 21 cells per four linear inches (Rehman and Singh, 1943b) and that for *A. mellifera* this mill has been imported from the U.S.A.

Wiring Board and Wiring Roller: These are used to wire the hive frame through the holes in the side bars. The wire should be tight enough to 'sing' when thumbed Tinned wire No. 28 is recommended for this purpose. This wire strengthens the comb and prevents the breakage of the honey comb during extraction.

Protective Dress: It comprises of an overall, bee-veil and gloves. It is used for protection against honey bee stings during manipulation of the colony.

Smoker: It is used to apply smoke to bees to facilitate their handling. The best material to produce smoke is saw dust, wood shavings, pieces of cloth rags or old gunny bags.

Hive Tool: It is used for separating hive frames, prying apart hive parts, for scrapping frames and bottom board of the waste material.

Queen Handling Equipment: It consists of queen excluder, wire entrance guard, queen introducing cage and queen mailing cage.

a) *Queen excluder:* It was invented by Abbe' Collin of France in 1885. It is used to restrict the queen bee to the brood chamber e for keeping two queens in a colony. It consists of series of parallel wires fixed in a wooden frame or a perforate zinc or plastic sheet with holes of 0.15" and 0.163" distance between the wires or as a diameter of perforations in the zinc sheet or plastic sheet, respectively, in case of eastern bee and the western bee.

b) *Wire entrance guard:* It is used to confine the queen to the hive and is placed in front of the hive entrance. It is prepared on the same principle as the manufacture of queen excluder. It prevents accompanying of the queen bee with the other members of the colony at the time of absconding and this compels the bees to return to the hive. It is a signal to beekeepers to remove the distress of the colony which compels it to abscond.

c) *Queen introducing cage:* It is used for introducing queen in a queenless colony successfully.

(d) *Queen mailing cage:* It is used to send the queen at distant places. There is a provision of copious ventilation and of food for the queen while in transit (Rehman and Sharma, 1948).

Feeder: It is used to provide sugar syrup as food to the bees during scarcity periods or for stimulating bees to rear brood. There are different kinds of feeders, but the two most important are described as under:-

a) *Division brood feeder:* It is a wooden trough of the size of a standard Langstroth hive frame with shoulders provided on the ends so that it could be hanged in the hive just like a frame. It is filled with sugar syrup and a wooden bar is floated on it which serves as a resting place for the bees while sucking syrup and thus preventing the drowning of the bees in the syrup. It provides food quickly to the strong colonies and can be refilled without removing from the hive.

b) *Friction-top pail feeder:* It may be a five-pound, ten-pound or of variable capacity plastic jar, an unused paint can, custard powder

can or any other container of this type with 6-8 nail holes in the lid. It is filled with sugar syrup (50% or of higher concentration). It is inverted over the frames and after placing an empty hive body the hive is closed as usual. The syrup oozes out of the holes in the lid and is collected by the bees of the colony. It is a slow method of feeding. The lid may be replaced with a piece of muslin cloth for quick feeding

Swarm Catching Basket: It facilitates catching and hiving the swarm of the honey bees. It is also used to catch a colony that has absconded and settled on some other object.

Honey Extraction Equipment: It consists of uncapping knife, uncapping tray, honey extractor and storage tank.

a) *Uncapping knife:* It is a flat sharp-edged knife used to remove the cell cappings of sealed honey combs prior to honey extraction in honey extractor.
b) *Uncapping tray:* It is used to receive the cappings of the honey combs, when being uncapped.
c) *Storage tank:* The extracted honey is received in the storage tank in bulk from the honey extractor and it remains there till it is bottled for marketing.

Honey Extractor: It was invented by an Australian Major Mr. F. Hruschka in 1865. It works on the principle of centrifugal force and ensures removal of pure honey without any damage to the comb which can be used by the bees over and over again for honey or pollen storage or for rearing brood. A simplified honey extractor has been constructed (Rehman and Singh, 1943b).

BEE MANAGEMENT

Application of better bee management practices to suit different areas according to different seasons of the year ensures the well-being of the bee colonies and high honey yields. A brief description of such practices based on experimental evidences is given below:-

Winter Management

a) *Packing the Bees:* Winter season that extends from November to February is severe for bees in the hills but moderate in sub-mon-

tane tracts and plains. It is not economical to keep the bees in the hills during winter. These should be shifted to lower hills or plains where the bees remain active throughout winter and collect pollen and nectar mainly from 'toria', 'sarson', eucalyptus, loquat, etc., rear brood and also store surplus honey.

In order to safeguard the bees and brood against cold weather and to ensure crop of surplus honey, it is advisable to pack the bees with the advent of winter with a three inch thick packing made up of sugarcane trash, rice, toria or wheat straw. Wood shavings on all sides of the hive, except the hive entrance, held in position with gunny cloth, has given very good results (Rehman and Lal, 1945). However, if bee hive is lying in the open or under a tree, it should be covered with some water-proof material, like polyethylene sheet to prevent the packing getting wet from rains as the wet packing adversely affects the colony development. When the above-mentioned packing material is provided in the wired hive frames or on the dummy boards-solid wooden planks of the size of hive frames, and placed on either side of bee frames in the hive and a packing pad underneath the inner cover also help the bees in conserving hive temperature. This packing also gets wet due to the metabolic water produced by the colony. These packings should, therefore, be sun-dried. The aforesaid packings would protect the colony against the cold waves and consequently would prevent the bees from consuming large quantities of honey for maintaining optimum hive temperature. The honey thus saved could be extracted as surplus honey or used by the bees for colony build-up.

b) *Uniting Colonies:* Stronger colonies with sufficient food stores thrive well in winter even without packing. Therefore, weak colonies should be united, using a newspaper method, in order to get one stronger colony out of two or more weak colonies. Thus in this way weeding out weak colonies and building up strong ones would result in surplus honey (Rehman and Singh, 1942). If a weak colony is to be kept as a separate entity, the inner cover of a double division screen of a strong colony should be removed and the weak colony should be put above this screen, and after providing the inner cover over this unit, the hive should be down. A

double screen is a wooden frame holding two layers of 8-mesh wire screen and preventing the contact of the bees of the two colonies held together. A rim with an entrance cut in the division screen on the opposite side of the entrance of the stronger colony will serve as a bottom board for the weaker colony while the heat from the colony below will keep the upper unit warm.

c) *Wind Breaks:* Protection from winds is important for survival during winter. Shrubs, fences or other artificial wind breaks help the colonies survive by preventing the loss of heat from the bee hives. Placing colonies facing south-east against the wall or wind break helps keeping the colonies warm most of the day and thus improving their foraging activity.

d) *Manipulation of the Bee Hive:* The bee hive should be opened only on a hot sunny day for knowing about the requirements of the bees for pollen and honey storage as well as for brood expansion. Further, the rear of the hive should be about one inch higher than the front to drain out accumulated moisture in the hive from the entrance hole. A small top entrance or auger hole (.75" in diameter) in the corner of the hive body (with inner packing), just below the resting place of the hive frame, can serve as an outlet for the metabolic water produced by the colony, during winter.

Spring Management

Beekeepers' spring season extends from March to May in plains and March to June in sub-montane tracts. Spring management aims at extensive brood rearing with an ultimate object of producing the maximum number of young bees for the main honey flow. It is usually achieved through feeding the bees on 50% syrup of white crystalline sugar in early spring and by replacing the old queens with young, vigorous, prolific queens as these are capable of laying eggs at a higher rate.

The prevalence of optimum environmental conditions and availability of plenty of nectar and pollen in the early spring stimulate intensive brood rearing in the bee colonies and as a result the bee colonies gain strength and consequently issue swarms in this season. However, the optimum conditions prevailing in the months of March and April have been found to be really a prelude to the major honey flow in order to enable the bees to take full advantage of the situation, it has been found to be a good practice to prevent swarming in bees.

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Swarming and Swarm prevention

a) Swarming is no doubt the natural method of propagation for honey bee colonies but swarming in colonies of medium strength and excessive swarming in stronger colonies is highly detrimental to the well-being of the swarm and the swarming colony as well as to the honey yield (Rehman, 1941). The swarms are issued in succession. The first or the primary swarm consists of an old queen, some drones and about 50% population of the worker bees in the parent colony. It leaves the parent colony and settles as an independent colony. The primary swarm is followed by secondary or after-swarms each headed by a young queen but having smaller populations

The causes which have been found to induce swarming include (a) a poorly laying queen, (b) lack of space to lay eggs and for storage of pollen and nectar (c) heat, (d) lack of ventilation in the hive and (e) deficient production of queen substance by the old queen bee. Control of swarming is, therefore, one of the most important management practices and the following practice has been found very useful in achieving this objective.

The colony may be allowed to swarm with the old queen which may be caught and hived at the old stand (A). The swarm should be given a brood frame, a frame of honey and pollen from the same or another colony and 3-4 drawn combs or comb foundation sheets. The parent colony (B) be removed and placed at a distance of about 30 metres from its old site. The forager bees of the colony will join and strengthen the swarm (A) placed at the parent stand and it will store surplus honey. The young queen will emerge in the present colony (B) which will lose forager bees and will be too weak to issue second swarm. When the young queen mates and starts laying, the parent colony (B) be united with the swarm (A) at the old stand by placing newspaper sheet in between the brood chambers of the two units (A, B). The old queen may be removed before union. The bees will gnaw away the newspaper sheet overnight and join together peacefully. The colony after union will be headed by a young and vigorous queen and will collect surplus honey during the main honey-flow. Thus substituting old failing queen with a young vigorous prolific queen during spring can check swarming habit in bees.

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b) *Two-Queen System:* It involves the use of two queens in a colony for about two months in spring and then reducing it to a single-queen system at the beginning of main honey-flow. This system ensures twice the population of a single-queen colony and consequently results in more honey production. It also checks swarming tendency in bees. This system can be operated as follows:-

(i) In the aforesaid swarm prevention technique (a) the parent colony (B) should be separated from the swarm (A) at the time of union, by means of a queen excluder having a newspaper sheet sprinkled with 40% sugar syrup. The upper unit (B) should have a separate exit on the same side as that on the lower unit (A). The bees of both the units will mix together through the queen excluder after gnawing away the newspaper sheet. However, the queens of both the units will continue laying in their respective brood chambers. This practice will result in twice the population of a single-queen colony and consequently will produce more honey.

(ii) The operation of this technique involves: selection of a strong colony, shifting of old queen along with about 50 per cent population of bees and emerging brood in a separate hive unit and its removal to a 1-2 kilometre distant place, introduction of young queen or queen cell to the parent unit and uniting the two units after 3-4 weeks as mentioned under (i) above. It would facilitate the working of the foraging bees of both the units as a single force.

c) *Supering for Honey:* The strong colony needs supers during main nectar flow to store the nectar and honey made from it. There is no hard and fast rule to decide how many supers to add at one time. This, of course, depends upon the strength of the colony and the amount of the incoming nectar. It is better to give copious room to the bees.

d) *Removing the Honey Crop:* The honey combs that are fully capped or their .75 part is capped, contain ripe honey and should be removed for extraction. The honey in the uncapped combs contains more moisture and if extracted will ferment. The removal of bees from the combs to be extracted is achieved by different methods. Firstly, by giving puffs of smoke to the colony in the super fol-

lowed by brushing the bees from the honey combs over the colony. Secondly, by replacing the inner cover over the super by a fume board treated with repellent chemicals like benzaldehyde or 50% carbolic acid (pure) at first placing it crosswise over the super to avoid mortality of the bees, and then completely covering the super for a short time. It would drive the bees into the lower hive bodies leaving the honey bees free of bees in the super. The honey combs thus cleared off bees are removed and extracted with the help of honey extractor. Thirdly, bees are removed from honey combs by using bee blower. It produces a large volume of rapidly moving air that quickly blows the bees out of the combs without injuring or annoying them.

e) *Honey Extraction:* The capped honey frames must be extracted by using honey extractor and the extracted frames given back to the bees for refilling. More than one extraction during the main honey-flow will yield more honey than single extraction. However, the last extraction should be done two weeks prior to the end of the main honey-flow to enable the bees to store honey for their future use.

Summer and Autumn Management

a) *Removal of Extra Frames:* The extra frames should be removed from the hive and stored. It would help protect these frames from wax moth attack inside the hive during summer and autumn (June-October).

b) *Uniting Colonies:* The weak colonies must be united with stronger colonies by placing a newspaper sheet (having about a dozen small holes punched with a nail) in between the two units as it pays to have a few strong colonies than several weak ones. The two colonies should not be disturbed until they are thoroughly united. Keeping of strong colonies with abundant stores means less trouble from bee enemies, absconding and adverse climatic conditions, etc.

c) *Robbing:* It is the habit of some colonies to pilfer the honey of others, usually the weaker ones, during the food scarcity periods. As a result of robbing, the affected bee colonies lose their bees and are rendered so weak that their existence becomes at a stake Maintenance of strong bee colonies with plenty of food stores is a

safeguard against robbing. However, if the robbing starts, hive entrance should be reduced to a bee space and the robber colony be removed to some distant place to avoid further spread of this menace (Rehman and Singh, 1944b)

d) *Absconding:* The bees are compelled to desert their hive usually due to: (i) lack of food stores in the colony; (ii) high temperature; (iii) lack of ventilation in the hive; (iv) robbing of weak colonies by strong ones; (v) too frequent and prolonged handling of bees and (vi) attack of bee enemies. The absconding can be checked if the above-mentioned factors are taken care of well in time: (i) by placing the entrance guard at the hive entrance to prevent the escape of the queen along with the absconding bees; (ii) providing better ventilation by placing one empty hive body above or below the brood chamber; (iii) removing or replacing the inner cover by wire gauze screen board; (iv) feeding the bees on sugar syrup to stimulate the queen to lay and (v) controlling the bee enemies (Rehman, 1945).

e) *Feeding:* The bee colonies short of food should be fed on 50% sugar syrup to avoid robbing or absconding. However, feeding should be done late in the evening in the division-board feeder by friction-top fail feeder to avoid robbing in bees. The best food is the honey in the combs, if available. However, feeding royal jelly or juice of crushed honey bee larvae to queen bees increased their egg production during summer (Gondal and Hashmi, 1976).

f) *Bee Enemies:* The most important bee enemies are the large wax moth *(Galleria mellonella),* wasps *(Vespa* spp.) black ants *(Camponotus* spp.), green bee eater *(Merops orientalis)* and mites. The control of these bee enemies as recommended later in this chapter should receive special attention.

g) *Migration of Bees:* Dearth of bee flora besides high temperature during May-June and high relative humidity in combination with high temperature from July to early September are very hard for the bees. Since these conditions are conducive for bee activity, therefore, queen bees either stop or reduce egg laying to a great extent while the older bees meet their natural death and consequently the colony strength dwindles considerably. The attack of bee enemies during this period further worsens the situation. Therefore, in order to avoid colony ¬ishape the bees must be mi-

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grated to some cooler places or where plants like 'kikar' *(Acacia* spp.) 'ain-ul-asl *(Robinia pseudoacia)*, asl-i-amir *(Vitex negundo)*, etc., are in bloom during summer.

The availability of bee flora viz., *Brassica, Antigonon*, etc., and prevalence of mild climatic conditions during late September and October induce brood rearing. The bee colonies should be provided raised combs for egg laying and honey and pollen storage. The bees may be fed on 50% sugar to stimulate them for raising new combs. These practices will ensure colony build up which is essential for successful overwintering.

Miscellaneous Practices

a) *How to Start:* The knowledge of bee behaviour is essential for the proper management of bees and the beginner will do well if he attends any of the short training courses in beekeeping being offered in the country. He can add to his knowledge by studying literature on beekeeping. However, he would learn the best when he actually works with the bees "the practice makes the man perfect."

In the plains the ideal time beekeeping is commensurate with *Brassica* flow (October-November). Moreover, the winter is mild and is usually free from different drawbacks that stand against the well-being of the colonies. The beginner will have sufficient time to learn the various activities of the bees. He will be fully prepared to handle them for intensive bee activity during spring season (February-April) for bringing an increase in the number of bee colonies through swarming and preparing them for main honey flow (April-May) with a view to collecting surplus honey. As regards the sub-montane tracts, spring season would suit the beginner in beekeeping.

A beginner beekeeper should make a humble start with 2 to 5 healthy colonies purchased from Government Bee Farms at Rawalpindi and Islamabad or from private beekeepers, Haripur - Hazara and Beekeepers Society of Karachi. Getting started with more than one colony has the advantage of helping any of the colonies, if need be, through the exchange of brood and food.

b) *Suitable Localities:* Previously it was considered that beekeeping can be practised in the hilly areas alone, but as a result of researches done on the hill bee, *Apis cerana*, it is now possible to

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take up beekeeping in the plains as well (Rehman, 1943). The main point in judging the suitability of a locality for beekeeping is the availability of numerous flowering plants which secrete copious quantities of nectar and which produce sizeable amounts of pollen. Some of the important crops and plants which come up to this standard have already been mentioned under bee flora. It is, therefore, quite understandable that for a locality to be suitable for beekeeping it is necessary that there should be plenty of nectar and pollen plants besides a large acreage of field crops of importance to honey bees within a radius of one to two kilometres from the apiary. Since the good bee flora is not available in any particular locality all the year round, therefore, migratory beekeeping should be practised for better results. If the main object is the utilization of honey bees for pollination purposes to obtain higher crop yields then every tract where these crops are grown may be reckoned as suitable for beekeeping.

c) *Location and Arrangements of Colonies:* The site selected for placing the bee hives should be sheltered from hot and cold winds and should have a neat and clean water supply during summer. It would result in stronger colonies. During winter the hives should receive sun-heat at least in the morning and early afternoon. However, during summer these should be placed under shade as it would help bees to forage better because fewer bees would be required to cool the hive and to carry water for evaporation.

Arrangement of hives in the apiary in straight rows encourages drifting of the bees. Therefore, it is better to place the hives in some irregular pattern or with some prominent coloured patterns with broken outline, e.g., simple and multiple crosses painted on front of the hive body. This would facilitate the foraging bees to return to their own hive. The distance of about 2 metres between the hives or placing them in groups of four facing in different directions would also help prevent drifting of bees.

d) *Examination of Colonies:* The hive has to be opened occasionally to see if (i) the queen is working normally (ii) enough brood is present (iii) there is enough room (iv) members are free from wax moth and mites, and (v) they are not suffering from any other abnormality.

The colonies should be examined on such days when the bees are

working normally, i.e., forenoon and afternoon during summer and on bright sunny days during winter. They should not be disturbed on cold, rainy or windy days or at night. The hive should be closed soon after the examination is over. To examine the colony proceed as under:-

Put on the overall, gloves and the bee-veil in such a way that the honey have no chance to slip towards the face; string to fasten your sleeves and trousers' legs to avoid crawling up of the bees on the arms and legs, respectively; light the smoker, approach the bee hive from the side, remove the top cover and put it aside, pry apart the inner cover with hive tool then lift it gently and blow a few puffs of smoke below it. Remove the inner cover and place it in front of the hive in a slanting position with its inner side facing upward. It would help the bees on the inner cover to move into the hive through the entrance. Pry apart the frames also with the hive tool and take out the frames one by one holding them in a vertical position over the hive. Watch the queen, usually on the brood frame, and avoid its crushing during manipulation. Handle the bee frames gently and continuously. Avoid jerks, so that the bees are not irritated and induced to sting, because apart from the sting being painful, though for some time, the odour of the poison irritates them and then these become difficult to manage. The smoke neutralizes the odour and heat relieves the pain. However, the bees that sting, can die on account of the shock of breaking their stinging organ into the beekeeper's skin.

e) *Remedies for Bee Stings:* The effect of a bee sting can be reduced by promptly scrapping the sting with a finger nail or hive tool in such a way that the sting is not squeezed and the injection of additional venom into the body is prevented. Rubbing of the affected part should be avoided as it would diffuse the poison more readily into circulation and it would do more harm than good. Fomenting with towel wrung out of hot water, (as hot as can be borne) will give instantaneous relief and if continuously done alternately with cold fomenting will give relief from local tension and reduce swelling. Some people never have any swelling while others become immune after having been stung for quite a few times. However, persons allergic to bee stings suffer from severe itching, nausea, vomiting, diarrhoea and develop trouble in breathing or

may go into shock unconsciousness followed by death. Such persons may immediately be taken to a doctor for treatment.

f) *Bee Venom:* It is a secretion of a small alkaline gland and a large acid gland, accumulated in the poison sac associated with the sting of the honey bee. The active substances in the bee venom are two proteins, histamine and melittin, and two enzymes, hyaluronidase and phospholipase A. Histamine causes rapid decrease in blood pressure and melittin, a high molecular weight protein, causes general and local toxicity of the venom and in higher doses it causes respiratory paralysis or death. Hyaluronidase helps spread the bee venom through cell cementing substance. Phospholipase A, catalyses the process of haemolysis of red blood cells on account of melittin (Pursley, 1973). However, it is recognized that the bee venom cures arthritic and rheumatic ailments among human beings.

g) *Requeening:* A colony which has lost its queen or possesses a failing queen has to be requeened. A prolific queen ensures rapid build-up of the colony. A failing queen deposits more than one egg in a cell or she becomes a drone layer. Remove the failing queen, a few hours prior to the introduction of the prolific queen. Smoke the queenless colony and then place the desired queen, contained in a queen introducing cage, at the top of the central frames or hang it between the bars of two of these frames. The exit hole plugged with candy (moistened ground sugar) should face upward. Close the hive, the bees will release the queen. If the candy is hard, pass a small nail through it, so that a hole is made in the candy and let the worker bees clear the rest of the way for the exit of the queen. The queen bee introduced without queen cage is likely to be balled and killed by the bees. However, in spring season direct introduction may be successful. In case, a queen is not available, a ripe queen cell from another colony may be provided. However, if neither a queen nor a queen cell is available then a brood frame with some eggs and younger larvae taken from some other colony be provided, the bees will rear the queen. However, fertilization of the virgin queen will only be possible if drones are available in the apiary. Under odd circumstances the queenless hive should be united with some queen right colony.

h) *Laying Workers:* Worker bees are females but possess rudimentary ovaries. When a hive remains queenless for some time, some of the workers start laying eggs up to five or more in a cell, against one egg per cell in case of a good queen. Since these eggs are unfertilized, therefore, only drones will emerge. Attempts to re-queen such colonies usually fail. It would be better to shift the laying workers' colony at a distance of about 30 metres or more from its site and then shake out the bees from its combs. The normal worker bees will fly back and will enter into other hives when they do not find their own hive at the original location.

i) *Moving Colonies to a New Spot in the Apiary:* As and when it becomes necessary to shift a colony a few yards in an apiary, it should not be shifted at once but should be moved about a metre every day till the desired spot is reached. But if the colony is to be moved a few hundred metres in the same apiary or in the vicinity of that apiary, the best plan is to shift it to a place about 2-3 kilometres away from the apiary and keep it there for about a week and then bring it to the desired spot.

j) *Moving the Bees to New Localities:* To prepare the colony for moving to a new locality proceed as under:-

> Fix bottom board, brood chamber/super and inner cover of the bee hive to be moved, by nailing them so that these become bee-tight and also act as a single unit. The inner cover with a piece of wire-gauze screen (3-4 inches) in the centre with adjustable lid has proved better. It facilitates ventilation and allows provision of food and water to bees while in transit. The bee frames should also be nailed at their shoulders (resting ends). Screen the entrance of the hive with wire-gauze when all bees have entered the hive, i.e., in the evening.

A specific transportation 7-frame bee hive has been designed with adjustable screens of wire-gauze on the sides, at the top and in front of the hive. It has proved very convenient and suitable for this purpose, the entrance of the bee hives in the transport carrier should be in line with the front of the carrier. It would avoid crushing of the bees between the frames at the start and top of the carrier.

The frames full of honey should not accompany bees as they are

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likely to break, due to jerks while in transit and consequently the oozed out honey from the damaged frames results in the death of the bees in confinement. However, some honey should be left in the hive as food for the bees enroute. In hot weather and during long journeys water should be sprinkled at regular intervals on the wire screens during transit.

k) *Bee Poisoning:* Honey bees are so sensitive to insecticide sprays that even the wind carrying toxic odour from the insecticides treated fields in the vicinity of the apiary would be sufficient to kill the bees in the hives. Poisoning of honey bees usually occurs when they come in contact with toxic materials used for insect pests control. Contact with insecticides occurs when these are applied to blooming crops visited by the bees, by drift of sprays or dusts from the adjacent crops fields, collection of pollen contaminated with toxic dust or collection of water by the bees from the flowers or foliage treated with insecticides. Laboratory and field studies have revealed high mortality of honey bees on account of insecticide poisoning (Haq and Haq, 1984; Muzaffar and Munawar, 1985).

One of the obvious symptoms of bee poisoning is a large number of dead bees lying in front of the bee hives. Most insecticides will cause stupefaction, paralysis and an unusual behaviour. Regurgitation of material in bees is usually caused by phosphatic insecticides. The affected colonies become weak within a short span of time.

The best way to protect the bees from bee poisoning is to remove the colonies at some distant place (2-3 kilometres) prior to the application of the insecticides on the crops growing in the vicinity of the apiary. The closure of the hive entrance during the insecticide application reduces the bee mortality to a considerable extent as the honey bees escape from the direct fall of the insecticide on their body (Haq and Haq, 1984).

HONEY

Honey is a converted form of nectar which is mostly produced in the floral nectaries of the plants. It is well-known for its nutritional and medicinal values (Rehman and Singh, 1942). Mention has also been made in the Holy Book 'Quran' about its health giving properties.

As regards the phenomenon about the manufacture of honey from nectar, it has been found that the honey bees store nectar as long as they are in the field, in a special portion of their gut called 'honey stomach' and on their way back to the hive, the enzyme, invertase secreted by their salivary glands converts sucrose of the nectar into invert sugars, glucose and levulose, which being simple sugars are directly absorbed into the human system. This nectar is then haned over to the 'house bees' which put it into the cells of the honey comb in thin layers. The bees then agitate the air in the colony by rapid vibrations of their wings, thereby setting up currents of air within the hive which evaporate the excess water from the honey in the cells. When the desired consistency of honey (about 80% sugar) is reached the cells are sealed with non-porous beeswax cappings (Rehman and Singh, 1941b). This honey us usually called capped or ripe honey.

It is estimated that 4 lbs of nectar are required to produce one lb of honey and that 1,60,000 honey bees are required to perform this extra-ordinary work. Taking three miles to be the average distance that a bee has to fly to and from the source of nectar in order to collect enough to make one lb of honey, a bee will have flown over a distance equal to almost five times round the globe for the purpose. A worker bee collects about a desert spoonful of honey in its life time (Rehman and Singh, 1942).

Honey is a natural product and it has as many tastes, flavours and colours as the varied flavours and colours of the nectars of different flowers from which it is derived. For example, honey from Egyptian clover is golden in colour, that of 'sarson' and 'toria' light-yellow, from shain light in colour, from loquat it is white while dark-amber in colour from 'shisham.'

The analysis of honey samples, collected from *Apis cerana* colonies has shown that it contained 14.3-18.6% moisture, 71.1-76.9% reducing sugars, 34.2% glucose, 39.1% levulose, 1.9-2.75% sucrose, 0.112-0.32% ash and 0.069-0.161% formic acid. It has also been found that chemical difference exists in the honey gathered by other species of honey bees. For example, moisture percentage and formic acid were found to be the maximum and reducing sugars to be the minimum in the honey gathered by *Apis florea*. In the honey collected by *Apis cerana* reducing sugars were found to be maximum and formic acid minimum as compared to that in the *Apis dorsata* honey (Latif *et al.*, 1956b).

BEESWAX

Beeswax is a useful by-product of the honey bees. It is produced in the

four pairs of glands situated on the underside of the abdomen of the younger bees. It is secreted only when sufficient amount of nectar is available or the colony is fed sugar or honey. Besides its use in the preparation of comb foundation it is put to use in many ways (Rehman and Singh, 1944). It has been found that the comb foundation prepared from the wax of *A. dorsata* is readily accepted by *A. cerana* but not by *A. mellifera*. However, the latter species does not hesitate to accept it when it is coated with a thin layer of beeswax of *A. mellifera*.

The analysis of the samples of beeswax obtained from the combs of three indigenous species of honey bees revealed no difference in the melting point, specific gravity, and saponification values. However, the melting point of beeswax of cappings from *A. cerana* was lower than that of any other sample of beeswax from any of the three species of bees (Latif *et al.*, 1960).

POLLINATION

Honey bees specially visit flowers for nectar and pollen collection as they need them for their maintenance and rearing their young ones. Their hairy body and modified hind legs are very well suited for pollen collection, therefore, the honey bees are rated as the most efficient pollinators of fruits, vegetables and agricultural crops (Muzaffar, 1982; Rehman, 1940; Rehman and Singh, 1944). In fact all the crops that are not wind pollinated need the services of insect pollinators including honey bees to set their seed or fruit successfully. It has been claimed that the value of bees in crop pollination is 14 times the value of honey which they produce (Rehman and Singh, 1944).

The domesticated species of the honey bees are manageable and they can be moved from one crop to another for pollination. The honey bees have further become indispensable for crop pollination due to the low population or elimination of other insect pollinators because of frequent use of insecticides for controlling crop insect pests.

At least one colony of honey bees per acre is required although in many cases two colonies per acre are desirable. The strength of the colony, however, is an important factor in pollination as weak colonies proportionately have a smaller number of bees that could be sent in the field for pollination.

Studies conducted in Pakistan on the role of bees in pollination have revealed that beekeeping and fruit growing should develop side by side as both of these are mutually benefitted (Latif and Qayyum, 1956; Rehman and Singh, 1943c).Studies conducted with *A. cerana* to determine its role in the pollination of Egyptian clover indicated that its seed yield increased 100%

and that of the 'toria' 43% and 'sarson' 47% exclusively due to the pollination activity of this bee. Further, pollination also resulted in viable and bold size seeds (Latif, *et al.*, 1960; Latif *et al.*, 1965; Latif *et al.*, 1956a). The seed yield of radish and cauliflower, respectively, increased by 18.7% and 23.6% through the pollination services of this bee (Gondal and Haq, 1973). It has also been found that significantly more fruit was set and matured, besides significant increase in fruit size, juice content and number of seeds in case of Kinnow Mandarin (Haq *et al.*, 1978). Further, a highly significant increase in fruit set, fruit size and fruit weight in 'phalsa' (Haq *et al.*, 1979) and high yield of good quality seed of Armaveric variety of sunflower (Haq and Fiaz, 1980) have been achieved through the activity of insect pollinators including honey bees.

BEE ENEMIES

Honey bees are attacked by a variety of pests but most important of these found in Pakistan are described as under:-

1. Mites

Mites (Acarina), like insects are tracheate arthropods but mostly having four pairs of legs as against three pairs of legs in insects. Their importance remained ignored for a pretty long time due to their unnoticeable size but these are now well-known for their damage to agricultural and horticultural crops besides stored grain and stored products. Some of these are of medical and veterinary importance. Three species of mites that have been found attacking bees in Pakistan are described below:-

(i) *Acarapis woodi* (Rennie): The infestation of this mite on adult honey bees is called 'Acarine disease.' The eastern bee *A. cerana* is more susceptible to the attack of this mite and infestation is more serious during autumn and spring seasons. It completes its life cycle (egg, larva, nymph, adult) in large prothoracic trachea of the younger bees. The adult mites migrate to new host bees when the first host bee dies and the infestation from one colony to another spreads through infested bees. The healthy silken white trachea becomes dark in colour when heavily infested with this mite.

The infested bees usually wonder restlessly in front of their hive or climb on the vegetation nearby. Since the wings of infested bees become disjointed, therefore, they crawl but cannot fly. The life span of the infested bees is reduced and consequently the colony dwindles.

Control methods

(a) Replacement of the old queen with a young, healthy, mated queen.

(b) Folbex strip treatment: Fumigation with ignited folbex strip by hanging it vertically with a frame in an empty super at the rate of one strip per 10-frame colony for one hour period during early spring and autumn, where there is little or no brood, has proved effective.

(ii) *Varova jacobsoni* (Oudemans): It is more serious in *Apis mellifera* colonies. The female enters the cell of the fully developed larva before it is capped and feeds and lays, on an average, 7-8 eggs on the larva. The male mite completes its life cycle in 7-8 days and female mite in 8-9 days. They mature and mate inside the cell and leave it along with the emerging stunted and deformed bees and then climb on other hive bees and settle between the head and thorax, between thorax and abdomen or on any other part of the body from which they cannot be dislodged by the infested bees. The deformed bees are rejected by their hive mates and such colonies gradually become weaker and weaker. Scattered brood pattern is also a symptom of its infestation.

Control methods

(a) Fumigation of the infested colony with Folbex VA strip as done in case of acarine disease has given very good results.

(b) Dusting the bottom board with sulphur and exposure of colony with closed entrance in a hot room above 46°C for an hour would dislodge and kill the mites.

(iii) *Tropilaelaps clareae* (Delfinado and Baker): It infests and kills the brood of honey bee. The infested bees that emerge are stunted, deformed and consequently are not tolerated by the other bees in the hive. It scatters the brood. The infested colonies gradually become weak.

Control methods

(a) Dequeening of the colonies against this mite.

(b) Treatment of the infested colony 2-3 times with Folbex at fortnightly interval.

(c) Dusting of hive frames and board at the bottom twice a week for two weeks with sulphur.

2. **Wax Moths**

There are two species of wax moths, viz., large wax moth, *Galleria*

melonella L. and the lesser wax moth, *Achoria grisella* F. which damage the combs both inside the hive and during storage. The large wax moth is of great economic importance and does considerable damage to combs during monsoon season (July-August). The part of the comb that is not covered by the bees is usually attacked by this pest. This situation mostly occurs in weaker colonies as their bees are unable to cover the combs completely.

The fertilized female of the large wax moth is greyish-brown in colour and lays eggs glued together on uncovered combs and in cracks and crevices of the hive. A female in her life time of about 2 to 3 weeks lays up to 600 eggs. Egg stage occupies 7 days. The newly hatched larvae are creamy-white in colour, become dark when old, burrow into the comb and make silken tunnels which extend to the midrib of the comb where they feed on pollen, honey and waste products of the cell and thus grow protected from the worker bees. The larvae are fully developed in 18 to 19 days attaining a size of about 2.2 cm and then spin their cocoons inside the hive usually away from the feeding site. The pupal stage in the cocoon lasts for about 10 days. When the attack is severe, the comb is covered with silken tunnels with numerous black faecal matter of the larvae and the infested combs are reduced to a mass of web and become unfit for brood rearing as well as for pollen and honey storage. If no attention is paid to remedy this situation the bees abscond.

Control methods

(a) Maintenance of stronger colonies and removal of extra combs.

(b) Removal of silken tunnels, along with their residents, from the comb, and debris at the bottom board at fortnightly interval during monsoon season.

(c) Release of a braconid wasp, *Apanteles galleriae* 'Wilkinson (a larval parasite), to keep the pest population low (Ahmad, 1981).

(d) Fumigation of stored combs with Phostoxin or Detia at the rate of one tablet per three stacked air tight hive bodies makes them free from wax moth infestation. The treatment may be repeated, if necessary, at monthly interval during monsoon season.

(e) Treatment of wax combs with Thuricide, the sprayable formulation of *Bacillus thuringiensis* Berliner at the rate of 15 mg per 3 gm wax in combination with 1% boric acid (Ahmad and Haq, 1976).

Wasps

Out of various species of wasps, *Vespa orientalis* in the plains and *Vespa velutina pruthii* and *Vespa tropical haematodes* in the sub-montane tracts attack the honey bees and their brood during summer. *Vespa orientalis* builds her nest in the walls of the houses while the other two species build their nests on the trees and in the walls of the deserted houses. These wasps rear their young ones on the larvae, pupae and adult bees. They catch the adult bees flying at the entrance of their hive. The western bees, *A. mellifera* is more susceptible to their attack as compared to *A. cerana.*

Control methods

(a) Killing the wasps visiting the apiary using fly flapper or the like.
(b) Spraying or dusting their nests with potent insecticides.
(c) Placing poisoned bait, consisting of talcum powder, water and minced meat in equal proportions and mixed with BHC, at different sites in the apiary (Ahmad and Muzaffar, 1984).

Black Ants

They sneak into the hive and take away honey, brood and pollen and the bees abscond when there is high infestation.

Control methods

(a) Keeping the legs of the stands of the bee hives in earthen or plastic cups full of water or by coating the bases of these legs with Ostico - a sticky substance can keep the ants away from the hive.
(b) Treating the ant nests in and around the apiary with BHC dust or 5% Endrin, etc.

Birds

The status of the insectivorous birds when prey upon useful insects including honey bees is changed from useful to that of harmful. Some 24 birds have been found preying upon honey bees but the most important of these is the green bee eater, *Merops orientalis orientalis* which is described as under:-

The green bee eater, a migratory bird, is commonly known as 'Swan chiri'. It is a bird with slender build body emerald green tinged with reddish-brown on head and neck. Wings are short but central pair of tail feathers are prolonged. It breeds from March to August in serpentine holes in the banks of canals and water channels, in the gardens and in the cultivated areas. It

feeds on insects but where there is an apiary it plays havoc with the bees (Latif and Younus, 1950a).

Control methods

(a) Shooting with an air gun.
(b) Destruction of the nests during the breeding season.

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Chapter 15

SERICULTURE

Syed Muzaffar Ahsan Makhdoomi and Muhammad Anwar Zia*

INTRODUCTION

The art of rearing silkworm for the production of silk is known as sericulture. There is an interesting incidence about the discovery of silkworms in China. About 4000 years ago, the Queen See Lang of China had a lot of interest in insects, birds and animals. Her garden was famous for a variety of these creatures and to study their habits very closely was her hobby. One day it was raining in torrents, while the Queen was busy with her breakfast, her servant brought an insect in a saucer to show her. She picked up the stout insect in a hurry and so it dropped down in the cup of her tea. The Queen took it from the cup and felt in her fingers a lusterous fiber around the body of the insect. It was in the form of very fine silken threads. A lot of discussion took place. Among the many craftsmen present in the palace, one of them claimed that he can prepare a silken handkerchief for the Queen if he is provided with one hundred silken cocoons. As desired by the Queen similar insects were searched out from the mulberry trees and reared on the tender mulberry leaves. The silk thus prepared by these insects was used in preparing the silken handkerchief for the Queen. This incidence took place 4000 years ago and the Chinese people named the art of silkworm rearing on the name of their Queen See Lang. This industry in China is called as See. Every year with the advent of spring season, new sprouts appear on the mulberry trees and the Chinese people inaugurate a festival in the memory of this happy incidence.

The silk is produced by a number of species of the family Bombycidae, order Lepidoptera. *Bombyx mori* L. (Silkworm caterpillar) feeds on mulberry leaves. Other species have a variety of food plants. The silk produced by *B. mori* is of superior quality. It is univoltine i.e. produces only one crop in a year. Mulberry plant is the best food plant and can be

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grown successfully in hilly and irrigated areas of Pakistan. It has got serrated leaves which are taken by the caterpillars very easily. *B. mori* requires low temperature and a little humid climate for its rearing on commercial scale. This type of climate is found in sub-mountainous tracts. Sericulture has very bright prospects in Pakistan. Sub-mountainous tracts of Pakistan are very suitable for growing mulberry trees on a large scale.

In addition to all these, there are some other advantages of growing mulberry trees because the juice of mulberry fruit has a great aesthetic value, the wood may prove useful as a raw material in sports, match sticks and pencil industries. The pulp of paper mulberry variety can be used in the manufacture of paper.

DESCRIPTION AND DURATION OF DIFFERENT STAGES OF *BOMBYX MORI* L.

ADULT

Dirty white, about one inch long. Male with smaller and more pointed abdomen. Wings covered with scales and not used for flight. Immediately after emergence from cocoons both sexes, flatter their wings and crawl slowly in search of their mates for copulation. After finding their mates the copulatory organs of both the sexes cling together firmly at the tips of their abdomens. They remain in this position for many hours, then they separate. Just after separation, the female starts laying eggs. The male dies after mating, while the death of the female takes place after completion of the egg laying process.

EGG

Eggs are hemispherical, greyish and very small about the size of opium plant seed ("KASHKHASH"). The incubation period ranges from 10–12 days. After hatching the small caterpillar starts eating mulberry leaves and growing in bulk for about a month.

LARVA

Full-grown caterpillar is elongated, greenish grey, about 3 inches long with a swollen and wrinkled thorax. Silk is produced in the silk glands (Salivary glands) of the caterpillar in the form of saliva which after coming out from the mouth gets in contact with air and stiffens into a fine silken

thread. The labium portion of the mouth parts of the caterpillar is modified into a spinneret.

PUPA

Before going for pupation, the spinneret starts oozing out the silk thread which are woven around its own body and within 2-3 days the cocoon is prepared in which pupa is concealed. The pupa remains hidden in its own prepared silken cocoon for 8 to 10 days. During this period morphological changes take place in its body inside the cocoon till it becomes adult winged moth. Then it secretes some chemical on the inner side of one end of the cocoon, with the result, the wall of the cocoon becomes soft and weak. The adult moth pushes itself out of the cocoon at this point and adult moth emerges out from the cocoon.

PROCUREMENT OF SILK SEED

The eggs of silkworm moth can be procured from the nearest office of the Sericulture Inspector or Deputy Director Sericulture, Upper Mall Road, Lahore every year during the month of February.A silk seed (Eggs) production laboratory has been established by the Sericulture Department, at Murree Hills, from where healthy seed is being supplied to the interested persons and Sericulture stations in the country. One ounce of the seed contains approximately 40,000 to50,000 eggs. For rearing one ounce of the seed, at least 25 full-grown mulberry trees are needed. This side industry should be started in the plains by the end of February as the mulberry plants sprout up during the first week of March.

SELECTION OF THE INCUBATION ROOM

Incubation of the silk seed in an incubator is the best method but if this facility is not available, the eggs can be kept in a room. The room should be neat and properly disinfected and fumigated by burning sulphur before placing the eggs for incubation. It should be safe from the winds and can easily be heated by burning coal or cow-dung cakes to maintain the optimum temperature.

INCUBATION OF THE SILKWORM EGGS

In the desired room (selected for incubation)the eggs are placed on a sheet of paper kept on a stool or table. The eggs should be scattered on the

paper sheet in the form of a fine film and these should be covered with a basket for the safeguard against rats, white ants or sparrows, etc. Room temperature should be maintained from 22.2°C to 26.6°C. The desired temperature can be attained with the help of an electric/gas heater or burning coal. For maintaining proper humidity in the room, two or three buckets of water should be kept inside the room. So a thermometer and a hygrometer should be properly hanged in the room. The eggs should be disturbed twice or thrice in a day with the help of a very soft and disinfected birds' feather, so that they receive uniform heat from all sides. The hatching of the young ones (silkworm caterpillars) starts after 10 – 12 days and it is completed in 2-3 days. After hatching, place some cloth over them and put shreded tender mulberry leaves on the cloth. The newly hatched caterpillars will creep out of the cloth for eating the leaves. The cloth alongwith the caterpillars should be lifted very gently and kept on a proper place to start their rearing.

REARING OF THE SILKWORMS (CATERPILLARS)

Do not touch the newly hatched caterpillars. Each batch of the caterpillars hatched out in every 24 hours should be kept separate and all such batches should also be reared separately. The success in the art of rearing silkworm caterpillars depends upon synchronising the dates of egg hatching with the sprouting of mulberry leaves. Roughly speaking, the age of the leaves fed should be the same as that of the caterpillars as far as possible. It is advisable that first two stages of the caterpillars should be fed on shreded fresh green tender mulberry leaves. There are five instars/stages of silkworm caterpillars. During rearing plenty of space should be provided otherwise due to congestion the mortality of the caterpillars will increase. The space needed for different stages of the caterpillars hatched out from one ounce of the eggs is given as under:

Stage of Caterpillars	Space required
1st Stage	2.55 square meter
2nd Stage	4.25 square meter
3rd Stage	8.51 square meter
4th Stage	17.00 square meter
5th Stage	35.10 – 53.20 square meter

It is necessary to check the mulberry leaves before providing them to the caterpillars. The leaves should not be dusty, wet or very dry. The dirty

leaves are liable to bring the spores of many diseases. The feeding should be started from 7 to 10 a.m. and should be done 4 – 7 times in a day at an interval of 3–5 hours.

HOW TO PROCURE THE LEAVES FOR FEEDING PURPOSE

The leaves from the mulberry plants are brought twice in a day i.e. once 9 or 10 a.m. after the dew has become dry and then in the evening. The leaves collected first time in the morning are used for feeding during the day time up to evening whereas the leaves collected in the evening are fed during night up to 7 a.m. the next morning. The leaves thus collected for feeding purposes should be kept covered with a cloth etc., before they are fed to the caterpillars. There are five moults in the life of a caterpillars. They stop feeding and become sluggish in the beginning of every moult. They also keep 1/3rd of their anterior body raised up. The caterpillars withdraw their thoracic legs during the moulting stage, so no feed should be provided to them at such stages. After moulting when about 75% of the caterpillars start moving, then mulberry leaves should be given to them. In second and the succeeding moults, the same process should be repeated each time. The duration of different moults in days is given as under:

I moult	after	6 days
II moult	after	5 days
III moult	after	7 days
IV moult	after	9 days

QUANTITY OF MULBERRY LEAVES REQUIRED FOR REARING VARIOUS STAGES OF SILKWORM

The worms consume less feed during initial instars but their requirement for the mulberry leaves after moult increases. The total weight of the leaves required for rearing one ounce (34 gram) of the silk seed is about 1300 kilograms which can be had from about 25 mulberry trees. The quantity of mulberry leaves needed by different stages of the caterpillars is given as under:

First stage larvae emerged from 34 grams of silk seed	10
Second stage larvae emerged from 34 grams of silk seed	20
Third stage larvae emerged from 34 grams of silk seed	30
Fourth stage larvae emerged from 34 grams of silk seed	240
Fifth stage larvae (Before pupation)	1000

Sanitation is very essential for rearing. The refused leaves and excreta must be removed from the rearing place to keep the caterpillars neat and clean. The trays should be cleaned two days after the first moult and then two days after the second moult and so on. These should be cleaned at least five times in their life cycle. The caterpillars become restless in the fifth stage and begin to move right and left in search of a resting place or a place where they can pupate undisturbed. At this stage "Toria paller" or dried whole wheat straw should be kept in the trays in the form of 'arch ways'. The worms come down to this heap and start secreting the silk to prepare cocoons for pupation. The length of thread given out by a single caterpillar is about 120-150 meters.

COLLECTION AND DRYING OF THE COCOONS

The cocoon formation is generally completed in 3 to 4 days. The next stage after the cocoon formation is the adult stage. If the cocoons are not collected at proper time, the creature (moth) will make a hole in order to come out and thus injuring the whole cocoon. Therefore, killing of pupa inside the cocoon is very essential, so that the silk thread of the cocoon is not out and destroyed. The process of killing the pupae inside the cocoon is known as stifling. It is done by two methods:

i) By Sun Heat: The cocoons are collected and exposed for 2 to 3 days in the sun by keeping them covered with a black cloth. The pupae will die. It is liable that the colour change of cocoons may occur when exposed in the sun without covering them with a black cloth.

ii) By Steam: The steam is passed over the cocoons and the pupae will die

MARKETTING OF THE COCOONS

The concerned Sericulture Supervisor should be consulted before selling the cocoons, in order to get reasonable and correct rates prevailing in the market.

DISEASES AND ENEMIES OF SILKWORM

The important and commonly occurring infectious diseases of the silkworm are as under:

1. **Flacherie or Flaccidity**

The fourth and fifth stage of the silkworm is generally susceptible to this disease. It is very fatal, as all of a sudden the silkworms stop spinning become sluggish and die off.

2. **Pebrine Disease**

It is a heritable and most serious disease of the silkworm larvae. The eggs laid by the moths are infected and the worms which hatch out from them die before reaching maturity. Black spots appear on the body of caterpillars and internally there will be oval corpuscles in the serum. The only preventive measure is to rear healthy seeds by examining them microscopically.

3. **Grasserie**

The caterpillars become restless and yellowish in colour. The disease is not serious.

4. **Muscardine or Calcine**

The disease is caused by a fungus and is contagious in nature. The general appearance of the caterpillars becomes mealy.

In addition to the above mentioned diseases, the rats, lizzards and brown or black ants are noxious enemies of the silkworms. So it is necessary to take proper preventive measures against these enemies while adopting sericulture.

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Chapter 16

LAC CULTIVATION

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INTRODUCTION

Lac like silk and honey is an insect product. It is resinous secretion of a very minute insect known as Indian lac insect, *Laccifer lacca* Kerr. It belongs to the family Lacciferidae, sub-order Homoptera of the order Hemiptera (Rhynchota). The male of this insect is generally alate or winged while the female is always apterous, and it is only the female which is responsible for producing lac. The fertilized female fixes herself firmly on the tender twigs of the host plants and starts secreting lac around her degenerated and deformed body in which it is concealed. It looks like an irregular globular body enclosed in a dense resinous cell. Thus it can hardly be recognisable as an insect. Millions of such females on the host plant establish themselves, with the result the twigs of the host plants are covered with their resinous secretion, known as lac. Lac is gaining importance with the advancement of modern industries. The secretions of this insect provides the stick-lac from which shallac is prepared. The shallac – a purified form of lac, is used widely for the preparation of cosmetics and ammunition for the defence forces. It is an indispensable commodity for the subsistence of a number of cottage industries both in the rural and urban areas. Lac is an important article of commerce and its cultivation is a profitable side industry, which if developed and carried out in a systematic manner must bring substantial income to the cultivators.

Shallac is used in the manufacture of gramophone records, stamps, bangles, ornaments, electrical installations, plastic and so many other important articles of daily use. Luckily, lac is a monopoly of this sub-continent but it is rather unfortunate that all these areas where lac culture and lac industry are well established and properly developed, have fallen to the lot of the Indian dominion. Pakistan is, therefore, now dependent for most of its requirements of lac from import. To overcome this difficulty it is

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most essential to develop lac culture in our country.

BRIEF HISTORY

Prior to partition, work on lac culture was in progress under the Entomologist in Karnal district in 1945. Some work on this aspect of Entomological cottage industry remained in progress since 1952 in Punjab province.

We do not lack in host plants of lac like 'ber', 'dhak', 'siris', *Ficus* sp., 'gular', etc. We also got brood lac here and there immature in the sub-mountainous areas of the province and in D. G. Khan district. The forests in the province have also got host plants of lac in plenty. There is no dearth of such plants growing in the fields of cultivators to propagate lac in the province successfully. Therefore, what is needed is research for finding out the best host plants and the best methods of breeding lac and educating the tillers of the soil and others concerned by means of demonstration and propaganda, that they should take to this useful and important side industry.

IDENTIFICATION AND DESCRIPTION OF STAGES OF LAC INSECT, *LACCIFER LACCA*

ADULT

(i) **Male:** Dimorphic, both winged and apterous forms being present. First generation (March-April-Rabi crop) comprises both alate and apterous forms, the second (September-Kharif crop or Brood crop) consists solely of wingless ones.

(a) Winged male: Light crimson in colour, about 0.5 mm long, possesses ten jointed antennae, mouth parts are vestigial.

(b) Apterous male: Larviform, about 0.65 mm in size, having massive thorax.

(ii) **Female:** Sac like fleshy structure; devoid of legs and antennae; mouth parts sucking, three pores in the cell of the female are prominent (from these pores the milky coloured breathing thread like filaments hang out for respiration of the female), brood chamber appears near maturity which helps in forecasting the swarming.

EGG

The female does not lay eggs directly but these are stored in brood sac

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of its body, and the young ones come out from the brood chamber through anal opercular opening of the mother cell.

LARVA (Lac Seed)

(i) **First Stage Larva:** Crimson red in colour, elongated oval, tapering posteriorly, body size 0.575 mm., antennae six segmented, mouthparts typically sucking, eyes dotted, brachial pores perforated and plates prominent, two pairs of spiracles present.

(ii) **Second Stage Larva**

(a) *Male:* The larva after moulting looses all body appendages except mouth parts, two pairs of spiracles present, body length 0.97 mm., male cell cigar shaped and measures 1.85 mm, with two distinct pores for respiration.

(b) *Female:* After moulting all body appendages except mouth parts are lost, number of anal setae increase, and become bushy, apical hairs absent, rosin and honey dew secretion enhanced. Cell oval and typically emarginated with 3 distinct pores from which milky threads for respiration are protruded freely.

PREPUPA AND PUPA

These stages are only found in the larvae which will give rise to male ones. No prepupal and pupal stages are found in females. In prepupa, body size is 1.425 mm., the legs and antennae becoming apparent and the cell slightly arched or dome shaped. The insect continues feeding and secreting rosin. In pupae the antennae and aedeagus are distinct, the insect ceases sucking and is encased in the second larval skin, caudal setae projecting out.

EFFECT OF WEATHER ON THE DEVELOPMENT AND BEHAVIOUR OF LAC INSECTS

The development zone of the lac insect has been found to range from 4.44°C to 43.33°C (40°F to 110°F); the temperature below or above this range being detrimental to the insect. Relative humidity of 40-70 has been found conducive to the proper growth of lac encrustation.

Hibernation starts at 7.77°C (46°F) and mortality occurs at 4.44°C (40°F) in leafless hosts. No mortality has been observed on shady trees like ber during winter. Hibernation ceases when the temperature rises above 14.44°C (58°F). Hailstorms cause mechanical injury to the living lac insect

and are also indirectly harmful as these result in sudden fall of temperature. Hot winds during summer may cause cent percent mortality of ber brood but the brood of shady fig plant is little affected by them. The extremes of temperature have been found to cause 10% and 90% mortality of the lac insect during winter and summer, respectively.

The fertilized females have been found to have better resistance towards high temperature than those that are unfertilized.

SUITABILITY OF DIFFERENT TRACTS FOR GROWING LAC

The mountainous districts of Rawalpindi, Jhelum, Gujrat, Sialkot and Gujranwala Salt range and riverian tracts have been found suitable for growing lac. In the canal colonies lac can be grown successfully provided the host receives regular water supply.

Climatic Conditions: The temperature range from 4.44°C to 43.33°C (40°F to 110°F) with average relative humidity 40-70% and annual (well distributed) rain fall of 30 inches have been found most conducive to the proper development of lac insect.

Lac Hosts: Although rearing of lac insect has been tried on 23 prospective hosts, lac has been commercially produced only on the following five major hosts given in order of preference.

(1) 'Ber' (*Zizyphus jujuba*): Ber has been found to be the best host for lac insect. Lac produced is of superior quality as it responds well to pruning. Ber brood lac can be tried on all other hosts.

(2) 'Fig' (*Ficus* sp.): Wild figs are not so good. Best specie is *Ficus carica*. Lac produced is lighter in weight and superior in quality. The lac brood can be protected in the summer season as it is difficult to keep it on ber.

(3) 'Dhak' (*Butia monosperma*): It is best lac host where it is already growing; as it cannot be grown in the new localities.

(4) 'Kiker' (*Acacia arabica*): In Hyderabad district it is the most important host. The lac produced is of inferior quality.

(5) 'Siris' (*Albizzia lebbak*): It is the inferior host and the brood becomes specific.

LAC CROPS

There are two lac crops i.e. Kharif and Rabi, in a year as the lac insect has two generations.

(i) **Kharif Crops:** The trees are pruned during the months of January-March. It is essential because by doing this the tissue of the host plants becomes succulent. It should be done six months before inoculation. The inoculation is done during first fortnight of July and this crop matures in October. During October the healthy seed is taken for propagation. Kharif is a brood crop and its duration in 3.5 months.

(ii) **Rabi Crops:** Before doing inoculation the host plant should be divided in two blocks and only one block should be used in one year. It is advisable to have only one crop from a tree in a year. The inoculation is done in October. Rabi is commercial crop and its duration is eight months.

METHODS OF PROPAGATION OF LAC INSECT

For the propagation of lac insect there are only two methods:

(i) **Natural Method:** The swarming takes place as usual on the mother plants and larvae after emergence settle underneath the branches. The inoculation is not uniform in this case. Therefore, the natural method of inoculation should not be encouraged.

(ii) **Artificial Method:** In this method the lac can be grown under controlled conditions. The required quantity (1.0–2.5 kg) of brood lac is inoculated on each tree after conducting the necessary pruning. The pruning should be done at least 4-5 months before the date of inoculation. This practice has resulted in 400% increase in inoculation capacity and 40–60% increase in yield in ber and fig hosts.

METHOD OF INOCULATION

Out of various methods of inoculation brood lac stick method is the quickest, efficacious and economical. From the healthy branches of the trees brood sticks measuring 22.5 to 30.0 cm in length are cut and tied with the underside of the fresh branches to be inoculated. If the branches are parallel the brood sticks are tied across these branches. When the larvae swarm out they crawl to the underside of the branches and continue up to 24 hours and then find suitable place for feeding. They thrust their needle like mouthparts, begin to suck the sap and settle there. The first fortnight of July and the second fortnight of October have been found to be the best inoculation seasons in Punjab.

HARVESTING OR CROPPING

The rabi crop is harvested in the month of August whereas the harvesting of kharif crop is done during the months of November–February. Harvesting is done when the swarming is completed. The infested branches are cut and the lac is scraped off. The lac is dried in the shade and it is stored after thorough drying. Raw lac should not be stored more than six months to avoid deterioration of its quality.

LAC PRODUCTS AND THEIR PROCESSING

(i) **Stick Lac:** The quality of stick lac has been found to depend on the type of lac hosts, time of removal and scrapping instruments used. Stick lac obtained from ber is the best and that obtained from dhak and fig comes next and that from kikar and siris is inferior in quality. The fig lac is easier to wash as compared to the kikar lac. After scraping it is crushed and washed to separate the impurities.

(ii) **Seed Lac:** It is the purest form of lac obtained by washing the stick lac. Crushing the stick lac into grains of about 0.5 cm diameter makes the product easier to wash into seed lac. Four washings with tap water have been found enough to remove the dye. Sprinkling boiled solution of a mixture of washing soda and alum in equal parts over the freshly recovered lac has been found to improve the lustre of the product. Average recovery of seed lac from stick lac is 50%. It is soluble in alcohol which confirms the purity of seed lac.

(iii) Shallac: This is the pure form of lac but it is often found highly adulterated with rosin in the market. Its adulteration with up to 10% rosin has been found to be tolerable.

ECONOMICS OF LAC CULTIVATION

It is very profitable and recommended as cottage industry. One ber tree yields 4.5 kg of stick lac. The price of stick lac is Rs. 15 per kg. Therefore, the average income from a tree will be Rs. 68.00. The yield of seed lac from 4.5 kg, of stick lac is about 2.5–3.0 kg and price of seed lac is Rs. 30.00 per kg. In Rawalpindi areas only kharif crop is recommended and thus during winter the leaves can be fed to the cattle as there is shortage of fodder in that season. In winter during hibernation the lac insect does not suck the plants sap up to 15th March and by this time the ber fruits become

matured which can also be used for human consumption.

FACTORS DETRIMENTAL TO LAC PRODUCTION

(i) **Temperature:** The range of favourable temperature is 4.4°C to 43.3°C. The temperature up to 46.6°C (116°F) is not favourable for the development of lac insect. In summer season 80% mortality of lac insect is due to high temperature on ber plant only. The low temperature below 4.4°C (40°F) is also harmful during winter season. The ber trees are shady but fig and dhak have no leaves which are, therefore, better hosts in winter season.

(ii) **Predators:** *Eublemma amabilis* Moore, *Holcocera pulverea* Myrs. larvae of *Chrysopa* sp. are commonly found as lac insect predators. The removal of brood lac sticks just after swarming has proved very effective as a remedial measure against them.

(iii) **Pests of lac hosts trees:** The following insect and mite pests have been found attacking the lac host trees.

(a)	Fig borer		*Batocera rufomaculata* DeGeer
(b)	Ber chafer beetle		*Adoretus pallens* Blanch.
(c)	Mealy bug		*Drosicha* sp.
(d)	Hairy caterpillar		*Euproctis* sp.
(e)	Fig mites	(i)	*Bryobia praetiosa* Koch
		(ii)	*Agistemus mirabilis* Chaudhry
		(iii)	*Eutetranychus orientalis* (McGregor)

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INSECT PEST MANAGEMENT
Taxonomy and Identification

Volume 3

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1994

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FOREWORD

One of the most difficult thing in the world is transforming ideas and scribbles into an organized format. The present book is a testimony to the fact that Pakistani scientists have the capability and capacity to do so. With our own brand of ideas, beliefs, social values and a tendency to doubt the veracity of obvious, the present effort is a courageous and laudable step towards self-reliance in text books. It will help standardise and improve quality of education in plant protection and lessen dependency on foreign books. Although an onerous task, the book is based on the principle of inclusion of diverse experience and intellect in order to elicit a sense of national cohesion and identity-awaited for since the creation of Pakistan.

It is universally acknowledged that one of the factors that lead to the initiation and sustenance of the process of development is a sound footed education which is not possible without indigenous books.

The material presented is not a narration of the facts but a happening in which the real life situation about pest insects hitherto unrecognized has been subtly yet scholarly unfolded. There is a touch of futurism and a pinch of surrealism. The true aim is to achieve greater naturalism by exact analysis of diverse insect-plant interactions and available techniques to weaken this symbiosis.

After the publication of "Pests and Pesticides in Pakistan", this three volume book on Insect Pest Management is a breath taking sojourn into a realm of devotion and untiring stamina of Dr. Hashmi. The book symbolizes his perseverance, tenacity and insight about resolution of national issues.

It is a matter of great satisfaction to note that the book covers sufficient material to meet all the immediate and diverse demands of students, teachers, researchers, extension workers and above all progressive as well as small farmers and thus fulfills PARC mandate of dissemination of

knowledge. It is expected to bring a change in the style of thinking and acting of researchers and to facilitate wider practical application of the available knowledge to realities of life. This book will serve as a stimulus to further improvement of the principles and methods of integrated plant protection, and will further enhance the development of the new technologies for each and every crop and its zones of cultivation.

(Dr. Zafar Altaf)
Chairman
Pakistan Agricultural Research Council,
Islamabad

April, 1994

PREFACE

Global experience shows that even in the best managed agro-ecosystems where optimum levels of agro-chemicals and energy inputs are maintained the annual losses due to insects are as high as 20-30% of the total yield. These can be even higher for same crops in years of epidemic outbreaks.

Consequently one cannot seriously think of increasing the effectiveness and stability of agricultural production, unless the losses are reduced to minimum. Innumerable studies and practical experience has shown that adaptation of individual measures are insufficient to ensure long-term suppression of a number of harmful organisms. The great diversity of insect pests, the dynamics of their development and a whole range of susceptible commodities/crops, all make different demands on plant protection technologies.

During the last two decades three new concepts have entered the scenario of agricultural research in Pakistan. These are: Integrated Pest Management (IPM), Farming System Research (FSR) and National Coordinated Programmes (NCP) on various commodities.

There is also a group of researchers who have acquired specialized knowledge about different groups of organisms. Their knowledge and experience is equally useful for workers in IPM, FSR and NCP and it also sets a stage for inroads in research in the years to come.

All of these three themes require accurate, detailed and in-sequence information. For instance, for decision making in IPM, one needs proper diagnostics of all life stages of an insect, its life and seasonal history, host-plants and various options of control methods to subdue its population. For farming system research, the economic aspect of pre- & post-harvest pest control technology becomes a demanding element. And how the crops, and

animal husbandry technology should be meshed up for economically profitable, environmentally sound and socially acceptable endeavours? The commodity programmes for their successful optimization of yield aspect need a detailed information about the total insect pest complex of the crop and how the occurrence of various pest species is linked with the phenology of each crop. Is there any carry over of the pests on a commodity from one season to the other? What will be possible insect pest scenario under intensive agriculture?

In the educational institutions most of the teaching in entomology is carried along the taxonomic lines or individual pests are discussed as information communication unit. Thus, there are different groups of clients with different demands for information.

In this book, therefore, an effort has been made to meet the needs of all groups by apportioning the book into insect pests attacking agricultural crops, forests, stored grains, some special groups of insects and mites on which useful work at national level has been done. To these some material has also been added on the entomological industries e.g. apiculture, sericulture and lac culture.

The book tends to provide mostly the basic information and does not cover an extensive review of each and every insect. Part of this is that most research papers dealt with dose estimations of different insecticides, some of which never got into the recommendation domain. Thus, large number of research papers of this kind could not be utilized. The Fundamentals of General and Applied Entomology have been discussed in a separate book and it is expected that both books will be utilized simultaneously to reinforce the materials' utility.

March, 1994

Ali Asghar Hashmi

ACKNOWLEDGEMENTS

Credit for initiating the idea of writing indigenous text and reference books in various disciplines of agriculture goes to Dr. Amir Muhammed, who always motivated and encouraged the scientists to make efforts in line with national needs and aspirations. This book also owes debt to his inspiring imagination. Dr. Zafar Altaf, who believes in originality, creativity, pragmatism and dynamism, immediately sanctioned the necessary funds as soon as three-volume manuscript was presented to him for publication. A deep sense of gratitude is expressed for the kindness of both of them.

During the preparation of this book Mrs. Afzala Tashfeen, (Scientific Officer) and Mr. Gul Zaman, (P.A) gave lot of their time for proof reading, correcting and retyping of the manuscript, respectively. Mr. Javed Iqbal, Senior Scientific Officer, assisted in preparation of species index. The book got into the presentable form due to help in editing by Ms. Sabira Hussain.

It would not have been possible to give final shape to the book and ultimately publish it without technical input of the Directorate of Publications, PARC. The staff of the Directorate finally edited the manuscript before and during composing in frequent consultation with the author. They also designed and determined the format of three volumes of this publication and finally read and checked the composed manuscript, besides technically supervising their printing. In this context, the input rendered by Malik Mushtaq Ahmad, Mr. Nassar Iqbal, Mr. Afzaal Haider and Mr. Abdul Ghaffar is respectfully acknowledged.

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Such a stupendous task of writing a book could not have been possible without the patience of my wife Munazza Hashmi and my little loving son Kamal Asghar Hashmi.

Cooperation of Mr. Mohammad Iqbal of Asad Printers, needs special mention for his efficiency and quality assurance in print outs.

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Chapter 17

GRASSHOPPERS AND LOCUSTS

Muhammad Shafi*

The grass hoppers and locusts belong to order Orthoptera of Class Insecta. The distinctive features of Orthopteran insects are: mandibulate mouth parts; usually enlarged hind leg modified for jumping, large prothorax; usually two pairs of wings, fore-wings generally long narrow and somewhat thickened, usually well developed ovipositor in female. Metamorphosis is incomplete. The pupal stage is usually absent and the immature (nymphs) stages resemble the adults.

GRASSHOPPERS

The grass hoppers are of two types. In Long Horned Grasshoppers, antennae are longer than their bodies whereas in Short Horned Grasshoppers they are shorter than body.

Short Horned Grasshoppers are the members of Super-family Acridoidea which is characterised by presence of 3 segmented tarsi, short ovipositor with 2 pairs of valves. They are placed under Acrididae which is the largest Orthopteran family. There are about 9000 species of the family which inhabit different countries. Acrididae is further classified into various sub-families on the basis of morphological characters. In Pakistan five sub-families of Acrididae have been recorded. The Acridinae are represented by 23 species, Catantopinae by 31 species, Oediopo-dinae being the dominant sub-family with 46 species, while Pyrogomorphinae and Pamphaginae include 11 and 5 species, respectively. Some distinctive features of these sub-families are:

(i) Acridinae; Antennae are sword, club or leaf shaped; frons often strongly sloping.
(ii) Catantopinae; Regular feather shaped area on hind femora.
(iii) Pyrogomorphinae: Head somewhat conical.

*Director Plant Protection and Advisor to Government of Pakistan, Department of Plant Protection, Malir Halt, Karachi

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(iv) Pamphaginae: Head with widely rounded angles, body usually without wings.

(v) Oediopodinae: Antennae thread like often brightly coloured with blue yellow or red, hind wings crossed by black fascia.

LOCUSTS

The term 'Locust' is generally applied to some members of family Acrididae. They differ from other members of grasshoppers family, mainly due to their gregarious habit of forming bands in the immature stages and migrating swarms when adult, under certain conditions. According to Uvarov (1921, 1966) each species of locust can exist in two main forms i.e. phases which differ structurally and biologically. Thus a locust has both solitary and gregarious phase. These two forms are so distinct that they were regarded as separate species by earlier taxonomists. As a result of harmonal changes solitary locust can transform into gregarious ones. The solitary nymphs are variable in colours: green, grey or similar to the colour of their environment. In solitary adult, pronotum is longer, crested and hind femur is relatively longer than fore wing. In gregarious nymphs, colouration pattern is mainly of black and yellow or orange. In adults, pronotum is saddle shaped and hind femur is relatively short. Swarming adults of locusts are tremendously destructive to crops. The most important species of locust is:

Schistocerca gregaria (Forsk) **(Acrididae: Orthoptera)**
(Desert locust)

This species has a wide range of invasion areas. It invades about sixty Afro-Asian countries including Pakistan. There are two main breeding seasons of desert locust in Pakistan i.e. winter/ spring (March-June) and summer (August-September). The total breeding area of Pakistan is approximately 400,000 square kilometer. The swarms produced in the winter/spring breeding areas (Balochistan and some parts of NWFP) generally migrate eastwards into Sindh, Punjab and the bordering areas of India during May-July. From September onward, many additional swarms fly westward into Balochistan, Iran, Eastern Arabia, etc., Karachi (Sindh) and Lasbela (Balochistan) thus it falls into the cross path of the summer and winter/spring breeding areas.

ECONOMIC IMPORTANCE

The desert locust is our ancient and deadliest enemy which can undo our labour in no time. Catastrophic invasions by locust resulting in famines and misery to millions of people can be traced in Holy Quran, Bible and other Sacred books. About the tenacity and remarkable adaptability and survival of locusts may be quoted a saying of prophet Muhammad (May Peace Be upon Him) as quoted by Hazrat Umer-Bin Khattab "God has created thousands of living being, of these sixty percent live in water and 40 percent on land and out of these extinction of locust will be first sign of the end of the world and when the locust is killed, the death of all other things will follow just as the breaking of ore link of a chain means end of the whole organization".

LIFE HISTORY

The life history of desert locust (*Schistocerca gregaria* Forsk) which means the story from birth to death. The desert locust is one of about a dozen species of short horned grass hoppers that can form dense, mobile swarms (of adults) or HOPPER BANDS (of nymphs). The desert locust is one of the most important locust species because of its:

(i) Great mobility upto 1,000 km
(ii) Vast invasion area
(iii) Ability to build up to prodigious numbers
(iv) Ability to eat its own weight of fresh food daily.
(v) Sudden and severe damage to a wide variety of crops.

The life cycle of all species of locusts and grass hoppers comprises three stages:

(i) Egg (ii) Hopper (iii) Adult

Egg stage

It is the period between the depositing of the eggs by females in clusters (pods) into the soil and their hatching. This is commonly known as incubation period.

Hopper stage

This stage is also known as nymphal or larval stage. This is the stage in the life of the locust between emergence of hoppers and their fledging into

adults. These wingless nymphs or larvae have 6 stages separated by moults after each instar.

Adult stage

Sex differences (external): The males are smaller than the females. Twenty four hours after fledging, the average weight of a male is about 1.5 gm and of a female about 1.8 gm. A fortnight later it is about 2.2 gm and 3.2 gm., respectively. At the end of the abdomen of the female there are two pairs of curved hooks with black strips. These are known as ovipositor valves and are used for digging holes in the soil for egg-laying. The abdomen of the male terminates in a conical genital plate.

Colour changes: Immature locusts are pink in colour, lighter or darker according to the high or low temperature in which they have lived. After some time, depending on the condition of temperature, humidity and nature of food, they become grey or brownish and finally turn yellow. The males are generally more bright yellow than the females. Yellow first appears on the dorsal surface of posterior abdominal segments and at the bases of the front edge of the wings. Disappearance of pink colour from the hind tibia of females coincides with the beginning of yolk formation in the eggs. When eggs develop, the abdomen of the female becomes distended. (In the case of adults developing from hoppers bred singly, there is no development of pink or yellow pigment except that the hind wings becoming yellow gradually).

Copulation: On attaining sexual maturity, pairing and copulation begins. The male crawls up to the female and by a single jump rides on its back. Often when the number of females is less than the males, the males fight to take hold of the females. While copulating, the front of the male is just above the occiput of the female and his front legs clasp her pronotum, the claws interlacing at the lower margin. The middle legs grasp, with their claws, the mesothorax of the female, while the hind legs remain raised up and make jerky movements from time to time. The male lowers and twists his abdomen sideways and the penis feels its way between the lower valves of the female ovipositor and enters the opening of the receptaculum seminis. Copulation may last up to fourteen hours. During the act of copulation male sex cells (spermatophores) are transferred to the female where they are stored and can fertilize more than one set of eggs. Polyandry and polygamy are

quite common, i.e. males and females mate with the opposite sex several times. Copulating pairs are very sluggish. Wind, rain and sound have very little effect in interrupting copulation.

The interval between fledging and the first copulation is known as the pre-copulation period. The minimum period has been recorded as 10 days but it is about three weeks at temperatures ranging between 28 and 36°C.

Egg laying: After copulation, the female crawls about restlessly. She selects a laying site, generally open ground with very little vegetation. Having found a suitable place, she raises herself on legs and curves the abdomen over until the tip rests on the soil. The ovipositing hooks are then pressed in and a hole 8 to 16 cm (generally about 10 cm) deep is dug in moist soil. Thereafter, she deposits generally 60-80 eggs (minimum 17 and maximum 157) at the bottom of the hole. Eggs are rice-shaped, 7-8 mm in length and 1-1.3 mm in diameter. The remaining upper part of the hole is filled with frothy secretion which hardens into a waterproof plug. After depositing the froth, the female withdraws her abdomen. During the process of egg laying the abdomen may be extended to as much as thrice its normal length. Egg laying takes about one to two hours, of which about one hour is spent in digging the hole and twenty minutes in the actual deposition of eggs. Sometimes an indication that a locust has laid eggs may be obtained by examining its ovaries. If rows of orange-red spots are found, it has probably already laid some eggs. These spots are known as corpus lutea. In the case of a swarm, these spots are in large numbers. Sometimes, however, such spots are formed due to absorption of yolk and are known as resorption bodies. These are found in overwintered females.

Sometimes females make what are known as trial bores but do not lay eggs. When the soil is dry or very hard they drop eggs on the soil surface or on vegetation because fully mature eggs can be retained by them up to a maximum of three days and thereafter they have to be released even if a suitable site for egglaying has not been found. Sometimes eggs are laid parthenogenetically i.e. without copulation. Hatchings can occur from such eggs.

The desert locust lays a number of egg-pods at intervals. On an average a female lays three egg-pods at intervals of one week (minimum three days and maximum about a fortnight). In India and

Pakistan a female is known to have laid as many as 11 egg clusters, the total number of eggs being 800. At the Anti Locust Research Centre, London, however, there is a record of a single female having laid 25 clusters. The density of egg-pods can be up to 100 per square foot.

Pre-oviposition period: The interval between fledging of a female and first egg laying is known as the pre-oviposition period. This period depends upon temperature, humidity, light, type of food consumed and density of rearing.

Temperature: The pre-oviposition period is inversely proportional to the air temperature. From Table-1 it is obvious that it is 13 days at 40°C and 87 to 213 days (about 7 months) at 18-21°C.

Table 1. Oviposition period in relation to temperature

Temperature (in °C)	Pre-oviposition period (in days) Minimum	Maximum	Average
40	13	17	14
36	13	23	18
30	17	28	24
18 to 21	87	213 (about 7 months)	133

Humidity: Sexual maturation is inhibited in dry weather but it is generally not affected if fresh and succulent food is consumed by the locusts. Optimum humidity is 50-70%.

Light: The observations on photoperiodicity recorded at the Anti-Locust Research Centre, London, have shown that locusts fledging during April-September mature in about 53 days, whereas those fledging in October-March do so in about 33 days only, although they are kept under the same temperature. This difference in the rate of maturity is due to more length of daylight in the case of the former. Subjecting of adults emerging in winter (October-March) to an artificially extended photoperiod of 15 to 16 hours resulted in a high incidence of delayed maturation. Restriction of the photoperiod to 7 or 8 hours reduced the incidence of delayed maturation in adults

emerging in the summer (April-September). Thus, longer exposure to light increases maturation period. It has also been shown that maturation may be affected by day length during hopper life. Adults developing from hoppers reared at photoperiods of 12 hours, mature much more rapidly than those reared at 13 hours photoperiod.

Type of food: Locusts eat their own weight of food daily. The type of food on which locusts feed has a marked effect on their maturation. For instance, adults fed on cauliflower leaves *(Brassica oleracea* var. *botrytis)* commenced copulating within 28 days and ovipositing after 28 days. On the other hand, those fed on *bordi (Ziziphus nummularia), Kherjri (Prosopis spicigera), booh (Aerua persica)* and moist wheat bran survived for 14, 43, 93 and 67 days, respectively, without any sign of sexual maturation. In another case, adults fed on cauliflower laid eggs within 20 days, whereas those on *Prosopis* did not mature even for 5 months. Their ascorbic acid contents (per 100 gm weight) were: cauliflower - 66 mg, *bordi* - 28 mg, Khejri-14 mg, booh-38.8 mg and moist wheat bran-106 mg. Higher ascorbic acid contents of cauliflower may be one of the factors hastening sexual maturity.

Density of rearing: The rate of sexual maturation is roughly proportional to adult density: the higher the density the more rapidly the locust matures. The females of isolated pairs lay their first egg-pods in an average of 38 days, whereas when 30 pairs are kept together, egg laying may start in 3-4 weeks. From what has been described, it is obvious that there is no true dispause in the adult stage, though the pre-oviposition period gets prolonged as a result of unfavourable environment. The diapause which is the result of certain environmental factors is termed as 'facultative diapause' and can be broken by providing the requisite favourable conditions.

Another locust found in India and Pakistan, viz; the Bombay Locust (*Patanga sucinta*) has a true diapause in the adult stage. This locust begins acquiring wings in September and continues in the adult stage without attaining sexual maturity for about 9 months. Copulation and egg laying occur during June-July. Thus there is only one brood in a year. Attempts to break this diapause, by providing suitable conditions in the laboratory, have failed.

Longevity of adults: Generally, males live longer than females. A swarm may be comprised only of mature males, the females having all died after egglaying. Adult life at constant temperatures has been recorded.

Table 2. Longevity of adults under constant temperature

Temperature (in oC)	Adult life (in days) Maximum	Average Male	Average Female
40	43	35	33
36	87	40	36
30	75	63	64
27	85	85	-

Incubation period: The incubation period varies according to the soi temperature, as shown inTable 3.

Table 3. Incubation period

	Temperature (in oC)	Incubation period (in days)
Below	18	No hatching
	18.5	85
	20-21	32-33
	22	28-29
	27	20
	32-37	12-13
	40	11
	43	2
	46*	No hatching

**Eggs kept at this temperature for 8 hours were killed*

These values indicate that there is no development of eggs below 18°C (developmental zero or threshold of development). The eggs, however, remain viable and their development begins when the temperature rises above 18°C. For instance, eggs exposed to 13°C for 34 days hatched in 12 days (normal incubation period) when subsequently exposed to 35°C. Similarly, eggs kept at 10-15°C at night time and above 20°C during day time hatched successfully. On the other hand, eggs exposed to temperatures above 45°C are killed. It may be said that, within limits, the incubation period is inversely proportional to temperature - 9 days at 43°C and 85 days at 19°C.

Under natural conditions the temperature at egg-pod level would vary from season to season. The incubation period will vary in relation to season, latitude and altitude.

Soil moisture: Water is necessary for the development of the embryo. The requisite amount of water is absorbed from the soil. If the water content of the soil is high, eggs are attacked by mould and if it is too low the eggs dry up. The freshly laid eggs are least resistant to water loss. The egg development may be inhibited if soil moisture is deficient but development recommences when soil moisture is made available.

It will be seen that there is no true embryonic diapause. The delay in egg development may be caused by low temperature or absence of soil moisture but the development recommences when favourable conditions are provided. In the case of the Moroccan locust (*Dociostaurus maroccanus*) there is a true embryonic diapause which cannot be broken even when suitable conditions are provided. Normally the eggs laid in May hatch during March of the next year.

Hatching: At the end of the incubation period each egg hatches and a creature known as 'vermiform larva' comes out. The eggs in the top portion of the egg-pod hatch first. The vermiform larvae wriggle their way out, through the froth column, to the soil surface. Soon after reaching the surface they shed the white skins in which they are enveloped. These skins are known as intermediate moults and are of the size of poppy seeds. Time taken in shedding the intermediate moult ranges from about 10 seconds to 5 minutes, the average being about 1 minute (air temperature 28-32°C and relative humidity 57-81%). The surface of the area where hatching has occurred is studied with these white skins. Sometimes, when the vermiform larvae come across cavity under the ground, the intermediate moults are shed before they emerge to the soil surface. In such cases the resultant hoppers may or may not be able to find their way to the soil surface. In the latter case they die under the soil.

Hopper stage

After the intermediate moult, we have the first instar hoppers, which are pale in colour but within 1 to 2 hours turn black. They form dense groups and [illegible]rch about in bands, feeding on vegetation. After a few days they stop fee[illegible] and move up on grass stems and bushes and hang down by their legs.

A slit appears in the cuticle (skin covering the body) on the back behind the head and a new hopper (second stage or instar) emerges. This casting of the skin is known as moulting and the skins so shed are known as moults. The old cast-off skins which are left behind on vegetation look exactly like the hoppers which had emerged there from. This process of moulting takes place five times during life of a hopper and as such there are five larval instars. The 5th moult leads to the emergence of adults with fully-developed wings. These adults, are known as fledglings. After a day or so they begin undertaking short low flights, while the exoskelton hardens. After a week or so their cuticle fully hardens and sustained migratory flights can occur. They fly together in the form of a swarm and evacuate the breeding areas to repeat the life cycle again.

Duration of larval stages

Temperature: The duration of the larval period is dependent only on the temperature at which the hoppers are bred, as will appear from Table 4.

Table 4. Duration of larval stages in relation to temperature

Temperature (in °C)	Duration of each instar (in days) I	II	III	IV	V	Total larval period (in days)
20 & below	No development. Freshly hatched hoppers lived for 31 days at 20°C and died without moulting.					
21	13-16	13-16	All died			
24	8-9	7-9	10-11	13	21-23	62-64
27	6	6-7	7	8-9	18-19	46-47
30	4-5	4-5	4-5	5-6	11	31
33	4	4-5	4	5	9	26-27
36	3-4	3-4	4	4	7	22
40	3	3	4	4	7	21
44	-	-	-	-	-	27

These observations indicate that 20°C is the lowest and 44°C the highest limit at which hopper development can occur.

If during the larval stage, winter sets in, the larval period may get prolonged, depending on the duration for which the larvae remained at temperatures below 20°C. In one case when the mean minimum temperature

ranged between 4.9 and 14.6°C and mean maximum between 22.8 and 32.7°C, the total larval period was 161 days (I-12, II-13, III-40, IV-72 and V-24 from 12th Oct. to 22nd March). In this case the hoppers had remained at a suitable temperature during the warmer part of the day only whereas throughout the night and the greater portion of the day, temperature had remained below the developmental zero, particularly during III and IV stage.

Under natural conditions the duration of the larval period will vary according to season, latitude and altitude; for instance in Indo-Pakistan region it is 21-28 days during monsoon and 28-42 days in spring. In the northern spring breeding belt (North Africa, Iran, etc.) the duration is 29.52 days.

Humidity: The influence of low atmospheric humidity on hopper development is insignificant, provided fresh food is available. A completely saturated atmosphere is, however, detrimental - it slackens larval development and increases mortality.

Quality of food and duration of larval period

The type of food affects larval period, as seen from Table 5.

Distinguishing features of various stages

1st instar hoppers: At first pale, turn black after one or two hours. Median line on head which is continuous along the pronotum and abdomen. Length 7-12 mm, antennal joints 13.

2nd instar hoppers. Black and white colour pattern. There is very slight growth, laterally on thorax, of two wing pads (wings or well defined wing) rudiments) on each side but these are very small and may be seen only under a magnifying lens. Length 13-18 mm, antennal joints 19.

3rd instar hoppers: Abdomen pale yellow (sometimes pinkish) with black pattern. Wing pads still lateral but bigger and can be seen with the naked eye. Length 19.25 mm, antennal joints 21.

4th instar hoppers: General ground colour yellow with well-developed black pattern. The wing pads become bigger and turn dorsally. These are still

shorter than length of the pronotum at the median line. The hind pair of wing pads cover the front wing pads. Length 26.35 mm, antennal joints 23.

5th instar hoppers: General colouration yellow or orange yellow with black pattern. The wing pads are longer than pronotum, the second pair still covering the first. Length 36.45 mm, antennal joints 26.

The black pattern among hoppers varies according to temperature. It is more extensive at lower temperatures and less so at higher ones. Those reared at 28°C and below are almost entirely black, at 40°C at night time and at 34°C during day time, the yellow and black colour is approximately equal. (In solitary hoppers, the ground colour is that of the vegetation on which they live and there is practically no development of black pigment. The larval instars are 5 or 6).

Table 5. Duration of larval period in relation to quality of food

Hoppers fed on	Larval period (in days)
Lucern	37 days
Cotton or sorghum	28-30
Cotton Maize	Those fed on cotton flagged in 25-29 days by that time, those fed on maize had completed only the first three larval stages.
Cauliflower	Those fed on cauliflower commenced entering 5th instar in 31 days and those on spinach in 39 days.
Cabbage	31
Sorghum	35.9
Indigofera cordifolia	36
Tribulus terrestris	37
Convolvulus pluricaulis	38.7
Heliotropium undulatum	40
Maize seedling	44
Crotalaria burhia	44.5
Aerua persica	45.6

Adults

They have fully developed wings. At first they look like crumpled cloth but soon become fully extended and folded with fore wings or elytra covering the hind wings. Body pink when immature, and yellow when mature, length 46-60 mm, antennal joints 26.

Number of Broods in a Year

In India and Pakistan during summer, under natural conditions, there are one or two broods depending on the duration of the rainfall period. When the locusts overwinter in the country (as occurred during 1941, 1945, 1951 and 1955) a third brood may also develop in spring, egg laying occurring generally in February-March.

Phase Transformation causes and course of Plague

It is an established fact that swarm of desert locust is present somewhere in vast breeding areas of the world. Extensive control measures and unfavourable climatic conditions and natural enemies may for some years check the rapid multiplication and in such conditions the locust passes solitary and isolated life. The phase transformation of the solitary locust into gregarious form is still not fully understood, any how this may be safely presumed that favourable climatic conditions are helpful in the process of transformation, when the inactive solitary locust becomes active, the grass-hoppers change their phase, feed voraciously and breed frequently. The accumulation and association of the locust results in the form of swarms. This is termed Phase Transformation.

During the last one hundred years out-break records of locust swarms show that the occurrence of swarms is of a periodical nature. They appear suddenly and remain active for four to five years and disappear for four to five years. In the past 177 years record of Indo-Pakistan subcontinent shows 24 outbreaks i.e. from 1810 to 1813, 1821, 1833 to 1834, 1843 to 1845, 1860 to 1866, 1869 to 73, 1876 to 80, 1889 to 94, 1960 to 64, 1972, 1978 and 1982 to 83. The vicious cycle once started may continue for 3 to 8 years until unfavourable climatic or anti locust campaign may reduce its population to such an extent that they disperse and adopt solitary life.

Power of Flight

Desert locust is one of the most powerful fliers among the insects of the world. Its swarms are capable of flying about 100 miles a day which may even

increase if the wind velocity and direction is favourable. Unlike most other, insects it is capable of flying during night and flying for a week or so without feeding.

Food Preferences in Desert Locust

The desert locust feeds on a wide variety of plants and vegetation and different opinions have been attributed in this connection. From this it becomes difficult to state as to whether it has distinct taste or preference to a particular plant. Perhaps food eaten or rejected depends on the state of hunger, depending on the particular stage and physiology of the insect at the time and space. Uvarov cited it as an extreme example of polyphagy. Mehrotra (1980) suggests that over clouding, changing seasons and poor food may affect the adoptive, dispersal and migration of insects.

Food Plants of Solitaries

The desert vegetation is usually composed of perennial plants, which drive their water supply from the deeper layer of soil and annuals which thrive only during rainy season and wither off when the rains are over. It is, therefore, of prime importance to know as to under what vegetational umbrella solitary adults and hoppers survive in nature under desert conditions.

Rao (1960) has listed the following plants (wild as well as cultivated) in this connection. Local common names are given as under:

S.No.	Scientific Name	Local Name
1.	*Heliotropium undulatum*	Marrand
2.	*H. eichwaldi*	Popat
3.	*Aerua tomentosa*	Booh
4.	*Chrozaphora verbascifolia*	Kapoocham
5.	*Sericostoma pauciflorum*	Kharzan
6.	*Tribulus terristris*	Sareng
7.	*Indigofera cordifolia*	Bekkar
8.	*Cenchrus biflorus*	Bharut
9.	*Zizyphus nummularia*	Bordi
10.	*Dactyloctenium scindicum*	Gandhi
11.	*Pennisetum typhoideum*	Bajri
12.	*Cyamopsis psoraliodes*	Guar
13.	*Phaseolus aconitifolius*	Mooth

14.	*Sesamum indicum*	Til
15.	*Citrullus vulgaris*	Watermelon, matira

Bhanotar *et al.* (1973) have also listed the following wild plants where solitaria breeding occurred during 1972 in Rajistan state. Adults and hoppers were mostly seen in bhakra bushes. However, individuals alongwith their excreta were seen under many bushes given below. Local common names are mentioned against each scientific name:

S.No.	Scientific Name	Local Name
1.	*Tribulus alatus*	Bhakra
2.	*Indigofer-a cordifolia*	Bekkar
3.	*Indigofera* sp.	(Bekkar dhanwanti)
4.	*Indgofera linifolia*	Gulia Bekkar
5.	*Indigofera* sop.	Siyan
6.	*Aerua javanica*	Booi
7.	*Cenchrus barbatus*	Bhurat
8.	*Crotolaria burhia*	Chog
9.	*Barleria* sp.	Chapri
10.	*Gesekia communis*	Chapri sarli
11.	*Euphorbia grannulate*	Dudeli
12.	*Boerhavia legans*	Hirla
13.	*Capparis aphylla*	Ker
14.	*Corhorus tridens*	Kataro
15.	*Barleria* sp.	Chapri Kantewalli
16.	*Arzstida adscensionis*	Lamph
17.	*Haloxylon solicornium*	Lana
18.	*Eragrostis ciliaris*	Lathia
19.	*Panicum turgidum*	Murth
20.	*Caligonum polygonoids*	Phog
21.	*Launea chondrilloides*	Phade
22.	*Elionurous hirsutus*	Sewan
23.	*Boerhavia diffusa*	Sinawari
24.	*Capparis* sp.	Ker moonia
25.	*Citrullus colacynthis*	Tombe ki bel

CONTROL MEASURES

The aim of modern locust control is plague prevention. The control work begins right from breeding places of locust and an all out effort should

be made to suppress the hoppers at the place of their emergence. If the operation has been carried out in an extensive area, there is very little possibility of swarm formation. Locusts can be controlled in all their stages i.e. egg, hopper and adult, but the effective and economical control is achieved on hopper stages.

Egg Stage Control

Mechanical: Collection and control of eggs by old methods is now discarded as it has been found uneconomical. The practice adopted previously was ploughing, irrigating and digging of the area where eggs have been laid. The other difficulty in adopting this practice is that large area cannot be ploughed or irrigated.

Chemical: Spraying and dusting before egg hatching with Aldrin or Dieldrin @ 1.80 03/acre is effective in killing fresh hatched hoppers.

Hopper control: Most vulnerable stages from control point of view are I, II and III stages and if they cross this stage the affected area increases and control work and expenditure also increase proportionately. Spraying, dusting and baiting has been successful. For dusting against I, II, and III stages of hoppers, 0.3% BHC dust is effective. For control of IV and Vth stages the formulation should be 1%. It should be spread by hand or power dusters in the morning when hoppers are sitting on the bushes.

Poison baiting: Poison baiting has also been considered successful and economical. Usually rice husk is taken as bait. BHC 2.6% is used @ 21 lbs per 100 lbs of rice husk or Aldrin 40% @ 2 oz/100 lbs of husk. The husk and the poison should be wetted, mixed with little water so that it should not be too wet to make it lumpy. This should be spread around the bushes where hoppers have roosted for the night. The best time for spreading is in the early morning hours, but it may be spread on the route of the marching bands during time of the day.

Spraying: The most economical and effective insecticides for spraying purpose among chlorinated hydrocarbons are Aldrin and Deildrin. These serve dual purpose, i.e. making the surrounding vegetation poisonous which can act as a bait. Aldrin 40% EC or W.P. @ 8 oz/100 gls of water or Dieldrin

20% EC or W.P. @ 1 lb in 100 gls of water is spread in the field. In first stage hoppers the effect is observed just after spraying, while in advanced stage hoppers it takes time. There are two techniques of spraying i.e. direct and barrier. In direct spraying the spray formula is to spray directly over each hopper band and lay 2 to 3 spray in front of the marching band at 200 yards distance, As far as the barrier spraying is concerned, lines of spray are laid after every 2 furlongs. Only a gallon of water or oil will suffice to spray an acre with Aldrin 40% EC or W.P. @ 8 oz. Insecticides of phosphorous group are uneconomical and hazardous for workers and grazing animals.

Spraying by Exhaust Spray

It is a new and latest device in controlling locust and its hoppers. This is simple technique of using exhaust. It has a tank of insecticide fitted in the body of land rover or jeep in which pressure is created by diverting exhaust gases of engine which forces liquid insecticide to pass through restricted orifice of exhaust nozzle. If used in right manner drift spraying vehicle speed should be five miles per hour in 5-10 miles per hour wind speed. It will consume 1/36 gls or 1/4 pint per acre for a swath of 120 yards. Involatile Dieldrin on Shell Dieldrin is especially made for this purpose. The vehicle should move across the wind.

Spraying with Aircraft

This is another mechanism fitted with micronair and boom-nozzle type of sprayer on to a spray aircraft, for breaking down the concentrated insecticide and dispersing in the air. The latter acts as a carrier and thus insecticide gets deposited on desert vegetation. Aircraft-spraying procedure against locusts can be classified into two broad divisions, but there is often some degree of overlap.

1. Air-to-ground spraying when the locusts are settled on the ground such as settled swarm, hopper-band and group of egg fields.
2. Air-to-air spraying when the locusts are flying.

Unlike the exhaust nozzle technique, this can be applied irrespective of the topography of the area and other difficulties. The cost of operations has been further reduced and large infested areas can be covered in the shortest possible time.

Adult Stage Control

Control of adult flying swarm is most difficult and impracticable, but some of the following precautions will help reduce the damage to crops:

1. Swarms should not be allowed to settle in the fields by arranging parties of adults and school boys, waving cloth sheets, and flags to scarce them away.
2. Smoke should be produced at various places in the field.
3. Swarm in mating and egg laying stage can be dealt with by beating with brooms, collecting into bags or crushing them by means of suhaga and trampling by sheep, goat and herd of cattle, etc.
4. Hand collection for food and manure purpose.
5. Dusting BHC 2.5% by machines.
6. Spreading poison bait (2 lbs of 2.6% BHC to 1 Md of rice husk @ 10 to 20 seers per acre).
7. Aerial spray can also be done by Aldrin @ 8 oz of 40% in one gallon of water or oil per acre. The optimum height for aerial spray is 10 feet above ground.
8. When swarm settles on high trees and bushes, it can be shakened down during night and crushed or burnt.
9. If the insecticide is not available the settled swarm can be burnt by use of flame thrower or by use of mashals. But it should be first brought down when locust has settled on bushes and trees at night and the temperature is low.

PROPOSED FUTURE WORK

With all this knowledge we are still far from understanding the built up of real epidemiology of locust cycle. The precise factors which cause the sudden upserge of the locust population in a particular season or year initiating swarming cycle and vice versa has yet to be known.

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Chapter 18

TERMITES

Muzaffer Ahmad* and Muhammad Saeed Akhtar*

INTRODUCTION

Termites, commonly called 'white ants', are a group of social insects belonging to the order Isoptera which includes nearly 2000 species. The name 'white ants' is, however, a misnomer because neither termites are all white nor are they ants. It is only in their social life that they have a similarity with ants and other social Hymenoptera. Phylogenetically, they are very remotely related to ants. Their closest relatives are the wood-eating cockroaches. It is now well established that termites and wood-eating cockroaches have had a common origin (Ahmad, 1950). Termites are most abundant in the tropical and sub-tropical regions of the world. A few species have extended their range into the temperate region also.

Besides being insects of considerable economic importance because of the damage they cause to agricultural crops, forest trees and woodwork in buildings, the termites are also of great biological significance. They provide an excellent material for study of some of the fundamental biological principles. Their highly organized social life, intricate nest-building behaviour and their association with bacteria, fungi, protozoa, and some insects have attracted the attention of a large number of biologists with varied interests (Ahmad, 1971).

Termites live in highly organized societies with well-defined castes comprising reproductives, soldiers and workers. The imagos have two pairs of wings of more or less similar size, shape and venation. It is because of this characteristic of the wings that the order Isoptera got its name. After swarming, the wings are neatly shed along basal sutures (Figure 1.), leaving behind wing scales or wing stumps (Figure 1) which the adults retain throughout their life. The basal suture, also called humeral suture, is a line of weakness allowing quick detachment of the wing. No other insects possess

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BIOLOGY

Social Organization

All the termites, without any exception, have evolved a social mode of life with well-defined castes, each adapted to perform specific functions. All the members in a colony work harmoniously for the good of the society.

The size of the termite colony varies with the evolutionary status of the species. The lower wood-dwelling termites have small colonies comprising a few hundred to a few thousand individuals, while the higher termites build up very large populations. The carton nests of some nasute termites may contain nearly 2.0 million individuals (Holdaway *et al.,* 1935).

Termite Castes

Reproductives

Primary reproductives

Winged adults which appear in large numbers during the swarming season and which, after swarming, segregate into pairs and establish new colonies are known as primary reproductives. They have two pairs of wings, functional eyes and ocelli (Figure 1-A). Their mandibles are like those of the workers.

The adult male and female which together establish a new colony later on come to be known as king and queen. When a sizeable number of workers and nymphs have been produced in the colony, the female as a result of constant supply of food by the workers, starts increasing in size due to increase in the size of the ovaries and deposition of fat. It is only the abdomen which increases in size. In wood-dwelling termites with small populations, the queen is also small, whereas, in higher termites the queen may attain a length of 10 cm or even more, some 3000 times the size of the workers (Figure 2-A). It is just an egg-laying machine, depositing several thousand eggs per day throughout her estimated life-time of 50 years

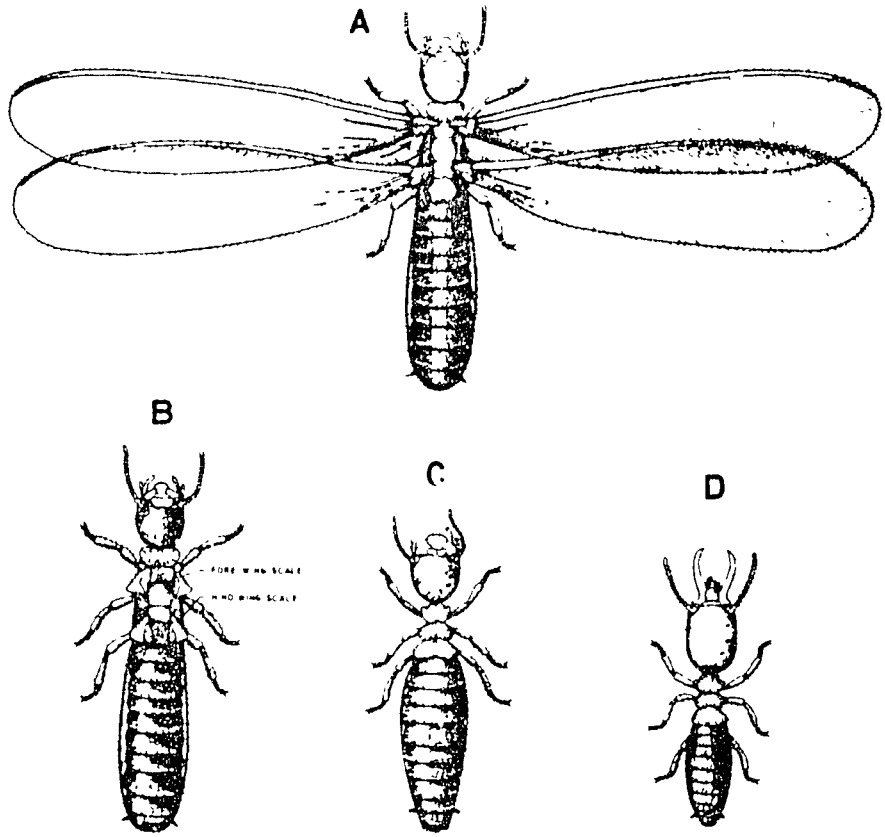

Figure 1. *Microcerotermes baluchistanicus* Ahmad; A. alate (basal suture of wing indicated by arrow); B, dealate; C, workers; D. soldier

(Emerson, 1949). The king (Figure 2-B), in contrast to the queen, is much smaller. Sometimes more than one queen may be present in a mound (Figure 3).

Replacement reproductives

In the event of the death of the original royal pair or their becoming sexually non-functional due to age when they are killed by the workers, replacement or substitute reproductives are produced in the colony.

The production of replacement reproductives may involve either the winged adults awaiting exodus from the colony or nymphs of different ages. In the first case, the wings of the adults are broken haphazardly (not along the basal sutures) and their reproductive system starts undergoing development. These are known as adultoids or first-form replacement reproductives. The female may attain a size comparable with the original queen. The adultoids are recognizable by the irregular, notched outer margins of the wing scales. Such adultoids are of rare occurrence, having been reported from the colonies of some fungus-growing termites (Hicken, 1971).

The nymphoid or second-form replacement reproductives, which are more common than the adultoids, are produced out of the older nymphs with wing-pads. They are recognized by the presence of wing-pads and reduced eyes (Figure 2-C). Since these females are much smaller than the primary queens and have much lower egg-laying capacity, several such females may be present in a colony to maintain the population level characteristic of the species. Polygamy is common among these replacement reproductives.

Rarely, the workers may also become reproductively functional to form ergatoid or third-form replacement reproductives. They have no wings and there are only traces of eyes (Figure 2-D). Like the nymphoids, they are also polygamous.

Workers

The workers (Figure 1-C) are the most numerous individuals in a termite colony. It is the workers which cause damage to human property. They are soft-bodied, mostly blind, wingless and even without wing-pads, but with well-developed mandibles for chewing the wood. It is because of the soft-bodied workers that termites lead a concealed life, reaching the food source by covered runways. In some species, however, the workers have more sclerotized body and come out of the nest for foraging in the open. They are sterile males and females.

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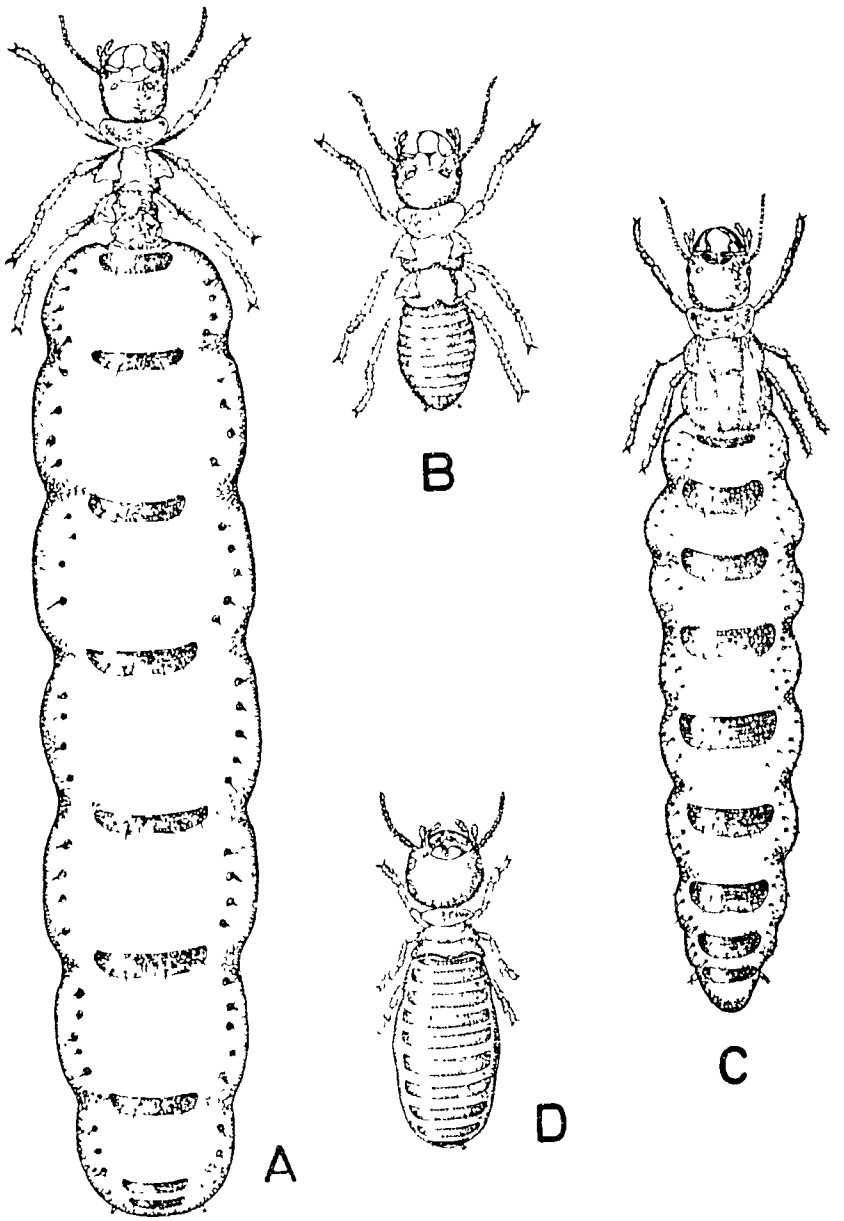

Figure 2. A, primary queen and B, primary king of *Odontotermes obesus* (Rambur), X 3.5; C, nymphoid or second form replacement queen of *Microcerotermes baluchistanicus* Ahmad, X10; D, ergatoid or third-form replacement queen of *Amitermes atlanticus* Fuller. (ID from Skaife, 1955).

Figure 3. Two queens and one king in the royal chamber of the mound of *Odontotermes obesus* (Rambur). King shown by arrow. (From Chaudhry, et al., 1972).

Not all the termites have workers. Termites belonging to the family Kalotermitidae are devoid of true workers. Their functions are performed by the nymphs. *Bifiditermis beesoni* (Gardner), *Epicalotermes pakistanicus* Akhtar, *Postelectrotermes pishinensis* (Ahmad), *Postelectrotermes pasniensis* Akhtar and *Cryptotermes karachiensis* Akhtar are the workerless termites of Pakistan.

In their structural plan the workers show much less diversity than the soldiers and imagos. They are, therefore, of limited value in the identification of termites at the species level. However, at the generic and higher levels the workers provide an excellent taxonomic characters in their mandibular patterns (Ahmad, 1950) as shown in Figure 4.

The workers play the most important role in the economy of the termite society. All the duties, except reproduction and defence, devolve upon them. They collect the food, feed the other individuals of the colony dependent on them for food, build and repair the nests, cultivate fungi, attend to termitophiles and maintain sanitary condition in the colony. The large-sized workers may even take part in the defence of the colony.

Soldiers

Since the workers are blind and defenceless, the defence of the colony against enemies, particularly the ants, has been made possible by the evolution of the soldier caste which is structurally well-adapted for defence. Except for a few genera (Sands, 1972; Ahmad, 1976), the soldier caste is present in all other termites.

Structurally, the soldiers are very different from the workers and reproductives (Figure 1-D). It is the head capsule and the mandibles which have undergone modifications in relation to modes of defence. Like the workers, the soldiers are also blind (with a few exceptions), wingless, and reproductively non-functional (with a few exceptions). The soldiers exhibit a great diversity in their structural plan (Figure 5). Hence, they are of great value in termite taxonomy.

Majority of the termite soldiers are mandibulate, i.e., they possess well-developed mandibles which are used for biting the enemies but are otherwise useless for chewing the food (Figure 5-A-H). This is why the soldiers are fed by the workers on pre-digested food.

Several termite genera have evolved long snapping type of mandibles (Figure 5-I-J). They are slightly to highly asymmetrical. In the highly asymmetrical type, the right mandible is straight, blade-like, and the left

mandible is twisted like the horn of a goat. Together they function as a pair of scissors, cutting the ant into two pieces.

Some termites have their whole head capsule so modified that they use it for plugging the holes in the nest to prevent the entry of the enemy while the workers are busy repairing the holes. *Cryptotermes karachiensis* has this type of phragmotic head (Figure 5-K). The mandibles in the termites with phragmotic head are much reduced compared to their relatives which defend the colony by their mandibles.

An entirely different defence mechanism using a sticky chemical has evolved in the termites commonly known as nasutes. In these soldiers (Figure 5-L), the head looks like a round flask, with a long tubular neck, the nasus, at the tip of which is the opening of the frontal gland. The secretion from the frontal gland is ejected with force from the tip of the nasus. It is sticky and caustic in nature. When it is squirted at the ant, the latter is immediately put out of commission; its legs and antennae get glued up and after sometime it dies.

In some termites *(Schedorhinotermes* and *Rhinotermes)* the chemical defence is of gaseous nature. The fluid from the frontal gland on reaching the tip of the elongated tongue-like labrum (Figure 5-M) volatalizes. It acts like a tear gas.

COLONY FOUNDATION

Colony foundation by imagos

New colonies are generally established by colonizing flights of termites, a common sight during the swarming season. At a certain time of the year, winged adults are produced in large numbers in the colony for swarming. With the suitable combination of temperature and humidity in the atmosphere which is obtainable in greater part of Pakistan with the onset of monsoons, the stage is set for the exodus of the winged termites. Holes are opened in the nest by the workers to allow their exit. While emergence is taking place, soldiers in most of the termites stand at guard around the emergence holes.

Most of the swarming takes place during the night, a little before or after sunset on a rainy day. Swarming of termites has been observed during other timings also at Lahore, in the morning after sunrise *(Eremotermes* sp.), late afternoon *(Heterotermes indicola)* and early hours of the morning, 4.00 a.m., *(Microtermes* sp.).

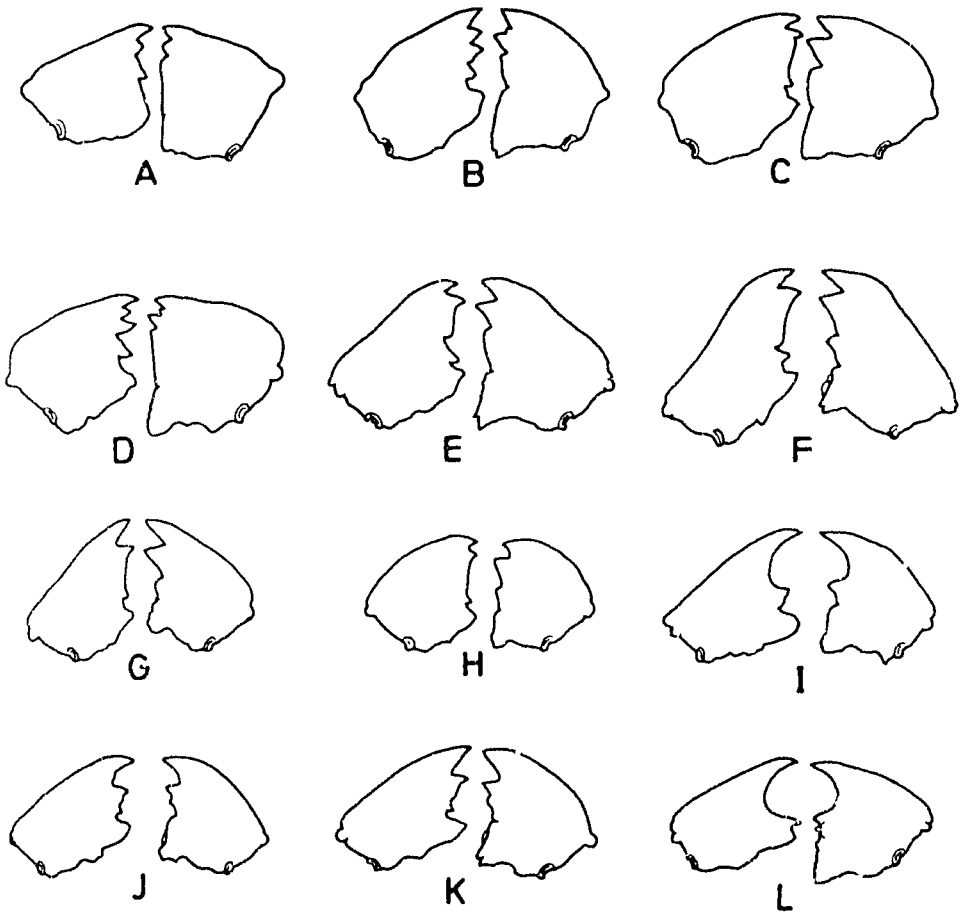

Figure 4. Worker mandibles; A, *Cryptotermes*; **B,** *Archotermopsis*; **C,** *Anacanthotermes*; **D,** *Psammotermes*; **E,** *Odontotermes*; **F,** *Speculitermes*; **G,** *Eremotermes*; **H.** *Trinervitermes*; **I,** *Tuberculitermes*; **J,** *Anqulitermes*; **K,** *Capritermes*; **L,** *Serritermes* **(From Ahmad, 1950).**

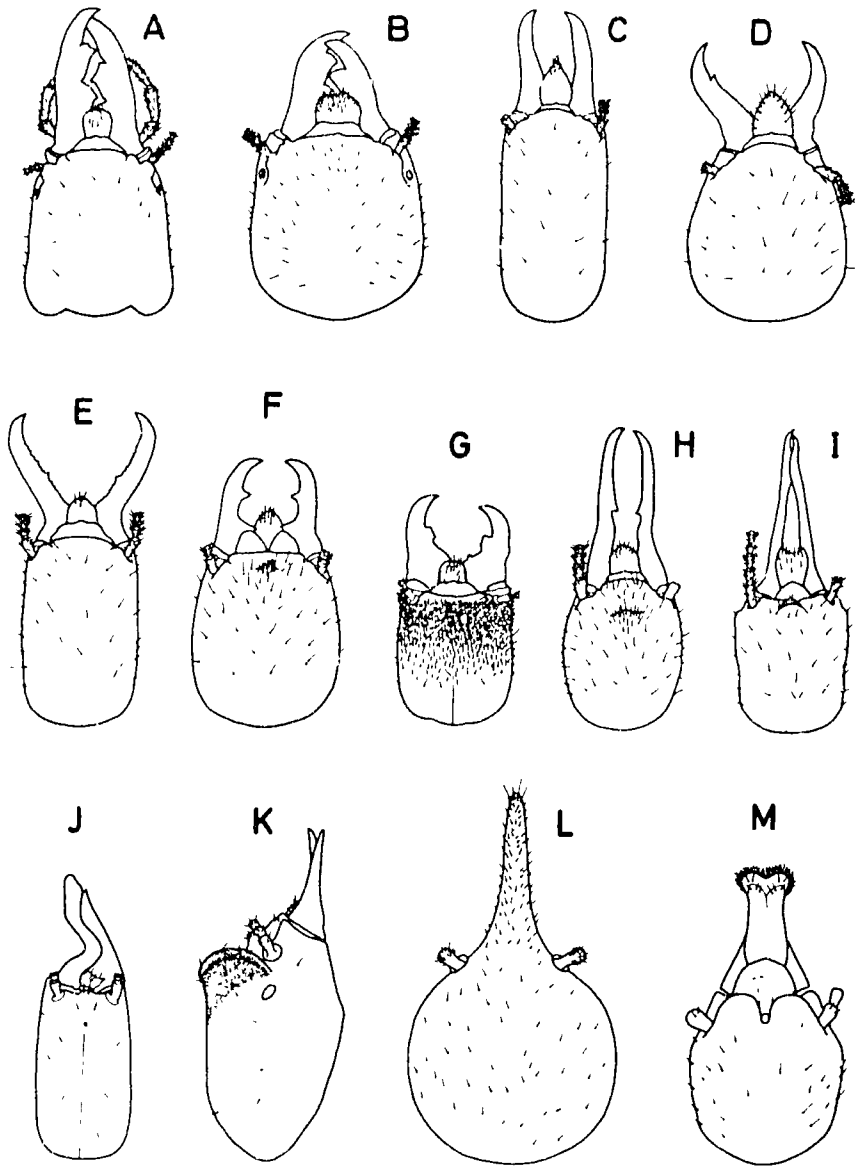

Figure 5. Termite soldiers (heads); A-H, soldiers with biting type of mandibles; I, soldier with slightly asymmetrical snapping type of soldiers; J, soldier with highly asymmetrical type of snapping mandibles; K, soldier with phragmotic head; L, nasute soldier; M, soldier with gaseous defence mechanism. (5A-F and H-I from Ahmad, 1955; G and J from Ahmad, 1965; K-M from Chaudhry, et al., 1972).

It has been observed that the termites do not swarm only on the rainy day, but also keep on swarming for several days following the rains (Akhtar, 1978). When the humidity in the atmosphere decreases appreciably, the swarming stops till the next rains.

Detailed studies on swarming of *Bifiditermes beesoni* have been made by the group working at the University of the Punjab, Lahore (Ahmad *et al.*, 1979). In nature, the swarming of this termite begins 1.5 hour after sunset. The daily emergence reaches peak by about 9.00 p.m. Usually, the swarming stops by 10.00 p.m., rarely it may continue up to mid-night. In the laboratory colonies, the timings are slightly different. The emergence begins a little before or after sunset and most of the emergence is over by 11.00 p.m. On one occasion, a few imagos continued to emerge till 4.00 a.m

The duration of swarming varies with the species, *e.g.*, *Coptotermes heimi*, June-September (Ahmad, 1955; Akhtar, 1972, 1978), *Heterotermes indicola*, August-September (Ahmad, 1955; Akhtar, 1978), *Odontotermes obesus*, August-September (Chaudhry *et al.*, 1972; Akhtar, 1978), *Microtermes obesi*, June-August, (Ahmad, 1955; Akhtar, 1972, 1978), *Eremotermes paradoxalis*, June-September (Ahmad 1955; Akhtar, 1972, 1978).

After the winged adults have flown at the light for sometime, they drop on the ground and shed their wings immediately or in some species the shedding of the wings is delayed. The imagos of *Bifiditermes beesoni* retain their wings for several days or even weeks.

The males and females then segregate into pairs, the female followed by the male. The pairs in tandem are a common sight during the summer. In some species, *e.g.*, *Bifiditermes beesoni*, tandem formation does not take place. If the pair is able to find a suitable niche it will enter into it, excavate it and then seal it off to a lead concealed life.

After the pair is able to establish itself, egg-laying begins. The pre-oviposition period varies with the species. In the laboratory it was noted that in the case of *Bifiditermes beesoni*, initiation of egg-laying occurred between 7 and 13 days after releasing the de-alates (Ahmad, *et al.*, 1979). In the higher termites, e.g. *Odontotermes lokanandi*, the pre-oviposition period is shorter. Within 2-3 days of introducing the de-alates in the dish, egg-laying begins (Akhtar, 1977).

The growth of colony is very slow in the wood-dwelling lower termites with small colonies of a few hundred to a few thousand individuals. The laboratory colonies started by primary reproductives of *Bifiditermes beesoni*

did not produce any winged adults during a period of 4 years. The first pre-soldier appeared 410 days after the colony foundation. At this age of the colony, the population consisted of only 8 individuals (2 primary reproductives, 1 first instar, 2 second instar, 2 third instar nymphs and a pseudergate). In another wood-dwelling kalotermitid, *Neotermes tectonae*, not even nymphs with wing-buds were produced in 7 years old colonies (Kalshoven, 1930).

In contrast to kalotermitids, the rate of colony growth in higher termites which have large populations is much higher. An 80 day old laboratory colony of *Odontotermes obesus* has been reported by Chaudhry, *et al.*, (1972) to grow to a size of 178 individuals, comprising 2 primary reproductives, 100 workers, 10 soldiers and 66 nymphs. Another fungus-grower, *Odontotermes lokanandi*, produced 48 workers including nymphs and 12 soldiers after 38 days in the laboratory (Akhtar, 1977).

Colony Foundation by Part of an Existing Colony

In a diffuse type of nest system, sometimes a portion of the nest may get isolated from the rest of the nest. If in this portion replacement reproductives are already present or if they are produced following isolation, such isolated portions will continue as independent entities. It has also been reported that in those cases where the existing nest cannot be further expanded due to one reason or the other to accommodate the ever increasingly population, duplicate mounds may be built in close proximity with the original nest to accommodate the seasonal increases in the population. With the development of replacement reproductives, the isolated duplicate mounds may become independent of the original mound and may continue as independent communities. This is an example of colony foundation through 'budding' (Harris, 1971).

Colony Foundation by Migration

Emergence of the queen, king, workers, soldiers and nymphs from the ground and marching into a column has been reported by some workers (Grasse and Noirot, 1951). After having moved for some distance, the entire column buries itself into the ground to grow into a new colony, leaving the original colony without king and queen for the time being. The replacement reproductives in the original colony would take over and continue to add to its population.

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CASTE DIFFERENTIATION

Caste differentiation and regulation in termites is one of the most interesting and intriguing problems which has attracted the attention of a number of workers. It is now well established that all the newly hatched nymphs have the genetic potential to follow any course of development leading to reproductives, soldiers and workers. The blastogenic theory of caste determination has been completely discarded.

Studies on the colony development of *Bifiditermes beesoni* carried out in our laboratories revealed that the third instar nymph may take up any course of development. The nymph may moult into a replacement reproductive, into a pre-soldier or into the next instar and ultimately become replacement reproductive or winged adult. The soldiers may be produced from any instar beyond the third. The older nymphs with wing-buds or wing-pads may either become replacement reproductives or winged adults or even soldiers, under the influence of juvenile hormone analogues. Further, these late stage instars have the potential to undergo reverse moulting also (Afzal, 1981).

In higher termites, even the first instar nymphs may moult into a small second instar nymph which may ultimately produce a minor worker or a soldier (minor and major) or it may moult into a large second instar nymph which w develop into major worker or follow the line of development leading to the production of imago (Noirot, 1969).

It was first suggested by Pickens (1932) that the sexual forms secreted some substances which inhibited the nymphs from developing into reproductives and that soldiers also produced some substance which likewise prevented the nymphs from transforming into soldiers.

In the lower termites there exists an inhibitory mechanism. The inhibition is exerted by pheromones with antagonistic effects circulating in the colony through trophallaxis (Luscher, 1976). The pheromones of the reproductives inhibit the development of reproductives and stimulate the development of soldiers. The pheromones of the soldiers likewise probably inhibit the formation of soldiers but stimulate the production of reproductives. It is, however, not yet certain whether the soldiers give off any pheromone It is speculated that the soldiers exercise inhibitory influence by either absorbing or inactivating the pheromones given off by reproductives (Luscher, 1976).

In the incipient colony, no reproductives, whether primary or replacement, are produced for at least a year because the colony being yet

small, all the nymphs are in close contact with the parents and are, therefore, under the influence of the pheromone produced by them

The replacement reproductives also inhibit the further development of replacement reproductives Studies on inhibitory action of replacement reproductives on further development of reproductives have also been carried out in our laboratories (Ahmad, *et al*, 1979). In the case of *Bifuditermes beesoni*, when the replacement reproductives were removed immediately after their appearance, new replacement reproductives appeared within 14-32 days of the setting of the experiment In the control series in which the replacement reproductives were not removed, no further replacement reproductives were produced after the appearance of the first replacement reproductives

In higher termites there is no direct evidence for the existence of pheromones (Luscher, 1976), responsible for caste differentiation However, an inhibitory influence of the royal pair on the transformation of wing-padded nymphs into winged forms has been demonstrated in a fungus-growing termite (Bordereau, 1975).

FOOD AND FEEDING HABITS

The food of termites consists primarily of cellulose from whatever source they may get it It is occasionally supplemented by animal matter like bones, leather, faeces and other materials. The injured individuals in the colony are also eaten up. This cannibalistic behaviour enables the termites not only to meet their protein requirements but also to maintain hygienic conditions and regulate the colony population. Cannibalism is initiated by injury The injured part attracts the attacking individuals. The deficiency of nitrogenous material also stimulates cannibalistic activity.

While trying to reach the food source, the termites will damage any non-cellulosic material they may come across Considerable damage to electric and telephone cables has been reported. As a matter of fact any material, be it metal or plastic, which can be chewed by the worker mandibles is likely to be damaged

The young nymphs, soldiers, the royal pair and winged adults awaiting swarming are all fed by the workers and older nymphs on pre-digested regurgitated food and saliva. In the lower termites, proctodaeal feeding also takes place. The worker or the older nymph, under stimulation from contact with the soliciting individual, discharges a drop of the contents of the rectum through anus which is immediately taken up by the individual demanding

food. Secretions given out by the queen are in great demand by the workers which gather in large numbers around her. The more secretions they get from the queen the more they feed her which ultimately results into excessive enlargement of her abdomen, a phenomenon called physogastry. The termitophiles living inside the termite nest are also fed stomodaeally by the workers because they in return get exudates from them.

Trophallaxis, i.e., exchange of food in social insects, is one of the most important mechanisms in bringing about integration in the termite society. The digestion of cellulose in the lower termites is helped by the flagellates because these termites do not produce their own cellulase. During the course of evolution, a close termite-flagellate relationship has been established. The higher termites do not harbour any flagellate as they are able to produce the cellulose digesting enzyme.

HABITAT TYPES

A knowledge of the habitat and habit types is necessary to get an idea of the mode of damage the termites cause, a pre-requisite for effective termite control. Termites are grouped into two main categories with regard to their habitats. They may be either wood-dwelling with no contact with the ground or ground-dwelling.

Wood-dwelling Termites

The wood-inhabiting termites establish their colonies in branches of trees, stumps, logs, wood-work in buildings or in furniture. Among these termites, some species inhabit damp-wood requiring a constant source of moisture, and some establish their colonies in dry-wood.

Damp-wood Termites

In Pakistan there occurs only one termite species which may be called a truly damp-wood dweller. It is *Archotermopsis wroughtoni* (Desneux). It occurs in the conifer forests of north and northwestern regions up to a height of nearly 9000 feet. It is regarded as a useful termite (Chaudhry, 1954), bringing about disintegration of the stumps and thus helping in the clearance of dead wood. It does not attack sound wood.

Dry-wood Termites

Dry-wood termites are represented in Pakistan by four species - *Bifiditermes beesoni, Postelectrotermes pasniensis, Epicalotermes pakistanicus*

and *Cryptotermes karachiensis*. While termites belonging to the genera *Bifiditermes*, *Postelectrotermes* and *Epicalotermes* make galleries in dead portions of the trees, (sometimes, the activity of these termites may extend into the living part also), those assigned to the genus *Cryptotermes* can also live in completely dry and seasoned wood (Figure 6), and may cause considerable damage to woodwork in buildings and furniture. These dry-wood termites got introduced in many countries where they are now well-established and are regarded as serious pests. In Pakistan, only one dry-wood termite of the genus *Cryptotermes* has been reported. It is *Cryptotermes karachiensis* Akhtar, reported from Lasbella and Karachi infesting *Ficus* trees. This termite needs to be further studied to know whether it occurs only in nature or has been able to extend its activity into buildings also.

Ground-dwelling Termites

Most of the termites are ground-dwellers. Their nests may be completely or partly underground, partly in the wood, or exposed as mounds. Their contact with the ground is necessary. In some cases, however, e.g., *Coptotermes*, they can lose all contact with the ground and nest in logs, poles, etc. if they have sufficient moisture. The termites of Pakistan are mostly ground-dwellers, with diverse modes of life, largely determined by the environmental conditions.

Fungus-growing Termites

Most abundant among the termites of Pakistan are the fungus-growers, belonging to the genera *Odontotermes* and *Microtermes*, which together constitute 56 per cent of the termite fauna. Most of the fungus-growing termites of Pakistan make concealed underground nests, reaching the food source through covered passages. *Odontotermes obesus* (Rambur), however, builds mounds which are most abundant in the forest plantations and are larger than those found outside. The size of the mound depends upon the environmental factors and the building capacity of the termite. The maximum building potential of *Odontotermes obesus* is realized in rain forests. In the rain forests of Bangladesh some of the mounds of this termite may attain a very large size, measuring 2.45 m in height and 1.54 m in girth at the base (Figure 7).

The mounds of fungus-growing termites are made of soil mixed with saliva. Inside the mound are built a large number of oval cavities known as fungus chambers, containing sponge-like bodies, the fungus combs (Figure

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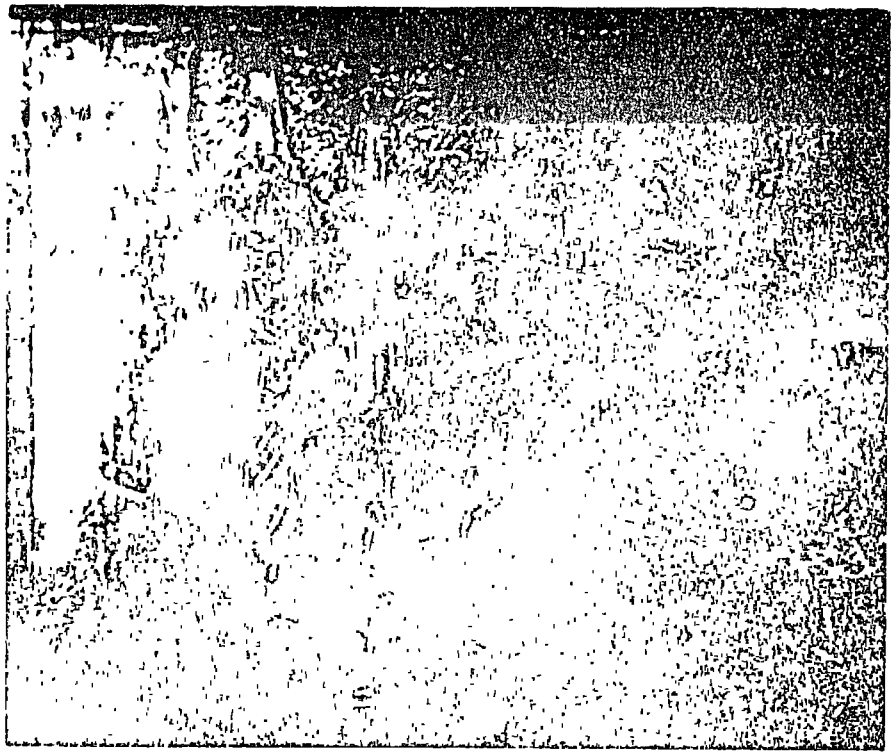

Figure 6. Colony of drywood termite *Cryptotermes havilandi* in plywood. (from Harris 1971)

Figure 7. Mound of *Odontotermes obesus* (Rambur), Bengladesh. (From Chaudhry, et al., 1972).

8). The latter are constructed out of chewed wood mixed with saliva. These are used for cultivating fungi which form an important component of the food of the community. The shape, size and design of the combs are characteristic of the species.

Microtermes spp. do not build mounds, but have a diffuse pattern of chambers underground

Harvester Termites

The harvester termites which feed on grasses, leaves, and food grains have adapted to life in dry areas. The workers come out of the nest and forage in the open, and store the food in their nests. Four species of harvester termites have been recorded from Pakistan.

The nest building behaviour of the more common harvester termite of Pakistan, *Anacanthotermes macrocephalus* (Desneux) has been studied in detail by Afzal (1982).

The presence of *Anacanthotermes macrocephalus* is indicated by small mounds of loose soil, 6-13 cm in diameter and 1.7-2.5 cm in height. The opening of the gallery becomes visible by clearing the mound. The galleries leading to the nest are provided with pockets of different sizes and shapes (Figure 9) in which are stored pieces of leaves, grasses, stems, seeds and seed pots etc. The diameter of the gallery leading for the small mound remains the same throughout its length, except for the pockets. Not all the pockets contain stored materials. The first 2-3 pockets nearest the opening of the gallery were found empty. The related species, *Anacanthotermes vagans*, sometimes builds larger mounds, 15 cm high and 210.0 cm wide at base (Figures 10 and 11).

Termites belonging to the genus *Microcerotermes*, which is represented by all species in Pakistan, build carton nests. These nests are constructed out of excreta which largely consists of lignin, cellulose and other plant materials. Round or oval nests, a few inches below the ground at the base of *Saccharum munja* bushes are built by *Microcerotermes championi* in Lahore area. The nest consists of a large number of chambers looking like a honey comb (Figure 12). The same termite in Bangladesh builds dirt-carton mounds, measuring 20-45 cm in height, 30-40 cm in diameter at the base, and 15-20 cm deep in the soil.

Figure 8. Fungus combs (indicated by arrows) in a mound of *Odontotermes obesus* (Rambur). (From Chaudhry et al., 1972).

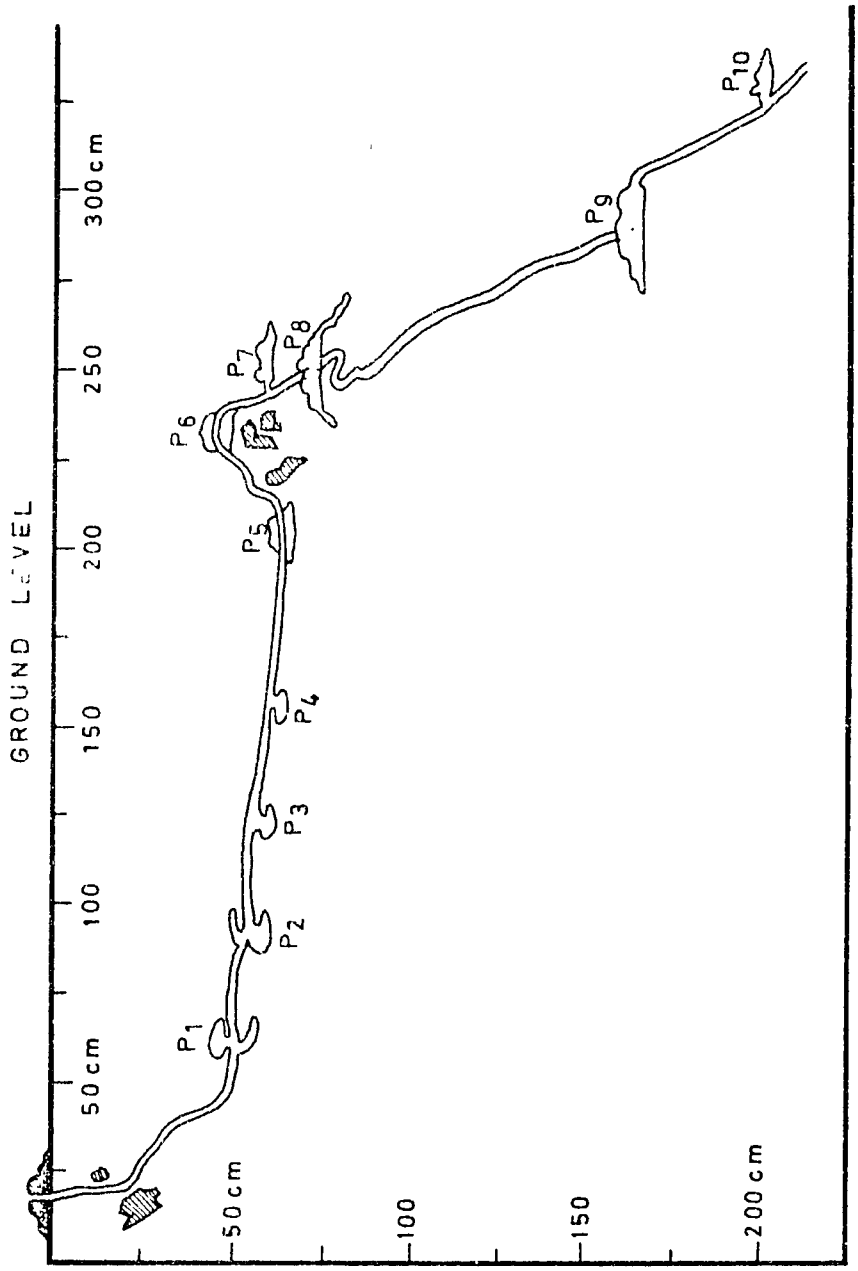

Figure 9. Subterranean nesting system of *Anacanthotermes macrocephalus* (Desneux); P_1-P_{10}, pockets. (From Afzal, 1982)

Figure 10. Mounds of *Anacanthotermes vagans* (Hagans) in Quetta, Baluchistan. (From Chaudhry et al., 1972).

Figure 11. Covered runways of *Anacanthotermes vagans* (Hagen) on a tree trunk (left) and on the ceiling of a house (right). (From Chaudhry et al., 1972).

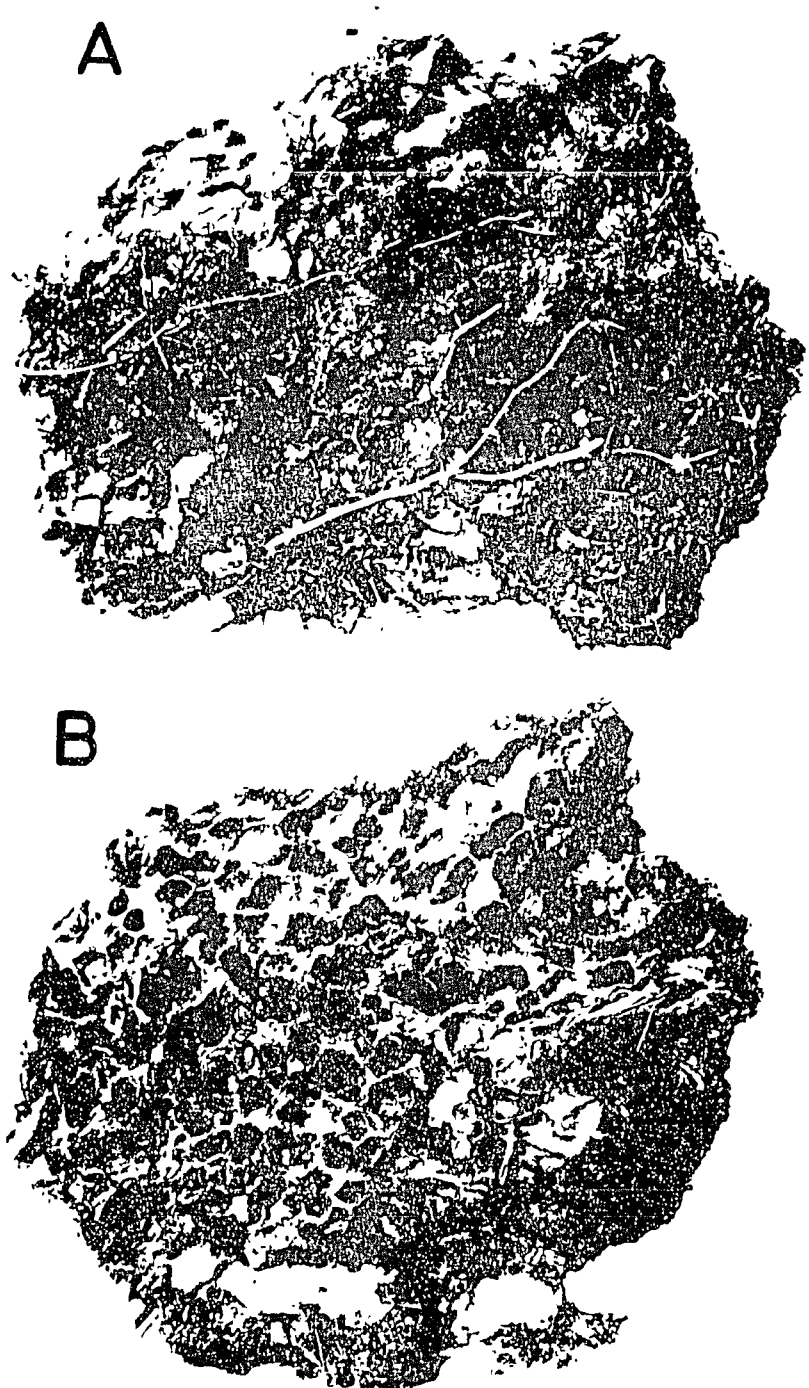

Figure 12. Carton next of *Microcerotermes championi* Snyder; A, whole nest; AxB, sagittal section.

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EFFECTS OF TERMITE ACTIVITY ON SOILS

Effects on Chemical and Physical Characteristics of Soils

Termites, being an important component of soil fauna in tropical and subtropical countries, bring about significant changes in the chemical and physical characteristics and fertility of the soil as a result of their activity (Lee and Wood, 1971).

Sheikh and Kayani (1982) have analyzed soils from mounds and subterranean nests of 13 species of termites in Pakistan and compared them with the corresponding adjacent termite-free soils. The samples of soils from mounds were obtained from inside the central part. Adjacent termite-free soil was sampled from the depth up to which the mounds extended. The authors report that the mound soils had more clay, water-stable aggregates, organic matter, Ca and Mg and higher porosity, water holding and cation exchange capacities than adjacent termite-free soils.

Subterranean nest soils generally had a greater clay content, higher water holding and cation exchange capacities and greater amounts of Ca and Mg as compared to termite-free soils, but with regard to pH, electrical conductivity and soluble Na, the two soils did not differ significantly Among the termite species studied for their effects on soil characteristics, *Anacanthotermes macrocephalus* and *Anacanthotermes vagans* brought about maximum changes in their nest soils (Sheikh and Kayani, 1982).

Effects on Fertility of Soils

Since, soil characteristics are altered as a result of termite activity, the termite-affected and termite-free soils show significant differences in their fertility (Sheikh and Ahmad, 1981, 1982).

Using wheat as the test plant, it was found that the soil taken from the upper part of the mound was less fertile than the adjacent termite-free soil collected from the surface, but when the mound soil was mixed with the adjacent termite-free soil from the surface it resulted in the improved growth of wheat plants as compared to that in the mound soil (Sheikh and Ahmad, 1981).

The soil from the interior of the mound was found to be more fertile than the adjacent termite-free soil collected from a depth up to which the mounds extended but when the adjacent termite-free soil was mixed with the mound soil, it resulted in improved growth of wheat plants as compared to that in the adjacent termite-free soil (Sheikh and Ahmad, 1982). These

studies confirm that termites improve the fertility of sub-soil used by them in building their mounds. Ploughing in the mound may increase the fertility of the soil.

TERMITES OF PAKISTAN

Desneux (1906) was the first worker to report on the termites of those areas of the Indo-Pakistan sub-continent which now constitute Pakistan. He described four species - *Anacanthotermes macrocephalus*, *Microtermes mycophagus*, *Microtermes sindensis* and *Amitermes belli* from Karachi. Later on, Holmgren and Holmgren (1917) described *Discuspiditermes punjabensis* from Lyallpur (now Faisalabad) and reported *Odontotermes obesus* (Rambur) from Faisalabad and Kasur. For the next 36 years there appeared no paper on the termites of Pakistan. In 1954, however, Khan and Ahmad reported 13 species from Lahore, seven of which were new records from Pakistan. Chaudhry (1955) reported the occurrence of 3 more species from Pakistan.

The first monograph on termites of Pakistan was published by Ahmad (1955). It dealt with 29 species. With the discovery of another 13 new species and 8 new records by Akhtar (1972, 1974-b), the number of termite species from Pakistan rose to 50.

Most of the studies on termites of Pakistan till 1972 concerned their taxonomy. During the last ten years, however, several aspects of their biology have been studied. Among the more important works are those of Chaudhry *et al.* (1972), Akhtar (1974-a, 1977, 1978, 1979, 1980, 1981, 1982), Farhat and Iqbal (1976, 1977, 1979, 1980), Jafri *et al.* (1976), Khan *et al.*, (1977), Khan, *et al.*, (1977, 1978), Ahmad *et al.* (1979, 1980), Kayani *et al.* (1979), Akhtar and Ali (1979), Akhtar and Jabeen (1980-a, b, 1981), Chaudhry and Ahmad (1980), Afzal, (1981, 1982), Khan (1981), Khan *et al.* (1981), Afzal and Ahmad (1982-a, b), Afzal *et al.* (1982), Ahmad *et al.* (1982) and Sheikh and Kayani (1982).

A. Check list of termites

Termite species	Distribution
Family Kalotermitidae	
1. *Bifiditermes beesoni* (Gardner)	Punjab
2. *Postelectrotermes pakistanicus* Akhtar	Balochistan

Cont'd

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Termite species	Distribution
3. *P. pishinensis* (Ahmad)	Balochistan
4. *Epicalotermes pakistanicus* Akhtar	Balochistan
5 *Cryptotermes karachiensis* Akhtar	Sindh
Family Hodotermitidae	
6. *Archotermopsis wroughtoni* (Desneux)	Punjab, N.W.F.P. Azad Kashmir
7. *Anacanthotermes baluchistanicus* Akhtar	Balochistan
8. *A. macrocephalus* (Desneux)	Balochistan, Sindh, Punjab
9. *A. peshawarensis* Akhtar	N.W.F.P.
10. *A. vagans* (Hagen)	Balochistan
Family Rhinotermitidae	
11. *Psammotermes rajasthanicus* Roonwal and Bose	Balochistan, Sindh, Punjab
12. *Coptotermes formosanus* Shiraki	Sindh
13. *C. heimi* (Wasmann)	Balochistan, Sindh Punjab, N.W.F.P.
14. *Heterotermes indicola* (Wasmann)	Balochistan, Sindh Punjab, N.W.F.P., Azad Kashmir
Family Termitidae	
15. *Odontotermes almorensis* Snyder	Punjab, N.W.F.P.
16. *O. assmuthi* Holmgren	N.W.F.P.

Cont'd

Cont'd

Termite species	Distribution
17. *O. dehradum* (Snyder)	Punjab
18. *O. gurdaspurensis* Holmgren and Holmgren	Punjab, Azad Kashmir
19. *O. horai* Roonwal and Chhotani	Punjab,N.W.F.P.
20. *O. lokanandi* Chatterjee and Thakur	Punjab
21. *O. obesus* (Rambur)	Sindh, Punjab, N.W.F.P
22. *O. parvidens* Holmgren and Holmgren	Punjab, N.W.F.P.
23. *O. peshawarensis* Akhtar	N.W.F.P.
24. *Microtermes mycophagus* (Desneux)	Balochistan, Sindh Punjab
25. *M. obesi* Holmgren	Baluchistan, Sindh Punjab, N.W.F.P.
26. *M. sindensis* (Desneux)	Sindh
27. *M. unicolor* Snyder	Sindh, Punjab, N.W.F.P
28. *Speculitermes cyclops* (Wasmann)	Punjab
29. *Microcerotermes baluchistanicus* Ahmad	Balochistan, Sindh, Punjab
30. *M. championi* Snyder	Punjab

Cont'd

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Cont'd

Termite species	Distribution
31. *M. chaudhryi* Akhtar	Punjab, N.W.F.P
32. *M. heimi* Wasmann	Sindh, Punjab, NWFP
33 *M. lahorensis* Akhtar	Punjab
34. *M. longignathus* Ahmad	Balochistan
35. *M. maliki* Akhtar	N.W.F.P.
36. *M. pakistanicus* Akhtar	N.W.F.P., Azad Kashmir
37. *M. prochampioni* Akhtar	Sindh
38. *M. sakesarensis* Ahmad	Punjab, N.W.F.P
39. *M. tenuignathus* Holmgren	Balochistan, Sindh, Punjab, NWFP
40. *Eremotermes maliki* Ahmad	Punjab
41. *E. neoparadoxalis* Ahmad	Punjab, N.W.F.P
42. *E. paradoxalis* Holmgren	Punjab, N.W.F.P
43. *Amitermes baluchistanicus* Akhtar	Balochistan
44. *A. belli* (Desneux)	Balochistan, Sind, Punjab, N.W.F.P
45. *A. paradentatus* Ahmad	Sindh

Cont'd

Cont'd

Termite species	Distribution
46. *Trinervitermes biformis* (Wasmann)	Punjab
47. *Angulitermes dehraensis* (Gardner)	Punjab, N.W.F.P Azad Kashmir
48. *A. hussaini* Ahmad	Punjab
49. *A. punjabensis* Akhtar	Punjab
50. *Dicuspiditermes punjabensis* (Holmgren and Holmgren)	Punjab

B. Key to the Termites of Pakistan

In order to enable the students to identify the species without referring to the original description, the key has been made very comprehensive by including the measurements which are in millimetres. The figures in parenthesis indicate the number of specimens measured. The source of measurements is also given.

Key to Families

Imagos

1. Fontanelle absent 2
   Fontanelle present 3
2. Cerci long, with 3-8 articles; antennae with 25-29 articles; right mandible with a small subsidiary tooth at base of anterior cuttings edge of first marginal tooth (reduced in *Anacanthotermes);* left mandible with three marginal teeth (second marginal much reduced in *Anacanthotermes)* ..... Hodotermitidae
   Cerci short, with 2 articles; antennae with 14-18 articles; right mandible never with subsidiary tooth; left mandible with two marginal teeth ..... Kalotermitidae
3. Right mandible with a distinct subsidiary tooth at base of anterior cutting edge of first marginal tooth; left mandible with three marginal teeth; forewing scales large, overlapping hind wing scales (except in *Psammotermes);* wing membrane reticulate ..... Rhinotermitidae

Right mandible with a minute subsidiary tooth only in some primitive fungus growing genera; left mandible with 1-2 marginal teeth; forewing scales small, not overlapping hind wing scales; wing membrane not reticulate ..... Termitidae

Soldiers

1. Head without fontanelle and frontal gland; eyes present about the size of base of antenna; mandibles with prominent marginal teeth 2
   Head with fontanelle and frontal gland; eyes if present, dot-like, much smaller than base of antenna; mandibles with or without marginal teeth. 3

2. Cerci long, with 3-8 articles; antennae with 22-23 articles ..... Hodotermitidae
   Cerci short, with 2 articles, antennae with 10-18 articles ..... Kalotermitidae
   Pronotum flat ..... Rhinotermitidae
   Pronotum saddle-shaped ..... Termitidae

Family *Kalotermitidae* Enderlein
Key to genera

Imagos

1. Forewing with media and cubitus arising from a common stem outside wing scale; arolium absent 2
   Forewing with media and cubitus arising from inside wing scale; arolium present or absent 3

2. Left imago-nymph mandible with anterior margin of third marginal tooth longer than one-and-a-half times the length of posterior margin of first plus second marginal tooth ..... *Epicalotermes*
   Left imago-nymph mandible with anterior margin of third marginal tooth clearly longer but not more than one-and-a-half times the length of posterior margin of first plus second marginal tooth ..... *Bifiditermes*

3. Middle tibia with three apical spines and an additional outer spine ..... *Postelectrotermes*
   Middle tibia with only three apical spines, outer spine absent; media joining redial sector in middle or beyond middle of wing .... *Cryptotermes*

Soldiers

1. Middle tibia with three apical spines and an additional outer spine.....*Postelectrotermes*
   Middle tibia with three apical spines, outer spine absent..... 2

2. Head short, thick highly phragmotic (Figure 5).....*Cryptotermes*
   Head not phragmotic..... 3

3. Mandibles strongly curved throughout from base to tip, third antennal article club-shaped; head dorsoventrally flattened.....*Epicalotermes*
   Mandibles distinctly less curved: third antennal article not club-shaped; left mandible with more than three, usually five, marginal teeth.....*Bifiditermes*

Genus *Postelectrotermes* Krishna
***Postelectrotermes pasniensis* Akhtar**

Imagos

Head reddish brown, postclypeus lighter than head; legs light brown, with reddish tinge; abdominal tergites reddish brown; head and pronotum with a few short hairs and scattered long bristles; head semicircular posterior to eyes, long arms of Y-suture slightly indicated; labrum dome-shaped; ocelli touching eyes; antennae with 15-16 articles; length of head to tip of labrum, 1.35-1.52 (17); length of head to side base of mandibles, 0.98-1.11 (17); maximum width of head 1.18-1.25 (17); long diameter of eye, 0.23-0.26 (17), (Akhtar, 1974).

Key to Species

Soldiers

1. Head rectangular, posterior margin almost straight; length of head to side base of mandibles 1.80-3.19 (24); maximum width of head, 1.28-1.71 (24); length of left mandible, 1.12-1.51 (23), (Akhtar, 1974).....*P. pasniensis* Akhtar
   Head elongately oval, posterior margin convex; length of head to side base of mandibles, 2.09-2.25 (3); maximum width of head, 1.57-1.64 (3); length of left mandible, 1.29-1.32 (3), (Ahmad, 1955).....*P. pishinensis* (Ahmad)

Genus *Bifiditermes* Krishna
Bifiditermes beesoni (Gardner)

Imagos

Head almost round; eyes not quite round, anterior margin rather straight, ocelli oval, touching the eyes obliquely; antennae with 16-18 articles, second nearly twice as long as third, fourth slightly shorter than third; length of head to tip of labrum, 1.51-1.81; length of head to side base of mandibles, 1.18-1.56; maximum width of head, 1.36-1.51; long diameter of eye, 0.48-0.59; length of ocellus, 0.18-0.25 (Ahmad, 1955).

Soldiers

Head reddish, lighter in posterior fourth, frons and antennal carinae darker than rest of head; head rectangular, posterior margin indistinctly depressed in middle; mandibles stoutly built, with prominent basal humps; antennae with 11-14 articles, third article strongly sclerotized, slightly longer than first, one-and-a-half times as long as fourth; length of head to side base of mandibles, 1.99-2.51 (14); maximum width of head, 1.73-2.06 (15); length of left mandible, 1.32-1.61 (14) (Akhtar, 1972).

Genus *Epicalotermes* Silvestri
Epicalotermes pakistanicus Akhtar

Imagos

Head parallel-sided, Y-suture present; eyes broadly oval; ocelli broadly oval, almost touching eyes; antennae with 15-16 articles; third article longer than second, fourth slightly shorter than third; tibial spurs 2:3:3; length of head to tip of labrum, 1.31-1.62 (8); length of head to side base of mandibles, 0.94-1.17 (8); maximum width of head, 1.10-1.28; long diameter of eye, 0.38-0.45 (8); length of ocellus, 0.14-0.17, (Akhtar, 1974-b).

Soldiers

Head dorsoventrally flattened, lateral sides weakly convex, converging anteriorly, widest in posterior half; eyes large, pigmented, broadly oval to slightly triangular; antennae with 12-13 articles, in specimens with 13 articles second slightly longer than fourth, third long, club-shaped, strongly sclerotized; length of head to side base of mandibles, 1.19-2.44 (15); maximum width of head, 1.61-1.93 (15); length of left mandible, 1.44-1.71

(15); long diameter of eye, 0.20-0.28; short diameter of eye, 0.10-0.22 (Akhtar, 1974-b).

Genus *Cryptotermes* Banks
Cryptotermes karachiensis Akhtar

Imagos

Head with lateral sides almost parallel, posterolateral sides rounded; eyes elongately oval, slightly bulging; Ocelli oval, almost touching eyes; length of head to tip of labrum, 1.19-1.31 (2); length of head to side base of mandibles, 0.95-0.97 (2), width of head, 1.00-1.01 (2); long diameter of eye, 0.33-0.36 (2); short diameter of eye, 0.26-0.026 (2) (Akhtar, 1974-b).

Soldiers

Head strongly phragmotic, short, frontal flange prominent, notched in middle, not over-hanging frontal area, slightly turned back and near middle over-hanging vertex, with two tubercles, lower indistinctly longer than upper; antennae with 10-13 articles, third shortest; pronotum with anterolateral corners smooth and rounded; length of head to side base of mandibles, 1.19-1.31 (11); maximum width of head, 1.26-1.38 (11); length of left mandible, 0.55-0.58 (11); width of pronotum, 1.23-1.44 (11), (Akhtar, 1974-b).

Family Hodotermitidae Snyder
Key to genera

Imagos

Left mandible with three well-developed marginal teeth; right mandible with a conspicuous subsidiary tooth at base of anterior margin of first marginal tooth; tarsi five-jointed ..... *Archotermopsis*

Left mandible with only two marginal teeth; tarsi our-jointed ..... *Anacanthotermes*

Soldiers

Head trilobed posteriorly; tibiae with lateral spines; tarsi five-jointed; ocelli absent ..... *Archotermopsis*

Head not trilobed posteriorly; tibiae without lateral spines; tarsi four-jointed; ocelli weakly developed ..... *Anacanthotermes*

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Genus *Archotermopsis* Desneux
Archotermopsis wroughtoni (Desneux)

Imagos

Head round, slightly produced behind in middle, Y-suture indicated; eyes large, bulging, kidney-shaped; ocelli absent; antennae with 25 articles, second one-and-a-half time as long as third; length of head to tip of labrum, 2.81-3.05 (10); length of head to side base of mandibles, 2.12-2.28 (10); width of head, 2.44-3.61 (10); long diameter of eye, 0.94-1.04 (10); short diameter of eye, 0.57-0.65 (10), (Akhtar, 1972).

Soldiers

Head longer than wide, head-mandibular index 0.82-0.90; lateral sides slightly converging anteriorly, posterior margin trilobed; eyes small, spindle-shaped; antennae with 22-26 articles; second longer than third, latter shortest; postmentum elongate, flat, postmentum-head index, 0.69-0.79; length of head to side base of mandibles, 2.96-4.76 (10); maximum width of head, 2.81-4.32 (10); length of left mandible, 2.45-4.19 (10), (Akhtar, 1972).

Genus *Anacanthotermes* Jacobson
Key to species

Imagos

1. Head widest almost in middle, anterolateral sides not bulging; antennae with 24-25 articles, first longest, second twice as long as third, latter shortest; length of head to tip of labrum, 2.07-3.44 (4); length of head to side base of mandibles, 2.37-2.54 (4); width of head, 2.82-3.07 (4); long diameter eye, 0.47-0.59 (4); short diameter of eye, 0.36 (4), (Akhtar, 1972)..... .....*A. vagans* (Hagen)
   Head widest in apical fourth, anterolateral sides bulging; antennae with 26-29 articles. 2

2. Head narrower posteriorly, widest in front of eyes; antennae with 27-29 articles, in specimens with 27 articles second nearly twice as long as third; length of head to tip of labrum, 3.81-3.90 (10); length of head to side base of mandibles, 2.37-2.74 (10); width of head, 2.91-3.24 (10); long diameter of eye, 0.53-0.61 (10); short diameter of eye, 0.32-0.38 (10), (Akhtar, 1974-b).....*A. peshawarensis* Akhtar

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Head wider posteriorly, antennae with 26-29 articles, second as long as third and fourth combined; length of head to tip of labrum, 3.44-3.70 (10); length of head to side of mandibles, 2.41-2.66 (10); width of head, 2.96-3.18 (10); long diameter of eye, 0.48-0.52 (10), short diameter of eye, 0.32-0.37 (10), (Ahmad, 1955)..... ..... *A. macrocephalus* (Desneux)

Major Soldiers

1. Pronotum distinctly notched posteriorly in middle; head squarish, sides almost parallel with a slight depression in middle; antennal carinae strongly developed; antennae with 23 articles; second nearly one-and-a-half times as long as third; length of head to side base of mandibles, 4.17 (1), maximum width of head, 3.53 (1), length of left mandible, 2.71 (1), (Akhtar, 1974 b)... ....*A. baluchistanicus* Akhtar
   Pronotum not notched posteriorly..... 2

2. Antennae with 24-26 articles, head squarish; size highly variable, left mandible with anterior cutting edge above first marginal tooth convex; length of head to side base of mandibles, 2.58-4.40 (27) maximum width of head 2.54-3.78 (27); length of left mandible 1.96-2.76 (25), (Akhtar, 1972)... . .. . *A. vagans* (Hagen)
   Antennae with 29 articles.... 3

3. Head widest across eyes; mandibles moderately curved apically; length of head to side base of mandibles, 3.52-3.93 (2); maximum width of head, 3.23-3.56 (2); length of left mandible, 2.21-2.29 (2), (Akhtar, 1979) ....*A. peshawarensis* Akhtar
   Head widest in posterior half; mandibles strongly curved apically; length of head to side base of mandibles, 3.80-4.56 (8); maximum width of head, 3.70-4.56 (8); length of left mandible, 2.66-3.05 (8), (Ahmad, 1955).....*A. macrocephalus* (Desneux)

Minor Soldiers

1. Antennae with 27 articles..... 2
   Antennae with 24-25 articles..... 3

2. Head widest across eyes; length of head to side base of mandibles, 3.03-3.07 (2); maximum width of head, 2.87-2.91 (2); length of left mandible, 1.92-1.96 (2), (Akhtar, 1979).....*A. peshawarensis* Akhtar
   Head widest in posterior half; length of head to side base of mandibles,

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3.01-3.34 (5); width of head, 2.94-3.14 (5); length of left mandible, 1.63-1.69 (5), (Ahmad, 1955)..... .....*A. macrocephalus* (Desneux)

3. Anterior margin of labrum distinctly concave; length of head to side base of mandibles, 3.20 (1); maximum width of head, 2.91 (1); length of left mandible, 2.25 (1), (Akhtar, 1979). .....*A. baluchistanicus* Akhtar
Anterior margin of labrum almost straight .....*A. vagans* (Hagen)*

Family Rhinotermitidae Light
Key to Genera

Imagos

1. Head round; ocelli well-developed..... *Coptotermes* Wasmann
Head parallel-sided; ocelli poorly developed, dot-like ...*Heterotermes* Froggatt

Soldiers

1. Head narrowed anteriorly; fontanelle opening far in front, with a short tubular elongation, left mandible with crenulations at base..... .....*Coptotermes*
Head parellel-sided..... 2

2. Mandibles with many teeth; fontanelle opening with a shallow groove running in front..... .....*Psammotermes*
Mandibles without teeth; labrum elongate, with needle-shaped hyaline tip ....*Heterotermes*

Genus *Psammotermes* Desneux
***Psammotermes rajasthanicus* Roonwal and Bose**

Soldiers

Head almost rectangular, size highly variable; fontanelle distinct, placed a little in front of middle; eye in some specimens slightly indicated; mandibles stoutly built with many marginal teeth; antennae with 14-15 articles, second shortest, third twice as long as second; length of head to side base of mandibles, 1.13-1.57 (30); maximum width of head, 0.95-1.29 (30); length of left mandible, 0.80-1.23 (27), (Akhtar, 1972).

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*Because of overlapping measurements distinction between minor and major soldiers of *A. vagans* is not possible.

Genus *Coptotermes* Wasmann
Coptotermes heimi (Wasmann)

Imagos

Head round; eyes small, not quite round; ocelli large,broadly oval, separated from eyes by less than their short diameter; antennae with 20-21 articles, second one-and-a-half times as long as third; length of head to tip of labrum, 1.32-1.56 (20); length of head to side base of mandibles, 1.06-1.20 (21); width of head, 1.32-1.40 (22); long diameter of eye, 0.32-0.40 (20); short diameter of eye, 0.30-0.36 (20); long diameter of ocellus, 0.11-0.17; short diameter of ocellus, 0.08-0.13; width of pronotum, 1.20-1.32 (22), (Ahmad, 1955).

Key to species

Soldiers

Head narrower, difference between length of head and width of head, 0.25; length of head to side base of mandibles, 1.41-1.52 (7); width of head at side base of mandibles, 0.70-0.75 (7); maximum width of head, 1.11-1.21 (7); length of left mandible, 0.82-0.90 (7); width of pronotum, 0.84-0.93 (6); (Akhtar, 1972)..... *C. fomosanus* Shiraki

Head comparatively wider, difference between length of head and width of head, 0.14-0.22; length of head to side base of mandibles, 1.19-1.38 (32); width of head at side base of mandibles, [illegible]3-0.74 (32); maximum width of head, 1.05-1.19 (32); length of left mandible, 0.74-0.92 (32); width of pronotum, 0.78-0.94 (32), (Akhtar, 1972). .....*C. heimi* (Wasmann)

Genus *Heterotermes* Froggatt
Heterotermes indicola (Wasmann)

Imagos

Head elongate, parallel-sided; eyes small, not round, slightly produced antero-laterally; ocelli indistinct, dot-like; antennae with 16-19 articles, second twice as long as third, fourth longer than third; length of head to tip of labrum, 1.05-1.27 (27); length of head to side base of mandibles, 0.75-0.90 (30); width of head, 0.80-0.87 (31); long diameter of eye, 0.20-0.24 (32), (Ahmad, 1955).

Soldiers

Head elongate, parallel-sided; fontanelle opening distinct; labrum tip elongate, hyaline; left mandible with crenulations at base; right mandible without such crenulations; antennae with 14-15 articles, second slightly longer than third; pronotum anteriorly notched in middle, posterior margin slightly depressed; length of head to side base of mandibles, 1.54-1.83 (10); maximum width of head, 0.92-1.03 (10); length of left mandible 0.90-0.98; width of pronotum, 0.77-0.86 (10), (Akhtar, 1972).

Family Termitidae Westwood
Key to genera

Imagos

1. Right imago-worker mandible with posterior edge of second marginal tooth straight 2
   Right imago-worker mandible with posterior edge of second marginal tooth concave 4

2. Left imago-worker mandible with a deep cut in front of second marginal tooth..... 3
   Left imago-worker mandible without a cut in front of second marginal tooth, cutting edge between first and second marginal teeth concave; head parallel-sided in front of eyes ..... *Microcerotermes*

3. Antennae with 15-18 articles ..... *Microtermes*
   Antennae with 19-20 articles ..... *Odontotermes*

4. Imago-worker mandibles with apical tooth as long as first marginal tooth; head with a median ocellus-like spot; median line of postclypeus well indicated ..... *Speculitermes*
   Imago-worker mandible with apical tooth distinctly longer than first marginal tooth..... 5

5. Molar plate reduced; left imago-worker mandibles without cut in front of second marginal tooth, margin between first and second marginal teeth concave..... *Eremotermes*
   Molar plate projecting; left imago-worker mandible with a notch or cut in front of second marginal tooth 6

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6. Right mandible with second marginal tooth distinct; angle between apical tooth and first marginal tooth in both mandibles narrow ..... *Dicuspiditermes*
   Right mandible with second marginal tooth considerably reduced; angle between apical tooth and first marginal tooth broad... *Angulitermes*

Soldiers

1. Head produced into a nasus; mandibles degenerate, antennae with 12-13 articles ..... *Trinervitermes*
   Head not produced into a nasus; mandibles functional, well-developed 2

2. Mandible symmetrical, curved at tip, used for biting 3
   Mandibles slightly asymmetrical, long and slender, used for snapping like a pair of scissors ..... *Angulitermes*

3. Postmentum broad, arched in middle 4
   Postmentum narrow, not arched in middle 5

4. Mandibles delicate, concave at base; antennae with 12-15 articles ..... *Microtermes*
   Mandibles stout, left mandible with a tooth in different positions, antennae with 15-19 articles ..... *Odontotermes*

5. Mandibles serrated; antennae usually with 13 articles, mid tibia with extra spines; head parallel-sided ..... *Microcerotermes*
   Mandibles not serrated 6

6. Head with frontal projection; mandibles slender, outer margin almost straight or with a concavity in middle or in basal third, tips slightly incurved; antennae with 14 articles ..... *Eremotermes*
   Head without frontal projection, clypeus bilobed ..... *Amitermes*

Genus *Odontotermes* Holmgren
Key to species

Imagos

1. Ocelli separated from eyes by not more than half their short diameter 2
   Ocelli separated from eyes by more than half their short diameter 4

2. Larger species: width of head, 2.76-2.87 (3); length of head to tip of labrum, 2.89-2.96 (3); length of head to side base of mandibles, 1.93-2.15, long diameter of eye, 0.80-0.90 (3); short diameter of eye, 0.67-0.77 (3); length of ocellus, 0.31-0.45 (3); width of ocellus, 0.25-0.28 (3); ocellus from eye, 0.09-0.12 (3); width of pronotum, 2.51-2.60 (3), (Akhtar, 1972)..... .....*O. obesus* (Rambur)
Smaller species, width of head 2.27-2.57 3

3. Ocelli separated from eyes by half their diameter; length of head to tip of labrum, 2.35-2.75 (11); length of head to side base of mandibles, 1.57-1.80 (12); long diameter of eye, 0.67-0.72 (13); length of ocellus, 0.30-0.37 (13); width of ocellus, 0.22-0.27 (13), ocellus from eye, 0.10-0.12 (12); width of pronotum 2.07-2.30, (Ahmad, 1955)..... .. *O. dehradani* (Snyder)
Ocelli separated from eyes by one-third of their short diameter; length of head to tip of labrum 2.73-2.93 (3); length of head to side base of mandibles 1.77-1.93 (3); width of head 2.31-2.57 (3); long diameter of eye 0.70-0.80 (3); short diameter of eye, 0.61-0.70 (3); length of ocellus 0.38-0.38 (3); width of ocellus 0.25-0.26; ocellus from eye 0.09-0.09 (3); width of pronotum 2.25-2.31 (3), (Akhtar, 1977)*O. lokanandi* Chatterjee and Thakur

4. Ocelli separated from eyes by more than their long diameter; length of head to tip of labrum, 2.83-3.06 (9); length of head to side base of mandibles, 1.85-1.96 (9); width of head, 2.55-2.77 (10); long diameter of eye, 0.55-0.64 (10); short diameter of eye, 0.48-0.55 (10); length of ocellus, 0.22-0.26 (10); width of ocellus, 0.18-0.22 (10); width of pronotum, 2.25-2.43 (10), (Ahmad, 1955) ..... *O. almorensis* (Snyder)

Ocelli separated from eyes by their short diameter; length of head to tip of labrum, 2.39-2.81 (9); length of head to side base of mandibles, 1.67-1.80 (10); width of head, 2.22-2.39 (10); long diameter of eye, 0.55-0.61 (10); short diameter of eye, 0.48-0.54 (10); long diameter of ocellus, 0.25-0.29 (10); short diameter of ocellus, 0.16-0.20 (10); ocellus from eye, 0.16-0.22 (10); width of pronotum, 2.13-2.31 (10), (Akhtar, 1976) .....*O. horai* Roonwal and Chhotani

Soldiers

1. Postmentum extra-ordinarily wide, arched, almost as long as wide or only slightly longer than wide; length of head to side base of mandibles,

0.88-1.17 (93); width of head at side base of mandibles, 0.57-0.72 (93), width of head at posterolateral ends of antennal carinae, 0.76-1.03 (93); maximum width of head, 0.87-1.09 (93); length of left mandible, 0.57-0.82 (93); tooth of left mandible from tip, 0.16-0.24 (89); length of postmentum, 0.41-0.56 (92); width of postmentum, 0.39-0.49 (92), (Akhtar, 1972)..... *O. lokanandi* Chatterjee and Thakur
Postmentum not extra-ordinarily wide or arched, distinctly longer than wide..... 2

2. Antennae not uniformly coloured, distal articles darker than proximal articles..... 3
Antennae uniformly coloured 5

3. Head elongately oval, longer than wide, head index, 0.86-0.91; head mandibular index, 0.62-0.70; length of head to side base of mandibles, 1.19-1.59 (132); width of head at side base of mandibles, 0.63-0.92 (132); width of head at posterolateral ends of antennal carinae, 0.98-12.1 (132); maximum width of head, 1.09-1.38 (131); length of left mandible, 0.84-1.00 (128); tooth of left mandibles from tip, 0.22-0.39 (127); length of postmentum, 0.59-0.96 (132); width of postmentum, 0.47-0.58 (132), (Akhtar, 1972)..... *O. obesus* (Rambur)
Head rectangularly oval 4

4. Larger species; length of head to side base of mandibles, 1.51-1.58 (10); width of head at posterolateral ends of antennal carinae, 1.15-1.23 (10); maximum width of head 1.25-1.35 (10); length of left mandible, 0.99-1.06 (10); tooth of left mandible from tip, 0.38-0.41 (10), (Akhtar, 1972)..... *O. gurdaspurensis* Holmgren and Holmgren
Smaller species; length of head to side base of mandibles, 1.07-1.14 (8); width of head at side base of mandibles, 0.65-0.72 (6); width of head at posterolateral ends of antennal carinae, 0.87-0.90 (6); maximum width of head, 0.95-1.00 (6); length of left mandible, 0.74-0.78 (6); tooth of left mandible from tip, 0.27-0.30 (6); length of postmentum, 0.63-0.70 (6); width of postmentum, 0.39-0.44 (6), (Akhtar, 1974-b)..... *O. peshawarensis* Akhtar

5. Tooth of left mandible placed in anterior third; length of head to side base of mandibles, 1.44-1.62 (21); width of head at side base of mandibles, 0.82-0.94 (21); width of head at posterolateral ends of antennal carinae, 0.98-1.14 (21); maximum width of head, 1.06-1.25

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(21); length of left mandible, 0.78-0.88 (20); tooth of left mandible from tip, 0.28-0.35 (20); length of postmentum, 0.94-1.07 (21); width of postmentum, 0.48-0.54 (7), (Akhtar, 1972) .....*O. assmuthi* Holmgren
Tooth of left mandible placed in basal half 6

6. Smaller species; length of head to side base of mandibles, 1.60-1.83 (18); width of head at side base of mandibles, 0.88-1.03 (18); width of head at posterolateral ends of antennal carinae, 1.15-1.29 (18); minimum width of head, 1.27-1.41 (18); length of left mandible, 0.94-1.03 (18); tooth of left mandible from tip, 0.51-0.56 (18); length of postmentum, 0.99-1.11 (18); width of postmentum, 0.51-0.59 (18), (Akhtar, 1972)..... .....*O. horai* Roonwal and Chhotani
Larger species; length of head to side base of mandibles, 1.98-2.32 (10); width of head at side base of mandibles, 1.16-1.34 (10); width of head at posterolateral ends of antennal carinae, 1.48-1.72 (10); maximum width of head, 1.71-1.96 (10); length of left mandible, 1.21-1.39 (10); tooth of left mandible from tip, 0.72-0.85; length of postmentum, 1.26-1.39 (10); width of postmentum 0.64-0.74 (10), (Akhtar, 1972).....*O. parvidens* Holmgren and Holmgren

Genus *Microtermes* Wasmann
Key to species

Imagos

1. Ocellus very close to eye, separated by about one-third of its short diameter; length of head to side base mandibles, 1.03-1.11 (10); width of head, 1.36-1.44 (10); long diameter of eye, 0.40 (10); short diameter of eye, 0.35-0.37 (10); eye from lower margin of head, 0.09-0.11 (10); length of ocellus, 0.18-0.25 (10); width of ocellus 0.12-0.18 (10); Ocellus from eye, 0.03-0.07 (10), (Ahmad, 1955) .....*M. unicolor* Snyder
Ocellus farther away from eye..... 2

2. Postclypeus distinctly shorter than half its width, larger species; length of head to tip of labrum, 2.17-2.37 (17); length of head to side base of mandibles, 1.35-1.50 (15); width of eye, 1.77-1.85 (15); long diameter of eye, 0.43-0.52 (15); short diameter of eye, 0.40-0.45 (15); eye from lower margin of head, 0.18-0.22 (15); length of ocellus, 0.17-0.27 (15); short diameter of ocellus, 0.16-0.18 (14); ocellus from eye, 0.09-0.13 (14), (Ahmad, 1955).....*M. mycophagus* (Desneux)

Postelypeus half as long as wide, smaller species 3

3. Eye separated from lower margin of head by about half its short diameter; head dark brown; length of head to tip of labrum, 1.66-1.81 (10); length of head to side base of mandibles, 1.18-1.29 (10); maximum width of head, 1.38-1.49 (10); length of ocellus, 0.29-0.34 (10), eye from lower margin of head, 0.15-0.18 (10); length of ocellus, 0.13-0.18 (10), width of ocellus, 0.09-0.13 (10); ocellus from eye, 0.13-0.16 (10), (Ahmad, 1955) ....*M. sundensis* (Desneux)
Eye closer to lower margin of head, separated by one-fourth its short diameter; head reddish brown; length of head to tip of labrum, 1.62-1.73 (10); length of head to side base of mandibles, 1.08-0.15 (10); width of head, 1.33-1.42 (10); long diameter of eye, 0.36-0.40 (10); short diameter of eye, 0.32-0.36 (10); eye from lower margin of head, 0.10-0.12 (10); length of ocellus, 0.18-0.20 (10); width of ocellus, 0.10-0.12 (10); ocellus from eye, 0.08-0.10 (10), (Ahmad, 1955) ..... . *M. obesi* Holmgren

Soldiers

1. Labrum with broadly curved tip; length of head to side base of mandibles, 0.82-0.98 (45); width of head at side base of mandibles, 0.57-0.67 (45); width of head at posterolateral ends of antennal carinae, 0.72-0.88 (45): maximum width of head 0.80-0.96 (45); length of left mandible, 0.53-0.63 (44); width of postmentum, 0.39-0.43 (45), (Akhtar, 1972) .....*M. mycophagus* (Desneux)
Labrum lancet-shaped 2

2. Head moderately hairy; length of head to side base of mandibles, 0.76-1.00 (74); width of head at side base of mandibles, 0.49-0.63 (64), width of head at posterolateral ends of antennal carinae, 0.63-0.82 (64); maximum width of head, 0.72-0.90 (74); length of left mandible, 0.45-0.53; length of postmentum, 0.32-0.47 (74); width of postmentum, 0.30-0.41, (74), (Akhtar, 1972) ....*M. obesi* Holmgren
Head densely hairy; length of head to side base of mandibles, 0.74-0.96 (39); width of head at side base of mandibles, 0.51-0.65 (40); width of head at posterolateral ends of antennal carinae, 0.63-0.80 (40); maximum width of head, 0.72-0.90 (40); length of left mandible, 0.47-0.57 (40); length of postmentum, 0.35-0.47 (40); maximum width of postmentum, 0.32-0.43 (40), (Akhtar, 1972) .....*M. unicolor* Snyder

(10); width of postelypeus, 0.39-0.41 (10), (Akhtar, 1972)..... .....*M. baluchistanicus* Akhtar

Antennae with 14 articles..... 2

2. Eyes almost circular, head reddish brown with smoky tinge..... 3

Eyes not circular, slightly triangularly oval, head dark brown with smoky tinge, length of head to tip of labrum, 1.23-1.35 (10), length of head to side base of mandibles, 0.88-0.96 (10); width of head, 0.92-1.03 (10), long diameter of eye, 0.23-0.25 (10); short diameter of eye, 0.20-0.22 (10), eye from lower margin of head, 0.12-0.14 (10), length of ocellus, 0.06-0.10 (10); width of ocellus, 0.06-0.08 (10), ocellus from eye, 0.06-0.08 (10); length of postelypeus, 0.24-0.26 (10); width of postelypeus, 0.43-0.47 (10), (Akhtar, 1974-b) . . *M. longignathus* Ahmad

3. Postelypeus slightly less than half as long as wide, length of head to tip of labrum, 1.04-1.15 (10), length of head to side base of mandibles, 0.76-0.83 (10), width of head, 0.83-0.90 (10); long diameter of eye, 0.20-0.21 (10); short diameter of eye, 0.16-0.18 (10); eye from lower margin of head, 0.12-0.15; length of ocellus, 0.09-0.10 (10); width of ocellus, 0.72 (10); ocellus from eye, 0.72 (10), (Ahmad, 1955). . . *M. championi* Snyder

Postelypeus almost as long as half its width or slightly longer 4

4. Ocelli close to eyes, separate by a distance of 0.07-0.08 (10); length of head to tip of labrum, 1.03-1.21 (10); length of head to side base of mandibles, 0.78-0.86 (10), width of head, 0.85-0.91 (10); long diameter of eye, 0.22-0.24 (10); short diameter of eye, 0.20-0.22 (10); eye from lower margin of head, 0.10-0.12 (10), length of ocellus, 0.07-0.08 (10), width of ocellus, 0.05-0.06 (10), ocellus from eye, 0.07-0.08 (10), (Akhtar, 1972) . . ..*M. sakesarensis* Ahmad

Ocelli slightly more widely separated, distance between ocelli and eyes, 0.08-0.12; length of head to tip of labrum, 1.07-1.17 (31); length of head to side base of mandibles, 0.75-0.84 (43); width of head, 0.83-0.93 (44), (Ahmad, 1955) . .....*M. heimi* Wasmann *M. tenuignathus* Holmgren

Soldiers

1. Apical half of mandibles distinctly wider than basal half; length of head to side base of mandibles, 1.38-1.75 (5); maximum width of head, 0.86-1.06 (5), (Akhtar, 1974) .....*M. maliki* Akhtar

Apical half of mandibles not wider than basal half 2

Genus *Speculitermes* Wasmann
Speculitermes cyclops Wasmann

Imagos

Head capsule dark brown; head densely hairy with many short hairs and a few scattered long bristles; head almost circular, with a large sub-triangularly oval, white, mid-dorsal spot; length of head to tip of labrum, 1.54-1.81 (10); length of head to side base of mandibles, 0.88-0.98 (10); width of head, 1.35-1.52 (10); long diameter of eye, 0.35-0.39 (10); short diameter of eye, 0.30-0.35 (10), eye from lower margin of head, 0.10-0.10 (10); length of ocellus, 0.14-0.16 (10); width of ocellus, 0.11-0.12 (10), (Akhtar, 1972)

Genus *Trinervitermes* Holmgren
Trinervitermes biformis (Wasmann)

Major Soldiers

Head round with scattered microscopic hairs; antennae with 13 articles, third two and-a-half times as long as second; length of head with nasus, 2.26-2.42 (10); length of head without nasus, 1.39-1.52 (10); width of head, 1.29-1.44 (10), (Akhtar, 1972).

Minor Soldiers

Head long, lateral sides slightly depressed below antennal carinae; antennae with 13 articles, third two and-a-half times as long as second; length of head with nasus, 1.65-1.74 (10); length of head without nasus, 0.94-1.93 (10); width of head, 0.64-0.71 (10), (Akhtar, 1972).

Genus *Microcerotermes* Silvestri
Key to species

Imagos

1. Antennae with 13 articles; length of head to tip of labrum, 1.03-1.14 (10); length of head to side base of mandibles, 0.72-0.78 (10); width of head, 0.84-0.90 (10); long diameter of eye, 0.20-0.24 (10); short diameter of eye, 0.18-0.20 (10); eye from lower margin of head, 0.10-0.12 (10); length of ocellus, 0.06-0.10 (10); width of ocellus, 0.05-0.08 (10); ocellus from eye, 0.06-0.08 (10); length of postclypeus, 0.22-0.25

D. BUILDINGS

The annual losses due to termite attack in buildings are enormous as is evident from figures available from some countries. In the United States of America, the public spent nearly half a billion dollars yearly on termite eradication and replacement of damaged woodwork in 1960s (Ebeling, 1968). The total loss due to termite attack in Australia has been estimated at more than A$ 7.0 million. In Malaysia, the repair to government buildings resulting from termites infestation was estimated to be 75,000 in 1953 (Harris, 1971). The present day losses would be much higher than the figures reproduced here.

Except for a survey conducted by Chaudhry and Ahmad (1980) to assess the gross damage caused by termites to different timber species used in rural and urban houses in different parts of Pakistan, no other study has been undertaken in the country to estimate the losses to buildings, agricultural crops and forestry. The losses should be enormous as there occur several highly destructive termites all over the country. The amount of business the commercial termite operators are doing at present in Pakistan is no indication of the actual damage being done by termites because it is only in recent years that these firms have started the business. Moreover, a very small number of house owners in Pakistan get the termite eradication or termite-proofing done.

The termites reach the woodwork in buildings through covered runways from nests which may be located some distance from the building. They eat up the whole of the wood, leaving a thin shell intact. Some termites fill the space in the shell with soil. The covered runways and encrustations on the woodwork, walls and ceilings are a common sight in houses infested with termites. Sometimes, the termites make vertical tubes to reach the wood. When the wood is in contact with the earth under the floors as in the case of door frames in our houses, the termites get into them from below and start eating the wood. In some cases, there might not be any indication of the presence of termites. When the infestation is detected, considerable damage has already been done.

Chaudhry and Ahmad (1980) reported that 28 timber species are used in houses in different parts of Pakistan. Of these, *Eugenia comauni* was found to be attacked most, whereas *Prunus amagdalus, Pinus gerardiana, Olea cuspidata,* and *Platanus orientalis* were found free of termite infestation. The two common timber species, *Pinus roxburghii* and *Pinus wallichiana* were

by *Heterotermes indicola*. This termite has been reported to attack also 'Lokat', *Eriobotrya japonica*, (Chaudhry *et al.*, 1972).

It has been reported by Butani (1979) that *Odontotermes obesus* is very active in citrus plants especially in sandy and sandloam soils in India. The termites work into the trees through the roots. Seedlings and young trees die of the attack and in the older trees the growth is arrested. Treatment with 5.0 per cent Aldrin or Chlordane dust prior to planting reduces the attack considerably.

In localities where termites incidence is high, the young fruit trees should be planted in plastic containers with Aldrin or Dieldrin treated into the soil.

C. FORESTRY

Most of the termites damage to forestry has been reported from young plants and seedlings. Damage to older trees may not be as serious as in the case of saplings. Among the older plants *Eucalyptus* is, however, damaged considerably (Harris, 1971). When there is severe infestation, the trees are rendered useless for commercial purpose.

The young plants are attacked by subterranean termites mostly belonging to the genera *Coptotermes*, *Heterotermes*, *Odontotermes* and *Microtermes*.

The dry-wood termites which attack trees in Pakistan are *Bifiditermes beesoni*, *Postelectrotermes pishinensis*, *Epicalotermes pakistanicus* and *Cryptotermes karachiensis*. *Bifiditermes beesoni* has been recorded from *Ficus bengalensis*, *Dalbergia sisso*, *Bauhinia variegata* and *Zizyphus* jujuba (Ahmad, 1955, Chaudhry *et al.*, 1972). *Epicalotermes pakistanicus* attack *Acacia* sp. and *Zizyphus jujuba* in the sandy coastal areas of Pakistan (Chaudhry *et al.*, 1972). *Ficus* trees growing by the roadside in Karachi have been found infested by the dry-wood termite *Cryptotermes karachiensis* (Chaudhry *et al.*, 1972).

The activities of dry-wood termites are mostly confined to the dead branches of the trees. Occasionally, the activity may extend into the living portions and it may then cause damage to the trees.

Aldrin, Dieldrin, BHC and Chlordane are being extensively used in forest nurseries and later on when planting these are used again to spray the roots before the soil is filled back. Dieldrin 2.0 per cent dust used at the rate of 10- oz per cubic yard of potting mixture is sufficient for treating 500 pots. This treatment gives protection against termites for 8 years (Harris, 1971). By that time the plants grow to a size when they are less likely to be damaged by termites.

mixed with sawdust applied to soil has proved very effective against *Microtermes* sp. (Gameel, 1969).

Wheat

Odontotermes obesus and *Microtermes obesi* are important pests of wheat also. *Microtermes obesi* is reported to cause 6.0 per cent loss in the yield of wheat in India. In some localities the loss may be higher (Harris, 1971). Irrespective of wheat variety, the damage caused by *Microtermes obesi* in Haryana State, India resulted in average loss of 91.4 per cent in yield from damaged tillers (Verma *et al.,* 1978). The harvester termites are known to cause substantial damage by feeding on all stages of development of wheat in some parts of South Africa (Harris, 1971). These termites occur in Pakistan also.

In Pakistan, dusting with Aldrin or Dieldrin before sowing has given good results (Chaudhry, 1978). Control of *Odontotermes* in India has been successful using Aldrin 5.0 per cent dust at 60 kg/ha, Chlordane 5.0 per cent dust at 40 kg/ha and applying BHC 10.0 per cent (30 kg/ha) into the soil before sowing. The use of Aldrin has been reported to stimulate the germination (Ghose, 1964). Soil application of 10.0 per cent Thimet at the rate of 10.0 kg/ha at the time of sowing or 10.0 per cent Birlane (Chlorfenvinphos) granules at 10 kg/ha has also proved effective against *Odontotermes obesus* attacking wheat in India (Srivastava *et al.,* 1978). Seed treatment with 5.0 per cent Aldrin before sowing or soil treatment with 10.0 per cent BHC is recommended by the International Maize and Wheat Improvement Centre, Mexico.

B. FRUIT TREES

Several species of dry-wood and subterranean termites have been reported causing damage to fruit trees, especially the young plants, in different parts of the world. *Bifiditermes beesoni* causes damage to several fruit trees in Pakistan and India. These include plum, pear, apricot and guava in Pakistan (Ahmad *et al.,* 1979) and apple in India (Roonwal, 1970). Citrus, which is one of the most widely cultivated fruits in the sub-continent and other warmer parts of the world, is attacked by several species of termites, particularly the fungus-growers belonging to the genera *Odontotermes* and *Microtermes*. *Coptotermes heimi* in Indo-Pakistan sub-continent and *Coptotermes curvignathus* in Indonesia have been reported to attack young mango trees. In Pakistan and India, mulberry trees are sometimes attacked

A. AGRICULTURAL CROPS

Sugarcane

Though the sugarcane may be damaged by termites at any time of its growth, the early attack on planted setts may sometimes be quite serious. In severe case of attack on setts, the crop loss up to 30.0 per cent has been reported in some parts of India (Avasthy, 1967). In some parts of Africa, termites are included among the major pests of sugarcane (Rouzaud, 1962).

The more important species which cause damage to sugarcane in Pakistan are *Microtermes obesi*, *Microtermes mycophagus* and *Odontotermes obesus*. *Coptotermes heimi* and *Heterotermes indicola* may also sometime attack sugarcane. In areas of low rainfall or during dry period the damage may be maximum. In Cholistan desert area, *Microtermes mycophagus* feeds on setts and seedling of sugarcane. It penetrates through the buds of the sugarcane setts which get filled with sand (Chaudhry *et al.*, 1972).

Termites damage to sugarcane can be appreciably reduced by spraying the setts and the furrows with Aldrin emulsion at the rate of 2-3 kg a.i./ha and Dieldrin emulsion at 0.35 kg a.i./ha ~ Luke and Ploeg (1950). Chlordane and Heptachlor have also given good results. Heptachlor emulsion at 0.5-1.1 kg/ha ~ has an additional advantage of reducing the borer attack later on (Singh and Soneja, 1966). Dipping the setts for ten minutes in a mixture of orango-mercury fungicide and Aldrin besides reducing the termite attack stimulates germination (Muthuswamy and Aravamudhan, 1958). The use of gamma-BHC, as a part replacement of nitrogen applied to the sugarcane increases germinaton of setts planted late in the season by protecting them from termite and borer attack (Singh and Kumar, 1979).

Cotton

A large number of termites have been recorded as pests of cotton in different parts of the world. Thirty-three per cent of the young plants have been reported to be damaged by *Microtermes* in the Gezira of Sudan (Hickin, 1971). In Rajasthan, India the loss of cotton crop has been reported to be considerable (Bhatnagar, 1962). In Pakistan, *Odontotermes obesus* and *Microtermes obesi* cause damage to cotton significantly. Control of *Odontotermes* in India has been possible by drilling in with the seeds BHC dust (0.0675 per cent gamma) at a rate of 56 kg/ha (Patel, 1962). In Sudan, seed treatment with Aldrin at a rate of 1.0 kg a.i./ha and 6.0 kg Agrocide-3

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Genus *Anguliternes* Sjostedt
Key to species

Soldiers

1. Head strongly constricted in middle, labrum shallowly concave; length of head to side base of mandibles, 1.13 (1); width of head 1.05 (1); length of left mandible, 1.42 (1), (Akhtar, 1974-b) ..... *A. punjabensis* Akhtar
   Head only slightly or not at all constricted in middle, labrum deeply concave..... 2

2. Frontal projection in lateral view with a notch in ventral third; length of head to side base of mandibles, 1.21-1.27 (7); maximum width of head, 0.92-1.00 (7), (Akhtar, 1972)..... *A. dehraensis* (Gardner)

   Frontal projection in a lateral view with a shallow depression in middle; length of head to side base of mandibles, 1.06-1.16 (5); maximum width of head, 0.86-0.90 (5), (Akhtar, 1972) ..... *A. hussaini* Ahmad

Genus *Discuspiditermes* Krishna
Discuspiditermes punjabensis Holmgren and Holmgren

Imagos

Head brown and round, fontanelle small, somewhat oval, antennae with 15 articles; length of head to tip of labrum, 0.91-1.09 (10); length of head to side base of mandibles, 0.70-0.77 (10); width of head ,0.90-0.95 (10); long diameter of eye, 0.19-0.21 (10); short diameter of eye, 0.18-0.19 (10); length of ocellus, 0.09-0.12 (10); width of ocellus, 0.07-0.09 (10); ocellus from eye, 0.07-0.09 (10), (Ahmad, 1955).

TERMITE DAMAGE AND ITS CONTROL

Termites are of great economic importance because of the damage they cause to agriculture, forestry and buildings. The damage to crops and trees is generally not as serious as the damage to buildings. Occasionally, however, the loss to agricultural crops particularly the annual cash crops may be quite serious. The dry-wood termites occasionally extend their activities from the dead to living portions of the trees and may then assume the status of serious pests.

2. Tooth on mandibles minute, indistinct; length of head to side base of mandibles, 0.78-0.88 (10); width of head, 0.72-0.78 (10); length of left mandible, 0.94-1.00 (10); tooth of left mandible from base, 0.45-0.47 (10), (Akhtar, 1972) ..... *E. neoparadoxalis* Ahmad
Tooth on mandibles distinct; length of head to side base of mandibles, 0.87-1.05 (18); width of head, 0.77-0.82 (18); length of left mandible, 1.00-1.10 (18); tooth of left mandible from base, 0.47-0.57 (18), (Akhtar, 1972) ..... *E. maliki* Ahmad

Genus *Amitermes* Silvestri
***Amitermes belli* (Desneux)**

Imagos

Head and body brown; head round, fontanelle elongately oval; antennae with 15 articles; length of head to tip of labrum, 1.04-1.15 (16); length of head to side base of mandibles, 0.74-0.81 (18); width of head, 0.94-1.06 (18); long diameter of eye, 0.21-0.25; ocellus from eye, 0.07-0.09 (Ahmad, 1955).

Key to species

Soldiers

1. Mandibles with tooth laterally directed, placed a little anterior to middle; length of head to side base of mandibles, 1.16-1.25 (7); maximum width of head, 0.95-1.06 (7); length of left mandible, 0.54-0.65 (7); tooth of left mandible from tip, 0.21-0.25, (Akhtar, 1972) ..... *A. paradentatus* Ahmad
Mandibles with tooth slightly or distinctly posteriorly directed, placed almost in middle 2

2. Tooth distinctly posteriorly directed, distance from tip, 0.42-0.45 (20); length of head to side base of mandibles, 1.17-1.27 (20); width of head, 0.98-1.08 (20); length of left mandible, 0.77-0.83 (20), (Akhtar, 1972) ..... *A. belli* (Desneux)
Tooth only slightly posteriorly directed, distance from tip, 0.33-0.41; length of head to side base of mandibles, 1.19-1.40 (18); width of head, 1.06-1.21 (18); length of left mandible, 0.72-0.82 (18), (Akhtar, 1974-b) ..... *A. baluchistanicus* Akhtar

2.40-2.50 (5); length of head to side base of mandibles, 1.40-1.50 (7); width of head 0.87-0.95 (7), (Ahmad, 1955).....*M. championi* Snyder

10. Mandibles comparatively long and strongly incurved in apical half; length of head to side base of mandibles, 1.26-1.66 (20); maximum width of head, 0.64-0.79 (20); length of left mandible, 0.94-1.05 (18), (Akhtar, 1974).....*M. chaudhryi* Akhtar
Mandibles comparatively short and stout, hooked at tip only; length of head to side base of mandibles, 1.40-1.68 (21); maximum width of head, 0.85-0.96 (21); length of left mandible, 0.90-0.94 (21), (Akhtar, 1972) *M. sakesarensis* Ahmad

Genus *Eremotermes* Silvestri
Key to species

Imagos

Head with numerous short hairs and long bristles; length of head to tip of labrum, 1.04-1.09 (10); length of head to side base of mandibles, 0.66-0.71 (10); width of head, 0.78-0.84 (10); long diameter of eye, 0.19-0.20 (10); short diameter of eye, 0.16-0.17; length of ocellus, 0.08-0.09 (10); width of ocellus, 0.06-0.07 (10); ocellus from eye, 0.04-0.06 (10), (Akhtar, 1976).....*M. neoparadoxalis* Ahmad
Head sparsely hairy; length of head to tip of labrum, 1.00-1.07 (8); length of head to side base of mandibles, 0.68-0.75 (16); width of head, 0.76-0.86 (15); long diameter of eye, 0.18-0.23 (15); short diameter of eye, 0.16-0.20 (15); length of ocellus, 0.07-0.12 (15); width of ocellus, 0.07-0.10 (15); ocellus from eye, 0.04-0.06 (15), (Ahmad, 1955).....*E. paradoxalis* Holmgren

Soldiers

1. Mandibles shorter than head capsule, outer margin concave near middle just behind level of tooth; frontal protuberance prominent; length of head to side base of mandibles, 0.82-0.90 (10); width of head, 0.75-0.81 (10); length of left mandible, 0.75-0.82 (9); tooth of left mandible from base, 0.39-0.44 (9), (Akhtar, 1972).....*E. paradoxalis* Holmgren
Mandibles longer than head capsule, frontal protuberance weakly developed.....2

2. Lateral sides of head below antennal carinae bulging; mandibles strongly curved in apical half; length of head to side base of mandibles, 1.40 (1); width of head, 1.09 (1), (Akhtar, 1974-b) ..*M. lahorensis* Akhtar
Lateral sides of head below antennal carinae not bulging 3

3. Mandibles as long as head capsule; length of head to side base of mandibles, 1.13-1.21 (6); width of head, 0.86-0.89 (6); length of left mandible, 1.13-1.21 (6), (Akhtar, 1976).....*M. longignathus* Ahmad
Mandibles shorter than head capsule 4

4. Mandibles finely serrated..... 5
Mandibles coarsely serrated..... 7

5. Head capsule relatively broad, head index, 0.83-0.89; lateral sides of head capsule convex; length of head to side base of mandibles, 0.94-1.07 (7); width of head, 0.84-0.88 (7); length of left mandible, 0.82-0.88 (7), (Akhtar, 1972)..... .....*M. baluchistanicus* Ahmad
Head capsule relatively narrow, head index, 0.69-0.78 6

6. Mandibles less curved; length of head to side base of mandibles, 1.09-1.19 (20); width of head, 0.80-0.92 (20); head index, 0.69-0.78 (20); length of left mandible, 0.90-0.94 (20), (Akhtar, 1972).....*M. heimi* Wasmann
Mandibles more curved; length of head to side base of mandibles, 1.03-1.27 (16); width of head, 0.81-0.90 (16); head index, 0.69-0.78 (16); length of left mandible, 0.82-0.99 (15), (Akhtar, 1972)....*M. tenuignathus* Holmgren

7. Mandibles short, almost half the length of head capsule, slender, straight, but strongly incurved in apical one-fourth; length of head to side base of mandibles, 1.44-1.64 (22); width of head, 0.86-0.98 (22); length of left mandible, 0.76-0.89 (22),
(Akhtar, 1974-b) .....*M. pakistanicus* Akhtar
Mandibles distinctly longer than half the length of head capsule 8

8. Mandibles slightly incurved at tip..... 9
Mandibles strongly incurved at tip 10

9. Mandibles long, delicate; only slightly incurved at tips; length of left mandible, 1.03-1.07 (4); length of head to side base of mandibles, 1.44-1.54 (4); width of head, 0.89-0.96 (4).....*M. prochampioni* Akhtar
Mandibles comparatively short, thick; length of head with mandibles,

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found infested in 12.0 per cent cases. *Cedrus deodara,* used in whole of Pakistan, was found to be fairly resistant to termite attack.

The extent of damage to structural wood depends upon the species of the timber and the species of termites. Different species of termites have different food preferences. Akhtar (1981) reports that *Pinus wallichiana* is highly resistant to *Coptotermes heimi* but the same wood was found to be susceptible to the attack by *Bifiditermes beesoni.* Akhtar and Ali (1979) reported that wooden blocks of *Cedrus deodara* dried at 60^{0}C for 48 hours were readily eaten by *Odontotermes obesus,* but were highly resistant to *Coptotermes heimi* (Akhtar and Jabeen, 1981-a). Undried blocks of the same wood when offered to *Bifiditermes beesoni* produced diarrhoeaic conditions in the termite (Akhtar, unpublished).

Termite Species Attacking Buildings in Pakistan

Eleven species of termites destructive to woodwork in buildings have been reported from different parts of Pakistan (Akhtar, 1982).

1. *Anacanthotermes vagans:* This termite occurs in Balochistan where it is very widely distributed. It stores small pieces of stones, straw, flowers and grass in some chambers of its mound. Like *Odontotermes obesus,* it makes earthen encrustations on trees and woodwork in buildings (Figure 11). It is one of the most destructive termites of Balochistan, damaging woodwork in buildings, roadside trees, fence poles, etc.

2. *Psammotermes rajasthanicus:* This desert termite makes subterranean nests. The foraging galleries are very delicate. They are made of sand particles glued together. This termite is common in Sindh, where it has been collected from woodwork in buildings. It has been reported infesting woodwork in buildings in India also (Roonwal, 1970).

3. *Coptotermes heimi:* This highly destructive termite is widely distributed in Pakistan. It nests in trees, stumps, doors and fence poles. It does not build mounds in Pakistan. Its feeding pattern is very characteristic. It consumes the inner part of the wood, leaving the outer layer intact. The interior of the attacked wood contains carton type nest material consisting of reddish brown thin partitions of the deposited excrements. It does not bring soil in the wood.

4. *Heterotermes indicola:* It is one of the most destructive termites occurring in Pakistan and India. An entire town in India has been reported to have been completely ruined by this termite (Roonwal, 1970). It makes subterranean nests and reaches wood at long distances through hard galleries

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of cemented excrements mixed with soil particles. The consumed wood is generally replaced by brownish carton of excrementous material. Sometimes the consumed wood is replaced by earthy material (Akhtar, unpublished).

5. *Odontotermes obesus:* This fungus-growing termite has been recorded infesting structural wood in the Punjab and N.W.F.P. It is now more common in villages than in urbanized areas. Since it is a mound-building termite, it is easily located and destroyed when the land is cleared for putting up buildings. Covered galleries and encrustations are seen all over the infested wood. The wood consumed is replaced by soil. The galleries made by this termite can be easily distinguished from those of *Heterotermes indicola* by their colour, size and texture. They are lighter, broader, more delicate and are made of earthy material.

6. *Odontotermes parvidens:* This is a non-mound building fungus growing termite. It has been recorded damaging woodwork in houses in N.W.F.P. and Azad Kashmir, where mud houses are common. It easily makes its way through mud wall. Like other fungus-growers, this termite also replaces the consumed wood with earth.

7. *Microtermes obesi:* This species, also a fungus-grower, makes subterranean nests consisting of numerous small, widely separated earthen chambers connected by narrow passages. It has been reported damaging woodwork in cities in the Punjab.

8. *Microtermes unicolor:* The feeding habits of this termite are like those of *Microtermes obesi*. These two species together come next to *Heterotermes indicola* in damaging structural wood.

9. *Microcerotermes baluchistanicus:* It has been collected from buildings in Khanewal and several localities in Sindh. It makes light reddish brown galleries or runways consisting of excreta.

10. *Microcerotermes heimi:* It is a widely distributed termite having been recorded from many localities in the Punjab and N.W.F.P. Its feeding habits are like those of *Microcerotermes baluchistanicus*.

11. *Microcerotermes tenuignathus:* It has been recorded from all the provinces of Pakistan. Its presence in buildings has been reported from Khanewal and Bahawalpur. Serious damage to library books by this termite has been reported by Chhotani (1980) in Delhi.

Prevention of Damage to Buildings (Pre-construction Treatment)

The buildings can be kept safe from termites for a long time if the

insects are prevented from gaining entry into them. The measures involved are taken at foundation stage of the building by putting up chemical barriers in the soil. The chemicals to be used should be of long persistence and low toxicity to plants.

The chemicals that have proved very effective as chemical barriers in the soil belong to the chlorinated hydrocarbon group of insecticides.

The results of the long term termite experiments carried out at the Southern Forest Experiment Station Gulfport, Mississippi, U.S.A. show that the following chemicals remained 100 per cent effective for the period mentioned against each; Chlordane (1.0 per cent), 30 years; Aldrin and Dieldrin (0.5 per cent each), 29 years and Heptachlor (0.5 per cent) 26 years (Beal, 1980).

The following strengths of the emulsifiable concentrates and the dilutions are recommended:-

Pounds of insecticide per gallon of emulsifiable concentrate	One gallon of emulsifiable concentrate added to following gallons of water
Aldrin: 4	99
Chlordane: 8	99
Diledrin: 1.5	36
Heptachlor: 4	99

(Data from Hickin, 1971)

Dilute water emulsion of the insecticide is applied on all the sides of foundation trench by means of coarse spray and when the foundation wall reaches the ground level it should also be treated before the trench is filled in. A second treatment is recommended when the trench is half filled.

The Pakistan Burmah shall have recently marketed an insecticide under the proprietory name of "Shelldrite" for use as soil insecticide against termites.

The use of Aldrin, Dieldrin, Chlordane and Heptachlor, the four most effective and most widely employed chlorinated hydrocarbon insecticides against termites, is now being discouraged because of the environmental hazards they cause. Already, in some countries these insecticides have been

banned except for use against termites. It is likely that in the future they may not be allowed to be used against termites also. Therefore, the scientists are now engaged in finding suitable substitutes for the chlorinated hydrocarbon insecticides.

Several broad spectrum insecticides which are now marketed for control of agricultural pests have been tested against termites. In the field no treatment was more than 50 per cent effective for 11 years (Beal, 1980-b). Chloropyrifos (2.0 per cent) remained 50.0 per cent effective for 10 years. It was only during the final year that its effectiveness decreased to 50.0 per cent. Comphechlor at 1.0 and 2.0 per cent was the only other chemical which remained effective for more than five years. The chemicals proved effective for longer periods when applied under a concrete slab. Under a concrete slab the chemicals which remained 100 per cent effective for 11 years at 2.0 per cent were Proxpur, Comphechlor an Chlorpyrifos. At 1.0 per cent only chlorpyrifos was found to be effective for 11 years (Beal, 1980-b).

Studies on some non-chlorinated hydrocarbon insecticides for soil treatment against termites have been conducted at the University of the Punjab, Lahore also. The field tests were carried out under specially designed concrete slabs. Preliminary results indicate that Oftanol (Isofenphos) and Lorsban (Chlorpyrifos) have the potentiality for use as chemical barriers in the soil against termites.

CONTROL METHODS

Long-term Measures

To control termite infestation from the building and make it termite free for some years, the access of termites from outside into the building should be prevented. This is done by treating the soil around the building with chlorinated hydrocarbons. Water emulsions of Dieldrin (2.0 per cent) and Chlordane (1.0 per cent) are recommended.

To treat the building with concrete floors, holes are bored through the slab or bored horizontally through the foundation wall from outside below the level of the slab. The holes in the floor are bored 30-45 cm apart along a line nearly 15 cm from the wall reaching the soil below the floor. The holes to be bored into the foundation wall from outside should be 1.0 to 1.5 m apart. The holes are then filled in with the insecticides under pressure. The foundation of the building should also be treated to provide an effective and durable chemical barrier. For this purpose, a trench 30-36 cm deep and 15-30

cm wide is dug all round the building. Holes are bored 30 cm apart into the bottom of the trench. The trench is then sprayed with insecticide at the rate of 4.0 g per 10 linear ft. The excavated soil is filled back and treated with the insecticide at the same rate as the trench.

If it is not possible to expose the foundation masonary due to concrete covering holes are bored in all around and the insecticide is pushed in under pressure

Short-term Measures

For temporary relief, the infested woodwork should first be cleaned off the covered runways and encrustations and treated with any of the four chlorinated hydrocarbon insecticides mentioned above by means of brush or cotton swab. Wooden almirahs should not be placed in contact with the wall. The legs of the almirah should be frequently treated with insecticide. In the case of built-in almirahs the entire inner surface should be treated with the insecticide. Shelldrite (neutral grade), marketed by Pakistan Burmah Shell, is also effective against the termites infesting the woodwork

E. New Approaches to Termite Control

In recent years some new lines of investigations in the field of termite control have been initiated with a view to exploring the possibility of controlling these insects through the use of chemicals which interfere with chitin deposition during matamorphosis, juvenile hormone analogues, baits, antibiotics and pathogens Most of these studies are still in the laboratory stage.

Chemicals Inhibiting Chitin Deposition

A new chemical under the name of Dimilin, commonly known as Diflubenzuron, has been produced by Duphar b.v., the Netherlands. It is very different from the conventional insecticides in that it causes the death of the insect through interfering with chitin deposition during metamorphosis. The moulting larva or nymph under the influence of Dimilin is not able to cast off the exuviae and, as a result, it dies. The new chemical has ov.cidal effect also, because the deposition of the chitin in the embryo is interfered with.

While this insecticide has been tried successfully against several insect pests, only one reference is available in literature concerning its effect on termites. Deppelreitar and Korioth (1981) have reported that Dimilin inhibited the development of *Heterotermes indicola* and *Reticulitermes*

flavipes, resulting into high mortality. The application of 1000 ppm Dimilin caused 100 per cent mortality, *Heterotermes indicola* after 12 weeks and in *Reticulitermes flavipes* after 14 weeks.

Some studies on the effect of Dimilin on *Coptotermes heimi*, *Heterotermes indicola* and *Microcerotermes championi* have been carried out at the Punjab University Zoological Laboratories. Dimilin at a dose rate of 1000 ppm caused 100 per cent mortality in *Coptotermes heimi* between 14 and 16 days. Within 24 hours of treatment, blister-like swellings started appearing on the abdomen which later on burst and caused the death of the termite. *Heterotermes indicola* was equally susceptible to Dimilin. *Microcerotermes championi* was found to be more susceptible than either *Coptotermes heimi* or *Heterotermes indicola*. Application of the insecticide at the dose rate of 1000 ppm caused 100 per cent mortality in 8 days.

Juvenile Hormone Analogues

A number of synthetic organic chemicals are now known to mimic juvenile hormones. Besides being of great importance in the caste determination in social insects, these juvenile hormone analogues (JHA's) have attained added importance as biological control agents (Salama *et al.*, 1974). They cause mortality in insects by inhibiting ecdysis. The JHA's have been utilized in controlling some insect pests, particularly the lepidopterons.

It has been reported that JHA's produce many effects on termites, the most pronounced of which is the production of superfluous soldiers, which may be normal individuals, worker-soldier and imago-soldier intercastes. Low dosages of JHA's may convert up to 70 per cent of the workers and nymphs into pre-soldiers within 2-6 weeks of treatment (Howard and Haverty, 1979). This high production of soldiers which are needed only for defence is a great drain on the economy of the termite colony which may ultimately be annihilated. Death of termites, both directly and indirectly through inhibition of ecdysis under the influence of JHA's has also been reported.

With a view to exploring the possibility of controlling termites through the use of juvenile hormone analogues, some studies have been carried out at the Punjab University.

Our studies on the effects of juvenile hormone analogues AY-22, 342 (a product of Ayerst Research Laboratories, Montreal, Canada) and ZR-515 (produced by Zoecon Corporation, Palo Alto, California) on local termites

give a clear indication that they have a potential to control the termites. The results are summarized below:-

(i) JHA - treatment results into the production of superfluous soldiers in significantly large numbers.

(ii) There is some correlation between the number of superfluous soldiers produced and the mortality in the colony.

(iii) Some spread of JHA's in the colony does take place through trophallaxis.

(iv) JHAs inhibit or reduce significantly the production of replacement reproductives which adversely affects the colony.

(v) Hatchability of eggs is greatly affected under the influence of juvenile hormone analogues.

(vi) The response to JHA's treatment varies with the species and the JHA. *Heterotermes indicola* is more responsive than *Bidifitermes beesoni* in the production of superfluous soldiers when fed on ZR-515 treated food, while the latter is more effective than AY-22, 342 against *Bifiditermes beesoni.*

Termiticidal Baits

Exploiting the habits of social insects to groom one another and exchange food, a phenomenon known as Trophallaxis, attempts have been made to transport slow-acting chemicals to termite colonies using attractants. It was first reported by Esenther *et al.,* (1961) that the subterranean termites, *Reticulitermes* spp., were attracted to wood decayed by the fungus *Lenzites trabea.* Since then, fungus-decayed wood bait blocks have been used in several laboratory and field studies and their effectiveness in attracting the termites is now well established.

The field trials of fungus-decayed wood bait-block using Mirex as the slow-acting insecticide were initiated by Esenther and Gray (1968). The results provided a basis for controlling termites by baits. Further trials were made by Esenther and Beal (1974, 1978). Information from these studies indicated a possibility of making use of bait-treatment in buildings also. Mirex bait treatment in simulated buildings, consisting of a 15 cm square concrete foundation has given promising results (Esenther and Beal, 1979). Encouraging results have also been obtained in treating termite-infested buildings by placing Mirex-treated fungus-decayed wood blocks at points accessible to termites (Beard, 1974). Prior to placing the insecticidal bait blocks, non-insecticidal bait-blocks were put to attract the termites.

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Fungal-decayed wood bait blocks have also been used in the transport of antibiotics to the termite nest for defaunation of the gut fauna. The same technique has been very successfully put into operation for transport of juvenile hormone analogues to the termite nest for creating imbalance in the termite colony resulting from the production of superfluous soldiers. Toilet paper rolls also attract termites in the field and can, therefore, be used for field baiting against some termites. It was reported by French and Robinson (1980) that if toilet paper rolls are put on the ground in proximity with wooden stakes to be tested for termite attack in the field, the infestation is hastened. The toilet paper rolls attract the termites. They can also be used for detecting the presence or otherwise of the termite in the field.

French and Robinson (1981) have used toilet paper rolls for aggregating subterranean termites. Steel drums with small holes in the bottom packed with dampened toilet paper rolls when buried in the ground up to one-quarter of their length attracted termites in large numbers. In our studies also we have used toilet paper rolls for detecting the presence of termites in the field. The material is attractive to our local termite, *Heterotermes indicola.*

Antibiotics

It has been known for a long time that the survival of lower termites depends upon flagellates, because they do not produce the enzyme required for digestion of cellulose. This aspect of termite biology is now being studied to control the termites by elimination of gut protozoa using antibiotics and other chemicals.

Several antibiotics have been tried at Forest Experiment Station, Gulfport, Messissippi, USA for elimination of the gut fauna. Mauldin and Rich (1980) reported that Chlortetracycline eliminated all the flagellates from *Reticulitermes flavipes* and killed the termites. His laboratory findings are now being tested in the field.

Some studies on the possibility of using antibiotics for termite control have also been carried out at the Punjab University. Of the several antibiotics tested in the laboratory for defaunating termites, tetracycline proved most effective against *Heterotermes indicola.* Within ten days of feeding the termites on antibiotic-treated food, all the termites in the test dishes died.

Pathogens

During recent years, lot of work has been done to develop microbial

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control of insects. Being specific to insects and harmless to man, the pathogens now being employed for biological control of insects have a definite advantage over chemical insecticides in many respects.

Among bacteria, *Bacillus thuringiensis* has shown a great potentiality as a microbial insecticide. Several strains of this bacterium have been successfully tried against various insect pests. Commercial preparations of *Bacillus thuringiensis* are now available in the market.

Besides bacteria, several entomogenous fungi have also shown a great promise in insect control (Steinhaus, 1956).

While extensive literature has accumulated on the use of microbial pathogens on a wide variety of insect pests, only a few studies have been carried out on their effects on termites (Lund, 1971; Vypijach, 1972).

Extensive studies have been carried out at the Punjab University to test the pathogenicity of various bacteria and fungi against local termites. The results show that *Bacillus thuringiensis* and its commercial preparations such as Bactospeine, Biotrol and Thuricide are highly pathogenic to termites *Heterotermes indicola*, *Odontotermes obesus* and *Microcerotermes championi*. One of the strains of *Bacillus thuringiensis*, i.e., 201:11 toumanoff was most effective against *Bifiditermes beesoni*. *Heterotermes indicola* was highly susceptible to all the strains of *Bacillus thuringiensis* tested in the laboratory.

Several pathogens have been collected from termite colonies in different parts of Pakistan. These include *Serratia marcescens*, *Staphyllococcus aureus*, *Pseudomonas fluorescens*, *Citobacter freundii*, *Enterobacter aerogenes* and two new strains of *Bacillus thuringiensis* and *Bacillus cereus*. Their pathogenicity to termites in the laboratory was tested. They showed varying degrees of pathogenicity to termites.Two fungi - *Aspergillus flavus* and *Aspergillus* sp. - tested in the laboratory also proved toxic to termites. It was found that *Aspergillus flavus* when combined with *Bacillus thuringiensis* or *Pseudomonas fluorescens* or *Serratia marcescens* caused mortality in termites more rapidly than when used alone.

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Chapter 19

LEAF AND PLANT HOPPER PESTS IN PAKISTAN

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The leafhoppers (Family-Cicadellidae), and planthoppers (Superfamily-Fulgoroidea) are regarded as important groups of hemipterous insects from economic point of view all over the world. Though these consist of large number of species, the studies in Pakistan on their systematics, biology and ecology are rather inadequately done. These insects feed by piercing through the tissues of leaves, tendered parts of stems and soft surfaced fruits, on nutrients in the mesophyll tissue, or more deeper in the xylem or phloem vessels. Thus they deprive the plants of the food material needed for their growth, vigour and health. They may also damage the plants by injecting salivary toxins into the tissues during the process of feeding; by spreading diseases in plants by carrying, maintaining, providing suitable environment in their own systems for the multiplication of viruses, and organisms like mycoplasma, and spiroplasma, and then injecting them along with saliva into healthy plants. They damage leaves, and kill cells by feeding punctures, disfigure fruits, and decrease their healthy, normal appearances, and so reduce their market value. They may deteriorate the food contents of fruits, and their taste, and provide substrata for fungal growth on their feeding punctures, and on the excreta ejected on leaves. They also reduce the chlorophyll of leaves, and interfere in the process of photosynthesis, as well as mechanically damage the leaf or fruit surface or of the tender stems by oviposition punctures. Those species which are transmitters of viral diseases, are capable to render much more damage as compared to their numbers. Though the damage of leafhoppers is not easily visible in the field, they are pests of some of our important grain crops, fruit and vegetable plants, and in some cases of ornamental, woody and forest plants.

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I. LEAFHOPPERS OF AGRICULTURAL CROPS

1. Zyginidia Quyumi (Ahmed)

(Cicadellidae : Homoptera) (Fig. 1)

Ahmed (1969) and Ahmed and Jabbar (1972) reported this species as a pest of wheat and maize in the Punjab, NWFP and Balochistan.

The males are pale-white in appearance and are 3.30 mm long; scutellum with two black spots anterolaterally, posterior extremity black. Abdomen black dorsally, fore wings pale-green.

The leafhopper has not been recorded in Sindh. The southern districts of the Punjab comprising Rahim Yar Khan, Bahawalnagar and Bahawalpur have negligible number of this species on any of the main host/food plants. The wheat crop in districts of Central Punjab i.e. Multan, Sahiwal, Faisalabad and Jhang is seriously damaged by this leafhopper. It sometimes builds up moderate to heavy population on wheat in districts of D.G. Khan and Muzaffargarh, and some districts of central Punjab i.e. Lahore, Sheikhupura, Gujranwala, and Sialkot. The wheat remains free of its attack in Rawalpindi Division. However in NWFP, Balochistan, and Campbellpur districts, the maize crop suffers due to this leafhopper.

Mating takes place usually within the first three days of its attaining maturity, and the female starts laying eggs at the rate of 3-8 eggs per day. The average life history periods of the leafhopper are given in the table-1 (Jabbar and Ahmed, 1975).

Table 1. Life history of *Zyginidia quyumi* on wheat and maize.

Stages/Factors	On wheat (Faisalabad) (during March-April)	On maize (Abbottabad) (during August)	On maize (Faisalabad) (during May)
Total life of female (days)	28.85	43.83	36.60
Oviposition period (days)	14.85	31.33	33.6
Total eggs laid	59.42	106.50	137.4

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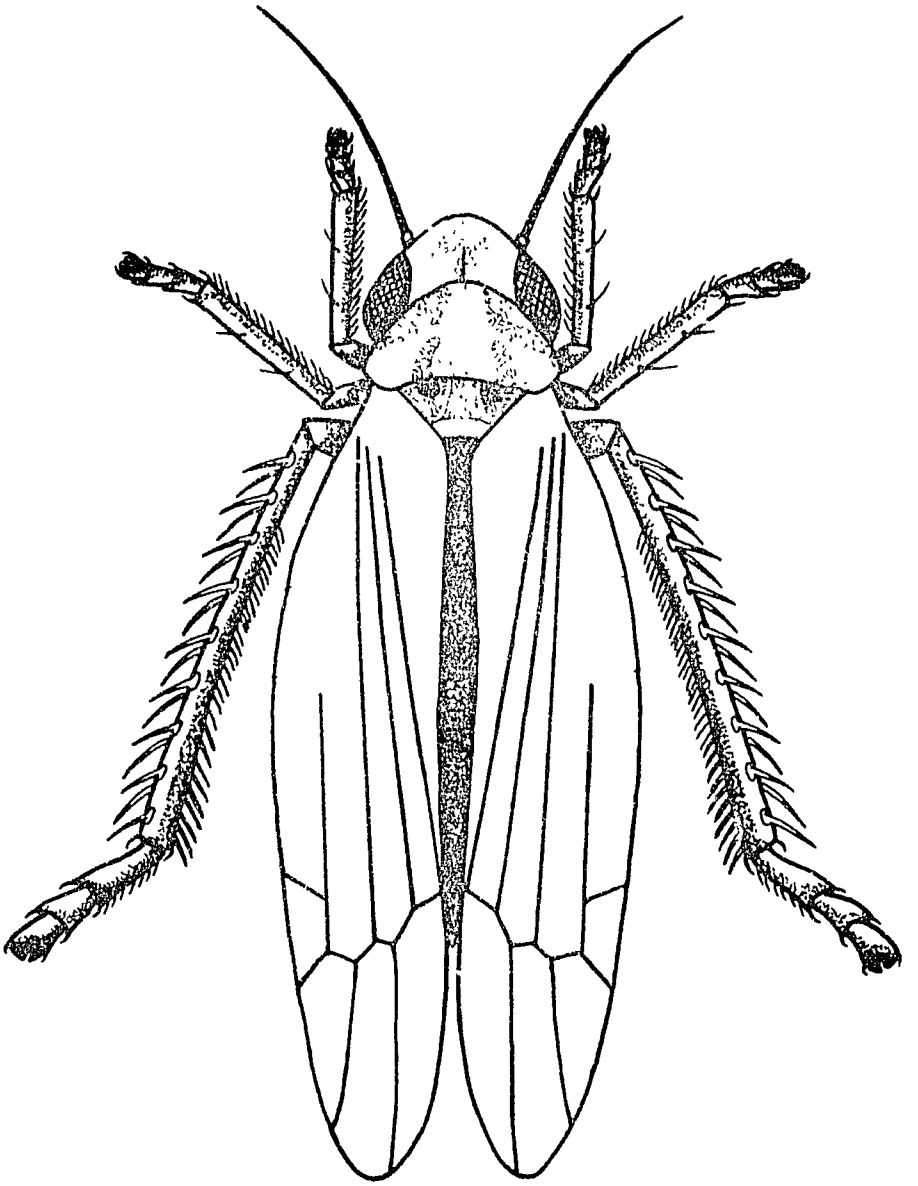

Figure 1. *Zyginidia quyumi* (Dorsal view)

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Stages/Factors	On wheat (Faisalabad) (during March-April)	On maize (Abbottabad) (during August)	On maize (Faisalabad) (during May)
Incubation period	9.2	11.2	8.9
Nymphal life (days)	14.5	16.3	8.9
Total life history (days)	20.9	27.4	17.0

HOST PLANTS

The leafhopper has wheat, maize as the principal and a number of other alternate host or food plants. It passes winter in the northern areas of the country as egg, and in the Punjab and warmer parts of Pakistan both as egg and adult. Infestation of wheat in Punjab starts in later half of February, or beginning of March, when the day temperature rises to 75^{0}F or more, and the overwintering eggs on wheat start hatching. In rapid succession three overlapping generations of *Z. quyumi* pass on the wheat crop during March and April. During the later half of April, when the leaves of wheat lose their succulence and dry up, the remaining nymphs on wheat perish, but the adults migrate to germinating maize in the adjacent fields. The day temperature in the plains of Punjab during May, June and July is often above 110^{0}F., which is lethal for the leafhopper.

The maize in the plains of Punjab is irregularly sown. *Z. quyumi* continues breeding on maize, and thus 4-5 generations of the species pass on maize in Punjab. The conditions are not so extreme in colder parts of NWFP, where again 4-5 generations are passed on maize (Fig. 2).

Apart from wheat and maize which are the principal host plants of the species, the plants like *Arundo donax* Linn., (in Punjab and NWFP) *Echinocloa coloum.* (Linn.) (in NWFP), *Avena sativa* Linn., *Setaria verticellata* Beauv., *Pennisetum americanum* (Linn.). *Sorghum bicolor* (Linn.), and *Hardeum vulgare* Linn., all in Punjab, are observed as its host and food plants.

The nature of damage caused by the leafhopper is similar to that caused by other typhlocybine species. It is a mesophyll feeder, and during the

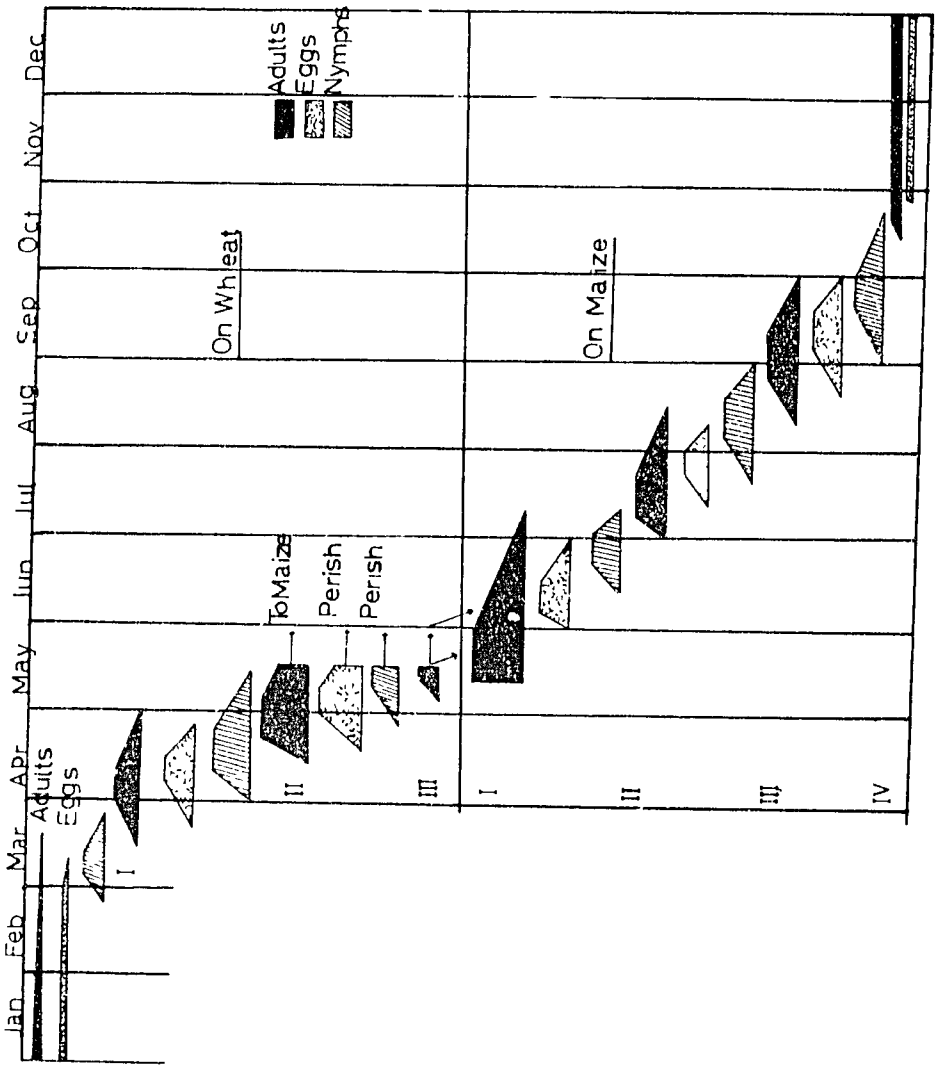

Figure 2. Generations of *Zyginidia quyumi* on wheat and maize

process of sucking nutrients, some of the cells in the area of puncture appear whitish pale. Both nymphs and adults have similar feeding habits. In case of heavy attack, the entire leaf is rendered dead. The yield loss of wheat in some districts of Punjab ranged from 19.40% to 44%; the mean loss being 30.41% as studied by Ahmed *et al.* (1977).

2. **Amrasca Devastans (Distant)** (Typhocybinae: Cicadellidae) (Fig. 3)

The leafhopper has been studied as a pest of cotton, okra, egg plant, potato and several other plants by Afzal and Ghani (1953) Lal (1942), Sexena and Saxena (1971), Yunus (1970), Ghouri (1976) Ahmed (1982 a, b), Ahmed *et al* (1981), Baluch *et al* (1980), amongst several others.

The adult leafhoppers are about 3.00 mm in length, with general body colour greenish. Vertex, Pronotum and scutellum somewhat pale to brownish; the colours varying in shades at different times of the year. The vertex possesses two prominent black spots anterolaterally. The face and the ventral side of thorax and abdomen are pale, brownish all over. The legs possess a greenish tinge, and rows of spines on tibia. The pronotum and scutellum have a few whitish spots, whereas each fore wing possesses a black spot near the base of first apical cell.

The life history of the species has been studied on different host plants by several workers including Afzal and Ghani (1953) on cotton, Saxena and Saxena (1971) on okra fruit, Naheed and Ahmed (1974) on okra leaves, and Baluch *et al.* (1980) on brinjal.

As stated by Afzal and Ghani (1953), the females of *A. devastans* mate in the early morning hours or late in the evening, and lay eggs singly on cotton, inside the main leaf veins in the spongy parenchymatous tissue lying between the vascular bundles and the epidermis. The maximum number of eggs laid by a female was recorded to be 29. The incubation period lasts for 3-10 days, and the nymphal life for 6-12 days. The adult life on cotton was estimated to be 5-7 weeks depending upon weather.

Sexena and Saxena (1971) reported that the adults of *A. devastans* survived on okra fruit for 33-50 ($\bar{x}$ = 37.2) days; mated females start egg laying 6-7 days after emergence, and the number of eggs laid are 9.1 to 14.3 ($\bar{x}$ = 11.6).

In nature the leafhopper infests the leaves rather than the fruit of the host plant okra. Naheed and Ahmed (1974) studied the life history of *A.*

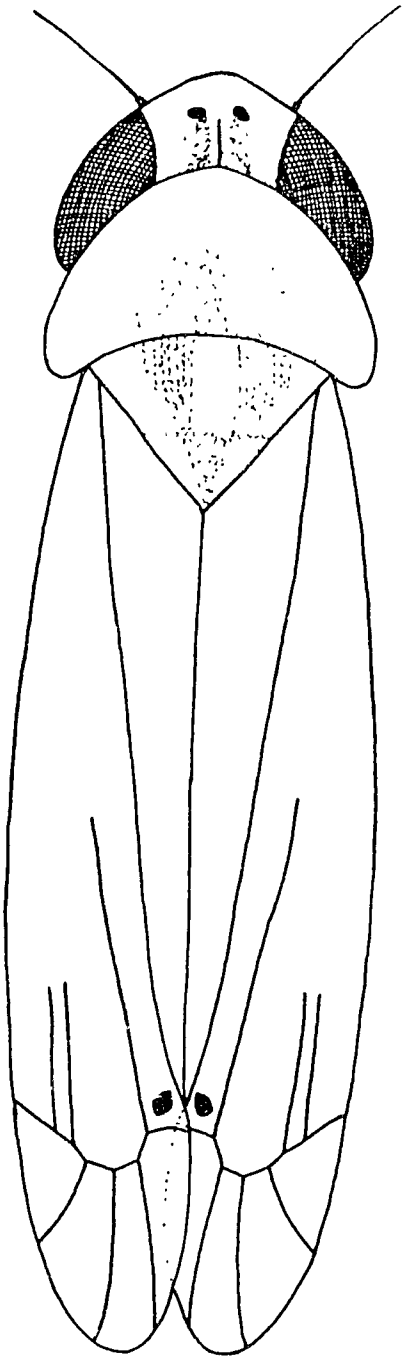

Figure 3. *Amrasca devastans* (Dorsal view)

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devastans on okra leaves and reported that at a temperature range of 80°F – 89°F, the leafhopper survives for 4–37 ($\bar{x}$ = 17.1) days and lays 9–29 ($\bar{x}$ = 17.7) eggs per female. The eggs hatch in 4–11 ($\bar{x}$ = 8.4) days, and the total life history is completed in 15–23 ($\bar{x}$ = 22.1) days.

Baluch *et al* (1980) studied the life history of *Amrasca devastans* on the leaves of brinjal, another important host plant of the species, and reported that at a temperature range of 23°C – 43°C, the life history of the leafhopper is completed in 15–18 ($\bar{x}$ = 15.8) days. The female survives for 1–17 ($\bar{x}$ = 7.9) days, lays 26–70 ($\bar{x}$ = 47.5) eggs in 4–13 ($\bar{x}$ = 7.25) days.

The loss of nutrients from the plant by the leafhopper feeding results into shrivelling and premature death of the leaves. The damage symptoms on okra, brinjal and potato indicate its feeding on mesophyll of the leaves. Thomas and Krishnaswami (1939) stated that the leafhopper transmitted a viral disease known as little-leaf of brinjal, but according to Sohi (1977), this has not been confirmed by later studies.

Afzal and Ghani (1953) observed that from June to August the insect is most active on okra, and during August and September on cotton. Thereafter its abundance declines on cotton and okra. From November to January it breeds on potato, holyhock and more so on brinjal. From February to April it is present on potato, brinjal, hollyhock or other plants whichever are available in the field, till it migrates to okra.

Parnell (1925-26) pointed out that with the reddening of cotton leaves, caused by feeding of leafhoppers, the development of plant ceases, squares and very young bolls are shed, and partly developed bolls dry up. Afzal and Ghani (1953) concluded that the leafhoppers bring about retardation in plant height, and number of flowers and deteriorate the quality of lint. Yunus (1976) stated that at Faisalabad an increase in Jassid population from zero to 2, 4 and 6 per leaf resulted in decrease of 23.13, 30.60 and 58.13% in plant height; 25.93, 44.44 and 77.78% in number of bolls, and 21.12, 36.89, and 66.69% in yield of cotton seed. Similarly Ghouri (1976) estimated, that in fields where population varied from 1–4 jassids per leaf, the yield per acre was 12 maunds (447.84 kg.) against 19 maunds (709.88 kg.) where jassids were effectively controlled. Ahmed (1982 a, b) and (1983) stated a –ve correlation between the number of *A. devastans* and yield of okra and brinjal. Ahmed *et al.* (1981) observed a mean loss of 28.2 to 36.7% in yield of potato in fields infested by *Amrasca devastans*. Afzal and Ghani (1953), and Ahmed (1978) listed a large number of host and food plants of the species in Pakistan.

3. **Rice-leafhoppers,** *Cofana spectra, Nephotettix* spp.

The commonly found leafhoppers of rice are the white rice leafhopper, *Cofana spectra* (=*Cicadella spectra*) (Fig. 4) and the green rice leafhopper *N. nigropictus* (Fig. 5). Mahmood and Aziz (1979) treated in all four species of *Nephotettix* in Pakistan. In addition to feeding on rice plants, these leafhoppers are found on grasses, wheat, spinach, maize, etc., *N. virescens* was not collected by Mahmood and Aziz (1979) from Pakistan, though listed by Ahmed (1978) in insects of rice.

The species of *Nephotettix* are regarded as serious pests of rice. These species are generally widely distributed and their biology and systematics have been studied by Atwal (1976), Pathak (1968), Alam (1964), Ghauri (1971), Mahmood and Aziz (1979), and Ahmed *et al* (1970).

The *Nephotettix* spp. are more serious on rice in parts of India, Bangladesh, other south-east Asian countries, and Japan. In Pakistan, these leafhoppers are not known as serious pests of paddy.

The *Nephotettix* spp. resemble in their life history pattern. The eggs are laid, on the underside of leaves, along the midrib, in masses of 8–16 eggs per mass. A female is capable to lay 200–300 eggs. Incubation period and nymphal development period are the quickest at 25^{0} – 30^{0}C and are 3–8, and 12–21 days, respectively. The adults live for 7–22 days in summer. The highest abundance of the species appears during July and August.

The white rice leafhopper *C. spectra* is also observed to damage rice less commonly and in the late season, when the temperatures become mild. As no biological studies of the leafhopper have been carried out in Pakistan, their pest status remain doubtful.

II. LEAFHOPPERS OF FRUIT PLANTS

1. Mango Leafhoppers

Amritodus atkinsoni (Leth.) (Fig. 6)
Idioscopus clypealis (Leth.) (Fig. 7)
(Idiocerinae : Cicadellidae)

Mango leafhoppers is a term collectively used for the leafhopper species occurring on mango trees. The common ones are *Amritodus atkinsoni,* and *Idioscopus clypealis*. Three others occurring, parinsly and studied from

Karachi – Pakistan by Ahmed *et al.* (1980) are *A. saeedi, Idioscopua karachiensis,* and *Idioscopus freytagi.* These leafhoppers are distributed far and wide in India and Pakistan. Haq and Akmal (1960), and Uppal and Wagle (1944) considered these leafhoppers as the most destructive pests of mango trees. The adults are wedge-shaped, and grey in colour. *A. atkinsoni* is bigger in size than *I. clypealis.*

The leafhoppers become active in February, after a period of inactivity during winter, and lay eggs singly by cutting slits in the tender shoots, panicles, unopened flowers, and young leaves. A single female may lay 150–220 eggs ($\bar{x}$ = 193) during her life span. After an incubation period of 7.5–10.5 days, the hatching takes place. Nymphs take 17–21 days to become adults. Ahmed *et al.* (1980) stated that the two commonly met species i.e. *A. atkinsoni,* and *I. clypealis* formed about 80% of total collection of leafhoppers on mango.

Haq and Akmal (1960) stated that the leafhoppers breed twice a year, once during February–April, and again during June–August. However Ahmed *et al.* (1980) observed that after middle of February the nymphal hatching continued with short breaks up to November. The highest population of leafhoppers in Karachi was recorded in the later half of April. The population starts declining from May, onwards till it touches the lowest level by the end of January. The temperature and relative humidity are linearly positively correlated with population density of mango leafhoppers. They perish when the temperature is about 50°C.

These mango leafhoppers are strongly built, very active, and hop around at the slightest disturbance. Even if a person moves under a tree, the hopping of leafhoppers, and striking against leaves can be heard like a sound that resembles rain drops falling on leaves.

Haq and Akmal (1960) stated that both the nymphs and adults are responsible for causing damage, but the former being more common during the active season, are more destructive. They (1960) also stated that due to the sucking of sap from the leaves and panicles, the plants become weak, and their fruiting is reduced. In severe causes of infestation, no fruit is set. Poos and Johnson (1936) and Ahmed and Ahmed (1980) demonstrated that the Idiocerine leafhoppers affected the growth of plants, destroyed the foliage, and were helpful in the large-scale fungal infestation of leaves. Uppal and Wagle (1944) reported that the mango leafhoppers could potentially destroy the entire orchard, but usually the loss varied from 25–60%. Rehman (1940,

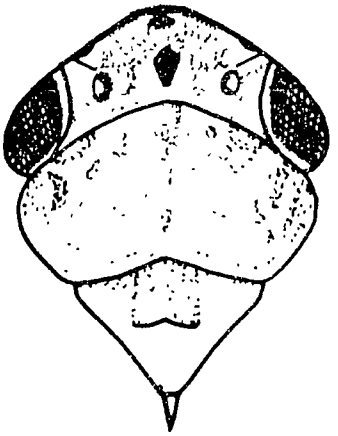

Figure 4A. *Cofana spectra*, Dorsal view of head

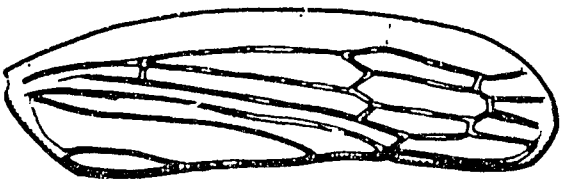

Figure 4B. *C. spectra*, Fore wing

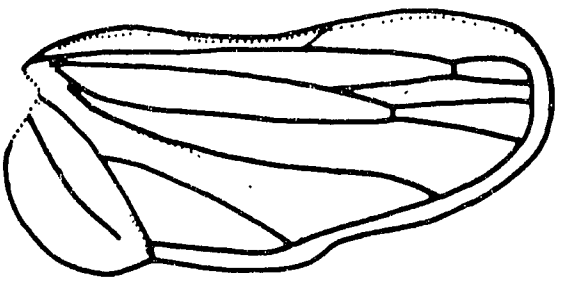

Figure 4C. *C. spectra*, Hind wing

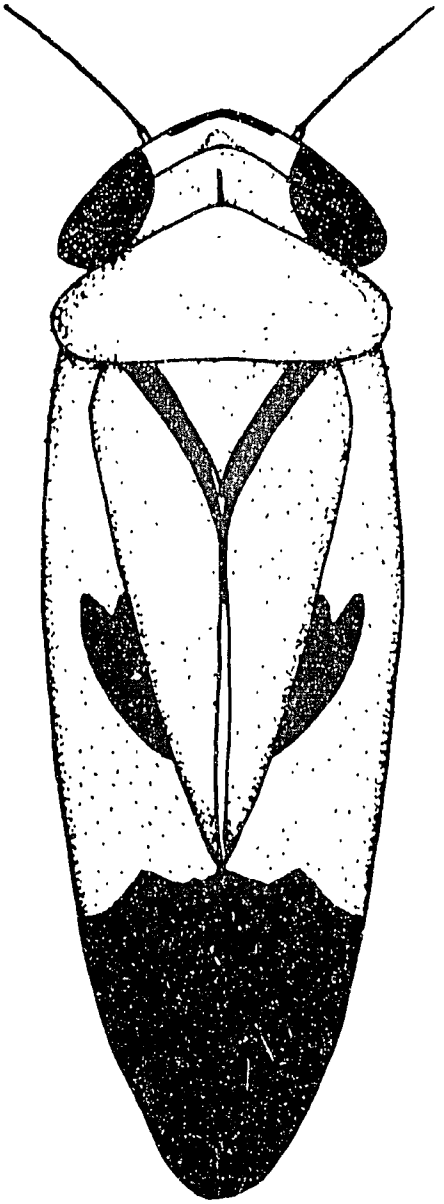

Figure 5. *Nephotettix nigropictus* (Dorsal view)

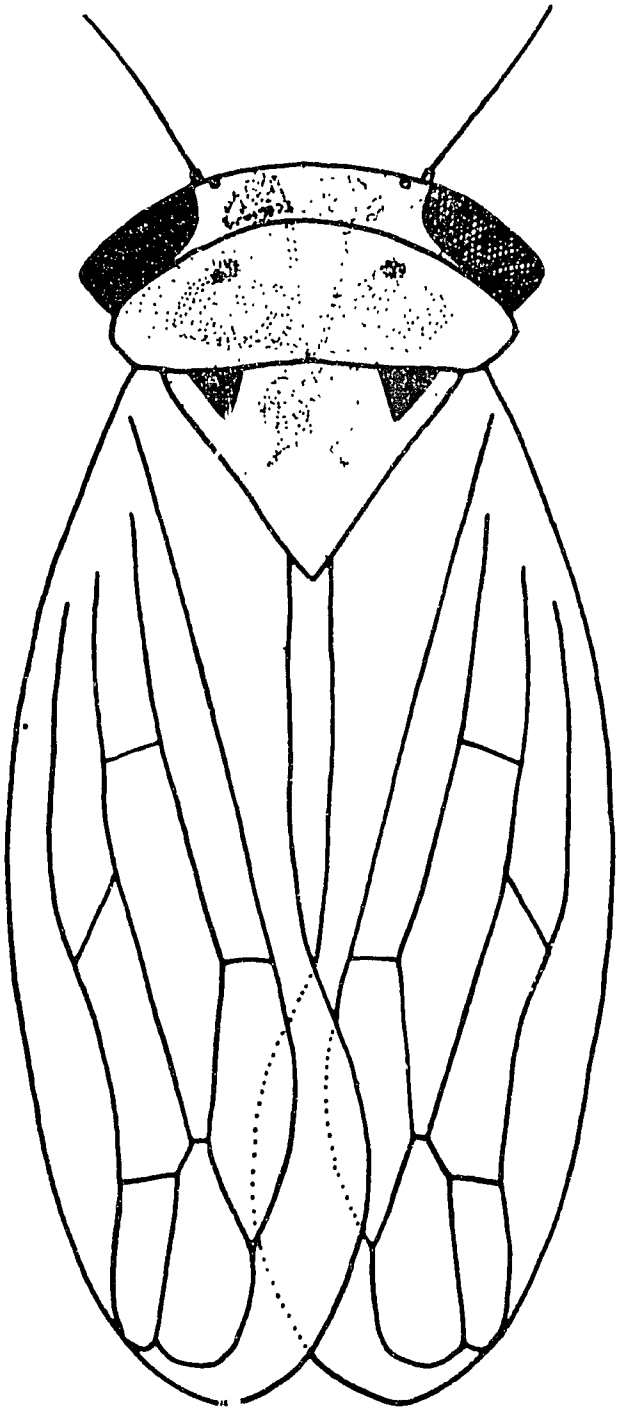

Figure 6. *Amritodus atkinsoni* (Dorsal view)

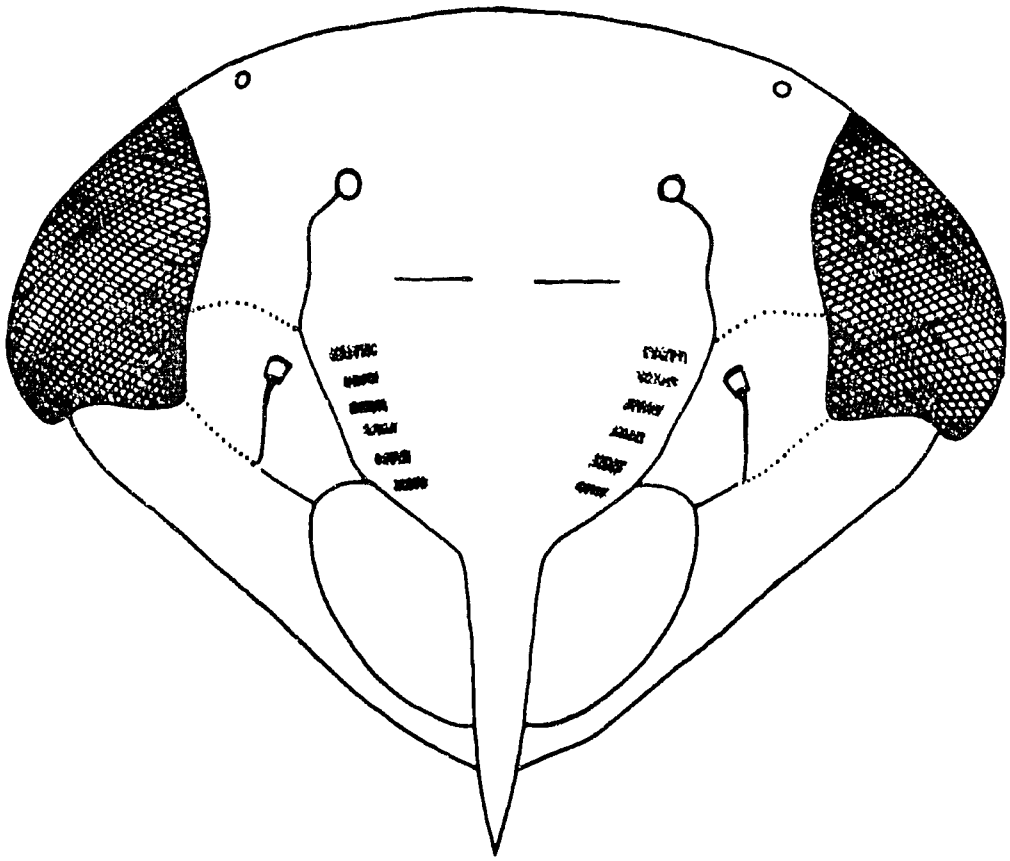

Figure 6A. *A. atkinsoni*, Ventral view of head

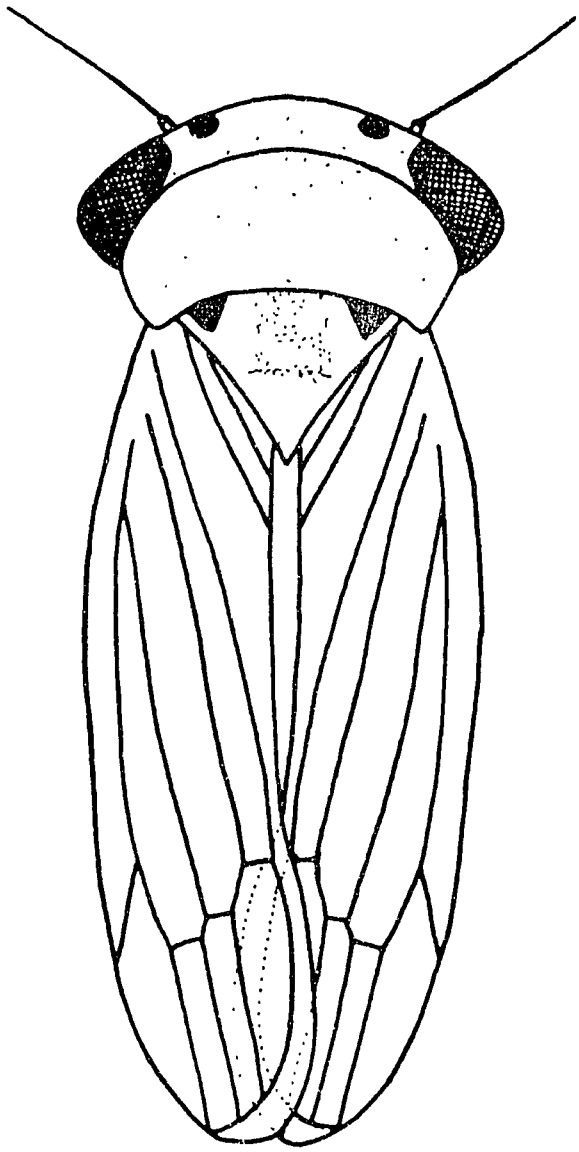

Figure7. *Idioscopus clypealis* (Dorsal view)

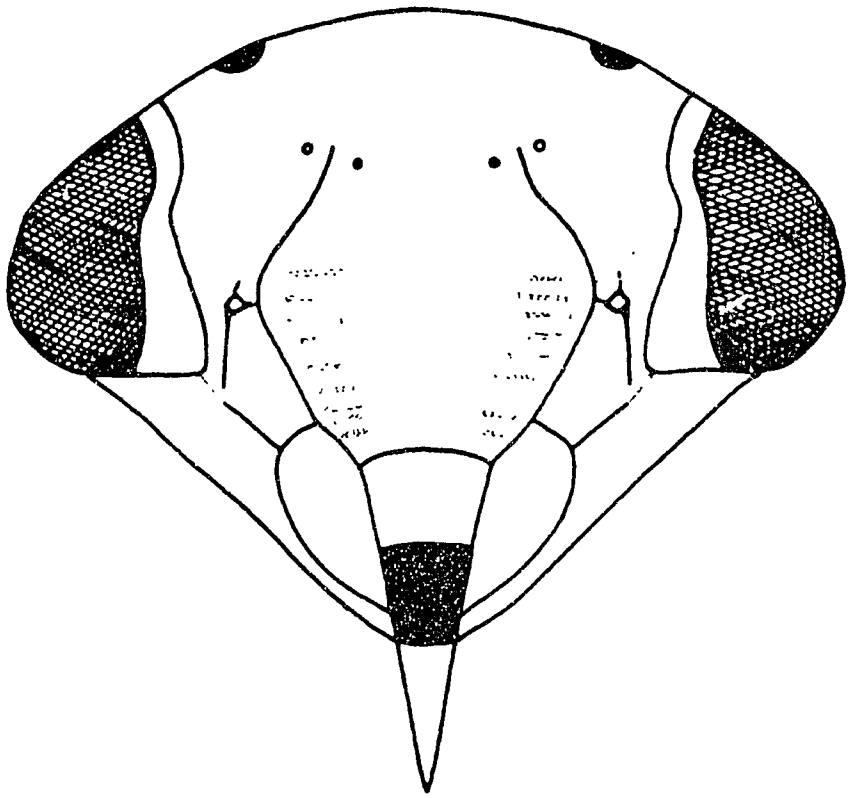

Figure 7A. *I. clypealis*, Ventral view of head

1945) remarked that the mango leafhoppers were responsible for premature falling of inflorescence.

Ahmed *et al.* (1981) reported 15 species of fungi in the sooty mould of mango in Karachi area. The fungi developed on honey-dew exerted by the leafhoppers. The fungal infestation appeared in maximum abundance from late May to July following the large-scale population of the leafhoppers from March to May.

Haq and Akmal (1960) recommended spray of 1/2 lb. of Malathion or Diazinon per acre for control of mango leafhoppers. They (1960) considered that the most appropriate time for spraying is the preblossoming period from middle of December to the beginning of February. A number of workers consider the use of resin with crude oil emulsion, fish oil resin soap, resin mixed with sodium carbonate, Taxaphene with sulphur, BHC, and DDT satisfactory for the control of mango leafhoppers. During a recent study at Faisalabad, it was experimentally studied that Lebaycid applied at the rate of 1.00 lb. a.m. per 100 gallons of water proved very effective and could kill all the insects within half an hour.

2. Grapevine Leafhoppers

At least seven species of leafhoppers are known to occur on grape-vine in different parts of Pakistan. These include *Empoasca bostanensis, Empoasca decedens,* and *Edwardsiana quettensis* in Balochistan, *Arboridia vinealis* (Fig. 8) and *Erythroneura chaudhrii* in NWFP, *Austroasca viriferae* and *Erythroneura samadi* in Sindh. The species *A. vinealis* appears distributed more widely and renders serious damage to grape-vine, when temperatures are mild, and rainfall is delayed. Samad and Ahmed (1979) recorded a number of alternate host plants of the species, like *Melia* sp., *Morus alba,* and *Quercus incana* in Azad Kashmir, *Gleditshia triacanthus* and *Bauhinia variegata* at Abbottabad (NWFP).

3. Apple Leafhoppers

Important leafhopper species infesting apple in Pakistan are *Edwardsiana quettensis* (Fig. 9), *Empoasca punjabensis, Empoasca decedens,* and *Erythroneura rhamnicola. E. quettensis* is the most widely distributed species in apple growing areas of the country, whereas *E. punjabensis* has a large number of host and food plants. The damage rendered by these species is similar to that rendered by other typhlocybines.

Ahmed (1981) studied the biology, and life history of *E. quettensis* on apple at Quetta (Balochistan) and stated that the mean lives of males and females were 8.2, and 9.8 days, respectively. The mean egg incubation period, the nymphal period, and the total life history periods are 14.1, 18.02 and 32.12 days, respectively.

The economic impact of the leafhoppers on apple has not been studied in Pakistan, and so no information is available of the losses rendered by it.

4. Leafhoppers of Miscellaneous Fruit Plants

Leafhopper infestation has not generally been observed on fruit plants like banana, sapota, citrus, and guava in Pakistan. In addition to the species already discussed, small numbers of *Amrasca devastans, Erythroneura hazarensis, E. rhamnicola, Zygina kashmirensis* infest apple in various parts of Pakistan. Similarly *Erythroneura rhamnicola* was observed on almond at Chinari (Azad Kashmir), *Edwardisiana quettensis, Empoasca punjabensis,* and *Erythroneura rhamnicola* on apricot. *Edwardsiana sharfi* infests cherry at Quetta (Balochistan), and *Zygina rubronotata* infests grewia, at Karachi-Mirpurkhas (Sindh). Ahmed and Ahmed (1980) considered *Z. rubronotata* (Fig. 10) a serious pest of grewia (falsa) in lower Sindh. The leafhopper is frequently observed on the host plant from September to February with peak population during December. The leafhopper affects the foliage of plants by sucking the nutrients as well as attracting fungal growth of the species *Phakopsora grewiae* (brown dust). From early September, the destruction of foliage increases from nil to complete defoliation by the end of February.

A number of species including *Velu caricae* affect the wild fig. At Mirpurkhas (Sindh) several specimens of *Zygina sindhensis* were also collected from mango plants. *Erythroneura rhamnicola, Empoasca punjabensis, Empoasca decedens,* and *Arboridia vinealis* were collected on fruit plants like peach, pear and plum. *Erythorenura kashmirensis* was collected from NWFP on walnut and *Zygina pakistanica* (Fig. 11) from the plant Zizyphus. *Z. Pakistanica* has a very wide distribution in Pakistan. Naheed and Ahmed (1980) described *Empoasca halaensis* from citrus, at Hala (Sindh).

III. LEAFHOPPERS OF WOODY TREES AND ORNAMENTAL PLANTS

Trees like neem, *Melia azadirachta*, siris, *Albizzia lebbek,* babool, *Acacia nilotica,* gul mohr, *Delonix regia,* chestnut, *Aesculus indica,* oaks,

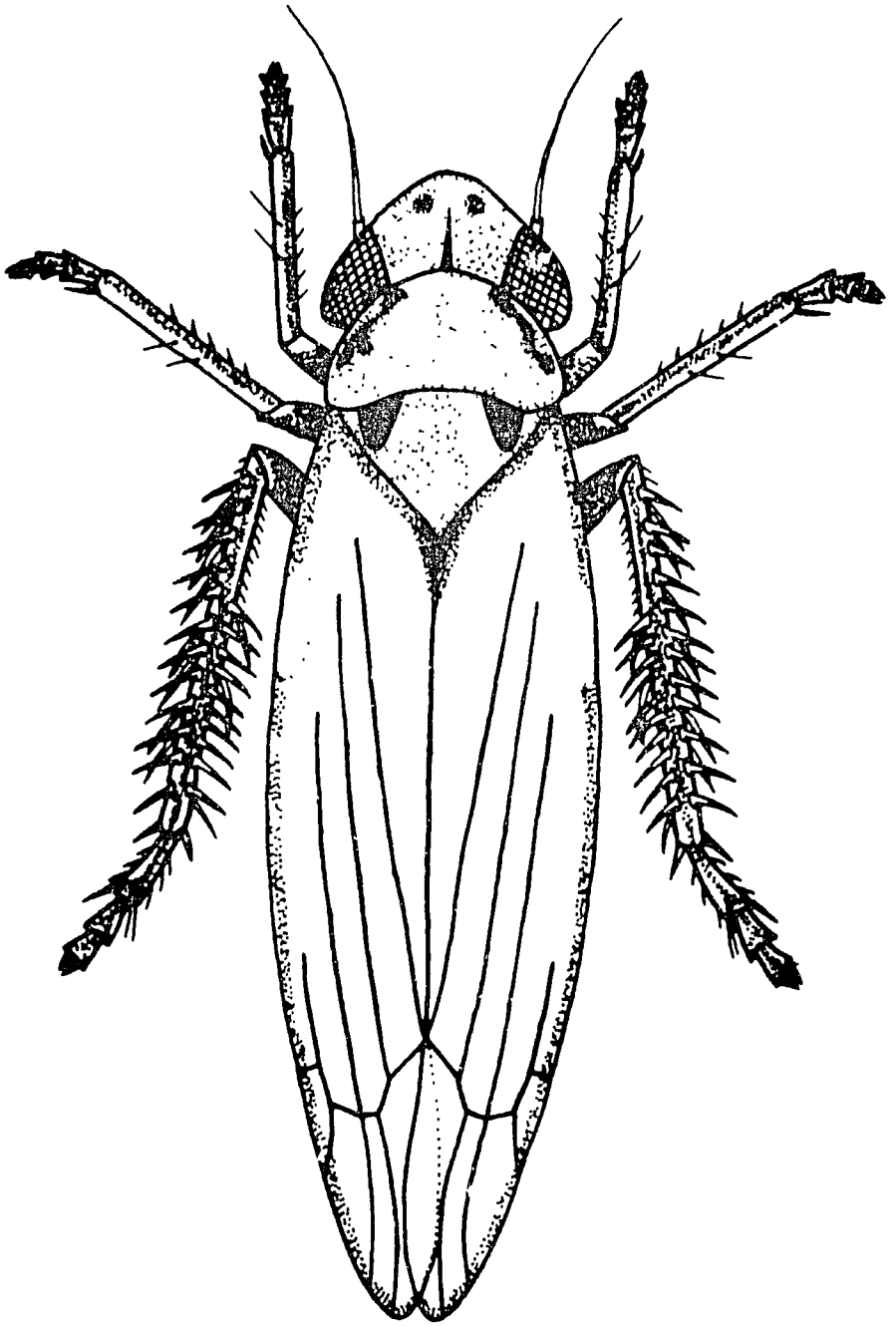

Figure 8. *Arboridia vinealis* (Dorsal view)

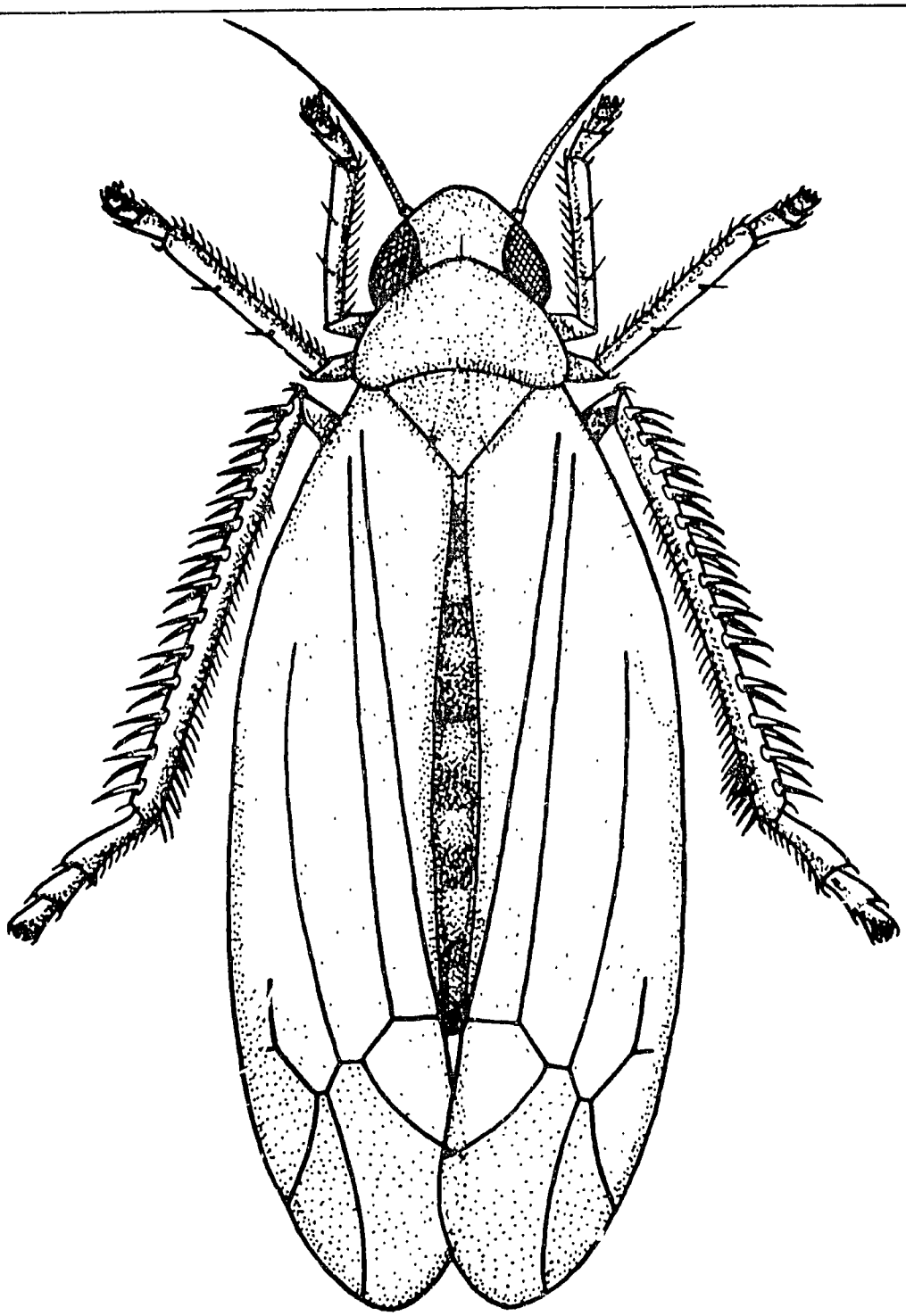

Figure 9. *Edwardsiana quettensis* (Dorsal view)

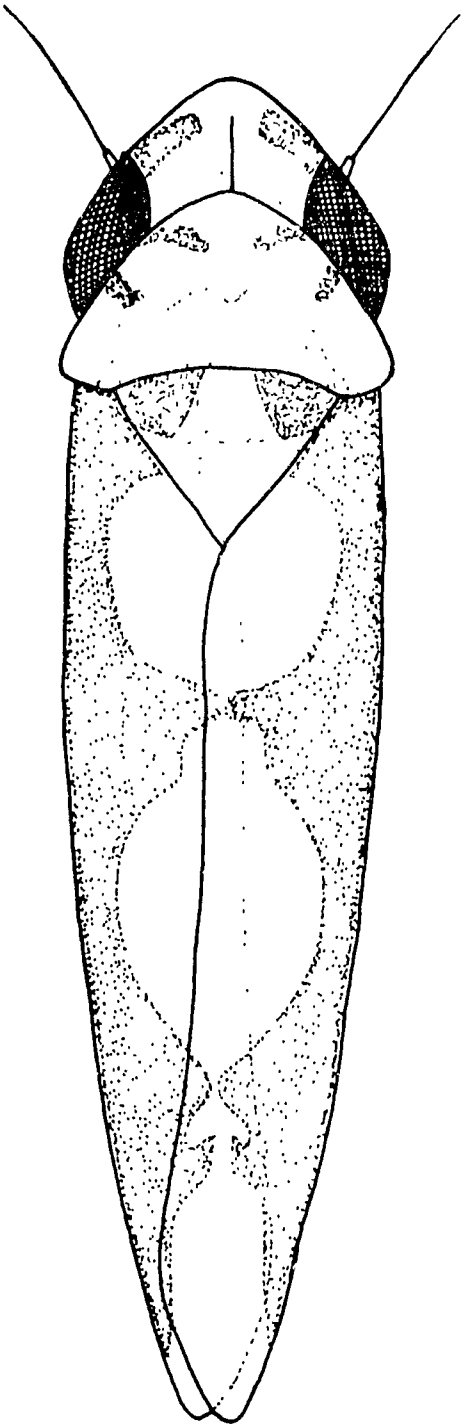

Figure 10. *Zygina rubronotata* (Dorsal view)

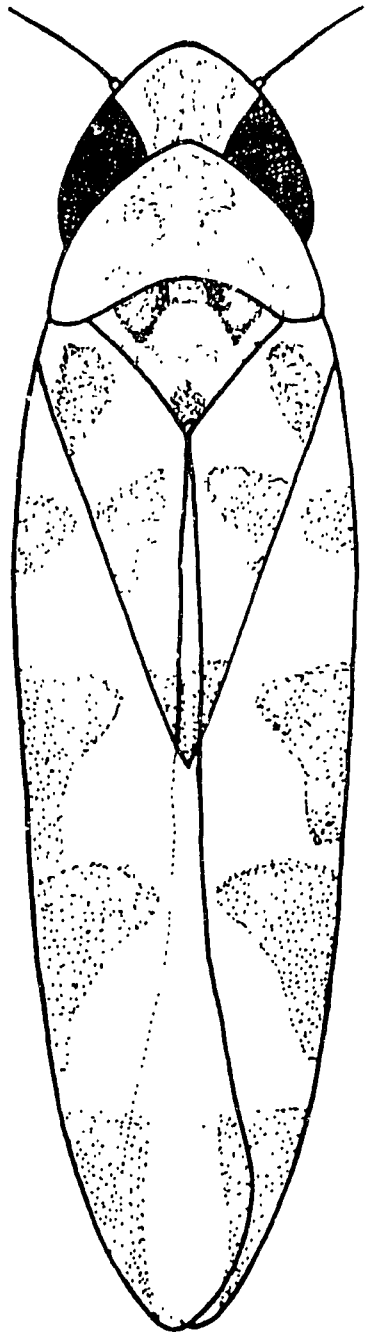

Figure 11. *Zygina pakistanica* (Dorsal view)

Quercus dilatata, and *Quercus incana*, amaltas, *Cassia fistula*, willow, *Salix tetrasperma*, bauhinia, *Bauhinia variegata*, wild rose, *Rosa moschata* and many others harbour leafhopper species. Important among these are *Empoasca albizziae* on siris, *Watara binotata* (Fig. 12), on bauhinia, *Helionidia notata* on wild rose, and *Togaritettix acuta* on cultivated rose. The leaves are d and destroyed as a result of intensive feeding activity of the leafhoppers. Ahmed and Ahmed (1980) estimated a mean 71.26% loss of chlorophyll from bauhinia leaves due to the feeding of the leafhopper. Naheed and Ahmed (1981) regarded *W. binotata* as a serious pest of kachnar, and studied its population at Karachi, and its relationship with different environmental factors. From August to October the mean population of leafhopper was 30.7 leafhoppers per leaf. On some more heavily infested plants 200–300 leafhoppers per leaf were recorded. Rainfall drastically cuts down its population.

IV. LEAFHOPPERS OF WILD PLANTS

A number of wild bushes, and small sized plants also harbour quite a number of leafhopper species. *Andrabia kashmirensis* was studied on timber, *Xanthoxylum alatum*, in Azad Kashmir, *Kapsa mingorensis* on spairkey, *Plectranthus rugosus* at Mingora (Swat-NWFP), *Erythroneura atropictila* on teen patra, *Rubus peniculatus* at Abbottabad (NWFP), *Tautoneura alba* on Chinjal, *Debregeasia hypoleuca* at Abbottabad (NWFP), *Zygina irfani* on baker, *Adhatonda vasica* at Muzaffarabad (Azad Kashmir), *Zygina peshawarensis* on wild mint at Peshawar (NWFP), and *Ayubiana lantanae* on Gutch, (*Viburnum nervosum*) at Murree (Punjab).

V. LEAFHOPPERS OF GENERAL VEGETABLE PLANTS

Of the general vegetable plants, potato is very seriously infested all over the country by a number of species of leafhoppers. More important amongst these species are *Empoasca signata* (Fig. 13), *E. punjabensis*, and *Amrasca devastans*. Ahmed *et al.* (1981) described *Austroasca tuberosa*, and *A. jamkandensis* on potato in the suburbs of Karachi. Naheed and Ahmed (1980) studied the life history of *E. signata* on potato and caster at Karachi.

The leafhopper feeding of potato results into browning, wrinkling, and rolling up of leaf tips and margins. These symptoms are exhibited first in the older leaves, and later on even the youngest leaves show signs of injury. The feeding and oviposition punctures become the sites of fungal infections.

Table 2. Life history of *Empoasca signata* on castor and potato at Karachi

Description	On castor	On potato
Premating period (days)	2.4	3.6
Preoviposition period (days)	3.1	2.6
Female oviposited (for days)	20.3	43.4
Longevity of male (days)	19.0	28.5
Longevity of female (days)	40.7	45.4
No. of eggs laid	72.9	70.3
Total nymphal period (days)	7.67	13.38
Total life history period (days)	13.9	19.38
Nymphal mortality (%)	28.57	38.27

Husain and Lal (1940) remarked that the 'hopper burn' may be due to the injections of salivary toxins by leafhoppers into the leaf tissues.

Ahmed *et al* (1981) observed that the insecticidal control of leafhoppers brought about an increase of 81.3 to 176% in yield of potato tubers. The leafhoppers also deteriorated the quality of potato tubers by sucking away the nutrients. Ahmed (1983) observed a strong -ve correlation of leafhopper numbers with yield of potato under experimental conditions. Other important species of leafhoppers infesting vegetable plants are *Empoasca kerri* on cluster bean (*Cyamopsis tetragonoloba*) all over Sindh and Punjab, *Empoasca punjabensis* on bitter gourd, carrot, chillies, clusterbean, luffa, cowpea, mint, mustard, pumpkin, spinach, tomato, and some other host and food plants. *Empoasca sesamae* infests till, (*Seasmum indicum*) in large numbers in suburbs of Karachi. *Empoasca sindhensis* occurs on bitter gourd at Tandojam (Sindh), and *Empoasca masoodi* on spinach at karachi. *Empoasca cicerae* occurs on green gram in Balochistan, *Empoasca bostanensis* on pumpkin at bostan (Balochistan), *Empoasca apodema* on pumpkin at Haripur (NWFP), *Empoasca capsicae* on chillies at Mardan (NWFP), and *Austroasca elongata* on mint at Quetta (Balochistan). The biology and ecology of none of these species is known.

VI. PLANT HOPPERS (FULGOROIDS)

Qadri and Mirza (1960) remarked that quite a few species of plant hoppers of the superfamily Fulgoroidea were injurious to paddy in areas

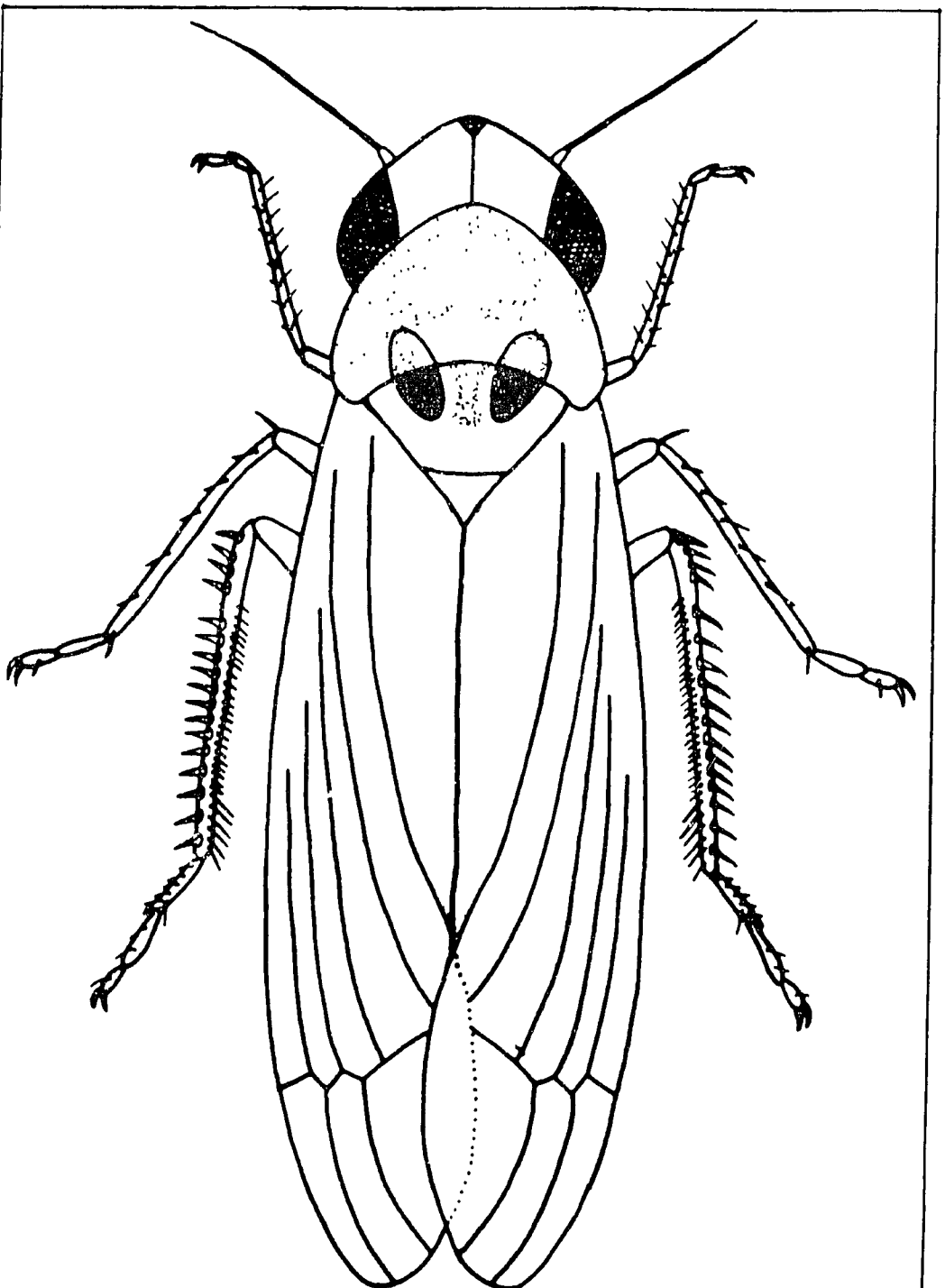

Figure 12. *Watara binotata* (Dorsal view)

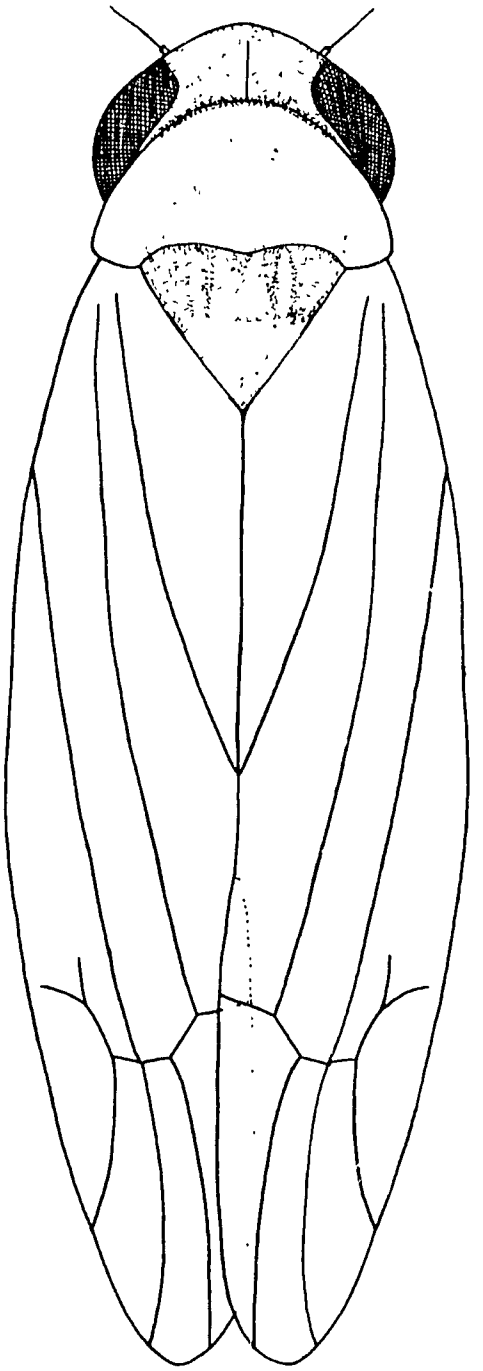

Figure 13. *Empoasca signata* (Dorsal view)

irrigated from G. M. barrage in Pakistan. According to them (1960), some species were involved in transmission of viral diseases. Qadri and Mirza (1960) listed the following species reportedly collected from districts Tharparkar, Thatta, Mirpurkhas and Karachi.

1.	*Sogatella furcifera* (Horv.)	Family Delphacidae
2.	*Sogata pusana* distant	Family Delphacidae
3.	*Sogata tandojamensis* Qadri and Mirza	Family Delphacidae
4.	*S. cornicaudatus* Qadri and Mirza	Family Delphacidae
5.	*S. striatus* Qadri and Mirza	Family Delphacidae
6.	*Oliarus hodgarti* Walker	Family Cixidae
7.	*O. albifacialis* Qadri and Mirza	Family Cixidae
8.	*Nisia atrovenosa* Leth.	Family Derbidae

Later on Ahmed (1978) also reported *Nilaparvata lugens* on rice from various parts of Pakistan. Of all the planthoppers, the brown planthopper (*N. lugens*) and the whitebacked planthopper (*S. furcifera*) have a wider distribution in rice growing areas of Asia, and are regarded of greater economic significance.

1. White-backed Planthopper, *Sogatela furcifera* Horv. (Fig. 14)

Qadri and Mirza (1960) reported this species on rice in all the provinces of Pakistan. They (1960) considered it a serious pest of wheat and millet in Tandojam, and Mirpur Khas areas in Sindh, and Faisalabad in Punjab. On paddy their outbreak starts in the beginning of rainy season, and the population becomes widely distributed during September. Two generations of planthoppers pass from July to October. Nasu (1964) did not include Pakistan in his distribution range of this species, probably due to the unreliability of records. Mahar *et al.* (1978) remarked that the species was observed for the first time in Pakistan during 1976 at Rice Research Station, Dokri (Sindh). Ahmed and Perwin (1981) considered the population of planthoppers on rice negligible throughout the season near Thatta (Sindh).

Mahar *et al.* (1978) reported that during the rice crop of 1976 around Dokri (Sindh), the white backed plant hopper (WBPH) infestation and hopperburn appeared on the Semi-dwarf variety IR6 of rice in October at late stages of the plant growth. The infestation appeared in patches ranging

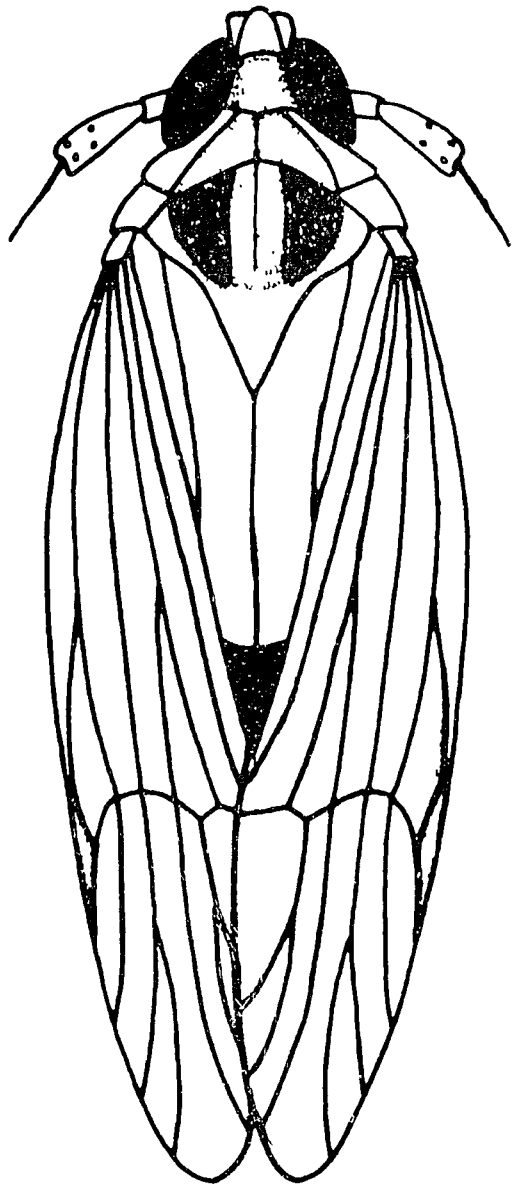

Figure 14. *Sogatella furcifera* (Dorsal view)

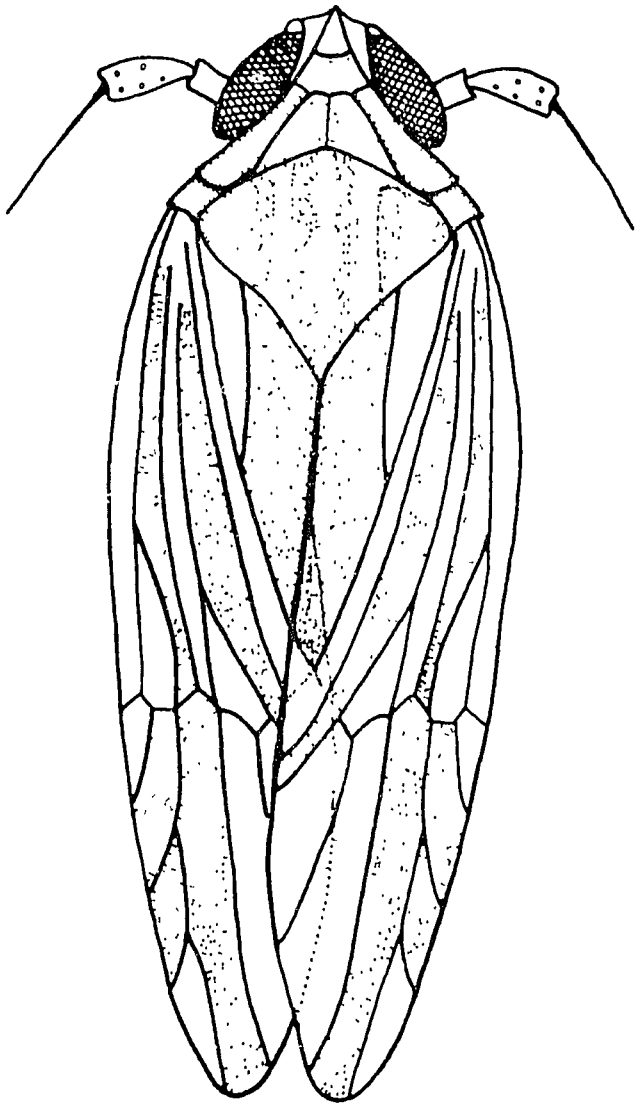

Figure 15. *Nilaparvata lugens* (Dorsal view)

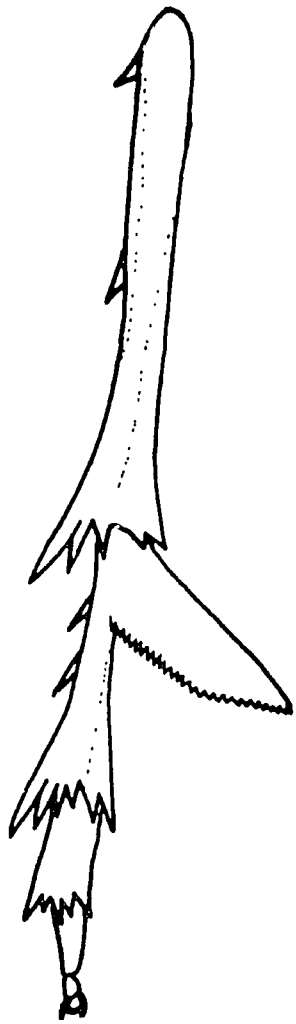

Figure 15A. *N. lugens*, Hind leg (Tibia and tarsus)

in size from a few square meters to 25 m^2, and extended to areas of 10 to 15 ha. The infestation reappeared in the area on 1977 crop, but was smaller in scale. It was pointed out that the pest could not thrive on local varieties in Pakistan due to their being highly resistant. IRRI (1971) reports confirmed that WBPH is an important pest of rice in several parts of Asia. It had been less so far Pakistan. It damages plants by direct feeding, and is not a vector of any of the viral diseases.

The studies on the ecology of the WBPH and related species are urgently needed in Pakistan.

2. Brown Planthopper, *Nilaparavata lugens* Stal (Fig 15)

Nasu (1964) did not include Pakistan in his range of distribution of the species. Later, however, Ahmed (1978) reported the species from Pakistan, on rice plant. Nasu (1964) regarded this species like *S. furcifera* as tropicopolitan. *N. lugens,* is according to Claridge (1981) the most important pest of rice in Asia, but he (1978) also did not consider the species occurring in Pakistan. The species has assumed much biological importance, as several biotypes of the species are being cultured, and studied in U.K., and at IRRI. The species is considered a vector of 'grassy stunt disease' or rice. The biology and ecology of the species have not been so far studied in Pakistan.

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Chapter 20

COCCIDS OF PAKISTAN

Muhammad Abdul Qayyum*

The scales and mealy bugs are together grouped in Coccoidea. These are minute, inconspicuous and highly specialised insects in their feeding habits. They infest leaves, stems, fruits and roots of a wide variety of cultivated crops.

Frequently, quoted examples are: (1) the San Jose scale (*Quadraspidiotus perniciosus*) - a pest of fruit trees (2) the cottony cushion scale (*Icerya purchasi*) - a serious pest of citrus and other fruit trees, (3) the mango mealy-bug (*Drosicha stebbingi* (Green) - a pest of mango trees (4) the sugarcane mealy bug, (*Saccharicoccus sacchari* (Ckll)).

Some coccids are useful organisms. The secretion of lac insect, *Laccifer lacca* is used to obtain shellac of commerce value. The prickly pear cochineal, *Dactylopius tomentosus* is used to eradicate the weed *Opuntia dillenii*

Coccids are also of interest, because they manifest diverse kinds of reproduction, e.g. bisexual, parthenogenetic, oviparous, ovoviviparous, etc. Functional hermaphroditism noticed in *Icerya purchasi* is quoted in books, as a unique biological phenomenon. The scale insects infesting different crops are listed below:

SCALE INSECTS OF SOME CROPS

1. **SUGARCANE:** In Pakistan the mealybugs recorded on sugarcane are *Kiritschenkella sacchari* (Green), *Saccharicoccus sacchari* (Ckll.), *Heterococcus rehi* (Lind.) and *Heliococcus* sp. (Mahmood *et al.*, 1982). Of these *K. sacchari* and *S. sacchari* are comparatively serious and their combined infestations have been recorded throughout Pakistan.

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2. **MANGO:** As a result of survey for scale insects and their natural enemies a large number of them were recorded. Natural enemies of scale insects have been dealt by Ahmad and Ghani (1972), Ghani and Muzaffar (1974) and Mahmood *et al.* (1980). Only scale insects are listed here.

Aspidiotus destructor Sing., *Parlatoria crypta* (Mck.), *P. cinerea* Had., *P. pseudopyri* Kuw., *Lindingaspis ferrisi* Mck., *L. floridana* Ferris, *Aonidiella orientalis* (Newst.), *A. citrina* Coq., *Hemiberlesia lataniae* (Sign), *Aulacaspis tubercularis* Newst., *Chrysomphalus aonidum* (L.), *Genaparlatoria pseudaspidiotus* (Lind.), *Lepidosaphes pallida* Green (Diaspididae); *Ferrisia virgata* (Ckll.), *Pseudococcus filamentosus* Ckll., *Spilococcus* sp., *Rastrococcus spinosus* (Rob.), *Planococcoides robustus* Ezz. and McC. (Pseudococcidae); *Icerya aegyptiaca* (Dougl.), *Drosicha stebbingi* (Dougl.), *Drosicha stebbingi* (Green) (Margarodidae); *Ceroplastes actiniformis* Green, *C. floridensis* Comst., *Coccus hesperidum* L., *C. mangiferae* (Green) and *Vinsonia stellifera* (Westw.) (Coccidae) were recorded from Mango. *Aspidiotus destructor* became serious pest in 1975 in mango orchards near Lahore.

3. **CITRUS:** *Aonidiella citrina* Coq., *A. aurantii* (Mask.), *Chrysomphalus aonidum* (L.), *Lepidosaphes gloverii* Peck, *L. conchiformis* (Gmelin.), *Parlatoria oleae* (Colvee), *P. ziziphus* (Lucas), *Pinnaspis strachani* (Cooley) (Diaspididae); *Icerya aegyptiaca* (Dougl.), *Perissopneumon tamarindus* (Green) (Margarodidae); *Ferrisia virgata* (Ckll.), *Nipaecoccus vastator* (Mask.), *Pseudococcus filamentosus* Ckll., and *Spilococcus* sp. *(Pseudococcidae)* were recorded from citrus. *Aonidiella* spp. and *N. vastator* are serious pests.

4. **GUAVA:** *Aonidiella orientalis* (Newst.), *A. aurantii* (Mask.), *Chrysomphalus aonidum* (L.), *Hemiberlesia lataniae* Sign. (Diaspididae); *Ferrisia virgata* (Ckll.), *Pseudococcus filamentosus* Ckll., *Spilococcus* sp. (Pseudococcidae); *Ceroplastes actiniformis* Green, *C. floridensis* Comst., *Coccus hesperidum* L. and *Saissetia nigra* (Nieten.) (Coccidae) were recorded from it. *F. virgata* and *Aonidiella orientalis* are important pests.

5. **JAMUN:** *Aspidiotus destructor* Sign., *Aonidiella orientalis* (Newst.), *A. aurantii* (Mask.), *A. citrina* Coq., *Chrysomphalus aonidum* (L.) *Cryptoparlatoreopsis meccae* Hall, *Lindingaspis ferrisi* Mck., *Parlatoria crypta* (Mck.), (Diaspididae); *Nipaecoccus vastator* (Maskk.), *Pseudococcus*

filamentosus Ckll., *Maconellicoccus hirsutus* Green, *Spilococcus sp.* (Pseudococcidae); *Icerya aegyptiaca* (Dougl.), (Margarodidae); *Vinsonia stellifera* (Westw.), and *Coccus discrepens* Green (Coccidae), were recorded from it. *Aonidiella orientalis* and *Chrysomphalus aonidum* are important pests.

6. **MULBERRY:** *Aonidiella orientalis, A. citrina* Coq., *Hemiberlesia lataniae* Sign. (Diaspididae); *Ceroplastodes chiton* Green, *Coccus discrepens* Green, *Parthenolecanium* sp. nr. *persicae* (F.), *Saissetia* sp., *Saissetia nigra* (Nieten.) (Coccidae); *Nipaecoccus vastator* (Mask.), *Ferrisia virgata* (Ckll.), *Pseudococcus filamentosus* Ckll. (Pseudococcidae); *Icerya* sp. nr. *seychellarum* (Westw.) and *I. aegyptiaca* (Dougl.) (Margarodidae) were recorded. *N. vastator, Coccus discrepens* and *Aonidiella orientalis* are serious pests.

7. **LOQUAT:** *Aonidiella aurantii* (Mask.), *Parlatoria oleae* (Colvee), *Perorinia neriifolii* Borchs. and William (Diaspididae); *Spilococcus* sp. (Pseudococcidae) and *Ceroplastes floridensis* Comst. (Coccidae) were recorded. *P. oleae* is an important pest.

8. **DATE PALM:** *Parlatoria blanchardii* (Targ.) (Diaspididae); *Icerya aegyptiaca* (Dougl.), (Margarodidae) and *Ferrisia virgata* (Ckll.) (Pseudococcidae) were recorded from it. *P. blanchardii* is a serious pest.

9. **BANANA:** *Aspidiotus destructor* Sign., *Chrysomphalus aonidum* (L.), *Parlatoria crypta* (Mck.) (Diaspididae); *Pulvinaria* sp. and *Saissetia nigra* (Nieten). (Coccidae) were recorded. *A. destructor* is an important pest.

10 **JUJUB:** *Aonidiella orientalis* (Newst.), *A. aurantii* (Mask.), *A. citrina* Coq., *Aonidia zizyphi* Rehman and Ansari, *Temnaspidiotus excisus* (Green) (Diaspididae); *Nipaecoccus vastator* (Mask.), *Pseudococcus filamentosus* Ckll., *Maconellicoccus hirsutus* Green (Pseudococcidae); *Ceroplastodes chiton* Green, *Laccifer lacca* (Kerr.) (Coccidae); *Icerya* sp. and *Perissopneumon* sp. (Margarodidae) were recorded.

11. **ALMOND, PLUM, PEACH, PEARS AND PISTACHIO:** *Diaspidiotus pronorum* (Laing), *Parlatoria* sp., *Parlatoria oleae* (Colvee), *P. cinerea* Had., *P. pseudopyri* Kuw., *Quadraspidiotus perniciosus* (Comst.), *Lepidosaphes*

pistaceae Arch., *L. baluchistanensis* Rao, *Lepazia peshawarensis* Rehman and Ansari (Diaspididae); *Eulecanium* sp. nr. *tiliae* L., *Eulecanium* sp., *E. corvli* (Lin.), *Coccus* sp., *Parthenolecanium* sp. nr. *persicae* (F.), *Pulvinaria loralaiensis* Rao, *Platylecanium* sp. and *Eriochiton amygdalae* Rao (Coccidae) were recorded.

THE COCCOID FAMILIES OF PAKISTAN

Thirteen coccoid families have been recorded (Ahmad, and Ghani, 1972, 1974, Ansari, 1945, Ghauri, 1962, Kazimi and Ghani, 1963; Ghani and Muzaffar, 1971; Latif, 1949; Mohyud-Din *et al.* 1977, Rahman and Latif, 1944, 1944a, Quayyoom, 1972, 1980, 1980a, Quayyoom and Khan, 1974; 1983, Mohyuddin, 1983 and Mahmood and Mohyuddin, 1986) from Pakistan. These are: (i) Ortheziidae, (ii) Margarodidae, (iii) Monophlebidae, (iv) Pseudococcidae, (v) Coccidae, (vi) Aclerdidae, (vii) Datyloppidae (= Dactylopiidae), (viii) Kermesidae, (ix) Eriococcidae, (x) Kerridae, (xi) Cerococcidae, (xii) Phoenicoccidae and (xiii) Diaspididae.

Of these the two families viz., Pseudococcidae and Diaspididae are fortuous organisms and have proliferated extensively on a variety of biota in Pakistan as well as in most parts of the world (Eastop, 1978).

EVOLUTIONARY BIOLOGY

The general remarks about the evolutionary biology of the group are:

1. The group is clearly dimorphic sexually. The males are winged and the females wingless.
2. The males undergo one to two moults in excess of those undergone by the females to become adults.
3. The males are ephemeral, do not feed as adults, and live hardly a day or two, to fecundate the females, if available.
4. The females are wingless and loose appendages gradually during their period of growth, from the archeo- to the neo-coccoid direction. This implies from a primitive to a specialized conditions, or character state.
5. The males exhibit clearly the conservative (Ahmad, 1949) sternorrhyncan features while the females in most cases are difficult to identify anatomically except possibly through the shape of the beak, the stylets, and salivary pump (Russel, 1974, Latif and Khan, 1961).

6. The group is perhaps next to Aphidoidea, in successfully invading a variety of biota, in many different climatic zones, although some fifty per cent of the total world fauna harbours the temperate belt of the globe, (Eastop, 1978; Khan and Quayyoom, 1983).

NATURE OF DAMAGE

The mouth parts comprise of stylets, implying that the coccoids suck the sap of their host plants and in most cases introduce microbes; many of the coccoids secrete honey-dew which attracts formicids and other insects (Lefroy, 1908).

POSSIBILITY OF BIOLOGICAL CONTROL

The group is extensively parasitized, even hyper-parasitized. The work of Ahmad and Ghani (1972), Ghani and Muzaffar (1974), and more recently Mahmood *et al.*, (1984) would bear a testimony to this fact, and it is this fact of the coccoid phenology, which could be further exploited in reaching somewhere near a definitive control operation, since these insects, otherwise are tenacious and are not easily killed by the hazarduous chemicals, a long list of which has been provided by any book on the chemical control of these pests (Hill, 1979).

UNCONVENTIONAL METHODS OF CONTROL

Fortunately two articles viz., Kosztarab (1977), Miller and Kosztarab (1979) have appeared and emphasize the unconventional methods of control for this group.

The coccoid fauna of Pakistan snugly keys with the faunas of Paelearctic and Nearctic regions. The super family coccoidea has been even elevated as sub order coccinea by Danzig (1949).

RECOGNITION CHARACTERS OF COCCOIDEA

Small insects with marked sexual dimorphism; females degenerate, apterous, often sessile, resembling galls on bark or lichen, usually covered with waxy secretions; males with one pair of wings, normally developed legs, and antennae and vestigial mouth parts; females many times, sometimes 50-100 times larger than males. Tarsi with one claw, exceptionally a second pretarsal segment, not easily discernible, can be noted (Quayyoom, 1972)

particularly in the margaroid families. The following descriptions are based mainly on females:

Body of adult female not clearly divided into head, thorax and abdomen, flat, convex, hemispherical or spherical, its outline oval, round or pear-shaped, usually 1-7 mm long. Head fused with prothorax; antennae, eyes and mouth parts on the ventral side. Antennae filiform, 5 to 11 segmented, often reduced. Eyes simple, in the form of small tubercles, situated posterior to antennae, sometimes absent. Mouthparts situated between 1st pair of legs, consisting of clypeus, 1 to 3 segmented labium or proboscis (Russel, 1974) and 4 long sclerotized setae arranged in loops; mouthparts sometimes absent or vestigial.

Thorax often completely fused with head and abdomen, parts of thorax and abdomen sometimes distinctly separate. Legs normally developed, sometimes reduced or absent; tarsi 1 segmented, rarely 2 segmented. Claws simple or with ventral denticle, with 2 (rarely up to 12) pointed or clavate setae at the base. Two pairs of thoracic spiracles; transverse rows of disc-shaped glands often have 3 or more spines at their end, sometimes (in Coccidae) reaching from thoracic spiracles to margin of body. A pair of lip-shaped dorsal glandular organs (circulus) sometimes present on prothorax in Pseudococcidae.

Abdomen usually consisting of 8 distinct segments; abdominal segments V-VIII or IV-VIII of Diaspididae fused, more or less sclerotized and forming one complex segment (the Pygidium); all abdominal segments of Coccidae and Aclerdidae fused with cephalothorax. Anus situated at posterior end of body, often surrounded by a chitinous anal ring with pores and setae, sometimes located at the end of anal tube. Margins of the last abdominal segment sometimes forming anal-lobes with one, rarely several apical setae; in Coccidae and Aclerdidae posterior end of the abdomen with anal-slit; 1 or 2 triangular anal-plates at the base of the anal-slit (dorsal to anus). Genital opening of the female on venter of the body. In Margarodidae and Orthezidae, margin of dorsum of abdomen with 1-8 spiracles. A pair of glandular organs is often present between abdominal terga V and VI in Pseudococcidae; these organs are sometimes present on the venter, usually one between abdominal sterna II and III; in the other cases 2-4 organs are present on the venter. Margin of pygidium of Diaspididae with numerous broad sclerotized processes (lobules); 1-4 pairs of lobules are usually arranged symmetrically at the posterior margin of the pygidium. The median pair of lobules is called the 1st (L_1); the next lobules lateral to L_1 are called

the 2nd pair (L_2). Further pairs are called L_3 and L_4. L_2 and L_3 are sometimes bifurcate. Margin of pygidium at base of L_3 sometimes concave, forming the pygidial-indentation. Elongate seta like or serrated, weakly sclerotized processes (combs) are often present between the lobules and posterior to them at the margin of the pygidium. Some Diaspididae have strongly sclerotized fingerlike cuticular thickening (paraphyses) on the ventral side of the pygidium, at the base of lobules or close to the margin of the pygidium, other Diaspididae possess paired shorter formations (densaria).

Wax-glands of the female numerous, disc-shaped or cylindrical. The disc-shaped glands (pores) are: 1) simple disc-shaped glands with finely granular surface, 2) multicellular-glands with one or several cells in the centre and with a peripheral ring of cells, 3) 5-celled glands with one cell in the centre and 5 peripheral cells, 4) 3-celled glands, 5) paired glands, 6) circumgenital glands (Diaspididae) usually arranged in 4 or 5 groups, around the genital opening. The circumgenital glands are divided into an anterior group, anterolateral and posterolateral groups, the number of glands in each group is not constant in the same species, and is, therefore, indicated by a formula, e.g. 4-7 (5-13) 4-16 or (6-15) 4-10, before the brackets, comes the possible number of glands in the anterior group; if no numbers are given before the bracket, the anterior group is absent; the number of glands in the anterolateral groups is given in the bracket, the number of glands in the posterolateral groups after the bracket. Cylindrical glands of Diaspididae are of the following 2 types: (i) with 2 chitinous rims, short and broad; these are divided into: (a) marginal glands at the margin of the pygidium; (b) dorsal glands on the dorsal side of the pygidium, rarely on other abdominal and thoracic segments; (ii) with one chitinous rim, long and slender on the dorsal side of the pygidium, rarely on its ventral side. They are also found on other abdominal and thoracic segments near the margin of the body.

Cylindrical glands of other families are of the following types: (i) tubular glands, with cylindrical duct and a narrow chitinous rim around the opening (ii) mushroom-shaped glands, also tubular, but with a hemispherical cuticular rim around duct (iii) bottle-shaped glands, with a distally widened cylindrical duct, without chitinous rim around the opening (iv) radiating tubular glands, with a long conical protuberance, often with 1-5 basal spinules. Spines and spinules have the form of blunt or pointed cones or fingerlike processes, which secrete waxy formations. Hairs of varying length,

both on dorsum and venter of body or only on venter. The groups of disc-shaped glands and of spines of many pseudococcidae form the so-called wax-secreting tract (ceraria); the ceraria usually consist of 2 or several conical spines surrounded by disc-shaped glands; in addition, the spines are often surrounded by hairs.

SECRETIONS

Females secrete various waxy formations. Most Coccinea (= Coccoidea) are covered with powdery wax (Margarodidae, Pseudococcidae, Eriococcidae, Coccidae); during oviposition, the females secrete woolly or feltlike ovisacs (Quayyoom, 1980, Weber, 1954) which cover the body partly or completely. The females are sometimes covered with compact (Ortheziidae) or loose (Pseudococcidae) wax-plates or with a layer of hard opaque wax (wax-secreting Coccidae). Females are sometimes covered by a semitransparent horny layer (Coccidae); or by a scale (Diaspididae) which can be easily separated from the body of the insect; the scale consists of 1 or 2 larval exuviae and a layer of secretion. Species with strongly sclerotized dorsum (some Coccidae and Kermococcidae) (= Kermesidae) have no waxy formations, like some species living under leaf sheaths of Gramineae.

MALES

Males with one pair of transparent, irridescent wings with a 1 or 2 branched longitudinal vein; the hind wings are replaced by halteres (hamulo-halteres, (Kawreki, 1965) bearing hamuli, in the form of hooklike setae or scales. Antennae filiform, long, sometimes longer than body, 10 to 30 segmented. Legs well developed; tarsi 1 or 2 segmented. Eyes simple or compound. Mouthparts lacking. Abdomen 7 to 9 segmented; last abdominal segment often with 2 filaments or with a fasicicle of white waxy filaments. Copulatory apparatus sclerotized, protruding as a tubular, sword-shaped process.

GENERATIONS

Most species have 1 or 2 generations per year. Eggs, larvae or females hibernate. Fertility is usually high, e.g., *Parthenolecanium corni* in the Crimea (Nearctic) may lay up to 2780 eggs. Eggs are laid under secretions, in ovisacs or beneath the abdomen (Quayyoom, 1980); the abdomen of many species becomes invaginated during oviposition, while the dorsum becomes strongly

sclerotized, forming a spurious scale which covers the eggs. Eggs oblong oval, 0.25-0.5 long. The egg stage lasts several hours to several months. Some species are, however, viviparous. The 1st instar larvae always have well-developed legs, antennae, eyes and mouth parts. During the first day of life (rarely during the first 3 days) the larvae ("crawlers") crawl about on the plant, searching for a suitable place to feed, during this period they are easily scattered by the wind. At the beginning of the feeding period the females of many species lose the capacity to move for their whole life; females of other species are capable of moving, but mainly on the food plant. The female larvae become adults after 2 or 3 eedyses; the larvae and females of most groups of coccids resemble each other closely. Sexual differentiation takes place after the 1st or 2nd eedysis; the male has 2 additional nymphal stages during which it becomes inactive and does not feed. The metamorphosis of the male takes place beneath the scale (Diaspididae) or in special cocoons. Before becoming adults but still in the larval capsule (cyst) the females of many species of Margarodidae undergo a pause in activity and feeding (diapause) during which new organs are formed and other organs disappear. Parthenogenesis is also very common among Coccidae.

FEEDING

Larvae and adult females feed on branches, stems, roots, rarely fruits and leaves of various trees, shrubs and grasses. A number of species are serious pests of sub-tropical and southern fruit trees and hot-house-plants (Nearctic); many of them are introduced exotic forms; some species cause severe damage of fruit and berry cultures and even decorative plants in the central belt and northern parts of Nearctic. Heavy infestation of stems and twigs may result in death of the sap-transporting part of the bark, which in turn results in desiccation of whole of the branches or whole of the trees. Some Diaspididae cause spot disease of fruits; many Coccinea (= Coccoidea) cause defoliation of evergreen trees. The damage caused by Coccinea in the sub-tropical countries and in hot-houses is increased by the presence of sooty moulds settling on the sweet secretions of the insects.

PRESERVATION

Old, strongly sclerotized females of Coccidae, Kermococcidae and also Diaspididae and Asterolecaniidae should be kept dry together with plant parts on cotton with naphthalene; other species should be kept in 70%

alcohol; part of the collection should be kept dry to preserve the waxy formations.

COCCOIDEA SCALE INSECTS OR COCCOIDS

Adult females are always wingless. All coccoids with legs, have one or two segmented tarsi, each bearing a single claw. The antennae have 1-13 segments. The three main body regions are usually fused. The body and eggs are usually protected by waxy secretions, which may form a scale cover, feltlike sac cottony wax threads, or other covering. First instars or "crawlers" have functional legs and are active. Later instars may be sedentary, without functional legs. Adult males are usually winged, but only the first pair of wings is developed, they have no functional mouthparts.

Development usually takes place through three or more instars in the female and usually four or five in the male. The female metamorphosis is gradual, while males develop with complete metamorphosis involving prepupal and pupal stages. Adult females, their immature stages, and also first and second instar males feed on plant juices by inserting long sucking styles into the host plant. Some coccoids are host specific, others feed on a wide variety of plants. They reproduce parthenogenetically or bisexually, through eggs or by giving birth to young. They usually have one or more yearly generations; rarely, it takes two or more years for a generation to develop. Adult males live usually only 1 or 2 days.

Coccoids contain considerable morphological variation and include highly specialized forms. They are adapted to very diverse ecological habitats and are considered among the most destructive pests of horticultural and silvicultural production. Injury results from the ingestion of plant sap and from the production of honey-dew, which is usually contaminated with sooty mould and impairs photosynthesis. Some coccoids transmit plant diseases. Discolorations and deformations are often produced on infested plants. Some which feed on noxious weeds (for example, cacti), are considered beneficial and are used in biological control. Others have been utilized by humans since ancient times as sources of medicines, dyes, resins, waxes for candles, "pearls" for necklaces, waterproofing substances, cosmetic paints, and so on.

There are 22 families with over 5,000 species recognized in this superfamily, but many new species are discovered yearly. Classification is based primarily on adult female character. Primitive families are included in

Archaeococcoidea, while the more advanced ones are included in Neococcoidea.

ARCHAEOCOCCOIDEA

Primitive Coccoids: Adult females have retained primitive characteristics. They usually have abdominal spiracles, which are often concealed by thick body setae; and usually lack tubular ducts. The apical seta of the labium is absent; the apical sensory organ of the labium is present. Males have multifaceted compound eyes. This superfamily includes 3 families (Ortheziidae, Margarodidae, and Phenacoleachiidae). Distribution is worldwide.

1. Ortheziidae

Ensign Scales: Females have abdominal spiracles. The anal opening is surrounded by a sclerotized anal ring with six long setae and many pores. Disk pores are usually quadrilocular; there are seldom multilocular or clustered pores. The labium is three segmented with 26-36 setae; the first segment is reduced. The antennae are three to eight segmented, with the apex bearing an elongate, thick seta. The eyes are often bulging, set on eyestalks. The legs are usually as long as the body; the tibia and tarsus or trochanter and femur may be fused. There are thick body spines of various shapes, usually species specific, which cover the body in wide bands, often concealing the abdominal spiracles. These spines form a semicircular or crescent-shaped ovisac band that is characteristic of the family.

Females are covered with white wax plates, making them most attractive. Eggs are carried in an ensignlike ovisac made of wax plates, attached to the abdomen. These insects infest and feed on all parts of plants. Many are host specific, others are polyphagous. There are four instars in females, five in males. Most species appear to have more than one yearly generation.

The family is present on all continents, but only introduced species occur in the Australian, Ethiopian and Oriental regions. Worldwide, there are 81 species in 6 genera: there are 4 genera with 31 species in North America. Only a few species are of economic importance, for instance, greenhouse *Orthezia*.

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Ortheziidae			
Orthezia sp	*Amaranthus* sp	Rawalpindi	--

2. Margarodidae and 3. Monophlebidae

Giant Scales: Adult females have abdominal spiracles (two to eight pairs). The anal ring is absent, except for its internal structure; and ring pores are only internally present, setae are absent. In some the anal tube and four thoracic spiracles are well developed. Tubular ducts are absent. Disk pores vary from simple to multilocular. Cicatrices are found as large, pore-like structures; they often appear on the body, surrounded by a chitinized rim. The antennae may be from 6-10 segmented. The beak is seldom absent and is normally one to three segmented, with setae variable in size and number. The legs are five segmented, seldom absent. The tarsus may be divided into two segments, sometimes with numerous claw digitules. The forelegs are sometimes adapted to digging in soil.

During oviposition, white waxy filaments are often produced to cover the body and eggs. Females may be up to 35 mm in length. Males of *Callipappus* (in Australia) have long wax tails and are called "bird of paradise flies." Females have three to five instars; males have four, five, or more. Some species form cysts (ground pearls) during development; these are used as beads in some parts of the world. Nymphs which are encysted may endure several years of quiescence under drought conditions. Biologies in this family are very diverse. Several species are important pests; the best known is the cottony-cushion scale. Some are host specific, but most are polyphagous.

They are distributed in all zoogeographical regions and are most abundant in tropical and subtropical areas. Worldwide, about 250 species in about 50 genera have been described for the family.

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Margarodidae			
Crypticerya sp	*Picea smithiana*	Shogran (Kaghan)	--
Drosicha sp	*Mallotus philippinensis*	Ghari (Kashmir)	--

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(Cont'd)

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
D. mangiferae (Green)	*Acacia modesta*	Rawalpindi	*Sumitus* sp. and *Rodolia funida* Muls
D. stebbingi (Green)	*A. modesta*	Rawalpindi	*Cryptochetum monophlebi* Skuse and *R. funida*
Icerya sp.	*Zizyphus mauritiana* (Kazmi & Ghani, 1963)	Rawalpindi	*Tetrastichus* sp.
I. aegyptiaca (Dougl.)	*Phoenix dactylifera*, *M. alba*, *Erythrina* sp. and *Rosa indica*	Karachi	*Cryptochetum grandicorne* Rondani.
Icerya sp. nr. *seychellarum* (Westwood)	*Olea cuspidata* and *Morus alba* (Alam, 1965)	Saidu Sharif (Swat)	*Tetrastichus* sp.
I. seychellarum (Westwood)	*Cynodon dactylon*	Rawalpindi Lahore Sahiwal and Karachi	*P. coccidivora*
I. pilosa (Green)	*Apluda* sp.	Rawalpindi	*Encarsia* sp. (Kazmi and Ghani, 1963)
Pentissopneumon ferox (Newstead)	*Vicia* sp. *M. azedarach*	Rawalpindi	
P. (Drosichiella) tamarindus (Green)	*Citrus* spp., *Ficus carica*, *Grevillia robusta* and *Musa sapientum* (Rehman and Latif, 1945)	Central and northern regions	--

4. PSEUDOCOCCIDAE

Mealybugs: Adult females usually have ostioles, characteristic trilocular pores, and uninvaginated tubular ducts, sometimes with circuli or cerarii. The antennae are two to nine segmented. The legs are usually five segmented, but are sometimes reduced or lacking. Often, there are translucent pores on the legs, and tarsal claws with digitules and sometimes with a denticle. Spiracles sometimes have associated disk pores and usually have multilocular pores.

The anal ring has six or more setae and one to three rows of pores. The derm is often covered with mealllike waxy powder, thus their common name. The eggs are normally protected by an ovisac of cottony wax threads.

Generally there are four instars in females and five in males. Adult males are enclosed in a cocoonlike sac. Mealybugs infest all parts of plants. Most live in temperate climates, with one generation per year; others, in green-houses or in the tropics, have up to six. They lay eggs or give birth to young.

This is the second largest family of coccoids, with over 1,100 species in about 180 genera. They occur in all zoogeographical regions. Many species are pests on cultivated plants.

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Pseudococcidae			
Idelosoma phragmitidis Borchsenius	*Arundo donax* (Kazmi and Ghani, 1963)	Rawalpindi	*Xanthoencyrtus* sp
Intorsina sp	*Conyza onispus*	Rawalpindi	-
I. graminis (Mask.)	*Chloris gayana*	Sargodha	*Neodusmetia sangwani* Rao (= *Indica burks*)
Centrococcus insolitus (Green)	*Abutilon indicum*	Rawalpindi	*Aphycoideus* sp., *Tetrastichus* sp., and *Hyperaspis maindroni* Sic
Dysmicoccus carens Williams	*S. nitidum*	Rawalpindi Thal (Kohat)	*Anagyrus* sp
Linococcus sp	*Berberis ceratophylla*	Murree	*Aniceetus* sp
Lemisia virgata (CKll.)	*Lantana camara*	Hyderabad and Karachi	*Alenasius advena* Comp
Gen. nr *Planoco-occoides*	*Acer* sp. and *Platanus orientalis*	Peshawar	--
Heterococcus rehi (Lindinger)	*Cyperus rotundus*	Rawalpindi	*Leptomastix* sp

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Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Kuntshenkella sacchari (Green)	*D. bipinnata*	Hyderabad	--
Macronellicoccus hirsutus (Green)	*Cordia* sp	Thatta	*Brumus suturalis* (F.) and *P. coccidivora*
Nesomaryarodes niger (Green)	*C. crispus*	Peshawar	--
Nipaecoccus vastator (Mask.)	*A. modesta*	Rawalpindi	*Anagyrus dactylopii* (How.)
Phenacoccus spp	*Ficus infectoria*	Peshawar	--
Pseudaspidoproctus sp	*C. crispus*	Rawalpindi	*Cryptochetum* sp.
Pseudococcus sp	*Adhatoda vasica*	Abbottabad	--
P. filamentosus (Ckll)	*Citrus* sp	Central region	--
Saccharicoccus sacchari (Ckll.)	*S. officinarum*	Peshawar	*Anagyrus* sp. nr *sacchaicola* Timb
Spilococcus sp	*Citrus* sp	Peshawar	*Tetrastichus* sp

5. COCCIDAE

Soft scales or coccids: Adult females have an anal cleft and, usually, anal plates. The anal ring has pores and may have no setae, or as many as 12. The body appears to be one segmented. The antennae are five to nine segmented. The legs are five segmented. The body may have or lack tubular ducts, it usually has submarginal tubercles with multilocular pores. The posterior spiracles are often larger than the anterior ones; spiracular pores are usually quinquelocular, in rows or bands; spiracular setae usually occur in depressions and are differentiated from marginal setae. The dorsal derm is often heavily sclerotized with age and serves, with the venter, as a protective shield for eggs and nymphs; in other species a cottony ovisac protects the eggs.

Females have three or four instars; males have five. The males develop under a fragile, often translucent, waxy test. Most species in colder climates have one yearly generation; those in warmer climates have two or more. These insects are pests on fruit and ornamental trees, in green-houses, and on house-plants. They reproduce sexually or parthenogenetically; they may lay eggs or give birth to young. The crawlers lack waxy protection and thus are the most susceptible stage to insecticidal treatment. This is the third largest coccoid family.

Worldwide, there are about 1000 species in about 90 genera; in the United States, there are 84 species in 23 genera. The family is distributed in all the zoogeographic areas of the world.

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Coccidae *Ceroplastes* sp	*Ficus* sp	Peshawar	--
C actinformis (Green)	*M indica*	Thatta	*Coccophagus* sp and *Anysis alcocki* (Ashm)
C floridensis Comst	*M. indica*	Karachi & Hyderabad	*Aneristus ceroplastae* and *Tetrastichus* sp
Ceroplastes chiton Green	*F. palmata*	Peshawar	*Aphycus* sp
Coccidae sens Str	*A. modesta*	Rawalpindi	*Tetrastichus* sp.
Coccus sp.	*Cedrela* sp.	Muzaffarabad	*Cocophagus* sp
C discrepens Green	*Bauhinia* sp	Central region	--
C hesperidum L	*Carica papaya*	Karachi, Thatta and Hyderabad	*A. ceroplastae*
C mangiferae Green	*M. indica*	Mirpur Khas	*C longifasciatus*
C viridis Green	*Carissa opaca*	Abbottabad	*A. ceroplastae*
Eriochiton amygdalae Rao	*Cydonia vulgaris*	North western region	--

(Cont'd)

(Cont'd)

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Lulecanium sp. nr *iliae* (L.)	*Cotoneaster nummulana*	Murree Hills	
Lulecanium sp. (a)	*Cedrela toona*	Dewal (Murree Hills)	*B. sencea*
Lulecanium sp. (b)	*Q. dilatata*	Murree	*Microterys chaloostomus* (Dalm.)
Platylecanium sp.	*Pistacia integerrim*	Abbottabad	*Aphycus* sp.
Pulvinaria sp.	*M. sapientum* (Rahman, 1947)	Central and northern regions	--
P. lonalaensis Rao	*M. pumila* and *Pistacia* sp.	North western	--
Kuzopulvinaria sp.	*Amaranthus spinosus*	Peshawar	*A. ceroplastae*
Saissetia sp.	*M. alba*	Changa Manga	--
S. nigra (Nietn.)	*Adhatoda vasica*	Muzaffarabad and Kohala (Kashmir)	*A. ceroplastae*
S. oleae (Bern.)	*Erythrina* sp.	Karachi	*Encyrtus* sp.
Vinsonia stellifera (Westw.)	*M. indica*	Karachi	*A. ceroplastae*

6. ACLERDIDAE

Flat grass scales: The adult female body is unsegmented and flat, with a short and cleft that is partly covered by a single anal plate. The caudal margin has many characteristic ridges and furrows; the ventral margin has tuberculate setae. The antennae are usually reduced to stubs. The legs are absent or vestigial. The spiracles are large, with pores in the atrium. The anal ring is hidden, and has about 10 setae and no pores. The dorsum has simple disk pores. The venter has quinquelocular pores and microtubular ducts. There are slightly invaginated macrotubular ducts on both body surfaces. The body may be naked or covered with wax powder.

The biology of the family is poorly known; apparently there are four female and five male instars. There is one generation yearly in the species

studied; they produce young in a small pouch under the anal opening. Most of their hosts are in the Gramineae; a few are in the Cyperaceae, Orchidaceae, or Combretaceae. These insects usually occur under leaf sheaths.

Worldwide, the family comprises 3 genera *(Aclerda, Nipponaclerda,* and *Rhodesaclerda)* with about 50 species. They are distributed on all continents. Two species which are found on sugarcane are sometimes of minor economic importance.

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Aclerdidae			
Aclerda sp	*Arundinella nepalensis* *A donax*	Murree Hills	

7. DACTYLOPHIDAE

Cochineal scales: Adult females have quinquelocular dorsal pores with a common duct forming sclerotized clusters on the body. Most pore clusters have a central invaginated tubular duct; other disk pores have three or four loculi. There are large dorsal truncate setae; their shape and size are important in species identification. The invaginated tubular ducts usually have a large filament that exceeds the size of the duct. The anal ring is absent or greatly reduced. The labium is very large and distinctly three segmented, with 18 setae. The legs are short and five segmented. The antennae have six or seven short segments.

The female body and the eggs are covered with a white, waxy secretion. These insects feed on *Opuntia* and *Nopalea* cacti only; they are often important in biological control of noxious cacti. *Dactylopius coccus,* a source of red dye, is cultivated in South America. Mexico, and the Canary Islands. There are three instars in females, five in males. These insects lay eggs and some reproduce parthenogenetically; there are three to six yearly generations.

The family is native to the New World, and has been introduced for the control of cactus to Australia, Hawaii, the Senta Cruz Islands (California), and South Africa. The family includes only 1 genera *(Dactylopius)* with 9 species.

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Dactylopiidae			
Dactylopius confusus Ckll	*Opuntia dillenii*	Rawalpindi	*Exochomus flavipes* (Thunb.) var. *nigripennis* Er

8. KERMESIDAE

Gall-like Scales: In adult females, part of the dorsal derm folds ventrally under the body; therefore, the term "tergum" is applied to it, while "sternum" is applied only to the membranous true venter. The tergum of the adult female extends and hardens with age and becomes ball or gall-like, thus unusable for classification. The sternum, during oviposition, forms two brood chambers with a medial partition. A false venter is also formed by the collapsed posterior lobes. Young females usually have six segmented antennae. The legs are small and five segmented. The labium is long and slender, three segmented with 12-14 setae. The spiracles are usually large, with the first pair smaller than the second; both are surrounded by 5 locular and 7 locular pores. The anal lobes have large setae which surrounded the sclerotized anal ring. Mixed disk pores with loculi usually occur in a submarginal band and in spiracular furrows on the ventral side of the tergum. Tergal tubular ducts are of two types. The larger ones, with bulb like expansion, form a wide band submarginally on the ventral side of the tergum; spinescent pores are often present in transverse bands on the dorsal side of the tergum. The smaller, cylindrical ducts with 5 locular and 7 locular pores are scattered on the dorsal side of the tergum. Multilocular disk pores with 10 loculi often occur in groups on the sternum of the abdomen. Multiloculars are also abundant between the vulva and the anus; simple, amorphous ducts are scattered on the tergum. Thick setae occur on the body margin and in the submarginal area; long spinelike setae are situated behind the anal tube. The anal ring is narrow; the anal lobe is wide, with many long setae.

Most species feed on oaks, and a few feed on chinquapin, both in the family Fagaceae. Some produce galls. They often lay 3000-5000 eggs, protected in brood chambers. There is one yearly generation. The first instars overwinter. Males are common. Females have four instars; males have five.

The family (= Kermidae, Kermococcidae) is distributed in the Northern Hemisphere only. It comprises about 68 described species in 4 genera: *Fulbrightia, Kermes, Olliffiella,* and *Physeriococcus.*

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Scale insects	Host Plants	Localities	Natural enemies (Secondary parasites)
Kermesidae			
Kermes sp	*Quercus* sp	Ghora Gali (Murree Hills)	–

9. ERIOCOCCIDAE

Felt Scales: Adult female morphology is very diverse. Normally there are distinctive microtubular ducts and invaginated macrotubular ducts. 5-locular and 7-locular pores and large, thick scale. The number of leg setae is reduced.

Often there are cruciform pores and large, protruding anal lobes. Denticles occur on the claws. There are seldom trilocular, bilocular, or simple pores. These insects lack anal plates, sigmatic setae, or mealybug-typetrilocular pores. The legs are usually five segmented, sometimes reduced. The labium is normally three segmented, with 10-20 setae. The anal ring usually has setae and pores, but sometimes lacks them.

Some species feed on a wide variety of host plants, but many are host-specific. Their biologies are very diverse. They occur in a large variety of habitats, from roots to foliage, often on bark; they may produce galls. Adult females and their eggs are often entirely or partially enclosed in a field sac. There are three instars in females, five in males. Most species have one yearly generation, some have two and a few, perhaps, have more. Most overwinter as eggs or adult females. Males are fairly common, but because they live only for 1 or 2 days they are seldom seen and collected. A few eriococcids have economic importance, for example, European elm scale, azalea bark scale, and Eriococcus coccineus on cactus in green-houses and homes.

Eriococcids are distributed in all major zoogeographical areas except Micronesia. They are most abundant in the Australian Region; very few are found in the Ethiopian Region. Worldwide, about 350 species in about 50 genera have been described in the family.

10. KERRIIDAE

Lac Scales: The adult female is globular or pear-shaped, with a brachial plate pair as extension of the enlarged first thoracic spiracles, and a dorsal spine; both structures are specific to the family. These insects have dorsal, ventral, marginal and sometimes perivulvar duct clusters. The ducts

are invaginated and have filaments in the marginal clusters. Quinquelocular pores are associated with the spiracles. The antennae are one to seven segmented. The legs are vestigial or absent. The labium is one or two segmented, with 10-12 setae. The anal ring has pores and 10 long setae. The anus is located on the anal lobe or tubercle; its base, the anal process or supra-anal plate, is cleft and has a fringe. Males are common. Females have three instars; males apparently have five. Females are "imprisioned" in a secreted resinous test with three apertures: two for the brachial processes, one for the anal process and as an exit for nymphs. The resin produced has a medicinal use in Mexico. It is also used commercially as lac or shellac for varnishes, as sealing wax, and as insulating material in electrical works. Some species are harmful on trees. Commercial production of *Laccifer laccu* for lac is carried on in India, Ceylon and Burma.

Kermidae are distributed in the drier areas of the tropics or the subtropics, except for the Palearctic Region. The family (= Tachardiidae, Lacciferidae) comprises about 65 species in 7 genera.

11. CEROCOCCIDAE

Ornate Pit Scales: The adult female has a shieldlike anal plate and cribriform plates on the abdominal dorsum. There are 8-shaped pores and tubular ducts with a large terminal filament on both surfaces of the body; 8-shaped pores form transverse bands on the abdominal venter. Bilocular pores occur on the head and the thorax; multilocular pores occur in the spiracular furrows and form transverse rows on the abdominal venter. There is a cluster of quinquelocular pores at the base of the antennae. The antennae are reduced to stubs, with setaceous and fleshy setae. The labium is three segmented, with 8-12 setae. The legs, if present, are vestigial. The anal complex includes a plate and a ring with 6-10 setae. Adult males, females, and their eggs are covered by an ornate, waxy, papery test. Males are common.

There are three instars in females, five in males. In the species studied, there is one yearly generation in the United States. The eggs overwinter under the female's test; the adults mature in late July. Worldwide, there are 3 genera (Asterococcus, Cerococcus, and Solenophora) with about 64 species described in the family. Cerococcidae occur in all major zoogeographical regions. Some are host specific; others are polyphagous. They produce pits on twigs and damage fruit and ornamental trees.

Scale insects	Host Plants	Localities	Natural enemies (Secondary parasites)
Cerococcidae*			
Cerococcus hibisci Green	*Hibiscus syriacus*	Karachi	*Muscidea* sp

* The family Cerococcidae is based on the Genus Cerococcus

12.. PHOENICOCCIDAE

Palm Scales: The adult female body is membranous, elongate, or pear-shaped, often with irregular dermal papillae; it is covered by a mass of waxy filaments. There are no anal lobes or multilocular pores; 8-shaped tubular ducts are scattered on the dorsum and often on the venter. Quinquelocular pores are associated with the spiracles. The antennae are reduced and unsegmented, each having an invaginated apex containing five sensory setae. Legs are absent. The labium is one or two segmented, usually with 10 setae. The anus is on the venter. The anal ring is sclerotized, with no setae or up to two, and with no pores. There is no true pygidium, but there is often a semicircular pygidium like terminal lobe. Males are wingless, and the body is not clearly divided into three regions in the red date scale.

Females have three instars; males have five. Most of these insects feed on palms. They are often economic pests, such as the red date scale. They may infest all parts of the plant. They are distributed in the tropical and subtropical areas of the world. There are 2 species in 2 genera (*Phoenicococcus and Xanthophthalma*) included in this family.

13. DIASPIDIDAE

Armored Scales: Adult females possess a wax cover that rests tentlike over the body and is not attached. A pygidium is formed from the posterior abdominal segments, with lobes, plates, or gland spines on the margin, and with disk pores and ducts for wax production. Antennae, eyes and legs are reduced or lacking. The labium is one segmented. The vulva may be surrounded by groups of perivulvar disk pores.

There are three instars in the female, and five in the male. Most economically important species have two or more generations in a year. First generation crawlers usually appear in the spring, second generation in mid-summer. Diaspidids overwinter as eggs, nymphs, or adult females. Adult

males are usually present for about 2 weeks in each generation. The females may lay eggs or give birth to young.

The largest family of coccoids, comprises about 1,500 species in about 350 genera. Its members occur in all zoogeographic regions, but most species are tropical or sub-tropical. They are common and important pests of fruit and forest trees, and ornamental house, and green-house plants. The host plant range is very wide, a diaspidids are adapted to all kinds of ecological habitats.

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Diaspididdae			
Acanthomytilus sp	*A. nepalensis, S. bengalense*	Murree Hills	--
A. sacchari (Hall)	*Neyraudia arundinacea*	Rawalpindi	--
Andaspis sp	*A. modesta*	Thatta and	*Aphytis* sp Karachi
Andaspis kazumiae Williams	*Quercus* sp	Behrain	*P. flexibilis* and *sucholous* sp
Aonidia zizyphi Rahman and Ansari	*Z. mauritiana*	Northern region	--
Aonidiella abietina Hall & Williams	*Abies pindrow*	Murree Hills	*Aphytis* sp.
A. aurantii (Mask.)	*Cannabis sativa*	Peshawar	*Aphytis* sp.
A. citrina (Coq.)	*Ceratonia siliqua*	Northern region	*A. melinus*
A. orientalis (Newat.)	*A. marmelos*	Northern region	*A. melinus*
Aspidiella sacchari	*Anthistria anathera*	Charrapani (Murree Hills)	? *Gen.* nr. *Anabrolepis* sp. of *Apterencyrtus* sp.

(Cont'd)

(Cont'd)

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Aspidiotus sp	*Rhazya stricta*	Peshawar	*P flavibilis*
A destructor Sign	*B variegata*	Central and southern regions, Larkana	*A melinus*
Aulacaspis sp	*Eriantbus filifolius*	Timurgarah (Dir) Swat	--
A discorum Hall and Williams	*Panicum psilopedium* (Hall & Williams, 1962)	Charrapani	--
A tubercularis Newst	*M indica*	Lahore and Karachi	*Aphytis* sp.
Caia quernia Williams	*Quercus* sp (Williams, 1963)	Behrain	*Sticholotis* sp.
Chionaspis chir Green	*Pinus griffithii*	Muzaffarabad	--
C polypora Borchs	Unidentified plant (Alam, 1964)	Shogran	--
Chortinaspis sp	Unidentified grass	Malakand	--
C decorata Ferris	*Apluda* sp.	Murree Hills	--
C fissurella Hall and Williams	*C. stracheyi*	Murree Hills	--
Chrysomphalus ficus (Ashm)	*Citrus* sp.	Central & northern regions	--

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(Cont'd)

Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Cornuaytulus afghanensis (Borchsenius)	*Salix* sp	Muzaffarabad	--
Cryptoparlatoreopsis sp	*Tamarix articulata*	Dargai and Peshawar	*Azotus* sp
C. halli Bod & Theo	*Tamarix articulata*	Chirat	*C. semiflavus*
Diaspis echinocacti Bouche	*Echinocactus echidnae*	Hyderabad	--
Diaspidiotus caucasicus Borchs	*Populus nigra*	Thal	*C. semiflavus*
D. pronorum (Laing)	*Prunus cerasus* *P. persica* (Janjua, 1959)	Western region	--
D. transcaspiensis (Marl.)	*Populus alba*	Quetta	*Anthemus* sp.
Dupiachionaspis sp	*Panicum* sp.	Peshawar	--
Duplaspidiotus tesseratus (Charm.)	*Ligustrum* sp	Karachi	*Cybocephalus* sp.
Fiorinia sp.	*Pinus* sp.	Miandam (Swat)	--
F. distinctissima (Newstead)	*Nerium oleander* (Borchsenius and Williams, 1962)	North western regions	--
F. hederae Hall and Williams	*Convolvulus.* sp	Madyan and Balakot	--

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Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
F. nerifolii Brochs and Williams	*Eriobotrya japonica*	Saidpur	--
F. pakistanensis Ahmad	*Olea cuspidata*	Dewal and Saidu Sharif	*A. curinus* and *P. flexibilis*
Genaparlatoria pseudaspidiotus (Lind.)	*M. indica*	Karachi	*Cybocephalus* sp.
Gen. nr. *filipia*	*Olea* sp.	Phagwari	--
Gen. nr. *palmaricoccus*	*Salim* sp.	Quetta	--
Gen. nr. *parlaspis*	*Carissa opaca*	Saidu Sharif	--
Greenaspis decurvata (Green)	Unidentified grass	Murree Hills	*Aphytis* sp.
Gymnaspis sp.	*Carissa spinarum*	Rawalpindi, Murree Hills and Abbottabad	--
Hemiberlesia lataniae (Sign.)	*N. indicum* and *Erythrina* sp.	Karachi	*Tetrastichus* sp.
Lapazia peshawarensis Rahman and Ansari	*P. bokharensis* and *P. persica* (Rahman, 1947)	Central and northern regions	--
Lepidosaphes conchiformis (Gmelin)	*Reinwardtia trigyna*	Murree Hills	*Aphytis* sp.
L. baluchistanensis Rao	*P. amygdalus* (Janjua, 1959)	Western region	--
L. gloveri Pack	*Citrus* sp. (Rahman, 1947)	Central region	--

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Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
L. pallida Green	*M. indica*	Gujranwala	*Aphytis* sp
L. sp. nr *pallida* Green	Unidentified grass	Batrasi	--
L. pistaceae Arch	*Pistacia integerrima*	Abbottabad	*A. maculicornis*
L. tubulorum Ferris	*Viburnum* sp	Murree Hills	--
Leucaspis coniferarum Hall and Williams	*Pinus griffithii* and *P. roxburghii* (Hall and Williams, 1962)	Shogran, Otrore and Murree Hills	*Aphytis* sp. nov.nr. *aonidiae*
Lindingaspis ferrisi Mckenzie	*L. cumini* and *M. indica*	Lahore and Sahiwal	*A. melinus* and *Derostenus* sp
L. floridana Ferris	*E. cumini* and *M. indica*	Hyderabad and Mirpur Khas	*Aphytis* sp
Lopholeucaspis sp	*F. bengalensis*	Hyderabad	--
L. japonica (Ckll.)	*F. carica*	Mirpur Khas	*Aphytis* sp.
Melanaspis glomerata (Green)	Unidentified plant	Behrain and Miandam	--
M. inopinata (Leon)	*Cedrela* sp.	Murree Hills	--
Nilotaspis halli (Janjua, 1959) Green	Fruit trees	North western region	--
Odonaspis sp	*Panicum* sp	Peshawar	--

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(Cont'd)

Scale insects	Host plants	Localities	Natural enemies (secondary parasites)
Odonaspis sp ? *secreta* Green	*Andropogon pertusus* (Kazimi and Ghani, 1963)	Charrapani	
O penicillata Green	*Bambusa* sp	Peshawar	*Habrolepis* sp.
O secreta Green	*D strictus*	Karachi	--
Parlatoria sp	*Alnus nitida*	Murree Hills	*A. maculicornis*
P blanchardii (Targ)	*Phoenix* dactylifera	Lahore	*Aphytis* sp.
P cinerea Hadden	*Grewia asiatica*	Central and northern regions	--
P orypta Mck	*A. lebbek*	North western region	*A. maculicornis*
P ghani Hall and Williams	*A. modesta* (Hall and Williams, 1962)	Rawalpindi	*A maculicornis, P. coccoidivora*
P oleae (Colvee)	*Adhatoda vasica*	Murree Hills	*C semiflavus*
	Pinus griffithii	Shogran	*C. semiflavus*
	Pongamia glabra	Lyallpur	*C semiflavus*
	P. amygdalus	Abbottabad	*A. maculicornis*
P pseudopyri Kuw.	*Grewia asiatica*	Central region	--
P. ziziphus (Lucas)	*G. sinensis*	Karachi	*Aphytis* sp.
Parlatoreopsis longispinus (Newst)	*C. fistula*	Mianwali	*Aphytis* sp.
Paralepidosaphes ussurienses Borchs	*Alnus nitida*	Murree	--

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Scale insects	Host plants	Localities	Natural enemies (Secondary parasites)
Phenacaspis sp	*Ficus infectoria*	Peshawar	--
P hedyotidis (Green)	*M. philippinensis*	Balakot	–
Pinnaspis sp	*A modesta*	Rawalpindi	
P buxi (Bouche)	*D oleoides*	Parachinar	*Ablerus* sp.
P exercitata (Green)	Fruit trees (Janjua, 1959)	Western region	-
P strachani (Cooley)	*F palmata*	Muzaffarabad	*Aphytis* sp. nov. nr. *citrinus*
Quadraspidiotus sp	*Quercus incana*	Murree	*Anabrolepis zetteratedti* (Westw.)
Q armenicus Borchs	*Salim* sp.	Abbottabad	*Aphytis* sp.
	Salim sp	Gilgit and Mingora	–
Q perniciosus (Comst)	*Cydonia vulgaris*	Parachinar	–
Rhizaspidiotus sp.	*Artemisia* sp.	Parachinar	*Apterencyrtus* sp.
Rhizaspidiotus sp.	*Artemisia* sp	Parachinar	*Apterencyrtus* sp. and *Cybocephalus* sp.
Teminaspidiotus ? sinensis Ferris	*Apluda* sp	Pirowal (Multan)	–
T sinensis Ferris	*Saccharum* sp	Peshawar	Gen. et. sp. indet. (Bothrio-thoracini), *Aphycus* sp. and *Azotus* sp.
	Sporobolus sp.	Hasan Abdal	*Aphycus* sp.

DESCRIPTION OF SELECTED SPECIES

Aonidiella citrina (Coq.)
(Yellow scale)

DIAGNOSTICS

Female Scale: Length 1.64-1.7 mm, breadth 1.51-1.6 mm, thin, more or less circular; slightly convex, yellow because of the yellow female which shows through. Exuviae yellow, central or shifted very slightly to one side.

Female: Length 0.97-1.19 mm, breadth 1.00-1.06 mm, pyriform and whitish yellow in early adult life, becoming strongly reniform and yellow at maturity.

Pygidium with four pairs of lobes; I pair of lobes largest, distinctly separated, disto-lateral margins emarginate, distal margins rounded. II pair of lobes smaller, otherwise similar to the pair. III pair of lobes smaller than II, with lateral margins irregular medially. IV pair of lobes poorly developed, triangular.

Incisurae present, filled with serrated plates: I incisura with two slender plates, which branch profusely distally. II incisura with two plates, outer margins of which are serrated along their distal halves. III incisura with one stout plate, which is deeply bifurcated, each bifurcation being serrated along the distal and lateral margins. IV incisura with three stout plates, each of which is bifurcated apically, each one of the inner bifurcation being slightly serrated and each one of the outer bifurcation being with deeper serrations.

Twelve long, filiform, one-barred,sub-dorsal ducts connected with rows of dorsal pores, disposed of in definite groups; four pairs of paraphyses also present.

Ventrum furnished with one slender, acute inverted V-shaped sclerotized apophyses (Ferris, 1938). Perivulvar pores absent.

This insect resembles *A. aurantii* and can be differentiated from San Jose scale by the characters mentioned under it. It can be differentiated from A. aurantii by the presence of only one narrow inverted V-shaped apophyses.

HOST PLANTS

Citrus spp. and jaman *(Eugenia jambolana)*. The leaves infested with this scale show many yellow spots or streaks where the chlorophyll has been

destroyed; green fruit too may show such spots. Jaman leaves develop red spots.

DISTRIBUTION

Bannu and D. I. Khan in the N.W.F.P. and Faisalabad and Nabha in the Punjab.

Aonidiella aurantii (Mask.)

(California red scale)

DIAGNOSTICS

Female Scale: Length 1.72 mm, breadth 1.65 mm, thin, almost circular, slightly convex, yellowish grey, reddish because of the red female which shows through,exuviae brilliant orange, central.

Female: Length 0.88-1.20 mm, breadth 0.98-1.36 mm, pyriform and yellow in early adult life, becoming strongly reniform and reddish brown at maturity. Cephalo-thoracic region produced posteriorly forming two covergent lobes which enclose the pygidium.

Pygidium with four pairs of lobes: I pair of lobes largest, distinctly separated, disto-lateral margins emarginate, distal margin rounded. II pair smaller, otherwise similar to the I pair; some specimens, however, may have the inner margins entire. III pair smaller than II, their inner margins entire, but outer margins distinctly wavy medially. IV pair very poorly developed, triangular.

Incisurae present, filled with serrated plates; I incisura with two slender plates, which are serrated distally. II incisura with two plates, inner plate with its apex serrated and with a median serration laterally and the outer plate bifurcated apically, furcae serrated. III incisura with two stout plates, the inner one deeply bifurcated distally, each branch being serrated along the outer margin and pointed distally, the outer plate deeply serrated on the apex and along its outer margins. IV incisura with three stout plates deeply bifurcated apically, inner branch being slightly, and the outer branch deeply, serrated.

About 12 long, filiform, one-barred, sub-dorsal ducts connected with rows of dorsal pores, disposed of in definite groups; six pairs of paraphyses or the dorsal club-shaped thickenings are also present.

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Ventrum furnished with three heavily sclerotized bodies, one of which has usually a globular inverted V or U-shaped apophyses. Perivulvar pores absent.

This species resembles San Jose scale in the general appearance of the scale and in the general shape and colour of the body of the female. It differs from San Jose scale in: (1) the female becoming red and strongly reniform in shape at period of gestation, (2) the female pygidium having three well-developed and one very poorly developed pair of lobes, (3) the presence of a group of small scleroses on ventrum, and (4) having six pairs of club-shaped paraphyses.

HOST PLANTS

It is abundant on leaves, bark and fruit of Citrus spp. (chakotra, galgal, grape-fruit, kimb, lemon, malta, oranges, etc.).

It has also been found fairly abundant on *Aegle marmelos, Agave sp., A. variegata, Aloe vera, Alstonia scholaris, Bauninia alba, B. racemosa, Bombax malabaricum, Bronssonctia papyrifera, Canna indica, Cassia fistula, Cassia sp., Cordia mayxa, Diospyros montana, Dombeya acutangula, Eucalyptus sp., Euonymus juponicus, Ficus sp., F. bengalensis, F. elastica, F. religiosa, F. roxburghii, Grevillea robusta, gul-i-fanus (Lagerstroemia indica), Hibiscus sp.,* Jasmine *(Jasminum pubescens* and *J. sambac),* Jaman *(Euginia jambolana), Mangifera indica, Morus alba, Murraya exotica, Musa sapeientum, Nerium odorum, N. oleander, Poinsettia sp., Pongamia glabra, Psidium guyava, Rosa spp., Tecoma spp., Vitis vinifera, Vitis sp. and Zizyphus spp.*

Other workers have found it on the following food plants also, *Agave americana, Aloes* sp., *Camellia thea, Coffea vrabica, Cycas circinalis, C. recurvata* and *Morinda tinctoria* (Ramachandran and Ayyar, 1934).

DISTRIBUTION

Punjab: Ahmadgarh (Malerkotla State), Ambala, Alipur, Campbellpur, Changamanga, Dasua, Gangapur, Gobindgarh (Nabha State), Gujranwala, Gujrat, Gutkar (Mandi State), Jhelum, Jind, Kahuta, Kalka, Kotgarh, Lahore, Lyallpur, Malerkotia, Montgomery, Multan, Muzaffarabad, Nabha, Phagwara, Sangrur (Jind), Sargodha, Sialkot, Taxila, Una.

N.W.F.P.: Bannu, Charsadda, Darband, Darsamand, D.I. Khan, Gardi, Ghoriwala, Jamal-Garhi, Kohat, Mardan, Peshawar, Phulera State, Tarujabba, Thall, Thana and Totkan (Malakand Agency) and Totkas.

It has also been recorded from Ceylon, Coimbatore, Dhamdha, Godavari-Palghat, Pusa, and Someshwaram in South Kanara (Ramachandran and Ayyar, 1934).

Aonidiella orientalis (Newst)

(Oriental yellow scale)

DIAGNOSTICS

Female Scale: Length 1.47-1.64 mm, breadth 1.23-1.64 mm, thick, more or less circular, slightly convex, yellow to yellowish brown. Exuviae orange-yellow to orange-brown, central or situated slightly to one side.

Female: Length 1.04-1.15 mm, breadth 1.01-1.18 mm, ovate, yellowish brown in early adult life, becoming roundish and yellowish brown at maturity.

Pygidium with four pairs of lobes and is retracted into prosoma: I pair of lobes stoutest, distinctly separated, disto-lateral margins emerginate. II pair smaller, otherwise similar to the I pair. III pair smaller than II, their outer margins with an almost median emargination. IV pair poorly developed, squat.

Incisurae present and filled with serrated plates: I incisura with two slender plates, which are distally serrated deeply. II incisura with two plates which are serrated distally. III incisura with three plates, each with a deeply serrated apex. IV incisura with three plates, the median arm of each plate being large and produced posteriorly.

Sub-dorsal ducts, one barred, long, filiform, and confined to the sub-marginal region only where they are disposed of in groups; six pairs of paraphyses also present.

Ventrum furnished with perivulvar pores which are arranged in five groups.

This species resembles San Jose scale in the shape of the scale and in general colour and shape of the body of the female. It can be separated from San Jose scale by the: (1) colour of the scale which is yellow, (2) three pairs of well-developed lobes and one pair of rudimentary lobes (these appear as a point), (3) well-developed and serrated plates the last group of which is club-shaped, and (4) presence of five groups of perivulvar pores.

HOST PLANTS

Acer oblongum, A. pictum, Adhatoda vasica, Aegle marmelos, Agave

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sp., *A. americana, A. variegata, Ailantus aladulosa, Slbizzia* sp., *A. lebbek, Aloe vera, Alpinia nutans, Alstonia* sp., *A. scholaris, Antigonon leptopus, Aristolochia* sp., *Asparagus* sp., *Averrhoa carambola, Barleria cristata, Bassia latifolia, Bauhinia alba, B. purpurea, B. racemosa, B. vahlii, B. variegata,* ber *(Zizyphus sp., Z. jujuba, Z. oenoplia), Bignonia radicans, B. vinusta, Bischofia javanica, Bixineae* sp., *Bombax malabaricum,* borth *(Ficus bengalensis) Boswellia serrata, Bougain vielae mrs butt, Buxus sempervirens, Broussonetia papyrifera, Bursera serrata, Butea frondosa, Cactus* sp., *Caesalpinia bonducella, Canna indica, Callicarpa macrophylla, Calistemon rigidus, Calotropis procera, Carissa carandas, Cassia auriculata, C. fistula,* castor *(Ricinus communis), Codrela toona. Celastrus paniculata, Celtis* sp., *C. australis, Ceratinia siliqua,* chandni *(Calonyction roxburghii), Citrus* spp., *Citharexylum subserratum, Clematis paniculatus, Clerodendron phlomoides, Cordia* sp., *C. myxa, C. obliqua, C. rothii, Crataeva religiosa, Croton tiglium, Cocculus laurifolius, Dalbergia lanceolaria,* dharek *(Melia azadirachta* and *M. composita), Diospyros embryopteris, D. montana,* duranta *(Dyranta ellisi* and *D. plumieri), Ehretia serrata, Eriobotrya japonica* (Japan Medlar), *Erythrina crista galli, Eucalyptus* spp., *Eugenia jambolana, Feronia elephantum, Ficus* sp., *F. elastica, F. infectoria, F. palmata, F. retusa, F. roxburghii,* fig. *(F. carica), Gmelina arborea, Grewia asiatica,* guava *(Psidium guyava*), gular *(Ficus glomerata),* gul-i-fanus *(Lager etroemia indica), Hiptage madablota,* imli *(Tamarindus indica), Inga dulcis, Ipomaea* sp., *Jasminm* sp., *Kigelia pinnata, Lonicera chinensis, Maclura aurantiaca, Magnolia grandiflora, Mallotus philippinensis, Mangifera indica, Melia indica, Minusops elengi, M. kauki, Mirabilis jalapa, Moringa pterygosperma,* mulberry *(Morus sp., M. alba and M. laevigata), Murraya exotica, Musa sapientum, Myrtus communis, Nephelium litchi, Nerium* sp., *Nyctaginacea* sp., *Nyctanthes arbor-tristis,* oak *(Grevillea robusta), Ochna squarrosa, Olerodendron inerme, Opuntia* sp., *Oroxlum indicum, Phoenix* sp., pipal *(Ficus religiosa), Pistacia integerrima, Poinsettia* sp., *Pongamia glabra, Poplar* sp., *Populus alba, Porana paniculata, Pterospermum acerifolium, Punica granatum, Putranjiva roxburghii, Pyrus sinensis, Quisqualis indica, Rhomnus persicus, Rosa* sp., *Salix tetrasperma,* sanatha *(Dodonaea viscosa), Sapindus detergens, Sapinum sebiferum, Saraca indica, shisham (Dalbergia sissoo). Stephegyne parviflora, Sterculia* sp., *S. alata, Swietenia mahagoni, Tabernaemontana coronaria, Tecoma australis, T. stans, T. undulata, Terminalia arjuna, T. belerica, Thunbergia grandiflora, Ulmus* sp., *U.*

integrifolia, Vitex negundo, Vitis vinifera, Wrighta coccinea, zard kaner *(Nerium oleanaer), Zizyphus* sp., and *Z. jujuba.*

Other workers have found it on the following plants: *Anacardium occidentale, Atylosia candollei, Bauhinia* sp., *Calotropis* sp., *Carissa* sp., *Chloxylon swietenia, Cocos nucifera, Dalbergia* sp., *Hygrophylo spinosa, Limonia alata, Manihot glaziovii, Osbeckia* sp., *Punicum* sp., *Polyathia* sp., *Scheleichera trijuga, Solanum* sp., *Solanum melongena, Tephrosia* sp. (Ramachandran and Ayyar, 1934).

DISTRIBUTION

Punjab: Ahmadgarh (Bahawalpur State), Bahawalpur, Bilaspur, Darbhanga, Dera Nawab (Bahawalpur State), Dujana, Hoshiarpur, Jind, Jullundur, Lahore, Lyallpur, Montgomery, Muzaffargarh, Nahar (Dujana State), Nabha, Pataudi, Sangrur, Sufidan (Jind State), and Taxila.

N.W.F P.: Bannu, Nowshera and Thall.

It has also been recorded from Aleppey, Calcutta, Ceylon, Coimbatore, Dhamdha, Guntur, Kistna, Muzaffarpur, Pusa, Rajanagar, and Tinnevelly (Ramachandran and Ayyar, 1934).

Chrysomphalus ficus (Ashmed)

(Red scale of Florida)

DIAGNOSTICS

Female Scale: Length 1.97-2 mm, breadth 1.88 mm, circular of moderately so, slightly convex, rather flat, dark reddish brown. Exuviae crimson or dark orange with brown depositions, central or very slightly to one side.

Female: Length 1.1-1.31 mm, breadth 1.18 mm, ovate and yellowish in early adult life, becoming almost roundish at full maturity. Extremeties of the posterior thoracic margins provided with thoracic tubercles.

Pygidium, broader than long, with three pairs of rather equal lobes; I pair very stout, distinctly separated, their outer margins medially emerginate, and their outer anterior angle with a small sets. II pair similar to the I pair but smaller and with a little deeper emargination, their inner lateral margin usually entire, occasionally slightly notched, the small basal setae being located medially on its base. III pair similar to II pair but smaller. Pygidial

margin lateral to the III pair of lobes, strongly sclerotized with two equidistant emarginations.

Incisurae present, filled with variously fimbriated plates. I incisura with two plates which are serrated distally. II incisura with two plates which are deeply serrated distally. III incisura with one weaker and two stronger plates, all distally serrated. IV incisura with three stout plates, the anterior and the median arm of each plate being large but slender and produced posteriorly.

Sub-dorsal, one barred ducts slender, narrow, arising from about the posterior margin of the abdomen, each connected with three dorsal rows of macropores, which are 12 in the marginal, 18 in the sub-marginal, and about 22 in the sub-median group. Median group composed of 3-4 stout ducts, which arise from macropores betwen I and II pair of lobes and extend up to about the middle of pygidium. 1-2 scattered ducts also met with.

Four dorsal scleroses are transversely placed just near the anterior pygidial margin.

Ventrum with five groups of perivulvar pores, median group usually scattered and never making up a definite group, sometime lacking. Microducts few, present along the margin only.

The scale of this species resembles that of San Jose scale in shape and colour, the females of the two being also identical. It differs from San Jose scale in the following characters: (1) Four pairs of lobes, three pairs being well developed, and the IV pair being represented by a rounded projection, (2) Pygidial plates well developed, and (3) Five groups of perivulvar pores.

HOST PLANTS

Cassia auriculata, C. occidentalis, Citrus sp., *Feronia elephantun, Ficus* sp., and jaman *(Eugenia jambolana).* It has also been recorded from the following plants: Areca *catechu, bamboo, Cocos nucifera, Garcinia indica, Mangifera indica,* Palms, *Pandanus* sp., *Phoenix* sp., *Rhododendron* sp. and *R. arboreum* (Ramachandran and Ayyar, 1934).

DISTRIBUTION

Lahore, Lyallpur, Multan, Sargodha and Sialkot. It has also been recorded from Anantpur, Bombay, Calcutta, Cochin, Coimbatore, Maddur, Mysore, Nilgiris, Penukonda, Poona and Malabar (Ramachandran and Ayyar, 1934).

Quadraspidiotus (= Aspidiotus) perniciosus (Comst.)

DIAGNOSTICS

Female Scale: Length 1.31-1.64 mm, breadth, 1.15-1.31 mm, almost circular, slightly convex, greyish. Exuviae yellowish brown with dark grey mid-dorsal cover, almost circular.

Female: Length 0.91-1.48 mm, breadth 0.75-1.23 mm, ovate or almost circular, yellowish.

Pygidium acute, with three pairs of lobes (Rahman, 1940). I pair of lobes large, strongly sclerotized, deeply notched about midway on the outer margins. II pair of lobes smaller, strongly sclerotized, conspicuously notched on the outer margin. III pair of lobes rudimentary, represented by a triangular projection.

Incisurae furnished with plates. I incisura with a pair of small setaceous plate. II incisura with one setaceous and one narrow plate which is finally serrated dorso-laterally. III incisura with three narrow plates, serrated dorso-laterally. Three low, broad plates lateral of the III lobe.

Dermal sclerotic areas well defined along the margin and sub-median areas.

Sub-dorsal, one-barred, tubular ducts short, narrow, about 24 in number, connected with dorsal circular pores arranged in four definite groups, as well as scattered at random.

Ventrum without perivulvar pores, ventral ducts very few, narrow and short. Pygidial ventral inter-incisural scleroses (densariae) are well developed.

HOST PLANTS

Akik *(Canna indica),* alder *(Kosh: Alnus nepalennis* and *A. nitida),* almond *(Prunus amygdalus),* wild almond *(Prunus* sp.), alubukhara *(Prunus divaricata),* apple *(Pyrus malus),* crab apple *(Pyrus* sp.), apricot (*Prunus armeniaca*), wild apricot *(Prunus* sp.), arghanjo (Parachinar wild plants: *Pyrus* sp. and *Prunus* sp.), bhang *(Cannabis sativa),* chestnut *(Castanea sativa),* cherry *(Cerasus vulgaris),* wild cherry *(Prunus* sp.), hawthorn *(Crutaegus* sp.), lilac *(mahan: Ulmus* sp.), Oak *(Quercus dilatata),* Peach *(Prunus persica),* wild peach *(Prunus* sp.), pear *(Pyrus communis),* wild pear *(shegal, batangi,* etc. *P. pashia),* Plum *(Prunus cummunis),* cherai (Parachinar local plum: *Prunus* sp.), Japan plum *(P. japonica),* wild plum *(Prunus* sp.), quince

(Cydonia vulgaris), siris *(Albizzia lebbek)*, walnut *(Juglans regia)* willow *(Salix* sp.), rose *(Rosa* sp.) and Persian rose *(Rosa* sp.).

The attacked plant becomes greyish in colour and appears scurfy and scabby. The infested fruit develops prominent scarlet circular areas at the point of infestation

DISTRIBUTION

Punjab: Simla Hills; Dagshai, Darora, Dhagi, Dhai, Dhari, Kaithu, Kaliana, Kasauli, Khanog, Kiyar, Kotgarh, Kotkhai, Kufri, Loga, Loshta, Marela, Mashobra, Phagu, Rhoga, Sabathu, Sabathu Cantt., Salogra, Shainhan, Simla, Solan, Summer Hill, Thanadar.

Simla Hill States: Balsan (Balsan State), Balu (Mandi State), Chaku (Koti State), Gutkar (Mandi State), Jhiri (Mandi State), Jogindar Nagar, Jubbal town (Jubbul State), Kiyar (Koti State), Kiyar (Koti State), Kuptu (Koti State), Mandi proper, Nagwain (Mandi State), Rajpura (Chamba State), Sundar Nagar (Suket State), Tandu (Mandi State), Tatal (Madhan State).

Kulu Valley: Ani, Aramgarh, Arsu, Rahu, Bandrol, Bajaura, Banuri, Chowai, Deem, Dhaogi, Dhara, Dhobi, Haripur, Jibi, Jagat Sukh, Katrain, Kulu, Manali, Naggar, Nigali, Ohalpur, Palampur, Pati, Raison, Sharar, Trimli, Urthu.

Gurdaspur District: Dalhousie, Banikhet.

Murree Tehsil: Lower Rewat.

Kashmir Valley: Achhabal, Barmula Harwan, Islamabad, Khanabal, Srinagar.

United Provinces: Saharanpur, Chaubattia (Almorah district), Mussoori (Dehra Dun district).

N.W.F.P.: Peshawar, Hazara district: Abbottabad, Boi (Pattan side), Kakul, Malikpur, Oghi (Agror Valley).

Kurrum Valley: Agra, Alizia, Bilyamin, Gharbina, Kirman, Lukmankhel, Malana, Parachinar, Shalozan, Shingak, Shublan, Sultan, Ziran.

South Waziristan Agency: Wana,

Aspidiotus destructor **Sign.**
Bourbon aspidiotus **Ferris G.F.**

DIAGNOSTICS

Female Scale: Length 0.74 mm, breadth 0.65 mm, very thin, circular, very slightly convex, whitish yellow. Exuviae pale yellow, central.

Female: Length 0.59-0.65 mm, breadth 0.52 mm, ovate, yellowish with pygidium deep yellow.

Pygidium with three pairs of sub-equal lobes. I pair of lobes prominent, well separated, their margins distally emarginate. II pair of lobes emarginate on outer margins only. III pair of lobes similar to II pair but smaller.

Incisurae furnished with long prominent plates. I incisura with two about plates II incisura with two plates. III incisura with three plates, one of which is lacinate. There are six to seven plates beyond the III pair of lobes also.

One-barred dorsal ducts moderately long and narrow, and arranged in four groups

Ventrum with four to five groups of perivulvar pores.

The adult female of this species resembles the adult female of San Jose scale in colouration and shape and in the number of lobes on the pygidium. It differs from it as follows: (1) Scale very thin and parchment-like, (2) Three pairs of well-developed but narrow lobes, (3) About 15 fimbriated plates along each pygidial half, and (4) Perivulvar pores present.

HOST PLANTS

Banana *(Musa sapientum)*, *Bauhinia* sp., *Jasminum* sp., mango *(Mangifera indica)* and *Psidium guyava*. It has also been recorded on *Alocasia* sp., *Camellia thea*, *Calotropis* sp., *Carissa* sp., *Citrus* sp., *Cocos nucifera*, *Eugenia* sp., *E. jambolana*, *Gelonium lanceolatum*, *Loranthus* sp., *Maesa indica*, *Musa paradisiaca*, *Piper nigrum*, *Phoenix* sp., *P. dactylifera*, *Psychotria* sp., *Ricinus communis*, *rubber*, *Solanum melongena*, *Tamarindus indica* (Ramachandran and Ayyar, 1934).

DISTRIBUTION

Amritsar, Jind, Lahore, Lyallpur, Multan, Muzaffargarh, Pataudi, Sufidan and Sangrur (Jind State) in the Punjab and Bannu and Dera Ismail Khan in the N.W.F.P. It has also been recorded from Anantpur, Bombay, Bengal, Ceylon, Coimbatore, Gujrat, Kumbalenguna, Laccadives, Malabar, Mundanthurai, Mysore, Nilgiris, Pusa, South Canara, Tinnevelly and Wynad (Ramachandran and Ayyar, 1934).

Aonidia zizyphi (Rahman and Ansari)

DIAGNOSTICS

Puparium of female 1.1-1.2 mm long, 0.9-1.1 mm broad, whitish grey, almost circular, convex dorsally. Exuviae yellow to dark orange, slightly towards the margin.

The first skin 0.28-0.39 mm long, 0.26-0.37 mm broad, orange yellow; antennae five jointed, a little longer than the space between them, last segment a little longer than the other four taken together, I pair of lobes of the pygidium widely separated, tridentate apically and prominently notched on their outer margins. II pair of lobes tooth-like, III pair of lobes inconspicuous.

The second skin 0.88-1.2 mm long, 0.8-1.1 mm broad, almost circular and covers the female completely: I pair of lobes of the pygidium prominent, slightly dentate apically and prominently notched on their outer margins; II pair of lobes triangular; III pair of lobes small but easily made out; pygidial margin beyond the II pair of lobes provided with eight glandular spines, fimbriated plates absent. Dorsal ducts very small, confined to the margins only.

Adult female almost circular, yellowish to reddish brown, enclosed in a puparium, 0.65 mm long and 0.73 mm broad, with no lateral projections. Prosoma with no lateral ducts, abdominal segments with gland spines and lateral gland ducts. Antennal segment situated just behind the frontal margin, is bidentate, and has a long bristle; spiracles as in other species, but the I pair with three parastigmatic pores, which are arranged in the form of a triangle.

Pygidium without perivulvar pores; I pair of lobes fairly well developed, basally convergent and apically divergent, disto-lateral margin emarginate, II pair of lobes small, triangular and without emargination. Pygidial margin lateral of II pair of lobes, distinctly irregular, fringed with eight setae. Pectinae or plates are entirely wanting. Anal orifice small, quite near the median lobes. Dorsal pores marginal, sub-dorsal ducts very few, small, slender, and thread-like.

HOLOTYPES

Female puparia from Bannu (Nartahal Ram) on *Zizyphus jujuba,* in the Entomological Laboratory, Punjab Agricultural College, Lyallpur.

This species resembles *Aonidia shastae* (Coleman) (Ferris, 1938) from

which it is separated by the absence of fimbriated plates on the pygidial margin.

The scale of this species resembles San Jose scale in its form and colour, specially when II stage puparium is exposed. The female differs from that of San Jose scale in the: (1) absence of serrated plates, (2) dorsal ducts being very short and distributed along the margins only, and (3) presence of two pairs of lobes on the pygidium.

DISTRIBUTION

Bannu, Ghoriwala, Nar Sabat Shah (Bannu), Nartahal Ram (Bannu) and Nurar Road.

HOST PLANT

Zizyphus jujuba.

Parlatoria oleae (Colv.) *Olive parlatoria* Ferris G.F.

DIAGNOSTICS

Female Scale: Length 1.23-1.64 mm, breadth 1.06-1.31 mm, ovate or slightly round, convex, whitish grey to pale grey. Exuviae yellowish brown, apical.

Female: Length 0.69-0.85 mm, breadth 0.57-0.65 mm, ovate, whitish yellow to yellowish brown, excepting pygidial centre which is pinkish yellow.

Pygidium with four pairs of lobes: I pair of lobes well developed and distinctly separated, outer margins alone deeply notched. II and III pairs slightly smaller than the I pair, otherwise similar to it. IV pair very small, ill-defined, triangular.

Incisurae furnished with broad plates: I incisura with a pair of very short, narrow plates, the distal margins of which are poorly bifurcated. II incisura with two slightly stronger, narrower plates with at least three distal furcae. III incisura with three similar plates, but broader than the preceding ones. IV incisura with 4 plates, sub-sequal, irregularly furcated on the distal margins. Three plates beyond IV incisura, slightly different in depth of dentation: four to five plates succeeding these are bluntly dentate and tuberculate.

Sub-dorsal, two-barred ducts numerous, broader and smaller. Margina ducts broader and smaller and opening in very heavily sclerotized semi-lunar

oral scleroses. The comparatively smaller, distributed along lateral margins of the abdominal segments only.

Ventrum with three groups of glandular tubercles on thorax: five groups of perivulvar pores. Micro-ducts few, small, disposed off along the margins of the abdominal region.

This species resembles the San Jose scale in the colour of the scale which is surrounded by a reddish inflammed area. It differs from the San Jose scale as follows. (1) Four pairs of lobes (three well developed, 4th ill-defined), (2) About 18 plates on each pygidial half, (3) Five groups of perivulvar pores, and (4) Sub-dorsal ducts two-barred and numerous.

HOST PLANTS

Crab apple *(Pyrus* sp.), apple *(Pyrus malus*, apricot *(Prunus armeniaca)*, arghanju (Parachinar wild plant: *Prunus* sp.), *Caragana ambigua*, dharek *(Melia composita)*, gui-i-fanus *(Lagerstroemia* sp.), hari *(Prunus* sp.), *Jasminum sambac*, *J. pubescens*, kaint *(Pyrus* sp.), Kaner *(Nerium odorum and N. oleander)*, kosh *(Alnus nepalensis* and *A. nitida)*, loghuna (Parachinar wild plant), loquat *(Eriobotrya japonica)*, *Mangifera indica*, *Melia azadirachta*, nim *(Melia indica)*, olive *(Olea europaea)*, peach *(Prunus persica)*, wild pear *(Pyrus pashia)*, pear *(Pyrus communis)*, Persimmon *(Diospyros kaki)*, plum *(Prunus communis)*, taklu and wang (Parachinar local plants) and *Zizyphus jujuba*. It has also been recorded as *P. calianthina* B & L on *Michelia* sp. (Ramachandran and Ayyar, 1934).

DISTRIBUTION

Punjab: Ahmadgarh (Bahawalpur State), Aleo (Nabha State), Arazi (Kahuta Tehsil), Bahawalpur, Balao (Theog State), Bansragali (Murree), Barian (Murree), Bhagali (Banjar), Bhanuri, Bilaspur, Chabiana (Bahawalpur State), Charhan (Murree), Chattar (Murree), Dera Nawab (Bahawalpur State), Dharampur (Simla), Dharamsala, Dhami, Dujana, Ghoragali (Murree), Gurdaspur, Jind, Jullundur, Junga (Keonthal State), Kalka, Katrain, Kherpur (Bahawalpur), Kiyar (Koti State), Kumarsain, Lahoru, Luan (Kumarsain), Lyallpur, Malerkotla, Mashobra (Simla), Masot (Murree), Mukerian, Mul Bhaji (Bhaji State), Nabha, Narkanda (Kumarsain State), Palampur, Parola (Theog State), Patandi, Raison, Rawalpindi, Rewat (Murree), Sabathu (Simla), Saidpur, Sambli (Murree), Sanawar, Shali (Theog State), Simla, Sowl, Topa (Murree).

N.W.F.P.: Bannu, Boorki (Parachinar), Dadar (Hazara), Darsamand, Ghoriwala (Bannu), Hangu tehsil, Jandota (S. Waziristan), Kasar Fatehkhel, Lookmankhel, Lora village, Lundicak, Mirjamal, Mistakhel, Paharpur, Parachinar, Shablan (Parachinar), Shingok, Wana and Ziran (Parachinar). It has also been recorded from Central India, Madras and Pusa (Ramachandran and Ayyar, 1934).

Parlatoria pseudopyri (**Kuwana**)

DIAGNOSTICS

Female Scale: Length 1.64-1.8 mm, breadth 1.15-1.45 mm, oval, convex whitish grey to dark grey. Exuviae pale yellow and apical.

Female: Length 0.82-1.00 mm, breadth 0.71-0.82 mm, pyriform translucent, yellowish pale, pygidium being deeper yellow.

Pygidium with four pairs of lobes: I pair of lobes stoutest, well separated, deeply notched on both sides. II pair smaller and narrower than I, deeply notched only on the outer margin. III pair similar to II pair, but smaller. IV pair rudimentary, without notches.

Incisurae furnished with broad serrated plates: I incisura with two narrow spine like plates which are distally serrated. II incisura similar to the I incisura. III incisura with one seta like and two serrated plates. IV incisura with two strong and broad, distally truncate plates and one narrow, setaceous plate. About 16 broad and strong plates beyond, all of them more or less similar in form but different in size and degree of dentation.

Sub-dorsal two-barred ducts small, scattered, quite numerous in the sub-marginal region of the pygidium. Marginal ducts broader, opening in heavily sclerotized semi-lunar scleroses; sub-marginal ducts narrower and smaller.

Ventrum with two groups of glandular tubercles on the thoracic region and one such group near the perivulvar pores. Four groups of perivulvar pores are present. Micro-ducts very few or obsolete.

This species closely resembles *P. olea* (Colv.). For characters by which it resembles San Jose scale as well as those by which it differs from it see under *P. olea* (Colv.).

It is recorded for the first time from India. We believe it to be present in all places where rose is grown. At Lyallpur there was very heavy infestation on rose in 1937-38. An unidentified chalcid parasite and a coccinellid *(Thea bisoctonotata* Mul.) checked it very successfully at Lyallpur.

HOST PLANTS

Almond *(Prunus amygdalus)*, apple *(Pyrus malus)*, bael *(Aegle marmelos)*, *Bauchinia* sp., *B. alba*, *B. purpurea*, *B. vahlii*, *B. variegata*, *Boswellia serrata*, *Buxus sempervirens*, *Buddleia mapagascamensis*, *Calotropis procera*, chandni *(Calonyction roxburghii)* *Cestrum nocturnum*, *Celastrus paniculata*, *Croton tiglium*, *Cryptostegia grandiflora*, *Cocculus laurifolius*, dharek *(Melia* sp. and *M. azadirachta)*, *Ebenacea* sp., *Eugenia jambolana*, *Euonymus japonicus*, *Flacourtia sapida*, gul-i-fanus *(Layerstroemia indica)*, *Haematoxylon campachianum*, *Hamelia patens*, *Hibiscus mutabilis*, *H. rosa-sinensis*, *H. tiliaceus*, *Hypericum cernum*, Jagan booti (Bahawalpur local plant), junga (A parachinar shrub), jasmine *(Jasminum arborescens*, *J. humile*, *J. pubescene* and *J. sambac)*, kaner (red and white flowers: *Nerium odorum* and *N. oleander)*, *Lonicera chinensis*, lasura *(Cordia myxa*, *C. obliqua and C. rothii)*, loquat *(Eriobotrya japonica)*, mango *(Mangifera indica)*, *Myrtus communis*, *Nandia domestica*, *Nephelium litchi*, nim *(Melia indica)*, *Nyctanthes arbortristis*, *Ochna squarrosa*, Phalsa *(Grewia asiatica)*, pipal *(Ficus religiosa)*, *Prunus divaricata*, *Prunus persica*, *Prunus communis*, *Pyrus sinensis*, *Rhamnus persicus*, *Rosa* spp., *Rubus fruticosus*, *Spirae corymbosa*, *Tabernaemontana coronaria*, *Urena lobota*, *Vitis sp.*, *Woodfordia floribunda* and *Zizyphus* sp.

Tabernaemontana coronaria, *Urena lobota*, *Vitis sp.*, *Woodfordia floribunda* and *Zizyphus* sp.

DISTRIBUTION

Punjab: Amritsar, Bahawalpur, Bannu, Bahakkar, Dera Nawab (Bahawalpur State), Dujana, Gobindgarh, Jind, Kalka, Kherpur (Bahawalpur State), Lahore, Lyallpur, Malerkotla, Muzaffargarh, Multan, Pataudi, Rawalpindi, Sangrur (Jind State) and Taxila.

N.W.F.P.: Bannu, Darsamand, D.I. Khan (Musazai and Bilot) Serai Narang, Shabqaddar and Wana.

Lapazia peshawaresis (Rahman and Ansari)

DIAGNOSTICS

Puparium of female 0.82-1.18 mm long, 0.36-0.51 mm broad, elongate, whitish grey to yellowish grey, convex, excepting apical third which is flattened. Larval pellicles terminal, reddish brown, covering at least half of the scale.

The first skin 0.29-0.38 mm long, 0.16-0.19 mm broad, yellowish red; antennae six jointed, proximal joint longer and setaceous; I pair of lobes of the pygidium squat, widely separated; II pair of lobes vestigial; pygidial margin furnished with two prominent spurs.

The second skin 0.59-0.74 mm long, 0.25-0.41 mm broad. I pair of lobes of the pygidium wider than long, notched at the apex, widely separated, II pairs of lobes smaller, triangular. Margin of the pygidium with four spur-like prominences; each spur with a setaceous plate below it and a fifth plate inner to the lobe of the pygidium. Six to eight marginal two-barred ducts present.

Adult female 0.59-0.64 mm long, 0.21-0.33 mm broad, elongate, fusiform, translucent white or slightly yellowish, pygidium always deeper yellow. Prosoma provided with a few lateral ducts throughout; abdominal segments clear; gland spines absent, glandular ducts present along the lateral margins. Antennae situated midway between the front and the mouth parts with a blunt tooth above and two stout setae below. Mouthparts normal, spiracles without parastigmatic pores.

Pygidium with two lobes: I pair well defined, broader than long, their lateral margins straight, and apical margins rounded and slightly notched at end. II pair smaller, dentate. Margin of pygidium with four spur-like prominences, each bearing an oval pore; plates reduced, simple and spine-like, each with a micro-duct at its base.

I incisura with two setaceous plates. II incisura with one plate, one plate at the base of each glandular spur and two on abdominal segments. Two-barred sub-dorsal ducts somewhat irregularly distributed on metathoracic and abdominal segments, except on pygidium, where they are arranged roughly in marginal, sub-marginal and sub-median groups. Marginal ducts comparatively broader, sub-marginal and sub-median ducts varying generally from two to three and always arranged in a definite pattern. Anal opening just near the anterior pygidial margin. Vaginal opening almost central. Ventrum with very fragile micro-ducts which are not easily discernable. Perivulvar pores absent.

The leaves attacked by this species develop greyish patches, tender shoots begin to dry up from their tips downwards.

It produces red spots on fruits, closely resembling those caused by San Jose scale. It differs from San Jose scale in the following features: (1) Scale elongate, (2) Adult female fusiform, (3) Two pairs of pygidial lobes, (4) spur-like pygidial prominences, (5) Plates reduced and spine-like and (6) Dorsal ducts two-barred.

HOLOTYPE

Female puparia from Taru Jabba (Peshawar) on peaches, in the Entomological Laboratory, Punjab Agricultural College, Lyallpur.

This species was placed in the genus *Pinnaspis* by Dr. Takshashi, but the authors differ from him because this genus includes those species which have strongly zygotic median lobes, and five groups of perivulvar pores: *Lapazia peshawarensis* does not possess these characters. Ferris (1937) described only one species of this genus and *Lapazia peshawarensis* does not resemble it.

HOST PLANTS

Plum *(Prunus communis)* and peach *(Prunus persica)*..

DISTRIBUTION

Bannu, Charsadda, Darsamand, D.I. Khan, Malana, Mardan, Parachinar, Paharpur, South Waziristan (Sarwaki, Tanai and Wana), Taru Jabba and Thall.

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Chapter 21

FRUIT FLIES AND THEIR CONTROL

Ch. Mohammad Mahmud Khan*

INTRODUCTION

Fruit flies of the Tephritidae family are important pests of crops every where except the arctic and antarctic regions of the world. This family of flies has received different names in the past, i.e., Trypetidae and Trypaneidae. On the basis of priority of application, the name Tephritidae, (Kapoor, 1972) was preferred. Most of the species are bred in different kinds of fruits, that is why they are commonly known as fruit flies. More than 4,000 species of this family which occur throughout the temperate, sub-Tropical and Tropical areas have been described to date (Christenson and Foot, 1960). So far, 798 species from the orient and 310 from the Indo-Pakistan sub-continent have been reported. Out of 26 species of fruit flies recorded from Pakistan, four were mentioned to be endemic (Kapoor, *et al.*, 1980), Figure 1.

Fruits and vegetables are important sources of food, nutrition and income. With severe infestations of fruit flies, the quality as well as the commercial value of these crops is affected. In fact their attack poses a very serious constraint for increased quality production of crops.

The important fruit flies which cause heavy losses to fruits and vegetables are the Oriental fly, *Dacus dorsalis* Hendel; peach fruit fly, *D. zonatus* (Saunders); melon fruit fly, *D. cucurbitae* Coq: Ethiopian melon fly, *D. ciliatus* Loew, Balochistan fly, *Myiopardalis pardalina* Bigot and ber fruit fly, *Carpomyia vesuviana* Cost.

In view of day to day needs of research workers, students, extension agents and farmers, an account of fruit flies regarding their identification, biology, host plants, nature and extent of damage is presented in the following pages, which is expected to prove useful. Particularly, the

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management strategies when adopted by the farmers can reduce ravages of these insect pests.

TAXONOMY

A lot of taxonomic work is under way on these flies in other countries while in Pakistan this group is largely neglected. Moreover, work relating to the identification of common fruit flies is not available at one place. Therefore, easy keys have been provided for separation of the common species.

COLLECTION: Fruit fly adults can be collected by insect net or by baiting. These should be immediately pinned and kept in the insect storing box. The specimens reared from infested vegetables and fruits must be kept alive at least for 4 days and fed on 25% honey from a cotton swab. The freshly emerged adults are soft bodied and their wings are folded. They must be given time to expand their wings, harden their bodies and to develop colour so that it may be possible to identify them.

The specimens when preserved wet, must be kept in 70% alcohol. All specimens whether pinned or preserved in alcohol should carry appropriate label indicating name of the collector, host, locality, date etc,

To study the taxonomic characters more clearly it is always desirable to take dry specimens. The specimens preserved in alcohol can be mounted on pins employing the technique of Sabrosky (1966).

IDENTIFICATION: The identification of the species involves many characters but here only the important ones are given.

The family characters are: presence of lower orbital bristles (Figure 2); subcosta bent forward at approximately right angle and fading out before reaching costa (Figure 4).

IMPORTANT CHARACTERS

Head (Figure 2), cheeks broad or narrow, face with or without brown or black spots of variable shape. Antennae short or long; 1st and 2nd segments usually short, 3rd slightly or distinctly longer than broad and rounded or pointed apically. Bristles used at lower taxonomic level.

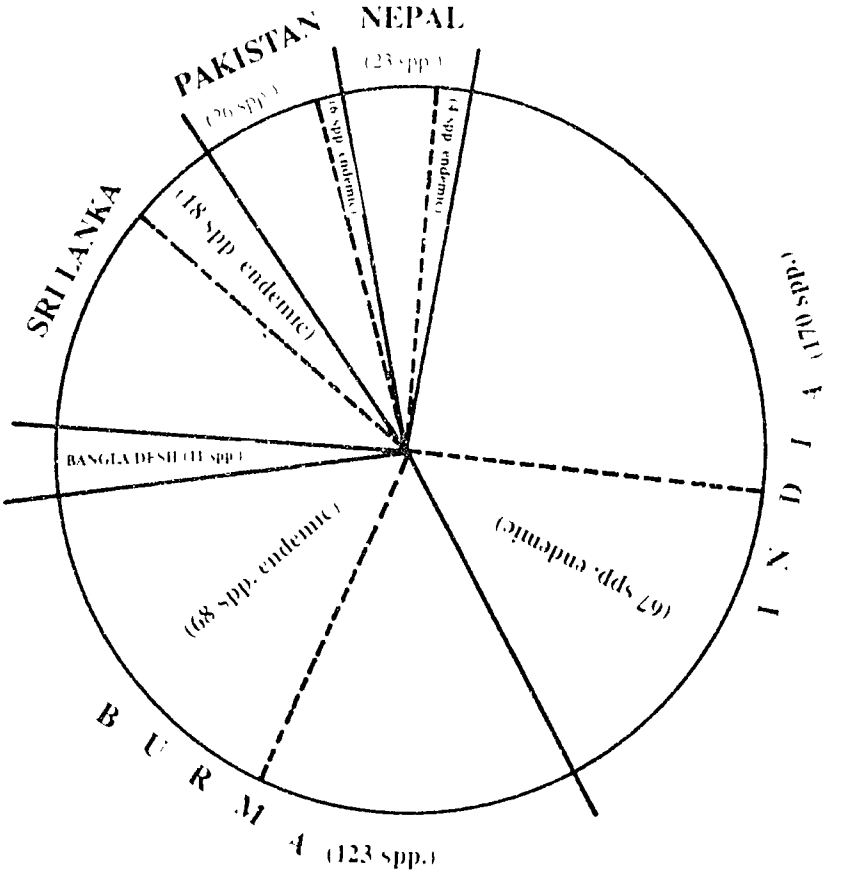

Figure 1. Relative occurrence of the fruit fly species in the Indo-Pakistan sub-continent, endemism is also shown (Kapoor, et al., 1980)

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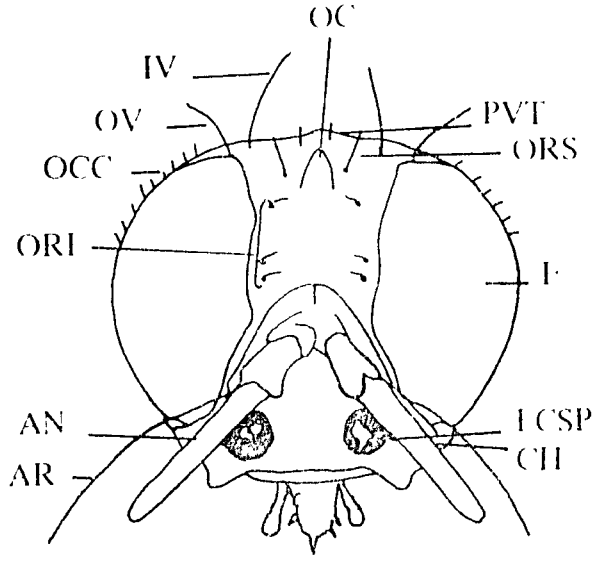

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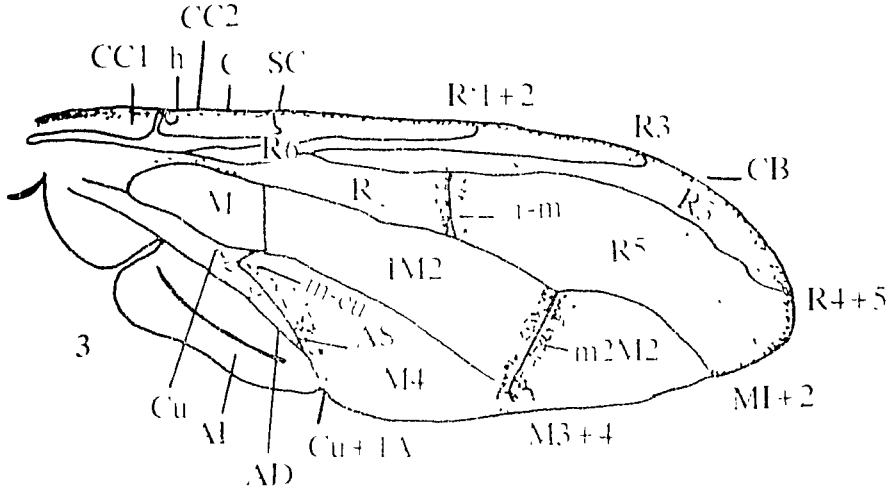

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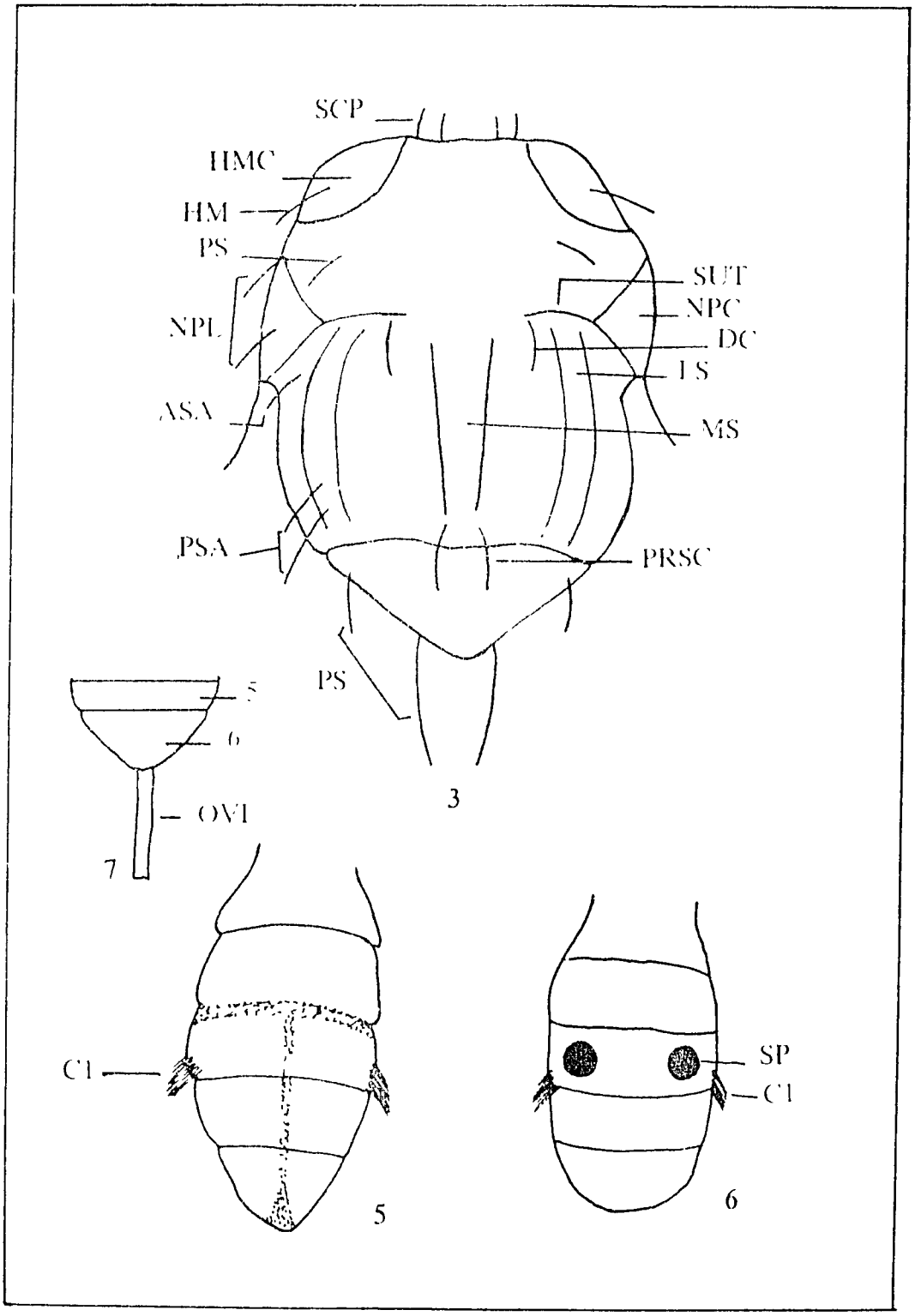
Figures 2-7 Important characters of fruit flies identification (After Kapoor et al 1980)

ABBREVIATIONS

AD Apical dilation of cell Cu, Al - Axillary lobe, An Antenna, AR - Arista
As Anal stripe, ASA Anterior supra-alar bristle


SCP
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C1
5
SP
C1
6

Thorax (Figure 3). Dusty or dustless, with or without pubescence; bristles constitute important taxonomic characters. The anterior supra-alar bristle inconspicuous, present on the side on the dorsum, a little in front of the root of the wings. Spots on the thorax also offerd important identification characters. A yellow lateral stripe present on either side on the dorsum behind the suture and, sometimes a median one is also present; the scutellum is usually pale yellow sometimes provided with dark spots.

Abdomen (Figure 5). Dusty or dustless with or without pubescence; cylindrical or petiolated. The tergites may be free or fused; when free, each tergite overlaps the preceeding one and when "fused" (Figure 6) they are united firmly along their adjacent margins. Third tergite ciliated or non-ciliated. Ovipositor short or long (Figure 7).

Wings: Hyaline except the costal margin which may be narrow or broad, ending between R_{4+5} and M_{1+2} (Figure 4), apically the costal band may be broadly dilated; sometimes the costal band is very narrow and ends at or near R_1 and in this case a small isolated dark spot usually present covering vein R_{4+5} at both ends. Anal stripe is narrow, wide or absent; pale, black or brown; extending from the cubital cell to the point of dilation of the cell may also be absent, the wings may be banded or reticulate i.e., dark ground colour with numerous rounded small hyaline spots.

A dark pale, brown, or black, narrow stripe may cover the cross-vein 'm' or r + m, also dark spot sometimes present in between the cell 'M' and base of the radial sector.

DACINAE

The fruit flies belonging to the sub-family Dacinae are serious pests of fruits and vegetables and occur throughout this sub-continent. This sub-family is usually represented by three genera, of which *Dacus* Fb. is the most important.

The members of this group are of medium to large size; brown, ferrugineous, pale-yellow, or black in colour. Chaetotaxy being reduced, the enlarged 2nd basal cell in the wing is used for separating the species.

SEPARATION OF SPECIES

(A) Size large; scutellar bristles 2 or 4; costal band broad and anal stripe well developed.

(a-1) Three pairs of lower orbital bristles and one pair of scutellar bristles; costal band broadly dilated at the apex; hind cross-veins thickly margined with brown.....*cucurbitae* (Coquilett)

(a-2) Two pairs of lower orbitals and two pairs of scutellar bristles; costal band thick, nearly of equal thickness throughout, hind cross veins not margined....*tau* (Walker) = *hageni*

(B) Size small to medium; scutellar bristles always 2; costal band narrow or incomplete; anal stripe narrow or absent.

(b-1) Tergites fused and look like a hemispherical capsule; anterior supra-alar bristles absent; oval black spot present on either side of 3rd tergite.. ..... *ciliatus* (Loew)

(b-2) Tergites free; anterior supra-alars present; oval spots not present on 3rd tergite.

(C) Costal band narrow, nearly of equal width up to the end; anal stripe narrow.

(c-1) Thorax greenish black, also with a yellow middle stripe; male without cilia on 3rd abdominal tergite; ovipositor very long and thin (Figure 6)..... *diversus* (Coquillett)

(c-2) Thorax ferrugineous, without yellow middle stripe; male with cilia on 3rd abdominal tergite; ovipositor short and thick..... .....*dorsalis* (Hendel)

(D) Costal band incomplete with an isolated spot at the end of the wing; anal stripe absent; pleural region with usual yellow markings.

(d-1) Body yellowish-red, facial spots rounded and always distinctly isolated; in female, ovipositor red but with black end; pale yellow band on third tergite..... *zonatus* (Saunders)

(d-2) Body blackish-brown, facial spots very close to each other or more or less joined in the middle to form a transverse band; ovipositor red ..... *correctus* (Bezzi)

TRYPETINAE

Chaetotaxy complete; wing with dark cross bands or spots, sometimes with hyaline incisions but never reticulate; 2nd basal cell small, 6th abdominal tergum shorter than 5th in the female, scapular bristles present.

Myiopardalis pardalina Bigot and *Carpomyia vesuviana* Costa are the most important and common species of this sub-family. The former is a serious pest of melons, while the latter is a serious pest of ber. These can be easily identified as below:

Cheeks narrow, ocellar bristles absent; no median black line on thorax, two oval spots, very much approximated to each other, present posteriorly on scutellum; basal part of wing from cubital cell to one-third of 2nd costal cell black ..... *C. vesuviana*

Cheeks broad; ocellar bristles present; median longitudinal line on thorax present; only one medio-posterior axe-shaped spot with semi-circular posterior margin on scutellum; 1st costal cell and basal part of 1st basal cell hyaline ..... *M. pardalina*

TEPHRITIDAE

Chaetotaxy complete; wing reticulate; 2nd basal cell small; 6th abdominal tergum as long as the 5th or longer, scapular bristles usually absent.

In this sub-family one species, *Acanthiophilus helianthi* Rossi is widely distributed in India. It is a serious pest of flower heads of the plants belonging to the family Compositae especially sunflower and safflowers. This species can be easily distinguished by the following characters:

Black; 3rd antennal segment pointed at the end; frons brownish-yellow, about 1.5 times as long as broad; bristles black except yellow occipitals; thorax and abdomen with grey pubescence; dorso-central bristles just behind suture; wings hyaline except outer half tending to become reticulate and with rays apically (more distinct in females); ovipositor very long, basal three-fourth part provided with white hairs.

BIONOMICS AND BIOLOGY

Dacus (Strumeta) dorsalis Hendel

This species has been treated in Indo-Pakistan literature under the name *Dacus ferrugineus* (Fabricius). Dr. D.E. Hardy of the University of Hawaii has, however, pointed out that the name *ferrugineus* is pre-occupied and is not available for this species. He has discussed this in detail in his paper titled "Taxonomy and Distribution of the Oriental Fruit Fly and Related Species."

DISTRIBUTION

In Pakistan this fly is popularly known as the mango fruit fly and the oriental fruit fly elsewhere. It is widely distributed throughout Pakistan (Figure 8). This species is rapidly assuming the status of a major pest in the countries where it is present. Outside Pakistan, it has been recorded from Sri Lanka, Burma, Siama, Java, Malaya, Mauritius, Philippines, East Indies, Amboina, China, Formosa, Taiwan, Bonin Islands, Australia and Hawaii. In Hawaii the fly was first recorded in 1946. It has lately assumed a serious form and has displaced the Mediterranean fruit fly which was so far the major species.

HOST PLANTS

The fly attacks a wide variety of fruits and vegetables such as mango, guava, loquat, apricot, plum, peach, pear, wild fig, cultivated fig, persimmon, banana, alu-bukhara, pomergranate, chiku, ber, sweet lime, malta orange, santra, pomelo, sour orange, galgal, orange, chillies, brinjal and ripe bael.

It may be pointed out that the indices of infestation vary in these particular fruits and is influenced by the maturity of same. Some of the hosts serve ovipositional sites only.

In the case of hard fruits as walnuts and coconut, the female oviposits into the mesocarp of the fruit when they are tender. But the development and growth of fibrous tissue in these fruits retards the growth of developing larvae and causes their death.

NATURE OF DAMAGE

This species causes severe damage to fruits and vegetables. Indeed the external damage varies from host to host. The pattern of the damage inside the pulp is more or less similar. As the orchard grower and the scientists will be interested in the external symptoms of the damage caused by this fly each fruit has been dealt with separately and the way damage is caused has been described in detail. The adult female lays eggs just below the epidermis or sometimes a little deeper in the pulp. The insertion of the ovipositor causes wounds on the fruit or vegetables in the form of punctures, which appear like dark spots on the fruits. In freshly punctured specimens, the fluid that exudes collects in the form of a droplet which later dries up and appears like brown resinous deposit. In other fruits such as pineapple, wild yeasts collect at the point of incision and fermentation of the fruit results. As soon as the eggs

hatch the maggots bore their way to the interior, destroy and convert the pulp into a bad smelling, discoloured semi-liquid mass totally unfair for human consumption or even for cattle. The fruit develops a brown rotten patch and falls on the ground. The nature of damage caused to different fruits is briefly described below:

Guava: The guava, which is widely grown in plains is a very popular fruit-famous for its delicious flavour. The attack by the fly is observed in orchards in the beginning of July and continues uninterruptedly throughout the season where the climatic conditions are equable as in the subtropical south, or till the extreme cold sets in about the middle of November in the north when the fly hibernates in the pupal stage. The attacked fruit has on its surface a small round depressed area in which there is a clear dark greenish puncture about the size of the sharp end of a pin. The damage to guavas is generally at its peak during mid-July to September when the hard fruits as well as those that are ripe are heavily infested. Over 12 punctures have been counted on one medium sized fruit. The fruit falls only when it is over-ripe. A fairly hard fruit seldom falls during the winter. It generally dries up on the tree. The harvest of the summer crop of guava is generally completed by the middle of October. The winter crop goes on gradually ripening and provides an excellent medium in which the flies continue to breed. Often the fly punctures different parts of the fruit but does not lay eggs at all, or lays eggs only in a few of the punctures where it finds the pulp soft. Those punctures where eggs are not laid are known as pseudo-punctures and though the fruit may be quite healthy and palatable, the commercial value of the crop is often reduced because of the discolouration. The larvae, when full-fed, bore their way out of the fruit, sometimes through as many as four exits and fall to the ground where they pupate. In the case of small hard fruits, the larvae develop rather slowly as the fruit ripens. Later the rind becomes dry and hard. In such exceptional cases, the larvae pupate inside the fruit but in doing so most of them perish. Occasionally, however, some flies are able to emerge from such fruits when through some accident the hard fruit splits or organisms of decay cause decomposition of the fruit.

Loquat: Mostly, this fruit is grown in the North Punjab, and Haripur district of N.W.F.P. The fruit begins to ripe in March-April and it is almost immediately attacked by the fly. The puncture made by the fly is dark and is clearly visible against the deep yellowish background. The juice starts trickling just after the attack. The fruit does not fall but remains in situ till it has completely dried up. The season for the fruit is over by the middle of

Localities of occurrence:

1 = *D. zonatus*
2 = *D. cucurbitae*
3 = *D. dorsalis*
4. *D. pardalina*
5. - *D. diversus*

Figure 8. Map of Pakistan
Distribution of Fruit Flies

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May, but the fly continues to breed in the undersized and over-ripe loquat which remain unpicked on the tree till the end of May.

Appricot: This widely popular fruit is grown in north-western parts of country and in Balochistan. The area is bound to increase as years pass, in the Swat hills. The attack by the fly appears on the fruit in the form of a dark coloured puncture which is quite conspicuous against the yellow or light greenish white background of the fruit. The maggots feed in the pulp of the fruit, as a result of which the pulp begins to rot. The damage is often heavy. The fruit drops on the ground. The period of attack by the fly lasts from May in the plains up to the last week of July in the hills.

Plum: The cultivation of plum is confined to areas where apricot and other deciduous fruits grow at an elevation of about 600 to 2,000 metres. The plum is attacked only if the fly is unable to find any other fruit like loquat, apricot, peach, etc., in the field. The damage caused to it by the fly is negligible. The fly begins to lay eggs from the second week of May up to the end of June in the plains and up to July in the hills. The juicy as well as the pulpy varieties are attacked. In juicy fruits, the fluid comes out of the punctures and it is often difficult to locate the young maggots. Many perish in the fluid and only a few reach the maturity. In pulpy varieties, a brown patch of hardened tissue is visible. The affected fruits eventually drop down.

Peach: The peach is a well-known deciduous fruit famous for its rating excellence and canning qualities. The fruit fly puncture is not so very conspicuous in this fruit due to the soft hairy pubescence on the skin. The fruit is attacked when it is immature. If the freshly attacked fruit is slightly pressed a dirty brown fluid oozes out from the point of puncture. With the growth of maggots inside, a brown soft rotten patch becomes visible on the surface of the fruit. This is soon followed by the dropping of the peach. The damage is often extensive as well as intensive. Early ripening varieties of peach are attacked in June-July. Late ripening varieties are attacked in August.

Pear: The pear is mostly grown in the hills but some of the harder varieties are grown in the plains also. The fly attacks the fruit in July when it is very hard and raw, and the attack is continued right up to the month of October, only in places where guava fruit does not grow; otherwise the fly migrates to guava orchards where the fruit is attacked as soon as it begins to ripen. As in the previous cases a clear dark puncture is visible on the surface of the fruit. As the maggots feed towards the core, the fruit begins to rot. A

shiny drop of fluid oozes out when the fly punctures an unripe fruit, and as the maggot begins feeding inside, a gummy brown fluid is observed oozing out from the point of puncture. The fruit fall is gradual in the case of under-ripe fruit, but it quickens in the case of ripened fruit.

Wild Fig: The wild fig is attacked during the month of June in areas where fruits mentioned earlier are not grown. The fruit is attacked when ripe. As the maggots feed inside, the fruit rots. The fully-grown maggots escape in the soil for pupation and the fruit dries up in the tree.

Cultivated Figs: Cultivated varieties of figs are grown in small areas in some parts of Balochistan. They are attacked by the fly when the fruit is fully ripe. The latex of the under-ripe fruit is not conducive to the growth and development of the larvae. When the fruit is under-ripe the eggs are inserted through the calyx. In the calyx there is less latex and the maggots bore directly into the pulpy mass of the fruit. This is an ingenious method of getting over the injurious effect of the latex of the unripe fruit. Dark brown gummy exudate oozes out of the puncture caused by the ovipositor of the fly. The figs are attacked from the second week of July to the end of November.

Mango: The mango is rightly called the king of fruits in Indo-Pakistan, and is the only fruit that the poor as well as the rich equally enjoy. The dark puncture caused by the oviposition of the fly in mango is not conspicuous as its colour blends with the dark green colour of the fruit. It is, however, visible on some pale brown varieties which are attacked first when they begin to ripe. After the maggots have fed on the pulp of the fruit for a few days, a brown rotten patch appears on the fruit surface. The mesocarp also becomes dirty brown in the region the maggots feed. The fruit eventually falls and the maggots emerge to pupate in the soil. The fruit is attacked from June to August. The damage caused is often times heavy.

Apple: The apple is grown in the hilly regions especially in north-western parts of Pakistan, Murree hills, Azad Kashmir and Quetta valley. Generally, this fruit is not attacked by the fly, but during the years of severe outbreak even this is not spared. A dark puncture appears on the fruit which, later on, develops into a brown hard patch as the maggots feed and grow in size. It is attacked in August-September.

Persimmon: In this fruit the dark puncture made by the fly is very prominent against the reddish background of the fruit. Rot sets in and the fluid oozes out of the ripe fruit as the maggots feed inside. The fruit does not fall unless fully decayed. It is attacked in the month of October.

Banana: The banana when under-ripe is seldom attacked. This fruit is attacked by flies during the months of August-September.

Pomegranate: The pomegranate is grown throughout Pakistan. The rind is too thick and strong for the fly to thrust its ovipositor in, but eggs are deposited through the natural cracks which are very common in this fruit in the months of September and October. The fruit is spoiled and emits a nasty smell after infestation.

Quince: The quince is grown in the hills of Balochistan. It is attacked only when it has developed a pale green colour which is the symptom of ripening in October. The dark puncture is clearly visible then. The maggots riddle the core and render the pulp unfit for consumption. As soon as the maggots feed and develop, the fruit begins to fall to the ground.

Citrus Fruits: Many species of citrus are attacked by the fly, namely sweet lime *(Citrus limetta)*, Malta orange *(Citrus sinensis)*, santra *(Citrus reticulata)*, pomelo *(Citrus grandis)*, sour orange *(Citrus aurantium)* and galgal *(Citrus medica)*. The sweet lime is attacked when still green, which causes it to turn orange prematurely and thus the dark puncture is easily visible against the orange background. Except in sweet lime and malta orange, the maggots in the rest of the fruits perish soon after hatching in fruits with thick rind. It is only when the eggs have been laid near the pulp that the maggots survive. In sweet lime and sometimes in malta orange the eggs are laid directly in the pulp. The fruit begins to fall slowly after the eggs have been laid. The maggots that hatch out from these eggs eventually develop into adult flies. Circular and depressed almond brown patch is visible on the surface of the fruit as a symptom of attack when the maggots feed inside. Citrus fruits are attacked from October to December.

Percentage damage to guava, mango, plum, pear, apricot, peach and loquat fruits have been reported to be 100%, 100%, 54%, 52%, 48%, 14% and 10% respectively (Syed, *et al.*, 1970).

BIONOMICS

Janjua and Chaudhry (1964) have published the bionomics and biology of this pest under the name *D. ferrugineus* Fab. The salients are as under:

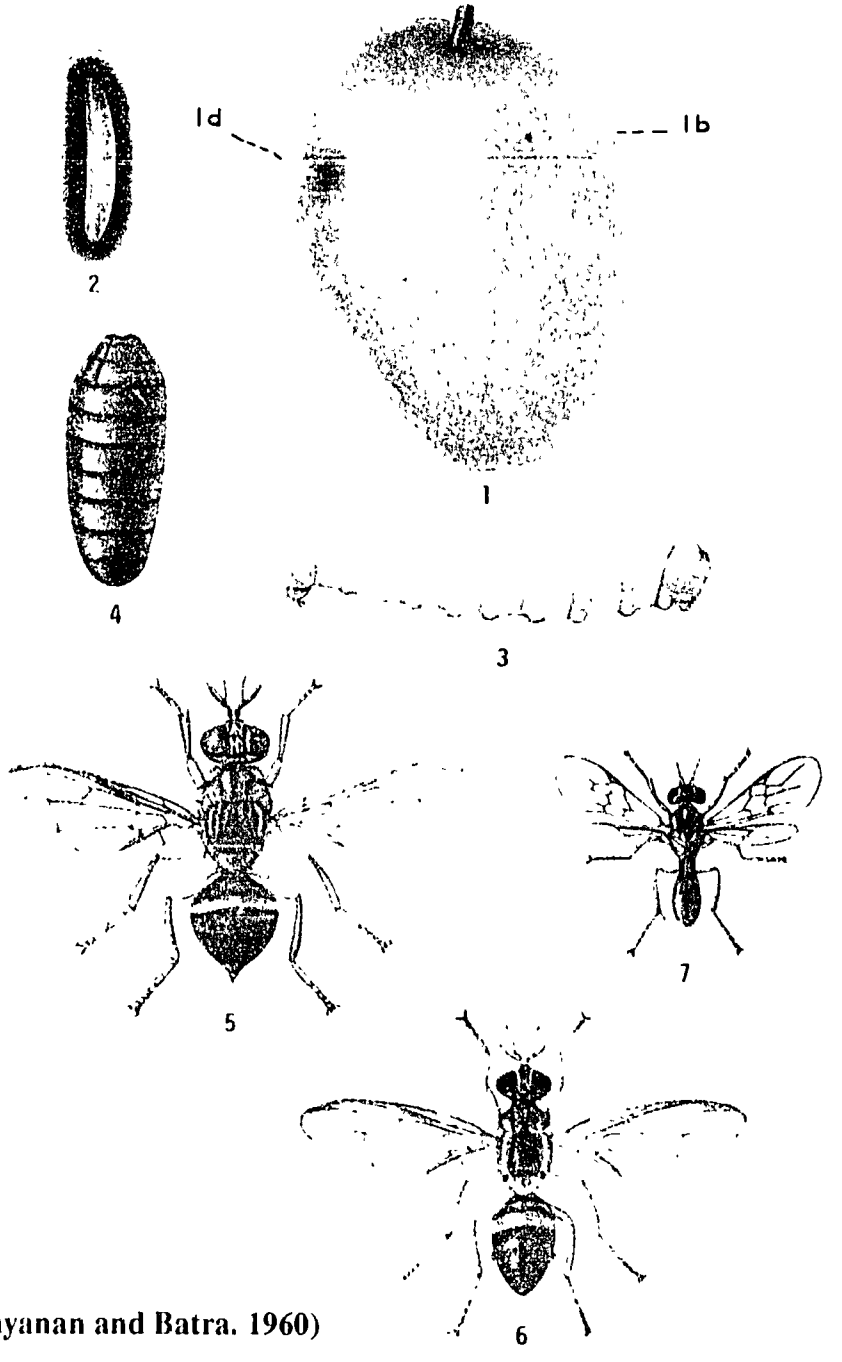
The fly has been observed to be active in the field almost throughout the year where the weather is equable. In places where there is a clear-cut winter it enters into hibernation in the pupal stage from the first week of November up to about the beginning of April in the plains and

June in the hills. If, however, the season is early or late, the hibernation may end even in March or May as the case may be. The flies are observed flying about in orchards and kitchen gardens where the fruits are grown. They are most active at temperatures ranging between 25-30°C and become inactive below 20°C. In the beginning of the summer the damage caused by the fly is not severe but soon several broods complete their life cycle in quick succession, the population increase and the intensity of attack as well as the damage increase proportionately. There are a large number of deciduous fruits that grow and ripen throughout the summer for the flies to feed and breed upon. In March, guava abounds, while the period between April and May is passed in loquat, apricot and plum. June is passed in peach, wild fig and brinjal. June is a month of fruit scarcity in many places. About this time the fly resorts to breeding in brinjal. Owing to drought, shortage and un-suitability of this host material, the population of the pest in its immature stages is dropped. The adults, however, successfully survive and tide over this period by feeding on the honey-dew of the aphids infesting brinjal. July is passed in mango, peach and pear. The peak of attack is reached from August to October when the shortest duration of its life cycle from egg to adult is about a fortnight, which is, generally, four to six times this period in colder months. During this period the flies mostly breed in guava but may be found in pear, fig, quince, apple, persimmon, citrus and ripe banana also. In winter, i.e., from November onwards, the host supply runs short and, therefore, the damage to individual fruits is rather severe. The number of maggots in a single fruit is then the maximum. In November when the seasonal conditions do not force the flies to hibernate as pupae they breed in late pear, quince, winter guava and citrus fruits that may be growing in the smaller areas. Guava and citrus are the main hosts in the winter months. The broods of flies generally overlap. The adults are long-lived and may live for four months in the field. They are observed hovering about the orchards for a fortnight to three weeks after the fruits have ripened and have been picked. They also do this in presence of fruits. As the summer passes into winter, the flies gather in numbers under the leaves in the evening and rest there during night. In the morning, they may continue to rest even upto 12 noon until the temperature warms up. Slightest disturbance is enough to warm them of the approaching danger and they quickly fly away if it is sunny and warm. The flies are

active and agile but can be easily collected by hand in a tube when in the act of oviposition on the fruit or resting on under-surface of the leaf. Infested fruits normally show one puncture but when the intensity of attack is high and the number of fruits left on the tree is small, one fruit may contain as many as a dozen punctures. In the act of oviposition, the flies lay a few eggs in fruit like loquat which have less pulp than mango, etc., where the pulp is hard, the flies merely make pseudopunctures like those often found in the guava. Due to pressure of population the flies oviposit and develop in such unnatural hosts as cotton bolls. It has also been observed that the fruits of common ornamental palm serve as an alternate host. The population goes down from December onwards and thereafter the pest is observed only in its immature stages till the beginning of summer. The maggots are able to mature in strongly acidic fruits but prefer those with 3.5 pH. There is heavy mortality, viz., up to 60 per cent or even more, in the pupal stage during the winter months. With the beginning of spring, however, the flies are able to build up their population and become a menace again.

LIFE HISTORY

Mating between the adult flies takes place at about dusk and lasts for about an hour or more. The pre-oviposition period is two to five days but it may range from ten to fifteen days or longer in varying conditions of climate and diet. The female fly lays eggs in small clusters just underneath the skin of the fruit, 1-4 mm deep in the rind. Tactile bristles on the ovipositor assist the fly to discriminate between hard and soft surfaces for oviposition. As soon as a suitable spot on the fruit is located it bends its abdomen at a right angle to the long axis of the body and moves the distal needle-like structure of the ovipositor and the proximal tube deeper and deeper until it disappears entirely and the eggs are then deposited. After the act of oviposition the ovipositor is withdrawn leaving a puncture behind (Plate 1, Figure 1). The complete act of oviposition takes above five minutes. Each cluster may contain 2 to 15 eggs (one egg is shown: Plate 1, Figure 2) depending upon the texture and quantity of the pulp available in each kind of fruit. On an average about 50 eggs are laid, but under favourable conditions a single fly may lay as many as 150-200 eggs, in about one month. The incubation period of the eggs is 2-3 days during March and April and 24-36 hours throughout the summer months. It may be prolonged up to ten days in winter.



(Narayanan and Batra. 1960)

Dacus dorsalis **Hendel**

1. **Mango showing puncture caused at the time of oviposition 1a and the rotten patch developed afterwards 1b, 2. Egg (x 24). 3. Full-fed maggot (x9), 4. Pupa (x 9). 5. Female fly (x 6). 6. Male fly (x 6). 7. Braconid parasite (x 6).**

The young larva is white, translucent and measures 1.5 mm x 0.3 mm. The full-grown larva is 8 to 9 mm long and 1.5 mm broad across the posterior end (Plate 1, Figure 3). The larva is yellowish in colour due to the accumulation of reserve material in the form of fats, etc., and is hence opaque. The head of the cephalic segment is pointed anteriorly and trapezoidal in outline. It bears on its dorsal surface two antennal protuberances and the maxillary palps. Red stigmata which constitute the posterior spiracles are very conspicuous and are present on the last abdominal segment. A pair of anterior spiracles is, however, borne by the first thoracic segment. Normally a fruit may contain a dozen maggots but in the case of shortage of host fruit, one fruit may have ten times this number. The larval period lasts from 6 to 29 days depending upon the period of the year. The shortest period of six days was worked out during September and the longest period in the last week of December and the first three weeks of January. In April it was 12 days. The fully developed larva (only third instar) has a habit of jumping a short distance (three to four inches) to find a suitable place for pupation. The pre-pupal period ranges from 18 hours in summer to two days in winter. The pupa (Plate 1, Figure 4) is cylindrical in shape and is 4-5 mm long and 2 mm broad. The colour varies from dull deep reddish yellow to ochraceous. Under-fed pupae are straw-coloured and measure on an average 4.25 mm x 1.25 mm. The internal transformation in such pupae hardly takes place in the normal way and even if the fly emerges it is small and weak and succumbs to the slightest adversity in its biotic struggle. There are 11 distinct segments, the last segment being a little more prominent. The anterior spiracles are much darker but similar to those of the larva. The posterior spiracles are situated below the mid-horizontal line and are yellowish in colour. Each spiracle has three small but relatively broad openings. The pupal period lasts from 6 to 44 days. Pupation normally takes place three to seven inches below the soil surface. Pupae kept at a constant temperature of 33°C and varying humidities of 20, 45, 65 and 85 per cent showed that no development took place where the humidity was the lowest. At a humidity of 85 per cent the flies had formed and some of them broke open the pupal case but the adults died, before they could extricate themselves. Exposure of the adult flies to the above constant temperature and humidities revealed that the adults died within 24 hours in all the humidities except 85 per cent in which they lived for three days. Low humidity and high temperature of 33°C are fatal to the pupae and adults. The

temperature at which this species remains active is from 21°C to 22°C, mean annual temperature (Anon., 1986).

Even at low temperature of 10°C adverse effects are reported. The well-developed adult is stout and a little bigger than the ordinary house fly and measures 14 mm across the wings and 7 mm, in maximum length. The male fly (Plate 1, Figure 6), is slightly smaller in size than the female. The female (Plate 1, Figure 5) has a tapering abdomen which ends in a pointed ovipositor. The fly is brown or dark brown in general colour, with hyaline wings and yellow legs. The thorax is *ferrugineus* and brownish black with varying patterns.

Dacus (Strumeta) zonatus (Saunders)

The species *Dacus zonatus* (Saunders) is next to *D. dorsalis* Hendel in respect of the severity of damage that it causes in the orchards. It has been more often recovered from the peach fruit and, therefore, it is rightly called the peach fruit fly.

DISTRIBUTION

It has a wide distribution in the Punjab, Frontier Province and Balochistan (Figure 8). It also occurs in Sri Lanka and Egypt.

HOST PLANTS

In Pakistan, a variety of fruits are attacked by this species. Recorded cases are peach, mango, fig, guava, chiko, ber, citrus, brinjal and sharifa, pomegranate, apple and pear.

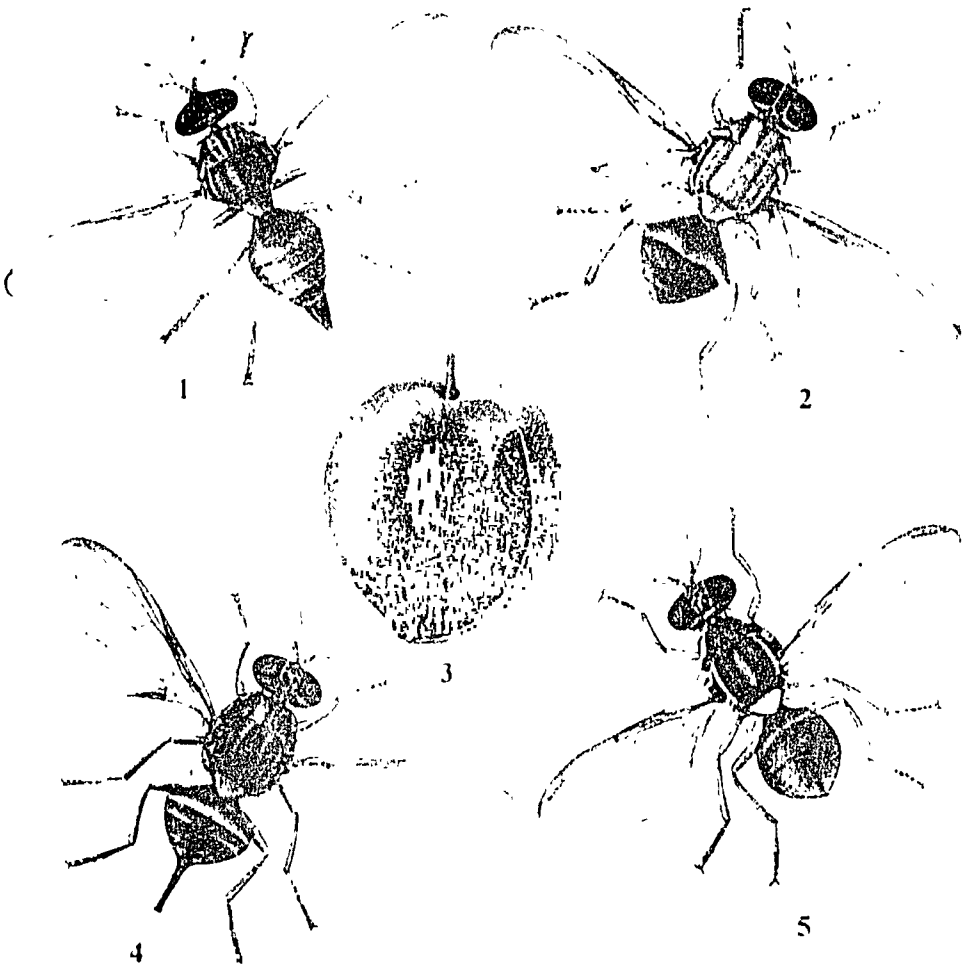
NATURE OF DAMAGE

The light dark coloured puncture, the characteristic oozing of fluid, the rotting of the fruit (Plate II, Figure 3) and its eventual fall are the usual symptoms. In case of this species, percentage damage to guava and mango have been reported to be 100 per cent and 70 per cent, respectively (Syed *et al,* 1970).

BIONOMICS

The adult flies (Plate II, Figures 1 and 2) remain active throughout the year except for a short period in winter, from the beginning of January to the

PLATE NO-II

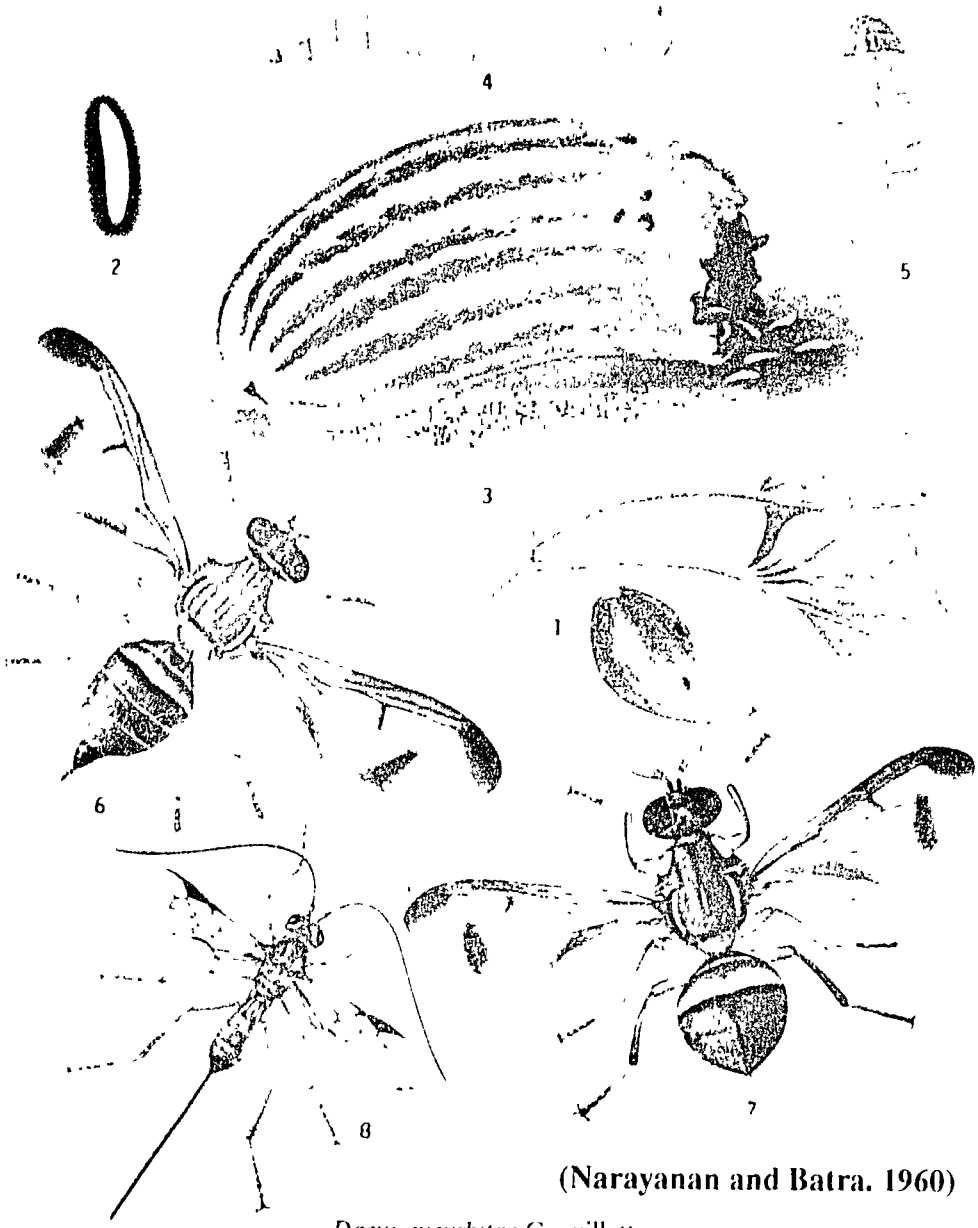


(Narayanan and Batra. 1960)

Dacus zonatus Saunders and *Dacus diversus* Coquillette

1. **Female of** *Dacus zonatus* **(x 9). 2. Male of** *Dacus zonatus* **(x9). 3. Damaged peach with the maggots in situ (natural size). 4. Female of** *Dacus diversus* **(x9). 5. Male of** *Dacus diversus* **(x9).**

PLATE NO-III



(Narayanan and Batra. 1960)

Dacus cucurbitae Coquillett

1. Tender snap melon showing the resinous deposit over the puncture caused after oviposition (natural size). 2. Egg (x18). 3. Damaged melon fruit with the maggots (natural size). 4. Full-fed maggot (x9). 5. Pupa (x9). 6. Female (x9). 7. Male (x9). 8. Braconid parasite *Opius fletcheri* Silvestri.

end of February. The pest over-winters mostly in the pupal stage. The flies have been observed under bushes during the winter months. In spring the fly becomes active earlier and breeds in ber *(Zizyphus jujuba)* which is common then. Later on, it causes damage to loouat and peach fruits in May and June. In the later months it breeds in cucurbit vegetables which are then plentiful. Months of monsoon are passed in mango and gradually the damage is observed in guava, pomegranate, citrus, etc., in the post-monsoon period. The pest is very active during the rainy months in summer when the population of the fly is at its peak.

LIFE HISTORY

The life history of this species bears some resemblance to *D. dorsalis* already described in detail. It is active throughout the year except for a short period from January to the middle of March. The pre-oviposition period is about 20 days and the female has been observed to lay about 137 eggs in her lifetime. The eggs are laid under the rind of the fruit in clusters of two to nine. The fully-developed larva falls on the ground and pupates in the soil. This species have been reported to be active at a mean annual temperature from 15.5°C to 36.1°C. At low temperature of 10°C adverse effects were observed (Anon, 1986).

Dacus (Strumeta) cucurbitae Coquillett

Dacus cucurbitae Coquillett is commonly known as the melon fly (Plate III, Figures 6 and 7). It attackes a large variety of cucurbits, other vegetables and occasionally fruits. Its native home is considered to be the Oriental region, probably Indo-Pakistan or south-east Asia.

DISTRIBUTION

The fly is distributed throughout Pakistan, (Figure 8). It has been also recorded from Nepal, Sri Lanka, India, Burma, Siam, Malaya States, Java, China, Philippines, Hawaiian Islands, Australia and East Africa.

HOST PLANTS

The hosts of this fly are pumpkin, cucumber, musk melon, snap melon, long melon, wild cucurbit, water melon, squash melon, bottle gourd,bitter

gourd, sponge gourd, snake gourd, tomato, brinjal, chilli, papaya, guava, peach, date and citrus.

NATURE OF DAMAGE

Where the fly laid her eggs in certain fruits, a thin but profuse watery fluid oozes out which later is transformed into a brown resinous deposit. The larvae that hatch out from the egg bore into the pulpy tissue through what are termed larval galleries. The fruit subsequently rots (Plate III, Figure 3). The young infested fruits of bitter gourd *(Momordica charantia)*, sponge gourd *(Luffa acutangula)*, parval *(Trichosanthes dioica)* snape melon *(Cucumis melo* var. *momordica)* and cucumber *(Cucumis sativus)* get badly distorted

The fly prefers green and tender fruits of pumpkins as it is not able to pierce the hard rind of the larger fruits. Similarly, some of the gourds with hard rind escape damage. The fly sometimes lays eggs in the corolla and other organs of the flower and the maggots that hatch out of these feed on the flower and a few have been observed to feed even on the stem of the cururbit vines. When the maggots feed in the stem, characteristic galls are formed.

The extent of damage that this fly causes to vegetable production in our country is not fully realized. Often 20 to 50 per cent of the vegetables and melons are either partially or totally damaged rendering them unsuitable for human consumption, (Junjua and Chaudhry, 1964).

BIONOMICS

The adult flies are generally long-lived and active. They can, however, be easily caught in tubes placed on them quickly when they are browsing on the leaves. They are attracted in numbers to the pulp and juices of cucurbit fruits when they are exposed by the removal of the rind or by the injury of the fruit. They feed on the cut surface of pear fruit and honey-dew of aphids infesting brinjal throughout summer. In the Hawiian Islands, flies have also been observed feeding on the flowers of the sunflower and Chinese bananas and on the juice exuding from sweet corn. This species is active and continues to breed throughout the year except for a short period, during the months of January and February when it is very cold. Sometimes eggs are laid even during the end of December. There is no doubt that the flies breed throughout the year where the climate is equable. In winter this species also has the habit of congregating under the leaves like, *D. dorsalis* Hendel and *D.*

diversus Coquillett but generally the population density of this species is more than *D. dorsalis* and less than *D. diversus*. In severe cold they hide under dried leaves of bushes and trees. In March when the weather warms up these flies are the first amongst the *Dacus* species to be on the wing. In places where the pre-monsoon period (April to June) is hot and dry the flies take shelter under humid and shady places and feed on honey-dew of aphids infesting brinjal or fruit trees. If under such situations they find suitable conditions for their breeding they may oviposit in guava, peach or cucurbit fruits grown as creepers under the shade of trees. Cucurbits are preferred but under exceptional circumstances the flies can breed in other fruits also. During the hot and dry months it is *D. ciliatus* that actively breeds on all forms of Cucurbitaceae and the population of *D. cucurbitae* in the fields is, therefore, low.

In the rainy months of July and August, the fly is at its peak and causes heavy damage to squash melon *(Citrullus vulgaris var. fistulosus)*, bitter gourd *(Momordica charantia)*, ribbed gourd *(Luffa acutangula)* and long melon *(Cucumis utilissimus)*. In other words this species actively breeds when the temperature falls below 90°F and the humidity is between 60 and 70 per cent. September and October months are passed in bottle gourd *(Lagenaria vulgaris)*, ribbed gourd *(Luffa acutangula)*, snap melon *(Cucumis melo* var. *momordica,)* cucumber *(Cucumis sativus)* and snake gourd *(Trichosanthes anguina)*.

During the cold months of November and December, the fly breeds on *Coccinia indica*, bitter gourd *(Momordica charantia)*, sponge gourd *(Luffa cylindrica)* and pumpkin *(Cucurbita maxima)* which are grown in this country up to December. The fly has also been observed in certain areas breeding on wild Cucurbitaceae *(Cucumis pubescens* and *Citrullus colocynthis)*, chilli *(Capsicum frutescens)* and tomato *(Lycopersicon esculentum)* during this particular period. Some of the adult flies live throughout the winter on honey-dew, plant exudations and fruit juices that exude through accidental injury to fruits or plants. The ratio of its population with its associate *D. ciliatus* Loew during September to December largely depends upon the prevailing weather conditions.

Mortality in this fly is also very high mainly because it is more or less specific in its host plant preference. It has already been mentioned that the flies continue to breed even in November and December. During autumn and early winter there are only a small number of cucurbitaceous plants in the fields and the few that are very heavily attacked. Naturally, there is not

enough food for all with the result that there is either heavy mortality or the individuals that emerge are undersized and weak. The biology of the fly is summarized below.

Emergence of the flies from pupae takes place between 6 and 8 a.m. during April to October and 9 and 11 a.m. during November to March. Mating has not been observed during the course of the day but like other *Dacus* species, probably it takes place at dusk for a short period. It has a pre-oviposition period of 14 days in August. It may range from 9 to 30 days or even longer in winter. In summer, the eggs are laid during the day in shade but in sunshine they are preferably laid during the evening hours.

In the act of egg laying the fly walks over the fruit and surveys it quickly by the up and down movements of the palpi and ovipositor selecting a suitable place for oviposition. Having selected the spot it bends its abdomen at right angles to the body or sometimes the abdomen forms an obtuse angle with the head, and the fly gradually inserts its ovipositor by forward and backward movement of the abdomen, and the telescopic extension and retraction of the abdominal segments, aided by the piercing action of the needle-like distal part of the ovipositor. Having thus selected and secured a cavity about 2-4 mm deep in the pulp, the fly makes the wall of the cavity impervious to moisture by a gummy secretion so as to stop the flow of excessive juice into the cavity and consequent injury to the eggs. The fly lays its eggs in the receptacle prepared by it. The wings remain fully stretched during the act of oviposition. With the ovipositor as its pivot it takes a turn to the right, covering about one-fourth of the circle, then stops for a while to lay more eggs and then continues its march round till it occupies a position exactly opposite to the one from where it started. That is to say before starting egg laying the head of the fly faced upwards and now it faces downwards. In this position also the fly stops for a while and affects the final delivery of the remaining eggs and moves round either back in the same direction from where it circled or completes the unfinished circle and comes to halt at the place from where it started. The fly before taking out the ovipositor releases a gummy secretion which cements the tissues surrounding the puncture and this cement solidifies as a shiny brown resinous mass around the aperture on the surface of the fruit (Plate III, Figure 1). As soon as the ovipositor is drawn out the fly walks a short distance and pauses for a while to clean the fully extended ovipositor by movements of the hind pair of legs. The whole act of oviposition lasts from about six to eight minutes, half the time being spent in selection of the spot and cleaning of the ovipositor

and the other half in actual egg laying. If, however, egg laying is not complete or the fly has to suspend egg laying owing to an apprehension of some danger it may return to the spot after several minutes to complete its oviposition.

Eggs are embedded vertically or slightly slanting and touching each other. They are sometimes laid in two or three planes. This, however, occurs when a number of flies use the same ovipuncture for egg laying. The eggs are laid singly or in clusters of four to ten. Usually there are about a dozen eggs in each puncture, the maximum number observed being 120 at a time when there was scarcity of host fruits. Compared to *D. dorsalis* Hendel the number of punctures made by this species is usually one and seldom exceeds three because the rind of the growing fruit soon becomes hard.

The number of eggs laid by one female is not exactly known. Dissections of the ovaries revealed that these contained 22 to 74 fully mature eggs. The number of eggs which the female deposits at one time ranges from five to fifteen. The two females were found to lay 58 and 95 eggs each in their oviposition period of 54 and 14 days respectively, during July to the middle of September. Owing to high tempeature both the females died abruptly in the middle of September. If the temperature had continued about optimum, these might have laid more eggs. They are active at mean annual temperature of 21.1-25°C (Anon, 1986) and like other species mentioned in foregoing pages temperature of 10°C adversely affected their development. Eggs are not laid daily but at an interval of 2-5 days or even longer because they are laid as they mature depending upon the availability of food and weather conditions. The number of eggs laid on a single day may vary from one to twenty-six. The egg (Plate III, Figure 2) is white, cylindrical and slightly curved on one side. The incubation period varies from less than 24 hours in summer to six to nine days in winter. The larvae that hatch out bore into the fruit and construct galleries. As many as 50 maggots have been bred from a single squash melon *(C. vulgaris* var. *fistulosus).* Decay of the vegetables is aided by bacterial action. The maggots are full-fed in about three days in summer to three weeks in winter depending upon the season and the rapidity with which the host plants decay as a result of the infestation. The full-grown larva has the peculiar habit of curving itself and springing into the air to a distance by the sudden relaxation of certain muscles. In this way six to eight inches of ground are covered to find suitable places of pupation. The full-fed larva is cream coloured or pale white. Sometimes its digestive tract is dark red or yellow from the contents of the food. The full-grown larvae measures 9 to 10 mm long and 2 mm broad

across the thorax (Plate III, Figure 4). Moist food is necessary for development of larvae. But, at the same time, if the moisture is excessive owing to rapid fruit decay, the larva also dies. The fully-developed maggots leave the fruit through one or two exit holes made in the fruit and pupate in the soil half to six inches deep depending upon the nature of the soil. The pre-pupal period varies from less than six to twenty-four hours. The pupa is barrel shaped, light brown or pale turning ochraceous as it develops. It is eleven segmented and measures 5.5 mm long and 2 mm broad (Plate III, Figure 5). The pupal period takes six to nine days in the rainy season, about three weeks in November and four weeks in December-January. The under-fed pupae measure 5 x 1.6 mm and, therefore, the flies that emerge from them are also small. The adult flies (Plate III, Figures 6 and 7) are reddish-brown with lemon yellow curved vertical markings on the thorax and fuscous shadings on the outer margin of the wings. The female is easily distinguished by the presence of a tapering abdomen ending in a pointed ovipositor. The adults can live for one to two days without food. If properly fed on the juices of cucurbits, the male can live for 56 days and female 66 days during the monsoon months. Out of the 358 flies reared during July to December, 183 were males and 175 females.

The pest produces several generations in one year. As the broods take from 28 to 66 days to complete their life cycle during the monsoon months, overlapping broods at this time of the year is the rule.

Dacus (Didacus) ciliatus Loew

Dacus (Didacus) ciliatus Loew is more commonly referred to as the Ethiopian melon fly.

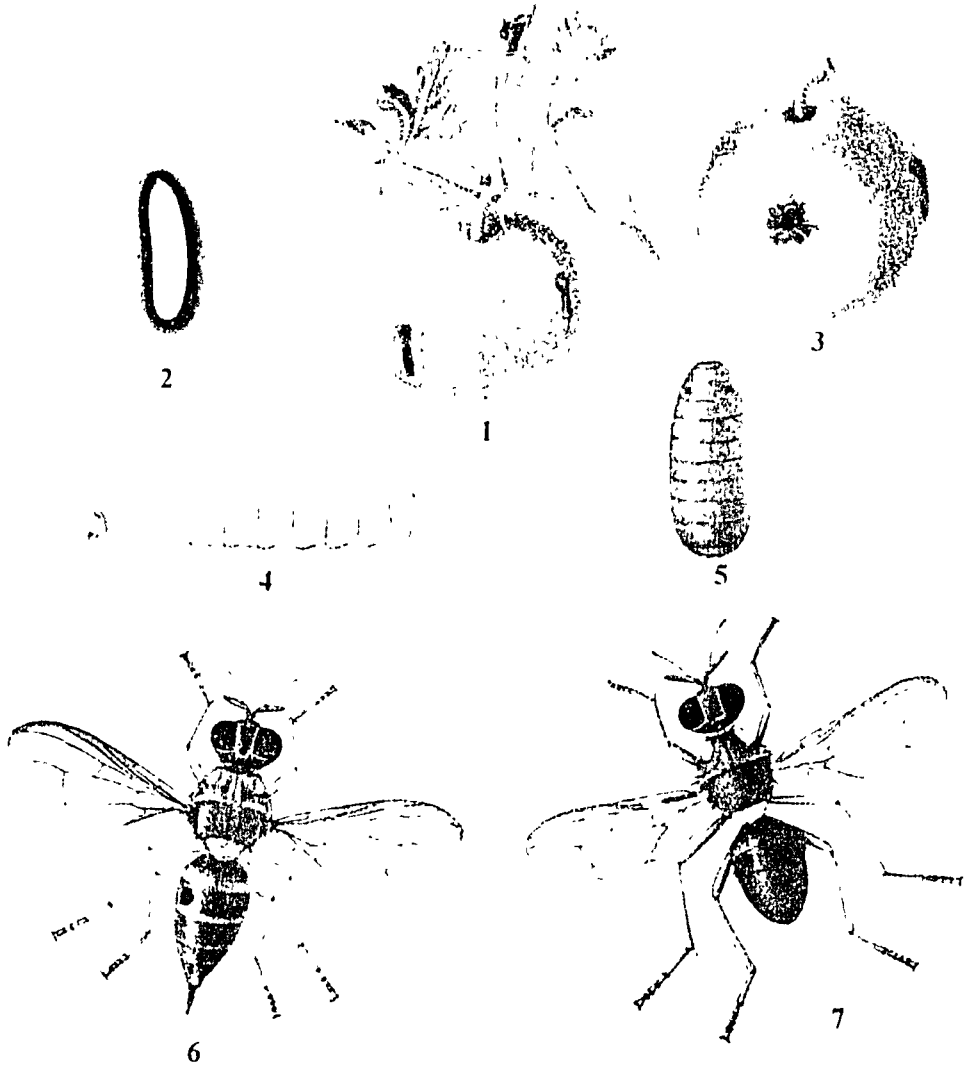
DISTRIBUTION

This species is of African origin and has been originally described from Eritrea, but it is now widely distributed in the European countries as a serious pest of melons. In Pakistan the fly is found in Sindh and coastal areas (Figure 8) outside Pakistan, it has been recorded from Europe, Transvaal, Sudan, South-West Africa, Rhodesia and India.

FOOD PLANTS

Different kinds of fruits like musk melon, snap melon, water melon,

PLATE NO-IV



(Narayanan and Batra. 1960)

Dacus ciliatus Loew

1. Squash melon showing the puncture caused by ovipositon and the resinous deposit at the site of the puncture (natural size). 2. Egg (x30). 3. Damaged fruit with maggots (natural size). 4. Full-fed maggot (x9). 5. Pupa (x9). 6. Female (x9). 7. Male (x9).

squash melon, bitter gourd, long melon, cucumber, sponge gourd, ribbed gourd, pumpkin and snake gourd are attacked by this fly.

NATURE OF DAMAGE

The nature and extent of damage are not very different from those caused by the melon fly, *D. cucurbitae* Coquillett. The fly has been observed to cause serious damage to cucurbit vegetables. Except for seasonal variations, the intensity of its population is the same as that of its associate the melon fly, *D. cucurbitae* Coquillett. In juicy fruits like squash melon *(Citrullus vulgaris* var. *fistulosus)* a mass of brown resinous deposit (Plate IV, Figure 1) is found at the point of incision made by the female during the act of oviposition. As the maggots feed, malformity characterized by a rugged surface is visible on the fruits of *Coccinia indica,* squash melon, *(Citrullus vulgaris* var. *fistulosus),* bitter gourd, *(Momordica charantia),* ribbed gourd *(Luffa acutangula),* long melon, *(Cucumis utilissimus),* musk melon, *(Cucumis melo)* and cucumber, *(Cucumis sativus).* The fruit remains attached to the vine till the whole of it is rotted.

BIONOMICS

The fly is active throughout the year and six generations have been recorded in areas where there is an equable and sub-tropical climate. The number of generations is less in the north where there is a clear-cut winter season accompanied by a fall in temperature. In these areas the flies are active up to the end of December and over-winter as pupae. The adult flies emerge from the pupae in April and are found flying about in the kitchen gardens in search of cucurbit fruits. The tender fruits that are formed in May are damaged. It is the only species that attacks cucurbit vegetables like *Coccinia indica,* bitter gourd *(Momordica charantia),* water melon *(Citrullus vulgaris),* squash melon *(Citrullus vulgaris* var. *fistulosus),* musk melon *(Cucumis melo),* cucumber *(Cucumis sativus)* and long melon *(Cucumis utilissimus)* in May and June, when the weather is hot and dry. After the first shower in July both *D. ciliatus* Loew and *D. cucurbitae* Coquillett are bred from one and the same fruit but gradually the larval population of the latter increases and that of the former decreases. During the heavy rains this species stops breeding and in autumn when the temperature rises and humidity falls the flies are again found breeding in association with *D. cucurbitae* Coquillett. The latter are, however, found in small number at this time of the year and the flies breed in *Coccinia indica,* bitter gourd

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(Momordica charantia), sponge gourd *(Luffa cylindrica)* and snap melon *(Cucumis melo* var. *momordica)*. *Coccinia indica* is the most preferred host that fruits early in summer and late in November and being perennial enables the flies to tide over the period of host scarcity. Very tender fruits hardly measuring 5 cm x 1.4 cm are attacked and they bear one to three punctures but as many as eight punctures have been observed on a fruit measuring 7 cm x 2 cm. This is due to the fact that the flies oviposit in the same fruit over and over again with the result that there is not enough food for the growing maggots. The larvae, therefore, are never full-grown and the pupae are small in size, the smallest pupa measuring 3 mm x 1 mm. There is heavy larval mortality and the few that successfully emerge are small and undersized. At certain periods of the year there is a keen competition between these two species, *D. ciliatus* Loew and *D. cucurbitae* Coquillett, for survival. Next to *Coccinia indica*, the flies prefer bitter gourd *(Momordica charantia)* and snap melon *(Cucumis melo* var. *momordica)*.

LIFE HISTORY

The adults emerge in the morning and the pre-oviposition period observed is four days. The female (Plate IV, Figure 6) is very active prior to egg laying and goes over the fruit a number of times to select a spot for egg laying. When the female pricks the fruit with its ovipositor a liquid of white colour oozes out of the puncture. The female, after licking the exudation, flies off but soon returns to feed on the fluid collected in the form of a globule and thrusts her ovipositor in the same spot a number of times to form a cavity to deposit her eggs. At the time of laying eggs the fly becomes motionless with its wings stretched across the body. After about two minutes, it takes a turn to the left covering about one-fourth the circle that it can make with its inserted ovipositor as a pivot. After a short pause of one minute it again moves round to the left and halts at a place exactly in the opposite direction of the one from where it started. After about a minute's pause it moves round and completes the circle and arrives at the place from where it started. After stopping for about a minute it turns round to the right and covers half the circle where it stops for about a minute and turns back the same direction and occupies its original place. Here it pauses for a while and then finally draws out its ovipositor which is held extended till it is cleaned with the hind pair of legs at a short distance from the puncture. This has been recorded so far in this species only. The whole process of egg laying takes about seven minutes. The liquid that oozes out of the fruit during the

act of oviposition dries up as a brown resinous mass around the aperture (Plate IV, Figure 1). On examination of the puncture, a cavity formed by the fly within the pulp to accommodate the eggs can be seen. The surface all around the cavity is made impervious by a cementing fluid which imparts a brown appearance to the tissues. The eggs are embedded 2.5 mm deep. The number of eggs laid varied between three to eight for each puncture made. As many as eight punctures have been noted on the fruit of *Coccinia indica* and as many as 22 eggs have been observed in three punctures. The egg (Plate IV, Figure 2) is shiny white, cylindrical, slightly curved and 2.5 mm in length. The incubation period is two to four days in September and October and very much less in early summer. The larvae fed on the pulp of the fruit. As many as 45 maggots have been bred from a single melon. The maggot is full-fed (Plate IV, Figure 4) within four to six days in October and is 8 mm long and 1.4 mm broad. It is then cream coloured and has a jumping habit like that of *D. cucurbitae*. The full-grown larva enters into the soil half to two inches deep for pupation. The pupa (Plate IV, Figure 5) is cylindrical, brownish to ochraceous in colour and is 5.5 mm long and 2.5 mm broad. The pupal period lasts six to eight days in summer and is longer in winter. Pupation, however, also takes place within the fruit even as the juice begins to dry up. In this character it markedly differs from *D. cucurbitae* that pupates invariably outside the fruit. The complete life cycle takes about 15 to 17 days. The flies have six generations. The adult flies (Plate IV, Figures 6 and 7) are smaller than *D. cucurbitae* and are bright brown or ferruginous brown in colour, with wings hyaline and void of dark markings. Two round dark brown spots are visible dorsally on the fourth abdominal segment (Plate IV, Figures 6 and 7).

Dacus (Gymnodacus) diversus Coquillett

Dacus (Gymnodacus) diversus Coquillett can be called the guava fruit fly as the flies are generally found in a large number in the guava orchards.

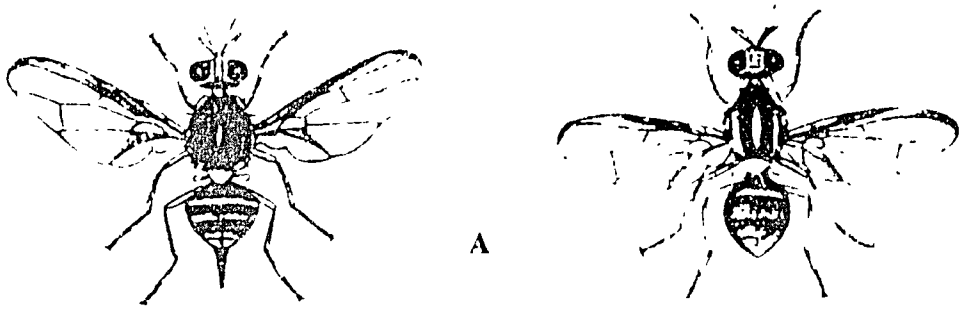
DISTRIBUTION

It has been recorded from plains of the Punjab (Figure 8).Outside Pakistan the fly has been recorded from Burma, Sri Lanka and India.

FOOD PLANTS

The fly attacks a variety of plants like guava, mango, banana, sour

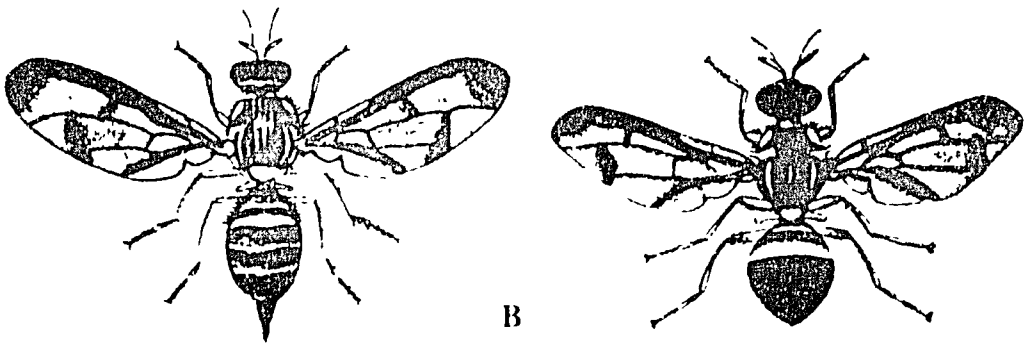
PLATE NO-V



A

FEMALE MALE

Dacus cucurbitae Coq.



B

FEMALE MALE

Dacus diversus Coq.

(Haq and Akmal, 1964).

orange, jamun and bottle gourd. This fly breeds in the flowers of gourd and *Luffa* sp. and might breed in other host fruits under exceptional conditions.

NATURE OF DAMAGE

The damage caused by this species is more or less similar as has been described in the preceeding pages. Minor points of differences have yet to be investigated. It is interesting to note that though the fly is found in large numbers in orchards as well in kitchen gardens, the damage caused by it, is insignificant as compared to the damage caused by the same number of other species. It has been observed that the fly breeds freely and completes the whole of its life cycle in the flowers of cucurbit plants.

BIONOMICS

This is an interesting fruit fly (Plate V, Figure B) which offers a vast scope for further research.

The flies over-winter in the adult stage. They are more numerous than the other species as determined when they congregate after dusk under the leaves of mulberry, fig, guava, citrus and loquat in the latter half of October and November. In the deciduous trees when the leaves fall the flies take shelter under evergreen fruit trees like guava, loquat and citrus. As there is a further drop in temperature, the flies hide under the folds of dried leaves of guava and loquat. In spring, the flies become active and are generally seen in orchards basking on the leaves and feeding on the honey-dew of black aphids, *Bterochlorus persicae* Cholodovsky, infesting peach, plum and apricot. The flies dwindle in numbers in the hot months of May and June and with the first shower in July they are seen flying about in small numbers in the vicinity of cucurbit flowers in which they oviposit. The rainy months with their optimum temperature and humidity enable them to complete their life cycle quickly and there is a steep rise in population. By about this time the loquat trees are in flower and guava and citrus begin to ripen, and the flies are attracted to these hosts from the kitchen gardens where the cucurbit fruits have begun to dwindle in numbers.

LIFE HISTORY

Though this species is found year after year in very large numbers both in the kitchen gardens as well as in the orchards it is astonishing that the life history of this species is not fully known.

Dacus (Zeugodacus) hageni **Demeijere**
(= *D. caudatus* **Fabricius**)

DISTRIBUTION

Dacus (Zeugodacus) hageni Demeijere has been recorded from Punjab and outside Pakistan; it has been recorded from Nepal, Burma, Sri Lanka, Java, Malayan States, Formosa, the Philippines and India.

HOST PLANTS

The fly has been known to attack pomelo, mango, chiko, snake gourd, bottle gourd, ribbed gourd, sponge gourd, cucumber and tomato.

NATURE OF DAMAGE

Although this species has a wide range in certain seasons, yet the extent of damage caused by the fly has not been studied.

BIONOMICS AND LIFE HISTORY

Observations on the bionomics of this fly have been scarcely recorded. However, there is a close resemblance between the adults of this species and of *D. cucurbitae* Coqillett.

Dacus (Strumeta) correctus Bezzi

DISTRIBUTION

This species has been recorded in Pakistan from Punjab province.

HOST PLANTS

Mango, peach, bael, ber and orange.

BIONOMICS AND LIFE HISTORY

Very little is known about the bionomics and life history of the fly. The adults are attracted to newly-opened termitarium.

Dacus (Strumeta) latifrons (Hendel)

This species, known as *Dacus (Strumeta) latifrons* (Hendel) has been bred from snake gourd, cucumber and *Solanum* sp., from March to May in

Pakistan. Accidently this species has also been introduced in Hawaii (Chaudhry, 1989).

Myiopardalis pardalina Bigot

DISTRIBUTION

Myiopardalis pardalina Bigot has been recorded from the NWFP and Quetta in Pakistan, (Figure 8). Outside Pakistan the fly has been recorded from India, Afghanistan, Mesopotamia, Palestine and Egypt. It is commonly known as the Balochistan melon fly.

HOST PLANTS

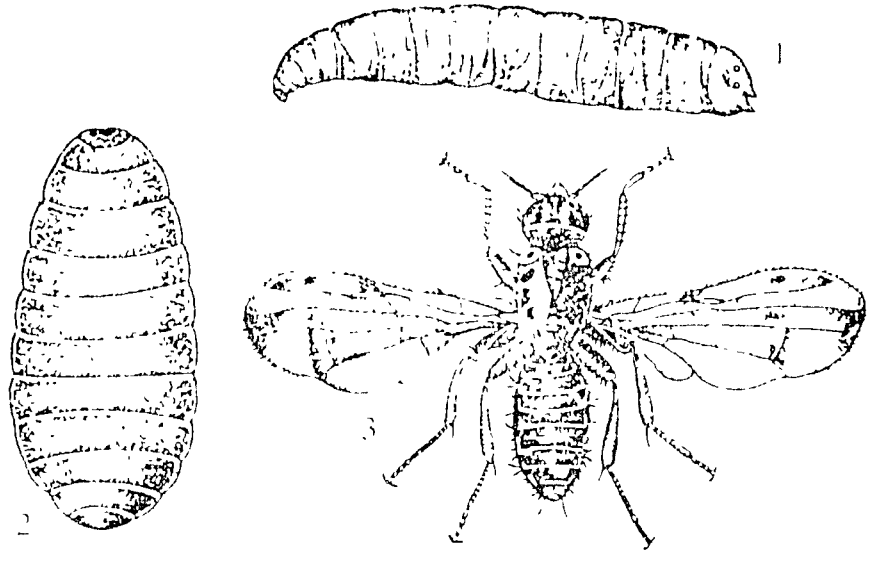
Musk melon, water melon and cucumber are attacked by this fly.

NATURE OF DAMAGE

The fly (Plate VI , Figures 1-3) selects tender-growing fruits sometimes even ovipositing in the ovaries that have just been fertilized and from which the sepals and petals have not yet fallen. The freshly punctured fruit is conspicuously marked with a reddish brown resinous secretion. When the fruit is severely punctured at several places, growth almost ceases and the fruit begins to rot before the eggs hatch. The tender fruit, if not badly attacked, rapidly increases in size. In about four days the position of the eggs caused by the growth of the melons appears altered and instead of lying just below the rind of the fruit or embedded in the pulp appears about three-fourths of an inch deep from the skin with only a hair-like line leading to the minute aperture caused during the act of oviposition. In cucumber and vegetable marrows, the maggots cause distortion by tunnelling and feeding in the pulp. The female fly, however, cannot successfully puncture the rind of a healthy melon of over four days' growth, but if it does and the fruit is about ten days old the aperture in the rind is obliterated and with this all traces of oviposition and the young maggots that feed and make their way inside the fruit through the pulp disappear.

The maggots cause very little damage to edible pulp and feed on the seed and its surrounding soft and spongy pulp, if they are prevented by any means from cutting their way out. But once the rind is punctured by the full-fed maggot the fruit completely loses its market value. Moreover, the fruit

PLATE VI



(Janjua and Chaudhry, 1964).

The Melon Fruit Fly, *Myiopardalis pardalina* Big.

Figure 1 Fullgrown maggot (x 10)

Figure 2. The Pupa (x 17).

Figure 3. The Adult (x 13).

itself begins to deteriorate, ferment and finally rot. In a normal season as much as 20 per cent of the fruits may be attacked in the peak period of July. The sardah melon, because of its soft skin, is very susceptible to attack by this species, but can be saved by covering the melon with earth. Musk melon is also equally susceptible and as it cannot stand covering by earth, this pest greatly limits its cultivation. The herati variety which is a late ripening variety escapes damage. If it is not punctured at many places and the growth is not arrested very much, the young fruit recovers because the maggots are drowned in the juice of the fruit. Only under-developed flies emerge from the badly attacked and stunted fruit. About 90 per cent damage to sardah melon have been recorded, (Janjua and Chaudhry, 1964) by this fly.

BIONOMICS

The fly is active in summer and overwinters in the pupal stage from September to April. Pupation may, however, commence earlier than September in certain years due to fluctuation in weather conditions. From April when the fly hatches out of the pupa to the time when the melon or other food plants begin to bear fruit, the fly feeds on honey-dew secreted by aphids on peach, pear and other trees. The fly is most active in July when the duration of its life cycle is the shortest, about a month. The pest completes two to three generations before it finally pupates in September for its long winter rest. In severe winter accompanied by a heavy snowfall a large number of these overwintering pupae perish, resulting in a mild attack during the following summer.

LIFE HISTORY

The biology of this melon fly has been studied in Peshin, Quetta (Janjua and Chaudhry, 1964). Pairing starts soon after the adults emerge from the pupae. The female generally selects tender fruits about two to three days old for oviposition. It is very interesting to note their ability to select tender fruits. The fly cannot puncture the rind of a healthy fruit of over four days' age. The location of the puncture on the rind is revealed by a small accumulation of reddish brown gum as described before, which, however, dries and falls off in a few hours. At this stage, it is difficult to find whether a melon has been punctured or not. The fly lays eggs in the morning during warm sunshine. She bends her abdomen at right angles to the rind in the act of oviposition. Eggs are laid just below the rind and are embedded in the

pulp. The number of eggs laid at one time averages five. The maximum number of eggs laid in a single fruit has been observed to be about 130 which naturally have been laid by more than one fly. Only about half a dozen maggots reach maturity and emerge as adults. When the fly lays eggs in fruits more than four days old, the maggots that hatch out of these eggs bore their way towards the core and get drowned in the juice of the pulp. A few (three to five) maggots appear not to affect the growth and development of the melon. If, however, a large number of maggots hatch and develop, the fruit becomes stunted and later deteriorates. The incubation period of the egg is about four days. The maggots that hatch out feed on the seeds and pulp surrounding them in the centre of the fruit. The larva is full-fed in about a fortnight. The full-grown maggots cut a circular hole and desert the fruit for pupation either in the soil or just below the melon on the surface of the soil. The maggot constructs a tunnel to protect itself from the fruit juice that accumulates by gravitation as it feeds its way upwards. The fruit growers in Balochistan with the practice of turning over of fruit prevent the full-grown maggots from boring their way outside for pupation. The market value of the fruit is thus not lost though the consumer has to take his chance that an apparently healthy fruit he may purchase in the market may contain an assorted sample of pupae and sometimes maggots also. The pupae are light and float on water. During the monsoon many of them are washed away and dispersed to new localities where they start their life cycle anew. The pupae can stand submergence in water for a long period without injury. The pupal period lasts for 13 days in summer and over six months in winter. The adult flies that emerge can be kept alive for three to four weeks fed on melon fruit juice.

Carpomyia vesuviana Costa

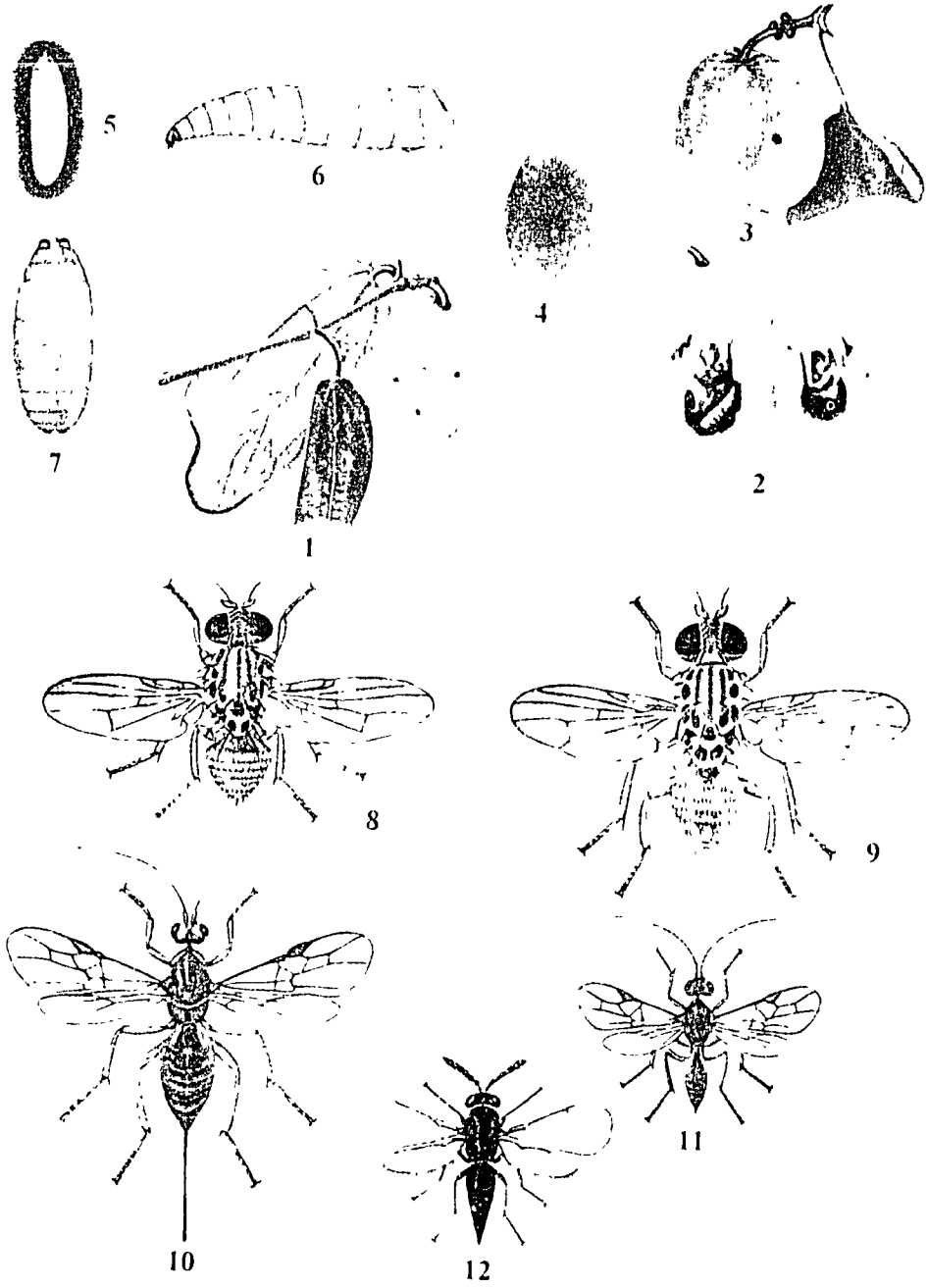
DISTRIBUTION

The fly, *Carpomyia vesuviana* Costa has been recorded from all over the Punjab. Outside Pakistan it has been recorded from India, Dalnatia and southern Italy.

HOST PLANTS

In Pakistan the fly damages the fruit of ber.

PLATE NO-VI



(Narayanan and Batra, 1960).

Carpomyia vesuviana Costa

1. Ber fruit showing oviposition punctures (natural size). 2. Damaged fruit with maggots (natural size). 3. Rugged fruit showing the exit hole of the maggot. 4. Exit hole of the parasite. 5. Egg (x 30). 6. Full-fed maggot (x9). 7. Pupa (x 9). 8. Female (x9). 9. Male (x9), 10 and 11. Braconid parasites (x9). 12. Eulophid parasite.

NATURE OF DAMAGE

The fly inserts its ovipositor into the fruit to lay eggs. The puncture caused in the act of oviposition is visible through the gummy secretion left around the aperture. The growth of the fruit at the spot where eggs have been laid ceases with the result that the surrounding tissues grow up and give the fruit a rough appearance (Plate VII, Figure 3). The puncture gets secondarily located in a slight depression (Plate VII, Figure 1). The minute aperture appears as a dark spot when viewed from a distance. The maggots as they hatch bore their way to the interior of the fruit, and in so doing form reddish brown galleries. As they grow they feed on the pulp which soon begins to rot and turns dark brown. The whole fruit smells offensive. A single maggot is enough to render the fruit totally unfit for human consumption. The damage caused by this fly is decreasing significantly the total production of this delicious fruit liked by rich in many parts of Pakistan.

BIONOMICS

The seasonal activity of this species is different in many ways from that of the *Dacus* species. The later is mostly active in summer. During winter it is either inactive or where the winter conditions are severe it overwinters in the pupal stage. In the case of the ber fruit fly, however, the activity commences from autumn and continues through winter and spring. It hibernates from April to August in the pupal stage. The peak damage to ber is observed in February-March when almost all the late ripening varieties of ber are attacked. During this period owing to the great density of the population, individual fruits are punctured more than once by the same or different flies with the result that in each fruit sometimes 12 to 18 maggots are found though in autumn one does not find more than one or two maggots in one fruit. The adult flies (Plate VII, Figures 8 and 9) are very active and fly fast. The flies seem to have pre-sense of approaching danger and fly away in good time. The female flies, however, can be caught easily while in the act of oviposition. The adults are long-lived. The pest remains in the soil as pupa in the summer and during the early monsoon period. The adults emerge from the later half of August to mid-November. In certain years due to wide variations and fluctuations in climate they emerge a little earlier but these generally die not only due to the absence of host material but also due to uncongenial environmental conditions. These flies are smaller in size. The period of normal emergence of the ber fruit fly synchronizes with the blossoming and formation of fruits by the ber tree. The fly attacks the fruit in

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November when the fruit is very small and tender. Two to three broods have been observed from November to April, where winter conditions are not so severe. Two broods were recorded where the winter is prolonged and severe. One characteristic feature of this fly is that it is monophagous in habit and it has been bred only from the ber fruits so far *(Z. jujuba and Z. nummularia).* The fleshy fruits are preferred to the non-fleshy ones because of abundance of pulp in them. *Z. nummularia* begins to flower in July-August and, by the beginning of September, tender fruits are formed. It may, however, be stated that a few of the flies that emerge at this time mostly die. In very few cases there may be successful oviposition and development. The damage caused is, however, negligible.

LIFE HISTORY

The male fly (Plate VII, Figure 9) is slightly bigger than the female. The pre-oviposition period of the fly has been observed to be about a month. The female fly (Plate VII, Figure 8) punctures the fruit a number of times with her ovipositor to form a cavity to lay her eggs. In each cavity one to two spindle-shaped creamy white eggs (Plate VII, Figure 5) are deposited 1 mm below the rind of the fruit. As soon as the eggs are laid the fly withdraws its ovipositor and covers the aperture (Plate VII, Figure 1) with a light brown resinous secretion. The incubation period of the eggs is two to three days. The maggots feed their way toward the endocarp. The freshly attacked fruit is found riddled with galleries (Plate VII, Figure 2). The maggots feed on the pulp and decay which gives an offensive smell. As many as 18 maggots have been reared from a single fleshy ber fruit. The larva (Plate VII, Figure 6) is full-fed in seven to ten days. The full-grown maggots cut one to two circular holes in the epicarp and come out for pupation. They are creamy white in colour and can jump six to nine inches high covering the same distance at each jump to find a suitable place for pupation. Pupation takes place two to three inches in soil. Pupa (Plate VII, Figure 7) are ochraceous in colour. The pupal stage lasts from 14 to over 300 days which is an extraordinary feature with this species. The shortest life cycle from egg stage to the adult is about 24 days.

TECHNOLOGIES DEVELOPED FOR ERADICATION OF FRUIT FLIES IN THE U.S.A.

Hawaii is the only place in the U.S.A. where the oriental fruit fly, *D.*

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dorsalis, the melon fly, *D. cucurbitae* and the Mediterranean fruit fly, *Ceratitis capitata* (Wied) are established. Recently, another species, i.e., the solanaceous fly, *D. latifrons* (Hendel) has invaded the Island of Oahu (Mitchell, 1985). There is a constant danger that one or more of these species may be introduced in the mainland. Eradication programmes have been conducted in California, Florida and Texas (Gilmore, 1986). Research scientists have developed safe and effective ways to detect and eradicate these insect pests. A lot of literature on these aspects have accumulated. Some salient features of this work are given below:

1. *Bait Sprays:* A mixture of Malathion and protein hydrolysate when applied by aerial or ground sprays at weekly intervals against fruit flies proved effective for their control. This technology was developed in Hawaii and used in many control programmes and could be adapted well in Pakistan too.
2. *Male Annihilation:* This method of control has been demonstrated against the oriental fruit fly, *D. dorsalis,* where a male lure, Methyl eugenol combined with naled was used by aerial application of treated blocks, strings, etc. About 99% of the population of the melon fly, *D. cucurbitae,* have been reduced with the use of male lure i.e. cue-lure and Malathion. In this technique, a minute amount of insecticide is used to kill the males attracted to the lure source. It has given an effective control where bait sprays can hardly be used.

3. *Attractants/Lures:* Three of the available lures that attract the males have been tested in a number of programmes and proved successful for detection and male annihilation of fruit flies. Efforts to find out better attractants for the Mediterranean fruit fly, *C. capitata,* are in progress. Likewise, several compounds and natural oils have been tested on the olfactometer for the oriental fruit fly, *D. dorsalis.* Currently the following three lures for different fruit flies are available:

S. No.	Species	Lure
1.	Mediterranean fruit fly, *C. capitata*	Tri-med lure
2.	Oriental fruit fly, *D. dorsalis*	Methyl eugenol
3.	Melon fruit fly, *D. cucurbitae*	Cue-lure

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4. *Extraction of Male-lures from Plants:* Methyl eugenol, the attractant of the oriental fruit fly, *D. dorsalis,* has been analyzed from the blossoms of golden shower, *Cassia fistula* L., and other plants.

5. *Mass Rearing of Fruit Flies:* So as to provide eggs, larvae, pupae and adults to various research projects, an efficient and economical method has been developed at Honolulu to rear three species on an artificial diet at 20°C and 40%-90% R.H. For this purpose more than 20 million of fruit flies are reared each week at Honolulu for studies on evaluation of lures and insecticides, irradiation of pupae for sterile insect release techniques and field tests of parasitoids.

6. *Irradiation of Fruit Flies:* A large number of laboratory reared fruit flies are sterilized by irradiation in the pupal stage at 150 gray. In this way the oriental fruit fly, *D. dorsalis* and Mediterranean fruit fly, *C. capitata,* have been eradicated with the continuous release of sterile fruit flies. The release of sterile fruit flies, need ratios of 100 sterile to 1 wild (100:1). The sterile females when mated with wild fruit flies, egg hatching is prevented. Ultimately, populations of wild fruit flies was diminished. The irradiation of fruit flies is done with Cesium 137 (one million electron volts) Irradiator, with gamma radioactive isotopes. A dose of 15,000 rads gives complete sterility.

7. *Genetic Sexing:* So as to enhance the effectiveness of the sterile insect release technique and to eliminate negative effects of fruit sting damage by sterile female oviposition punctures, research work is going on for developing only males in mass rearing of these insect species. This research is being pursued through the micro-injection of a resistant gene, DNA of *Drosophilla* into the eggs of the Mediterranean fruit fly, *C. capitata.* Hopefully, females would be killed off in the larval rearing, without injuring the males. Thus sterile insect rearing would be more economical.

8. *Demographic Studies:* According to interaction of ecological and biological factor models for prediction of growth rate of fruit flies populations are being developed by the research scientist. Knowledge has been advanced to evaluate mating behaviour of the laboratory reared fruit flies as compared with the wild flies.

9. *Augmentation of Parasitoids:* Biological control of the fruit flies has another alternative for insecticidal control. Therefore, with the concept of release of parasitoids (Knipling, 1979) significant advances here have

been made in the technology of mass-rearing and handling of suitable natural enemies for regular field releases of a Braconid, *Boisteres tryoni* (Cameron) for control of the Mediterranean fruit fly, *C. capitata.* Regular releases of this parasitoid in fields have achieved promising results. Similarly, *B. longicaudatus* Ashmead and *B. arisanus* (Sonan) which parasitize the oriental fruit fly, *D. dorsalis* and *Opius fletchri* Sylvestri, a parasitoid of the melon fruit fly, *D. cucurbitae,* are reared on large scale for releasing against these fruit flies in the fields. Tests of the releases of these parasitoids have been found to be compatible with the male annihilation technique as the parasitoids do not respond to the male lures of fruit flies.

INTEGRATED CONTROL

The control of these flies is very difficult at the damaging stage as the maggots live in fruits, vegetables, nuts or in the buds of the growing plants. Therefore, any insecticide that may be applied in the form of dust or spray cannot reach them. The only method left in the hands of economic entomologists is either trapping the adult flies or applying insecticides for controlling the adult populations.

The various methods of control for fruit flies are as follows:

MECHANICAL METHODS

1. **Orchard sanitation**

   (a) *Removal and Disposal of the Fallen Fruits:* One of the most valuable stages in the life cycle of the fruit fly is the larvae inside the fruit. Therefore, all the infested fruits that fall on the ground should be collected and burried deep in the soil. It is essential that the layer of the soil over the infested fruits that have been collected and put in the pit should at least be half a meter deep.

   This is one of the essential practices in orchard sanitation. While the disposal of the fallen fruits in summer is essential, it may be mentioned that the same precaution should be applied to winter fruits which serve as alternate hosts to these flies during such months where the flies breed owing to mild cold weather.

   (b) *Picking of Under-sized Fruits Left over on the Tree after Harvest:* Orchard sanitation needs care in respect of the fruits that are left unpicked on the tree. These may either be missed fruits, or under-

sized fruits or that are out of reach in the tender branches. Of these three categories, the one of under-sized fruit is the most dangerous and becomes the focus of later infestation. The other two categories of fruits mentioned above will soon fall on the ground and may be picked up and burried.

It may be mentioned that cucurbit plants in the kitchen gardens as well as in the field after the summer season left grown cause greatest danger of producing further infestation and carry over the flies like Melon fruit flies and Ethiopian melon flies in summer.

2. **Destruction of the Adult Flies:** The adults of Oriental fruit fly, and Melon fruit flies have the habit of congregating in large numbers. Varying from a dozen to 3,000 flies under the leaves of evergreen fruit trees like guava, loquat and citrus from November to February when the infestation is less, the flies congregate to overwinter in the adult stage. During the night and in the early morning hours, depending upon the intensity of cold, the flies congregate in numbers at suitable places for protection against cold. These flies should either be collected with hand nets and killed or be sprayed with a suitable insecticide like Malathion or Dipterex.

3. **Protection of Fruits by Butter Paper or Tissue Paper Bags:** This method can be used by householders who grow one or two trees or fancy vegetables for domestic use as here the question of sentiment of saving their crop plays a more important role than the question of economics.

CULTURAL METHODS

1. **Destruction of Pupae:** The fruit flies which damage fruits and vegetables pupate in the soil during the cold weather, especially in January and February. If during these months, the soil in the orchard is turned over or given a light ploughing a large number of these pupae could be exposed and would fall prey to parasites, predators, and birds. A large number of them die also of mechanical injury in the course of ploughing.

2. **Turning Over the Melon Fruit:** In the case of sarda melon, there is a peculiar practice popular among the melon-growers in the countryside around Quetta to prevent the fruit from being tunnelled and damaged by maggots of *Myiopardalis pardalina*. The fruit is turned daily for about six days after it grows for about a fortnight. This simple method in the case of melons

attacked by Melon fruit fly and Ethiopian melon fruit fly in other parts of our country may be tried.

Another recommendation to protect the sarda melon from the attack of fruit fly, *Myiopardalis pardalina* is to cover the fruit with earth for about a fortnight. During this period, the rind of fruit gets sufficiently hardened to prevent the flies from puncturing it for oviposition.

CHEMICAL METHODS

The chemical or the insecticidal methods of control of fruit flies fall under the following three main heads:

(a) Spraying the adult flies with suitable insecticides.

(b) Trapping of the adult flies by means of chemical attractants Male annihilation technique.

(c) Bait spray which in essence consists of an insecticide mixed with protein hydrolysate or syrup.

Spray with Insecticides

The flies can be killed in large numbers by the application of suitable spray i.e., Dipterex or Malathion when they converge on leaves of fruit trees during the cooler hours in autumn and spring.

Insects are attracted to the smell of certain chemicals and essential oils. The use of Methyl eugenol has been exploited to control peach fruit flies (Steiner, 1952; and Qureshi, 1983). This chemical is a powerful food and sex attractant for peach fruit fly (Howlett, 1912). It is mixed with concentrated sugar solution and naled in the ratio of 85:10 and 5 parts respectively. Four millilitres from this mixture is injected into cotton wicks which is held inside the trap in a wire loop. Such traps were suspended two metre above the ground on guava trees. Due to smell of the lure, the male flies were attracted in the trap and are killed as the mixture contains insecticide. The attraction of Methyl-eugenol is effective for a distance of 0.5 km or more. It is considered that each male fly removed from the wild fly population by an attractant, would represent one unmated female. Since the two sexes were assumed to be present in approximately equal numbers and to mate only once, the repeated application of such traps will wipe out males in large numbers from the test area and the population of fruit fly will be reduced drastically which will help in lowering the damage to sub-economical level.

In the various experiments conducted by Qureshi (1983) and Chaudhry (1989), it was found that traps containing lure/toxicant mixture and

suspended from guava trees, 2 metres above the ground, at the rate of eight traps per acre, were sufficient to reduce the fly population to sub-economic level. It was also observed that the fruit infestation was positively correlated with the reduction in fly population (Figures 9 and 10).

The lure/toxicant mixture in traps was replenished in February, March, July, September and November. The control of fruit flies by these techniques is specific, economical, non-polluting, less hazardous, easy to apply and leaves no harmful residues on the fruit.

Bait Sprays

The bait spray offers one of the most effective methods of control especially in the pre-oviposition stage when the flies require plenty of water to drink and are easily attracted to any solution of syrup. This habit of the flies is capitalised to poison and destroy them. A few branches and foliage in each tree in an orchard are swiftly sprayed so that the spray does not drizzle down but is retained on the leaves as droplets. Various formulations of bait spray have been used with a variable degree of success. But the most effective one has been reported by Steiner *et al.* (1965) which is as follows:

Ingredient	Concentrated spray	Dilute spray
Water	15-150 lit	150-600 lit
Yeast protein	450 gm	450 gm
Wettable powder (Malathion)	900 gm	1.5 kg

Instead of yeast protein, a commercially prepared ingredient, Buminal, can be used with advantage.

BIOLOGICAL CONTROL

Biological control of fruit flies holds some promise (Chaudhry, 1987). *Opius oophilus,* if introduced, will be useful against Oriental fruit flies, *Dacus dorsalis.* There is no known parasite of *D. zonatus,* occuring in somewhat ecologically similar area which can be introduced in Pakistan. Some parasites attacking other species may be tried but in view of a very large area of distribution of *D. zonatus* and excessive heat in summer, biological control of this fruit fly does not appear to be very promising. In the coastal and sub-coastal area, it may, however, be useful (Syed, *et al.,* 1970). Similarly, the

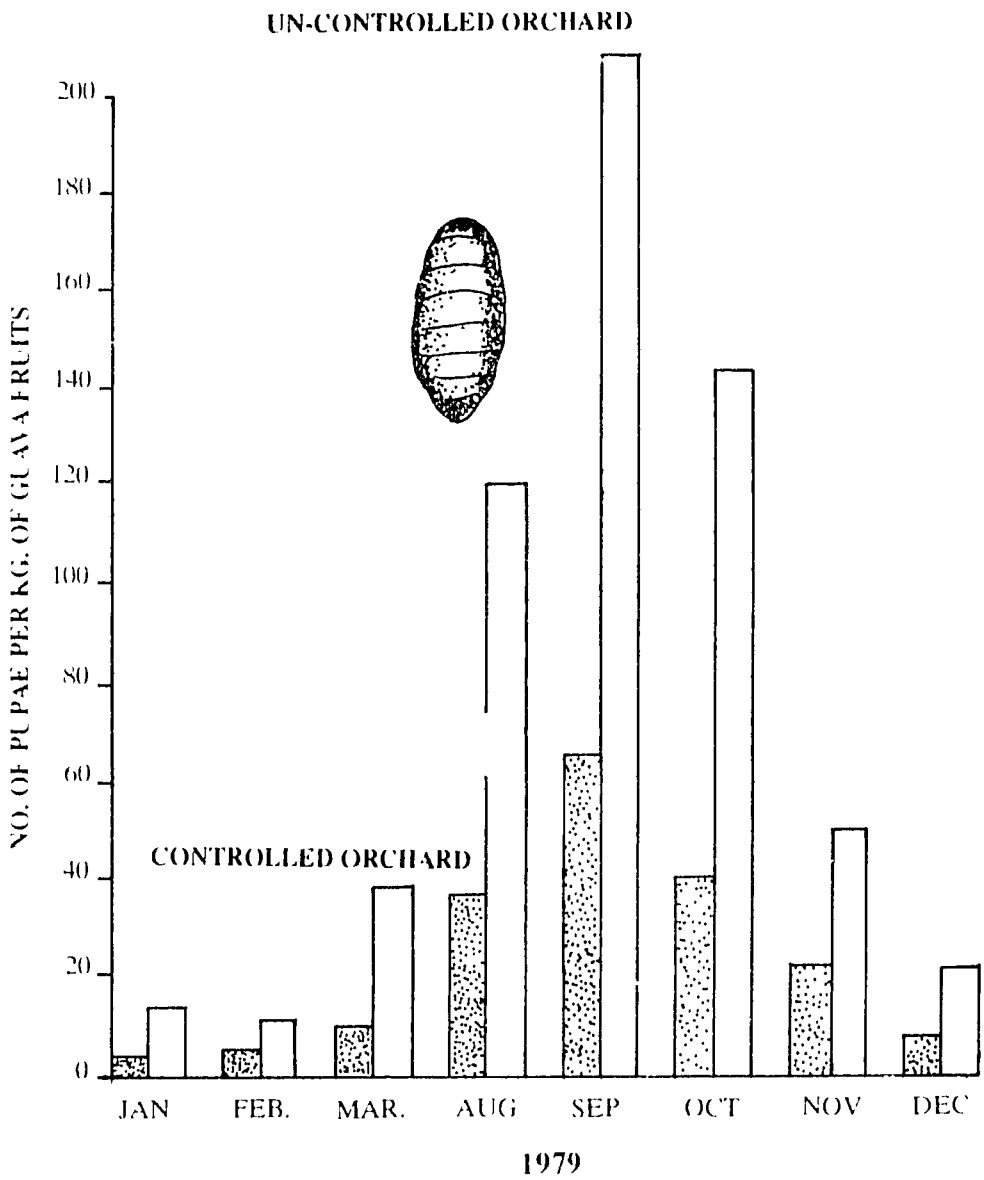

Figure 9. Pupal recovery from Guava fruits collected from controlled and un-controlled orchards

(Qureshi, 1983.)

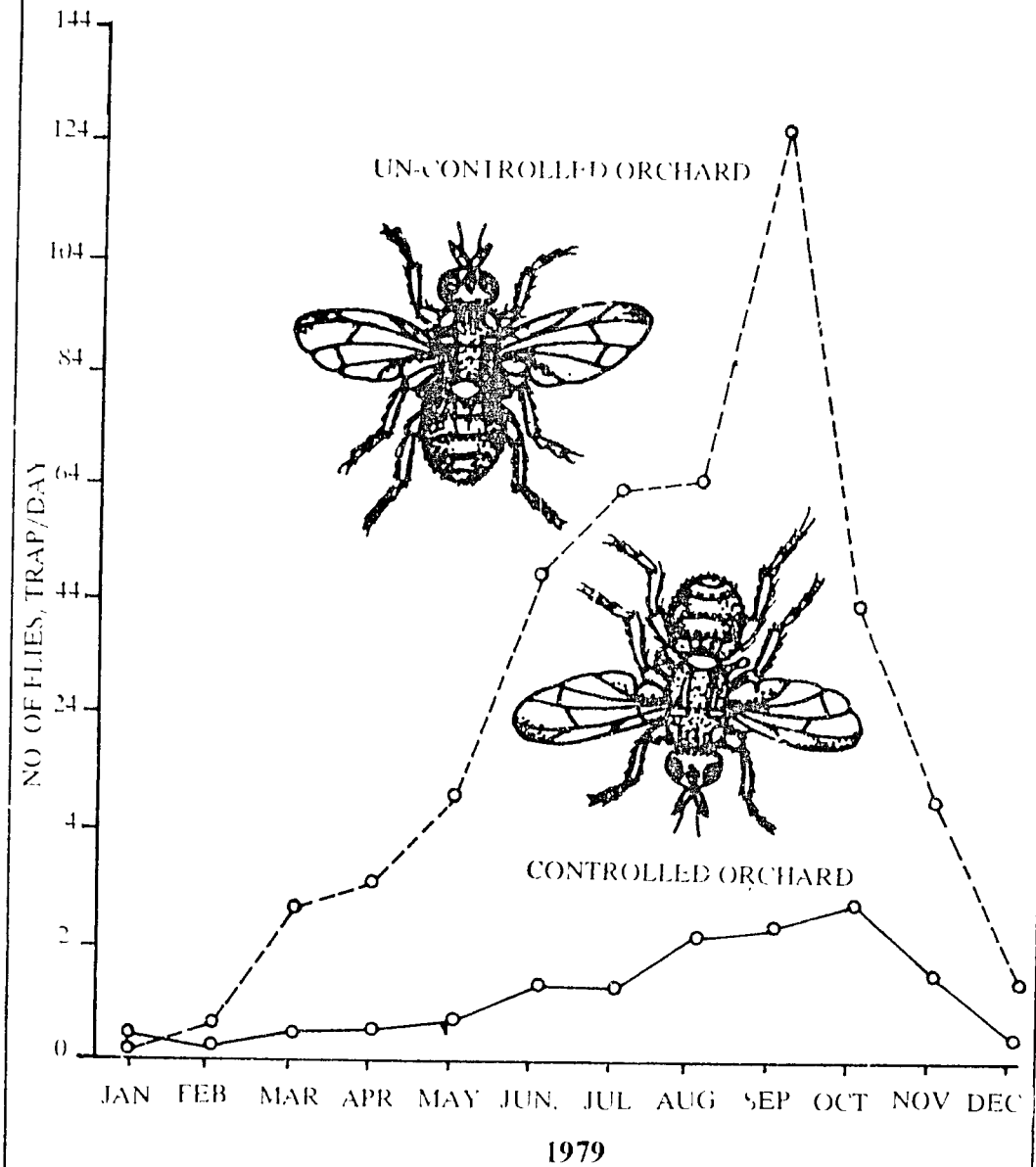

Figure 10. Population trend of fruit flies in controlled and un-controlled Guava orchards

(Qureshi, 1983.)

biological control of melon fruit fly, *D. cucurbitae* does not hold much promise in our country.

From the literature survey on the subject, it is revealed that biological control of fruit flies is not suited to our conditions. However, in some areas like the coastal and subcoastal areas, where fruits are grown extensively, it stands out fairly a good chance of success.

RADIATION USE TO CONTROL FRUIT FLIES

Sterile Insect Release Technique

Experiments conducted by Qureshi (1983), have shown that this technique is technically feasible for the control of peach fruit flies *D. zonatus*. Since initial cost will be very high for applying this technique and the requirements for the successful application of this method are such that under our conditions they are not fulfilled, therefore, it was considered that the technique is not feasible for the control of fruit flies.

FUTURE PLANS FOR MANAGEMENT

The control tactics and eradication strategies for fruit flies in Pakistan should be as under:

1. **Monitoring Survey:** To delineate the tephritid species in the area, lures are the standard tools. Therefore, to obtain this data, plastic traps baited with 5 ml lure and naled 2% may be set up in traps hung on host plants, in different ecological zones. Traps should be placed in ports of entry to catch any accidental introduction.

2. **Fruit Collection and Holding:** Fruits from definitely established sampling areas should be collected at weekly intervals and held in cages for rearing of fruit flies and parasitoids from them, to determine the parasitoid complex.

3. **Bait Sprays:** Sprays of Malathion and protein hydrolysate or Buminal in agricultural producing areas may be used during the summer and autumn.

4. **Cultural Control and Sanitation of Orchards:** All infested fruits may be buried in deep soil.

5. **Male Annihilation:** Synthetic lures attractive to adult males combined with naled or Dichlorvos should be applied at evenly distributed spots. 50-

per square km, on tree trunk, 3-5 ml per spot, so as to reduce population of the pests.

6. **Search for Male and Female Lures:** Studies to find male lures for other species of fruit fly should be initiated.

7. **Extraction of Attractants:** Extraction of Methyl eugenol, a male-lure, from the local sources, i.e., 'amaltas,' *Cassia fistula* L., and 'tulsi,' *Ocimum sanctum* may be done to meet the requirements of trapping the Oriental fruit fly, *D. dorsalis* and the peach fruit fly, *D. zonatus*

8. **Biological Control:** Opine parasitoids such as *B. arisanus* that are effective in Hawaii should be investigated to determine their effectiveness against Pakistan tephritids. Effective mass releases to control fruit flies is an alternative.

9. **Sterile Insect Release Technique:** Although this technique would be very much expensive, coordinated eradication programme may be pursued at the national level to achieve favourable results.

10. **National Fruit Fly Research Laboratory:** A well-represented coordinated research plan should be developed and carried out by setting up a fruit fly research laboratory at a national level, so as to accelerate the pace of development of management of fruit flies.

11. **Estimation of Losses:** It is imperative that studies should be initiated to estimate losses done by various species of fruit flies in different ecological zones. Data on fruit production and crop losses may be secured to have a thorough analysis of the economic impact of fruit flies.

12. **Taxonomic Aids:** There is a need for identification of the various species of fruit flies, causing significant losses to crops in Pakistan. This could be made available through the cooperation of PARC/NARC research laboratories.

13. **Training:** The best way to increase the effectiveness of management of fruit flies is to increase the competence of field staff through training. Therefore, training programmes should be arranged for them as well as for the extension workers and progressive farmers.

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Appendix 1: List of Host Plants of Fruit Flies in Pakistan

	Common/English Name	Category	Technical Name	Fruit Fly Species
1	Alu-bukhara, plum	F	*Prunus domestica*	1
2	Anar	F	*Punica granatum*	1,2
3	Apple	F	*Pyrus malus*	1,2
4	Aru	F	*Prunus persica*	1,2 3,7
5	Bahidan, quince	F	*Pyrus cydonia*	1
6	Banana	F	*Musa, sapienteem*	1,5
7	Ber	F	*Ziziphus jujuba* and *Z nummularia*	1,2,7, 10
8	Bel	F	*Aegle marmelos*	2,7
9	Bhindi	F	*Hibiscus esculentus*	2
10	Brinjal	V	*Solanum melongena*	1,2,3
11	Chicko	V	*Achras sapota*	1,2,6
12	Chillies	V	*Capsicum frutescens*	1,3,4
13	Cucurbit (Wild)		*Cucumis trigonus, C pubescens*	3
14	Date	F	*Phoenix dactylifera*	2,3
15	Fig	F	*Ficus carica*	2
16	Galgal	F	*Citrus medica*	1
17	Guava	F	*Psidium guajava*	1,2,3,5
18	Jaman	F	*Engenia jambolana*	5
19	Jioputa	F	*Putranjiva roxburghii*	1
20	Kadoo, bottle gourd	V	*Lagenia Jambolana*	5
21	Kareela	V	*Memordica charantia, M, balsamunda*	2,3,4,5,6
22	Khatta, Sour Orange	F	*Citrus aurantium*	1,2,5
23	Kheera, Cucumber	V	*Cucumis sativus*	3,4,6,8,9
24	Khurmani, apricot	F	*Prunus bokhariensis* and *P armaniaca*	1
25	Long Melon	F	*C utilissimus*	2,3
26	Loquat	F	*Eriobotrya japonica*	1
27	Malta Orange	F	*Citrus sinensis*	1,2
28	Mango	F	*Mangifera indica*	1,2,5,6,7
29	Mitha, Sweet lime	F	*Citrus limetta*	1,2
30	Musk melon	F	*Cucumis Melo*	2,3,9
31	Nakh, Pear	F	*Pyrus communis, P Sinensis*	1,2
32	Papaya	F	*Carica papaya*	2,3
33	Persimmon	F	*Diospyros kaki*	1
34	Pholsa	F	*Grewia asiatica*	2
35	Pomelo	F	*Citrus grandis*	1,6
36	Shamla	F	*Anona squamosa*	2
37	Snake gourd	V	*Trichosanthes anguina*	3
38	Sponge gourd	F	*L. cylindrica*	3
39	Tarbooz, Water melon	F	*Citrullus vulgaris*	1,3,4,9
40	Tomoto	V	*Lycopercicum esculentum*	2,3,6
41	Tori	F	*Luffa acutangula*	2,3,6

F = Fruit V = Vegetable

Appendix 2: Doses of Various Chemicals for Application against Fruit Flies

1. **Bait Spray**

1.	Malathion 50% W.P.	1 kg
2.	Protein hydrolysate or Buminal	0.5 kg (for an acre)
3.	Water	100 lit

Spray should be done at week's interval.

2. **Formulation of male-annihilation**

1. For *D. dorsalis* and *D. zonatus*

(i)	Naled 60 ml	10% Dibrom
(ii)	Min-u-gel	23% Min-u-gel
(iii)	Male lure 30 ml	67% Methyl eugenol

2. For *D. cucurbitae*

(i)	Naled 60 ml	10% Pibrom
(ii)	Male lure	90% Cue-lure

3. **Lures in plastic trap**

1. *D. dorsalis* and *D. zonatus*: 5 ml of mixture 98% methyl and 2% naled on 4x2 cm cotton wick.

2. *D. Cucurbitae*: 5% mixture of cue-lure and Dibrom on cotton wick. Lures should be replenished at 4 week's interval.

4. **Lure in Glass Trap**

1.	Nu-lure bait or protein hydrolysate	300 ml
2.	Borax	250 g
3.	Water	4 litre

Appendix 3: Sources of Lures for Fruit Flies

1. **Cue-Lure-4- (P-acetoxyhenyl)**

(a) **PHEROMONIS INTERNATIONAL LTD.**
29 Portom Court Portsmouth Row Subiton, Surrey KT6 4HZ, ENGLAND

(b) **CONSEP MEMBRANCES, INC.**
213 South West Columbia P.O. Box 6059, Bend, Oregon 97708 U.S.A

2. **Methyl Eugenol**

(a) **BWI PLASTICS & CHEMICAL CORP.**
8820 Bellance Auenue Los Angeles, California, 90045.

(b) **CONSEP MEMBRANCES, INC.**
213 South West Columbia, P.O. Box 6059, Bend, Oregon 97708, U.S.A.

3. **Trimedlure**

   (a) **NATIONAL CHEMICAL CORP.**
   Calor Div. P.O. Box 1457.

   (b) **CONSEP MEMBRANCES, INC.**
   213 South West Columbia, P.O. Box 6059, Bend Oregon 97708, U.S.A.

4. **PIB-7 or SIB-7**

   Staley's Insecticide Bait-7, Acid Hydrolysate of Corn Protein 49% Solids, 5% water, A E. Staley's MFG Co. Decature Illinois.

5. **Nu-Lure - Ph 4.0**

   24% Amino Acids and Amino Salts, 6% Sodium Chloride, 1.4% Ammonium Chloride, MILLER CHEMICAL & FERTILIZER CORP. P.O. Box 333, Nonover, Pennsylvania 17331, U.S.A.

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Chapter 22

MITES

Wali M. Chaudhry*

INTRODUCTION

The mites comprise a large group of arthropods belonging to subclass Acari of class Arachnida. They are among the dominant animals in pastures, forests and arable soils. These tiny creatures are microscopic in size and are well distributed in all types of habitats, biotic and abiotic, throughout the world. For example, they live in salt and fresh waters, in organic debris of all kinds, on plants and animals. Some even live in caves and in thermal springs. They outnumber all other arthropods in every type of habitat. Their associations with other animals include commensalism, predation and true parasitism. They have assumed so much importance that they now are recognized as a great source of trouble for agriculture, forestry, live-stock and human beings. Heavy populations of these mites are found in all types of crops, vegetables, fruits, ornamental and wild plants, stored grains and stored products. Consequently, they cause heavy losses to the commodities at every stage among plants and animals. In the U.S.A. the research work on mites started in early 1900, and at present, more than 700 acarologists/ entomologists are actively engaged in studies on different aspects of mites alone. A good deal of reserch work is also being done in other parts of the globe as well. So far, thousands of species of mites have been collected and described alongwith their economic importance, yet it is only a small fraction of the total Acarine fauna.

Rahman and Sapra did some research work on sugarcane and vegetable mites in the united India. After Pakistan came into being (1947), Dr. Wali M. Chaudhri (Acarologist) started research work on mites under PL-480/P.A.R.C. programme during 1967. A good deal of research work has been accomplished on both harmful and useful plant mites of Pakistan.

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Revised Page No.

Three Monographs and 48 research papers have been published containing 1 new subfamily,7 new genera and about 400 new species of mites alongwith many already known species of economic importance. In addition biology of a number of mite species has been studied.

ECONOMIC IMPORTANCE

Although the activities of majority of mites are still unknown, yet, on the basis of available information, they can be classified into two main groups.

(1) Harmful mites
(2) Useful mites

1. **Harmful Mites:** The vast majority of mites are known due to their harmful activities. They infest and damage fauna and flora by their multifarious activities directly or contaminate them with their excrement, exuviae, and eggs, etc, indirectly. Their feeding habits further help to divide them into three sub-groups.

A Phytophagous mites
B. Stored grain and stored products mites
C. Parasitic mites

A. Phytophagous Mites

These mites are provided with needle-like mouth parts by which they tear plant tissues and suck the cell sap thus affecting the vitality of the infested host plants, herbs, shrubs and forest plantations. They also affect their host plants by inhibiting photosynthesis by injecting toxic substances and by transmitting disease producing micro-organisms. The majority of the phytophagous mites of economic importance belong to families, Tetranychidae, Tenuipalpidae, Eriophyidae and Tarsonemidae

In addition to these families, the members of families Tydeidae, Pymotidae, Penthalodidae and Tuckerellidae are of lesser economic importance.

The mites of major importance, about which a good deal of research work has been done in Pakistan are discussed as under:

Family Tetranychidae

Mites of the family Tetranychidae form the important group of plant feeding mites. They are found in abundance on every type of vegetation.

Commonly they are known as spider mites because they spin silken webs, covering the leaves and other parts of the plants, beneath which they breed and cause infestations. As a result of this feeding, the chloroplast disappears and white patches on leaves become prominent. These patches turn brown in later stages of intestation. The infestation also accelerates transpiration rate and causes great disturbance in water balance. These mites can exhaust 18 to 20 cells per minute. In case of heavy infestation, the leaves first curl and then drop off from the twigs. The defoliation ultimately results in poorly developed and under-sized fruit. In addition, there is also reduction in number of fruit buds. On account of the introduction of toxic substances into the plant tissues while feeding, some members also transmit plant viruses e.g Potato virus Y is transmitted by *Tetranychus urticae* (Koch.). Other viruses like Tobacco ring spot virus, Tobacco mosaic virus, Southern bean mosaic virus and Cotton curliness are apparently transmitted by this mite species as well.

The representatives of the family Tetranychidae are described as follows.

(i) *Eutetranychus orientalis* (Klein.) (Oriental red mite). It is a pest of citrus, cotton, grapes, pear, squash, and walunt, etc. This mite feeds on upper surface of leaves and produces grey spots; leaves become weak and drop off. This affects the production of the plants.

(ii) *Bryobia praetiosa* Koch.(Clover mite). it damages clover, lawn grasses, ornamental flowers, wheat, rye, barley and other grains. Foliage and floral injuries are common.

(iii) *Schizotetranychus mustafai* Mustafa and Chaudhri. (New sugarcane mite or white mite of sugarcane). It has also been recorded from rice leaves and grasses. This mite forms white webs in a straight-line on either sides of mid-rib of sugarcane leaves. All the stages of this mite (egg, larvae, nymphs, adults) are found under these webs.

(iv) *Oligonychus (Reckiella) indicus* (Hirst.) (Red sugarcane mite). Profuse webbing is done on the leaves of sugarcane and other grasses. All the stages of this mite are also found under this webbing where they feed on the leaves and produce red, irregular patches. The infestation affects the quality and quantity of the crop.

(v) *Tetranychus urticae* (Koch.) This mite is commonly known as two-spotted spider mite. This has been recorded from 150 host plants including important agricultural crops and ornamental plants. These mites are very destructive to their hosts, often killing them very rapidly.

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(vi) *Tetranychus cucurbitae* Rahman and Sapra. It is also a major mite pest and has been reported on more than 110 host plants including peach, coconut, papaya, many vegetables and fruit crops. These mites form profuse webbing on the entire plants and all the stages are found under this webbing. The feeding of these mites produce white patches on the leaves which ultimately dry up and fall off. Their infestation decreases vitality and leaf drop adversely affects growth, flowering and fruiting.

Family Tenuipalpidae

These are commonly known as false-spider mites. The genera *Aegyptobia, Brevipalpus, Cenopalpus, Dolichotetranychus, Raoiella, Larvacarus* and *Tenuipalpus* of this family are of economic importance, as they infest and damage agricultural and horticultural crops, ornamental and wild plants. These mites are redish in colour, small in size and slow in movement. They usually feed near the mid-rib or veins of the leaves. Some species feed on bark, floral heads or under leaf sheaths of grasses. Some of the species viz., *Larvacarus transitans* (Ewing) form galls within which they feed.

A few representatives of this family are described as under:

(i) *Brevipalpus phoenicis* (Geijskes). It is an important pest of citrus and tea. It has also been recorded from coffee, peach, grapes. More than 50 genera of ornamental plants are also infested by this mite. It is world-wide in distribution.

(ii) *Brevipalpus californicus* (Banks). It is a widely distributed pest and causes serious injury to many plants of agricultural importance and ornamental plants. Due to feeding of these mites, silvery areas appear on the leaves which become brown. In case of severe infestation, the leaves become yellow and drop from the plants. They feed on all parts of the plants.

(iii) *Raoiella indica* Hirst. It is a serious pest of coconut, date-palm other palms. It attacks the young plants which show sickly yellowish appearance

(iv) *Larvacarus transitans* (Ewing). It forms galls on ber (*Zizyphus jujuba*) twigs. All the stages are found within galls.

Family Eriophyidae

Eriophyid mites are exclusively phytophagous. They are commonly known as gall mites/ blister mites/ rust mites/ or bud mites. They are found on all types of crops, vegetables, fruit plants, ornamental plants, and grasses.

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They deform and russet leaves and fruits. Edge-rolling, and furrowing in leaves, damaging and killing of new buds, blistering and brooming of fruits are caused by these mites.

Some inject toxic material alongwith saliva into leaf cells which either discolour these leaves or change growth pattern of the affected cells and this results in abnormal development of leaves, buds, etc.

Some of these mites are responsible for the transmission of certain plant viruses and diseases; e.g., wheat streak mosaic, current reversion disease, wheat spot mosaic, fig mosaic, rye grass mosaic, peach mosaic and latent virus of plum.

The representatives of this family are as under:

(i) *Phytoptes pyri* Payenstecher. (Pear leaf blister mite or Pear bud mite). It affects apples and pears. They reproduce disintegration blisters in leaves, cause bud deterioration or actually kill buds.

(ii) *Eriophyes sheldoni* Ewing. (Citrus bud mite). It infests citrus gardens all over the world. Its feeding often kills the entire bud. Blasting of the adventitious buds check twig growth and blossom development or results in inferior type of growth. There is no proper growth of plant parts. Fruit from damaged flowers may drop permanently or assume an abnormal shape.

(iii) *Eriophyes mangifera* (Sayed). (Mango bud mite). The feeding of this mite stunts and brooms twigs, causing bud proliferation. Young trees are seriously affected.

(iv) *Metaculus mangifera* (Attiah). (Mango rust mite). It causes russetting of terminal leaves, buds and inflorescences. Injury to young seedlings is called "bunchy top". Buds and inflorescens stop growing and ultimately dry off. There is compact mass of malformed flowers.

(v) *Eriophyes tulipae* Keifer. (Wheat curl mite or Dry bulb mite). It damages agricultural plants by feeding and carries plant viruses like wheat streak mosaic, wheat spot mosaic. Onion and garlic bulbs are also infested by these mites.

Family Tarsonemidae

Many species of tarsonemid mites are considered to be of agricultural importance. The first definite record of tarsonemid damage to an agricultural crop was made in 1877, when *Steneotarsonemus bancrafti* (Michael) was recorded as sugarcane pest in Queensland. Some tarsonemid mites act as parasites of scale insects and others have parasitic relationship to higher animals including man. Some of these mites are known as fungus feeders.

The mouth appendages of tarsonemid mites cannot penetrate the hard tissues of plants as palpi are quite reduced and chelicerae are simple and styliform. These appendages are suitable for thin-walled and lignified tissues of mature stems and leaves. Some of the tarsonemid mites inject toxic substances during feeding alongwith saliva which results in abnormal tissue growth of the host plants.

The representatives of the family are as under.

(i) *Polyphagotarsonemus latus* (Banks) (Broad mite/Yellow tea mite/Tropical mite). This mite attacks more than 50 agricultural crops, ornamental and wild plants. It has been recorded on cotton from Pakistan. These feed on the lower surface of the leaves. The attacked leaves become rigid and rolled under at the edges. There is sudden curling and crinkling of leaves followed by blister-like spots. Plants which are heavily attacked by these mites stop growing and die.

(ii) *Steneotarsonemus bancroftae* (Michael) (West Indian sugarcane mite). It is most specific and feeds on sugarcane and has been recorded from Pakistan. Feeding injuries by these mites allow the entry of red rot spores. The fungal spores establish red rot disease among sugarcane leaves and plants.

(iii) *Tarsonemus setifer* Kseng (White tailed mite). It attacks and damages citrus, pomegranate, strawberry, peach, grapes, balckberry, raspberry and many ornamental plants in the world. This species has been recorded from Pakistan on citrus and pomegranate.

(iv) *Luxomotarsonemus mycelophagus* (Massey). This mite is a serious pest of mushroom culture. Significant damage occurs when the initial infestation takes place soon after spawning.

B. Stored Grain and Stored Products Mites

The stored grain and stored products mites are included in families Tyroglyphidae, Saproglyphidae, Histiostomatidae and Acaridae belonging to sub-order Sarcoptiformes. These mites occupy a highly specialized biome. Almost all the species included in this group are of economic importance as they infest and damage stored grains, cheese, flour, seeds, bulbs, tubers, roots, dry fruits of all kinds, vegetables and dried plants. These mites penetrate the seed, eat away cavities where further development and multiplication of mites take place and the embryo is completely eaten away. This happens when relative humidity is up to 17% in the grains.

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These mites also contaminate the grains, raise the moisture contents, generate heat, filling of spaces between grain with mass of mites, cast skins and excrements. These hinder the circulation of air throughout the stacks and facilitate the appearance of bacterial and fungal infections. Flour prepared from the affected grains has a higher moisture content, a higher hygroscopicity, is more acidic, grains tend to stick togther, give fusty or stagnant smell, a bitter taste and consequently its baking properties get deteriorated.

Dispersal: Biologically speaking, majority of stored grain and stored products mites are restricted in activity, being clumsy, slow in movement and almost incapable of covering large distances by themselve. These mites move only in their adopted micro-climate. The existence of a hypopial stage in this group serves as a buffer to withstand adverse environmental and climatic conditions. The suckers on the ventral side, of hypopial stage facilitate its attachment to the phoretic hosts including insects, animals and other materials. Thus, they reach almost always a favourable environment for further development and breeding.

The representatives of stored grain and stored products mites are as under:

(i) *Rhizoglyphus echinopus* (F. and R.) (Bulb-mite). It attacks the bulbs of all kinds of decorative and vegetable plants, the tubers of potatoes, beetroots and other root vegetables, in the soil and also in stores. It makes tunnels into the bulb, touching the embryo shoot which is often consumed away. When the bulb is opened, it is found to be filled with a brownish or black frass having all developmental stages of the mite, their cast skins and excrement. Shipments of bulbs are usually infested with this mite. The spores of pathogens are also carried by these mites from one bulb to the other.

(ii) *Tyroglyphus farinae* L., *Tyrophagous noxius* A.Z. and *Tyrophagous perniciousus* A.Z.

These mites are the most serious destroyers of grains. They damage the flour and other grain products. Besides eating the flour, they also cause spontaneous 'wetting' and infection with micro-organisms which quickly leads to a spoiling of the flour and a lowering of its nutritive and baking qualities and is not suitable for use.

(iii) *Tyrophagus Entneri* (Osborne). It is widely distributed and is serious in stored food. It attacks the cultivated mushrooms, eats the spawn,

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makes holes in the stems and caps of the mushrooms and seriously hinders the mushrooms culture.

(iv) *Carpoglyphus lactis* (L.). This mite is widely distributed and is found on dried fruits, milk products, glucose, decaying potatoes, flour and many other food products.

C. Parasitic Mites

Parasitic mites produce irritation, painful dermatitis, itching, blood anemia, inhibit lungs, sinuses and nasal passages, cause nervous reactions of serious nature, swelling in lung tissues, coughing, sneezing, etc., both in animals and human beings.

A number of species are external or internal parasites and are well distributed throughout the world. They parasitize a variety of wild and domesticated animals. In case of severe infestations, they may cause the death of their hosts. Some of these mites act as disease vectors and transmit viruses among animals. A considerable number of parasitic mites are on record in which they become infected while feeding on an infected host and transmit it to others. It is reported that the mites can retain viruses in their body for years. The time for retension varies from few days to years, depending upon nature of virus and species of mites carrying the viruses. Viral transmission to next generation is also vital characteristic of some speeies of this group.

The major parasitic mites are of families Dermanyssidae, Trombiculidae and Sarcoptidae. Some Mesostigmatic and feather mites are well-known for their parasitic nature. Some parasitic mites are also of the Uropodidae, Halarachnidae, Psoroptidae, and Erythraeidae families.

The representatives of parasitic mites are as under:

(i) *Dermanyssus gallinae* (DeGeer). It is cosmopolitan in distribution. It parasitizes chicken and many species of wild and domesticated birds. It also attacks man causing painful skin irritation by its bite. Heavy infestation in poultry birds can cause the death of the hosts, while light infestations reduce egg production and retard growth. They feed at night. Sometimes, they are so many in nests that brooding hens leave their eggs. These mites can transmit the virus St.Louis Encephalitis. It can be retained in the body up to 5 month after propagation.

(ii) *Sarcoptes scabeii* (DeGeer). It is commonly known as itch-mite. It attacks and infests man and other animals such as dogs, cattle, pigs, sheep,

goats, camels, rabbits and horses. The fertilized female causes most of the trouble, tunneling just beneath the surface, laying eggs as she progresses. Some larvae and nymphs burrow but others are also found stuck in the hair follicles or on the skin surface. Males scarcely burrow and mostly stay on surface.

(iii) *Acaropsis woodi* (Rennie). Acarine disease of honey bees is caused by this mite called "Isle of Wight Disease". One form of this mite, lives in the tracheae and the other form lives externally. The damage to bees is due to mechanical injuries to the wing joints and not to the tracheae. Symptoms of this disease are : bees crawling or running on the ground in front of the hive and in the presence of dead bees, infected bees cannot fly and die from weakness and starvation. Entire apiaries are destroyed by these mites

2. Useful Mites: There is a large group of Acari which are recognized due to their beneficial contributions. Most of them are potentially important and play a leading role in the biological control of harmful mites, scale-insects and small insects, as a biotic component in pest control strategies.

In addition to these mites, there are some other known mite species of beneficial nature which play an important role in the decaying process of organic matter in the soil as well e.g. members of the family Oribatidae. In studies of soil fauna, there is an indication that the mites of the family Oribatidae, which constitute the high prercentage of the fauna, are important factors in promoting soil fertility through breaking down organic matter by digestion as do the earthworms.

The predatory mites are found among harmful mites and small insects. The species playing a leading role as biological control agents belong to families Anystidae, Bdellidae, Caligonellidae, Cryptognathidae, Cheyletidae, Cunaxidae, Raphignathidae, Stigmaeidae (suborder Trombidiformes) and Phytoseiidae (suborder Mesostigmata). These families contain valuable strains of predacious nature.

The representatives of these mites are as under:

(i) *Gnorimus tabella* Chaudhri. This is found feeding on tetranychid and tenuipalpid mites attacking cotton, other crops, vegetables and fruit plants.

(ii) *Amblyseius finlandicus* (Oudemans). This feeds on *Panonychus ulmi*(Koch.) damaging apple.

(iii) Citrus is attacked by *E.sexmaculatus* and is contolled biologically by a predatory mite, *T. floridanus* Muma.

(4) *Agistemus fleschneri* Summers helps the control of *Panonychus ulmi, Tetranychus cinnanbarium* and *T. kanzawai.*

(5) *Paracheyletus wellsi* (Baker) is a notable predatory mite, favouring fruit, leaves, bark of citrus plants and the litter under the trees; frequently it feeds on the harmful mites of families Tetranychidae and Tenuipalpidae.

(6) *Cheyletus eruditus* (Schrank). This is commonly found in association with acarid mites of stored grains and their derivatives; usually feeds on mite species of family Acaridae.

(7) *Biscirus lapidorius* (Kramer). This has been found controlling the lucerne flea.

(8) *Bdella* sp. This species occurs commonly on orange trees and is predacious on Collembola.

TAXONOMY OF MITES

In this section diagnostics of each genus of a family are followed by the name of type species and listing of various species along with host plants and localities wherefrom the species have been recorded so far.

Family Tetranychidae

GENUS *ANAPLONOBIA* WAINSTEIN

Diagnosis:

1. Dorsal setae 13 pairs including all setae well separated, not on strong tubercles.
2. Peritreme anastomosing distally.
3. Tarsi I and II each with 2 and 1 set of duplex setae, respectively.

Type Species: *Aplonobia calame* Pritchard and Baker

Name	Host Plant	Locality
1. *Anaplonobia contigus* Chaudhri	*Cynodon dactylon*	Lahore

GENUS *ANTETRANYCHUS* WOMERSLEY

Diagnosis:

Superficially this genus appears similar to genus *Oligonychus* but differs in the following points:

1. Para-anal setae, 2 pairs
2. Empodiai claw bare, not having ventrally directed proximoventaral hairs.

Type Species: *Anatetranychus hakea* Womersley

Name	Host Plant	Locality
1. *A. daleae* Tuttle and Baker	*Acacia nilotica*	Bahawalpur Lahore

GENUS *APONYCHUS* RIMANDO

Diagnosis:

1. Body subovate to elongate, dorsum finely granulate.
2. Stylophore with a pair of strong lobes distoventrally and mediodorsal protuberance or a convex area.
3. Dorsal setae, 13 pairs, broadly spatulate.
4. Legs attenuate having broad, serrate, tactile setae on proximal segments, slender and pointed setae on distal segments.
5. Empodium simple, reduced to knob-like protuberance.
6. Anal setae, 1 pairs.

Type Species: *Aponychus corpuzae* Rimando

Name	Host Plant	Locality
1. *A. lupus* Chaudhri	*Acacia modesta, Cannabis sativa*	Hasanabdal
	Arundo donax	Balkot 3500, Bhakkar, Cheechawatni, Choa Saiden Shah, Hasan-

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	Name	Host Plants	Locality
			abdal,Lala Musa, Sargodha, Sheikhupura, Charrapani 3500', Mansehar 3000', Mian Chanau, Samasata
		Malvastrum sp., *Morus alba*, *Withania somnifera*.	Sargodha
		Thysanolaena maxima	Dadar 4000', Kghi 3000'
2.	*A. sulcatus* Chaudhri	*Arundo donax* *Boerhavia procumbens*	Sheikhupura Attock
3.	*A. expansus* Chaudhri	*Acacia nilotica* *Arundo donax*	Choa Saiden Shah Hasanabdal

GENUS *BAKERINA* CHAUDHRI

Diagnosis:

1. Dorsal setae, 13 paris, pointed/bluntly pointed/ broadly pointed; barbed.
2. Peritreme simple, slightly hooked.
3. Propodosoma with reticulations in middle and fine dashes within reticulations; minute alveoli in lining of each reticulations (dimple) impart granular texture to its periphery; laterally irregular striations have dimpled appearance.
4. Dorsum hysterosoma with irregular striations.
5. Sacral setae not marginal.
6. Venter with simple striations.
7. Pre-genital, genital, anal 1 pair, 2 pairs and 2 pairs setae, respectively.

Type Species: *Bakerina lepidus* Chaudhri

Key to Pakistan Species of genus *Bakerina* Chaudhri

1. Dorsal setae pointed, lanceolate,barbed; tibia I without lanceolate, seta; tibia I, tarsi I, III and IV with 10, 15, and 9 setae,respectively..... 2
   Dorsal setae bluntly/broadly pointed, barbed; tibia I with 3 lanceolate setae; tibia I, tarsi I, III and IV with 9, 14, 10 and 10 setae, respectively..... 3

2. Peritreme slightly hooked; central seta I reaches base of II ..... *B.lepidus* Chaudhri

   Peritreme hooked; central seta I falls short of distance between I-II setae ..... *B.aculus* Chaudhri

3. Peritreme not bulb-like; dorsal setae broadly pointed..... *B.carracis* Chaudhri

   Peritreme bulb-like; dorsal setae bluntly pointed.... *B.normalis* Chaudhri

	Name	Host Plant	Locality
1	*B.lepidus* Chaudhri	*Acacia nilotica* *Albizzia lebbek,* *Salvadora oleoides.*	Multan
2	*B.aculus* Chaudhri	*Salvadora oleoides*	Abdul Hakim
3.	*B.carracis* Chaudhri	*Celtis* sp.	Kohala 3000'
4.	*B.normalis* Chaudhri	*Capsicum* sp.	Balakot 3500'

GENUS *BRYOBIA* KOCH

Diagnosis:

1. Propodosomal setae 4 pairs projection present or absent.
2. Peritreme simple or anastomose distally.
3. True claws uncinate, claws with tenent hairs.

4. Empodium pad-like with tenent hairs; empodium I with 1 or 2 pairs tenent hairs; empodia II-IV each with rows of tenent hairs.

Type Species: *Bryobia praet osa* Koch.

	Name	Host Plant	Locality
1	*B eharai* Pritchard and Keifer	*Chrysanthemum morifolium*	Pirmahal, Rawalpindi
2	*B.longisetis* Reck	*Salvia* sp.	Abbotabad 3500′
3	*B.praetiosa* Koch	*Iberis amara*	Abbotabad 3500′
		Prunus persica	Aliot 6000′
		Daphne papyracea,	Basian (Murree)
		Ranunculus laetus	4000′
		Chrysanthemum sp.	Attock
		Fumaria indica, *Lycium europaeum*, *Peristrophe paniculata*, *Pschschoizia californica*	Changa Manga Forests
		Justicia adhatoda, *Peristrophe* sp., *Prunus domestica*	Charrapani 4500′ Murree 7500′ Samli 3500′
		Alternanthera sp.	Khanewal
		Chaerophyllum sp., *Pyrus* sp., *Taxus wallichiana*	Kuldana (Murree) 7500′
		Tagetes tenuifolia,	Lahore, Pirmahal
		Alnus nitida	Mansehra

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Name	Host Plant	Locality
	Helianthus annuus	Multan
	Carsus sp.,Cotoneaster bacillaris, Ficus palmata, Indigofera heterantha, Crataegus monogyna, Geranium sp.,	Murree 7500′
	Lonicera sp , *Pyrus communis, Rhamnus virgata, Dianthus* sp., *Pinus* sp., *Prunus domestica*	
	Abies pindrow, Hedera nepalensis, Lonicera sp., *Pinus wallichiana, Sarcocca* sp.	Nathiagali 9000′
	Nerium indicum	Rajana Forest
	Achyranthes aspera, Heliotropium curassavicum Malus parviflora, Coronopus didymus, Verbascum thapsus,	Rawalpindi
	Pyrus communis	Rawat 4000′
	Debregeasia salicifolia Pyrus communis, Pyrus malus	Samli 3500′
	Cupressus sempervirens	Sialkot

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GENUS *EUTETRANYCHUS* BANKS

Diagnosis:

1. Empodium is lacking, only a rosended knob
2. True claws lacking, each point with a pair of tenent hairs.
3. Tarsus I with a pair of loosely associated setae that lay by homologans with the duplex setae

Type Species *Tetranychus banksi* McGregor, 1919

	Name	Host Plant	Locality
1.	*E.orientalis* (McGregor)	*Acacia modesta*, *Acer* sp	Havelian
		Acacia nilotica, *Tagetes tenuifolia*	Choonian
		Ailanthus excelsa, *Cannabis* Vigna unguiculata ssp. cylindrica beans	Lahore
		Albizzia procera *Amarnius* sp., *Althea rosea*	Basirpur,Bhakkar, Muzaffargarh Sadiqabad Cheechawatni, Sheikhupura
		Azadirachta indica	Bhakkar, Lahore
		Boerhavia procumbens	Attock
		Blumea membranacea, *Calotropis procera*, *Grewia tenae* *Tagetes tenuifolia*	Faisalabad
		Cassia occidentalis, *Kochia indica*	Shorkot Forest

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Name	Host Plants	Locality
	Cassia holosericea, Nerium indicum	Karachi
	Cassia sp	Pirowala Forest
	Chrysanthemum morifolium.	Basirpur, Rawalpindi
	Citrus limon	Bhakkar, Campbell-pur, Muzaffargarh, Sargodha, Sheikhpura
	Citrus sinensis	Nia Lahore, Okara
	Citrus sp., *Malvastrum Coromendelianum, Ricinus communis*	Okara
	Dahlia pinnata	Hasanabdal
	Ficus polmatus	Saido Sharif (Swat) 3500′
	Gossypium hirsutum	Abdul Hakim, Basirpur
	Gynandropsis gynandra	Choa Saiden Shah
	Helianthus annuus, Mentha piperita, Solanum nigrum, Withania somnifera,	Multan

(Cont'd)

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	Name	Host Plants	Locality
		Ipomoea sp., *Lathyrus odoratus, Pongamia pinnata*	Faisalabad, Jauharabad, Multan
		Lantana camara	Sheikhupura
		Luffa acutangula, Mollugo sp., Morus alba, Ricinus communis	Basirpur, Changa Manga, Lahore, Lyallpur(Faisalabad) Sargodha.
		Melia azedarach	Attock, Choonian, Talagang.
		Moringa oleifera	Bahawalpur
		Phoenix dactylifera	Bhakkar
		Prunus amygdalus	Mansehra
		Prunus persica	[illegible]ara, Sadiqabad
		Ricinus communis	Rahim Yar Khan
		Salvadora oleoides	Vehari
		Solanum nigrum	Rohri
		Tamarix aphyla	Alipur, Gatwala
		Verbena bonariensis	Sargodha
2.	*E.mirpuriensis* Chaudhri	*Cassia fistula*	Mirpur Khas

GENUS *GEORGIOBIA* WAINSTEIN

Diagnosis:

1. Dorsal setae 13 pairs including 1 pair humeral setae.
2. All setae on strong tubercles.
3. Peritreme anastomosing distally.
4. Empodium pad-like, with a row of tenent hairs.
5. Claws pad-like, each with a pair of tenent hairs.

Type Species *Petrobia shirakensis* Reck, 1960.

Name	Host Plant	Locality
Georgiobia hyderabadiensis Chaudhri	*Pseudo fruticosa*, undet. No. 1/71	Hyderabad

GENUS *OLIGONYCHUS* BERLESE

Diagnosis:

1. Single pair of para-anal setae.
2. Empodium claw-like, with proximoventral hairs set at right angles to the claw.
3. Dorsal setae with or without tubercles

Type Species: *Heteronychus brevipodus* Targioni Tozetti

	Name	Host Plant	Locality
1.	*O. (O) longus* Chaudhri	Undet No. 1/71	Lahore
2.	*O. (R) pratensis* (Banks)	*Hibiscus esculentus*	Kabal (Swat) 3500′

GENUS *PANONYCHUS* YOKOYAMA

Diagnosis:

1. Dorsal body setae, serrate and set on strong tubercles.
2. Dorsal setae, 13 pairs including 1 pair humeral setae.
3. Claws pad-like, each claw with a pair of tenent hairs.

4 Empodia claw-like, each empodium with 3 pairs proximoventral setae

Type Species. (*Panonychus mori* Yokoyama) = *Panonychus citri* (McGregor)

	Name	Host Plant	Locality
1.	*Panonychus citri* (McGregor)	*Debregeasia salicifolia*	Balakot 3500′

GENUS *PARAPLONOBIA* WAINSTEIN

Diagnosis:

1. Dorsal setae 13 pairs including 1 pair humerals; not on strong tubercles, well separated, serrate, may be short and broadly calvate.
2. Peritreme simple in subgenus *Paraplonobia* whereas it is anastomose in subgenus *Langella*
3. Tarsal claws and empodia pad-like each with tenent hairs

Type species. *Aplonobia (Paraplonobia) echinopsis* Wainstein

	Name	Host Plant	Locality
1.	*P (P.).penicillatus* Chaudhri	*Atriplex crassifolia* *Kochia indica*	Mian Channu Shorkot Forest
2.	*P. (L.) concolor* Chaudhri	*Pennisetum* sp	Sarai Krishna (Thal)
3.	*P (L.) daryaensis* Chaudhri	*Panicum* sp.	Darya Khan

GENUS *PORCUPINYCHUS* ANWAR ULLAH

Diagnosis:

1. Dorsal setae 13 pairs including 1 pair humerals; not on strong tubercles, well separated, serrate, may be short and broadly clavate.
2. Peritreme simple in subgenus *Paraplonobia* whereas it is anastomose in subgenus *Langella*.
3. Tarsal claws and empodia pad-like each with tenent hairs.

3. Peritreme anastomosing, distally forming a ball like structure.

Type Species *Porcupinychus abutiloni* Anwar Ullah, 1966

	Name	Host Plant	Locality
1.	*P. abutiloni* Anwar Ullah	*Alhagi camelorum*, *Cassia holosericea*, *Cupressus sempervirens*, *Euphorbia* sp., *Malvastrum* sp., *Nerium indicum*, *Petunia alba*, *Pithecolobium dulce*, *Prosopis spicigera*	Karachi

GENUS *PETROBIA* MURRAY

Diagnosis:

1. Dorsal body setae 14 pairs (Propodosomals 3 pairs, hysterosomals 10 pairs including 1 pair humerals).
2. Dorsal setae may be short and not on tubercles: may be long and on strong tubercles/not on strong tubercles.
3. True claws pad-like, each claw with a pair of tenent hairs.
4. Empodium uncinate, with 2 rows of ventrally directed tenent hairs.

Type Species. (*Trombidium lapidum* Hammer) = *Petrobia latens* (Muller), 1877

	Name	Host Plant	Locality
1.	*P.(P.) latens* (Muller)	*Althea rosea*	Jauharabad
		Mentha incana	Balakot 3500′
		Undet. No. 7/71	Murree 7500′
2.	*P (T.) tribulus* Chaudhri	*Cynoglossum lanceolatum*	Changa Manga
3.	*P.(T.) cardi* Chaudhri	*Lamium* sp.	Abbotabad 3500′
4.	*P.(T.) nocitus* Chaudhri	Undet. No, 2/70	Abdul Hakim

GENUS *TETRANYCHUS* DUFOUR

Diagnosis:

1. Dorsal setae 13 pairs including 1 pair humeral setae.
2. All setae serrate, pointed, without tubercles. Longer than distance between them.
3. Striations longitudinal on propodosoma, transverse on hysterosoma except in between III central setae and some times inner sacral setae.
4. Para-anal setae, 1 pair.
5. Empodium with free proximoventral hairs and if a claw like dorsal member is present, it is much shorter than the hairs.
6. Aedeagus always bends dorsally.

Type Species. *Tetranychus lintearius* Dufour, 1832

	Name	Host Plant	Locality
1	*T. uriticae* Koch	*Bidens pilosa*	Dadar 4000'

GENUS *TETRANYCOPSIS* CANESTRINI

Diagnosis:

1. Dorsal setae 16 pairs including humerals
2. All body dorsal setae serrate, set on strong tubercles.
3. Claws long and pad-like, each with 2 rows of short tenent hairs.
4. Empodia resemble the claws.

Type Species: *Tetranychus horridus* C. and F., 1889.

Name	Host Plants	Locality
Tetranycopsis naraniensis Chaudhri.	Undet. No. 2/72.	Naran (Kaghan Valley) 8000'

FAMILY TENUIPALPIDAE

Diagnosis:

1. Its mites are provided with U-shaped stylophore.
2. Chelicerae needle-like.

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3. Palpus simple, 1-5 segmented; terminal segment with a rod-like process and generally with 1 or 2 setae
4. Propodosoma always with 3 pairs setae.
5. Dorsal side rarely smooth but ornamented with striations or reticulations.

The mite species of the following genera of family Tenuiplapidae, have been collected from Pakistan.

Genera of Family Tenuipalpidae
(Found in Pakistan)

1.	Genus *Aegyptobia*	Sayed, 1950.
2.	Genus *Amissus*	Chaudhri, 1974
3.	Genus *Brevipalpus*	Donnadieu, 1875
4.	Genus *Cenopalpus*	Pritchard and Baker, 1958
5.	Genus *Colopalpus*	Pritchard and Baker, 1958
6.	Genus *Pentamerismus*	McGregor, 1949.
7.	Genus *Pseudoleptus*	Bruyant,
8.	Genus *Raoiella*	Hirst, 1924.
9	Genus *Tenuipalpus*	Donnadieu, 1875

GENUS *AEGYPTOBIA* SAYED

Diagnosis:

1. Presence of rostral shield.
2. Four pairs sublateral setae.
3. Palpus with 5 segments.

Type Species: *Aegyptobia tragardhi* Sayed, 1950

Key to Pakistan species of genus *Aegyptobia*
(Females)

1. Dorsal shield with a notch..... 2
   Dorsal shield without a notch..... 6
2. Dorsal setae setiform, simple..... *A. monitus* Chaudhri
   Dorsal setae spatulate..... 3

3. Dorsal setae spatulate, smooth; rostral shield deeply notched..... 4
   Dorsal setae spatulate, margins dentate; rostral shield slightly notched . ... *A.hamus* Chaudhri
4. Genua I-IV with 3-3-0-0 setae; few cells between sublateral setae II and III .... *A. forma* Chaudhri
   Genua I - IV with 3-3-0-0 setae; striations beween sublateral setae II and III.... 5
5. Palp segment IV with 1 seta; trochanters I-IV with 1-1-2-1 setae; femora I-IV with 4-4-2-1 setae. .... *A. leiahensis* Chaudhri
   Palp segment 4 with 2 seate; trochanters I-IV with 1-1-1-1 setae; femora I-IV with 3-3-2-1 setae.... ..... *A. semper* Akbar and Chaudhri
6. Rostral shield convex anteriorly, not bifurcated..... *A. nummulus* Chaudhri
   Rostral shield with 3 concave and 2 convex areas anteriorly..... *A. salubris* Chaudhri

	Name	Host Plants	Locality
1.	*A. monitus* Chaudhri	*Medicago* sp	Karachi
		Ipomoea batatus	Kotri
		Eriobotrya japonica	Muzaffargarh
2.	*A. hamus* Chaudhri	*Cassia glauca*,	Karachi
		Heliotropium sp.	
		Cassia fistula	Chakwal
		Thuja orientalis	Tandojam
3.	*A. forma* Chaudhri	*Artemisia scoparia*	Hassanabdal, Islamabad
		Undet No. 29/70	Karachi

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	Name	Host Plant	Locality
4.	*A. leiahensis* Chaudhri	*Salvadora* sp. *Heliotropium* sp. *Morus alba*	Jhang Leiah Mianwali
5.	*A. semper* Akbar and Chaudhri	Undet No. 9/80	Garam Chashma (Chitral)4000′
6.	*A. nummulus* Chaudhri	*Cupressus sempervirens*	Abbotabad, 3500′; Mian Channu, Pakka Anna, Pindi Bhatian, Samli, 4500′ ,Treemu.
		Dodonaea viscosa, *Thuja orientalis.*	Treemu
7.	*A. salubris* Chaudhri	*Cupressus* sp. *Morus alba*	Multan Faisalabad.

The type specimens of these mite species have been deposited in Acarology Museum, Department of Entomology, U.A.F.

GENUS *AMISSUS* CHAUDHRI

Diagnosis:

This genus resembles genus *Breviplapus* due to: number of setae on palptarsus; dorsal chaetotaxy; ornamentation and legs chaetotaxy. This genus differs from *Brevipalpus* due to:

1. Very broad deep notch of rostral shield.
2. Central seta III longer than I and II central setae.
3. Absence of posterior medioventral metapodosomal setae.
4. Absence of membranous folds around ventral and genital shields.

Type Species: *Amissus ochaliensis* Chaudhri

	Name	Host Plant	Locality
1.	*Amissus ochaliensis* Chaudhri	*Justicia adhalida*	Ochali 3000′

GENUS *BREVIPALPUS* DONNADIEU

Diagnosis:

1. Body small, egg-shaped, reticulated
2. Palpus 4 segmented
3. Rostral shield present
4. Sublateral hysterosomal seta absent

Type Species: *Brevipalpus obovatus* Donnadieu

Key to Pakistan species of genus *Brevipalpus*
(Females)

The species collected and given in this key belong to *cuneatus, californicus, obovatus* and *phoenicis* groups of the genus *Brevipalpus*.

1. Dorsolateral hysterosomal setae, 6 pairs 2
   Dorsolateral hysterosomal setae, 5 pairs 3

2. Dorsocentral hysterosomal setae, 3 pairs; tarsus II with 1 sensory peg..... .... 4. (*cuneatus* group)
   Dorsocentral hysterosomal setae, 3 pairs; tarsus II with 2 sensory peg..... ..... 7.(*californicus* group)

3. Dorsocentral hysterosomal setae, pairs; tarsus II with 1 sensory

	peg	11.(*obovatus* group)
	Dorsocentral hysterosomal setae, 3 pairs; tarsus II with 2 sensory pegs	19.(*phoenicis* group)
4.	Genua I-IV with 1-1-1-1 setae.....	*B. dosis* Chaudhri
	Genua I-IV with 3-3-1-1 setae.....	5
5.	Rostral shield reticulated; trochanters I-IV with 1-1-1-1 setae.	*B. plexus* Chaudhri
	Rostral shield not reticulated; trochanters I-IV with 1-1-2-1 setae	6
6.	Rostral shield simple	*B. favus* Chaudhri
	Rostral shield with striations....	*B. clypealis* Siddiqui et al.
7.	Rostrum reaching genua I.....	8
	Rostrum reaching femur I.....	9
8.	Trochanters I-IV with 1-1-1-0 setae; tibiae I-IV with 5-5-3-2 setae	*B. rica* Chaudhri
	Trochanters I-IV with 1-1-2-1 setae; tibiae I-IV with 5-5-3-2 setae..	*B. hashmii* Chaudhri and Akbar
9.	Rostral shield striated with 3 lateral lobes on each side; hysterosoma with transverse lines medially...	*B. californicus* (Banks)
	Rostral shield wihtout striations, with 4 lateral lobes on each side; hysterosoma with reticulations medially	10
10.	Genital shield setae lanceolate, serrate; anal shield reticulated.....	*B. disparis* Chaudhri and Akbar

Genital shield setae setiform,
simple, anal shield striated... ..... *B. juncas*, Chaudhri and Akbar

11. Trochanters I-IV with
1-1-1-0 setae 12
Trochanters I-IV with
1-1-2-1 setae 14

12. Rostral shield with 1 median and
3 lateral lobes on each side;
gential and anal shields striated..... *B. mingoraensis* Chaudhri and Akbar

13. Trochanters I-IV with 1-1-1-0
setae, ventral shields with
a deep notch caudally. ..... *B. ornantis* Chaudhri and Akbar

Trochanters I-IV with 1-1-1-1
setae; ventral shield without
notch caudally .... *B. obovatus* Donnadieu

14. Ventral and gential shields
striated.... 15
Ventral and genital shields
reticulated. 17

15. Trochanters I-IV with 1-1-2-0
setae .... *B. recula* Chaudhri
Trochanters I-IV with 1-1-2-1
setae 16

16. Rostral shield striated with
3 lateral lobes on each side..... *B. persicanus* Chaudhri
Rostral shield pitted with
4 lateral lobes on each side..... *B. spurcus* Chaudhri

17. Palpus terminal segment with
1 sensary rod and 2 setae ..... *B. amicus* Chaudhri

Palpus terminal segment with
1 sensory rod and 1 seta 18

18. Rostral shield pitted, ventral
shield reticulated entirely..... *B. solidus* Chaudhri and Akbar

Rostral shield striated; ventral
shield striated anteriorly . . .. *B. ventus* Chaudhri and Akbar

19. Hysterosoma with striations 20
Hysterosoma with reticulations..... 25

20. Propodosoma striated
mediolaterally... 21
Propodosoma reticulated
mediolaterally 22

21. Rostral shield simple with 3
lateral lobes on each side ..... *B. creber* Chaudhri
Rostral shield with striations,
2 lateral lobes on each side ..... *B. apalos* Chaudhri and Akbar

22. Rostral shield simple with 4-5
lateral lobes on each side 23
Rostral shield with less
than 4 lateral lobes on each side..... 24

23. Ventral shield reticulated
entirely; genital shield
setae serrate ... . *B. rugulosus* Chaudhri
Ventral shield without
reticulations medially;
genital shield setae simple..... *B. utriculus* Chaudhri and Akbar.
24. Dorsal setae on femora I and II
longer than width of segment;
genital shield striated..... *B. karachiensis* Chaudhri
Dorsal setae on femora I and II

smaller than width of segment;
gential shield reticulated .... *B. ziaii* Chaudhri and Akbar

	Name	Host Plants	Locality
1.	*B. dosis* Chaudhri	*Olea ferruginea*	Faisalabad
		Citrus sp	Jhang
2.	*B. plexus* Chaudhri	*Morus alba*	Rawalpindi
3.	*B. favus* Chaudhri	*Withania somnifera*	Faisalabad (Satiana)
		Eriobotrya joponica	Hassanabdal
		Maytenus royleanus	Taxilla
4.	*B. clypealis* Siddiqui Chaudhri and Akbar		
5.	*B. rica* Chaudhri	*Magnolia grandiflora*	Alipur, Abdual Hakim
		Withania somnifera	Chak Jhumra, Kamalia, Sadiqabad, Sargodha, Sukhekee
		Acacia nilotica	Chakwal, Charrapani 4500′
		Jasminum sambac	Changa Manga
		Tecoma grandis	Changa Manga
		Turmeric	
		Lawsonia inermis	Choonia,Faisalabad.
		Ocimum basilicum	Karachi
		Bambusa bambos	Kasur,
		Caesalpinia bonducella	Kasur,
		Conyza ambigua	Hyderabad,
		Heliotropium sp.	Hyderabad
		Cassia sp.	Lahore, Cheechawatni
		Peristrophe paniculata	Lahore
		Tagets tenuifolia	Multan, Muzaffargarh, Okara, D.G. Khan,

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	Name	Host Plants	Locality
		Momordica charantia	Muzaffargarh,
		Eclipta alba,	Okara,
		Phoenix dactylifera,	Okara,
		Vitis vinifera,	Okara,
		Cassia purpurea	Rahim yar Khan, Rajanpur
		Helianthus annuus	Sargodha, Lalian
		Azadirachta indica	
		Arundo donax	Karachi, Sukhe kee
6	*B. hashmii* Chaudhri and Akbar	*Cucurbita peppo*	Faisalabad
7.	*B. californicus* Banks	*Amarantus spinosus*, *Rosa inica*, *Solanum melongena*, *Solanum tuberosum*, *Vitis vinifera* No 2/81	Chiniot, Faisalabad Peshawar.
7.	*B. disparis* Chaudhri and Akbar	*Withania somnifera*	Gatwala Forest
9.	*Brevipalpus juncus* Chaudhri and Akbar	*Ocimun basilicum*	Karachi
10.	*B. mingoraennsis* Chaudhri and Akbar	Undet. No. 2/77	Mingora, 3500′
11.	*B. ornantis* Chaudhri and Akbar	Undet. No.1/77,2/77 *Mentha* sp.	Mingora, 3500′ Ckarrapani, 4500′ Balakot, 3500′
12.	*B. obovatus* Donnadim	*Capsicum pseudocapsicum*, *Hedera nepalensis*, *Dicliptera bupleuroides*, *Lamium* sp.	Abbotabad, 3500′
		basilicum,	
		Undet. No. 5/71	Ayubia, 8000′
		Melia azedarach,	Balakot, 3500′
		Oenothera rosea,	

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Name	Host Plants	Locality
	Otostegia limbata,	
	Verbascum thapsus,	
	Paspalum distichum	Bhera
	Helianthus annuus	Attock, Chakwal,
	Cupressus sempervirens	Chakwal
	Fragaria vesca,	Charrapani 4500′
	Plantago major,	Charrapani 4500′
	Potentilla sp.	
	Canabis sativa	Charrapani 4500′
		Kabol (Swat) 3500′
		Kawai 3000′
	Anisomeles ovata,	Choa Saiden Shah
	Malvastrum sp.	
	Lespediza sericea	Dadar 4000′
	Blumea sp.	Gujrat
	Polygonum glabrum,	
	Silybum marianum,	
	Cichorium intybus	Haripur
	Eriobotrya japonica,	
	Jasminum arborescens	
	Malvastrum sp.	
	Anemone sp., *Artemisia*	
	scoparia, *Datura*	
	metel, *Polygonum*	Kabal (Swat) 3500′
	aviculare, *Verbena*	
	officinalis	
	Periploca aphylla	Kalar Kahar
	Pyrus malus	Kawai 3000′
	Buddleia asiatica,	Lahore, Sadiqabad
	Cynoglossum sp.,	
	Datura metal,	
	Solidago sp.	Abbotabad, 3500′
		Faisalabad.

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Name	Host Plants	Locality
	Dryopteris sp.,	Madyan (Swat) 3500′
	Verbena sp.	
	Undet. No. 34/72	Mingrora (Swat) 3500′
	Echinops echinatus	Mirpur
	Helianthus annuus	Rawalpindi
	Malvastrum sp.	
	Phylla nodiflora	Rohri
	Nerium indicum	Sargodha
	Datura metel	Hyderabad
	Dicliptera bupleuroides	Khanaspur 7000′
	Anemone sp.	Nathiagali 9000′
13. *B. recula* Chaudhri	*Rosa indica*	Alipur
	Tegetes tenuifolia	Bahawalpur
	Helianthus annuus	Kotri
	Buddleia asiatica	Multan
14. *B. persicanus* Chaudhri	*Prunus persica*	Kasur
	Ocimum basilicum	Sahiwal
15. *B. spurcus* Chaudhri	*Ocimum basilicum*	Shakargarh
16. *B. amicus* Chaudhri	*Conyza stricta*	Abbotabad 3500′
	Mentha sp.,*Paeonia* sp.	Balakot 3500′
	Amarantus spinosus	Bhera
	Cupressus sempervirens	
	Jasminum arborescens	Chakwal
	Andrachne sp. *Bauhinia purpurea, Geranium* sp., *Morus alba*	Charrapani 4500′
	Boerhavia procumbens	Cheechawatni
	Peganum harmala	Hafizabad,
	Thuja orientalis	Hassanabadal
	Jasminum arborescens, *Rosa* sp.	Haripur
	Withania somnifera	Islamabad, Lahore, Rawalpindi

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Name	Host Plants	Locality
	Cordia abliqua	Jhang
	Hibiscus esculentus, *Verbena officinalis*	Kabal (Swat) 3500′
	Justicia adhaloda	Karachi
	Tagetes tenuifolia	Kasur
	Datura metel, *Thevetia peruviana*,	Lahore
	Barleria sp., *Barleria cristata*.	
	Mangifera indica	Muzaffargarh
	Luffa acutangula	Ochali 3500′
	Helianthus annuus	Rawalpindi
	Arundo donax	Pakpattan
	Citrus sp., *Ocimum basilicum*	Sargodha, Sialkot
	Chrysanthemum sp.	Shakargarh
	Vitis vinifera	Sheikhupura
	Daemia extensa	Shorkot Forest
	Mentha sp.	Tret 3500′
17. *B. solidus* Chaudhri and Akbar	Undet. No.26/72	Karachi
18. *B. ventus* Chaudhri and Akbar	Undet. No.5/81, Loquat, pear	Haripur
19. *B. creber* Chaudhri	*Arundo donax*	Changa Manga Forest
	Corchorus capsularis	Faisalabad
	Malvastrum sp.	Lahore.
20. *B. apalos* Chaudhri and Akbar	*Cassia fistula*, Falsa	Faisalabad
21. *B. rugulosus* Chaudhri	Undet.No.4/69	Lahore
	Verbascum thapsus	Sahiwal
	Citrus sp.	
22. *B. utriculus* Chaudhri and Akbar	*Malvastrum* sp., Bamboo	Sargodha

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	Name	Host Plants	Locality
		Solanum tuberosum	Gujranwala
		Kicxia ramosissima	Havelian
		Convolvulus sp.	Karachi
23	*B. karachiensis* Chardhri	*Periploca aphylla*	Kalar Kahar
		Tagetes tenuifolia	Kotri, Sialkot
		Ocimum basilicum	
		Undet. No. 6/72	Lahore
		Thuja orientalis	Shakargarh
24.	*B. ziaii* Chaudhri and Akbar	*Gossypium hirsutum*	Faisalabad
25.	*B. hafizii* Chaudhri and Akbar	*Azadirachta indica*	Karachi
26.	*B portheo* Chaudhri and Akbar	*Thuja orientalis*	Karachi
27.	*B. kasuriensis* Chaudhri and Akbar	Undet. No.10/70	Kasur
28.	*B. patulus* Chaudhri and Akbar	*Withania somnifera*, Mehndhi	Bhera

GENUS *CENOPALPUS* PRITCHARD AND BAKER

Diagnosis:

1. Presence of rostral shield.
2. One pair sublateral setae.
3. Palpus 4 segmented.
4. Tarsi I and II sensory setae slender and tapering.

Type Species: *Brevipalpus spinosus* Donnadieu

Key to Pakistan species of genus *Cenopalpus*

(Females)

1. Body reticulated 2
   Body striated 3
2. Dorsal body setae, lanceolate 4
   Dorsal body setae, setiform 9

3. Rostral shield with 2 median lobes; genital shield setae simple; anal shield simple..... *C.aratus* Chaudhri
Rostral shield with 1 median lobe; genital shield setae serrate; anal shield striated..... *C.saryabeinsis* Akbar and Chaudhri

4. Central seta 3 simple; complete striated area between metapodosoma and opisthosoma.. . ... *C.ramus* Manson
Central seta 3 serrate, no striated area between metapodosoma and opisthosoma..... 5

no striated area between

5. Rostrum reaching end of femur I; ventral shield striated..... 6
Rostrum reaching beyond femur I; ventral shield reticulated 7

6. Rostral shield with 1 median and 2 lateral lobes on each side; coxae I-IV with 2-2-0-0, setae, trachanters I-IV with 1-1-1-1 setae..... *C.haqii* Akbar and Chaudhri
Rostral shield with 1 median and 2 lateral lobes on each side; coxae I-IV with 2-2-1-1, setae; trochanters I-IV with 1-1-2-1 seta..... *C.capacis* Chaudhri

7. Terminal segment of palpus with 1 rod; rostrum reaching tibia I..... *C.picitilis* Chaudhri
Terminal segment of palpus with 1 rod and 2 setae; rostrum reaching distal end of genua I..... 8

8. Trochanter I-IV with 1-1-1-1 setae; femora I-IV with 4-4-2-0 setae; tibiae I-IV

	with 5-5-3-3 setae	*C.virgulatus* Akbar and Chaudhri
	Trochantre I-IV with 1-1-2-1 setae; femora I-IV with 4-3-2-0 setae; tibiae I-IV with 4-4-3-3 setae	*C.chitraliensis* Akbar and Chaudhri
9.	All dorsal setae serrate; trochanters I-IV with 1-1-2-1 setae.....	10
	All dorsal setae simple; trochanters I-IV with 1-1-1-1 seate.....	*C.dignus* Akbar and Chaudhri
10.	Ventral, genital and anal shields striated	*C.limbatus* Akbar and Chaudhri
	Ventral, genital and anal shields reticulated..... 11	
11.	Palpus terminal segment with 1 rod and 1 seta; coxae I-IV with 3-2-1-1 setae.....	*C.homalos* Akbar and Chaudhri
	Palpus terminal segment with 1 rod and 2 setae; coxae I-IV with 2-2-1-1 setae 12	
12.	Genua I-IV with 3-3-1-0 setae; genital and anal shields setae simple	*C.favosus* Chaudhri
	Genua I-IV with 3-3-1-1 setae; genital and anal shields setae serrate.....	*C.orakiensis* Akbar and Chaudhri

	Name	Host Plant	Locality
1.	*C.aratus* Chaudhri	*Prunus amygdalus*	Abbotabad
		Pinus sp.	Charrapani 3500′
			Orak Valley(Quetta)
		Pyrus malus	Mastung (Quetta)
		Pinus roxburglui	Murree Hills 7500′
		Solanum tuberosum	Samli, 4500′
		Desmodium sp.	

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	Name	Host Plant	Locality
2.	*C.saryabiensis* Akbar and Chaudhri	*Pinus* sp.	Saryab (Quetta)
3.	*C. ramus* Manson	*Abies pindrow* *Pinus wallichiana* *Pinus* sp.	Haripur, Lalazar 11000′ Kalam, 9000′,Naran, Murree, 7500′ Nathiagali 9000′
4.	*C.haqii* Akbar and Chaudhri	*Pyrus malus* *Prunus amygdalus*	Mastung (Quetta) Quetta
5.	*C.capacis* Chaudhri	*Pinus willichiana*	Naran, 8000′
6.	*C.picitilis* Chaudhri	*Cotoneaster* sp.	Kohala, 3000′
7.	*C.virgulatus* Akbar and Chaudhri	Undet. No.5/80	Garam Chashma (Chitral) 4500′
8.	*C.chitraliensis* Akbar and Chaudhri	*Pyrus malus*	Chitral
9.	*C.dignus* Akbar and Chaudhri	*Musa paradisiaca*	Charrapani, 3500′
10.	*C.limbatus* Akbar and Chaudhri	Undet. No. 10/80	Garam Chashma (Chitral) 4500′
11.	*C.homalos* Akbar and Chaudhri	*Prunus amygdalus*	Orak Valley (Quetta)
12.	*C.favosus* Chaudhri	*Pyrus malus*	Balakot 3500′ Kawai, 3500′ Ochali, 3000′
		Morus alba	Charrapani, 4000′
		Eriobotrya japonica	Hassanabdal, Samli 4500′
		Pinus sp.	Charrapani, 4500′ Murree, 7500′
13.	*C.orakiensis* Akbar and Chaudhri	*Pyrus malus*	Orak Valley (Quetta)

GENUS *COLOPALPUS* PRITCHARD AND BAKER

Diagnosis:

The genus *Colopalpus* resembles genus *Brevipalpus* in dorsal chaetotaxy and genus *Tenuipalpus* in having a long flagellate dorsolateral hysterosomal seta.

This genus has

1. Gnathosoma not covered with rostral shield.
2. Palpus 2 segmented
3. Rostral shield well developed, incised medially
4. Dorsosublateral setae absent
5. Female with a single large genito-ventral shield

Type Species: *Colopalpus mathysaei* Pritchard and Baker
(Type in U.S.N.M., U.S.A.)

Name	Host Plant	Locality
Colopalpus eriophyoides (Baker)	*Phoenix dactylifera*	Ghotki, Jhang

GENUS *PENTAMERISMUS* McGREGOR

Type species: *Tenuipalpus erythreus* EWING
(Type deposited in U.S.N.M., U.S.A.)

Name	Host Plants	Locality
Pentamerismus oregonensis McGregor	*Taxus wallichiana*	Murree 7500′

GENUS *PSEUDOLEPTUS* BRUYANT

Diagnosis:

1. Pulpus 4-5 segmented
2. Rostral shield narrow
3. Dorsum with typical striation pattern
4. Ventral shield absent/present

Type Species: *Pseudoleptus arechavaletae* Bruyant.

Key to species of genus *Pseudoleptus*
(Females)

1. Hysterosoma with 13 pairs dorsal setae; ventral shield present..... ..*P. granunosus* Meyer
   Hysterosoma with less than 13 pairs setae· ventral shield absent 2
2. Palpus 4 segmented 3
   Palpus 5 segmented..... 4
3. Palp segment 2 with 1 seta *P. peshawariensis* Akbar and Chaudhri
   Palp segment 2 without seta.... *P. zelihae* Pritchard and Baker
4 Rostral shield not extending past distal end of coxa I..... 5
   Rostral shield extending past distal end of coxa I 6
5. Smooth striations between metapodosoma and opisthosoma *P. palustria* Pritchard and Baker
   Tuberculate striations between metapodosoma and opisthosoma..... *P. hilaria*
6. Smooth striations between propodosoma and metapodosoma..... *P. arechavaletae* Bruyant
   Tuberculate striations between propodosoma and metapodosoma..... 7
7. Striations between metapodosoma and opisthosoma having large lobes..... .. ..*P. boutelone*
   Striations between metapodosoma and opisthosoma smooth 8
8. Dorsocentral hysterosomal setae of medium length ... .*P. tridens*

	Name	Host Plant	Locality
1.	*Pseudoleptus peshawariensis* Akbar and Chaudhri	Undet, No.31/79	Peshawar

GENUS *RAOIELLA* HIRST

Diagnosis:

1. Palpus 2 segmented, terminal segment with 1-2 setae and a lobe.
2. Rostral shield absent
3. Propodosomal, hysterosomal and humeral setae 3 pairs, 11 pairs and 1 pair, respectively

Type Species: *Raoiella indica* Hirst, 1924

Key to species of genus *Raoiella*
(Females)

1. Hysterosomal dorsocentral setae very small ..... *R. australica* Pritchard and Baker
   Hysterosoma with all or 1 pair dorsocentral setae long.....2
2. Hysterosoma with 4th pair dorsosublateral setae longer than first three pairs. 3
   Hysterosoma with 4th pair dorsosublateral setae shorter than first pair. 4
3. Dorsosublateral setae I and II as long as dorsocentral setae..... *R. macfarlanei* Pritchard and Baker
   Dorsosublateral setae I and II longer than dorsocentral setae ..... *R.shimapana* Meyer
4. Dorsosublateral setae II and III shorter than I; dorsocentral setae III 1/2 as long as distance to base of opposite member.....5
   Dorsocentral setae II and III about equal in length to I pair; dorsocentral setae III as long

as distance to base of opposite
member 6

5. Palp terminal segment with
1 seta; coxae I-IV with 1-1-1-0
setae; tibiae I-IV with 4-4-3-3
setae . . . . *R. indica* Hirst

Palp terminal segment with
2 setae, coxae I-IV with 1-1-1-0
setae, tibiae I-IV with 4-4-3-3
setae . .. .*R. empedos* Chaudhri and Akbar

6. Palp terminal segment with 2
setae, rostrum elongate reaching
middle of leg I femur 7

Palp terminal segment with 1
seta, rostrum broad reaching
base of leg I femur . . . .*R. camur* Chaudhri and Akbar

7 Dorsum striated, 4th pair
dorsolateral setae pointed.. .....*R. phoenica* Meyer

Dorsum smooth, 4th pair
dorsolateral setae clavate.....*R. neotericus* Chaudhri and Akbar

	Name	Host Plants	Locality
1	*R. indica* Hirst	*Phoenix dactylifera*	Alipur, Jhang, Karachi, Okara, Sargodha, Bahawalpur, Faisalabad, Hyderabad Lahore.
		Ocimum basilicum	Sargodha
2.	*R. empedos* Chaudhri and Akbar	*Phoenix dactylifera*	Faisalabad
3.	*R. camur* Chaudhri and Akbar	*Phoenix dactylifera*	Karachi
4.	*R. neotericus* Chaudhri and Akbar	*Phoenix dactylifera*	Faisalabad

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GENUS *TENUIPALPUS* DONNADIEU

Diagnosis:

1. Body elongate, oval, propodosoma broad, opisthosoma narrow.
2. Rostral shield present.
3. Palpus 1-4 segmented
4. Ventral and genital shields may be fused together to form a single genitoverntral shield.

Type Species *Tenuipalpus caudatus* Duges (= *T palmatus* Donnadieu)

Key to Pakistan Species of genus *Tenuipalpus*

1. Central setae 1 pair, palpus 2-4 segmented .....2 (*granati group*)
   Central setae 3 pairs, palpus 1-3 segmented .....3 (*caudatus group*)
2. Palpus 2 segmented; genua I-IV with 2-2-1-1 setae ..... *T. sparsus* chaudhri
   Palpus 4 segmented, genua I-IV with 2-2-1-0 setae ..... *T. citus* Chaudhri
3. Posterior medioventral metapodosomal setae 2 pairs 4
   Posterior medioventral metapodosomal setae 1 pair 13
4. Anterior medioventral metapodosomal setae 2 pairs 5
   Anterior medioventral metapodosomal setae 1 pair 7
5. Hysterosoma with transverse, irregular, broken striations; genua I-IV with 2-2-0-0 setae. ..... *T. rarus* Chaudhri
   Hysterosoma with longitudinal, broken striations, genua I-IV with 3-3-1-0 setae. 6
6. Palpus terminal segment with 1 sensory rod and 1 seta..... *T. stativas* Chaudhri

	Palpus terminal segment with 1 sensory rod only	*T. pisinnus* Chaudhri
7.	Body setae setiform, serrate, genua I-IV with 1-1-0-0 setae 8	
	Body setae broad, genua I-IV with 3-3-1-1 setae 12	
8.	Palpus terminal segment with 1 sonsory rod and 1 seta, ventral and genital shields with reticulations	*T. reticulus* Siddiqui and Chaudhri
	Palpus terminal segment with 1 sensory rod only, ventral and genital shields without reticulations 9	
9.	Ventral shield setae not reaching bases of gential shield setae 10	
	Ventral shield setae reaching bases of genital shield setae 11	
10.	Rostral shield striated, 1 median and 1 lateral lobes on each side, dosolateral hysterosomal seta III longer than distance III-IV	*T. trisegmentus* Siddiqui and Chaudhri
	Rostral shield simple, 1 median and 1 lateral lobes on each side, dorsolateral hysterosomal seta III shorter than distance between III-IV	*T. ghanii* Kazimi
11.	Rostral shield striated, 1 median and 3 lateral lobes on each side	*T. raptor* Akbar and Chaudhri
	Rostral shield not striated, 1 median and 1 lateral lobes on each side	*T. dimensus* Chaudhuri
12.	Terminal segment of palpus with 1 sensory rod and 1 seta; dorsolateral hysterosomal	

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	seta; III crosses base of seta III-IV ...	*T. pagina* Chaudhri
	Palpus terminal segment with 1 sensory rod only; dorsolateral hysterosomal seta III falls short of distance between III-IV ...	*T. legatus* chaudhri
13	Anterior medioventral metapodosomal setae 2 pair ... 14	
	Anterior medioventral metapodosomal setae 1 pair ... 18	
14.	All dorsal setae not lanceolate, hysterosoma with thick mediolateral ridge on each side ...	*T. erasus* Chaudhri
	All dorsal setae not lanceolate, serrate, mediolateral ridge absent ... 15	
15	Candolateral hysterosomal setae (except flagellate) setiform, serrate ... 16	
	Caudolateral hysterosomal setae (except flagellate) lanceolate, serrate ... 17	
16.	Propodosomal and dorsocentral hysterosomal setae long; 1 seta on femora I and II long ...	*T. ortus* Chaudhri
	Propodosomal and dorsocentral hysterosomal setae short, all setae on femora I and II same size ...	*T. eremicus* Chaudhri
17.	Genua I-IV with 3-3-1-0 setae ...	*T. pernicis* Chaudhri
	Genua I-IV with 2-2-1-0 setae ...	*T. ferosus* Akbar and Chaudhri
18.	Genua I-IV with 3-3-1-0 setae ...	*T. mustus* Chaudhri
	Genua I-IV with 2-2-0-0 setae ... 19	
19.	Dorsum with strong convolutions ...	*T. lustrabilis* Chaudhri
	Dorsum without strong convolutions ... 20	
20.	Rostral shield with striations; pores 2 pair ...	*T. haripuriensis* Akbar and Chaudhri

	Rostral shield without striations; pores 1 pair 21	
21.	Genital and anal shields simple.....	*T. decus* Chaudhri
	Genital and anal shields striated.....22	
22.	Ventral shield setae not crossing bases of gential shield setae	*T. hornotinus* Chaudhri
	Ventral shield setae cross bases of genital shield setae..... 23	
23.	Rostral shield with 1 median and 1 lateral lobes on each side; dorsocentral hysterosomal setae serrate.....	*T. chinariensis* Akbar and Chaudhri
	Rostral shield with 1 median and 2 lateral lobes on each side; dorsocentral hysterosomal setae simple.....	*T. placitus* Chaudhri

	Name	Host Plants	Locality
1.	*T. sparsus* Chaudhri	*Ipomoea biloba*	Hyderabad
2.	*T. citus* Chaudhri	*Salcx babylonica*	Ochali
3.	*T. rarus* Chaudhri	*Peganum harmala*	Gatwala Forest
		Undet. No. 4/71	Hyderabad
		Undet. No. 8/80	Shorkot Forest
4.	*T. stativus* Chaudhri	*Aerus Javanica*	Leiah
		Mangifera indica	Hyderabad
5.	*T. pisinnus* Chaudhri	*Heliotropium strigosum*	Attock
6.	*T. reticulus* Siddiqui and Chaudhri	*Vitis vinifera*	Faisalabad
		Punica granatum	Jhang
		Morus alba	Treemu
		Thuja orientalis	Leiah.
7.	*T. trisegmentus* Siddiqui and Chaudhri	*Jasminum arborescens*	Leiah
		Morus alba, Phoenix dactylifera,	Faisalabad

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(Cont'd)

	Name	Host Plants	Locality
		Pyrus communis	Faisalabad, Sargodha, Taxilla
		Prunus amygdalus	Mingora (Swat) 3500′ Peshawar
		Pyrus malus	Ochali
		Punica granatum	Abbotabad 3500′ Gatwala
8.	*T. ghanii* Kazimi	*Fraxinus xanthoxyloides, Malus pumila, Melia azedarach, Prunus amygdalus, Prunus bokhariensis.*	Rawalpindi
		Pyrus malus	Naran
		Prunus communis	Nathiagali 9000′
9.	*T. raptor* Akbar and Chaudhri	Undet.No. 3/79	Faisalabad
		Morus alba	
10.	*T. dimensus* Chaudhri	*Jasminum humile*	Multan
		Pyrus malus	Faisalabad
		Morus alba	Sargodha
		Punica granatum	Shujabad
11.	*T. pagina* Chaudhri	*Fagonia indica*	Karachi
12.	*T. legatus* Chaudhri	*Alhagi maurorum*	Karachi
13.	*T. erasus* Chaudhri	*Slavadora oleoides*	Rahim Yar Khan
		Tegetis tenuifolia	Mianwali
		Peganum hermala	Ochali
14.	*T. ortus* Chaudhri	*Aeura javanica*	Leiah, Mianwali, Rajana
		Aeura sp.	Alipur
		Cordia obliqua	Bahawalpur
		Tagetis tenuifolia	Mansehra 3500′
		Salvadora oleoides	Sukhekee, Wahwah
		Morus alba, Gisekia	

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	Name	Host Plant	Locality
		pharnaceoides,	Multan
		Aerua tomentosa.	
		Tocoma grandis	Nowshera
		Acacia nilotica	Sukhekee
		Arundo donax	Cheechawatni
15.	*T. eremitus* Chaudhri	*Atriplex crassifolia,*	Pirowala Forest
		Trianthema monogyna	
		Fagonia indica	Karachi
		Peganum harmala	Sukhekee
16.	*T. pernicis* Chaudhri	*Chrysanthemum* sp.,	Attock
		Citrullus colosynthis,	
		Boerhaavia diffusa	
		Argemone maxicana,	Hyderabad
		Fagonia indica	
		Citrullus colocynthis	Karachi
		Trianthema monogyna	Pirowala Forest
		Punica granatum	Faisalabad
17.	*T. ferosus* Akbar and Chaudhri	Undet No, 1/76	Muzaffarabad
18.	*T. mustus* Chaudhri	*Sesbania* sp.	Gatwala
		Acacia modesta	Hyderabad
		Morus alba	Islamabad
		Bauhinia purpurea	Pirowala Forest
		Eucalyptus sp.,	
		Vernonia cinerascens,	Sheikhupura
		Citrus limon	
		Thuja orientalis	Lahore
19.	*T. lutrabilis* Chaudhri	*Punica granatum*	Aiiot 3500′ Chakwal, Faisalabad, Hassanabdal Mian Channu, Multan, Mazaffargarh, Ochali,

(Cont'd)

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	Name	Host Plant	Locality
			Pasrur, Salooni Jhal, Samundari, Sukhekee Treemu
		Rosa indica	Balakot 3500′
		Tecoma grandis	Changa Manga
		Solanum nigrum	Kohala 3500′
		Olea ferruginea	Marghzar (Swat) 4000′
		Sesbania sesban	Narwala, Pirowala
		Acacia nilotica	Salooni Jhal
		Euphorbia pilulifera	Treemu
		Cassia sp., *Celtis tetrandra,*	Pirowala Forest
		Eriobotrya japonica	Haripur
		Undet. No. 5/79	Kasur
20.	*T. haripuriensis* Akbar and chaudhri	*Canabis sativa*	Haripur
21.	*T decus* Chaudhri	*Olea ferruginea*	Marghzar(Swat) 3500′
		Prunus amygdalus	Kawai (Kaghan) 3500′
22	*T. hornotinus* Chaudhri	*Punica granatum*	Abbotabad 3500′
			Murree 7500′
23.	*T. Chinariensis* Akbar and Chaudhri	*Punica granatum*	Chinari (Azad Kashmir)
24.	*T. placitus* Chaudhri	*Punica granatum*	Alipur, Dadar 3500′
		Daisy flowers	Mardan, Nia Lahore, Okara, Pakka Anna, Rahim Yar Khan, Salooni Jhal, Sheikhupura Sukkar.
		Chenopodium ambrosioides	Hassanabadal
		Cassia purpurea	Rahim Yar Khan
		Pyrus communis	Ochali 3000′.

Family Tuckerellidae

GENUS *TUCKERELLA* WOMERSLEY

Diagnosis:

1. Body oval to elongate: dorsum smooth or reticulated.
2. Dorsum with fan-like setae and posteriorly with a row of variable number of long, flagellate setae.
3. Legs short, pretarsus with strong claws, each with 2 tenent hairs; empodium splits into 2 fine, claw-like processes.
4. Palpus 4 segmented

Key to species of genus *Tuckerella*
(Famales)

1. Seven pairs long, flagellate setae.....11
   Less than 7 pairs long, caudal flagellate setae.....2
2. Six pairs long, caudal flagellate seate 3
   Five pairs long, caudal flagellate setae 7
3. Body without dorsal reticulations 4
   Body with dorsal reticulations all over.....5
4. Mediocaudal pair of setae and setae between 4th and 5th flagellate setae, small and not palmate..... *T. oblutus* Chaudhri
   Mediocaudal pair of setae and setae between 4th and 5th flagellate setae large and palmate..... *T. ghotkieusis* Chaudhri
5. Outer pair of posterior plamate setae, anterior in position as compared to inner pair; caudal flagellate setae all or partially ciliated.....6

	Outer pair of posterior palmate setae, slightly posterior in position as compared to inner pair; caudal flagellate setae ciliated posteriorly ...	*T. equalis* Chaudhri
6.	Caudal flagellate setae ciliated proximally...	*T. pavoniformis* (Ewing)
	Caudal flagellate setae entirely ciliated	*T. nilitica* Zaher and Rasmy
7.	Five pairs long, flagellate setae, 3 pairs small foliate setae 8	
	Five pairs long, caudal flagellate setae; 1 pair small foliate setae	*T. litoralis* (Collyer)
8.	Last 4 palmate setae on dorsal hysterosoma with lateral pair longer than median pair	*T. flabellifera* (Miller)
	Last 4 palmate setae on dorsal hysterosoma not with lateral pair longer than median pair 9	
9.	Tibia II with 3 palmate setae 10	
	Tibia II with 4 palmate setae	*T. murreensis* Chaudhri
10.	All caudal flagellate setae long; genital setae, 9 pairs	*T. ornatus* (Tucker)
	Outermost caudal seta small in size; 7 pairs genital setae	*T. saetula* Chaudhri
11.	All caudal setae, long, flagellate	*T. coleogynis* (Torgouson)
	Third caudal seta small	*T. spechiae* (Womersley)

	Name	Host Plant	Locality
1.	*T. oblutus* Chaudhri	*Triticum aestivum*	Hyderabad, Lyallpur (Faisalabad)
2.	*T. ghotkiensis* Chaudhri	*Tamarix aphylla*	Ghotki
3.	*T. equalis* Chaudhri	*Thuja orientalis*	Mazaffargarh
4.	*T. murreensis* Chaudhri	*Flacourtia indica*	Charrapani 4000′
		Hedera nepalensis	Balakot 4000′
5.	*T. saetula* Chaudhri	*Cupressus sempervious*	Lahore

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Chapter 23

LEPIDOPTEROUS LARVAE

Ali Asghar Hashmi*

INTRODUCTION

The lepidopterous insects comprise butterflies, moths and skippers. These have been studied by naturalists, entomologists and even common people due to their attractive colour patterns. Because of aesthetic appeal of their brilliant colours or striking patterns, they also display aposematic or warning colouration and engage in mimicry relationships.

It is estimated that for over three -fourths of the butterfly-species, the life cycles are not known, and most of the remaining one fourth are only partially described. What to speak of moths and skippers?

Many species including even the common ones have never been reared. Scientifically it is not only difficult but even impossible to identify field collected larvae to species level without rearing them. The families Saturniidae, Sphingidae, Nymphalidae, and Papilionidae contain many large and conspicuous species whose colours of living and externally feeding caterpillars are frequently striking and often useful in identification. But these families only make up a fraction of the total fauna.

Larvae of nearly all lepidopterous species feed on angiosperms and gymnosperms. The greatest economic loss to agricultural crops and stored products is caused by larval feeding. Many such larvae have been described in the literature of agricultural and applied entomology, but most descriptions are often inadequate or without illustrations. Many of the colour bands were described as intersegmental (due to poor magnifying lenses)but those are actually midsegmental. Plesimorphic and apomorphic states of

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characters have not been determined or clearly defined. Consequently, classifications using diverse array of larvae in a single family exist in Lepidoptera (Hashmi and Tashfeen, 1992). So difficulty exists when no single character is sufficient to separate families from other Lepidopterous larvae. Many of the documented larvae are so poorly understood that redescriptions, more host plant data, and direct field behavioral observations are needed, before this information could meet the current requirement of integrated pest management, farming system research, sustainable agricultural productivity and resource conservation.

One of the immediate step to overcome this problem and fill in the existing lacuna in our knowledge is to develop reliable keys with sufficient illustrations for localized faunae. These would greatly aid identification efforts.

It is beyond the scope of this chapter to treat every species of economic importance . However the illustrations provided will serve as an aid for developing an indigenous knowledge of this diverse group as Lepidoptera. This chapter therefore sets a trend for study of immatures based on larval morphology, host plants, and larval habits.

CHARACTERIZATION OF A LEPIDOPTEROUS LARVA

Lepidopterous larvae are called caterpillars, slugs, borers or miners. They are eruciform (5-135 mm long), with three primary body divisions and are usually recognized by virtue of the following characters/attributes.

i) A distinct heavily sclerotized (hypognathous) head
ii) Strong chewing mandibulate mouth parts
iii) Epicranial notch: often very deep, especially if miners in plant tissues.
iv) One pair of short 3-segmented antennae
v) Ocelli (simple eyes): 1-6 pairs or absent; often 1 pair, if several pairs often arranged in semicircle.
vi) Adfrontal areas usually evident
vii) A protruding labial spinneret
viii) Antennae arising in triangular or U-shaped membranous areas at base of mandibles
ix) Three pairs of 5-segmented thoracic legs
x) The abdomen 10-segmented and the segments with

unjointed prolegs on 3, 4, 5, 6 and 10 bearing crochets or short hooked spines. If prolegs are also present on segments 2 and 7, then 2 and 7 without crochets, if crochets arise directly from the venter, prolegs are said to be present. At the opposite extreme, many leaf mining larvae are apodous.

xi) Crochets are present in rows or circles, usually hooked, sometimes more spinelike especially if miner in plant tissues.

xii) Spiracles on the prothorax and abdominal segments 1-8. The presence of spiracle and the T_1 shield is the most striking difference of lepidopterous larvae.

xiii) Silk production through labial glands is common in larvae. This is used in construction of shelters, galleries, pupal shelters and cocoons by the larvae.

xiv) While majority of larvae are herbivores, many of Tineidae, Oecophoridae are scavengers, a few Lycaenidae and Geometridae are predators, Epipyropidae are Ectoparasitoids on homopterous insects (leafhoppers of Fulgoroidea); a number of species live on plant by-products.

xv) The phytophagous larvae consume roots, stalks, stems, leaves, buds, flowers, fruits and seeds; the larvae of Suborders Ditrysia (some) and Monotrysia feed in leaf mines, tunnels, galls, self-constructed shelters, or other concealed situations.

xvi) Most species are solitary but that of Lasiocampidae are highly gregarious.

xvii) Practically all species are terrestrial in habits; a few pyralid, however, live in moving water under web on stones or on submerged vegetation.

CLASSIFICATION

The order Lepidoptera has been classified in a variety of ways, some of which are listed below:

1. Based on the type of wing coupling apparatus as Frenatae and Jugatae.
2. Using body size as Microlepidoptera and Macrolepidoptera

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3. Shape of antennae as clubbed or not clubbed for suborders Rhopalocera and Heterocera.
4. Using structural features of pupae, adult mouth parts, and female reproductive system as suborders of Monotrysia, Zeugloptera, Daenonypha, Ditrysia.
5. Many of the lepidopterous families described in early ninteen have been proven to be obscured during the last 20 years by the researchers. Consequently in this chapter only those families of the order have been chosen, which appear to have relevance to agriculture in Pakistan and are listed in alphabet order for easy in use.

Suborder Zeugloptera: Thirty-five species world-wide only one family Micropterygidae. Larva slug-like with prolegs on A1-A8, A9 and A10 with large suckers.

Suborder Daenonypha: About 300 species worldwide and the common family is Eriocraniidae. Larvae, apodous, they initiate a linear mine in leaves of woody plants e.g. oak, chestnut. Larvae also mine in seeds of archaic conifers *Agathis* (Auricareaceae).

Suborder Monotrysia: Contains about 1008 species worldwide, which are highly diverse taxa hence polyphyletic also. Larva, caterpillar like or flattened apodous. They are external foliage feeders as well as borers in stems or tree trunks of woody plants. Some cause twig or petiole galls, while others are detritus feeders.

Suborder Ditrysia. They comprise the major chunk of lepidoptera. Most of the families listed herein belong to this suborder.

USEFUL CHARACTERS FOR IDENTIFICATION

Prolegs

In lepidopterous larvae the following two kinds of prolegs are found:

a) The proleg base is little more than a ring encircling the planta. A planta is the distal end of a proleg. The planta may be reduced (and crochets appear to arise from venter but planta never bears setae), elongate or even cyclindrical. In the insects which have this kind of proleg crochets are usually in (i) transverse bands, a complete or incomplete circle or (ii) a mesopenellipse. Representatives of Tineidae, Yponomeutidae, Tortricidae, Gelechiidae and Pyralidae have this kind

of prolegs. Larvae with this kind of prolegs are internal feeders that bore, live in nests, folded leaf mines, etc.

b) In the second kind the proleg base is elongate and forms the greater part of the proleg, planta is reduced to a lobe and crochets are in a mesoseries. Examples are Papilionidae, Geometridae, Bombycidae, Sphingidae and Noctuidae. Majority of the larvae with this kind of proleg are external feeders on vegetation.

Crochets

Crochets are small hooks arranged in rows or circles around the edge of the planta. If all crochets are in a circle and of the same length, they are uniordinal, two alternating lengths are termed biordinal and three alternating lengths are termed triordinal. The term ordinal refers to the lengths of the crochets. Most primitive families of Lepidoptera probably possess one or many complete circles of crochets about each proleg The circles of crochets are sometimes broken into rows, semicircles, bands, etc. If crochets are interrupted mesally and are continuous laterally, the arrangement is a lateropenellipse. If crochets are interrupted laterally and are continuous mesally, it is mesopenellipse. If a circle has a gap both laterally and mesally, the crochets are in two transverse bands. If a single transverse row of crochets is present, the arrangement is a single transverse band. Such a situation is uncommon on ventral proleg but is of common occurrence on anal prolegs.

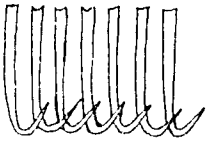
Most leaf feeders have a mesoseries which is a single longitudinal row of crochets on the mesal side of the planta, parallel to the meson. When the crochets are alike in structure and size throughout, they are termed as homoideous mesoseries If crochets in the centre of a mesoseries are longer than those on either end/side, the arrangement is heteroideous mesoseries. If two longitudinal parallel rows occur, the outer is a lateroseries and the inner is a mesoseries. In some geometrids crochets are interrupted by plantar "sucker" while in most lycaenids a spatulate fleshy lobe interrupts the crochets

Eversible Glands, Protuberances and Setae

Eversible glands are present in Yponomeutidae, Papilionidae, Lycaenidae, Lymantriidae, Noctuidae and Notodontidae. The protuberances are usually manifested by the presence of setae. A seta arises from a small

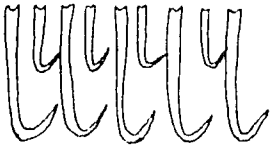
CROCHETS

UNISERIAL



UNIORDINAL

UNISERIAL

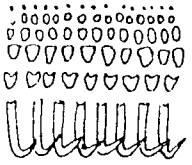


BIORDINAL

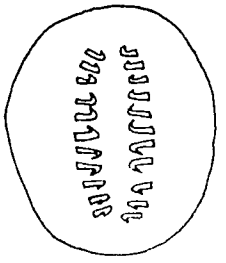
UNISERIAL

TRIORDINAL

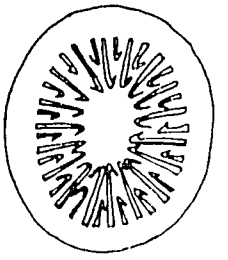
MULTISERIAL



UNIORDINAL

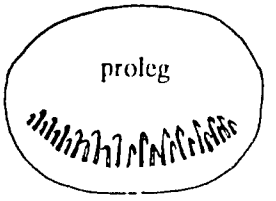


Uniordinal Transverse Bands



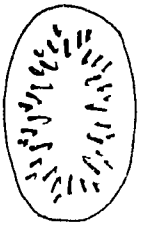
Biordinal Circle Pyralidae

Triordinal Mesal Penellipse Pyralidae

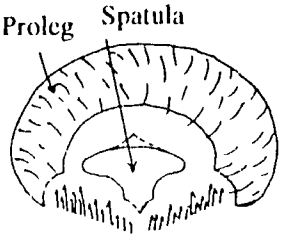


Biordinal Homoideous Mesoseries Saturniidae

CROCHETS

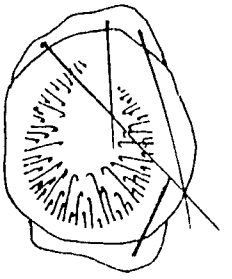


Multiserial Circle
Yponomeutidae

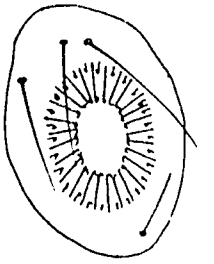


Triordinal Interrupted
Mesoseries Lycaenidae

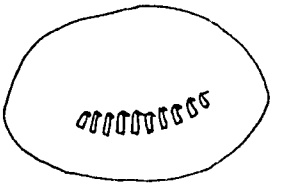
Crochets in
Transverse
Band



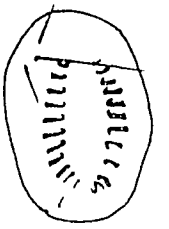
Crochets in
Incomplete Circle



Crochets in
Complete Circle



Crochets in
single band



Crochets in
Two Bands

sclerotized ringlike papilla on the integument and is connected with a hypodermal cell. A seta could be simple (hairlike), plumose, knobbed, spinelike, spatulate, poisonous or urticating. Setae, spines, bristles and horns vary in the order Lepidoptera. Sclerotized area around the base of setae is pinaculum, when pinaculum is elevated, cone-shaped and bears a single seta, it is a chalaza. When chalaza is larger bearing setae or branching spines it is termed scolus. Single or grouped setae, parallel or divergent also occur on non-sclerotized fleshy lobes, flat areas, disclike verricules or convex verrucae.

In the literature three kinds of setae viz; primary, subprimary and secondary setae are recognized. The primary setae are sensory in function, relatively constant in number, position and occur on all instars of all but a few groups. Variations in their position, length, structure and number provide important taxonomic characters for determination of family or lower taxa. Structures such as the middorsal horn or tubercle on A8 of Sphingidae, horn like structures, tubercles and antlers in some Nymphalidae, Notodontidae and Bombycidae, the anal comb or fork in Gelechiidae, Tortricidae and Hesperiidae are considered as modifications of setae or cuticular granules. The primary setae could be microscopic or proprioceptor setae (small in size and secondary in function) which are found near the anterior margin of body segments.

The secondary setae vary in number, size, and position within as well as between taxa and usually appear in the 2nd instar. These setae occur scattered over cuticle or as dense tufts (termed verrucae) or as hair pencils (verricules). Verrucae and verricules occur constantly hence they are as useful as primary setae from taxonomic view point. The secondary setae are usually present on external feeders (Hesperidae, Bombycidae) and absent on internal feeders. In this context they are considered as adaptation for sensory purposes for the external feeders.

Several Tortricidae, Noctuidae, and Lyonetiidae possess spinules, which are unarticulated minute spines.

How to Use Setae

The use of setae for identification or characterization is usually made by having a setal map. This map is a diagram depicting relative position and size of setae and other structures on the left side (by convention) of the thorax and abdomen. More commonly T1, T2 (T3 is similar to T2) A1 (A2 is similar to A1) A3 or A6 (A3- 6 are similar) and A7-10 are drawn.

The number and positions of the primary setae in relation to each

other are good taxonomic characters for lepidopterous larvae; since they are constant for species but quite variable between species. Because of their definite distribution on the head, thorax and abdomen they have been extensively studied by Dyar (1896), Fracker (1915), (Heinrich (1916), Gerasimov (1935) and Hinton (1946). Workers like Mutuura (1956), Peterson (1962), Hasenfuss (1963, 1969) and Wasserthal (1970) have elaborated the efforts of previous workers.

Matsuda (1976) has emphasized that setae can be a good object for homologization in insects because of their shapes, constant locations and fixed numbers. So far as the chaetotaxy of head is concerned, Peterson (1962) gave a comparative table showing the two systems employed in naming (Heinrich,1916) or numbering (Dyar, 1896) the setae or setal punctures on the head. An elaborate discussion can be found in Crumb (1929) and Whelan (1935).

For setal arrangement on thorax and abdomen two systems of nomenclature are in vogue, (i) assigning of Greek letters to given setae or (ii) use of numbers, usually Roman numerals (capital or small).

Most Lepidopterists have preferred to use Greek letters because the use of numbers may lead to confusion and disagreement. For this reason Peterson (1962) tabulated for comparison the summary of setal names and numbers given by Forbes (1910), Fracker (1915) and Heinrich (1916). However, Peterson (*loc cit*) was inclined to substitute Arabic numbers for Roman numerals. After going through the works of various people the present author felt that discussions by Crumb (1929), Whelan (1935) and Peterson (1962) have not led to any sound and understandable conclusion. With the passage of time the confusion has intensified rather than being diluted. Therefore, an effort has been made to remove this confusion by comparatively tabulating the various chaetotaxy nomenclatures for the taxonomy of lepidopterous larvae. For reasons of simplicity and ease of understanding it has been preferred to amplify the methodology of naming setae used by Hinton (1946). As an example (for use of this nomenclature) various setae on the body of maize borer have been labelled. This insect is one of the most commonly used laboratory specimens in the teaching of taxonomy of immatures of Lepidoptera. It is hoped that future workers by following Hinton's nomenclature will not ony be able to make substantial contributions but also correctly retrieve the previously published literature on the chaetotaxy by the comparative tables provided in this study.

For comparing the various nomenclatures, first the descriptive names

of the various body parts by Hinton (1946) for head (Table- 1), thorax (Tables-2 and 3) and abdomen (Table-4) have been given. This is followd by the corresponding abbreviation. For example abbreviation of Anterior part of the head is "A" and that of Extra- dorsal part of the thorax is "XD". If more than one setae are present they are numbered as XD1, XD2, etc. This condition is also called unisetose (one seta) or bisetose (two setae). Since the tables are quite illustrative repetition of the description of the body parts or their abbreviations are avoided. The setae which are present in maize borer are indicated by a +ve sign, while -ve sign means the absence of a seta (Hashmi et.al. 1980).

Table 1. Comparison of Nomenclatures of Head Chaetotaxy.

Hinton 1946 description	Generalized Abbreviations	Maize borer	Dyar 1896 Forbes 1910	Fracker 1915 Same as Forbes	Heinrich 1916.	Gerasimov 1935
Anterior	A1	+	IX		Anterodorsal Ad-1	Anteriores prima A1
	A2	+	VIII		Anterodorsal Ad-2	Anteriores secunda A2
	A3	+	IV		Anterodorsal Ad-3	Anteriores tertia A3
	Aa	-	-		Anterodorsal Ad-2a	Porus anteriorea Aa
Ocellar	O1	+	VII		Ocellar O-3	Ommatalis prima O1
	O2	+	V		Ocellar O-2	Ommatalis secunda 02
	O3	-	-		Ocellar O-1	Ommatalis tertia O3
	Oa	-	-		Ocellar O-1a	Porus ommatalis Oa
	-	-	-		-	Porus ommatalis Ob
Sub-ocellar	SO1	+	XI		Subocellar SO-1	Subommatalis prima SO1
	SO2	+	VI		Subocellar SO-2	Subommatalis secunda SO2
	SO3	-	X		Subocellar SO-3	Subommatalis tertia SO3
	SOa	-	-		Subocellar SO-2a	Porus subommatalis SOa
	-	-	-		-	Porus subommatalis SOb
	-	-	-		-	Porus subommatalis SOc
Lateral	L1	+	III		Lateral L-1	Lateralis L1
	La	-	-		Lateral L-1a	Porus lateralis La

Cont'd

Cont'd

Hinton 1946 description	Generalized	Maize borer	Dyar 1896 Forbes 1910	Fracker 1915 Same as Forbes	Heinrich 1916.	Gerasimov 1935
Posterior	P1	+	II		Posterodorsal Pd-1	Posteriores prima P1
	P2	+	I		Posterodorsal Pd-2	Posteriores secunda P2
	Pa	-	-		Posterodorsal Pd-2a	Porus posteriores Pa
	Pb	-	-		Posterodorsal Pd-2a	Porus posteriores Pb
Vertical	V1	-	-		-	Verticalis prima V1
	V2	-	-		Secondary	Verticalis secunda V2
	V3	-	-		Tubercles	Verticalis tertia V3
	Va	-	-		-	Porus verticalis Va
	Vb	-	-		-	Porus verticalis Vb
Genal	G1	-	-		Genal G-1	Genalis G1
	G2	-	-		-	-
	Ga	-	-		Genal G1-a	Porus genalis Ga
Prontal	F1	+	-		Frontal Fr-1	Frontalis F1
	Fa	-	-		Frontal Fr-a	Porus frontalis Fa
Adfrontal	AF1	+	-		Adfrontal Adf-1	Frontolateral prima Fr.L1
	AF2	+	-		Adfrontal Adf-2	Frontolat.secunda Fr.L2
	AFa	+	-		Adfrontal Adf-a	Porus frontolat, Fr.La
Ceypeal	C1	+	-		Ep-1	Clypealis prima Cl1
	C2	+	-		Ep-2	Clypealis secunda Cl2

Table 2. Comparison of Nomenclatures of Prothoracic Chaetotaxy

Hinton 1946 Description	Generalized	Maize borer	Fracker 1915. Jugatae	Frenatae	Generalized for all segments		Forbes. 1910	Heinrich 1916
Abbreviations								
Extradorsal	XD1	+	gamma	alpha	alpha	alpha	Cerv.	Ia

Cont'd

Hinton 1946 Description	Generalized	Maize borer	Fracker 1915 Jugatae	Frenatae	Generalized for all segments		Forbes. 1910	Heinrich 1916
	XD2	+	epsilon	gamma	beta	beta	Cerv.	IIa
Dorsal	D1	+	alpha	beta	gamma	gamma	Cerv.	Ib
	D2	+	beta	delta	delta	delta	Cerv.	IIb
Subdorsal	SD1	+	rho	epsilon	epsilon	epsilon	Cerv.	Ic
	SD2	-	-	-	rho	rho	Cerv.	IIc
	-	-	-	-	theta	theta	Psp.	III
Lateral	L1	+	eta	kappa	kappa	kappa	Psp.	IV
	L2	+	kappa	eta	eta	eta	Psp.	V
	L3	-	-	-	mu	-	-	-
Subventral	SV1	+	pi	pi	pi	pi	Subv.	VI
	SV2	+	nu	nu	nu	nu	Subv.	VI
	SV3	-	-	-	tau	-	-	-
	-	-	-	-	-	-	-	VII
	-	-	-	-	omega	-	-	-
Ventral	V1	+	sigma	sigma	igma	-	-	VIII
		-	-	-	lambda	-	-	-

Table 3. Comparison of Nomenclatures of Mesothoracic Chaetotaxy

Hinton 1946 Description	Generalized	Maize borer	Fracker 1915. Jugatae	Frenatae	Generalized for all segments		Forbes. 1910	Heinrich 1916
Abbreviations								
Extradorsal	XD1	-	-	-	-	-	-	-
	XD2	-	-	-	-	-	-	-
Dorsal	D1	+	alpha	alpha	alpha	ia	Ia	
	D2	+	beta	beta	beta	ib	Ib	

Cont'd

Hinton 1946 Description	Generalized	Maize borer	Fracker 1915. Jugatae		Frenatae	Generalized for all segments	Forbes 1910	Heinrich 1916
	-	-	-	-	gamma	x	-	
	-	-	-	-	delta	-	-	
	-	-	-	-	epsilon	iia	IIa	
Subdorsal	SD1	+	rho	rho	rho	iib	IIb	
	SD2	-	-	-	-	-	-	
Lateral	L1	+	kappa	kappa	theta	iii	III	
	L2	+	epsilon	eta	kappa	iv	IV	
	L3	+	theta	theta	eta	v	V	
	-	-	-	-	mu	-	-	
Subventral	SV1	+	pi	pi	pi	vii	VI	
	SV2	+	-	nu	nu	vii	vi	
	SV3	-	-	-	tau	ix	-	
	-	-	-	-	-	-	VII	
	-	-	-	-	omega	-	-	
Ventral	V1	+	sigma	sigma	sigma	viii	VIII	
	-	-	-	-	lambda	-	-	

Table 4. Comparison of Nomenclatures of Abdominal Chaetotaxy

Hinton 1945 Description	Generalized	Maize borer Abdominal Segments				Fracker 1915 Jugatae	Frenatae	Generalized for all segments	Forbes 1910	Heinrich 1916
	Abbreviatio is	2	3	8	9					
Extradorsal	XD1	-	-	-	-	-	-	-	-	-
	XD2	-	-	-	-	-	-	-	-	-
Dorsal	D1	+	+	+	+	alpha	alpha	alpha	i	I
	D2	+	+	+	+	beta	beta	beta	ii	II

Cont'd

Hinton 1945 Description	Generalized	Maize borer Abdominal Segments				Fracker 1915 Jugatae	Frenatae	Generalized for all segments	Forbes 1910	Heinrich 1916
	-	-	-	-	-	-	-	gamma	x	-
	-	-	-	-	-	-	-	delta	-	-
Subdorsal	SD1	+	+	+	-	rho	rho	rho	iii	III
	SD2	-	+	-	-	epsilon	epsilon	epsilon	iiia	IIIa
Lateral	L1	+	+	+	+	theta	kappa	theta	-	-
	L2	+	+	-	-	kappa	eta	kappa	iv	IV
	L3	-	+	-	-	eta	mu	eta	v	V
	-	-	-	-	-	-	-	mu	vi	VI
Subventral	SV1	+	+	+	+	pi	pi	pi	vii	VII
	SV2	+	+	+	-	nu	nu	nu	vii	VII
	SV3	+	+	-	-	tau	tau	tau	vii	-
	-	-	-	-	-	-	-	-	-	VII
	-	-	-	-	-	-	-	omega	ix	-
Ventral	V1	+	-	+	-	sigma	sigma	sigma	viii	VIII
	-	-	-	-	-	-	-	lambda	-	-

It needs to be cleared right at the out set that it was much easier to equate the nomenclatures of Forbes and Heinrich with Fracker, and that of Hinton with Fracker for this study. For this reason in this write up main emphasis will be on Hinton's and Fracker's nomenclatures, and the reader can very easily see the equal names given by Forbes and Heinrich by comparison given in the various tables.

A perusal of Table 1 and Figures A-B reveals that the position of setae on the head capsule of maize borer does not completely tally with the generalized scheme of Hinton (1946). There are 3 anterior (A1, A2, A3,) 2 each of ocellar (O1,O2), subocellar (SO1, SO2), posterior, (P1,P2), frontal (F1, Fa), adfrontal (AF1, AF2) and clypeal (C1, C2) setae and only one of the lateral side (L1). No difficulty was experienced with naming the various setae.

Tables 2 and 3 reveal that Heinrich's VII (on the prothorax and mesothorax) is not synonymous with Fracker's tau in (Jugatae and Frenatae), nor Fracker or Forbes has a comparable homologue for Heinrich's thoracic VII. Likewise, Heinrich gave no symbol for Fracker's thoracic tau or Forbes's thoracic ix. It may thus be argued that vii of Forbes on mesothorax (Table-3) should be vi as interpreted by Heinrich; since in Forbes's nomenclature v is followed by vii and there is no seta named as vi. Further according to Forbes's name x on the mesothorax may include three or four small setae like xa,xb,xc and xd.

Figures C-E show that in the Hinton's nomenclature the generalized sequential position of Fracker's setae changes in the prothorax (alpha and gamma), while the dorsal setae in Hinton's nomenclature are equatable with alpha and beta of Fracker in meso- thorax (Table 2). It appears that Hinton's nomenclature is logical in terms of description of a particular seta with respect to its location on a specific part of the thoracic segment. The use of Fracker's nomenclature complicates the situation by introducing contradiction even when we compare Jugatae and Frenatae groups within the order Lepiodoptera. For instance rho is equated with epsilon by virtue of their position.

Table 4 and Figures F-K reveal that on the abdomen tau belongs to the pi group and is thus a part of the VII of Heinrich or vii of Forbes. In view of this assertion if one could recall the VI and VII of Heinrich as well as those of Forbes it becomes quite obvious that the homologies of VI and VII between the thorax and abdomen were disputed by Fracker and Heinrich perhaps, because of wrong groupings. Our experience has shown that except for lateral setae the corresponding sequential position of Fracker's nomenclature, does not change very much with the use of Hinton's nomenclature. Further several of the setae in the generalized scheme of Fracker viz., gamma, delta, mu, omaga and lambda do not occur on the abdomen of the maize borer, and one would therefore, question that if all these at all occur in practice in all the lepidopterous larvae? It may also be noted that iv of Forbes equals theta among Jugatae according to Fracker's interpretation, whereas v equals kappa and vi equals eta among Jugatae. The corresponding positions in the Frenatae changes because theta in Jugatae is equal to kappa where as kappa in Jugatae is equal to eta in Frenatae and eta in Jugatae is equal to mu in Frenatae. Thus, to establish a standard or uniformity in naming the various setae either by Forbes or Fracker, is fraught with difficulty. In order to resolve this difficulty amongst the Fracker's,

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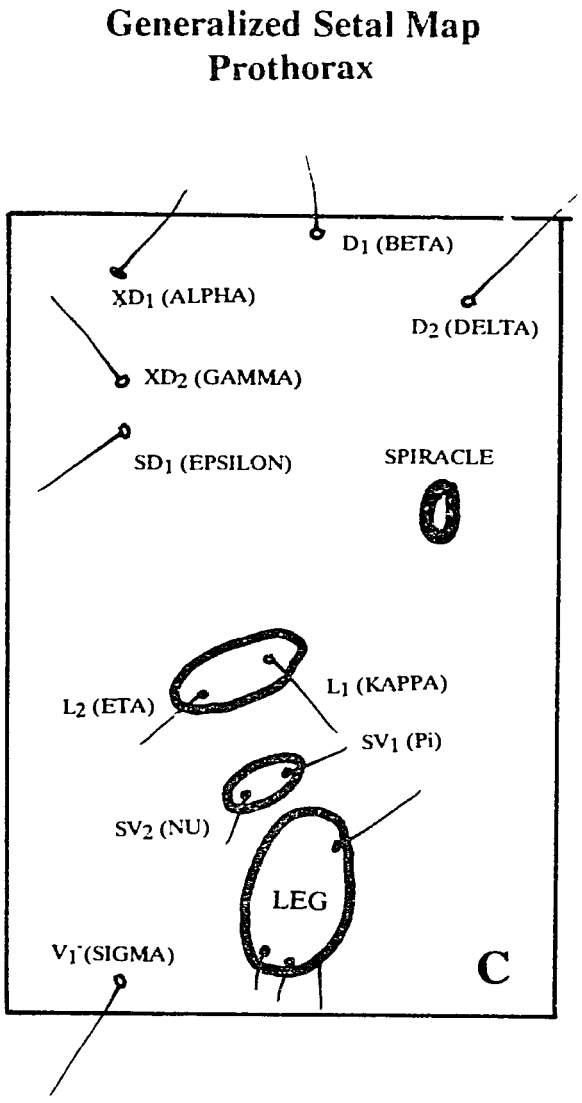
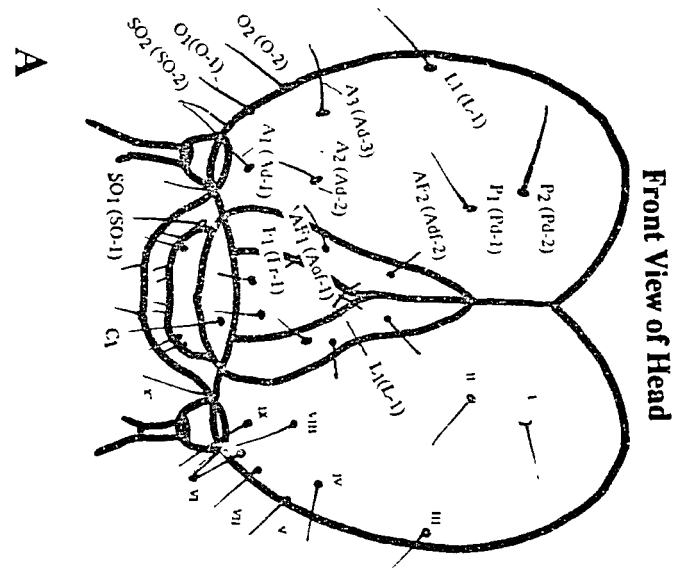
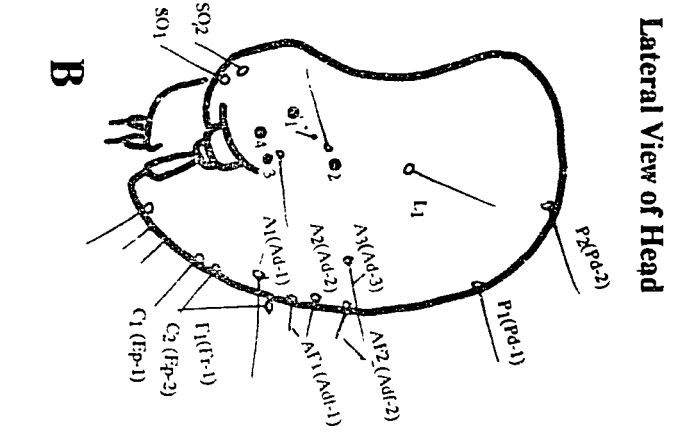

Generalized Setal Map
Prothorax
D1 (BETA)
XD1 (ALPHA)
D2 (DELTA)
XD2 (GAMMA)
SD1 (EPSILON)
SPIRACLE
L1 (KAPPA)
L2 (ETA)
SV1 (Pi)
SV2 (NU)
LEG
V1 (SIGMA)
C


Front View of Head
A
P2 (Pd-2)
P1 (Pd-1)
L1 (L-1)
Af2 (Adf-2)
A3 (Ad-3)
A2 (Ad-2)
A1 (Ad-1)
Af1 (Adf-1)
O2 (O-2)
O1(O-1)
SO2 (SO-2)
SO1 (SO-1)
F1 (Fr-1)
L1(L-1)
C1
I
II
III
IV
V
VI
VII
VIII
IX
X


Lateral View of Head
B
P2(Pd-2)
P1(Pd-1)
L1
Af2 (Adf-2)
A3(Ad-3)
A2(Ad-2)
Af1 (Adf-1)
A1(Ad-1)
F1(Fr-1)
C2 (Fp-2)
C1 (Ep-1)
SO2
SO1
1
2
3

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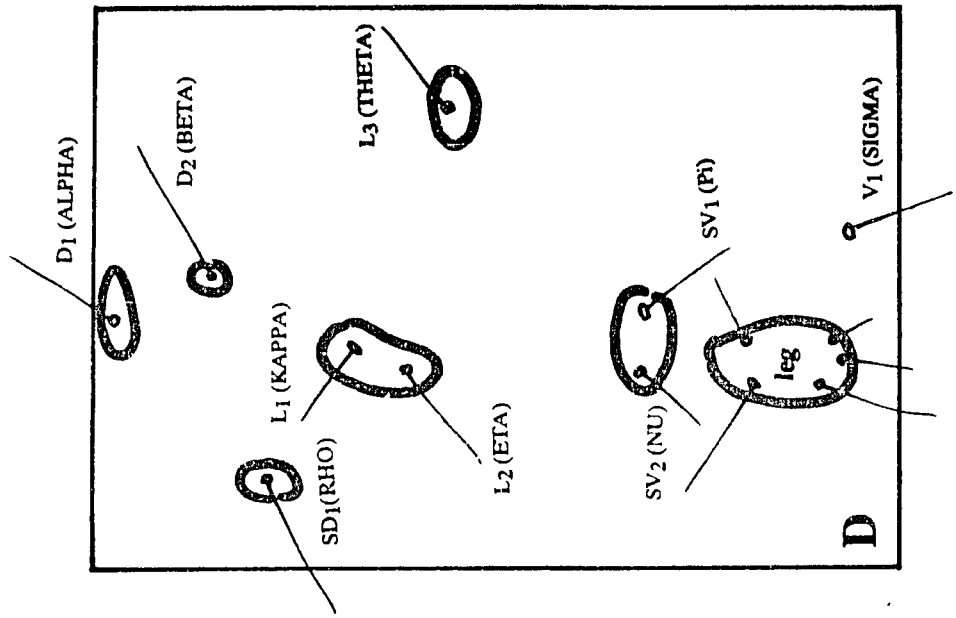
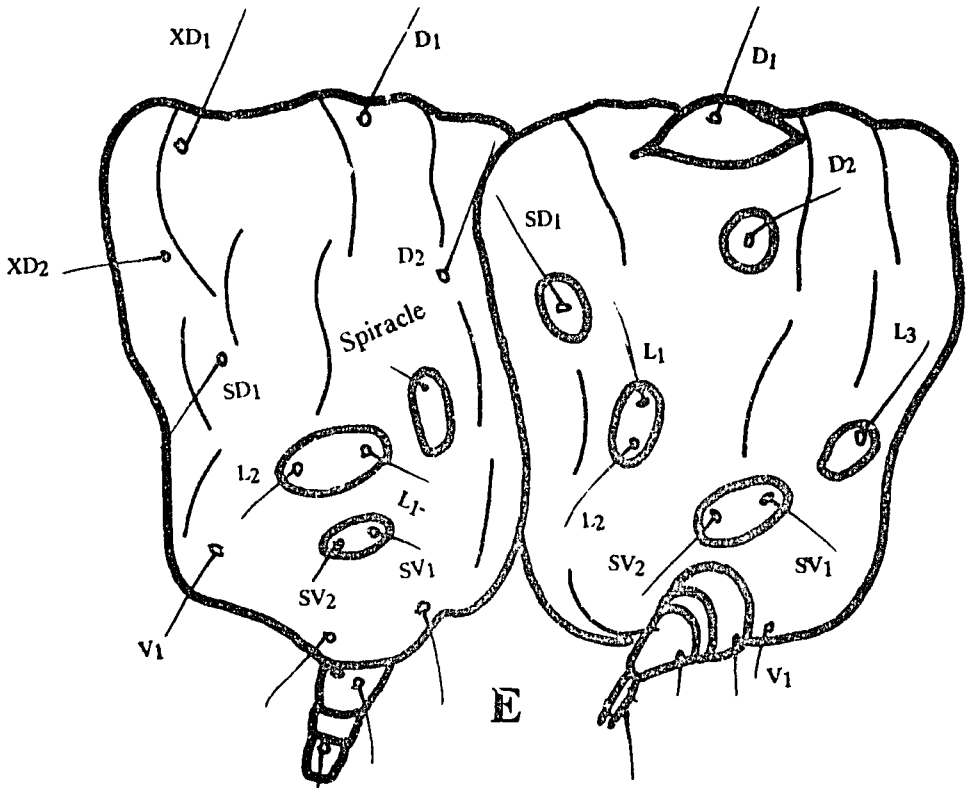
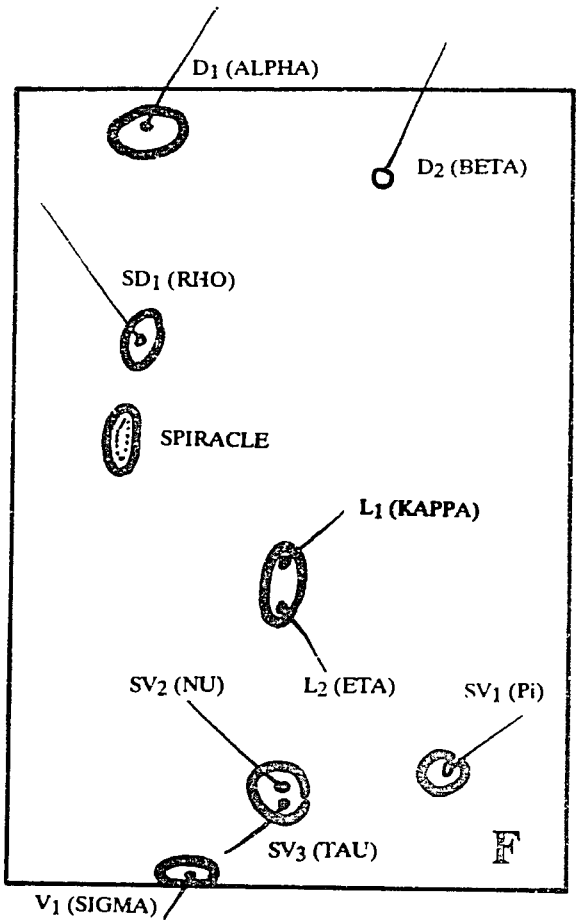
Generalized Setal Map
Mesothorax



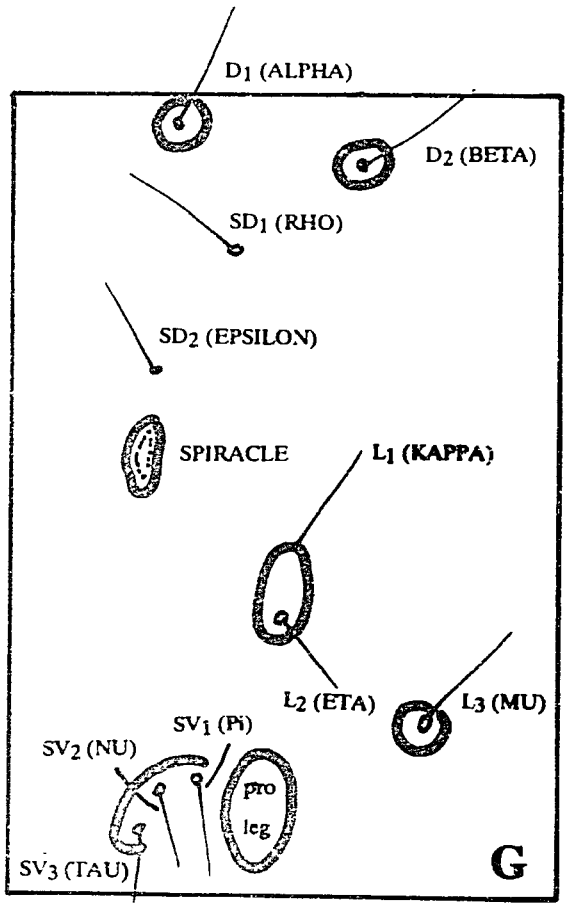


Pro and Mesothorax after Hinton

990



Second Abdominal Segment



Third Abdominal Segment

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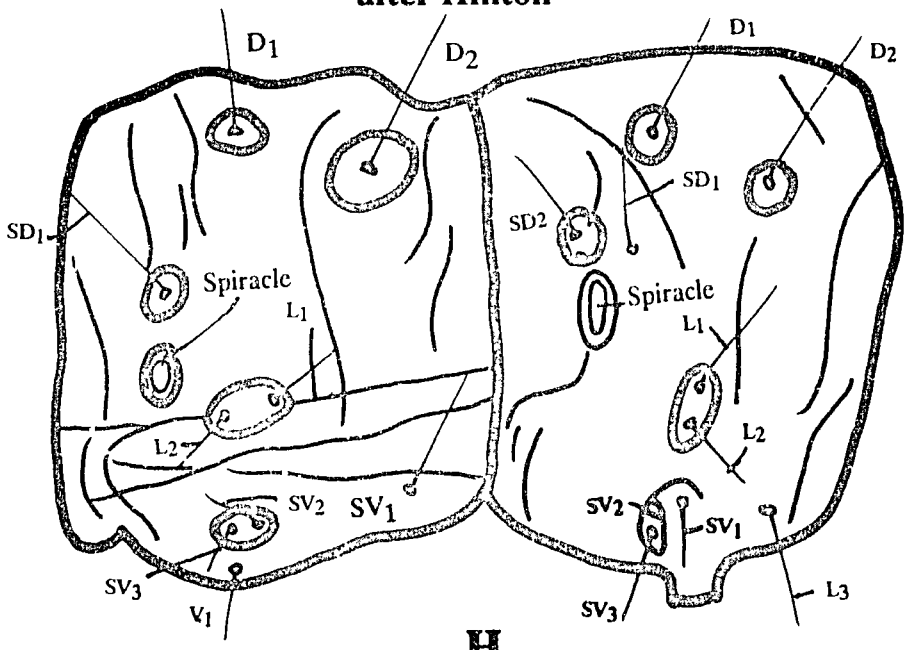
Second and Third Abdominal Segments after Hinton



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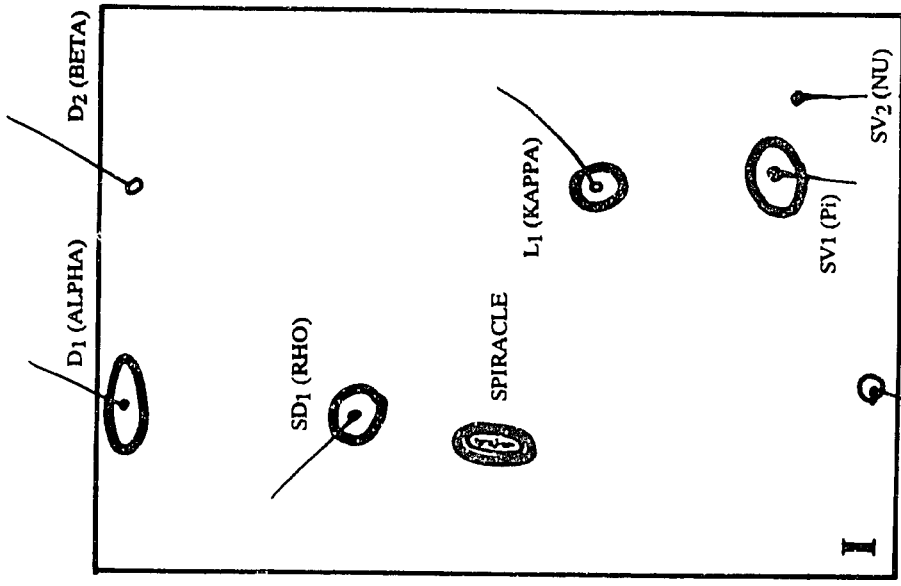

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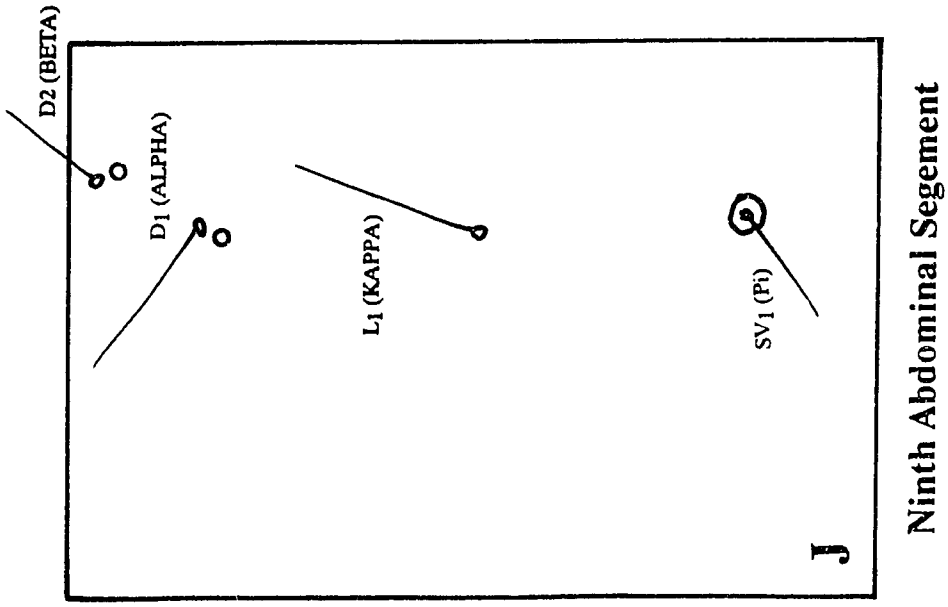
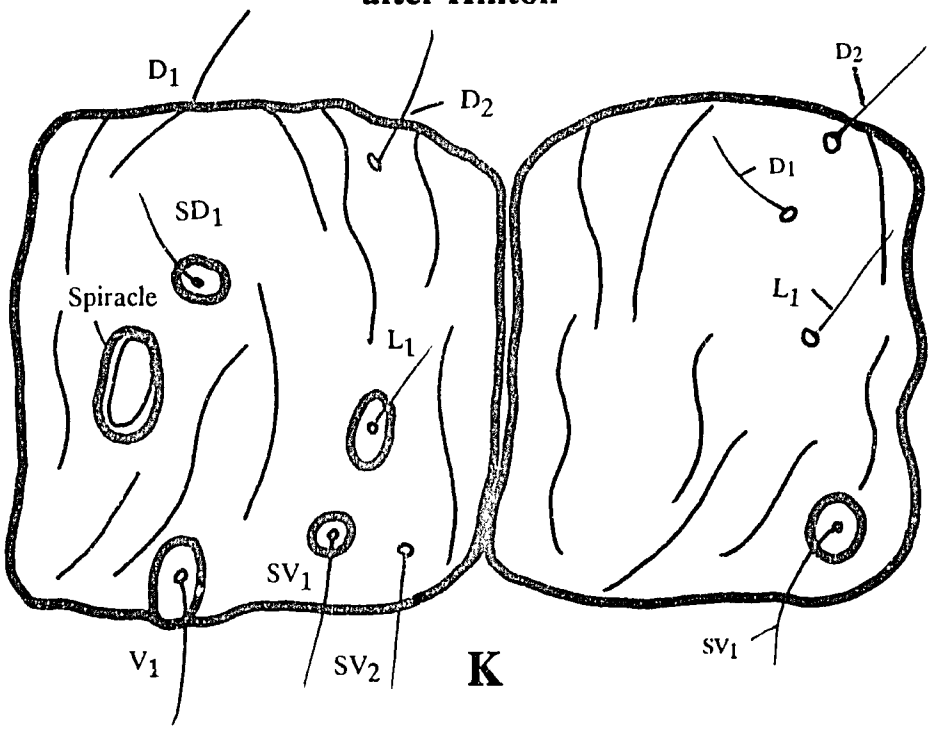
Eighth Abdominal Segment

992



Eighth and Ninth Abdominal Segments after Hinton



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Forbes's and Heinrich's nomenclatures and their corresponding setae in Hinton's nomenclature it is proposed that the best way to get oriented in mapping the setae is to follow the below given orientation method.

Orientation Method

Our experience with larvae of Lepidoptera in general and maize borer in particular has revealed that the best way to start mapping the primary setae is to locate the spiracle on the lateral aspect of the thorax. Once the spiracle is located the setae called SD2 (rho) and /or SD1 (epsilon) is situated above the spiracle. Sometimes SD2 (rho) could be situated on a raised or a pigmented area (pinaculum) which makes it even more prominent. Sometimes SD1 and SD2 can be present on the same pinaculum e.g. mesothorax of *Tryporyza incertulas* (Walk.) and *Chilo suppressalis* (Wlk.) (Williams, 1953). Right above SD2 (rho) four other setae namely XD1 (alpha), XD2 (beta), D1 (gamma) and D2 (delta) can be located. On the 2nd (and 3rd) thoracic metameres usually adjacent to SD2 (rho), another seta called SD1 (epsilon) also occurs and when these two occur together D1 (gamma) and /or D2 (delta) may be absent e.g. *Sesamia inferens* (Walk.) (Krishnamurti and Usman, 1952) and *Tryporyza incertulas* (Walk.) (Williams, 1953). Probably this could be the reason that so much anomaly has occurred in the literature.

In the abdominal region, three possibilities could exist, (a) Both SD2 (rho) and SD1 (epsilon) could be located on the same pinaculum e.g. 9th abdominal segment of *Chilo suppressalis* (Walk.); (b) SD2 (rho) and SD1 (epsilon) could be located above the spiracle just like the thoracic segments; (c) SD1 (epsilon) could be cephalodorsal above the spiracle whereas SD2 (rho) could be posterioroid of the spiracle e.g. *Tryporyza incertulas* (Walk.). The above guide lines only elucidate the tentative possibilities of occurrence of the most consistent of the primary setae with respect to spiracle. These assumptions are subject to further verification as the studies progress in our laboratory.

It is our contention that by following the above method one can trace the mistakes made in nomenclature by the previous workers in using either Fracker's or Forbes's names of the setae. Once the setal arrangement is determined properly, the corresponding names of Hinton's nomenclature given in Tables 1-4 can be found out. Thus in most of revisionary works of lepidopterous larvae the chaetotaxy can be put on a uniform pattern.

FAMILY CHARACTERS

In the following paragraphs characters of different families of Lepidoptera have been provided in alphabet order to cut across the diffused classification system of Lepidoptera. Under each family examples of some local insect pests of agricultural importance are cited.

ARCTIIDAE

Body small to large (10-80 mm), cylindrical, tuberculate, densely or sparsely covered with barbed and/or plumose setae arising from verrucae; hairs brightly coloured as reddish-brown and black, urticating in some species. Tufted hairs on primary warts, tufts reduced, rarely lost in last stage. SD_1 wart in abdomen with single setae; A3-6 crochets in heteroideous uniordinal mesoseries, abruptly shorter at both ends (*Utetheisa*). T_1 with SD_1 and SD_2 included on (surrounded by) prothoracic shield. T_2 and T_3 with at least 4 verrucae between coxa and middorsal line (i.e.D and SD verrucae separated) Verruca or seta L1 same distance from spiracle on A7 as on A6, verruca L1 on A6, 7, and 8 similar in size. A3-6 with only 1 seta per "D" verruca (above the spiracle). Six ocelli in a semicircle.

Most members can be distinguished by having full complement of verrucae (four-five verrucae) above the coxae on T_2 and T_3. Some noctuids resemble arctiids but arctiids never have integumental spinules, which similar noctuids usually have.

Amsacta moorei Butler (Red hairy caterpillar)

Caterpillar: Body colour light yellow or reddish brown, with black bands on either end, head black or reddish brown, dense tuft of reddish brown hairs all over the body. Full grown larvae measure 4- 5 cm.

Damage: The larvae on emergence are gregarious on the seedlings, but in later instars disperse. They are polyphagous and feed on leaves, tender branches, and even stems of different crops viz; sunhemp, jowar, bajra, pulses, groundnut, til, etc. and wild weeds. Sometimes the whole germinating fields are destroyed when the larvae march in bands in the fields.

Diacrisia obliqua Walker (Bihar hairy caterpillar)

Larva: It measures 40-45 mm in length. When full grown, it has orange

coloured hairy body with both ends black. Hairs are greyish.
Damage: It is a polyphagous insect, eats leaves and soft portions of stems and branches of many crops viz; jowar, bajra, maize, soybean, black gram, potato, tomato, peas, rice, cotton, sunflower, safflower, castor, jute, linseed, sesamum and many weeds. In the case of severe infestation, the plants may be completely denuded of leaves. Activity period is April - November.

Utetheisa pulchella Linn. **(Sunhemp hairy caterpillar)**

Larva: Dark grey, 3.8 mm long; body spotted with red, dark and white markings; a dorsal white band and subdorsal series of red spots; head yellow or brownish, clothed with dense long hairs. This insect is an exception where setae are on chalazae because verrucae are absent. A3-6 crochets heteroideous (abruptly shorter at both ends). A3-6 with a single seta per verruca
Damage: Caterpillars are gregarious, feed on the leaves, defoliate the crop and cause a decrease in seed production of sunhemp.

BOMBYCIDAE

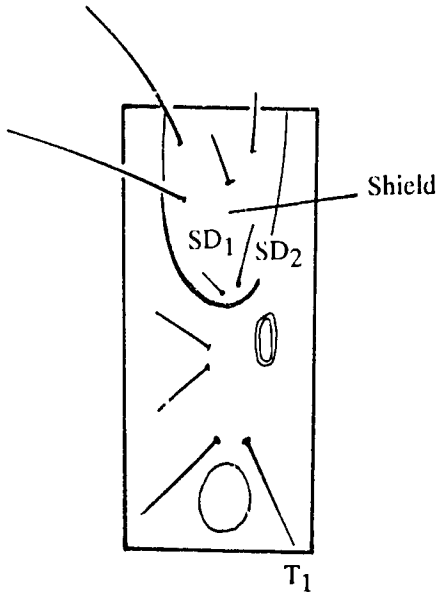
Abdominal segments with 3 or less annulets. Larvae are usually covered with tufts of hair, although *Bombyx mori*, the silkworm is naked and has a short middorsal anal horn on A8. T2 and T3 conspicuously humped
Larva: There are two types of larvae which include:

a) *Eupterote*, etc., larvae tufted with long hairs, short and coarse secondary setae always numerous, distinct verrucae wanting.

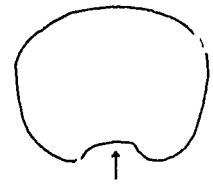
b) *Bombyx* larvae glabrous, elongate, usually with a medioadorsal horn (caudal horn) on 8th abdominal segment, larvae form dense silken cocoons. A3-6 and A10 prolegs normal with many secondary setae and crochets in a biordinal mesoseries.

Bombyx mori (L.) **(Silkworm moth)**

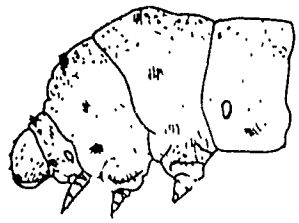
Caterpillar: Elongated, greenish-grey, about 50-60 mm long with a swollen and wrinkled thorax, abdomen 10-segmented; crochets on the planta of prolegs arranged in the form of a semicircle (biordinal in a mesoseries).



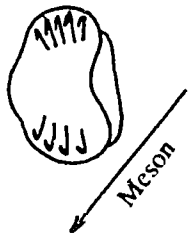
T_1 with SD_1 and SD_2 included in prothoracic shield (*Utetheisa*) (Arctiidae)



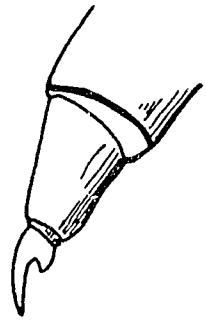
Labral notch shallow (Arctiidae)



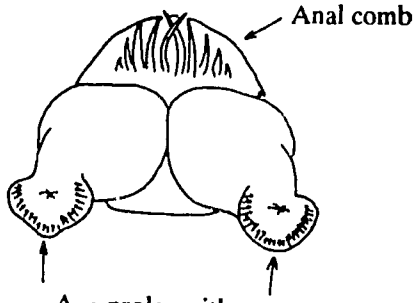
Thorax, especially T2 and T3 Conspicuously humped (Bombycidae)



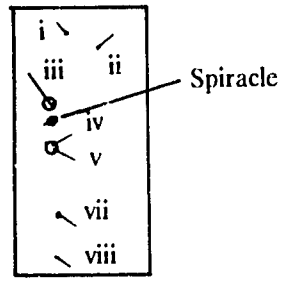
A_{10} with Crochets Divided by a Gap into 2 groups (Gelechiidae)



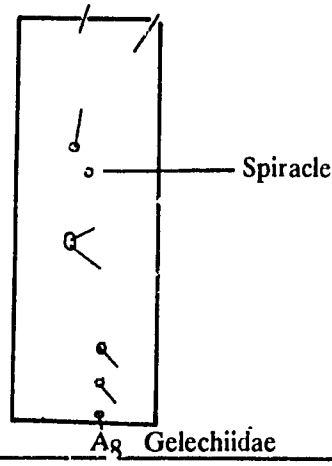
Thoracic Legs with Claw relatively short (Gelechiidae)



A_{10} proleg with crochets divided by gap into 2 groups (Gelechiidae)



Setae iv and v adjacent (Gelechiidae)



EPIPYROPIDAE

Head reduced and retracted into T1. Body stout and mandibles piercing. The larvae are hypermetamorphic; first instar an active triungulinid, compodeiform. Later instars secrete a thick, white covering of paraffin over most of their body. Mature larvae nearly sessile, small to medium, 5-10 mm. Numerous secondary setae. Spiracles round. Six ocelli clustered together. Pronotal plate, pinacula and anal plate absent. Prolegs greatly reduced. Crochets arranged in a uniordinal, uniserial circle on A3-6; each crochet hook with a small basal spine. Verrucae or elongate hairs missing.

The larvae are ectoparasitic on nymphs and adults of certain Homoptera (aphids, leafhoppers and scale insects) (Fulgorids, cicadellids, cicadids).

GELECHIIDAE

Fronto-clypeal suture complete, extending more than halfway to epicranial notch. Ocelli evenly spaced. Head seta L^1 farther from A^3 than A^3 is from A^2

Thoracic legs occasionally reduced/absent. Thoracic legs with the claw relatively short ; prolegs rarely absent, crochets in a longitudinal small group. Head seta $S0^2$ closer to ocellus 1 than 6. (in ellipse or in transverse rows). Crochets and prolegs arranged in 2 groups. A^{10} with crochets divided by a gap into 2 groups (sometimes each group may contain only a single crochet), L^1 ventrad to spiracle on A3-6. A3-6 with distance between L^1 and L^2 less than greatest planta diameter of A3-6 planta, Anal comb present. Two SV setae on A1, gelechiids never have 1 or 3 SV on A^1, A^9 with D1 setae (the shorter, smaller ones) closer together than D^2 setae, A^9 with hairlike SD1, anal fork present (also in tortricids)

The larvae of most species are web builders, but a few are miners or case bearers. Many speices show a tendency to attack the reproductive structures of their hosts - buds, flowers, tubers, etc. Important examples are:

Holcocera pulverea Meyr **(Lac predator)**

The larva of this insect is an important enemy of the lac insect and, hence, is harmful.

Gnorimoschema (Phthorimaea) operculella (Zeller) **(Potato tuber moth)**

Caterpillar: About 20 mm long, slightly fusiform, creamy white, greenish or pinkish white with fine hairs; head, thoracic legs and prothoracic shield dark-brown. A faint green border on either side of body, yellowish anal plate. No anal comb.

Damage: In the field, larva burrows or mines in leaves, petioles, young shoots or stems of potato. May also riddle exposed tubers in the field whereby patches are formed. Mainly a serious pest of stored potato, where slender, silk lined burrows are filled with excrement.

It is the later generations in the field that infest the tubers. The moths lay eggs on tubers, and the larvae on hatching may work their way just under the skin and later may make tunnels through the flesh, thus damaging the tubers.

Pectinophora gossypiella Saunders **(Pink boll worm of cotton)**

Caterpillar(s): These are pink with a yellowish brown head, cervical shield and anal plate. No anal fork. Larvae are found inside the flower buds, panicles and bolls of cotton. They also attack malvaceous plants.

Damage: The damage is caused in various ways: i) The larvae bore into the flower buds and they fall off prematurely.ii) The larvae bore into the flower, seal the tips of the flower petals together with a fine web giving flowers a rosette appearance.iii) The larvae bore into the boll and cut through the developing lint to the seed. As a result the lint development is retarded and the lint is weakened. iv) The caterpillars feed on the seed kernel. They devour the internal content of the seed completely. By eating away the seeds it reduces the yield, viability and oil content of the seeds. The seed germination is also lowered. Immature bolls are shed whereas the mature ones do not open fully.

Owing to the attack of this pest, there is excessive shedding of the fruiting bodies. Of the total shedding of 52.4 to 88.8 percent caused by all the boll-worms collectively, half may be due to the attack of pink boll-worm. The attacked bolls fall off prematurely and those which do mature do not contain good lint. It is considered that by controlling the pink bollworm, cotton yield

can be increased upto 50 percent. It also destroys fruits of okra and other allied plants.

Stomopteryx nertaria Myrick

Newly hatched larvae measure about 1.5 mm in length. Full grown larva is small and green and has a conspicuous dark head.

Sitotroga cereallela (Olivier) (**Angoumois grain moth**)

Caterpillar: Elongated, dirty-white body with a yellow brownish head, body covered with fine hairs. Measures 5 mm in length. Prolegs weakly developed; each proleg with only a few crochets.
Damage: It is an important pest of stored grains such as wheat, maize, sorghum, barley, oats, etc. It feeds on the grain kernels.

GEOMETRIDAE

Full grown larvae 20-50 mm in length. Body elongate, cylindrical and slender but rarely flattened. May bear processes, humps or protuberances or filaments of various shapes. Usually short primary setae present above spiracles, secondary setae may be abundant below spiracles, especially on prolegs. A subanal fleshy process on meson, between anal prolegs. The most striking character is absence of normal, fully developed ventral prolegs on abdominal segments 3, 4 and 5. Only two pairs present on 6 and 10th segment. Sometimes anal prolegs reduced. Thus abdominal legs appear on segments other than those normally carrying them in lepidopterous larvae. Larvae bear close resemblance to twigs. Usually with biordinal or triordinal crochets arranged in a continuous or broken mesoseries on lobate planta. Spiracles elliptical, with those on T_1 and A_8 larger. A_{10} with anal shield dorsal, often triangular and bearing four setae per side. Resemblance with twigs and reduced or absence of anterior 2-3 pairs of prolegs and their looping gait are the most important characters. L1 and L2 widely separated on A1-8, L3 more anterior than the usual posterior position on Lepidoptera.

Many geometrid larvae also have a secondary SV seta beneath the three primary SV setae on the A6 proleg, giving the appearance of four SV setae on the proleg and one above on the body. All but few Geometriids have two pairs of prolegs A6 and A10 ; additional prolegs, when present are

smaller than those on A6 and the crochets are reduced in number/or size. In noctuids with prolegs only on A5, 6 10, the A5 proleg is of the same size as A6. They make loop while moving by bringing A6 and A10 prolegs forward to place behind the thoracic legs. The setae of anal plate and proleg are considered useful below the family level.

All larvae are exposed feeders (not borers or miners), some live in folded leaves or cover themselves with debris of various kinds.

Primary hosts are deciduous trees and shrubs, some feed on coniferous foliage, and even coniferous seed.

The larvae of some species feed chiefly on foliage of many native and cultivated plants. Larvae of many species feed on Euphorbiaceae, which contain alkaloids toxic to vertebrates.

Paleacrita vernata (Peck) **(Spring cankerworm)**

Larva: Full grown larva is 22 mm long. Body light brown. The caterpillars are called loopers, measuring worm or spanworm, because of their method of locomotion.

GRACILLARIIDAE

Larval body generalized and cylindrical. They are hympermetamorphic with the following two distinct forms and habits:

(i) An early sap feeding stage (leaf miners) possesses a reduced head, very much flattended, apodal body (lacking thoracic legs as well as abdominal prolegs), without spinneret but having blade-like mandibles, and rudimentary maxillae and labium, which are used for lacerating cells and sucking exuding sap only.

(ii) Full grown larval stage usually possesses flattened head, thoracic legs and functional spinneret. Have normal head and mouth parts, for eating parenchyma tissues, and often living as leaf rollers. This is the later stage when they act as normal lepidopterous larvae. This is also called spinning stage. Ocelli absent or fewer than 4 per side and nearly in straight line always on lateral margin of head. Labrum much wider than frontoclypeus. No prolegs on 6th segment of abdomen, other legs variable if present occurring on A3-5, and 10. Body setae

more developed, Mature larvae 10 mm. Body varying from white to grey and usually ornamented. Two prespiracular "L group" setae on T1.

This is the only family of Lepidoptera that is sap feeding. They are external feeders, on foliage, may construct folded or rolled leaf shelter and skeletonize rolled leaves. Crochets absent on A6. Ocelli not only spaced (1 and 2 close together and separated from 3 by at least 3x the distance between 1 and 2.

Acrocercops phaseospora Meyrick **(Jaman gall forming insect)**

Full grown larva 3-5 mm long. Body pale-yellow with brownish head. Shape is cylindrical, delicate with body segments tapering anterio-posteriorly; bearing constrictions between each segment. The tiny larva makes large blister-like mines on the surface of the leaves. It is a minor pest of Jaman, *Eugenia jambelana* Lamk.

Phyllocinistis citrella Staint **(Citrus leaf miner)**

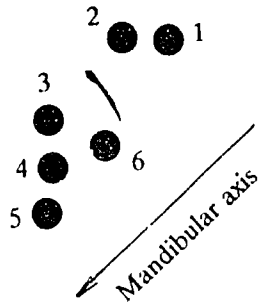
Larva: The larvae when young are white and turn yellow or pale green when fully grown. *Phyllocnistis* has 3 sap feeding instars and fourth (final) is non-feeding, spinning instar. The fourth instar in this genus is the most specialized larva in this family and in the entire order in having lost all legs, ocelli and mouthparts except functional spinneret; antennae greatly reduced and one segmented. Crochets absent in early instars and in all stages.
Damage: The larvae usually mine the underside of the citrus in the nurseries as well as in the young and old orchards, making zig-zag mines which are silver coloured due to the entrapped air. The mid leaves turn pale, curl up and may dry up. Heavily attacked plants can be spotted from a distance and also become prone to disease like citrus canker.

HESPERIIDAE

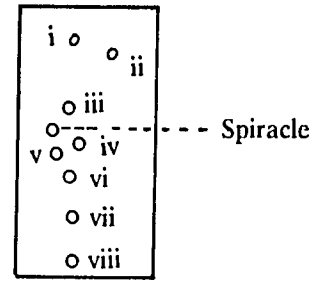
Hesperiid larvae (Skippers) may be recognized by characteristic constriction behind the head, giving the appearance of a neck. Numerous secondary setae on the head; bi-or triordinal crochets arranged in a circle, body tapering from middle both anteriorly and posteriorly; cuticle variously wrinkled.

Head nearly always distinctly larger than prothorax in profile; anal

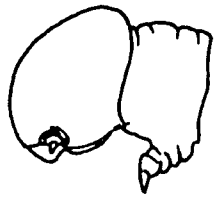
1003



Ocelli not evenly spaced
1 and 2 close and separated
from 3 by at least 3 times
the distance between 1 and 2
(Gracillariidae)



Setal map of 6th abdominal segment.
(Gracillariidae)



Head distinctly larger
than prothorax
(Hesperiidae)

Secondary setae
and scolus
(Limacodidae)

comb present, mature larvae usually less than 40 mm;crochets on prolegs forming an ellipse, at most narrowly interrupted. External feeders, often on grasses, usually constructing shelters.

Larvae construct shelters by joining or rolling leaves. They feed from webbed leaves. The larvae of primitive species feed on dicotyledons those of advanced forms on monocotyledons, especially grasses.

LASIOCAMPIDAE

The larvae are usually hairy and in many species are gregarious living in a communal silk. Full grown larvae are medium sized to large, often brightly coloured and many possess setae, very irregular in length. Head is smaller than the thorax, often retractable, depressed and without scoli. Labrum notched to one half its mesal length. Prothorax usually bears one or two pairs of blunt fleshy protubrances or swellings dorsal of leg. Protubrances present on other segments when setae lacking. A blunt gibbosity on eighth abdominal segment. Secondary setae usually numerous and distinct. Setae never in pencils, tufts, or verricules. Distinct verrucae rarely present. Prolegs occur on segments 3 to 6 and 10. Crochets biordinal in a mesoseries occasionally resembling a meso penellipse. Spiracles elliptical and somewhat larger on T1 and A8.

Lasiocampids are easily distinguished by crochets from other families, these are uniordinal in noctuids, lymantrids, and notodontids, and uniordinal or heteroideous uniordinal in arctiids.

Larvae feed on the foliage and young fruits of deciduous trees, shrubs and some evergreens. Some species construct extensive communal webs which may envelop large portions of the plant and thus cause severe defoliation. The larvae may feed singly, in small groups, semisocially, or socially in large tents or webs.

Malacosoma indicum Wlk. (Tent caterpillar)

Larva: Full grown larva measures 4-5 cm, its head and abdomen are black.
Damage: It is an important pest of apple and has been recorded on pear, apricot and walnut. The larva constructs a tent like nest at the branching point of shoots and hides in the nest during day time. It feeds at night on leaves sparing only the mid-ribs. It is active from mid March to May and it passes 9 months in the egg- stage. Since they build tents they are easily

located in field in all life stages, and they can also be easily reared in the laboratory.

LYCAENIDAE

Larvae usually (onisciform) shaped like a wood louse, tapering towards extremities. Secondary setae usually numerous, some larvae smooth or dorsally corrugated; many clothed with a short pile; others armed with bristle-bearing verrucae, a few hairy. Head capsule bare. Head smaller than prothorax and retractable, rarely more than one third as wide as body.

Abdomen often with median dorsal gland on segment 7 and a pair of dorso-lateral eversible organs on segment 8. A1 spiracle essentially in line with A2 spiracle Mandible bearing more than 2 setae. A8 with no trace of mid dorsal button, body setae rarely quite short, abdomen terminating normally. Larvae usually less than 25 mm when mature. Head/body ratio 54%. Ventral crochets reduced in size or interrupted near centre, by conspicuous fleshy pad. They appear as mesoseries, uniserial and triordinal to multiordinal. In some Lycaenids, the flesh lobe arises within the crochets of mesoseries or it may be laterad. Anal shield usually poorly defined and unsclerotized.

As plant feeders, the early instars in particular eat their way into tender flower buds, flowers, fruits or pods and become internal feeders. The liquid secreted by larvae is eagerly sought by ants hence many larvae are myrmecophilous. Many lycaenid species are phytophagous but others are predaceous on coccids and aphids (Homoptera).

Virachola isocrates Fab.
(Anar butterfly/Pomegranate butterfly)

Larva: Full grown larva louse-like, 2 cm long. Body blackish brown or dark brown in colour; short hairs and flesh coloured markings (some say whitish patches) all over the body.

Damage: The larvae bore into the developing fruits and feed on the seeds and tissues inside, just below the rind. An offensive smell and exuding excreta of the larvae from the entry hole are symptoms for recongnition of damage by this pest.

LYMANTRIIDAE

Larva: Secondary setae usually in tufts of different lengths and density on

verrucae, middorsal parallel pencils of setae on A1- 4, osmeteria (middorsal eversible gland,) frequently present on 6th and 7th abdominal segments, e.g. *Lymantria (Porthetria) dispar* (usually feeds on deciduous trees, many are forest defoliators).

Lymantria (=Porthetria) dispar L. **(Gypsy moth)**

Larva: It measures 55 mm., body colour dusky brown to gray, finely marked with darker spots, possessing a yellow head densely covered with black, pigment blotches and spots, a light brown stripe on the dorsomeson of the body with prominent, paired, pigmented verrucae (beta) on each side. The verrucae on the thorax and first two abdominal segments are blue while those on abdominal segments three to eight are brick red.
Damage: Feeds on foliage of more than 600 deciduous and coniferous plants, chiefly woodland, shade and fruit trees.

Euproctis fraterna Mo. and *Euproctis lunata* Wlk
(Castor hairy caterpillar)

Caterpillar: Dark reddish-brown with black spots, dorsum with a wide white stripe, body very hairy, head and prothoracic shield bright orange-red; gregarious.
Damage: The freshly hatched caterpillars feed on leaves of various host plants (moong, castor, pomegranate, plum) by scraping off the green matter. In case of severe infestation they may cause complete defoliation. The attacked plants remain stunted and produce very little seed, fruits, etc. The peak population is from April - June.

NOCTUIDAE

Larvae are typically smooth skinned and exhibit a clear division of body into head, thorax and 10 abdominal segments. Both hypognathous and prognathous forms occur. Head heavily sclerotized capsule, median and lateral adfrontal sutures present. Anal prolegs somewhat thinner than the ventral prolegs and always with crochets. 6 ocelli, 5 segmented legs, with a single claw; occasionally modified or reduced. Spiracles oval, on T1 and A1-8 . Prolegs present on A5, 6 and 10, planta bears small sclerotized hooks or crochets; may be uniordinal, bi-or triordinal or multiordinal; generally

uniordinal mesoseries. Primary setae almost present in first instar and fairly constant in number and distribution. Sub-primary setae in second and later instars. A8 with a small verruca. Verruca L1 farther from the spiracle on A7 than on A6. Verruca L1 on A7 sometimes reduced to one or a few setae or absent.

In noctuids homoideous mesoseries crochets dominate while in Arctiidae these are heteroideous mesoseries. Exceptions to generalized diagnosis that occur in some Noctuidae are:
Presence of secondary setae, reduced number of prolegs, vestigial prolegs, absence of crochets, and heteroideous crochets, Larvae may have two, three, or four pairs of abdominal prolegs in addition to caudal. Regardless of the number the pair on A5 is subequal to A6 and can be used to separate the semilooping noctuids from the Geometridae, in which the prolegs on A5 are totally absent or distinctly smaller than the pair on A6. Noctuids with no legs on A3 lack secondary setae. In many notodontids caudal proleg is reduced or stemapod (resembling cerci) but lack crochets. Many notodontids with medial groove from labral notch to the base of labrum. This groove is absent in noctiuids. Absence of middorsal gland on A6 and A7 separates Noctuidae from Lymantridae.

Larvae are herbivores on herbaceous and woody angiosperms and gymnosperms.

Achoea janata (L.) (**Castor semilooper**)

Larva: The larval body slender, dark with prominent blue-black, yellow (some say white) and reddish stripes. A pair of reddish processes and a dorsal hump near anterior end of body. Full grown larvae measure 30-35 mm in length.
Damage: The larvae feed voraciously on leaves, soft branches, and defoliate the plants.

Agrotis flammatra Schiffner - Muller (**Gram cutworm**)

Caterpillar: Dark-grey, head yellow with a pair of dark-brown longitudinal stripes in front. Skin smooth with small black spots.
Damage: The caterpillars spend the day in hiding near the base of the plants, cut the plants at the top 3-4 inches of the soil. The plants are cut just above or at slightly below the surface of the soil.

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Agrotis ipsilon (Hübner) (Greasy or black cutworm)

Caterpillar: Newly hatched caterpillar is 1/25" in length and fullfed nearly 2" long. The larva is greasy-grey to brown with faint lighter stripes.

Damage: The larvae live in the soil during day and feed at night. This pest causes considerable damage to potato, gram and wheat by cutting the seedlings in patches at ground level and sometimes even dragging them into the soil. It also attacks tobacco, peas, maize and cucurbits. The larvae do more harm by cutting the plants than by actual feeding.

Pseudoletia (Cirphis) unipuncta Haworth (Army worm)

Caterpillar: Fullgrown, grey-brown larva measures 1" in length.

It has a greenish brown head with numerous dark reticulations and dark streaks near the coronal and adfrontal sutures. The intensity of the pigment of the body varies considerably among individuals. Dorsum greenish-brown to black with a narrow, broken, light stripe along the dorsomeson. On each side a broad band of mottled brown darker at the edges and extending dorsad to seta beta with a narrow white line below this followed by an orange or brown band edged with white, then a dark stripe to the spiracles edged with white. Below the spiracles a pale orange stripe unmottled and edged with white. Venter gray to cream with brownish mottlings. Cervical shield dark brown with three light lines. A dark lateral stripe on remaining segments. Skin noticeabley granulated. Spiracles dark brown to black. Brown lateral patches on ventral prolegs. Mandibles without dentes. A plate over the base of each sucker foot (a character not found in other injurious Noctuidae in this country). Food preference is grains and cereals, however, it will consume any plant when hungrey.

Earias vittella (Fabricius) (= *Earias fabia* Stoll)

Caterpillar: White with a black head when newly hatched. Body short and thick tapering towards both ends. Body colour dull greenish white with the black markings all over and orange dots on the thorax. A dark prothoracic shield present. Under side of the body bluish green, hooks on the inner edge of the planta arranged in the form of a crescent. Body smooth and devoid of hairs.

Damage: In the beginning of the cotton season the pest bores into the top

tender portion of the growing shoots. When flower-buds and bolls appear (July - August), the larvae attack them. The attacked flower-buds and bolls drop off. The attacked shoots ultimately turn black.

Earias insulana Boisd. (Spotted bollworm of cotton)

Caterpillar: White, with a black head when newly hatched; when fullfed 18-20 mm in length, body tapering to both extremities. Body colour dull greenish white with a series of longitudinal black marks all over, and orange dots on the thorax; posterior margin of Ist and 2nd abdominal segments furnished with six spine-like processes (= tiny stout bristles), other segments with four spines, all arranged transversely and decreasing in size from head to trunk, under-side of the body bluish-green, hooks on the inner edge of the planta arranged in the form of a crescent.
Damage: When the cotton plants are young, the larvae bore into the terminal portions of the shoots which wither away and dry up. Later on, they cause 30-40 percent shedding of the fruiting bodies. The infested bolls open prematurely and produce poor lint which fetches a lower price.

Euxoa segetis Sch. (Surface caterpillar or Gram cutworm)

Caterpillar: Pale-grey, some specimens tinged with pink; head pale with two brown marks. When fullfed 40 mm long.

Eublemma amabilis Moore (Lac predator)

Larva: It feeds on lac insect and, hence, is harmful

Euxoa spinifera Roth. (Surface caterpillar)

Caterpillar: Pale-grey, tinged with pink.

Heliothis armigera Hbn.(Gram caterpillar)

Larva: It measures 35 mm., varies greatly in colour from a light greenish-yellow or pink to deep brown or near black, especially on the dorsal aspect. Venter may be light green or flesh coloured. Dark stripes on the dorsal aspect of the body are due, in part, to presence of numerous pigmented

microspines only visible when seen through a lens. Prominent, pigmented tubercles (chaiazae) of alpha and beta setae on abdominal segments 1, 2 and 8 are bare, without microspines. Head yellowish brown with faint markings. Mandibles possess no large tooth (retinaculum) on the mesal (oral) aspect.
Damage: A general feeder, attacking the foliage, stems, fruit or seed bearing portions of many plants, namely, maize, cowpeas, cotton, lima beans, tobacco, tomatoes, and food plants.

Heliothis obsoleta F. (**Gram caterpillar**)

Caterpillar: Green when newly hatched; dark-brown with yellow head when half grown, slightly hairy; colour scheme of fullgrown caterpillar very variable.

Damage: The caterpillars destroy gram seedlings in November- December. They are however, seriously injurious to developing gram seeds during March. It is estimated that to reach maturity a caterpillar requires the seeds of 30-40 pods.

Caradrina(Laphygma) exigua Hubner (**The lucerne caterpillar**)

Larva: It measures 30-35 mm. Body colour usually depends on host, may be pinkish brown to light green, thick and cylindrical with grooves and depressions. Possesses a brownish black head with a number of near-white spots on the epicranium. Cervical shield smoky or green and cut by light lines. Among extremely light or dark forms the following pigment distrubution is obscure. Dorsum, between the ligth narrow, subdorsal lines, dotted and lined confusedly in green or near black, heaviest near pale dorsomesal line. Area between subdorsal lines and the broad subspiracular greenish band is gray to black strongly dotted with near-white spots and frequently blotched in dull red. Bright near-white spots occur dorsad of the spiracles. Two yellowish/pinkish dark longitudinal stripes/lateral bands present on the back in later stages; sparingly clothed with short hairs, spiracles oval and black rimmed. Mesothorax possesses a prominent pigment spot on the spiracular line. Venter pale, mottled with white. Ventral prolegs green, thoracic legs brown. Food plants include numerous cultivated, garden and field crops and weeds.
Damage: It is a leaf feeding insect of jute, gram, linseed, lentil, cabbage, maize, cotton, etc. The larvae feed in the morning and evening. Sometimes

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they make holes while at others make webs on the leaves.

Plusia nigrisigna Walker (Semilooper)

Caterpillar: Leaf eating semi-looper, green with two lateral and a dorsal white line, and short hairs.
Damage: The larvae feed on leaves.

Plusia orichalcea Fabricius (Cabbage looper)

Caterpillar: Fullgrown larva about 25 mm long. Bluish-green with a few short dorsal hairs, slender dorsal white lines and lateral lines distinct.
Damage: It causes damage to cabbage, cauliflower and other winter vegetables. The larvae feed singly on the leaves.

Prodenia litura Fb. (Tobacco caterpillar)

Caterpillar: When full grown 35 to 40 mm in length. Quite fat, thorax tapering to the small head. On each segment of the abdomen there is a black lunulate patch above the lateral yellow line. The colour of lower surface is dull grey-green.
Damage: The caterpillar feeds on leaves by cutting holes.

Sesamia inferens Wlk. (Pink graminaceous stem borer)

Caterpillar: Body smooth, slightly tapering anteriorly, more so posteriorly beyond A6, uniformly pinkish brown dorsally and whitish ventrally with black spiracles. Head brown. A pair of caudal appendages at the tip of abdomen.
Damage: It is a pest of sugarcane, wheat and sorghum. The caterpillars bore into the stem or shoot and cause dead hearts in case of early infestation.

Sesamia uniformis Dudgn. (Pink graminaceous borer of maize)

Larva - Colour of the larvae depends upon the crop on which they feed. Smooth, brownish-green caterpillars feed on the foliage and move in large numbers from field to field. Caterpillar like that of the *Sesamia inferens* Wlk. and *Spodoptera exigua* (Hubner).

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Damage: The damaged crop on which larvae have fed gives a webbed appearance. The older caterpillars which feed in the morning and evening have a voracious appetite and strip off quite large patches on the foliage. They feed voracionly on leaves and tender shoots.

Tarache notabilis Wlk. (Cotton semi-looper)

Caterpillar: A semi-looper, dark-green or brown in colour with a velvety look, dorsum ornamented with six pairs of black and bright-yellow spots; full grown caterpillars about 40 mm long.

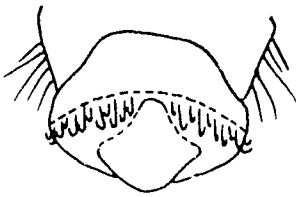
NOTODONTIDAE

Ventral crochets in uniordinal mesoseries only, no latero- series present, anal shield never modified into caudoprojecting process (although rudimentary caudal prolegs may be caudal- projecting and a pair of caudo-projecting process may be below the anus). Labral notch V-shaped and usually continued as groove to base of labrum. Mandible with 3 large, adjoined inner teeth. Abdomen without annuli or only very weak ones. A10 not terminating in 3 angular lobes. Caudal prolegs smaller than ventral prolegs. T1 with shield absent or not darkly sclerotized and with posterior pair of setae on each side shorter than anterior pair.

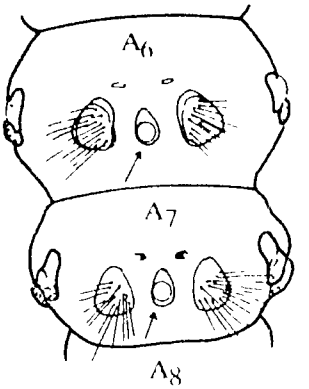
Larvae are exposed feeders found on trees and shrubs. When disturbed they raise the anterior and posterior ends of the body into the air and become motionless.

NYMPHALIDAE

Larvae slender, with branching spines or long paired fleshy filaments, or forked tail, or high hairy tubercles; or angulated or spined head, or head larger than prothorax, or legs with reduced crochets on outer side. Head with pair of protuberances nearly as long as or longer than frontoclypeus. T2 and A8 (and sometime other segments) bearing a single pair of subdorsal to dorsal filaments; remainder of head and body essentially bared and vertically stripped, with combination of black, yellow, and white. Crochets triordinal, all setae very short above the prolegs, no osmeterium on T1. A2 spiracle dorsal than A3 spiracle. A7 with middorsal scolus. Crochets usually triordinal sometimes biordinal, feeders on a wide variety of herbaceous and woody

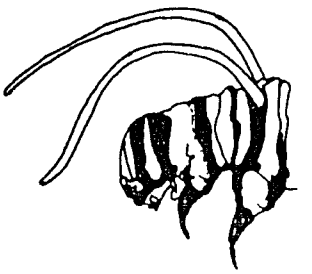


A_{3-6} crochets interrupted near centre by a fleshy pad (Lycaenidae)



A_6 and A_7 with middorsal eversible gland. (Lymantriidae)

Osmeterium on dorsum of T_1 (Papilionidae)



T_2 bearing a pair of dorsal (or subdorsal) filaments (Nymphalidae-Danainae)

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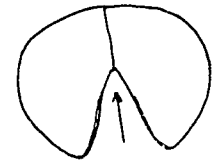
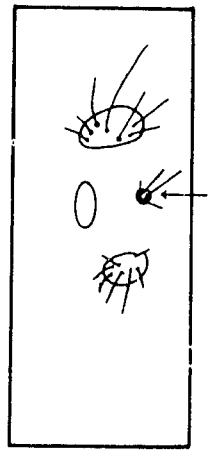
Crochets in a mesoseries

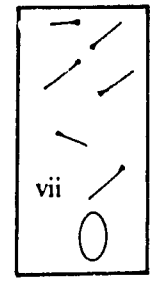


Labral notch v-shaped and extending to base of labrum (Notodontidae)



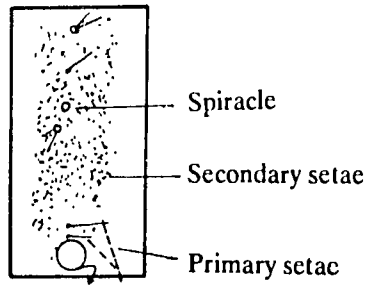
A8

A8 with a small verruca behind spiracle (Noctuidae)

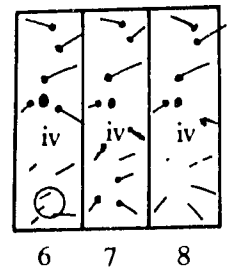


Mesothorax

Tubercle vii on mesothorax with 1 seta (Noctuidae)



Body segment showing primary and dense secondary setae (Noctuidae)



Setal map of 6th, 7th and 8th abdominal segment seta iv much lower on 7th segment (Noctuidae)

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plants. Crochets multi- ordinal. Bifid anal segment or horned head. The larvae are protected by hairs and spines.

Nymphalids universally possess a uni- bi- or triordinal mesoseries. This character also serves to separate them from hesperiids, which many nymphalids resemble because they have a head much larger than the prothorax.

Most nymphalids possess scoli, resembling saturniids, but nymphalids typically lack a middorsal scolus on A7, as well as having a triordinal rather than biordinal crochets. Head larger than T1 and often with prominent protuberaces, humhs, filaments or scoli; no osmeterium and a bifurcate anal plate in some. Six ocelli, with 2-5 on papillae and more prominent than 1 and 6. Abdominal and thoracic segments frequently annulate. Life histories of many of our species are totally unknown and we possess inadequate knowledge of majority of rest.

Vanessa cardui **(Painted lady butterfly)**

The larvae feed on the foliage and cause damage. They tie the leaves together.

Vanessa atlanta **(Red admiral butterfly)**
Vanessa io **(Peacock butterfly)**
Apatura iris **(Purple emperor)**

The larvae of all the four species appear to show preference to plants of Scrophulariaceae.

Subfamily *Danainae*

Full grown larvae 35 to 50 mm in length, smooth and cylindrical, transverse black and green, red or yellow stripes on most segments and head. Head as large as prothorax, deeply pigmented with black stripes and covered with numerous short secondary setae.

Two or four pairs of fleshy processes, at least on mesothorax, and often one or more on abdominal segments. The primary setae of the body are inconspicuous. Secondary setae abundant, particularly on venter, in some confined to the prolegs. Paired fleshy filaments occur on the dorsal aspect.

Frontoclypeus wider than long, apex 1/2 to epicranial notch. Six

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ocelli, 1-4 grouped in semicircle with 5 widely separated near antennal base; 2-5 on papillae, more prominent than 1 and 6; 6 caudad of 4, closer to 4 than 5. Secondary and primary setae inconspicuous or absent; cuticle appears bare without magnification. Head slightly bilobed, smaller than T1, colour light green, vertically banded with black.

In Danaus and Monarch butterflies a pair of long fleshy filaments is located addorsally on T2 and in some on T3. The larvae feed on foliage of several plants chiefly milkweed, oleander and *Ficus*.

Danais chrysippus Linn. (**Ak-butterfly**)

Larva: Full grown larvae 40-50 mm long. Body yellowish, bands velvety black. Head is shining black. There are 3 pairs of fleshy filaments; one pair each on T2, A2 and A8. Major host plant is Ak (*Calotropis procera* R. Br.). It also feeds on cotton, gardenia, lady's finger, etc. This insect is very common in Pakistan.

Danais plexippus L. (**Monarch butterfly**)

Larva: It measures 50 mm. Mature larva green or yellowish possessing one or more near-brown to black transverse stripes on all segments and the head. On most segments the median stripe of the three is conspicuous. Paired, fleshy, near-black filaments occur on the dorsal half of the mesothorax and the eight abdominal segments. Feeds on foliage of milkweeds.

PAPILIONIDAE

Larvae are smooth, or provided with a series of fleshy dorsal tubercles or sometimes with a raised prominence on 4th segment. Body devoid of setae, osmeterium on prothorax, used to repel enemies. Measures 40 mm +, in early instars, most species resemble bird droppings. In later instars, different species may be ornamented with large eyespots..

Most species are cryptically coloured, but species feeding on distasteful plants are brightly ringed or banded. The larvae erect an odoriferous osmeterium when disturbed. The larvae are external foliage feeders.

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Papilio demoleus Linn. (Citrus butterfly)

Larva: Full grown larva is yellowish green, horn-like structure on the dorsal side of the last body segment and is 40 mm long and 6.5 mm wide. When young with a blend of brownish black and white, when older green with a few oblique, brownish stripes down the sides of its body.
Damage :The larvae prefer to feed on the fresh leaves and terminal shoots. They feed from margin inwards, reaching the midrib. They occasionally feed on mature leaves and sometimes entire plant may be defoliated. Heavily attacked plants bear no fruit.

PHYLLOCNISTIDAE

Larvae apodous. The larvae are mostly leaf miners and skeletonizers.

Phyllocnistis citrella Stt. (Citrus leaf miner)

Caterpillar: Larvae when young are white and turn yellow or pale green with a brownish head. When fully grown, they are legless and measure 5.1 mm long.

Damage :Larvae damage young leaves. The injured epidermis takes the shape of twisted silvery galleries. Brown patches are formed on leaves which serve as foci of infection for citrus canker. The attacked leaves remain on the plants and damage gradually spreads to fresh leaves.

PIERIDAE

Larvae rather elongate, 20-40 mm long, abdominal segments A2-6 divided into five or more annulets (usually 6). Body colour usually some shade of green; often striped or banded. Ocelli 2, 3, 4 and 5 usually distinctly different from 1 and 6. Body bears numerous secondary setae (varying in size) on chalazae; without spines, warts or filaments; anal plate rounded; legs with a single band of crochets; head rounded and smaller than prothorax, crochets are also bi-or triordinal arranged in mesoseries. Prothoracic neck and osmeterium absent.

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Pieris brassicae Linn. (Cabbage butterfly)

Caterpillar: It is 40-50 mm long, pale-yellow when young, turns bright yellowish-green later on, dorsum marked with black dots. Body with chalazae, head black with white stripes, body with hairs on the dorsal side, found in cluster on cabbage leaves.

Damage:The first-instar caterpillars just scrape the leaf surface, whereas the subsequent instars eat up leaves from the margins inward. The damage is extended to shoots and pods, often the entire plants are eaten up.

PYRALIDAE

Larva: Body typically cylindrical, tapering anteriorly and prosteriorly, with normal complement of prolegs. Crochets usually bi-or triordinal, in a circle or penellipse, rarely uniordinal in two transverse bands. Well developed primary setae only, arising from pinacula or chalazae. Spiracles more oval; SV3 on A3-6 directly in front of crochets. A8 spiracle in line with the spiracles anterior to it and laterally oriented; spiracles usually oval. T2 and T3 with 3L setae.

Many phycitinae, pyralinae, and galleriinae have a pinaculum ring formed by a pinaculum with an unpigmented or unsclerotized center at the base of some setae.

Head often rounded, flattened in leaf miners. Mandibles simple, sometimes with extra distal teeth or retinacula or other modifications. Prothorax with distinct shield, six setae on each side of shield. Two L setae on a prespiracular plate of T1. D1 and D2 adjacent on T2 and also on T3. L group usually trisetose in T2 and T3. D1 and D2 usually on all abdominal segments except A9. On A8, SD1 with a sclerotized darkly pigmented, on A9, L2 present.

Larvae are aquatic as well as terrestrial, and are extremely variable in their habits. They are concealed feeders, as miners, web or tube builders;mostly pests of cultivated plants and stored products. They live in shelters of webbed leaves or shoots, or tunnels in shoots, stems, seed-heads, fruits or galls, or in silken galleries among mosses, herbaceous plants, or fallen leaves, or in shelters or cases amongst equatic plants in fresh water, in nests of Hymenoptera, rarely predacious on Coccidae. *Galleria melonella* and *Achroia grisella* infest beehives and are capable of digesting wax with the aid of intestinal bacteria. *Cactoblastis cactorum* which was utilized to control

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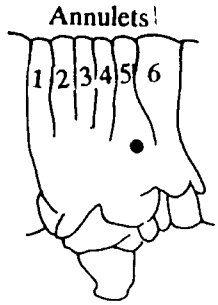
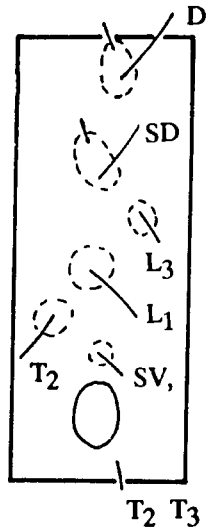
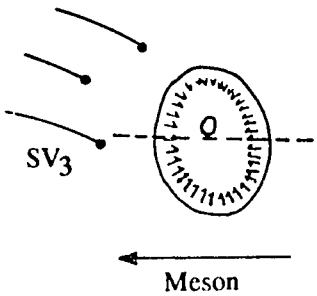


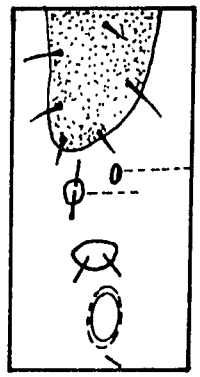
Body segments with distinct 6 annulets (Pieridae)



T_2 and T_3 with L_3 setae (Pyralidae-Schoenobiinae)



Spiracle more oval, SV_3 on A_{3-6} directly infront of crochets (Pyralidae-Crambinae)



Prespiracular wart of Prothorax with 2 setae (Pyralidae)

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Opuntia cactus in Australia also belongs to this family.

Acigona (= Bissetia) steniellus (Hampson)(**Gurdaspur borer of sugarcane**)

Caterpillar: A fullgrown caterpillar measures 25-28 mm in length and 2.5-3. mm in breadth. Body cylindrical, sparingly clothed in short setae. Head light orange, rest of the body creamy white with four wide longitudinal reddish brown (violet) stripes situated on along the spiracles and dorsal vessel. The lateral stripes, very prominent particularly between Ist and 9th abdominal segments. Hooklets on planta of prolegs form a complete circle.
Damage: The caterpillars after hatching feed gregariously for a while on the buds situated on the top Ist and 2nd internodes and there they bore into it from near the buds. They feed on the tissues first below the rind boring their way upward (from the point of entery) in a spiral manner. Externally this passage appears as a dark spiral streak which on closer examination is found to be made up of a series of punctures lying side by side like the beads in a rosary. When about 2/3 of the internode is damaged in this manner the caterpillars bore deeper in the softer tissues of the cane and feed by making a single straight and curved tunnel. The dark spiral streak rendered the affected internode weak which breaks off when shaken by wind or passing animals.

Emmalocera depressella Swinhoe (**Sugarcane root-borer**)

Larva:It is 30 mm long. Body tapering gradually towards its caudal extremy. Creamy-white with yellowish-brown head. Body appears rather wrinkled.
Damage:This pest is primarily destructive to the young plants and the attack is particularly severe from April to June. The newly hatched larva bores into the underground portions, consumes the inner contents of stalks by making semicircular tunnels, cuts the leaf whorl and produces greenish white dead hearts, which cannot be easily pulled and there is no foul smell from the dead hearts. Dry and hot weather favour its damage. It is a serious pest of sugarcane and also attacks sarkanda, sorghum, etc.

Etiella zinckenella Treitschke (**Phycitid pea pod borer**)

Larva: Full grown larva 12-15 mm long. It is green reddish or brown with

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dorsum frequently ruddy pink. Head as well as the tips of thoracic legs with a few pairs of dots. Younger larvae pale green to cream colour. Head amber yellow with brown caudal line, cervical shield yellowish with a few pairs of dots, also seta beta somewhat nearer to alpha than to delta, also rho distinctly nearer to epsilon than to gamma. Setae on abdomen yellowish with no pigmented pinacula. Mandible with four dentes on distal margin. Peritemes of spiracles near black.

Damage:It is a serious pest of lentils and green peas It bores into the pods and feeds on the grains inside.

Euzophera perticella Rag. **(Brinjal stem borer)**

Caterpillar: It is 20-22 mm long, scale-like, yellowish-white or creamy white with an orange-brown head. Body clothed with short bristly hairs, and tapers posteriorly.

Damage: The caterpillars bore into the stem at leaf or branch exil and cover the hole with excreta and frass. They feed exclusively in the main stem and have never been observed to bore into the fruits. As a result of their attack in the field, plants are seen withering; they remain stunted in growth and may even dry up. The fruit yield is adversely affected

Scirpophaga nivella (Fb.) **(Sugarcane top borer)**

Larva - Body 25-30 mm long. Black when young, creamy white or dirty white or greenish yellow when mature and rather sluggish. Dorsal vessel prominent, body cylindrical, thoracic region slightly tapering anteriorly towards the head, blunt posteriorly; segments with numerous depressions and elvevations (some call these as wrinkles). Spiracles elongate, oval with a black or brown rim, hooklets on planta of prolegs arranged in the form of an oval ring.

Damage:The eggs laid on the lower surface of the leaves, hatch into young larvae, which first move freely for sometime and then bore into the midrib and make tunnels downwards. They come out at axis and bore at 4-5 places and enter inside the growing point or top shoot. After feeding on tissues of 3-4 internodes it produces dead hearts.

This pest attacks young plants before formation of the canes. These plants are killed and are a total loss. In the subsequent broods, the pest

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attacks the terminal portions of the canes. The quality of the juice is also affected adversely. The young plants have reddish streaks on the midribs as well as number of shot holes on the leaves as symptoms of its attack.

Tryporyza incertulas (Walker) **(Rice stem borer)**

Larva: The caterpillars, when full grown measure about 20 mm and are dirty white or greenish yellow, having brown head and pronotum. Segments with numerous constrictions.
Damage: The plants attacked in early stage are killed altogether, whereas those infested at the earing stage produce ears devoid of grain and are known as the'white ears'. It is a pest of rice.

An allied species, *Tryporyza innotata* (Walker), the white moth borer, is also present in most of the paddy growing areas. The life-cycle and damage of this species is almost similar to *T. incertulus.*

Subfamily *Crambinae*

Conspicuous pigmented pinacula may disappear in hibernating instar. Pi group is bisetose crochets biordinal, occasionally triordinal. L2 on A9 missing.

Larvae bore in stems, roots and leaves of grasses or form silk tubes in the soil and feed on grasses.

Chilo (= Chilotrea) auricilia (Dudgeon) **(Sugarcane stalk-borer)**

Larva: Fullgrown larva is 25-30 mm long and light bluish pink in colour, The head and prothorax are dark brown. There are five longitudinal violet stripes on its back. Crockets arranged in horse shoe form, gap pointing outside.
Damage: The larvae feed on leaves for 21-30 days and then bore into the stem and feed in the unopened leaves of central whorl. The caterpillar bores into one internode after another and changes plants.

*Chilo infuscatellus (*Snellen*)* **(Sugarcane shoot borer)**

Larva: Body 20-25 mm, dirty white and have five light violet longitudinal stripes on the body. The head is reddish to brown.
Damage:The plants, are attacked at an early stage of the crop. In the infested

crop dead hearts are seen from April to June. This also leads to complete dry up of the crop. After the fc ·mation of canes, its attack does not produce dead-hearts and the damagc is confined to a few internodes only. In the beginning the caterpillars bore into the central shoot and make tunnel downwards. They feed inside the soft tissues giving rise to dead hearts, which can be easily pulled out. The central leaf sheath within the shoot gets rotten and gives very offensive smell when pulled out . Activity period is April to August.

Chilo partellus Swinhoe **(Maize borer)**

Damage: Caterpillars attack all parts of the maize plant except the roots. It bores into the stem, feeds on leaves and cobs and also grains.

Chilo suppressalis

Larva: It has greyish brown body with a yellowish brown head. There are three faint dorsal and two lateral, longitudinal brownish stripes. Full grown larva measures about 26 mm in length.

Subfamily *Gallerinae*

Galleria melonella **(L) (Greater wax moth)**

Larva: Body stout, most of it pink, yellowish white or gray in living larvae. Head yellowish to reddish brown with slightly darker platelets and dark reddish brown near mouthparts. Some ocelli (1 and 2 fused) some absent. T1 shield mostly yellowish to reddish brown, paler anteriorly. Most of T2, T3 and abdomen white with many minute pale brown to brown integument granules dorsally and laterally; Pinacula relatively obvious on prothorax, weakly developed to absent elsewhere. Spiracles pale yellowish, spiracular peritremes of uniform thickness. SD1 of A[illegible] and A8 with weakly developed pinacula rings;

A3-6 crochets few in number mostly biordinal in ellipses. Kappa group setae of prothorax on a line dorsad of spiracle, kappa and eta setae of abdominal segments 1 to 8 in an oblique position and mandibles stout without a conspicuous thin protuberance immediately distad of condyle.

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Damage: The caterpillars eat honey combs and interfere with brood- rearing by making silken galleries through the cells. In the case of severe infestation the whole becomes a mass of webbings in which excreta of the caterpillars is enmeshed. The infested bee colonies often abscond. In the off season when the combs are stored, the caterpillars damage them also. Larva, prefers old combs, which it riddles with silk lined burrows.

Subfamily *Phycitinae*

Base of SD1 on T2 with a sclerotized, usually darkly pigmented, pinaculum ring. The larvae vary greatly in habits and usually live in silken tubes by day, coming out to feed at night. On A8, SD1 with a sclerotized, darkly pigmented pinaculum ring. On A9, L2 missing.

Larvae feed within stored products (meal, dried fruit, chocolate, tobacco, etc), or tiers, webbers, rollers of leaves or borers of buds, shoots, stems, petioles, fruits, seeds, etc. of many plants, particularly legumes (Fabaceae), or are predaceous on scale insects.

Phycita infuseila Meyrick (**Cotton bud-caterpillar**)

Caterpillar: Full grown caterpillar measures 15 to 18 mm in length. General body colour greenish with ill-distinct longitudinal zig-zag brown (some say faint brown) stripes on dorsum. Head black, thoracic shield dark. Body is sparingly clothed with short hairs.

Damage: The larvae feed by webbing around the terminal leaves. Plant growth is checked and damaged leaves wither away, dry up and drop off. Flowering, fruiting and yield are poor

Plodia interpunctella (Hubner) (**Indian meal moth**)

Larva: Full grown larva 8.3 mm long. It is a small whitish often tinged with green or pink. Head reddish brown or yellowish, darker at adfrontals, frontoclypeus and near mouthparts, and with indistinct platelets. Setae, cervical/prothoracic shield, suranal plate, crochets and part of legs pale or yellowish brown. Frontoclypeus extending two- thirds, or more, the distance to epicranial notch.

T1 shield brownish yellow with pale brown to brown platelets.Mandibles with three distinct dentes, the middle one the largest.

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No pinacula or sclerotized rings about setae on the T2, T3 and A1-9 except rho on T2 and A8 approximately half way between rho and eta.

T2, T3 and abdomen mostly pinkish, sometimes white.

No pinacula evident, except SD1 to T2 and A8 with relatively indistinct brownish yellow pinacula rings.

A3-6 crochets biordinal in broad ellipses or circles.

Damage: It is world-wide in distribution. It feeds on all kinds of grains, including oats, wheat, and corn, dried fruits, nuts, seeds, meal, dried roots and herbs and many other materials of vegetable origin, as well as dried insects. Larvae also contaminate materials with silk and frass. They also web completely, over the surface of the heap of grains with silken threads. It can also feed on dead insects, excrement, exuviae and pollen in beehives.

Subfamily *Pyraustinae*

Larva: Crochets in a complete circle or in a mesopenellipse on A9, L2 present.

Damage: They are mostly folders or webbers of leaves, or stem or fruit borers, of mints, grasses, legumes and cucurbits.

Many species are pests of agriculture. The larvae feed in a slight web among spun-up leaves, or in stems, fruits and roots of maize, corn, sunhemp and other crops.

Hellula undalis F.

A mature larva measures 15-17m. Body greyish-yellow with five prominent brown to purplish longitudinal stripes on the dorsum. Lighter stripes occur on the sides and below the spiracles. Head dark brown to near black. Cervical shield shiny, purplish gray, pinacula when present inconspicuous.

Damage: The larvae save first instar cover their feeding area with a silk web on which faeces and dirt collects. Attack young leaves and heart of plants like cabbages, cauliflower, and even seed beds.

Leucinodes orbonalis Guen. **(Brinjal fruit borer)**

Caterpillar: It measures 18-23 mm in length. Creamy-white when newly

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hatched, when full grown dorsum of body pink, head brown, prothoracic shield dark-brown, four dark round spots on each body segment; body sparingly covered with minute hairs, spiracles black.
Damage: In early stage of crop larva can bore into the stem and cause dead hearts as a result of which shoots wither and dry. In the later stages it also bores into flower buds and developing fruits by making holes and feeds inside, which makes the fruit unfit for human consumption. Severe infestation leads to rotting of fruits.

Sylepta derogata Fb. **(Cotton leaf roller)**

Caterpillar: When mature, pale-green with a brownish head, sparingly clothed in blackish hairs. Measures 4-5 cm in length.
Damage: The larvae feed on cotton leaves from inside after having rolled them. In years of serious outbreaks, cotton plants may be completely defoliated. The American cotton is prefered to the desi cotton.

SATURNIIDAE

Larvae highly specialized; stout and smooth, possess well defined or rudimentry scoli. Head rounded; fronto-clypeal suture wanting; spiracular furrows rarely present; chrochets biordinal. D_1 wart of A8 fused into a caudal horn in some species. D_2 warts rarely fused. Larvae are characterized by the scoli (spiny protuberances) on their dorsal surface, which serves as diagnostics. Labral notch very deep, body segments nearly distinct dorsally and with annulae, and plate not forked. All secondary setae relatively stout and nearly equal in length and thickness, setae relatively spare and easy to count in occular/antennal area. Fleshy lobes not present above legs. Thorax not conspicuously humped. A8 and A9 with dorsal scolus, scoli usually present on other abdominal segments. Head is smooth and rounded in Saturniidae, but angulate or bearing dorsal tubercles or scoli in the Nymphalidae. The combined characters of the chalazae or scoli (at least rudimentary), smooth hypognathous head, and fully developed prolegs on A3-6 and A10 with strong biordinal crochets arranged in a homoideous mesoseries distinguish ultimate saturniid larvae from all other Lepidoptera.

Larvae feed predominantly on foliage of shrubs and trees. Most species are solitary, but some feed gregariously.

Philosania ricini

It feeds on *Ricinus communis* and yields Eri silk which is white or brick-red but not reelable, and is mainly used locally in Assam and Bengal.

SPHINGIDAE

Larvae stout and of naked appearance, usually smooth or with a granulated skin (in first instar), longer than 25 mm when mature. Head rounded to bumpy to angular. 8th abdominal segment bearing an obliquely projecting dorsal tapering horn, hence the common name "horn worms". Horn relatively longer in first than later instar. Crochets biordinal in a mesoseries, feeding exposed, in day time. The diagnosis is that larvae are smooth, abdominal segments divided into 6-8 distinct annulets, A8 with median dorsal horn or button that does not bear setae. A10 terminating in three sharply pointed (angular) lobes, one dorsal and two lateral. A3-6 prolgs with many setae. Caudal prolegs similar in size to ventral prolegs.

The domestic silkworm, some notodontids and a few saturniids are likely to be confused with sphingids because they also have A8 horn or scolus, but sphingid larvae have 6-8 annulets per segment while other three families have none. Spiracles elliptical, T1 and A8 spiracles about same size as A1-7 spiracles. Ocelli six, small, in a arc, 5 below and 6 behind 4.

The larvae consume prodigious quantities of foliage and several are pests of solanaceous plants such as tobacco, tomato, potato, etc.

Acherontia styx Westw. **(Death's head moth)**

Larva: Fresh larva is pale yellow, while full grown has hard integument and is greenish, measuring about 5 cm long and 1 mm in width, often retards some of its anterior body segments and looks like a sphinx. Lateral sides are adorned by dark green to yellow oblique 8 stripes. The strongly curved horn like projections on the caudal segment of abdomen is conspicuous. The body of the larva is plump and is decorated with a pleasant mixture of soft colours.
Damage: The larvae feed voraciously on leaves and defoliate the plants. Insect is capaste of inflicting heavy damage at times. It, however, draws our attention because of its peculiar characteristics.

Acheronitia luchesis (Fabr.) **(Til hawk-moth)**

Larva: Full grown larva 100-125 mm long. Body yellowish, sprinkled with violet brown. The double curved horn is rough and is of the body colour. It mainly feeds on till *Sesame indicum* Linn. potato, brinjal and balsam (*Myroxylon balsamum* (Linn.)

Herse convolvulii L. **(Til hawk moth)**

Caterpillar: Full grown larva 96-100 mm. Dorsum of the body smoky-brown, with short black lines across the secondary rings and clearly defined yellow subdorsal stripe. The head is pale yellow. Cryptic colouration, skin smooth or granulated. The 8th abdominal segment almost always bears an obliquely projecting dorsal horn.
Damage: Feeds on potato and green gram.

TINEIDAE

With anal prolegs unlike the ventrals; D_1 lower than D_2 on abdomen. Body elongate and covered with minute spinules arranged in vertical rows. Ocelli arranged differently, 1 & 2 separated from 3 & 4 with 5 beneath the antennae and 6 separated caudaly. Distance between ocelli 2 & 3 more than 2x the greater diameter of ocelli 2. Prothorax spiracles included on (surrounded by) the distinct L pinaculum, which may be continuous with prothoracic shield. A1-7 with L1 caudad of and at the same level as spiracle and as close or closer to spiracles than it is to L2. A3 with SD2 almost as large as SD1 and with L1, much closer to spiracle than L2 is, A3-6 with SD2 present above and in front of spiracle. Spinules absent on body. The abdomen possesses four pairs of ventral prolegs and one pair of anal prolegs; crochets always present and arranged in a uniserial circle or ellipse, rarely in mesal penellipse.

Larvae predominantly herbivores, many scavengers. Larvae occur in protected situations, some tunnel in fungi, others scavenge beneath loose bark, in bat caves and animal burrows, or in human habitations. Many members of this family consume material of animal origin, especially fur and feathers, including articles of apparel; hence their common name, "clothes moths". Many larvae construct tubes over their food or inhabit a portable protective case.

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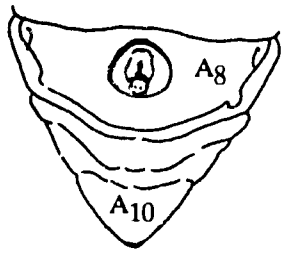
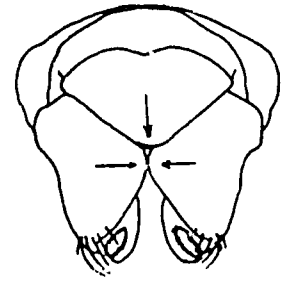
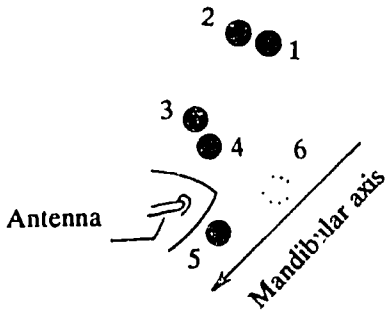


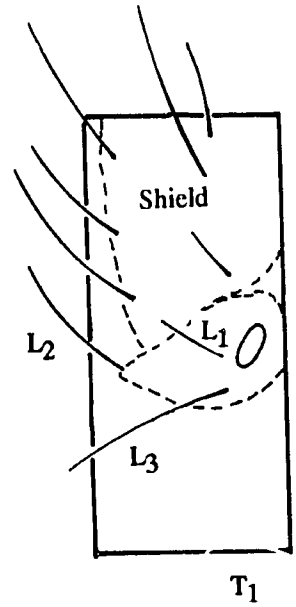
A_8 with middorsal inconspicuous button (Sphingidae)



A_{10} terminating in 3 angular lobes (Sphingidae)



Distance between ocelli 2 and 3 more than 2x the greatest diameter of ocellus 2 (Tineidae)



Prothoracic spiracle included on distinct L pinaculum (Tineidae)

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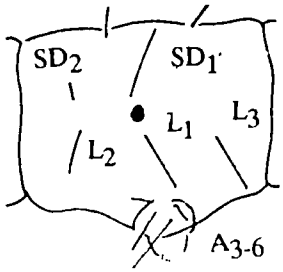
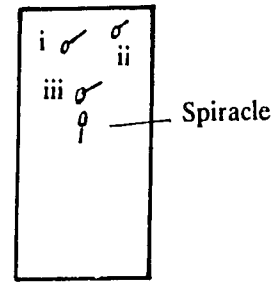
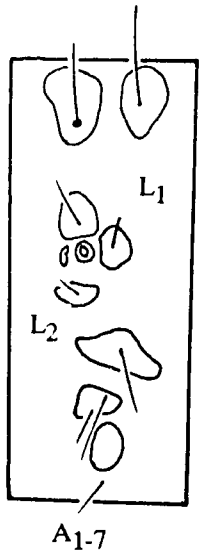


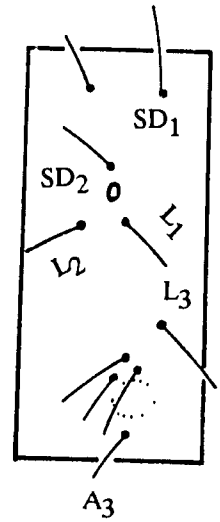
A_3 with SD_2 almost as large as SD_1 and L_1 much closer to spiracle than L_2 is (Tineidae)



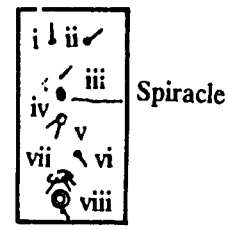
Abdominal seta i much lower than ii (Tineidae)



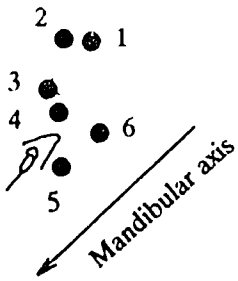
A_{1-7} with L_1 caudad of and at same level as spiracle, and as close or closer to spiracle than it is to L_2 (Tineidae)



A_3 with SD_2 much smaller than SD_1 and L_1 and L_2 nearly equidistant from spiracle (Tineidae)



Setal map of an abdominal segment (Tortricidae)



Ocelli not in a semicircle, ocelli 1 and 2 separated from 3-4, with 5 beneath the antenna and 6 separated caudally (Tineidae)

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Trichophaga tapetzella (L.) (Carpet moth)

Larva: Full grown larva is about 10 mm long and about 1.25 mm broad, cylindrical, yellowish dirty white. Skin soft and transparent, head yellow brown, segments with thin white scattered hairs.

Tinea pellionella (L.) (Casemaking cloths moth)

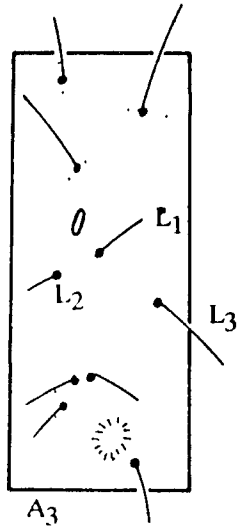
Caterpillar: White and vary in size from about 1/16 inch long when first hatched up to about 1/3 inch when full-grown, live in silken cases which are dragged about with them and enlarged as they grow. Head brown and a brown cervical shield, pigment along the dorsomeson lacking.
Damage:It feeds on wool, skin, feather, etc.

TORTRICIDAE **(includes Eucosmidae)**

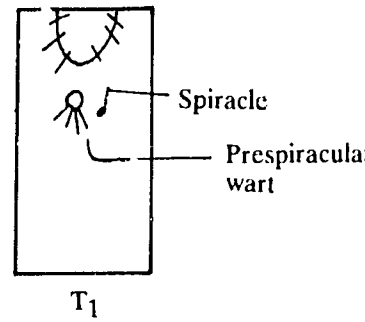
Full grown larvae are small, 10-25 mm in length, occasionally larger, somewhat cylindrical. Body is frequently more or less uniform in colour, near white, pink, green, purple or brown, and may possess a pigmented cervical shield, suranal plate and pinacula. Rounded, pigmented, head distinct, possessing a fron covering one-fourth to three-fourth of the distance between clypeus and vertical triangle, adfrontal areas usually touching vertical triangle, and six ocelli, usually unevenly distributed with the sixth always close to the fourth and fifth.

Spiracles are usually broadly eliptical with eighth pair usually somewhat larger and more dorsad. Prolegs present on segments 3 to 6 and 10 bearing uni- bi or triordinal crochets arranged in complete circles on the ventral prolegs. Crochets on the A10 prolegs are in a continuous row, wherease they are divided in some Gelechiidae.

L1 and L2 adjacent to A1-8; SD1 and A8 usually anterior; anterodorsal or anteroventral to the spiracle. A9 with D2 setae usually on a common middorsal pinaculum and closer to each other than each is to its own D1; A9 with D1 usually closer to S1 than to D2 and D1 and SD1 frequently on the same pinaculum. A trisetose, T1 L group distinguishes them from pyralids. Many of species are pests of agriculture or forestry. The larvae roll leaves and skeletonize them. Example are *Tortrix* sp., *Cacoecia* sp., *Dlulia* sp.



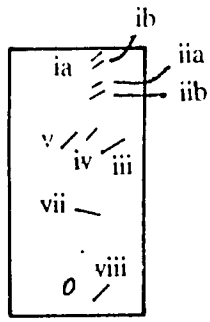
A_3 with L_1 distinctly closer to spiracle than L_2 (Yponomeutidae)



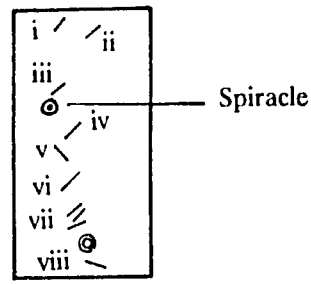
Setal map of prothorax

Prespiracular wart on prothorax with 3-setae (Yponomeutidae)

(*Plutella maculipennis* Diamond back moth)



Setal map of mesothorax



Setal map of an abdominal segment

Mesothorax with seta ia and ib closely associated; abdominal seta iv below level of spiracle (Yponomutidae)

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Larvae are concealed feeders on living plant tissues. they bore into fruits, nuts or seeds. Many larvae are external feeders especially on foliage by skeltenising in rolled, folded, webbed, or tied leaves. They may feed as miners of fruits, seeds, etc. or within twigs, flower buds, fruits, and nuts of many wild and cultivated plants. Some of the common fruits attacked are apple, pear, peach, chery and strawberry. A good example is codling moth, *Enarmonia (Carpocapsa) pomonella*, whose larvae mine in apples.

Enarmonia (Carpocapsa) pomonella (Linn) **(Codling moth)**

Larva: The larva is pinkish-white caterpillar with a brown head and is about 3/4 inch long. Full grown larva passes winter in a thick silken cocoon.

YPONOMEUTIDAE

The larvae are miners, web builders over food, or exposed feeders on foliage. Similar to Plutellinae, but have multiserial crochets on shorter prolegs than are found among the plutelids. D_2 lower than D_1 on prothorax, prespiracular wart with 3 setae; L1 and L2 approximate on segment A9, the converse of what is found among plutellid larva. Larvae are communal when external feeders.

Subfamily *Plutellinae*

Mature larvae 12-25 mm long. Colour yellow green, whitish marked with brown or orange stripes. Only primary setae. Frontoclypeus extending two-thirds to epicranial notch. 6 ocelli in a semicircle. Prolegs long, slender on A3-6 and A10, crochets usually uniordinal, sometimes biordinal as uniserial cricles or slightly incomplete circles.

Larvae of plutellids are similar to Yponomeutidae but have uniserial crochets, noticeably elongate prolegs, and L1 and L2 separate on A9.

Larvae feed in a slight web in leaves or occasionally mine leaves or stems; those of the cosmposlitan genus *Plutella* feed on leaves of cruciferae.

Plutella xylostella (Linn.) (Curtis) **(Diamond-back moth).**

Caterpillar: The fullfed caterpillar measures 1/3" in length, small, slender and is pale-yellowish green in colour with fine scattered (some say thin) erect

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black hairs over the body. Head yellowisn, mottled with dark brown spots.
Damage:The caterpillars damage leaves of cauliflower, cabbage, radish and knol-khol, particularly in the head or in the heart. Central leaves of cabbage, or cauliflower may be riddled. A shot hole effect all over leaves is a characteristic of its attack. When disturbed on the plants the larva drops and suspends itself by a silken thread.

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