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GUIDE TO ECONOMIC ENTOMOLOGY FOR SPECIALISTS

Compiled by

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Entomologist
U.S.A. Operations Mission to Nepal

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Introduction

Before beginning a study of insects and their relation to man, it may be well to first take a book at the world of living beings as a whole.

When we speak of living things as contrasted with non-living creatures, we seem to have rather definite point of view, but when we begin to describe the differences, we may find that it is not so easy. Therefore, it might be worthwhile for us to summarize some of the outstanding characteristics of living organisms.

1. Growth. Only living matter is able to take food and convert it into a part of its own body thus increasing its size through the process known as growth. Living matter, therefore, is actually able to convert the non-living food into more living matter. (Chemists have long dreamed of being able to duplicate this process in a test tube in the laboratory but, thus far, creation of additional living matter is a characteristic peculiar to living matter now existing).

2. Metabolism. Only living matter is able to carry on metabolism, which is a word that refers to the building up of a store of food within the cells and them combining this food with oxygen to release the energy contained in the food as needed. Of course, foods can be burned outside of the body by a process known as combustion, which is a rapid oxidation with quick release of heat; through metabolism the heat is released more slowly. When we exercise vigorously there is a burning of the food within our muscles. This food is not burned so rapidly that our muscles burst into a flame, but the same amount of heat is released as if the burning took place outside the body. Thus, this phase of metabolism is a comparatively slow degree of oxidation which occurs only in the living cells.

3. Definite size and shape. We can say that any particular kind of living thing, as an adult, has a certain size and shape within limits. For instance, we have big cats, and cats that have a variety of body shapes, but all cats fall within a certain minimum and maximum weight and they all have certain characteristics that make them recognizable as cats. On the other hand, non-living matter is not so limited. We may have a drop of water, a bucket of water, or an ocean full of water and it may be spread in almost any conceivable shape.

4. Cellular organization. All forms of life seem to be composed of, or divided into, cells. This point will be discussed more fully in the next chapter.

5. Response to environment. Living things show a definite response to their environment. In the case of animals this may be rapid, such as jerking your finger away from contact with a hot stove, while in plants it will be slower, but just as definite, such as a sunflower

plant following the sun in its path across the sky with its flowers, or arranging its leaves to receive the sun to the best advantage, or sending its roots toward needed moisture. Non-living matter does not thus respond, although it may show a purely mechanical reaction to changes in temperature, moisture, and other environmental factors.

6. Protoplasm. The essential part of all cells, whether plant or animal, is protoplasm, which has a similar nature in all forms of life. Non-living material varies greatly in its composition.

7. Reproduction. Since living things cannot continue to exist indefinitely as individuals there must be some method of reproducing other living things like themselves, so that their kind will not disappear from the face of the earth. In some primitive forms of life the problem is solved very simply; after a period of growth the organism splits in two to form two organisms; these grow and divide and so on. Many plants and some simple animals produce buds, or some outgrowth from their bodies, which grow into an entire new plant or animal. The great majority of living things, however, produce small sex cells which unite with cells from the opposite sex to initiate the life of a new organism. There is nothing remotely resembling reproduction in non-living matter.

Now that we have narrowed our field down to biology, we might separate it into its two divisions: botany, which deals with plants, and zoology, which deals with animal life. Most living things are easily placed in one or the other of these categories. People sometimes object to being called animals, yet, if they are alive, they must be animals, unless they wish to call themselves plants, since there are only these two forms of life. Occasionally, the term animal is confused with the word mammal, which is a group of animals that nurse their young and are only a small percentage of the total animal kingdom. Some persons do not think of birds, worms, fish, or insects as being animals, yet they are just as much animals as dogs, cows, monkeys, or other mammals.

It is not easy to list the points of distinction between plant and animal life. However, we can say that all plants can manufacture their food. The green plants do this with chlorophyll which is the green substance in their bodies; the non-green plants such as fungus do this by a chemical process. Animals cannot manufacture their food but must derive their food either directly or indirectly from plants. WWithout plants all animal life would disappear from the earth.

Arthropods

The animals which we will be studying are called insects and belong to a group called Arthropoda or Arthropods. This is a large group and includes in addition to insects such animals as crabs, prawns, scorpions, and millipeds.

Animals which have backbones such as men, cows, monkeys, dogs, etc. are called vertebrates. We commonly think of these vertebrate animals as being the dominant of all animal groups, yet, if the arthropods had the power of reasoning and could communicate their thoughts, they would probably claim this distinction. Furthermore, they would have very good arguments in support of their claim. They could point out that more than three-fourths of all animals on the earth are arthropods, so, if success is measured in total number of representatives, there could be no question of their superiority. They could point out that arthropods are found everywhere that vertebrate animals are found and in many places where vertebrates can not live. They may be found at the equator and in the arctic regions; they may be found flying high in the air and in the depths of the ocean; they inhabit the humid jungles and the dry sandy deserts. No extreme of environment seems to discourage them. Finally, it could be stated that there is no other group of animals on the earth so well armed for offense and defense. It is true that man, as one of the vertebrates, has been able to forge steel into terrible weapons of destruction, but the arthropods have forged their weapons from their own bodies and they are highly efficient and always ready for use. Of course, there would be some arguments in favor of the vertebrates, such as larger size and greater development of the brain and its functions. In the final analysis, however, we would have to conclude that the arthropods are at least the equal of the vertebrates in success as a group, although they have followed a different pattern of development.

Because of their great numbers and wide distribution, it is evident that this group of animals is of considerable economic importance to man. They are probably more important than any other phylum. On the harmful side, they are serious competitors for our food supply; we must constantly fight some of them in order to secure the food for ourselves. They spread serious diseases which cause untold human suffering and death and make some parts of the earth uninhabitable by civilized races of man. Many of them have bites and stings that are unpleasant, to say the least, and, in some cases, serious. On the beneficial side, they provide us with quantities of food, medicine, clothing, and chemicals; they kill many of our enemies, including some in their own group; and they crosspollinate many of our important plants. Thus, while we have a difficult time getting along with the arthropods, we would also have a hard time trying to get along without them.

Characteristics of the Phylum

The phylum name, Arthropoda, comes from Greek words meaning jointed feet and this is one of the most distinguishing features of the group. The feet, or legs, consist of a series of articulating joints which may be highly modified for specialized functions, such as

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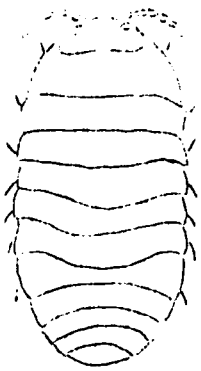
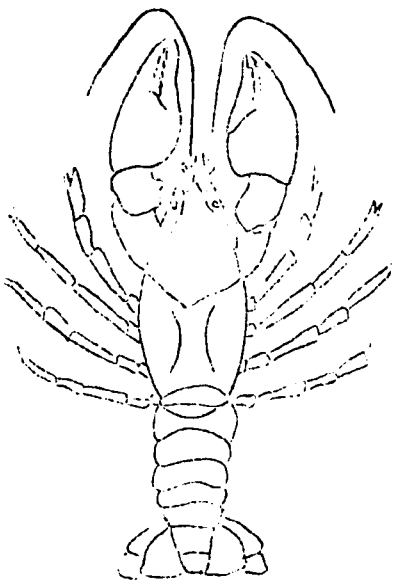
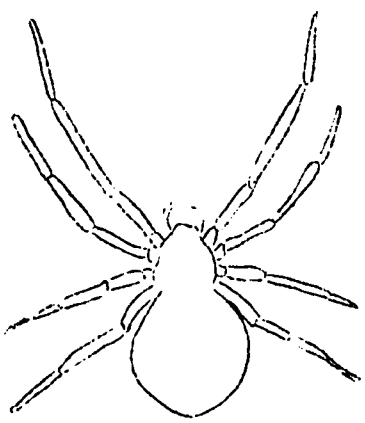
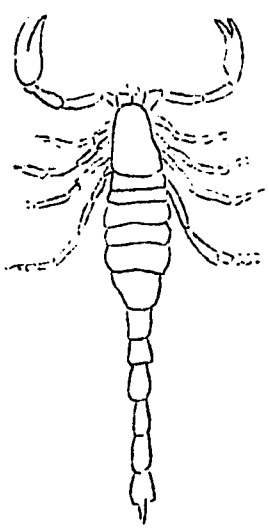








swimming, respiration, obtaining food, etc. Members of this phylum have segmented bodies, such as are found in the annelids, but the segments are not all similar to one another like the annelids, but may be fused or modified to meet specialized needs. They have an exoskeleton of chitin which is a very efficient skeleton. The term skeleton is commonly associated with an assortment of bones including a skull, ribs, vertebrae, and arm and leg bones; yet the outer covering of a grasshopper is just as much a skeleton even though it is found on the outside of the body. This is called the exoskeleton, which has its muscles inside, as contrasted to the endoskeleton, which has its attached muscles on the outside. Both serve their purpose very well, but there are certain advantages and disadvantages of each which might be considered.

The exoskelton has a great advantage in protection. With the soft body parts internal to the skeleton they are much better protected than when some of them are exposed to injury on the outside of the body. However, the endoskeleton has an important advantage in growth; the skeleton and the body parts can grow together, so the skeleton places no limitation on the size of the animal. However, the exo-skeleton incloses the remainder of the body and, one it is formed, there can be no further increase in the animal's size. Some of the arthropods partially avoid this disadvantage by shedding their skeletons completely, in a process called molting, and then growing larger ones for increased size. This method has its drawbacks, however, and even with molting the body size is definitely limited. Since, in general, a large animal has an advantage over a small one, this gives a point of advantage to the animals with an endoskeleton. We may well be thankful that we have this advantage in size, else we would not have a chance in competition with the arthropods. Imagine our consternation if we should find spiders as big as tigers lurking in dark places ready to pounce on us when we came near. Suppose there were wasps as big as buzzards that could zoom down out of the air an pierce us with a dagger-like sting that almost certainly would be fatal. Huge ants traveling in packs like wolves could terrorize and entire countryside. With all our modern weapons and ingenuity we would probably have little chance to survive attacks from such large arthropods with their protective armor and highly specialized weapons. In their present small size they can still give us considerable misery.

The Insects

One of the main reasons for the great importance of the arthoropods is the inclusion of the insects in the phylum. A person may feel be-littled when called an insect, but, after a study, he may feel compli-mented, for insects are certainly a very successful class of animals. They make up only one of about fifty animal classes, yet there are more species in this one class than there are in the other forty-nine. They are abundant almost everywhere on the face of the earth; there are probably more of them in your back yard than there are people

in your city. They have a persistence and aggressiveness that are unequaled in any other animals. Consider a mosquito humming around your head; no amount of slapping or waving discourages it; it will persist for hours if necessary until either a full meal or death rewards its efforts. Insects have an ingenuity that challenges the best that man has to offer. They were making paper from wood pulp when man was chiseling crude characters on stone tablets. Domesticated animals and cultivated plants were their source of food supply long before man had the idea. They have a highly developed social organization that functions more smoothly than the best that modern man has devised. They have a strength all out of proportion to their small size; an ant commonly carries loads several times its own size and weight; a flea easily jumps a hundred times its own body length. The list of insect accomplishments could be greatly extended; they are certainly not a group to be belittled in spite of their small size.

Insects, as a group, are one of man's greatest enemies. They destroy our food plants. It is very hard to find a peach or an apple without a "worm" in it unless the tree was carefully sprayed during the time the fruit was developing. Few ears of fresh corn can be bought at the market without one or two "worms" that have eaten some of the tender kernels at the end, or signs of their previous presence. Grasshoppers destroy and damage crops of all kinds. Hessian flies claim a large part of the wheat crop each year. Even after a crop is harvested it is by no means exempt from insect damage; large quantities of stored grain, fruit, and other foods are destroyed each year while awaiting consumption. Insects are a general nuisance with their bites and stings, and the most serious germ diseases of man are spread by insects. Our clothing is destroyed by insects; furs, woolens, mohair, and feathers furnish good eating for the larvae of the clothes moth. Some do not wait for material to be made into clothing before destroying it; the cotton boll weevil may take as much as a fourth of the entire potential cotton crop each year. Books and valuable papers are injured and destroyed by the silverfish, or fishmoth; termites destroy all types of wooden construction and may enter and destroy books and other stored paper products.

When we constantly have to battle insects to hold such destruction in check and spend millions of dollars each year in attempts to control them, we may wish that there were no such things as insects on the earth. Yet, insects are of such great economic value that if they were completely eradicated we would find this a very different world in which to live. Most of our fruits, many vegetables, and many of our grains would disappear with them. There would be no cotton or silk; most of the land birds and most of the fresh-water fishes would die of starvation. Most of the hair tonics would disappear from the market since they contain the juice of beetles to cause stimulation of the scalp. One of our important red dyes, made from the bodies of insects, would disappear. Many peoples of the

world would be without a direct source of food. Fried ants and grasshoppers are widely eaten in India; fried caterpillars are sold like hot dogs on the streets of some cities in Mexico; certain African natives eat the large tropical termites with great relish. We could probably continue to live without insects, but our lives would be greatly affected.

Insects have three distinct body parts, the head, thorax, and abdomen. In the embryonic or larval insects there are numerous body segments which are similar to one another, and thus resemble the annelids. Larval forms are often called worms because of this resemblance; a caterpillar or a maggot looks more like a worm than an adult insect. However, during a typical insect development the anterior six segmented fuse to form the head, the next three form the thorax, and the remainder of the segments form the abdomen. The dividing lines between the segments cannot be seen in the head, are visible as indentations in the chitin surrounding the thorax, and remain distinct with independent movement in the abdomen.

Insects have three pairs of legs. This is the most distinctive characteristic of the insects because no other group of animals has six legs and all of this group have this number. There is one pair attached to the ventral surface of each segment of the thorax.

Insects usually have two pairs of wings, one pair attached to each of the two posterior segments of the thorax. There are a few, however, that have no wings at all and others with only one pair, so this is not a universal characteristic of the group.

Insects breathe by spiracles. These are tiny breathing pores found on the side of the abdomen, one pair on each segment, and usually two additional pair on the posterior thoraxic segments. These connect internally with tiny tubes, trachea, which carry the air directly to the parts of the body where needed. These distribute the oxygen much more readily than can be done with lung or gill respiration and give insects the tireless energy which enables them to accomplish so much in spite of their small size. However, this method of respiration makes them very susceptible to foreign substances in the air for they are quickly distributed over the body. We take advantage of this by spreading insecticides in the form of sprays or dusts. A beekeeper can make a hive of bees quite docile by blowing a few puffs of smoke in at the tope of the hive. This causes them to settle to the bottom allowing him to remove the honey from the top. Chickens can often be seen "delousing" themselves by sitting in a nest of fine dust and working it through their feathers so that the lice are killed by a clogging of their spiracles by the fine dust particles.

Insects have compound eyes. All but a very few primitive insects have this method of vision, which was described in the discussion of the crayfish. Some species have larger compound eyes, with a

correspondingly greater number of individual facets than others, and accuracy of vision seems to depend on the number of facets. Since the eyes tend to curve around the head, there are some facets pointing in almost every direction so that it is quite difficult to approach an insect without being seen by some of these structures. About the only way a person could approach a fly without being seen is from below and to the rear and it would be a little difficult to get in that position.

Insect Metamorphosis

Through observation of larger animals we think it natural that the newly born or newly hatched offspring should rather closely resemble their parents, except for size, and that they should gradually grow into adult size. This is by no means true among insects, however; many larval insects would be classed in a different phylum if their life history were not known. There is no marvel of nature more astounding than the transformation of a green worm-like caterpillar into a beautiful butterfly.

Insect metamorphosis may broadly be divided into three major types. The first that we will consider is complete metamorphosis. Life starts with the egg which hatches into a larva, this being usually worm-like in nature. Common names of larvae indicate their similarity to worms -- bag worms, grub worms, silk worms, measuring worms, and fuzzy worms are all insect larvae. Insect larvae have a voracious appetite and eat nearly all the time. They are usually able to do this because their mothers have laid the eggs near a plentiful supply of food. Because of their rather gluttonous feeding habits they grow rapidly; a fly maggot will double its size in a few hours and increase its size several hundred times in a few days. A single tomato worm may eat half of a large tomato in a day and increase its size accordingly. Larvae have soft bodies and do not have the limitations to their growth that is offered by a hard exoskeleton.

Finally, the larva seems to have eaten its fill and goes into a quiescent stage called the pupa. It may spin threads of silk around itself to form a cocoon in which it spends its pupal state, or its outer body covering may simply harden to form a pupa case. The metamorphosis into the adult condition takes place within this covering and a fully developed adult emerges as the fourth and final stage in the development of an insect with complete metamorphosis. The adult is as large as it will ever be when it emerges; big flies do not grow from little flies; they are big or little flies when they leave the pupa case and retain their size throughout their lives. This is because of the confining exoskeleton from which insects with complete metamorphosis never molt.

The second method of insect development is called gradual metamorphosis. In this method, which may be illustrated by the grasshopper, the egg hatches into something that resembles the adult, but most undergo a series of gradual changes before it becomes the adult type. The immature stages of such metamorphosis are called nymphs. A newly hatched grasshopper nymph can be recognized as a grasshopper; it feeds in the same way as the adult and lives in the same type of environment, but its body proportion are somewhat different. It has no wings, its body is promprtionately shorter, and the hind legs are not as well adapted to jumping as in the adult. It increases its size and becomes like the adult through a series of molts. When a nymph is ready to molt a fluid will form between the body and the skelton to separate the two and the skeleton splits down the back to let the insect emerge. It has a soft body covering at this time and swallows air to stretch it while it is hardening. When the new skeleton hardens, which may be within an hour, the insect may be twice its original size and it seems impossible that it could have come from its cast-off exoskeleton. The grasshopper has five molts but other insects with gradual metamorphosis may have as many as twelve. The adult emerges at the final molting.

The third method of insect development is called incomplete metamorphosis. This is similar to the gradual metamorphosis in that the adult is produced after a series of molts of immature stages. The primary difference is that the immature insects with incomplete metamorphosis live in entirely different condition from their parents and feed in a different manner, with special body parts not possessed by the adult. The immature stages all live in the water and are called naiads. The dragon fly might be mentioned as an example of this type of metamorphosis. The adult flies in the air, catching other insects for food. The eggs are laid in the water and hatch into naiads that somewhat roughly resemble the adult, but have a very long tongue which they use to catch small water animals for food. Thus, the method of feeding is quite different from the adult. Respiration must also be different; the adult broathes air by means of its spiracles, the naiads suck water in and out of their anus in order to absorb the needed oxygen. When ready for its final molt the naiad will crawl up out of the water and emerge with fully formed wings ready to take up its life in the air.

Finally, there are a few primitive insects that have no metamorphosis. In these the egg hatches directly into the adult condition without intervening stages of development. The silver fish and some of the lice are examples of this method.

Insect Wings

The wings of insects show great variation and wing structure is frequently used as a basis for subdividing the class into orders. Some insects, such as fleas and fish mths, have no wings at all.

Others such as the flies, have only one pair, but the second pair is represented by a rudimentary projection at the place where the second pair should be. Some, such as the ants, have generations without any wings at all, but eventually produce a winged sexual generation that flies out of the nest to spread the species. The majority, however, have two pairs of wings as adults.

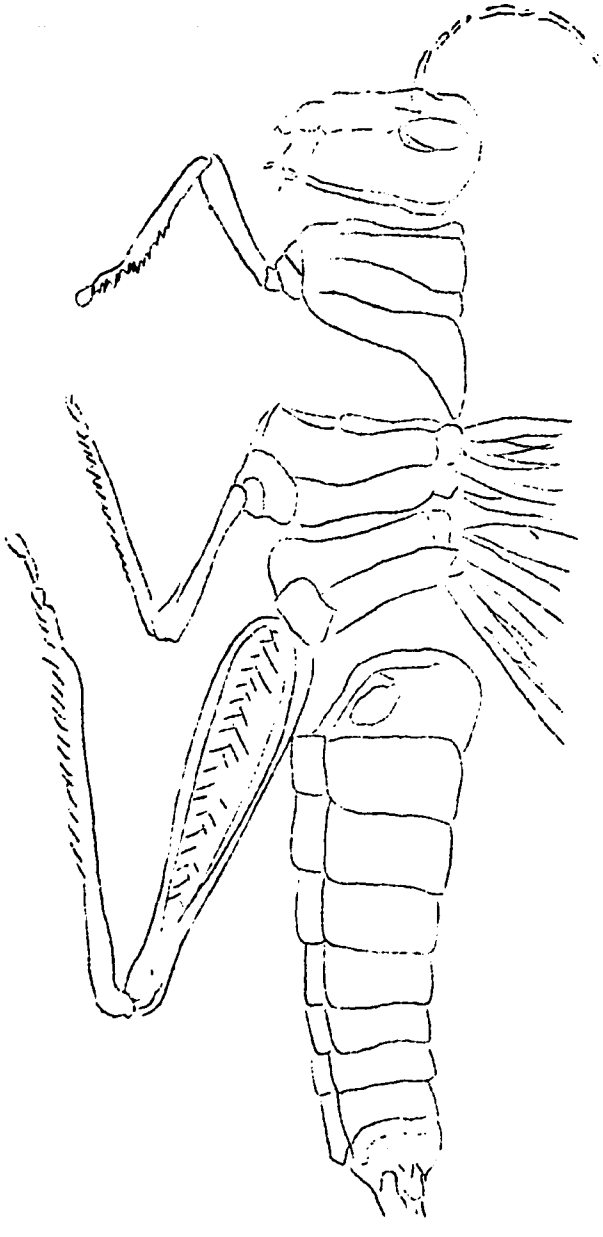
Wings which are used for flying are thin and light with delicate veins running through them. These are called membranous wings. In some insects, such as beetles, the front pair of wings has been greatly thickened and hardened to form horny wings. These are used for wing covers to protect the delicate second pair of wings which are membranous and used in flying. During flight the horny front pair of wings are held out to the side like the wings of an airplane. In other insects, such as the grasshopper, the front pair of wings become tough yet flexible and are called leather-like wings. They also act as wing covers and are held rigid in flying. Some insects, like the butterflies, have membranous wings covered with scales which rub off like a fine powder when they are handled. Some, such as the bugs, have a leather-like front part of a wing and a membranous hind part. With so many variations it is often possible to tell the order of an insect by glancing at its wings.

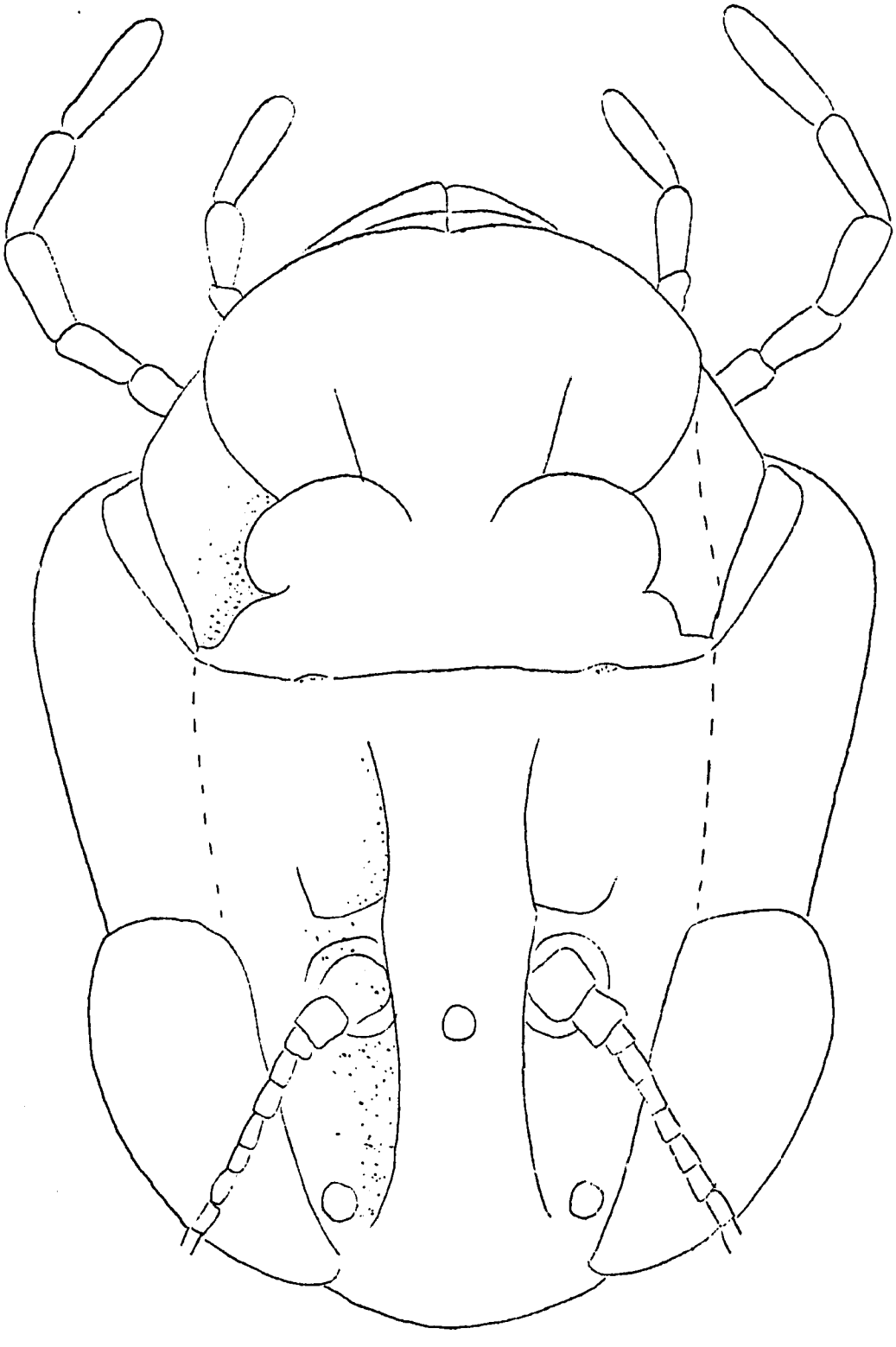
Insect Food and Feeding Habits

Insects are adapted to feed on almost every conceivable kind of organic matter. A small pile of manure dropped from the body of a cow, after the cow has extracted all possible nourishment from it, provides all the food necessary for hundreds of maggots to live and grow into flies. An inch of rain water standing in a tin can may contain organic matter that furnishes all the nourishment needed for dozens of mosquito wigglers to live and grow. Even solid dried wood, dry feathers, paper, and starched clothing contain sufficient food for some insects to live on for their entire life or a large part of it. There seems to be almost nothing that has an organic origin that they have overlooked.

Some insects are restricted in their feeding habits and can eat only one or a small group of foods. Termites eat only wood; silk worm stick to mulberry leaves; the cotton boll weevil restricts itself to the cotton square or boll; fleas must have the blood of a mammal; certain wasp larvae live only on spiders. Others are generalized and can have a varied diet. The house fly is certainly not particular about what it eats; it may have the equivalent of soup from the body of a dead dog, an entree from fried chicken on your dining table, and finish its meal with desert from a pile of manure. The grasshoppers certainly do not restrict themselves to grass as any farmer has learned from experience with the damage which they may do to almost any kind of crop.

The mouth parts of insects are highly specialized to accommodate the kind of food eaten and the method of obtaining it. In general, there are two types — biting and sucking mouth parts. Those with biting mouth parts have hard chitinous jaws which work from side to side to bite off and crush the food as it is taken into the mouth. In the other group the mouth parts are fused to form a proboscis through which liquid food may be drawn. This is often sharp on the end so that it may be thrust through the skin of animals to suck blood, or through the epidermis of leaves to such the plant sap. In attempting to control insect pests of plants it is important to know the kind of mouth parts which the insects possess. A poisonous spray put on the leaves will kill those with biting mouth parts, since they will eat the poison along with the leaves. However those with sucking mouth parts would not be affected since they stick their proboscis right through the poison and suck the unpoisoned sap beneath. A contact spray that will reach the bodies of these insects then becomes necessary for their control.





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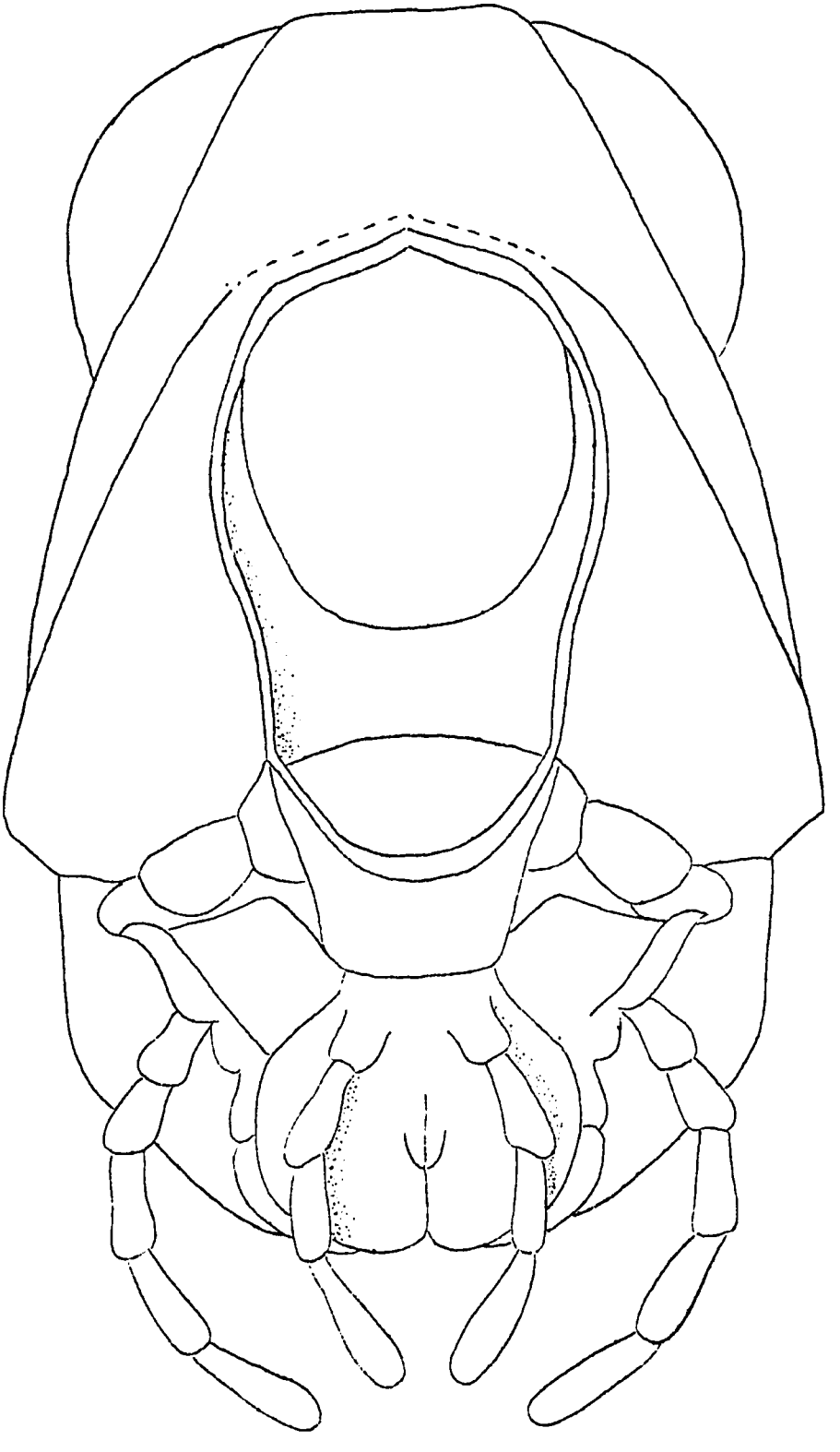

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INSECT ORDERS

Since the insects are such an extensive and diverse class of animals they need to be subdivided further in order to provide some idea of the many different types that exist and their economic importance. Accordingly, this chapter is given over to a survey of the important orders of insects. A few of the lesser known orders are omitted and all of the insects under each order are not listed, but an attempt has been made to include the order names, the outstanding characteristics of the order, and a list of interesting features of insects commonly encountered by the average person. Scientific names are given for the orders, but common names are used for smaller groups and genera.

Order —— Aptera

This is the most primitive group of insects. In fact, they are so primitive that they do not have all of the characteristics that are considered typical of insects. They have no wings, no compound eyes, and no metamorphosis. They have rudimentary appendages on the abdominal segments which is suggestive of a close relationship with the annelid worms. Some larval forms of other insects orders, such as caterpillars, have appendages on these segments, but this order is the only one with rudiments of them in the adult. They have biting mouth parts.

1. Fishmoths. These insects are covered with silvery scales that cause them to be sometimes called silverfish. They live on the starch in starched clothing and book bindings and eat paper. They do considerable damage because they are small and secretive and their presence is frequently not suspected until the damage is rather extensive.

2. Springtails. This insect keeps its abdomen curled under it and, by suddenly extending it, springs into the air. It is quite a nuisance in maple syrup producing areas because, after springing in the air, it often lands in a syrup bucket attached to the tree. It comes out so early in the spring that it is sometimes called a snow flea.

Order —— Ephemerida

These are the Mayflies which come out in the late spring or early summer by the thousands. They join in a dancing flight up and down in the air which ends in mating, after which the females deposit their eggs on or in the water and then die, usually no more than twelve hours after attaining adulthood. They usually emerge at about dusk and are often attracted to lights, but they may meet their doom in a flame before fulfilling their destiny. The naiads live in the water and develop about three years before becoming adults.

They have two pairs of membranous wings, but the hind pair are much smaller than the front pair. There are three long projections, cerci, from the posterior tip of the abdomen which are longer than the body itself. Metamorphosis is incomplete and, since they live such a short time as adults, the mouth parts are vestigial and entirely useless so far as feeding is concerned.

Order --- Odonata

This order includes the dragon flies and damsel flies. They have two pairs of membranous wings of about equal size. The metamorphosis is incomplete and the naiads live in the water preying on the larvae of many harmful insects. They have biting mouth parts and catch and eat insects which they find in the air.

1. Dragon flies. These are large, strong, and swift insects that dart through the air with great speed catching mosquitoes and other insects. They have many other names, among which are mosquito hawks, because of their habit of catching mosquitoes, and snake doctors, because of their supposed habit of administering to sick snakes. This last characteristic is pure superstition. They are very beneficial because of the large number of harmful insects that they destroy. A captive dragon fly will eat thirty or forty house flies without pausing.

2. Damsel flies. Built very much like a dragon fly, the damsel fly has a smaller and more slender body. It folds its wings over its bank when at rest, whereas the dragon fly holds the wings out to the side of the body. Their habits are similar.

Order --- Plecoptera

These are the stone flies. There are two pairs of membranous wings and the hind pair are distinctly larger than the front pair. They have incomplete metamorphosis and the naiads live in swift running streams and furnish an important source of food for brook trout. They are often used as bait for this fish. They have biting mouth parts and two long cerci projecting from the tip of the abdomen.

Order --- Orthoptera

These insects have two pairs of wings, the front pair being tough and leather-like and acting as wing covers, while the hind pair are membranous and are used in flying. The hind pair fold up like a Japanese fan in order to fit under the wing covers. A few are wingless. They have biting mouth parts and gradual metamorphosis.

1. Short-horned grasshoppers. These are the common grasshoppers or locusts that have antennae shorter than the body. They have powerful hind legs and prefer to jump rather than to fly. They are widely distributed and do damage of major importance by eating plants. The females deposit the eggs in loose soil in the late summer or early fall; these hatch in the spring and the young nymphs begin eating on almost any green plant that they can find. They spend most of their time feeding while they are nymphs. The great plagues of locusts mentioned in the Bible were, no doubt, the migratory type of grasshoppers. These grasshoppers have moved through the mid-western states, stripping the leaves from every plant in their pathway.

2. Long-horned grasshoppers. These have antennae that are longer than the body and are held pointing backward so that they arch over the body and extend beyond it. They include the katydids, meadow grasshoppers, camel crickets, and Mormon crickets. The last two are wingless forms. The Mormon cricket gets its name from an incident connected with the founding of the Mormon colony at Salt Lake City. These crickets were about to destroy the crops upon which these pioneers depended when a great horde of sea gulls flew in from the Pacific coast and devoured them, saving the crops.

3. Crickets. The field cricket is the one best known in this group. Their chirping and singing is a very common sound in the late summer months. They feed on both animal and vegetable material. The mole cricket burrows around under the ground and the front legs are very strong and adapted for this purpose. The tree crickets differ considerably from the other two in appearance. They are small and slender and a pale green color. As their name indicates, they live in trees and start their shrill song at dusk, continuing it far into the night.

4. Roaches. These insects are flattended so that they can crawl through small cracks. They prefer to run rather than fly, but have functional wings and will fly sometimes when cornered. They usually come out to feed during the night and hide during the day so that a house can be badly infested without the knowledge of its owner.

5. The mantids. These are commonly called praying mantids or devil-horses. They are large carnivorous insects that are very beneficial because of the great number of harmful insects which they eat. The praying mantis gets its name from the fact that it holds its front legs up in an attitude of prayer, but the name "preying mantis" would be more appropriate since it is probably just waiting for some insect to get within reach so that it can grab it with these legs.

6. The walking sticks. These have long stick-like bodies that are remarkably like twigs upon which they rest. They do some damage by eating leaves, but usually are not present in sufficient numbers to be serious.

Order —— Isoptera

These are the termites. The order name means equal wings and they have two pairs of membranous wings of equal size when they have wings at all, but there are many generations that never have wings. They have gradual metamorphosis and biting mouth parts. Their sole item of diet consists of wood. Wood is composed mainly of cellulose which cannot be digested by the majority of animals and it would seem that the termites would not fare so well on it. However, they have protozoans living in their intestine that secretes enzymes that can digest the cellulose which both the protozoan and the termite live on. This is another example of symbiosis, for the protozoan receives protection and the chewed up food to eat while the termite gets the wood digested and can exist on this abundant material without much competition from other insects. Their bodies are soft, possessing little pigment which makes them quite sensitive to light, and so they seal any openings that would allow light or dry air to reach their tunnels in the wood.

In the tropics they are extremely destructive; so much so that in some places houses cannot be constructed of wood. They are quite common in most of the southern states and seem to be extending their habitat as far north as the Canadian border.

They are social insects with an organization of tasks somewhat like the honey bee. There is a single queen and many workers of both sexes. Each year a winged generation is produced with pigmented bodies; these fly out of the nest, mate, and establish other colonies.

Order —— Dermaptera

These insects are commonly called earwigs due to the mistaken notion that they crawl into the ears of sleeping persons and bore into their brains to cause death. Some are without wings, but those that have them have a leathery front pair and a membranous hind pair that are folded both lengthwise and crosswide to fit under the front pair. The metamorphosis is gradual and the mouth parts are for biting. There are a pair of forceps-like cerci at the posterior tip of the abdomen. They feed on plants and do considerable damage where they are abundant.

Order —— Coleoptera

These are the beetles. The front wings are horny and serve as wing covers for the membranous hind wings which fold up underneath. When flying the front wings are held out to the side of the body like wings of an airplane while the membranous pair provide the power. When not flying the front wings meet in a line down the back and the membranous hind pair is so perfectly hidden that it is often thought that beetles do not have wings. The metamorphosis is complete and many of the larvae are called grubs. The mouth parts are for biting.

1. Tiger beetles. These are aggressive insects that run down and kill their prey which usually consist of other insects. Their bodies are often of brilliant metallic shades of green or bronze.

2. Ground beetles. These are small black or brown beetles that have flattened bodies so that they can easily crawl under logs and stones. They are one of the farmer's greatest friends because they destroy many insects that are harmful.

3. Whirligig beetles. Small compact black beetles that whirl around in circles on the surface of the water and datch any insects that happen to fall in are called "whirligig beetles." They walk on the surface film of the water which has enough resistance to prevent their sinking.

4. Carrion beetles. These feed on dead animals and are sometimes called burying beetles because they excavate under the body of a dead animal in order to get at it from underneath and, in the course of time, the carcass of the animal will sink below the surface of the ground.

5. Larder beetles. These are found in stored cured meat and cause great loss. They sometimes get in insect collections and do great damage to the dried insects.

6. Click beetles. These are large elongated beetles that have what appears to be two huge eyes on the thorax. They get their name from their habit of suddenly clicking the joint between the thorax and abdomen when they get on their back. This throws them several inches in the air and they try to land on their feet.

7. Fireflies. These are also called lightning bugs because of their habit of giving out flashes of light from the ventral surface of their abdomen as they fly at night. Some of the larvae also give out light and are called glowworms.

8. Tumble bugs. These collect manure and roll it into a ball and push it to a hole in the ground and lay their eggs with it so that the larvae will be able to feed on it when they hatch out. They sometimes have vicious fights when one female tries to rob another of a nicely rolled ball of manure.

9. June bugs. Possibly the most common of all beetles. The larvae are the very destructive white grub worms which eat plant roots. The adults are brown bugs that fly around lights in the summer. Outdoor gatherings may be spoiled because of them as they fall in the punch bowl or inside the backs of ladies' dresses. The adults are also harmful because they feed on leaves of fruit and shade trees.

10. Potato beetles. These small compact beetles eat the leaves of potato and related plants.

11. Meal worm. The larvae live in stored grain and destroy much valuable food, especially stored meal. Although they are vary destructive naturally, they are actually raised commercially as a food for soft-billed birds..

12. Blister beetles. The blood of these is poisonous and will raise blisters on human skin. They once were used to make an ointment that would blister a person's chest when rubbed on as a treatment for a chest cold. They are still used in very small quantities in hair tonics to give them a stimulating effect on the scalp.

13. The weevils. This group of beetles has jaws modified into snouts. They destroy apples, strawberries, sweet potatoes, and the developing squares and bolls of cotton. The cotton boll weevil claims a large proportion of our cotton crop each year.

Order --- Mallophaga

These are usually called the biting bird lice, although just biting lice would be more appropriate since they do not restrict themselves to birds by any means. As the name indicates, they have biting mouth parts with which they eat feathers, hair, or bits of skin that scale off. They are wingless and have gradual metamorphosis. City people often dream of accumulating a little money and retiring to a small farm and making a nice living raising chickens. They often fail to take the lice and many other bird parasites into account. It takes hard work on the part of poultrymen to keep them under control.

Order --- Anoplura

These are the true lice or sucking lice as distinguished from the biting bird lice and plant lice. They have strong beaks for piercing the skin. The metamorphosis is gradual and they have no wings.

1. Head louse. These live in the head of man and lay eggs in nits on the hairs which, when abundant, cause the hairs to stick together and become matted so that the hair cannot be combed.

2. Body louse. During World War I body lice, or cooties as they were somewhat affectionately called by the soldiers, were considered one of the necessary inconveniences of life at the fighting fronts. During World War II, our troops were relatively free of this parasite because of a vigorous "delousing" campaign that accompanied the men wherever they went.

These lice lay their eggs in the seams of the clothing and crawl on the surface of the skin causing a tickling sensation that is quite worrisome. Their great harm, however, comes from the fact that they spread typhus fever.

3. Crab Louse. These live on the hair around the reproductive organs and are often thought of as a venereal infection since they are usually spread by sexual contact.

Order —— Hemiptera

These are the bugs. The world bug is used loosely to refer to all insects and to many things that are not insects, but only members of this order can rightfully claim this title. The front wings are distinctive of the group; they are thickened and leather-like at the anterior half, but thin and membranous at the posterior half. They are held so that they overlap on the back when they are not flying. Mouth parts are for sucking and metamorphosis is gradual.

1. Aquatic bugs. These include the giant water bug that may grow two inches long, the water boatman, back swimmers, water scorpions, and water striders that walk on the surface of the water.

2. Predacious bugs. These include the assassin bug that feeds on soft-bodied insects, ambush bug that crawls in flowers and waits for some insect to enter in search of nectar, and kissing bug that has been known to pierce the lips of sleeping persons to suck their blood.

3. Bedbugs. This common pest makes itself at home in mattresses and other parts of the bed and surroundings and comes out to suck the blood of a person settled for the night. Thorough fumigation is about the only means of eradication once they get started.

4. Stink bugs. These are shield-shaped bugs that suck plant juices and have a pronounced, unpleasant odor. They are often found on berry vines and may leave their odor and taste on berries.

5. Plant bugs. These bugs are somewhat elongated with antennae about half as long as the body. The squash bug and chinch bug are common examples. They do serious damage to plants.

Order —— Homoptera

These insects have four membranous wings when they have wings, but there are some that have no wings at all. Metamorphosis is gradual and mouth parts are for sucking. The winged forms hold the wings sloping down the sides of the body somewhat like the roof of a house when at rest.

1. Cicadas. The cicada, dog day harvest fly, or locust is the insect that produces the loud singing noises that are so prevalent in the late summer. They live about two years in the ground as nymphs, feeding on plant roots. Then they crawl up on a tree trunk and go through their final molt and emerge as adults. Another species spends seventeen years in the ground and is called the seventeen year locust.

2. Plant hoppers. These are small hump back insects that hop when disturbed. They may be referred to as leaf hoppers, tree hoppers, or frog hoppers. They do great damage to plants upon which they feed.

3. Plant lice. These are the aphids that are used as cows by the ants. They are tiny and without wings. They live on the underneath side of leaves and make up for their small size by their tremendous numbers which do great damage to plants. Eggs hatch within the body of the females and the young are born alive, with ten generations or more each season. It is fortunate that they have many enemies that keep them in check or they could soon devour every plant on the earth.

4. Scale insects. These are serious plant parasites. The nymphs form a hard protective scale over their bodies and suck the plant sap. Some produce a soft cottony covering and are called mealy bugs. The adults are winged forms.

Order —— Neuroptera

This order name means nerve wing and is given because of the many branched delicate veins or "nerves" in the wings. There are four of these membranous wings of equal size, complete metamorphosis, and biting mouth parts. The larvae are carnivorous and are armed with powerful jaws with which they destroy many harmful insects.

1. Aphis-lion. The adult of this insect has beautiful, pastel-green wings that have earned for it the name lace-wing fly. The larvae on the other hand are vicious carnivores that kill and eat plant lice, aphids, by the hundreds. They have such a ravenous appetite that the female lays each egg separately and puts it on a tall stalk so that the first larva to hatch will not eat its brothers and sisters in their egg cases. They are extremely beneficial because the aphids are one of the most destructive of the plant parasites and some wise gardeners gather the adults with an insect net and release them in their garden.

2. Ant-lion. The adults of this insect are somewhat larger and more stockily built than the aphis-lion adults. Eggs are laid in dry loose dirt and hatch into the familiar ant-lion, or doodle bug, that builds a coneshaped pit in the dirt and waits for an ant or other insect, to venture over the edge of this trap. When this happens the insect finds that the harder it struggles to get out the faster it slips to the point of the cone where the jaws of the ant-lion are waiting to crush and devour it.

3. Scorpion-flies. These get their name from the fact that the male has claspers at the tip of its abdomen that make it look somewhat like a scorpion, but it has no sting.

4. Caddis-flies. The adults look somewhat like moths with fine hairs on their wings that resemble scales of moths. The larvae live in water and some have a habit of covering their bodies with sticks, gravel, and shels which adhere to them for protection.

5. Dobson-flies. The adult is a large vicious looking, but harmless insect. The larvae live in water and are called hellgrammites by fishermen that consider the excellent fish bait, especially for bass.

Order --- Lepidoptera

These are the butterflies and moths. They have two pairs of large membranous wings, which are covered with overlapping scales that come off like a fine powder when they are handled. The mouth parts are for sucking and the proboscis in some of them may be several inches long and is coiled up under the head when not in use. Metamorphosis is complete and the larvae are commonly called caterpillars and, unlike the adults, have biting mouth parts. This order includes the butterflies and the moths. The butterflies are better known than the moths because they fly in the daytime and usually have large colorful wings that attract attention, but the moths are much more common and their larvae cause great destruction to plants. However, the moths fly at night and are not seen so often. The butterflies bear a knob at the tip of the antennae while the moth antenna is usually feathered or may have a knob just short of the tip. The wings of the butterfly are usually held erect over the back when at rest while those of the moth are held folded down over the body. The moth larvae spin a cocoon of silk while most butterfuly larvae attach themselves by a thread of silk to a twig and the outer body covering hardens to form a chrysalis which serves as their pupa case.

1. Butterflies.
   a. Skippers. Stout bodied, somewhat moth-like and spin a silk cocoon.
   b. Monarchs. The common brown and yellow spotted butterfly.
   c. Sulfur butterflies. Many small forms, yellow and white in color.
   d. Swallowtails. These have a projection from the posterior and of the hind wings and include some of the most beautifully colored butterflies.
   e. Four-footed butterflies. The front legs are small and practically useless as legs so they seem to have only two pair of legs.
   f. The hair-streaks. These are small blue, red, and copper colored butterflies that have fine streaks of hair on their wings.

2. Moths. The list of moths is so extensive that space will not permit a listing of even the most important of the group. The larvae are frequently called worms; silk worms, bag worms, army worms,

measuring worms, and tomato worms are a few of these. The clothes moths might be mentioned because of the great destruction that they do to stored clothing and the great expense of protection from them. The adult moth lays its eggs on the clothing and the larvae do the damage.

Order —— Diptera

Many members of this order are referred to as flies. They have a complete metamorphosis and the larvae of many of them are called maggots, while those that develop in water are called wigglers. As the order name indicates they have one pair of wings which are membranous and are used for flying; the second pair are rudimentary and are called halters. The mouth parts are of the sucking type, but in some species there are also jaws which bite first to draw the blood which is sucked up the proboscis. They may be divided into two main groups; the short-horned flies, which have from three to five segments on their antennae; and the long-horned flies, which have more than five segments.

A. Short-horned flies.

1. Horse flies. Usually quite large and bite and suck blood of mammals. Horses seemed to be preferred, but they will bite many other mammals including man when they have the opportunity. Some breed in swampy regions and make life almost intolerable for cattle in such regions. They may be quite annoying to bathers on beaches that are near swampy areas.

2. Robber flies. Large and swift, catch other insects in the air for their food. Destroy many harmful insects, but they have a liking for bees so are not considered beneficial as a whole.

3. Bee flies. Look very much like bees in coloring and feed on the nectar of flowers. The larvae are quite beneficial because they feed on grasshopper eggs, grub worms, and other harmful insects that pass part of their life cycle in the ground.

4. The house fly. So named because it makes itself so thoroughly at home in the house. They are one of the greatest nuisances to be contended with on the farm. They reproduce readily in manure in the barnyard and come into the kitchen and dining table in spite of screens, fly paper, sprays, and other attempts at control. Because of their unclean habits they spread serious intestinal diseases such as typhoid and dysentery and rank as one of the most serious insect enemies of man.

5. The bot flies. Covered with hairs and look somewhat like bees. The larvae of these are parasites which develop within the bodies of mammals. The horse bot fly female lays eggs on the skin of horses and

horses lick them off and they develop as maggots in the stomach of the horse and pass out of the horse's body when they pupate. In others, such as cattle and rabbits, the eggs are laid on the skin and the larvae bore through to form "warbles" or "wolves" and the adult fly eats its way out when it matures.

6. Flesh flies. These live in the decaying flesh of dead animals and some of them are called "blow flies" because they live in and around the bodies of bloated animals. Some are called "screw worms" because the female deposits tiny living larvae in open sores of animals such as horses and cows and they work around in the sore. These are sometimes deposited in the nose of man and work around in the nasal cavity and sinuses until they pupate and eventually fly out of a nostril a full grown fly. Some species are beneficial; it has been found that they will eat only dead flesh and are sometimes put in human wounds to clean out the decaying flesh and speed up healing of the healthy tissue.

7. Tachina flies. Parasites on caterpillars in the larval state. Live larvae are laid on the caterpillar's back by the female tachina fly. These larvae work inside the caterpillar and live on its body. The caterpillar forms a pupa, but a number of dark colored sluggish flies hatch out instead of a moth or butterfly.

8. Tsetse flies. A blood sucking fly that inhabits a large part of Africa and spreads the dread disease of sleeping sickness discussed in detail in Chapter IV.

9. The fruit flies. The tiny little banana fly is one of this group. They may be found buzzing around stalks of bananas or decaying fruit and vegetables. Because of their small size, ease of handling, and short life cycle, they are favorite subjects for studies of heredity.

B. Long-horned flies.

1. Crane flies. Look like huge mosquitoes, but fortunately they do not bite. They have very long fragile legs that come off quite easily when handled.

2. Mosquitoes. Well known in nearly all parts of the earth. They may even be seen coming up out of the snow as it thaws in the spring in the Arctic Circle. The three main genera are: the Anopheles, which spread human malaria; Culex, which spreads elephantiasis; Aedes, which spreads yellow fever. As a group they are among the greatest enemies that mankind has. The larvae, "wigglers," develop in water.

3. Midges. Tiny, but blood thirsty little insects that can make life miserable for man and beast alike where they are abundant. One species is called the sand fly and spreads serious tropical diseases.

4. Gnats. These tiny worrisome insects often form an inescapable cloud around a person's head and no amount of waving and slapping can drive them away. The females of many species lay their eggs in leaves or twigs of plants and the plant forms a gall at the spot in which the larvae develop. Some develop in mushrooms. The Hessian fly is included in the group. The female lays the eggs at the node of wheat or rye plants and the maggots live between the stalk and leaf and greatly curtail production since the stem usually breaks at that point. In some years as much as fifty per cent of our wheat crop has been lost to this pest,

Order --- Siphonaptera

These are the fleas. As the order name indicates they are wingless forms that have sucking mouth parts. The metamorphosis is complete; they have little worm-like larvae than can exist on such apparently unpalatable substances as the dust that tends to accumulate under a rug. There are cat fleas, rat fleas, and human fleas, but none of them are particular about their host and readily change from rate to man and so on. Their bodies are flattened so that they can easily work themselves through the hairs of their host. They have a powerful sense of smell and powerful pair of jumping legs so that they can smell their victim coming and give a tremendous leap in that direction hoping to land on it. A person can get a nice collection of fleas by tying sticky fly paper around his legs and walking through a flea infested barn.

The "sticktight" fleas are great pests on poultry and sometimes get on them in sufficient numbers to cause their death. Unlike the majority of fleas that like to change hosts, this one usually stays put once it finds a satisfactory host.

The fleas are considerably more than just pests, however, because some of them spread serious diseases such as bubonic plague and typhus fever.

Order --- Hymenoptera

This order name means membrane wing and members of this group have two pairs of membranous wings. The front pair are noticeably larger than the hind pair, but all four are used in flying. The metamorphosis is complete and mouth parts are for biting, but may be modified for sucking in some, such as the bees.

1. Bees. These are rather compact insects with their bodies covered by hairs that have many short side branches, in comparison with the wasps that have a more slender body with simple unbranched hairs. The honey bee was discussed throughly in Chapter XVIII. There are many other species of bees, however. The bumble bee is well known for its large size, loud buzzing, and its powerful sting.

They are very important in cross pollinating plants. Red clover seems to depend on them exclusively to carry the pollen, for the blossoms of this plant are so constructed that smaller and weaker insects cannot get the nectar. There are other smaller species of bees that may be solitary, or live together in small social groups.

2. Ants. The ants have an advanced social life like the bees and construct nests housing thousands of the members of a single social group. They have stings and can also bite with their strong mandibles, although there is no poison injected with the bite. Like the termites, they do not need and do not have wings in the generations that are destined to spend their lives as workers in connection with the nest. However, a winged generation will be produced each spring. Both males and females in large numbers will come out of the nest and fly into the air singly and drop to the earth in pairs. As in the bees, copulation occurs as they fall. The male then wanders around aimlessly a short time and, his purpose in life having been accomplished, dies. The female finds a suitable spot to found another nest and digs a shallow hole in the ground and lays her eggs. She bites her wings off since she will not need them any longer. When the first workers emerge they take over the work and the female becomes their queen and concentrates on egg laying for the rest of her life.

Some species of ants have domesticated the aphids, plant lice, and no domestic animals of man receive better care than they. They are carried out to feed on leaves outside of the nest or the ants may build tunnels to the roots of plants so the aphids can feed underground. In return, the aphids secrete a sweet liquid called "honey dew" which the ants eat. This is another excellent case of symbiosis. Some ants chew up leaves which they use as a base for underground gardens of fungi. The fungus is carefully tended by "gardeners" who keep the spore-bearing bodies cut off so the crop will not go to "seed". The ants eat the vegetative part of the fungus plant. There are many varieties of ants with so many different habits and customs that it would require volumes to describe them, but our limitations of space prevent further discussion here.

3. Wasps. The wasps are noted for their powerful stings and their ready use of the sting upon those that intrude upon their privacy. Only the females sting but, since the sexes cannot readily be distinguished, it is a good idea to show due respect for all of them. They are subdivided as follows:

a. True wasps. These include forms like the red wasps, yellow jackets, and hornets. They make nests by chewing up bits of worm wood and spreading them out in the form of a paste to dry, thus duplicating our wood pulp process for making paper.

b. Thread-waisted wasps. Characterized by an extremely thin connection between the abdomen and thorax which looks little larger than a thread. These include such interesting forms as the muddaubers that build nests of mud containing several individual cells. After laying an egg in each cell the female will find and sting spiders in their thoracic ganglia so that they are paralyzed but not killed. She will put one or more of these in each cell and seal it up with mud. When the larvae hatch out they find fresh juicy spiders to feed on during their larval development.

c. Digger wasps. These dig holes in the ground and put paralyzed spiders or caterpillars in with the eggs. Some do not have wings and are called velvet ants.

4. Boring hymenoptera. In this group the females are adapted for boring holes in plants or animals to deposit their eggs. Those deposited in plants cause the plant to produce a gall at the spot and the larvae develop in this gall. Others deposit the eggs in the bodies of such animals as spiders or caterpillars and the larvae live as parasites in the body of the host.

Key to Orders of Common Insects

1. Wings well developed, the front pair sometimes forming hard wing covers. 2
   Wings reduced to minute pads, or no wings developed 24
2. Front wings hard, horny, opaque, and veinless, in repose folding over the body and forming wing covers, ... 3
   Front wings either transparent, membranous, or with definite veins 5
3. Mouthparts forming a needle-like piercing beak, venation usually indicated but indistinct. .... Hemiptera,
   Mouthparts with mandibles, fitted for chewing 4
4. Abdomen terminating in a pair of external forceps-like appendages, Dermaptera,
   Abdomen either without terminal appendages, or these pointed and stylelike, Coleoptera,
5. Having only one pair of wings, the hind pair at most forming, small clubbed, balancing organs, or halters, ... 6
   Having two pairs of wings, although the hind pair may be small 10
6. Wings leathery or parchment-like 7
   Wings membranous, sometimes dark in color 8
7. Mouthparts forming a piercing-sucking beak, Hemiptera
   Mouthparts filled for chewing, with generalized parts, Orthoptera
8. Abdomen without terminal filaments; hind wings represented by halteres Diptera
   Abdomen with two or three terminal filaments, 9
9. Halteres present; terminal appendages short, antennae long, (males of Coccidae) ..... Hemiptera
   Halteres not developed; terminal appendages very long, antennae short Ephemeroptera
10. Front wings, and usually also hind wings, clothed with overlapping scales, except for window-like areas, Lepidoptera
    Wings bearing only scattered scales, having chiefly fine hair, bristles, or no vestiture 11
11. Tarsus ending in a round bladder-like structure, without evident claws Thysanoptera
    Tarsus without a terminal bladder, sometimes having large pads and/or distinct claws, ... 12
12. Mouthparts forming slender stylets fitted together for piercing and sucking, and housed in a beak that is either triangular or rodlike Hemiptera
    Mouthparts not forming a beak, either vestigial or of the chewing or lapping type; mandibles not forming slender stylets, ... 13
13. Abdomen having two or three terminal filaments as long as the body, and head having short hairlike antennae, Ephemeroptera,
    Either abdomen having short termina filaments or none, or antennae long and slender, ... 14
14. Front wings leathery, hind wings membranous, the front ones when folded forming a protective covering over the hind pair, Orthoptera
    Both pairs of wings of about the same texture. 15

15. Both front and hind wings having many veins and many crossveins, forming a close network over part of the wing surface ... 16
Wings either with crossveins few in number or longitudinal veins reduced, or both 21
16. Front and hind wing each with radius and its branches sclerotized and forming a heavy anterior bank, remainder of venation semi-membranous or sub-atrophied, Isoptera
Venation sclerotized throughout 17
17. Antennae short and setalike, 5 to 8 segmented; wings long and exceedingly reticulate, Odonata
Antennae elongate, usually with more than 20 segments; wings various, ... 18
18. Tarsus 2- or 3-segmented Plecoptera
Tarsus 5-segmented 19
19. Head prolonged into a trunklike beak at the end of which are typical chewing mouthparts, Mecoptera
Head not prolonged into a beak 20
20. Pronotum large, its length greater than half its width; front legs not stouter than the others, Megaloptera
Either pronotum less than half as long as wide, or front legs enlarged and raptorial Neuroptera
21. Tarsus 2- or 3-segmented 22
Tarsus 5-segmented 23
22. Pronotum minute; either short wiee species, less than 4 mm. long, or stout species up to 8mm, with the mesonotum produced high above pronotum, Corrodentia
Pronotum large, flat, and nearly quadrate, either form slender or over-all length 10mm, or more Plecoptera
23. Mandibles sclerotized and large; wings clothed with minute setae, the venation either greatly reduced or forming a series of irregular cells, Hymenoptera
Mandibles difficult to detect, subatrophied; either small species (less than 6mm.) with extremely hairy wings, or venation composed of regularly branching veins, Trichoptera
24. Abdomen ending in two or three long "tails," 25
Abdomen without long terminal tails 26
25. Having three terminal tails, Thysanura,
Having two terminal tails, Diplura
26. Abdomen ending in a pair of strong sclerotized pincer-like jaws or forceps, 27
Abdomen without stout terminal forceps 28
27. Tarsi 1-segmented; head without eyes, Diplura
Tarsi 3-segmented; head having conspicuous eyes, as in fig. 21C Darmaptera
28. Tarsus 4- or 5-segmented 29
Tarsus 1- to 3-segmented 36
29. Base of abdomen constricted to a narrow joint hinged to forward part of body, Hymenoptera
Abdomen not constricted and hinged at its base 30

30. Antenna minute, flattened, and indistinctly segmented, or round, sometimes with a terminal hair 31
Antenna slender and long, many-segmented, 32
31. Antenna with many indistinct segments: body bilaterally compressed, with distinct segmentation; head and pronotum often with ctenidia, or rows of stout spines, ... Siphonaptera
Antenna globular, appearing as one segment, sometimes with a terminal hair body not greatly compressed from side to side, and often without distinct segmentation on abdomen; never having ctenidia on head or pronotum Diptera
32. Head prolonged into a beaklike projection at the end of which are located a set of chewing mouthparts, as in Mecoptera
Head not prolonged into a beak. 33
33. Mouthparts vestigial or composed chiefly of a short coiled tube, mandibles indistinct; body densely hairy or scaly Lepidoptera
Mouthparts having sclerotized and massive mandibles, mouthparts of simple chewing type; body never hairy 34
34. Pronotum enlarged, forming a long neck; a large saddle; or a shield partly or entirely hiding the head Orthoptera
Pronotum small, at most only slightly larger than mesonotum 35
35. Elongate sticklike insects, thorax as wide as or wider than abdomen Orthoptera
Stocky insects, thorax constricted and markedly narrower than either head or abdomen .... Isoptera
36. Head indistinct, antennae and legs short; body often covered by waxy filaments or plates or by detachable scale Hemiptera
Head distinct; other characteristics diverse but body never covered by a scale 37
37. Tarsus ending in a blader-like pad; mouthparts together forming a conical structure .... Thysanoptera
Tarsus ending in claws which may be small and sharp or large and hooked 38
38. Mouthparts forming a distinct external tubular beak Hemiptera
Mouthparts not forming an external beak 39
39. Pronotum forming a large sclerite, often saddle-shapped, and hind legs enlarged for leaping .... Orthoptera
Either pronotum reduced to a narrow sclerite or hind legs not particularly enlarged 40
40. Antennae 13 to 50 segmented .... Corrodentia
Antennae 3 to 6 segmented 41
41. Leg having tibia and tarsus united, abdomen often having a ventral spring. Free living species .... Collembola
Leg having tibia and tarsus separate, articulating with a joint; abdomen never having a spring. Ectoparasites of warm-blooded animals and birds 42
42. Mouthparts of chewing type, with segmented palpi and sclerotized triangular teeth .... Mallophaga
Mouthparts of sucking type, consisting of a bundle of stylets which are retractable into the head .... Anoplura

Insect as Enemies of Man

Insect Injury to Growing Plants

Nearly all the injury done by insects results directly or indirectly from their attempts to secure food. They are undoubtedly man's chief rivals for the available food supply of the world. When an insect desires as its food something that man also desires, it becomes his enemy, and we say it is an injurious insect. Because of the great numbers of insects and their unequaled variety we find that there are one or more species adapted to take as food, apparently every kind of organic material in the world -- plant or animal, living or dead, dry or decomposing, raw or manufactured, sweet or sour, hard or soft.

Injury by Chewing Insects

Insects take their food in a variety of ways. A primitive and very important method is by chewing off the external parts of a plant, grinding them up, and swallowing them, solids and liquid parts together, very much as a cow or a horse grazes, though of course, taking infinitely smaller bites. Such insects we call chewing insects. No one can fail to see examples of this injury. Perhaps the best way to gain an idea of its prevalence is to seek to find leaves of plants absolutely perfect in their freedom from such attack. Cabbageworms, armyworms, grasshoppers, the pear slug, and the cankerworm are common examples causing injury by chewing.

Injury by Piercing-Sucking Insects

A second very important way in which insects feed on growing plants is by piercing the epidermis ("skin") and sucking out the sap from the cells within. In this case, only internal and liquid portions of the plant are swallowed, although the insect itself remains externally on the plant. Such insects we call piercing-sucking insects. Their work is accomplished by means of an extremely slender and sharp-pointed portion of the beak which is thrust into the plant and through which the sap is sucked. This results in a very different looking, but none the less severe, injury. The hole made by the beak is so small that it is never seen, but the withdrawal of the sap results in either minute spotting of white, brown, or red on leaves, fruit, or twings; curling of the leaves; deforming of the fruit; or a general wilting, browining, and dying of the whole plant. Aphids, scale insects, the chinch bug, the harlequin cabbage bug, leafhoppers, and plant bugs are well-known examples of the piercing-sucking insects.

Aphids (plant lice) are probably the most universal group of plant-feeding insects. There is scarecely a kind of plant, cultivated or wild, but what supports from one to several species of aphids,

and large percentage of the individual plants will be found infested each summer. The innumerable beaks of these little pests continuously pumping sap from the plants constitute a very severe drain on their vitality. It curtails growth, and interferes with the size and flavor of the fruit developed, if, indeed, the plant is not killed outright.

Injury by Internal Feeders

So long as an insect feeds externally upon crops, it can usually be destroyed by the application of the proper insecticide. But many of our worst pests feed within the plant tissues during a part or all of their destructive stages. They gain entrance to the plant either by having the egg thrust into the tissues by the sharp ovipositer of the parent insect or by eating their way in after they hatch from the eggs. In either case, the hole by which they enter is almost always very minute, often invisible. A large hole in a fruit, seed, nut, twig, or trunk generally indicates where the insect has come out and not the point where it entered.

The chief groups of internal feeders are indicated by their common group names: (a) "borers," in wood or pith, (b) "worms" or "weevils," in fruits, nuts, or seeds, (c) "leaf miners," and (d) "gall insects." Each group except the third contains some of the foremost insect pests of the world. In nearly all of them the insect is internal in only a part of its life stages, sooner or later emerging for a period of free living, usually as adults. This often affords an opportunity to control internal insects by dusting or spraying before their progeny gains entrance to the plant again.

Borers may attack any plant or pact of a plant large enough to contain their bodies. Fruit and shade trees and many herbaceous plants suffer in this way. Jawar, maize (corn), millet, and paddy are all susceptible to the attack of a stem borer which feeds on the soft inner tissue of the stemsof these plants.

The mango stem borer and citrus borer attack the trunks and woody shoots of these trees feeding on the growing tissue and heartwood; resulting in severely weakening these plants and damazing the wood.

The pomegranate fruit caterpillar, the brinjal fruit borer are exampled of some of those borers we find feeding on the fruits of plants.

The above mentioned borers are by no means all the pest that bore in the plants but are merely exampled of the types to be found affecting some of the plants of Nepal.

A number of internal feeders are small enough to find comfortable quarters and an abundance of food between the upper and lower epidermits of a leaf. These are known as leaf miners. Surely these are the things Lowell had in mind when he said "There's never a leaf nor a blade too mean to be some happy creature's palace." Among the injurious forms are the apple leaf miner, spinach leaf miner and many others.

The gall insects "string" the plant and make it grow a home for them, within which they find not only shelter but also suitable and abundant food. This is probably the most marvelous instance in biology of the profound influence exerted over one organism by another. We do not know as yet exactly what it is that makes the plants, when attacked by the insect, grow these curios, often elaborate structures which are absolutely foreign to them in the absence of the gall insect. A strange feature of the work of gall insects is that the same species of insect on different species of plants causes galls that are similar; while several species of insects attacking the same plant cause galls that are greatly different in appearance. Although the gall is entirely plant tissue, the insect in some unknown manner controls and directs the form and shape it shall take as it grows. There is a marvelous variety of such homes for insects built by the "unwilling" but helpless plants. Many of these galls seem to be practically harmless to the plant that grows them.

Injury by Subterranean Insects

Almost as secure from man's attack as the internal feeders are those insects that attack plants below the surface of the ground. These include chewers sap suckers, root borers, and gall insects, the attacks of which differ from the aboveground forms just described, only in their position with reference to the soil surface. The subterranean insects may spend their entire life cycle below ground, e.g., the woolly apple aphid. This insect, as both nymph and adult, sucks the sap from the roots of apple causing the development of ugly tumors and the subsequent decay of the roots at the point of attack. More often there is at least one life stage of the insect that has not taken up the subterranean habit, as in the case of the white grubs, wireworms, Japanese beetle, root maggots, and grape and corn rootworms, in all of which the larvae are root feeders while the adults have largely retained the more primitive life aboveground. Interesting gradations and adaptations to the subterranean life are seen in the way in which the eggs of these insects are laid and in the place of pupation. In general it may be said that the more of its life stages the insect spends underground, the more difficult it is to control.

Injury by Laying Eggs

Probably 95 per cent or more of the direct injury to plants is caused by insects feeding in the various ways just described. Another instinct, almost as powerful, is the urge to provide for the welfare

of the offspring. While in general, the maternal instinct among insects is not developed to the point where they care for their young after birth, most insects have a marvelously effective instinct to lay their eggs in exactly the right place so that their young will have the best chance to survive; and there are some very striking cases of great effort and care in the preparation of a nest or the deposition of the eggs. Sometimes this provision for the young leads to serious injury to man's possessions. The treehoppers and tree crickets split and ruin the bark or twigs in pushing their eggs into the plant tissues. It is interesting to note that these are purely nesting sites. As soon as the young hatch, they desert the twigs and injure the plant no further. In other cases, the young, at least, subsequently feed upon the plant attacked by the egg-laying female; but we wish to emphasize at this point the injury by the egg-laying act, quite independent of any subsequent feeding of the young. Plum curculio ruins the fruits of apple, plum, peach, and cherry by her characteristic.

Insects as Disseminators of Plant Diseases

A serious phase of insect injury and one which may rival in importance the destruction caused by their direct feeding is the connection of insects with the ravages of plant diseases. Everyone has known something about insects that transmit human and animal diseases, but few have realized that other insects are engaged in spreading very disastrous diseases of plants. Since 1892, when it was first proved that a plant disease (fire blight of fruit trees) may be spread by an insect (the honeybee), the knowledge of this subject has grown rapidly, and at present there is apparently good evidence that more than 100 such diseases are disseminated by insects.

Insects are responsible for favouring plant diseases in a number of different ways: (a) By feeding or laying eggs or boring into plants, they may make an entrance point for a disease that is not actually transported by them. (b) They have been found actually to disseminate the pathogens on or in their bodies, from one plant to a susceptible surface of another plant, such as a blossom or to a wound made by some other agent. (c) They carry pathogens on the outside or inside of their bodies and inject them hypodermically into the plant as they feed. (d) They harbor the pathogens inside their bodies during adverse periods, as overwinter or through a period of drought or host-plant scarcity, protecting them from the adverse climatic condition and from natural enemies. (e) They may be essential hosts for an incubation period, for increase in numbers of the pathogen, or for some part of its life cycle that cannot be completed elsewhere; or they may be essential for dissemination that is not normally accomplished otherwise.

Insect Injury to Man and other Living Animals

The second great group of things that fall prey to insects is all manner of animal life. Insects in their relation to us make no distinction between man and other animals.

Annoying Insects

There are, first of all, a number of minor ways in which insects conflict with man's comfort and pleasure. They are annoying by their presence, by their sounds, by the bad odors and tastes of their secretions, by crawling over one's body, by getting into the eyes or ears, or by laying their eggs upon animals. All of us have experienced great annoyance from flying, buzzing, or crawling creatures at times, particularly when we desired to rest or apply ourselves to some exacting task. The unpleasant taste left by certain stink bugs on berries and other fruits, the disgusting odor of cockroaches about the table service of some restaurants, and the sharp pain caused by getting certain minute insects into the eye. The accidental invasion by living insects of the ears, nostrils, or stomach is usually serious but fortunately a rare experience. Animals suffer from the attempts of certain flies (the bottflies) to lay eggs on their bodies. This is sufficient to cause the wildest stampeding of these annoyances constitute the least important of all the phases of insect injury to animals, still they are sufficient to account for a great deal of monetary loss, discomfort, and inefficiency.

Venomous Insects

Insects are not popular. The innate abhorrence of "crawling things" possesed by some persons is unfortunate, however, because it prevents them from learning anything about insects and interfers unnecessarily with their enjoyment of out-of-door life. An extreme fear of bugs, caterpillars, spiders, and bees is not warranted by the facts. Nevertheless, there are a number of kinds that can bite and sting painfully, and these wounds may become infected with serious results. It is so often true as to be almost a rule that the worst-looking forms are generally harmless; while some of the most painful experiences result from contact with very innocent-looking specimens.

Bodily pain and illness may be caused by the venoms of insects applied to the body in the following ways: (a) by stinging, i.e., penetrating the skin with a defensive and offensive organ located near the tip of the abdomen, (b) by biting, i.e., with the mouth parts——generally inserted to secure food, but sometimes used in a defensive way when certain insects are handled; (c) by nettling with hollow poison hairs located on the bodies of certain caterpillars, which injected venom after the manner of the common nettle plant: (d) by the application of caustic or corrosive fluids to the unbroken skin; (e) by poisoning animals when they are swallowed, accidentally, or with food. Chewing insects are rarely able to cause much pain.

The "pinching bugs" which are about the worst of this kind, can scarcely break the skin. The really painful bites are made by insects with piercing mouth parts, are accompanied by the introduction of a venom, and are therefore, a chemical injury. The nature of the venom appears to vary but has the common characterisitc that it is in some way toxic to animal tissues and so causes pain.

Besides the spiders, ticks, and centipedes the following kinds of true insects are notorious for the injury inflicted by their bites: the Diptera or two-winged flies, including mosquitoes, black flies, the stable fly, tsetse flies, the sheep tick, etc., the Hemiptera or true bugs, including the bedbug, assassin bugs, back swimmers, water scorpions, etc., the Anoplura or blood-sucking lice; the Siphonaptera or fleas.

Many insects regularly feed on animal blood, including that of man, as their only food; and, while so deeding, usually introduce a poison that causes a painful irrigation.

The stable fly, that dreaded but constant companion of horses, mules, cattle, and hogs, all summer long, inflicts such painful bites and withdraws so much blood that animals are sometimes killed outright. Unable to don protective clothing, to retreat into screened houses, or even to "swat" efficiently, domestic animals must suffer beyond our comprehension from these many, bloodthirsty pests. This suffering is translated into losses to the livestock farmer in decreased milk yield, loss of flesh, unsatisfactory growth, inefficiency and unmanageableness of work animals, and in greater susceptibility of the weakened animals to diseases.

External and Internal Parasites

The most loathsome attack we suffer at the hands of insects is their very common habit of taking up their residence on or within our bodies or those of domesticated animals. Such insects are called parasites. Many insects, such as lice, lay their eggs on animals and live continuously on their hosts, generation after generation, never leaving them except as they instinctively transfer from older to younger animals of the same species or as they are forced to migrate when their host dies. Others spend certain life stages or certain ports of the day on the host and are free living the rest of the time. Some of these lay their eggs on the host and live there for a time but desert it in their later stages (e.g., botflies); others lay eggs and develop away from the host and then become parasites only as adults (e.g., fleas).

Three entire orders of true insects, viz., the chewing lice (Mallophags) the bloodsucking lice (Anoplura), and the fleas (Siphonaptera), a total of more than 3,000 described species, are entirely parasitic; besides hundreds of species from among the flies (Diptera) and true bugs (Hemiptera) and hundreds more of the ticks and mites of the class Arachnida.

The greater number of these species live externally on the surface of the skin. Their constant crawling about on the skin causes nervousness, restlessness, loss of sleep, failure to feed, and thus a general "run-down"condition and increased susceptibility to diseases. Their excreta and eggs mat the coat and create a foul condition that interferes with the excretory function of the skin. All these external parasites, except the order Mallphaga, feed by inserting their mouth parts and pumping out the blood. When they are abundant, this irritation, intensified by the animal's rubbing or scratching, may lead to great sores as in the case of the scab mite of sheep or the body louse ("cootie") of man. In other cases serious constitutional disturbances result. The mites known as chiggers or harvest mites often give rise to chills, nausea, and vomiting. The insertion of the mouth parts of the Rocky mountain spotted fever tick at the base of the head of man or sheep causes an ascending motor paralysis involving complete loss of the use of the limbs and finally death, unless the tick is removed.

External parasites that suck the blood of the higher animals include such common pests as the hog louse, the sheep "tick" fleas, bedbugs, and the cattle tick. There is one kind of lice that does not suck blood. These are the so-called bird lice or chewing live, including all common poultry lice and certain species of lice found on horses, cattle, and other mammals. Their mouth parts are formed to cut off and ingest solid particles rather than to draw blood. They feed upon the dry skin, parts of feathers or hairs, clots of blood, and the like, and their injury is probably chiefly due to nervous irritation from nimmling at the skin and running about over it.

Internal insect parasites of the higher animals are of few kinds. But they are so troublesome to our livestock that they constitute a group probably more destructive than the external parasites. These internal parasites are either mites (Acarina) or true flies (Diptera). With a few possible exceptions all internal insect parasites are transitory, i.e., they pass only a part of their life cycle inside the body. For example, in flies it is always the maggot stage that lives within the animal body; and adult, at least, living away from the host. In the mites the young may be internal, but they live as external parasites on the surface of the skin for at least a part of the adult life.

Just as there are borers in plants, so there are insects that live as borers in the animal body. The itch mite, scaly-leg mite and their kind dig tunnels into the flesh, in which their eggs are laid. This explains the intolerable itching that is the most prominent symptom of their attack. Before the cause of the disease was known, the "seven-year itch," as it was often called was a most loathsome and persistent affliction.

We have spoken of the injury insects cause when they try to lay their eggs on the bodies of the animals. The larvae from such eggs are very serious parasites. For example, ox warbles cause serious damage to the hides of cattle which are rendered more or less useless for making leather. The loss in value of the hides (augmented by the pain suffered by the animals, the depreciation in value of the carcass for beef, the loss of milk flow, and decreased growth) amounts to about $ 65,000,000 a year in the United States. In Africa the tumbu fly attacks man in a manner similar to that of the ox warble in cattle. Another species of botfly causes lumps in the necks of rabbits, and there is a species that emasculates squirrels by living the scrotum.

The screwworm and other flies live in the flesh of cattle, horses, hogs, man, and other animals during the maggot stage. These flies are attracted by any wound such as a barbed-wire cut, a dog's bite, dehorning or branding wounds, even the spot where a tick has bitten an animal, or by foul secretions, nasal catarrh, bad breath and the like. In such situations to eggs are laid, and the larvae tunnel about and feed, greatly aggravating the inflamation and suppuration of the wound and preventing its healing.

A few kinds of insects, habitually, and some others, accidentally, live in the alimentary canal of animals. These should not be confused with the intestinal worms which are not insects. The best known of intestinal insects are the several species of horse bots. A horse that is heavily infested with bots generally presents a badly run-down condition. There are no insects that habitually live in the alimentary canal of man, but the eggs or small larvae of bluebottle flies, flesh flies, the house fly, rattailed maggots, and others may be swallowed with impure drinking water, milk, or infested food. Their presence in the stomach generally causes symptoms of nausea, vomiting, and fever.

Insects as Carriers of Animal Diseases

The most complicated way in which insects injure man and his animals and the most sinister of all their attacks are as carriers of disease organisms. Any disease in order to persist must continually find new hosts to supplant those lost by death, for the death of a host is calamitous to the parasites that caused it and must often be followed by the death of all the parasites on or in its body. The transfer of disease organisms to new hosts may take place (a) during close association or bodily contact of a healthy animal with a diseased one, as in leprosy or smallpox; (b) by way of the air, as in tuberculosis; (c) through contaminated food or drinking water, as in typhoid fever; (d) by contact with infected soil, as in hook-worm; (e) by fomites, i.e., contaminated clothing, bedding, or towels, as in scarled fever; or (f) by being carried by insects or other small anthropods.

Of all these methods of transmission, none are so effective as the insects. Most of the pathogens are helpless and inactive, often so delicate that they cannot even withstand exposure to dry air. The insects which carry them are active, hardy, and ubiquitous; and they instinctively seek out for their own food the very animals upon which, along, the disease organisms can survive. The insects thus provide rapid, selective transportation; they also shelter the organisms in their bodies, often over winter; and in many cases are hosts for a part of the life cycle of the germ that cannot take place anywhere else. When these insect carriers bite man or other animals, the disease germs pass down the mouth parts into the blood or upon the skin; or the insects' excrement, laden with germs, may be deposited over the wound.

The bite of an insect, of itself, rarely kills man, but when their bodies and mouth parts are contaminated with disease germs, the slightest bite may mark the victim for death, as surely as the bite of a mad dog may cause hydrophobia or the slightest wound from a poisoned arrow prove fatal. Thus the damage the insect can do is multiplied a thousand-fold.

Insects as Depoilers of Stored Products and other Materials

We have reviewed the ways in which insects are injurious to living plants and to living animals, including man. The third great phase of insect injury arises from the fact that they compete with us for the possession and use of practically all our stored products — both stored foods and the many other articles with which we habitually surround ourselves. We find here, exactly as in the case with living plants and living animals, that the attacks of insects are motivated mostly by hunger. To a lesser degree, damage results from their efforts to make provision for their eggs or young or in seeking shelter or building nests for themselves.

Since hunger is the principal motive involved and since insects eat organic matter of every kind, and practically only organic matter, it follows that the chief stored products to be protected are things of plant or animal origin, including grains, seeds, flour, meal, candies, nuts, fruits, vegetables, meats, fats, milk, cheese, honey, wax, tobacco, spices, drugs, feathers, furs, leather goods, woolens, paper, books, labels, photographs, boxes, furniture, wooden buildings, bridges, piling, mine props, telephone poles, railroad ties and trestles, and collections of insects, plants, and animals. These are some of the things that must be guarded from insect depredations.

Food-Infesting Insects

The pests of stored products are the most expensive of all insects to feed, because they feed upon products that have been grown, harvested, stored, and, in many cases, have incurred further expense through manufacturing, advertising, selling, and distributing processes.

In times of strees, attacks by insects upon man's food supply may mean death to thousands. In earlier times one of the critical duties of sailors upon long ocean voyages was to guard the ship's biscuits from the ever-present and ravenous cockroaches. During the World War, large quantities of wheat, badly needed by the European nations, were destroyed by weevils in Australia, and entomologists were hurriedly dispatched to check the destruction. Seeds are among the most concentrated foods known, and a large part of the injury to stored producers is to seeds of our cereal and leguminous crops. Of the many animals that compete for this valuable food material in any community, such as birds, rats, mice, insects and man, insects probably get the largest share, next to man.

The method of attack is varied. Some species hide their eggs in the developing seeds as they grow in the field, and the injury becomes apparent only after the immature insects have been carried into the storehouse. Such is the case with the bean and pea weevils. Other kinds enter by stealth into kitchens, granaries, or factories and deposit their eggs on cured meats, harvested seeds, or any of the products manufactured from the raw-food materials. Some of the grain insects make their homes inside of single whole grains during all their growth; others attack only the broken or ground seeds, roaming about in flour, meal, and other foods and contaminating much more than they eat, with their excreta or the silk that they spin. Many other kinds do not breed in the stored foods, either having nests outside and entering our foods only on foraging expeditions, e.g., the ants; or leading a gypsy life, e.g., the cockroaches, which are objectionable more on account of the filth and disease germs that they probably carry than because of the amount of food consumed.

Two orders of insects are of prime importance as pests of stored foods: (a) the Coleoptera, including such notorious pests as the granary weevil, the confused flour beetle, the saw-toothed grain beetle, the pea weevil, the bean weevils, the larder beetle, and many others; and (b) the Lepidoptera, including the grain moth, the flour moth, the meal moth, and others. In the former of these groups both the grubs or larvae and the adult beetles feed on the stored materials, while among the moths only the caterpillars are directly injurious. In addition to these two groups of most importance, such pests as the book-louse, the cheese skipper, the cheese and ham mites, sporadically destroy large quantities of food.

No other economic group is more widely and equitably distributed than these insects of stored products. Many of the worst kinds are quite cosmopolitan. Some of them have been said to have spread over an entire continent in two or three years. They crawl and fly about seeking the concentrations of attractive foods that we bring together; they enter our storehouses on the crops we harvest; they are distributed in the seeds we purchase for planting; they go to market with the grains we sell; and they come back to us in the flour, breakfast cereals, cakes, and crackers from our grocers.

Pests of Wood and Wooden Articles, Clothing, and Drugs

A particularly insidious pest is the termite, or white ant, whose fondness for a diet of woody tissues leads to most surprising invasions of dwellings, libraries, trestles, fence posts, and indeed any article of wooden origin, such as stores of paper stock, cardboard boxes, library books, and the like. Since they avoid exposure to the air, they are seldom seen until great damage has been done. Living in the ground, they make an opening into any timber that touches the soil and, from that tiny entrance, excavate a honeycomb of connecting passageways, working always in the interior of the structure invaded, without breaking the surface, until the timbers are so weakened that they break through before the occupants are aware that an enemy has been at work beneath their feet. Many cases are on record of extensive damage to private and public buildings by this insect, and its numbers seem to be on the increase.

In a somewhat different way the silverfish usually establishes itself in new quarters before it is suspected, because it is nocturnal and hides in cracks during the daytime. It has a fondness for starchy material and glue, which leads it to eat at book bindings, photographs, wall paper and all kinds of labels. In a large engineering laboratory it was discovered that the silverfish, in order to get the sizing in the paper, had effaced the numbers on inventory cards that gave the only clue to valuable apparatus out on loan.

A few insects have the surprising habit of feeding upon such things as drugs and tobaccos. The tobacco beetle riddles cigars and cigarettes with fine holes.

Conclusion

It has been seen how widespread and diverse is the conflict between insects and man. Our growing crops must struggle against insect attackes from the time the seed is planted until the crop is safely harvested — attacks upon leaves, branches, stems, roots, buds, blossoms, and fruits. Our domesticated animals, and man himself, are harassed and bitten and worried and their bodies infested with maggots and inoculated with disease. Our foods are contaminated, our clothing ruined, our books and papers consumed, the wires that carry our messages rendered ineffective, and the timbers of our houses eaten piecemeal.

No one knows how much better off man might be were all his insect enemies destroyed. We can only conjecture and, by piecing together scattered records from many individuals of authentic losses, arrive at estimates of the total. Estimate of this kind have usually been based on the commonly accepted belief that insects destroy, on the average and the country over, at least 10 per cent of every crop every year.

Control of Insects

Harmful organisms may be held in check by many factors - those that occur naturally and are uncontrolled by man may be classified as natural control; those that man initiates and regulates may be classified as applied controls. Natural controls are of primary importance in keeping the numbers of pests at low levels; but when these fail, as they frequently do, plagues arise, and growers must apply control measures of their own or else suffer great crop losses.

Natural Controls

Natural controls are Nature's own methods of keeping populations within bounds. They consist of physical factors such as adverse weather, climate, and physical environment and of biological factors such as predators, parasites, diseases, and food supply.

Weather and climate are probably the most important factors that directly or indirectly limit the abundance of insects. A knowledge of what is beneficial and of what is harmful to certain insect species often makes it possible to predict their outbreaks. The effects of weather and climate on insects has been discussed previously and will not be covered again here. Years ago geographical features such as oceans, rivers, mountain ranges, and deserts were physical barriers to the spread of insects, but increased travel and speed of travel has decreased the importance of such barriers. Many pests may now successfully hitch-hike from continent to continent, and there is always danger that they will become established if conditions are favorable.

All the organisms that are naturally present in an environment and that attack and destroy insects or complete with them for food comprise the biological factors of control. These biological factors are of considerable importance, and sometimes they exert a greater influence than the climatic factors in reducing the abundance of pests. Probably every species of insect has parasites, predators, and diseases that attack it during some stage or stages in its existence, and these at times are so helpful to growers that other control measures are unnecessary.

PREDATORS. Predators are organisms that attack, kill, and eat other organisms but otherwise do not stay in contact with them. The most important predators of insects are other insects and closely related arthropods. These consist mainly of numerous species of lady beetles and their larvae, which feed mostly on aphid lions; syrphid fly wing flies and their larvae; nocturnal ground beetles and their larvae; tiger beetles; the praying mantis; robber flies; predaceous bugs; and spiders. Heavy aphid infestations are frequently completely destroyed by lady beetles, syrphid fly larvae, and aphid lions, when

sufficient time is allowed. At times some insects will eat each other when competing for the food of a plant. Usually only one corn earworm is found in an ear of corn although many eggs are laid on the silks, because the survivor destroyed all the others that got in its way.

A majority of the land birds are insectivorous or partly so and are of great value in destroying insects. Some heavy insect infestations have been eliminated by birds alone. Also, many small vertebrate animals are partly or wholly insectivorous and help in insect control. Among these are moles, shrews, shunks, bats, snakes, newts, lizards, toads, and fresh-water fish.

PARASITES. Parasites are organisms that live on or in the bodies of other organisms and feed on them, either greatly weakening or finally killing the host—usually when the parasite's development is complete. The most important parasites of insects are other insects. These insect parasites in their adult stage are generally minute to large wasplike insects and flies whose larvae feed within the eggs or bodies of many destructive insects. In some fields hardly a tomato hornworm escapes a tiny, braconid wasp. The hornworm shows no signs of the presence of these parasites until they emerge from its body and build conspicuous white cocoons over it. The caterpillar then sickens and dies. The tiny egg parasite is considered to be of great value because if attacks many different insect hosts, whereas most insect parasites limit their attacks to one insect species or closely related ones.

DISEASES. Both fungous and bacterial diseases are common among insects and take heavy tolls. Several species of fungi under damp hot conditions attack scale insects on citrus and effectively reduce their numbers. Many other fungous diseases of insects have been noted and under the proper conditions these diseases greatly reduce the numbers of a species that they attack. Bacterial diseases are also prevalent in insects, especially the larvae, and also help in natural insect control.

Applied control measures are those initiated by man and dependent on him for their success. They may be divided into (1) mechanical methods and devices; (2) cultural practices; (3) applied biological control; (4) use of resistant or immune plant varieties; (5) legal control; and (6) chemical control.

MECHANICAL METHODS AND DEVICES. These consist of methods or devices that kill or capture insects directly or exclude them without the use of insecticides.

1. Screens or netting to protect plants. This is practical only on a small scale where individual plants or valuable crops must be protected from insects that attack above ground.

2. Light traps, baid traps, and electric traps. Light traps are used for night-flying insects, but they generally catch as many beneficial as harmful species, Bait traps have been successful for some insects such as Japanese beetles, flies, codling moth, oriental fruit moth, and apple maggot flies but, in general, practical control is not possible by this method along. Bait traps for some of these pests are useful to check on their appearance and abundance in relation to the timing of control measures. Electric traps that electrocute insects may have either a light (at night) or a bait as an attractant, or they may be installed like a window screen. They are most valuable for fly control in buildings.

3. Hand picking of insects. This is sometimes feasible where only a few plants are involved or where labor is cheap. Other hand methods are digging out and killing borers with a knife or a wire; and jarring trees and collecting the insects on a sheet spread underneath this method is useful for insects that drop when disturbed, such as plum and quince curculios.

4. Erection of barriers. Banding of trees with sticky substance is a control method for insects that cannot fly but must crawl up the trees to lay eggs or feed. Tanglefoot bands are generally used for insects such as cankerworms and ants. Linear barriers such as deep, dusty furrows or metal strips are sometimes used to prevent invasion of a crop by migrating insects such as chinch bugs, armyworms, or Mormon crickets. Banding apple trees with corrugated paper or burlap is a method for capturing overwintering coding moth larvae that hibernate under and in these bands.

5. Flooding and draining. On land where irrigation is practiced or in cranberry bogs, flooding at the right time is often useful in killing insect pests, especially those that are in the soil. The draining of marshes and swamps and the elimination of all standing water not containing fish is one of the best methods of doing away with mosquitoes and some horseflies.

6. Extreme temperatures. Plant products stored below 40°F. are safe from insect attack, since insects are inactive below this temperature. Most insects cannot stand a 125° to 130°F. temperature range for more than a few hours. Such temperatures are often maintained for insect control in granaries, mills, and elevators. For effective kills, enough time should always be allowed for the heat to penetrate. Insects placed in a high-frequency electrostatic field are quickly killed by internal heat generation. This knowledge is utilized in destroying insects without affecting grains and food products (provided the moisture content is low) by passing the materials on a revolving belt through such a field.

7. Removal of all rough and loose bark from the crotches, trunks, and branches of fruit trees. This may be done during the winter or early spring with a jet spray to destroy overwintering codling moth larvae and to remove favorable hibernating places for future generations.

CULTURAL PRACTICES FOR THE CONTROL OF INSECTS. This includes all farm practices to destroy insects or prevent damage by them other than the use of insecticides. Cultural control methods are basic to all other control methods and should never be neglected in favor of chemical control alone. It has been often shown that healthy, vigorous, growing plants are their own best protection from insect and disease damage, and everything should be done to make them so through proper soil preparation and fertilization.

1. Crop rotations. Very few insects are general feeders, and most feed only on one crop or closely related crops. If the crop family grown on the same ground is changed from year to year, insects as well as plant diseases will result; this often happens when the same crop is grown in the same fields for many seasons. Much of the increased yield obtained from crop rotations is due to the reduction of insect and disease damage.

2. Sanitation. Sanitation includes the destruction of crop residues by plowing them under, burning them, or feeding them to domestic animals such as hogs, sheep, and poultry; and destruction of weeds and volunteer plants; the elimination of trash piles, weedy fence rows, and bushy hedges that offer hibernating places; and the proper pruning of trees and thinning of fruits. Sanitation is recognized as being of great insects that hibernate in crop residues or in heavy grass growth. Wormy fruit left lying on the ground under the trees encourages insects.

3. Timing of Planting and Plowing. Plowing or cultivating at the right time or at proper intervals so as to bury or expose insects can be used to advantage on insects such as white grubs and certain grasshopper eggs. Fall plowing to expose white grubs before they go below the frost line or to bury corn and weed stuble containing corn borers effectively reduces their numbers. A knowledge of the life history and habits of insects is necessary in order to time such practices to obtain the best results.

Some insects will not deposit eggs on bare ground, and if the fields can be kept barren during their egg-laying periods control will be achieved.

Time of planting can often be used to advantage in avoiding some insects pests. Conditions leading to the quick germination of seeds, such as warm weather and shallow planting, also help reduce injury.

INSECT-RESISTANT OR IMMUNE VARIETIES. A resistant plant variety is one that is badly attacked by an insect species only under conditions very favorable to the insect, whereas an immune plant variety is left alone by the insect species under all conditions. Although great advances have been made in recent years in developing disease-resistant or immune varieties of plants, little has been accomplished in developing or selecting plant strains resistant insect attack. The American

grape is resistant to the grape phylloxera (an aphid), but the European grape is very susceptible. By grafting European grapes on American rootstocks, damage from this pest is avoided, and European grapes can be grown. Corn varieties show differences in susceptibility to corn borer attack, and many grain varieties react differently to certain pests.

APPLIED BIOLOGICAL CONTROL. Natural biological control is often aided by encouraging the predators and parasites present in a region or by bringing in and liberating new species from other regions.

LEGAL CONTROL MEASURES. Control measures by means of legislation consists mainly in the establishment of quarantines. These quarantines may prohibit the entrance of certain plants or plant products into the country; may allow for inspection and entrance of plant products only when they are found to be pest free or only when disinfested by recognized methods; and may prohibit the movement of plants or plant products from infested to uninfested areas within a country.

Chemical control of insect pests.

Although in ancient times various recipes, some of which were simple but others plainly obnoxious, were recommended for the control of insects infesting plants, it is very doubtful if any of them accomplished more than a symbolic cleansing. The real history of chemical control began in the middle nineteenth century when anxious farmers in the United States were faced with the invasion of the Colorado beetle into cultivated potato lands and took the unprecendented step of applying arsenical poisons onto crops which were destined for human consumption; the arsenicals proved effective as a beetle control while the prophesied human mortality did not occur, and from that time onwards the development of control by insecticides has made steady progress. With the realization that insect attack could be suppressed, at least below the level of economic importance, came the need for the close study of the living insect in the field and today applied entomology is a science in which the entomologist and the chemist bear equal responsibility.

The suitability of a chemical to be used for insect control is not merely its degree of toxicity for there are a host of other factors to be considered; chief among these are the action on the plant and the cost of the product, while a secondary but vitally important consideration is the ease of application.

Before any detailed survey of the insecticidal field can be made, it is necessary first to give brief consideration to the broad classification of insect pests and the types of insecticides which can be most usefully applied for their control. The insects may be mostly conveniently divided into classes by their habits, as:

1. The chewing insects which bite into the plant surface and ingest the solid tissues. Representatives of this class are the caterpillars and leaf-eating beetles and the damage they cause is readily apparent to the naked eye. The usual method of controlling this class of pest has been by means of a protective insecticide which covers the plant surface with a deposit of poison and is ingested with the food.

2. Suctorial insects which have mouth parts modified into piercing and sucking organs and which feed on the plant juices but do not ingest the solid food. Aphids, plant bugs and scale insects are examples of this class and the damage they cause is not so readily apparent but is more insidious in its effects. A protective layer of poison for ingestion into the stomach is useless against suctorial insects which are taking their food from the plant interior below the surface. It is therefore necessary to use a direct poison which will kill the pest by simple contact with some part of its exterior.

Chemicals that are used in the control of insects are generally referred to as insecticides. Any given insecticide may act in one or more ways, but it is usually grouped according to its chief mode of action. The types are as follows: (1) a stomach insecticide is one that after being swallowed attacks the internal organs; (2) a contact insecticide kills upon contact with some external portion of the body; (3) a residual contact insecticide remains toxic to insects for long periods after application; (4) a fumigant has a great enough vapor pressure, naturally or heat induced, to produce lethal concentrations of vapor in the air; and (5) a repellent is a chemical distasteful or malodorous enough to keep insects away.

HOW INSECTICIDES ARE USED

The correct insecticide and method are determined by the crop and by the nature of the insect pest to be controlled.

1. Insecticides may be applied to the external parts of a plant as sprays or dusts to be eaten by or to make contact with insects.

2. Insecticides may be applied in the soil (soil insecticides) as liquids, powders, or suspensions to kill subterranean pests.

3. Insecticides may be exposed in or expelled into confined spaces so that their vapors or particles will remain in sufficient concentration for a long enough time to kill the insects involved. Aerosols are colloidal suspensions of solids or liquids in air. They may be effective as stomach insecticides, contact insecticides, or fumigants. They sometimes act very much like fumigants, but the actual method of killing is determined by the insecticide used, the length of time it stays suspended in the air, and the amount deposited on the plants. All the new organic insecticides and most plant-derived ones that can be dissolved in organic solvents may be applied in aerosol form.

4. Insecticides in the form of poison baits may be mixed and applied with food attractive to certain insects.

5. A relative new method of application termed chemotherapy has been employed with limited success for certain plant-feeding pests. This method makes use of the fact that some plants may absorb through their roots or foliage small amounts of chemicals poisonous to insects but relatively harmless to themselves. These plants then have the power to destroy or repel for some time many of the pests that feed on their juices. Chemicals useful in chemotherapy are referred to as systemic insecticides.

HOW TO SELECT AN INSECTICIDE

The number of insecticides appearing under trade names constantly increases. Many of these products are similar and are effective against many of the same insects, according to the information given on the labels. This is very confusing to the grower who is trying to find the most effective and economical material for a certain insect or groups of insects on his crops. Insects vary greatly in their susceptibility to different chemicals in insecticide formulations. Some plants also react adversely to some ingredients in insecticides. It is of great importance to read all the information on labels carefully and to know what to look for on a lable when making a selection.

The analysis or active ingredient statement on a label is of primary importance as a basis of insecticide selection; not the trade name, which is generally of little value. The insecticide companies or formulators use one or more active ingredients, usually selected from a relatively small number of basic insecticides; they mix in some other materials as diluting agents or some that their research men have found will enhance effectiveness; and then they give the mixture a new name to distinguish it from other companies' products that contain the same active, ingredients. The result is thousands of trade-named or proprietary insecticides with comparatively few different active ingredients. In order to purchase intelligently the grower should familiarize himself with the characteristics and uses of the basic insecticides and should not worry about trade names as long as well-known, reliable companies have their names or brands on the products. When the name of the active ingredient or ingredients is lacking, it is better not to purchase the product unless experience has shown it to be effective and safe.

Cost is another consideration in the selection of insecticides, all other things being equal. Comparative prices may be very misleading unless one realizes that price comparisons should be computed on the basis of the cost of a unit of diluted spray or dust applied on the crops and not on the basis of the cost of a unit of concentrated material purchased in the store. For example, let us compare two insecticides under different trade names but with the same active

ingredients or with different active ingredients or with different active ingredients allegedly effective against the same insect pests. The first material is priced at Rs. 10-0-0 per gallon, whereas the second sells at Rs. 20-0-0 per gallon. Apparently the second material is twice as expensive as the first. However, the label on the first material states that it must be diluted 1 part to 200 parts of water compared with 1 part to 800 parts of water for the second material. This makes the cost Rs. 5-0-0 for 100 gallons of the first material diluted and Rs. 2-8-0 for 100 gallons of the second material diluted. Actually, here, the apparently more expensive insecticide costs only one-half as much as the apparently less expensive insecticide. The only time a more expensive insecticide is justified on the basis of actual use is when it is more effective on insects or safer as far as injury to man, animals, or plants is concerned.

It is important when selecting insecticides to keep in mind that the susceptibility of some species of insects and plants to insecticides may vary with climate and geographical location. For that reason a material found effective and safe in one part of the country may not necessarily be effective or safe in another part.

INSECTICIDES

Chemicals in various forms are employed in controlling insects, mites, and related pests. These chemicals, or insecticides, are usually applied in the form of dusts, sprays, or fumigants. Since insects, generally speaking, are provided with either chewing or sucking mouth parts, two classes of insecticides, stomach poisons and contact insecticides, are used to combat them.

When insects of the chewing type, such as leaf-eating beetles and caterpillars, are infesting plants, a stomach poison, such as one of the arsenicals or one of the fluorine compounds, may be used. These insecticides are applied to the plants, and as the insects devour the tissue they swallow the poison with it and are killed. Certain species of chewing insects, however, may also be killed with contact insecticides.

The sucking insects, which include aphids, scale insects, mealybugs, leaf-hoppers, and plant bugs as well as plant-feeding mites, are not affected by stomach poisons because they draw their food from within the plant. Therefore they must be combated with insecticides which, on coming in contact with the body, will kill the insects by their burning action, by poisoning them through the breathing apparatus, by suffocating them or by affecting their nervous system. Among the more important contact insecticides may be mentioned pyrethrum, nicotine, sulfur, soap, certain organic thiocyanates, and oil emulsions. These are applied to the insect and only incidentally to the plant, since it is impossible to hit one and avoid the other. It is essential, however, that contact insecticides be applied in such a manner that the material will come into direct contact with the body of thepest.

Root or soil-infesting forms, on account of their underground habits, require a different treatment. Some may be killed by working poisons such as lead arsenate into the upper layer of the soil or by fumigating the soil with carbon disulfide, whereas others that come to the surface to feed may be combated with poisoned baits.

Stem and root-boring insects tunnel through the pith, under the bark, or in the fleshy roots or bulbs of plants. Since these insects are difficult to reach and kill with insecticides, other means must therefore be used to control them. These methods of control are usually given under the discussion of the pest concerned.

STOMACH POISONS

Used for the control of insects with biting and chewing mouth parts or those that lap food. The poison may applied to the leaf or mixed with bait that is more attractive to the insect. When on plant, it is used as a fine dust or spray. Dusting should be so done as to cover all parts of the plant evenly. Do not dust on a windy day. Spraying should be done with a machine that gives a fine spray with pressure. The best time for spraying is morning or noon. The following are more commonly used stomach poisons:

(a) Lead Arsenate. There are three types of lead arsenate, the Acid lead arsenate. Neutral Lead arsenate and Basic Lead Arsenate. Of these the best is first one and is called Straight Lead Arsenate. It is 98% or more chemically pure lead arsenate. It settles very quickly and so it is necessary to have through agitation. This helps to deposit the poison very quickly on the foliage. Most of the insecticide used in U.S.A. is of this type. They are employed to kill caterpillars, saw fly larvae, beetles and their grubs, grass hoppers, locusts and their numphs. Drenching of the plants should be avoided. It is sold in the form of a white paste or powder. It is a good insecticide as it does not burn the foliage. Since with little stirring it remains in suspension, it sticks well. The following are formulae for its use:-

(a) Lead arsenate paste

Lead arsenate paste	4 to 6 lbs	or 2 to 4 ounces
water.....	100 gallons	or 4 gallons

(b) Lead arsenate powder

Powder	2 lbs	or 1 to 2 ounces
water	100 gallons	or 4 gallons

(c) Lead arsenate for dusting

One part is to be mixed with 8 parts of hydrated lime. Work up the paste or powder in a thin cream in a small quantity of water with a wooden stick and then add the full quantity of water and keep it stirred well.

Every care should exercised in its care because it is a deadly poison for man and animals.

Lead arsenate lime mixture

Lead arsenate ..... 1 to 2 ounces
water ..... 4 gallons
lime ..... 2 to 4 ounces

Lime is first slaked with water and mixed. Lead arsenate should be mixed with water separately and then the two mixed. Very useful against the Lemon butterfly caterpillars.
Lead arsenate can be mixed with Bordeux mixture but the toxicity is reduced to half. It should never be mixed with Lime Sulphur.

2. Paris green

It is sold as an emeral green powder and contains 55-60% arsenic; 27 to 31% of copper oxide and 10% of the ecetic acid. It is voilent poison and may be used dry or as a liquid spray. It has a tendency to burn the foliage and so it should be mixed with lime in order to neuteralise any soluble arsenic present. When applied dry it is mixed with 18 to 32 times the same weight of air slaked lime and the mixture dusted lightly over the plants in the early morning. Dusting should be done on a calm day. When used as a spray it is used thus:-

Paris green	8 to 10 ounces	or	$\frac{1}{2}$ ounce
Water	100 gallons	or	4 gallons
Lime	2 lbs	or	2 ounces

or

Paris green	1 lb	) Slake lime first with little water
Lime	4 lbs	) and add about $49\frac{1}{2}$ gallons of water.
Water	40 to 50 gallons	) With the remaining half a gallon of

water work up the paris green into a very thin cream and to it the lime solution. Stir well and keep the mixture well agitated during spraying. Paris green should not be used on any fruit tree and should not be fixed with Lime Sulphur or any soap solution. It is a deadly poison and very great care should be used to its use.

3. Dusting with sodium Fluosilicate

Sodium fluosilicate ..... 1 part
Fine ashes or road dust ..... 6 parts

The mixture should be thorough and very fine. It is a slow acting poison and is also cheap. It should be dusted on a calm clear day for if rain follows dusting the foliage may be burns.

4. Calcium Arsenate.

Its usefulness lies in the fact that it forms a successful combination with Bordeaux mixture and Lime sulphur wash on account of its being insoluable in water. It is useful for grasshoppers and leaf cutting caterpillars on weeds and waste grass.

Calcium arsenate (Powder) ..... 1 lb
Hydrated lime ..... 3 to 4 lbs
Water ..... 50 gallons

When Calcium arsenate is added with Bordeux mixture, the lime is ommitted. It should be stored in air tight tins and should not be used on plants with tender foliage.

The other stomach poisons in the market are London Purple, Magnesium Arsenate, Arsenate of Zink and Basic copper arsenate, but none is so far popular.

CONTACT INSECTICIDES

Nicotine Sulfate as a Spray

Nicotine, in various forms, is one of the most generally used of the standard contact sprays because of its effectiveness and the ease with which a spray can be prepared. It is used against many sucking and other soft-bodied insects. Besides being available in the form of tobacco extracts, it can be purchased under a number of proprietary names as a liquid containing nicotine sulfate or nicotine itself. Both these liquids as commercially sold, contain not less than the equivalent of 40 percent of nicotine by weight. Since the concentrations of the commercial products vary, the directions for their dilution, which are usually given on the labels of the containers, should be followed. Concentrates containing 40 percent of nicotine sulfate should be diluted with soapy water as follows:

For small quantities, 1 to $1\frac{1}{4}$ teaspoonfuls to 1 gallon of water

For larger quantities, 1 fluid ounce to 8 gallons of water.

For more resistant insects it may be necessary to use a little more of the nicotine sulfate.

The solution is prepared by dissolving about 2 rounded tablespoonfuls of soap flakes, or the shavings of a 1-inch cube of some hard but cheap soap, in each gallon of water and adding the nicotine sulfate immediately before spraying. If the prepared spray has stood for some time, it should be mixed thoroughly before being used. For plants with a waxy or glossy surface it may be necessary to add more soap. This is easily determined by looking at the freshly sprayed plant. If the spray draws together in drops, more soap is needed. The insects must be wetted by the spray or they will not be killed.

Nicotine sulfate may be safely combined with most other insecticides.

Caution — Nicotine and its compounds are violent poisons, and care should be exercised in their use. Exposure to fumes or sprays for any length of time causes acute nausea in some persons. Combinations other than nicotine bentonite are most likely to give this effect. Susceptible persons should protect themselves with a respirator provided with pads saturated with a solution of citric acid.

Acute illness can be caused by the absorption of nicotine through the skin. If concentrated solutions of nicotine are spilled on the skin, they should be immediately washed off with water. The operator should not continue working in outer clothing which has become wet with nicotine-containing sprays, as the body will take up the nicotine from the clothing.

Nicotine Sulfate as a Dust

Nicotine sulfate combined with a dry carrier makes a dust which is useful whenever it is preferable to apply a dust rather than a spray. It can be obtained as a commercially prepared by adding the required proportion of nicotine sulfate to hydrated lime. These dusts are generally used for the control of aphids and other soft-bodied insects, where the temporary whitish deposit, on the plants is not objectionable. Strengths varying from 2 to 4 percent of actual nicotine are generally used, depending on the resistance of the insects.

To make a dust containing approximately 2 percent of nicotine (allowing for a slight loss by evaporation), the following formula may be used:

Nicotine sulfate, 1 to 1½ ounces, or 5 to 8 teaspoonfuls.
Hydrated lime, 1 pound.

For more resistant insects the proportion of nicotine sulfate over the dust and then passing it through an ordinary household flour sifter. Be sure that all lumps are broken up and passed through the sifter. Resift at least three times to insure a thorough mixture. Or, place a quart of fresh hydrated lime in a container which can be tightly closed, add a handful of small stones or marbles, pour in 1 fluid ounce of nicotine sulfate, close the lid, and shake well for several minutes. Remove the stones by passing the mixture through a sifter or screen. Larger quantities may be prepared by placing the lime and nicotine sulfate in a keg or metal drum with a tight-fitting cover, together with several sizeable stones or pebbles, and then rolling the drum for about 20 minutes to insure thorough mixing.

A single application is often successful but the treatment may be repeated as often as is required. It is best to use the dust promptly, otherwise it should be stored in tight metal or glass containers, as it loses its strength rapidly when exposed to the air. The dust should be applied by means of a hand duster, and the application should preferably be made when the temperature is about 65°F., the foliage dry, and the air still.

CAUTION - In mixing and applying the dust the operator should be careful to avoid inhaling much of it, for it may cause irritation in the nose and throat. See also caution on this page.

PYRETHRUM

Pyrethrum is a contact insecticide that may be safely used as a spray or dust in the flower garden. It is effective against such sucking insects as aphids, thrips, plant bugs, and leafhoppers. The insecticide must come in contact with the body of the insect.

Pyrethrum powder is made from the flower heads of several species of Chrysanthemum. The active ingredients or insect poisons are two oily substances known as pyrethrin I and pyrethrin 11. The strength of a spray or dust, therefore, depends on the percentage of total pyrethrins contained in the final mixtures. For spraying garden plants the liquid alcoholic extract,containing about 2 to 3 percent pyrethrins, and diluted according to the manufacturer's directions, is preferable. For dusting, the pure, fresh pyrethrum powder, containing approximately 1.3 percent of pyrethrins may be diluted with 3 parts of such non-alkaline material as tobacco dust, fine dusting sulfur, pyrophyllite, or talc. A manufactured dust containing 0.3 percent of pyrethrins is recommended for general purposes.

Since pyrethrum products lose their strength rapidly on exposure to the air, they should be kept in tight containers and not mixed until ready to be applied. It may be safely applied to most garden flowers without causing injury. Usually the effectiveness is increased by adding a suitable wetting or spreading agent to the spray; however, many commercial brands already have these materials included. Pyrethrum may be combined with derris or cube, as discussed under Derris and the combination makes a more effective spray against both chewing and sucking insects.

CAUTION - Although pyrethrum is comparatively nonpoisonous to human beings and other warm-blooded animals, persons allergic to ragweed in some instances are subject to attacks of hay fever when exposed to pyrethrum.

DERRIS, CUBE AND OTHER ROTENONE INSECTICIDES

Derris and cube powders are made by grinding the roots of certain tropical plants which contain rotenone and other ingredients that kill various insects. They are largely used as contact insecticides, although against some insects they seem to act as stomach poisons or repellents. These materials are effective against such sucking insects as aphids and thrips, and such chewing insects as young caterpillars, the cabbage looper, the imported cabbage worm, the Europea n corn borer, ants, young saw-fly larvae, and the adults of the Japanese beetle, cucumber beetles and flea beetles.

The rotenone content of these materials varies considerably, but a good derris-root or cube-root powder should contain from 4 to 5 per cent of rotenone and about 3½ to 4 times as much of other extractives. The dust may be stirred into water and applied as a spray, or mixed with some other fine dust for dusting infested plants. For sprays the final rotenone content usually ranges from 0.0056 to 0.025 percent, and for dusts from 0.5 to 1.0 percent. Liquid extracts of the active ingredients are also available; however certain of these may lose some of their effectiveness when mixed with water. The derris and cube insecticides are sold under various trade names, and since the strength of the active ingredients may vary in the different brands, they should be used as directed by the manufacturer.

Rotenone-containing insecticides lose their strength on exposure to sunlight and air, and several days after being applied to a plant they are usually no longer effective. All materials should therefore be stored in tight containers, and sprays or dusts should be prepared just before they are to be used.

CAUTION - These insecticides are comparatively nonpoisonous to man and other warm-blooded animals, although sometimes they do irritate the tender skin and mucous membranes.

HOME-MADE DERRIS SPRAYS

For the control of cabbage worms, leaf tiers, leaf rollers, and similiar caterpillars, and for the spotted cucumber beetle and other cucumber beetles, use a spray made by mixing 2 or 2½ ounces of derris powder, having a rotenone content of 4 percent, in 3 gallons of water. These proportions give the spray a rotenone content of about 0.02 or 0.025 percent.

To prepare a spray, first wet the derris powder with a small quantity of water, preferably containing a suitable wetting or sticking agent. Mix thoroughly to make a uniform paste. Then stir this paste into the bulk of the water in the spray tank.

A derris spray considerably weaker than the formula above, and containing 0.0056 percent of rotenone, is effective against the common red spiders and other spider mites, the cyclamen mite, certain thrips, and the very young stages.

HOME-MADE DERRIS DUSTS

Efficient home-made dusts may be prepared by mixing finely ground derris root or cube-root powder with various diluents. These diluents should be non-alkaline materials such as finely ground tobacco dust, clay, talc; wheat flour, diatomacoous earth, and sulfur. When mixing a derris or cube dust, follow the procedure outlined for nicotine sulfate dust (p.98), except that lime should not be used.

To prepare a dust containing 1 percent of rotenone, use the following formula:

Derris powder (4 percent rotenone)..... 1 lb (1 part by weight)
Diluent ..... 3 lbs (3 parts by weight)

To prepare a dust containing 0.5 percent of rotenone, use the following formula:

Derris powder (4 percent rotenone)..... $\frac{1}{2}$ lb (1 part by weight)
Diluent .....$3\frac{1}{2}$ lbs (7 parts by weight)

If the rotenone content of the derris powder is greater or less than 4 percent, the proportions of the inert diluent must be varied accordingly.

Soap Sprays

For such soft-bodied insects as aphids and trips and the young of scale insects, mealybugs, whiteflies, and leafhoppers, a concentrated solution of ordinary soap may be employed with some success as a spray. Such a solution may be prepared by dissolving 2 rounded tablespoonfuls of soap flakes, or a 1-inch cube of laundry soap, or a rounded tablespoonful of whale-oil or potash fish-oil soap, in 1 quart of hot water. For seedlings and tender plants, use only half the quantity of soap suggested above, since such plants are often injured if the full strength is employed. The white coconut-oil soaps are especially good as insecticides and will work well in hard water. Soap solutions are most effective when applied on calm, humid days, when the rate of evaporation is low.

Soaps are also used to a large extent in preparing emulsions, and also as spreading and wetting agents and as stabilizers for nicotine and pyrethrum sprays. The amount of soap required in a spray mixture is regulated somewhat by water hardness. If used with lead arsenate, some soaps may increase arsenical injury to foliage.

2. Kerosine oil emulsion

It is one of the oldest remedies and is used as below:-
Kerosine oil..... 2 gallon
Bar soap ..... 1 lb.
Water ..... 1 gallon

Shave the soap finely and dissolve in it in water by boiling. Hard water can be softened by using a little soda. Remove from the fire and add the kerosine when still quite hot and stir vigorously 5 to 10 minutes till kerosine oil is thoroughly emulsified. Take a small quantity of the solution in a glass and if there is no film of oil at the surface, then the oil has been thoroughly emulsified.

Do not dilute until ready to use. For soft bodied insects dilute one part of stock solution with 15 of water. A useful dilution for all times is 1 to 10. It is very effective against mealy bugs and wooly aphis. It should be applied only on bright sunny days as it has a tendency to brun the foliage.. Soft water should be used as the insecticide can not be made with hard water.

3. Crude oil emulsion

Soft soap or fish oil soap	5 pounds
Caustic soda (KOH 98%)	1 lb
Crude oil	6 gallons
Water	14 gallons

Dissolve the soap in 3 or 4 gallons of boiling water. Add the soda and make it up to 44 gallons. Start stirring and go on adding the crude oils slowly. Continue stirring for sometime. When spraying it should be very thoroughly stirred. When obtained in prepared form it should be applied by taking 12 to 15 gallons of crude oil emulsion and adding 100 gallons of water. It is useful for white-flies and aphids.

SPREADERS, WETTERS, AND STICKERS

Spreaders and wetters are materials that are added to insecticides to make them spread over and wet the leaf surface or the body of the insects to which they are applied, and thus increase their effectiveness. Stickers are added to make the insecticide adhere to the foliage. Soap is an excellent wetting and spreading agent for contact insecticides but has little value as a sticker. These materials are often used with lead arsenate in spraying shrubs and shade trees to insure a better and more lasting coverage of the plant surfaces. Powdered skim milk, glue, wheatflour, and soybean flour, and oil emulsions are good sticking and spreading agents, whereas raw linseed oil and fish oil are primarily stickers.

Do not use so much of the wetting agent that it will cause an excessive run-off of the insecticide from the sprayed plant surface; otherwise the effectiveness of the insecticide will be reduced.

FUMIGANTS

Ethylene dichloride and Carbon tetrachloride

A number of fumigants are available in the market but the most effective and harmless from the point of view of the viability of the grains intended for seed purposes is the fumigant sold under the name of Chlorosol, which is a mixture of three parts of ethylene dichloride and one part of carbon tetrachloride. The mixture is obtained in a liquid form but vaporises on exposure to air. All that is to be done is to cover up the infested grains under an air-proof cloth and pour this compound on a shallow dish on the top of the grain at the rate

of about 4 lb per 100 maunds of the grain. The exposure period is 24 hours. Fumigation of grains intended for food can be carried out with carbon disulphide, methyl bromide, hydrocyanic acid gas, etc. But these fumigants can only be handled by the dexterous hands of a well-trained entomologist. So it is recommended that Chlorosol is the safest fumigant to use.

The New Synthetic Organic Insecticides

Among the many new Synthetic Organic Insecticides are DDT (dichloro-diphenyl-trichlorethara) and BHC (benzene hepa chloride) Both of these are now available in Nepal. Both are available as wettable powders (that is, a form to be mixed with water and applied as a spray. It is not to be used as a dust). These may vary in connection from 25% to 75%. Likewise both can be obtained in dust forms varying in strength.

There is still much to be learned about most of these insecticides. Both are highly specific for some pests and ineffective for others. Both are more or less poisonous to warm-blooded animals and are cumulative in the body or have cumulative, injurious effects so that spray residues should be avoided on harvested crops. DDT may accumulate in the soil. BHC has an offensive odor and may give foodstuffs an off-flavor or taste. You should not be frightened away from the chemicals because of these dangers but before using them should become familiar with their properties in order to handle them competently. These new chemicals, if used correctly, are valuable additional weapons in the battle against insect pests.

SAFTY TO PLANTS - The safety of BHC & DDT to plants varies with their formulations, the plants, and the weather. In general, the wettable powders and dusts have a high margin of safety on plants. Both show a high degree of safety on most plant species at the recommended dosages, but some species or varieties, for example in the cucurbit family, may exhibit marked injury such as "burning" or stunting after treatments. DDT does not leach out of the soil or decompose readily; thus a toxic amount may be built up in the soil through repeated applications.

The superiority of DDT and most of the other new organics to the older insecticides lies in their effectiveness not only as stomach and contact poisons but also as residual contact poisons that kill many insect species by means of a slow paralysis after their feet have contacted the residues. Under outdoor conditions DDT stays effective for 2 to 3 weeks; but under indoor conditions where heavier applications are made it may kill insects such as flies and mosquitoes for 6 months or more. In addition to stomach and contact effect, benzene hexzchloride has considerable fumigating action, which adds greatly to its effectiveness in enclosed places.

There is some evidence that strains of flies and mosquitoes resistant to DDT have developed through its continuous use. Exterminators have reported failures to get fly control in many places where good control was previously obtained. Tests in laboratories have shown these flies are actually highly resistant to DDT and that resistance is retained by their offspring for a number of generations. There have been some reports also that leafhoppers are not as readily killed by DDT as formerly - it is entirely possible that other insects may develop strains resistant to one or more insecticides.

Although BHC is more toxic than DDT to some insects, its use is limited because of its persistent odor and tendency to produce off-flavor in fruits and vegetables.

Table of Measures

Liquid Measurements

3 teaspoons = 1 tablespoon
2 tablespoons = 1 fluid ounce

Imperial Weights	American Weights
1 pint ------ $1\frac{1}{4}$ lbs --20 ounces	1 pint ------ 1 lb or 16 ounces
1 quart ----- $2\frac{1}{2}$ lbs --40 ounces	1 quart -----2 lbs or 32 "
1 gallon ---- 10 lbs -160 ounces	1 gallon ----8 lbs or 138 "

Liquid Mixture using American Gallons

3 teaspoons (1 tablespoon) in one gallon	= approx. 1 part in 250 parts
2 teaspoons in one gallon	= approx. 1 part in 400 parts
1 teaspoon in one gallon	= approx. 1 part in 800 parts
3/4 teaspoon in one gallon	= approx. 1 part in 1000 parts
$\frac{1}{2}$ teaspoon in one gallon	= approx. 1 part in 1600 parts

Liquid Mixtures using British Gallons

3 teaspoons (1 tablespoon) in one gallon	= approx. 1 part in 300 parts
2 teaspoons in one gallon	= approx. 1 part in 500 parts
1 teaspoon in one gallon	= approx. 1 part in 1000 parts
3/4 teaspoon in one gallon	= approx. 1 part in 1200 parts
$\frac{1}{2}$ teaspoon in one gallon	= approx. 1 part in 1900 parts

Approximate quantities required to make one ounce

1 ounce 50% wettable DDT	= 6 level tablespoons
1 ounce hydrated lime	= 3 level tablespoons
1 ounce nicotine sulfate	= 5 teaspoons
1 ounce paris green	= $1\frac{1}{2}$ level tablespoons
1 ounce derris	= 6.1/3 level tablespoons
1 ounce sulfur	= $2\frac{1}{2}$ level tablespoons
1 ounce copper sulfate powder	= 5 level tablespoons

SPRAYING AND DUSTING EQUIPMENT

The effectiveness of an insecticide or fungicide depends to a large extent upon the thoroughness of the application of the material. The most effective way of applying an insecticide or fungicide is by the use of either sprayers or dusters manufactured expressly for the purpose.

Sprayers

Hand Atomizers (fig.1) — The hand atomizer is probably the most familiar type of equipment used in applying liquid insecticides, as it has been commonly used for applying fly sprays in the home. Its capacity is from ½ pint to 2 quarts and it is useful for spraying small plantings, although the under sides of the leaves of the plant are difficult to reach.

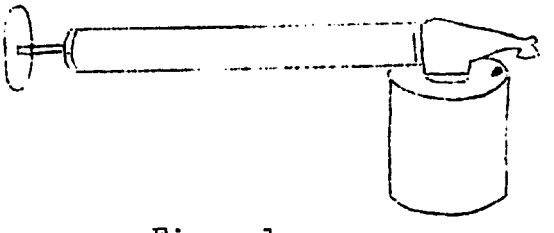


Figure 1

Compressed-air sprayers (fig.2) — The compressed-air sprayer is the most satisfactory for the small garden. It is usually made of galvanized sheet steel and has a capacity of 1 to 5 gallons. Since these sprayers are not equipped with an agitator, it is necessary to keep the materials well mixed by shaking the tank frequently during the spraying operations.

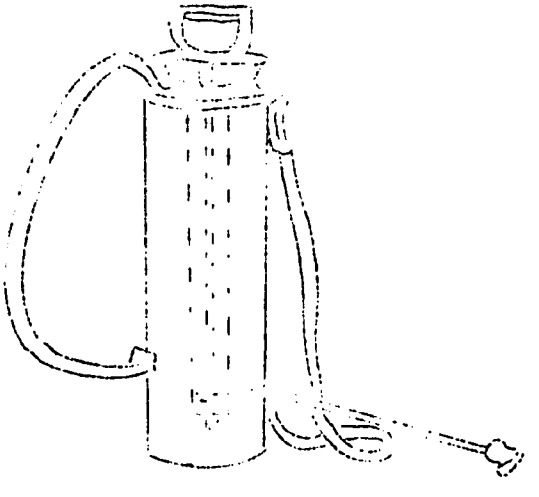
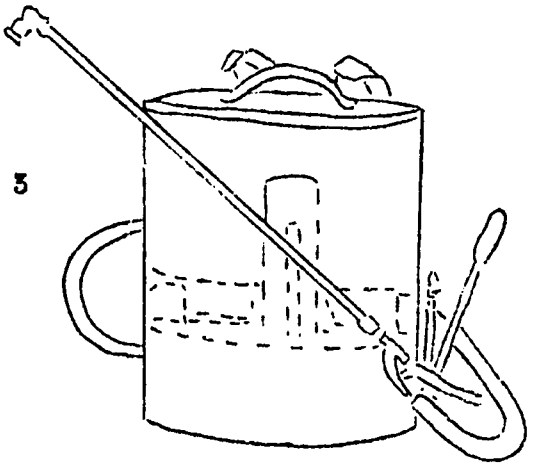


Figure 2

Knapsack sprayers (fig.3) — A knapsack sprayer is also a very useful piece of equipment for the home gardener. It costs more than the compressed-air sprayer but has an advantage over the compressed-air sprayer in that a higher and more uniform pressure can be maintained when the pump is kept in operation. An agitator is provided within the tank and operates with the movement of the pump handle.

Figure 3



Plunger type of duster — The plunger type of duster (fig.4), or dust gun, is the one most commonly manufactured for applying insecticides to small areas. Its dust-holding capacity ranges from 1 to 3 pounds. They are usually equipped with a tube and with a nozzle attachment that permits the dust to be directed to the under surface of the leaves.

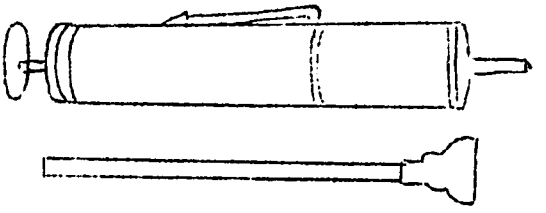


Figure 4

Bellows type of duster —— Two types of bellows dusters are on the market. The smaller type (fig.5) is made like the fireplace or blacksmith bellows, is equipped with special openings and a container for the dust or powder, and is satisfactory for small areas. The other type is the knapsack duster (fig.6), which is satisfactory for applying insecticidal dust to both small and large gardens.

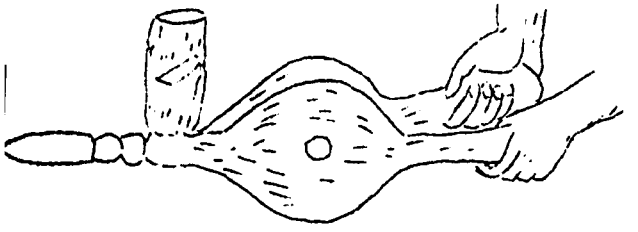


Figure 5

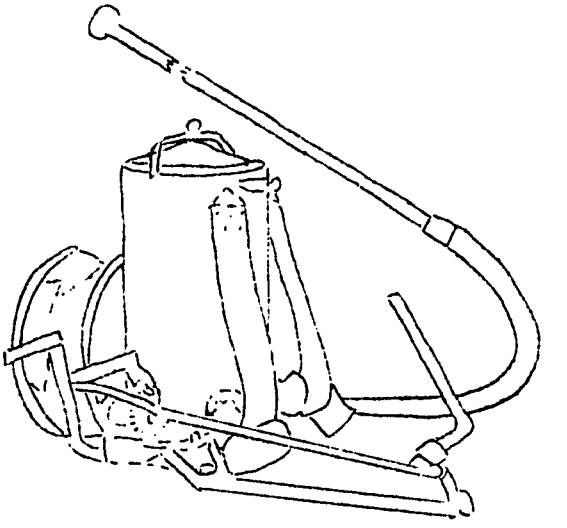


Figure 6

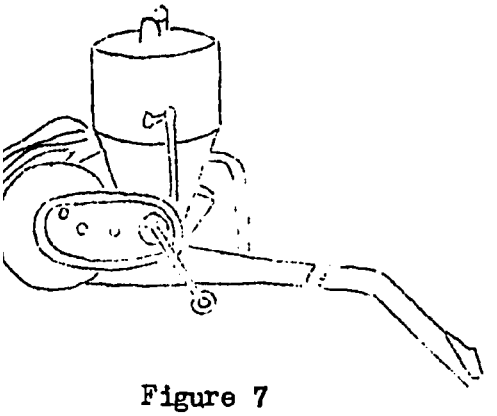


Figure 7

Fan or blower type of duster —— The fan or blower type of duster (fig.7) is a satisfactory piece of equipment for both small and large areas. The knapsack-bellows and fan types of dusters are priced much higher than the small plunger and fireplace bellows types, but from the standpoint of efficiency of application and long-time service they are a good investment.

Table and Formulas

It is a rare person who can remember all the mathematical constants and standard formulas. This section is provided to help you answer the questions of "how much" and "how many".

I Mixing Sprays

To obtain the quantity of insecticide needed to give a desired strength in the diluted spray use the following formula. The quantity needed is expressed in pounds.

Number of gallons desired x might of one gallon of water x Desired strength = Pounds needed known strength of insecticide used.

NOTE: One American gallon weights approximately 8 pounds
One Imperial gallon weights approximately 10 pounds

For Example: 2 gallons (Imperial) of 5% DDT is desired and you are using 50% Wettable DDT Powder.

$$\frac{2 \times 10 \times 5/100}{50/100} = 2 \text{ pounds}$$

Percentage is usually expressed in decimal units as 50% = .50. However, they can be expressed as fractions. Below are a list of percentages expressed in fractions which can be used as a guide in computations.

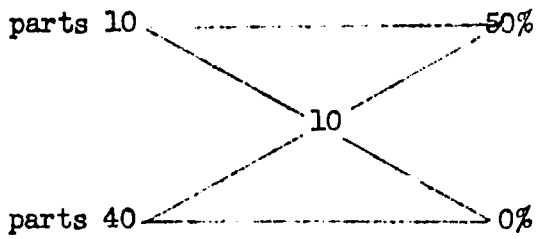
100% = 100/100
75% = 75/100
50% = 50/100
25% = 25/100
10% = 10/100
5% = 5/100
1% = 1/100
.1% = 1/100

II Dilution of Dust (Rectangular Method)

To reduce the concentration of a dust to a lower percentage by adding powdered diluent:

Example: to reduce a 50% DDT powder to a 10% powder by adding tale process as follows.

Write the percentage concentrations of DDT (50% for the DDT powder and 10% for the talc in the right hand corners of a rectangle. Write the desired strength in the center. Subtract along the diagonal lines, taking the smaller from the large number in each case. The dotted lines connect with their respective parts. The diagram is then read: Use 10 parts of weight of 50% DDT in 40 parts of talc (or 1 part in 4) for a 10% dust.



COMPATIBILITY OF SPRAYS AND DUSTS

It is frequently both advisable and economical to combine two sprays or two dusts in one application.

Before this is done it is necessary to be sure that one chemical does not interact with the other, causing loss of spraying or dusting efficiency. This is most likely to occur in the case of sprays. In the case of dusts, particle size and weight must also be borne in mind as, otherwise, if they are very different the two dusts will separate out, resulting in different plants getting an unequal share of each treatment.

When making a multiple spray, prepare one first to the correct dilution and then add the second concentrate to it. Do not mix the two concentrates together.

When mixing dusts remember that many are already diluted to the correct percentage and if mixed with another the dilution is increased with resulting loss of efficiency of the active ingredients. In this case more concentrated dusts should be used unless a lower strength is still sufficiently effective.

In the following pages are given Tables of Compatibility of Sprays and Dusts. Much evidence has still to be collected on this subject and in many cases small test mixing should be tried by potential users before bulk mixings are decided upon.

To use the tables follow the upper chemical down until it meets the horizontal column of the chemical. This point gives the interaction of the two;

COMPATIBILITY CHART

	Arsenate, basic lead	Arsenate, calcium	Arsenate, stand lead	Aldrin	"Aramite"*	Bordeaux	BHC (lindane)	Chlordane	Copper, fixed (insol.)	DDD	DDT	Dieldrin	Dinitro	Dithiocarbamates	Fluorine (cryolite)	Methoxychlor	"Neotran"**	Nicotine sulfate	Oil, summer	Oil, winter	Parathion	Pyrethrins	Rotenone	Selenium	Sulfur, dust	Sulfur, liquid lime	Sulfur, wettable	Tar Oil	Tartar emetic	TEPP	Thiocyanates	Toxaphene	Zinc compounds
Arsenate, basic lead																																	
Arsenate, calcium	Q																																
Arsenate, stand lead	Q	Q																															
Aldrin	S	S	S																														
"Aramite"		S	S	S																													
Bordeaux	S	S	S	S	D																												
BHC (Gammexane)	S	D	S	S	S	D																											
Chlordane	S	Q	S	S	S	Q	S																										
Copper, fixed (insol)	S	S	S	S	Q	S	Q	S																									
[illegible]	S	Q	S	S	S	S	S	S	S																								
[illegible]	S	Q	S	S	S	S	S	S	S																								
Dieldrin	S	S	S	S	S	S	S	S	S	S																							
Dinitro	Q	D	Q	S	D	Q	S	S	Q		S	S																					
Dithiocarbamates	S	Q	S	S	S	Q	S	S	Q		S	S	S																				
Fluorine (Cryolite)	Q	D	Q	S	S	D	S	S	Q		S	S	S	S																			
Methoxychlor				S	S	S			S			S		S	S																		
"Neotran"**	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S																	
Nicotine sulfate	S	S	S	S	S	S	Q	Q	S	S	S	S	Q	S	Q		S																
Oil, summer	Q	Q	S	S	S	S	S	S	S	Q	S	S	D	S	Q		S	S															
Oil, winter	Q	Q	Q	S	S	S	S	S	S		S	S	S	S	Q		S	Q	Q														
Parathion	S	Q	S	S	S	Q	S	S		S	S	Q	S	S	Q		S	S	Q	S													
Pyrethrins	S	D	S	S	S	Q	S	S	S		S	S	Q	S	S		S	Q	S	Q	S												
Rotenone	S	D	S	S	Q	S	S	S		S	S	Q	S	S		S	Q	S	S	S	S												
Selenium	D		D	S	Q	D			D			S	D		S			S	D	Q		D	D										
Sulfur, dust	S	S	S	S	S	Q				S	S	S		S	S	S	S	D	D	S	S	S											
Sulfur, liquid lime	Q	D	Q	S	D	D	D	Q	D	D	D	S	D	Q	D		Q	S	D	Q	Q	D	D	D	Q								
Sulfur, wettable	S	Q	S	S	S	D	S	S	S		S	S	Q	S	S	S	Q	S	D	Q	S	S	S	S	Q	S							
Tar Oil	S		S	S	Q	S					S								D	S						S							
Tartar emetic				S	S	B					S	Q		Q		S	Q	D	D				D	Q	D	D							
TEPP	Q	D	Q	S	S	D	S	S	Q		S	S	Q	Q	Q		S	Q	S	S	Q	Q	Q			D	S						
Thiocyanates	S	Q	S	S	Q	S					Q	S			Q		S	S	S	S		S	S		Q	Q	Q						
Toxaphene	S	Q	S	S	S	Q	S	S	S		S	S	S	S	S		S	S	S	S	S	S	S			Q	S						
Zinc compounds	S	Q	S	S	Q	S		S	S	Q	Q	S	S		Q		S	D	Q	Q		Q		Q	S	Q			D	Q	Q	Q	

Key to symbols: S= safe mixtures
Q= questionable mixtures, may decompose or be uneconomic or poor judgment
D= dangerous, react chemically, burn plants

* Trade name of U.S. Rubber Co., New York

** Trade name of Dow Chemical Co., Midland, Mich.

INSECT PEST OF PADDY

Rice Stem Borer

Order: Lepidoptera

Status - It is a major pest of rice and appears almost every season.

Marks of identification - It is a small moth almost straw coloured and looks like the moth of the Juar stem borer. The forewings have one black dot on each. The palpi project like a beak. The females bear a tuft of hair at the end of the abdomen.

Nature of damage - The caterpillars of this moth bore into the stem of the paddy plants and cause them to bear only empty ear heads. When a young plant is attacked no ear head is borne at all. An affected plant can be seen at once by the white and sickly appearance of the shoot and the leaves. If the stem is split open it will be found to be full of excreta.

Life history - Eggs are laid on leaves in clusters covered with yellowish hair derived from the anal tuft of the female moths. They are found usually near the tips of leaves. Each egg mass may contain 100 to 200 eggs and one moth may lay as many 600 eggs. A fresh egg is oval pearly white and scale like but when about to hatch after a week they turn blackish. The new larva is full fed in 3 to 4 weeks and the full grown caterpillar is 20 mm long, slender, smooth, segments distinct, in colour dull-whitish or yellowish sometimes with a green tint, head orange yellow. Pupation occurs in the larval tunnel which is lined with silk and lasts for about 10 days. The moth emerges through a hole previously cut by the caterpillar through the side of the stem. The hibernation takes place as a larva in the stubbles left in the field after harvest.

Seasonal history - Active period from April to November. Rest of the period as a hibernating larva.

Control

1. The moths are strongly attracted to light and may be caught in large numbers by means of light traps.
2. The egg masses are conspicious and when plentiful are easily hand picked.
3. Paddy stubbles should be ploughed up and if possible burnt after the harvest is over.
4. Rice straw should be chaffed and fed.
5. After harvest the fields should be well ploughed.

The Swarming Caterpillars
-Order: Lepidoptera

Status It is occasionally a major pest of paddy
Identification - Moth stoutly built, medium sized, dark brown in colour. Forewing with a black spot and irregularly waved line. Hind wings white with tufts of hair on fore tibia.

Host plants - Also noted on Juar, cane, and various wild grasses but it is particularly a pest of rice.

Nature of damage - The caterpillar feeds on the leaves of paddy plant. In case of serious attack the whole field gives the impression of having been grazed by cattle.

Life history - Egg stage 7 days, larval stage 30 days, pupa 8 to 10. Female moth is nocturnal and flies after dark. The eggs are laid on the underside of the leaves in clusters or 200 to 300 each. The eggs hatch in 7 to 8 days. Immediately on hatching them begin to feed on grasses or young seedlings of rice and do the damage mostly at night. During the day they hide under clods of earth. In about 39 days the caterpillar is full grown and then it is 35-40 mm. long, cylinderical paler or darker green above, greenish-yellow beneath with a reddish stripe along the sides at the junction of the two hues. When touched the caterpillar curls up until the head and the tail are nearly touching. When full fed it pupates in the soil, turning into a brownish pupa from which the moth emerges after 10 days. The pupa has two spines at the narrow end.

Seasonal history - The pest is active throughout the Kharif season but more so in the seedling stage. There are usually 3 to 4 broods and the most harmful is the second brood.

Control
1. Protect the seed-beds by surrounding them with narrow steep-sided trenches.
2. In small areas spraying and collection of eff masses is also possible.
3. Trapping the larvae by laying down sods, planks etc., might be tried.
4. Flooding of seed beds and turning in ducks to eat the caterpillars is also possible.
5. In Burma the cultivators attract the paddy-birds, crows and mynahs to attack fields by placing cooked rice in trenches.
6. Caterpillars can be dislodged by rope dragging and thrown into Kerosined water.
7. Spray with Pyrocolloid 1:600 or 1:800

The Rice Hispa -
Order: Coleoptera

Status - Occurs sporadically as a serious pest of rice
Identification - The adults are bluish small beetles with spines small all over the body.

Nature of damage - All the stages of the insect are passed on the paddy plant itself. The eggs are laid in the tissues of the young leaves close to the tip. The grub that hatches out burrows into the leaf tissue and feeds on the green matter and this produces the characteristic blister patches on infested leaf tips. The pupa is found in the same burrow and after the adults emerge. Two or three generations may be passed in one season.

Control - 1. In nurseries the beetles can be collected in any number very well by means of hand nets. 2. The leaf tips of seedlings can be cut. 3. Dusting of plants with 5% Gammaxone at 10 to 30 lbs. per acre. 4. Spray with Gammaxene Water Disparsible Powder 2 lbs in 100 gallon of water.

The Rice Grasshopper
Order: Orthoptera

Status - A major pest of paddy sometimes doing very great damage.
Identification - The variety common in Bombay is called elongata. The adults are greenish about 2 to 3 inches in length and there are incomplete wavy lines on the thorax. The hind tibia is bluish.

Nature of damage - The nymphs and adults eat away the leaves and destroy the crop. The adults sometime also attack the soft grains.

Life history - There is only one brood in a year. Eggs are laid by the female grasshopper in masses of 30 to 40 in the soil or on bunds in the month of October and December. They remain in the soil till June when they hatch and the young nymphs start feeding on the grasses etc. As soon as paddy come on they turn attention to it. The nymphal period lasts 70 to 80 days (about three months). They mould five times and reach the adult stage. Mating takes place soon after and egg laying starts. Both the nymphs and the adults do lot of damage to paddy.

Seasonal history - There is only one brood in a year. The pest is active from June to October.

Control
1. Before June in summer the bunds should be ploughed up and again made in order to expose the egg masses to the action of sun and to birds.

2. Dust with 5% gammaxene or Hexaclan at the rate of 20 lbs per acre.
3. Try bagging in the initial stages.
4. Drive the adults and nymphs to one corner of the field and beat to death with sticks.
5. Baits containing stomach poison are also used.

Paddy Blue Beetles
Order: Culeoptera

Status - The pest is occasionally serious.

Identification - Shiny metallic blue beetles with series of black spots on the elytra. Beetles flat.

Nature of damage - The grubs eat out longitudinal patches from the leaf and sometimes three to five larvae may be present on one leaf. The beetles also eat the leaves but most of the damage is from grubs.

Life history - The eggs are laid on paddy leaves and the grubs as they hatch out also feed exposed. They feed on the green matter of the leaves with the result that leaves look whitish in the beginning and later turn brown and roll inwards. Other insects then feed inside this roll. The grub when full fed pupates on the leaf. Pupa stage lasts for about four days.

Seasonal history - It is primarily a pest of seedlings and is active from July to September. As the crop grows up the pest disappears.

Control
Same as for rice hispa.

The Rice Bug
Order: Hemiptera

Status - A major pest of rice in the south.
Identification - Adults slender, Ocharaceous colour, black eyes, long antennae, body length 15 to 17 mm rostram reaching the middle coxae.

Nature of Damage - The bugs fasten on the rice ears and such out seed after seed; such ears turn wholly or partly white, little or no grain being formed. A badly infested field can be detected by the number of such white ears. This damage can be confused with that caused by the stem borers, in which case, whole stalk and ear withers from below. In the bug attack the stalk is quite sourd.

Life history - Eggs are laid in clusters in rows. In one row there may be as many as twenty. Each egg is 1 mm long, oval with a white spot at one end. The eggs are fixed firmly to the leaf with a gummy substance. The eggs hatch in about 6 to 8 days time. The nymphs pass through five in-stars. The nymphal stage may last 15 to 29 days. The nymphs feed on the juice of the leaves, stems and seeds of the plants and are cryptically coloured.

Seasonal history - The bugs are found all the year round. During the time when rice is not there, it breeds on wild grasses. During winter months it is found on dense grass in the jungly growth or on uncultivated lands.

Control

1. Dragging of ropes saturated with Kerosene oil or resin over the fields may give some relief.

2. Adults can be collected by hand nets.

3. Dust with 5% BHC Dust at the rate of 10 lbs, per acre when heads are in majority.

Crabs on Rice -

Crabs have been noted to do serious damage in many areas. When the paddy crop is young they feed on the tender shoots and cut them at the ground level and carry the pieces to their holes to be used as food. This generally done at dusk or at night. They make holes in the bunds and the irrigation water is drained off causing lot of trouble to the owners. The crabs are very active during the rainy season from June to October. The eggs remain attached to the abdomen of the female and the young crabs take about three years to reach to the adult stage. During winter they go into hibernation and at times burrow very deep into the soil. One of the ways to drive them out is to flood the holes which makes them think that the spring season has arrived and they issue forth. Some people make the collection of crabs as a profession as they can be sold at a good price to those that eat them as a delicacy. They can be baited to some bait like the cut-worms. One of the best ways to attack them is by cynogasing their burrows with a good cynogas pump. One tablespoonful of Cynogas is put in one hole and it is closes. If the burrow is not opened the crab is surely dead.

INSECT PESTS OF JOWAR MILLET AND MAIZE

Stem Borer
Order: Lepidoptera

The pest attacks all parts of plants except the roots. The caterpillars begin feeding on the leaves and finally bore into the stem, where they make tunnels and fill them with frass and excreta. Often times they bore into the cobs and make a meal of the tender grains. The attacked plants usually remain stunted in growth and often times die as well. In a young plant the damage is characterized by the appearance of a dried up central shoot greyish white in colour commonly known as the "dead heart". The caterpillars have been observed to exhibit a gregarious tendency and sometimes fifty of them have been found congregating and damaging a single maize plant. The pest is also known to attack sugarcane plants if they are grown in the vicinity of maize or jowar. They also show preference to tender plants more than to the older ones.

The moths which are of dirty brown colour are nocturnal in habit. During the day time they remain hidden under stones or dried leaves and are not usually visible to the untrained eyes. Eggs are laid invariably at nights in clusters numbering 10 to 40 on the underside of the leaves in two or three adjacent rows. They are oval in shape and are dull creamy white in colour which gradually turn black before hatching. The freshly hatched larva measures 2 to 2.5 mm. in length and 0.25 to 0.3 mm. in breadth. The full grown larva measures 20-25 mm. in length and 3 mm. in breadth. The larval period usually lasts for 16 to 24 days during the period when the pest is most active. The female pupa measures 12.5 to 17 mm. in length and 3 to 4 mm. in breadth while the male pupa is little smaller both in length as well as breadth. The pupal period lasts for about 4 to 7 days depending on the prevailing temperature and humidity of the season. Males are shorter lived than the females. The pest has at least five generations in a year. The moths from the over-wintered larvae usually start oviposition in the field towards the end of March or the beginning of April and the activity of the subsequent generations is maintained right upto the middle of October. The pest enters into hibernation in the larval stage from about the middle of October and continues to hibernate upto the end of March.

CONTROL MEASURES

1. All stubbles left in the field after harvest should be dug out and destroyed as these harbour the borer larvae and which become a source of infestation in the next season.

2. In small units removal of the affected plants showing the deadhearts with the larvae at a time when they are about 1-1½ ft. in height will also reduce subsequent incidence in the growing plants.

3. In case of servere infestation light traps may be set up and the moths trapped and destroyed.

GRASSHOPPER
Order: Orthoptera

The pest has been reported from Bombay, Madras, Madhya Pradesh, Bihar, Uttar Pradesh and Ajmer-Merwara. Within recent years it has been observed to be doing extensive damage to Kharif crops in Ajmer-Merwara and the adjoining States. In the south the pest has been observed causing serious damage in Nellore (Madras) only. It has also been observed in some villages in the Delhi State. Likewise it is present in other areas of the Indian Union but only as a minor pest. It is therefore necessary that a careful watch is kept about its activity lest it might not suddenly become a major pest in these new localities. Fortunately the pest as is commonly met with is short-winged and unable to fly long distances and occurs in the same place year after year. So it is easy to plant control operations well before hand. The pest has only one generation in a year and therefore with proper planning it is possible to achieve a measure of success in its control. The hoppers live on grasses that grow near and around the fields but as soon as maize and jowar as well as bajra come in the field they immediately migrate to these crops. It is, however, the nymphs that do more damage than the adults. In the beginning of the season the nymphs attack only maize and jowar but later they divert their attention to Til and Moong also. When the crop is young the hoppers feed on leaves only but later in the season when it develops grains the hoppers attack the ears also. The plant growth is generally arrested and an appreciable quantity of valuable food for men and fodder for cattle lost.

Adults mate more than once and the female lays eggs also more than once. Eggs are invariably laid under the soil on sides of bunds or raised grounds at a depth of 3-4 inches and very rarely in the cultivated fields. Eggs are laid in small cylindrically shaped pods and one female has been observed to lay as many as six such pods under laboratory conditions. In each pod there are about 50 to 60 tiny yellow coloured eggs. In the field we actually come across two distinct types of eggs, one freshly laid and the other 1 to 4 or even 5 years old. Compared to the old eggs, the fresh ones are a little smaller in size, not completely covered with mud and also softer in texture. The pest enters diapause in the egg stage by September and it is not until July-August next year when a few showers have fallen on the ground that these eggs start hatching. The small green hoppers just after coming out of the egg shells immediately start feeding and in the absence of maize, jowar or bajra they feed on grasses and later hatching feed a bit slowly and the damage is not so conspicuous but as they grow to maturity they become voracious eaters and the damage caused is very severe. The nymphal period usually covers from 60 to 82 days, the period being always less for those that hatch and thrive during July-August. The adults formed during September have been found to live from 33 to 18 days under different ecological conditions.

Eggs are laid by the end of September or the beginning of October. The whole life-cycle covers from 105 to 152 days depending on the prevailing temperature and humidity conditions.

CONTROL MEASURES

In the case of Hieroglyphus the climatic complex of temperature, humidity and rainfall vitally govern the activity of the pest in the field. Serious damage to the crop is oftentimes caused only in those years of good and regular rainfall. If in any year there are early rains followed by periods of drought, the pest usually fails to thrive well for the simple reason that the numphs that hatch out immediately fall a victim to the prevailing drought conditions and perish. Not only the numphs but a large number of eggs under soil are also found to be adversely affected due to this drought and degenerate on account of high soil temperature. If, however, the rains are regular and timely the pest gets the upper hand. The following control measures may be applied in the field to subjugate this pest:

1. Destruction of eggs by deep ploughing after the crop is harvested.
2. Poison baiting of hoppers when they are young with the following formulations:-

Bran	80-100 lb.
Sodium fluosilicate	2 lb
Molasses	2 lb
Water	Add as required

3. Dusting the hoppers with 5 per cent BHC at the rate of 10-12 lb. per acre. The operation is to be concentrated more in the early stages when the hoppers generally feed on grasses on the bunds. Dusting on the fodder crop or on crop meant for human consumption should be done with great caution and under expert supervision.

Hairy Caterpillar
Order: Lepidoptera

Status - Serious pests of millets.
Identification - The moths of hairy caterpillars are creamy white or pinkish white with black dots or streaks on the forewings. The body is red in the lower half and measures about 3/4 inch long and 1½ inches across the spread of wings. There are three species present in this province.

Amsacta moorei - strongly built moths with crimson abdomen and whitish colour.
Amsac lactinea, Cram - medium size, with black spots on the wings and red line along the anterior margin of the front pair of wings. Body bright orange with black bands and spots.

Amsacta albistriga, Wlk. - Abdomen yellow with a yellow band across the eyes. Costal border yellow.

It is recorded that all these species interbreed.

Nature of damage - The hairy caterpillars are voracious eaters on the leaves of a large variety of plants, eg., maize, juar, bajri, salhemp etc. They are gregarious feeders.

Life history - The moths appear at the break of the monsoon in late June or early July and lay eggs in conpicous, yellow masses chiefly on the underside of the leaves of various kharif plants. The egg stage lasts for about one week. The caterpillars start feeding on the leaves, at first gregariously and later singly, when they spread out on the plants. After about three weeks or less of active feeding they become full grown. A full grown caterpillar is blackish brown and very hairy and measures about 1½ inches in length. Now majority of the caterpillars go down to the soil to pupate. Fresh moths appear from these pupae in about a weeks time and there may be two generations thus. The caterpillars, that become full grown towards the end of the monsoon season, fall to the soil and pupate. The second brood is not so harmful. The pupation after the monsoon lasts for about nine months and the moths emerge from these only after 6 inches of rain has fallen. Early and scanty rains are not favourable for emergence.

Seasonal history - The pest is active only during the monsoon. Rest of the year the pest is hibernating as a pupa.

Control - This pest is easy to control provided organised efforts are made to collect and destroy the egg masses, caterpillars and the moths early in the monsoon. In this way much damage to the crops can be avoided.

1. Learn to recognise the moths of hairy caterpillars and as soon as they appear in the fields, set up light traps and destroy them. In addition to the moths that have fallen in the basin of water containing kerosene, large numbers will be found sluggishly hovering about the traps if the latter are visited early in the morning about 5 O'clock.

2. Look out for theegg masses of the pest on the leaves, clip them off and destroy them together with the eggs by crushing or dropping them in kerosined water. Children may be trained to do this.

3. Collect the caterpillars, specially when they are in the gregarious stage, from the leaves and destroy them.

4. The moths are attracted to light. The light traps should be put at dusk and kept burning all night. They are less useful after a heavy shower. These will not work on a windy night nor a weak light will be of any use.

5. In case when the caterpillars try to move from one field to another the place of serious infestation should be isolated by trenching.

6. The plants can be dusted with sodium fluosilicate mired with road dust in the ratio of 1:8 or 5% BHC at the rate of 10 lbs per acre.

7. Sanny may be grown near the fields as a trap crop.

8. Caterpillars have also been noted to eat the following bait and die:- Wheat bran 10 lbs., Jaggery $\frac{1}{2}$ lb., white arsenic $\frac{1}{4}$ lb., and water 9 lbs.

9. Pyrocolloid is reported to give good control. You might try different strengths.

PESTS OF SUGARCANE

Sugarcane Stem Borer
Order: Lepidoptera

Altogether seven different species of stem borer have been recorded from the various sugarcane growing areas in India, only one species Argyria sticticraspis is common to all the regions. Since the life cycle and habits of all are more or less similar to this form in so far as control measures are concerned, the following discussion, though relating specifically to Argyria sticticraspis is applicable to other forms as well.

Marks of identification:- The adult moth is greyish brown or straw-coloured and measures about 1½" when its wings are spread out. The lower wings are greyish white and the palpi are pointed forwards. The newly-hatched larva is somewhat greyish in colour, having a dark head and transluscent body with spots and hairs. The tiny spots develop into spines later. A fully-developed larva measures about 1¼" and is greyish white in colour. The body is often covered with dark marks, having tubercles and short setae on them.

Host plants:- In some areas maize and bajri as well as sugarcane are attacked.

Nature of damage;- The pest is mainly injurious to young cane. The caterpillars enter the plants from the side at ground level by making holes in the stalk and may bore either downwards or upwards or both ways. Thus, the central shoot dries up, causing "dead hearts", which is a characteristic sign of the presence of the pest within the plants. A dead heart can easily be pulled out.

Life history:- Oval, scale-like, whitish eggs are laid overlapping each other on the undersurface of leaves by the side of the midrib. The egg-stage last for 3 to 5 days. The newly hatched caterpillar enters the cane near the eye at ground lefel and later tunnels as far as the roots, sometimes, the borer is found to migrate from the roots to other tillers. The larval stage lasts for about a month and before pupation, it bites a round hole in the cane above ground level which is covered by a silken membrane from where the moth can escape. The pupal stage lasts for about a week and the entire life cycle is completed in about a month and a half. There are about 8 generations in a year.

Control measures:- Among these may be listed: (1) Removal of affected plants having "dead hearts" right from the ground level, ensuring that the larva or pupa has come out in the portion removed and feeding the same to the cattle or burying them deep in order to prevent further development, has been tried with success.

(2) Light earthing-up of cane will prevent the emergence of the moth by closing the holes with mud.

THE SUGARCANE TOP SHOOT BORER
Order: Lepidoptera

Marks of identification:- The moth is silvery or creamy white in colour, having a wing-span of a little over an inch when spread out and with orange hairlike structures at the tip of the abdomen of the female. The first pair of wings of certain males has a single black spot on each wing. Fully-developed caterpillars measure about 1 inch to 1½ inches in length and are yellowish white in colour.

Host plants:- In some areas jowar as well as sugarcane is attacked.

Nature of damage:- This is a very serious pest of sugarcane that breeds throughout the year and is capable of attacking cane at a later stage. The newly-hatched caterpillar enters first and midrib of the leaf and bores downwards into the shoot from the top. As a result of such feeding, the central shoot dries up in a characteristic way, which later results in giving off side shoots which form a bunchy top. The punctures on the leaves and the death of the central shoot and the bunchy top are the characteristic effects of this pest.

Life history:- Eggs are laid on the undersurface of leaves in groups consisting of 35 to 40 eggs which are covered with brownish hair-like structures and hence are clearly visible. The newly-hatched caterpillar, after remaining for some time on the leaves, enters the shoot through the midrib of the leaf. The caterpillar feeds as it travels downward. A fully-developed larva measures 1 inch to 1½ inches and, before pupation, it prepares a silken membrane from which the moth can escape. The pupa is found in the larval tunnel. The egg-stage lasts for 6 to 7 days, while the larval period continues for 3 to 6 weeks. The pupal stage continues for 7 to 10 days from which the moth on emergence lays about 5 to 8 egg-masses within 2 to 4 days of its life-time.

Control measures:- (1) Mechanical methods such as mass collection and destruction of egg masses and removal of affected plants are the only effective measures known so far.

(2) Conservation of egg-parasites with the help of special boxes can be tried. Chemical measures have not yet proved successful. However, for effective control of the shoot borer in general, the following measures are recommended:-

1. The crop should be harvested by digging out the stumps and not by cutting at ground level.

2. A large-scale campaign to collect and destroy the egg-masses of the top shoot borer should be carried out.

3. Two light earthings-up should be given during the early stages of the crop.

4. 0.5% BHC or 0.25% DDT may be sprayed, provided the operation can be timed with the maximum hatching of eggs and before the newly-hatched caterpillars enter the plants.

THE SUGARCANE LEAF-HOPPER
Order: Hemiptera

Marks of identification:- The adult pyrilla bug is a straw-coloured insect, with two pairs of wings folded in roof shape on the back and with its head drawn into a pointed beak which is quite readily visible. The young nymphs that hatch out from the eggs are pale brown in colour, having a pair of long characteristic processes covered by wax. They are active and are found in large numbers of cane.

Host plants: Its host plant is mainly sugarcane but it is sometimes found in small numbers on jowar and maize also.

Nature of damage:- The nymphs and adult bugs such the sap of cane leaves from the lower surface, as a result of which the leaves lose turgidity, begin to wither and ultimately get dried up. The bugs secrete a "honeydew" - like substance that spreads on the leaves on which a black fungus develops. As a result of pyrilla damage, the sucrose content of the juice is reduced.

Life history:- Pale greenish-yellow eggs are laid in clusters of 2 to 4 or 10 to 60, generally on the under surface of leaves and between the detached leaf sheaths and the stem. The eggs are covered with white cottony, waxy filaments. They hatch out within a week into tiny hoppers that start sucking the sap of leaves. The nymphs become adult bugs within 50 to 60 days. Egg-laying continues from April to November and the period of its great activity is July and August.

Control measures:- (1) Collection and destruction of egg-masses and crushing the egg masses between fingers on the leaves is found to be a convenient method of control.

(2) Stripping off the leaves to remove the eggs laid in the leaf-sheath was a method recommended for a long time. Now, however, insecticides are used.

(3) Dusting the crop with 5% BHC at the rate of 30 to 40 lbs. and 50 to 60 lbs. per acre in the pre-and post-monsoon periods, respectively destroys both the nymphs and the adults. This method is now widely used.

(4) The adults and nymphs of pyrilla should be bagged and thrown in kerosenized water.

(5) Spraying 0.12 to 0.25% BHC or 0.25% DDT at the rate of 30 to 50 gallons per acre during the pre-monsoon period and 100 gallons during the post-monsoon period also gives considerable relief.

MEALY BUGS ON SUGARCANE
Order: Hemiptera

Marks of identification:- Adults and nymphs of mealy bugs are soft-bodied, light coloured, oval creatures, found in large numbers near the nodes, covered over by a white, waxy powder and the leaf sheath.

Host plant:- Sugarcane

Nature of damage:- Being a minor pest, its damage to the crop is not considerable. The adults and the nymphs being lodged in leaf-sheaths continuously suck the sap and weaken the plant and, in case of excessive infestation, decrease the yield.

Life history:- The female deposits hundreds of eggs covered with a white waxy or mealy mass. The newly-hatched nymphs travel rapidly for some time to find new places for settling on the plant. The ants help a great deal in their dispersal and live a symbiotic existence by getting honeydew secreted by mealy bugs in return.

Control measures:- (1) Selection of sets free from the infestation of mealy bugs is one method. The sets may be treated with 1% fish oil rosin soap before planting.

(2) The affected plants should be sprayed with 1% fish oil rosin soap which gives some relief.

(3) Spray with Pyrocolloid 1 part in 400-600 parts of water.

THE MEALY WING OR WHITE FLY
Order: Hemiptera

Marks of identification:- Adults are active, tiny creatures with a pale body, black eyes and a pair of mealy white wings. The numph is a tiny pale yellow creature.

Host plants:- Sugarcane.

Nature of damage:- By sucking the sap from the leaves, the nymphs and the adults affect the vigour of the cane. In general, it is a very minor pest and is rarely troublesome.

Life history:- Small eggs are laid in the middle of the lower surface of leaves, which hatch out within about a week. The young ones require 3 to 4 weeks for becoming mature adults.

Control measures:- (1) Clipping off and destroying the early infested leaves prevent further spread. (2) Spraying the affected area with 1% fish oil rosin soap or rosin compound in case of serious infestation gives some relief. (3) Spray with Pyrocolloid 1 part in 400 - 600 parts of water.

WHITE ANTS ON SUGARCANE

Order: Isoptera

Nature of damage: The termites attack the planted sets either near the eye bud or from the cut end. They occasionally attack the entire roots through which they ascend the cane, which they fill with mud galleries. This indeed a very serious pest in North Gujrat in Bombay State.

Control measures:- Sets dipped in 2.5% suspension of BHC or DDT for 24 hours before planting have shown satisfactory germination and in case such infestation is found, the treatment can be repeated.

The following control measures against termites on sugarcane are recommended.

(1) The sets may be dipped in 0.25% BHC suspension or 1.25% DDT suspension or they may be soaked in a mixture of lime and lead arsenate in the proportion of 10:1 for 24 hours before planting.

(2) At the time of planting, 5% BHC dust at the rate of 20 lbs. per acre should be applied in furrows along with the sets.

INSECTS PESTS OF JUTE

The Hairy Caterpillar
Order: Lepidoptera

This is one of the most serious pest of jute. Actually there are more than one species of hairy caterpillar, but as the damage and control are about the same, they shall be discussed simultaneously.

As adults the hairy caterpillars are moths. Those belonging to the Genus Utethesia have yellowish forewings with red and black dots with the hind wings having black marginal dots. Those belonging to the group Argina may have crimson or orange dots on the wings.

The damage is done by the caterpillars only which feed on the leaves of the plant as well as the seeds.

The moths are day fliers and they can be seen climbing on the plant or fluttering about in a clumsy manner. The small whitish eggs are laid on the underside of the leaves and on the tender shoot especially when the plants are young. These hatch in three to four days. In two weeks the caterpillars after feeding on the leaves become full grown. This full grown larva is about 1½ inches long, rather stout with an irregular creamy pale line down the back, bodered on each side with a blackish hairs are distributed along the back and sides with those at either end being longer. Pupation occurs in the soil in a folded leaf. This stage lasts from five to six days. The total life cycle last about a month with the insects being active from April to November with there being many generations in one season. During winter the pest hibernates as a pupa in the soil.

Control: 1. The moths can be collected by hand nets as they are day fliers. 2. In the early stages hand picking the larvae is also effective. 3. Dusting with a 5% BHC dust will control the larvae or using 0.25% DDT spray. 4. The pest can be controlled through clean cultivation following the harvest or through crop rotation.

The Flea Bettle
Order: Coleoptera

The Flea Bettle

This is a small beetle which usually is a minor pest but can be of major outbreaks occasionally. Their habit of jumping when disturbed gives them their name. Generally they feed on the leaves which are thick and succulent. The eggs are laid on the leaves and the grubs that hatch are usually leaf miners.

Control: As yet no effective control has been developed though Bordeaux mixture with four ounces of Paris Green per 50 gallons of mixture is said to give good control.

SOME INSECT PESTS OF VEGETABLES

I. BHENDI

Cotton and bhendi, though differing widely in the usages of their products, are actually very closely related plants. In fact, the insect pests of cottons are found to be the major insect pests of bhendi. Though the following information concerning insect damage is based primarily upon studies of cottons pest, it is equally applicable to the insect damages to bhendi.

SPOTTED BOLLWORM
Order: Lepidoptera

This is a major pest of cotton with universal distribution. Actually, there are two species of moths whose larvae are known as the "spotted Bollworm", one Earias insulana and Earias fabia. As adults both have a wings span of almost one inch but they differ in coloration, E. fabia has a dull white head and thorax, likewise the forewings are dull white with a longitudinal green wedge shaped band; E. insulana has a green head, thorax, and forewings with the hind wings white.

Nature of Damage: The caterpillars of these moths bore into the buds, bolls, flowers and prevent their opening resulting in their being shed. When the bolls and other tender parts are not available they bore into the young stem and thus check further growth. This results in the entire habit of the plant changes with it becoming bushy and the erect habit is lost. The lint from the damaged bolls is not stained but of a shorter staple and poor in quality.

Life history:- The pest is active practically all the year. The female moths usually emerge in April-May. Mating takes place in the early hours of the morning and the egg laying begins. The eggs are laid single on the bracts, buds, shoots, buds, bolls and sometimes on the hairy parts of the leaves. These eggs are bluish in color with fine small ribs. They hatch in four to seven days. On hatching the young larva is dark in color but after a short feed they begin to change color. Then it bores into the buds or bolls. Most of the bored buds are shed, thereby reducing the yield. Bored bolls are full of excreta and the lint is also spoiled. The hole through which the caterpillar enters is never closed and this is a sure way of distinguishing the attack from that of the pink bollworm. This larval period lasts from ten to sixteen days. When full grown the larva is pale green with a lot of spiny hairs. It pupates inside a silken cocoon in the cracks of the soil. The pupal stage lasts from eight to fourteen days. In areas with cold enough winter, the overwintering form is the pupa form.

Host Plants: Cotton, bhendi, hollyhock, hibiscus, and Kanghi

Control:-

1. In the beginning of the season the attacked shoots should be collected regularly and burned.

2. When the pest is destroying flower-buds, and bolls, the plant should shaken thoroughly by dragging a rope over them. The attacked parts will be hurled to the ground. These should either be collected and burned or destroyed by flodding the fields immediately.

3. After the crop is harvested, the stalks should be removed from the fields by beheadings them 2 inched below the ground with a Kudali or some other instrument anytime during the January March season. The new sprouts that may appear after this operation should be destroyed in April. Wild plants that harbor these pest should be destroyed during the January to April period.

4. The larvae and pupa of the spotted bollworms are parasitized by a number of insects. These parasites should be encouraged.

COTTON JASSID
Order: Hemiptera

The color of this bug varies —— in winter sometimes it is reddish while in summer it is usually greenish-yellow, at times it may appear brown or green. Their front wings have a black spot and there are two black spots on the vertex of the head.

Life history: In Punjab the pest passes the winter on potato. It begins to breed in April on hollyhock and brinjal. The females insert yellow-white eggs singly in the veins of the leaves and on the underside of the leaves. These hatch in four to eleven days. The green nymphs resemble their parents in shape but are without wings. Depending upon the temperature they reach maturity in seven to twenty-one days.

Nature of Damage: The pests turns its attention to cotton and bhendi in June and it remains on these two plants up to November. It sucks the sap from the underside of the leaves with the result that in bhendi the edges of the leaves turn upward whereas in cotton the edges of the leaves turn downwards, the attacked leaves ultimately becoming red and dropping off. The furiting capacity of the plant is very seriously reduced. The pest shows a preference for American varieties of cotton.

Host Plants: Cotton, bhendi, hollyhock, brinjal and potato

Control:-

1. Spraying the crop with pyro-colloid, one part in 600 or dusting with pyro-dust 4000 has given fair control.

APHIDES
Order: Hemiptera

This is a serious pest of cotton and bhendi and has universal distribution.

Identification: Full grown females about 1/16 of an inch long. From above it appears somewhat egg-shaped in outline. The colour varies from season to season but is usually pale yellow to light green. Sometimes darker forms are encountered.

Life Cycle: There is no sexual generation except in cold climates where the last generation of the season consist of males and females producing overwintering eggs. Young produced Viviporously i.e. by the production of nymphs directly. Many generations in a season.

Nature of Damage: Nymphs and adults feed on the plant by sucking the plant juices. This affects the growth and production of the plant. Due to the honey dew excreted by the aphides a sooty mold may develop on the leaves which interferes with the photosynthesis of the plant.

Control:
1. Spray with nicotine sulfate 1 part in 800 parts water.
2. Spray with pyrocolloid 1 part in 1000 parts water.

II - BRINJAL

Epilachna Beetles
Order: Coleoptera

These constitute an important pest of brinjal. They are spherical pale insects with brown spots. Their grubs scrape the green matter from the leaves and the tender parts of the plants and cause serious damage when they appear in numbers. The leaves do not loose their shape but appear lighted or lace-like. All stages of the beetle are passed on the leaves. The eggs are laid in bunches and the grubs are spiny as well as fleshy. The pupas are hemispherical; and active beetles are found roving on the leaves. The grubs usually feed on the lower surface of the leaves.

Control:

1. In small plots, hand picking of egg clusters, adults, and leaves with grubs on them is very effective.
2. If there are no fruits on the plants, a DDT spray containing from .025 to 1% is effective or dust with 5% BHC at intervals of eight days.

THE BRINJAL FRUIT BORERS
Order: Lepidoptera

This insect is a major pest of brinjal. The borer is a larva of a moth which as adults have whitish forewings with blackish markings. The hindwings have black lines and some specks.

Nature of Damage: The caterpillars cause the damage by boring into the top shoots, causing them to wilt. Likewise they bore into the fruit.

Life Cycle: The adult moth lays her eggs on the leaves or stem and are laid singly. The eggs hatch in about one week and the larvae are into the fruit or stem. The mature caterpillar is about one inch or better in length, rather stout and may be pink or pinkish brown in color. Scattered over the body are shiny warts bearing short bristles. Pupation occurs in the stem of the plant, in the fruit or on the plant.

Control: 1. The most effective control is by collection of all infested shoots and fruits and their destruction.

THE LACE WING BUG
Order: Hemiptera

These are insects with sucking mouth parts; the adults are straw colored on the dorsal surface with the lower surface being black. The wings and pronotum are so formed and veined as to appear as place. They are small insects, being about one-eight of an inch in length.

Life Cycle: The insects usually copulate in the morning. The females insert their whitish eggs singly in the tissue of the leaves on the underside. An average of three to four eggs are laid daily and a female may lay an average 35 to forty eggs during its life-time. The eggs hatch in four to twelve days and the nymphs reach maturity in ten to twenty-one days. The nymphs oval in shape; greenish yellow in color; with numerous tubercles arising over the body each of which bears long branching spines. The nymphs moult five time before reaching maturity. Winter is passed in the adult stage.

Nature of Damage: The insect occurs as a pest only in those summers which follow a mild winter and warm spring. Very young numphs suck sap from the lower side of the infested leaves, but older nymphs and adults feed on both sides. The attacked leaf becomes pale yellow, shrivels, dries and falls off the plant. A severely attacked crop of brinjal may be completely defeliated. Afterwards the attacked plant dries up.

Control: The pest can be effectively controlled by spraying the attacked plants with rosin compound or rosin soap. The crop should be sprayed twice with an interval of about a fortnight between the first and second spraying.

III - PESTS OF CRUCIFERS

The plants called crucifers include cabbage, cauliflower, brussel sprout, broccoli, khol rabi and chinese cabbage.

THE MUSTARD SAW-FLY
Order: Hymenoptera

Marks of identification: The adult flies are short and thick-bodied, and are marked with black and orange. Their wings are smoky with black veins and though called "flies", they have four pairs of wings. Full-grown larvae are three-quarters of an inch long, black, smooth with 8 pairs of prolegs, in addition to three pairs of true thoracic legs, and have 5 long stripes on the body. On being touched, they have a tendency to curl up and frop on the ground, feigning death.

Host Plants:- Radish, cabbage, Brussels sprouts, cauliflower, mustard and turnip.

Nature of damage:- The larvae feed on leaves by cutting small holes into the leaves and ultimately skeletonise the plants. Frequently, a large number of larvae can be found on each leaf.

Life history:- The eggs are laid singly in the leaf tissues and hatch in about a week's time. On hatching, the larvae start feeding on leaves from the margin inwards. They feed in the morning and evening for about a fortnight and grow. Full-fed larvae descend to the ground and pupate in the soil in earthen cocoons. Their pupal period lasts 10 to 12 days.

Control measures:-

1. In the early stages of attack, hand-picking of the larvae and their destruction may be resorted to.

2. Shaking the affected plants in a tray containing kerosenized water is a common method.

3. Spraying with the following mixture is recommended
   4 lbs - Derris
   3 oz - Flour
   50 gallons - Water

4. Kerosinized ash dusted on the plant is recommended as a deterrent.

THE DIAMOND BACK MOTH
Order: Lepidoptera

Marks of identification:- The moths are small, about one-third of an inch long and brownish-grey in colour. The lower edge of the front wing has a white-coloured patch, which appears like the shape of a diamond when greenish, half an inch long, moderately stout, somewhat tapering at both ends and smooth, with some scattered hairs.

Host plants:- Cabbage, mustard, cauliflower and lmolkhol.

Nature of damage:- The caterpillars feed generally on under-surfaces of leaves and make holes into them and may skeletonize the plants when they are present in strength.

Life history:- Pale, whitish eggs are laid singly on the lower surface of leaves and they hatch in about a week's time. On hatching, the caterpillars feed on leaves for about 14 days and become full-grown. Full-grown caterpillars pupate on the leaves in thin silken cocoons. Their pupa period lasts a week. The pest is active from September to March and there are about 5 to 7 generations in a season.

Control:-

1. In the early stages of the crop, spraying with a stomach poison like calcium arsenate at 4 to 8 lbs. in 100 gallons of water has been found effective.

2. Spraying with pyrocolloid in the proportion of 1 part in 800 parts of water is another remedy.

3. Spraying D.D.T. containing 2 lbs. of 50% w/d D.D.T. in 100 gallons of water may also help to check the pest.

THE PAINTED BUG
Order: Hemiptera

Adults are oval shaped bugs, black in color with red or orange colored markings on the dorsal surface. The nymphs are of the same general coloration.

Host plants:- Cruciferous plants such as cabbage, radish, mustard, rape, sarson, toria, cress, etc.

Nature of damage:- Both nymphs and adults suck the cell-sap from the plants. The infested plants finally wear a sickly look and dry up.

Life history:- Dark-brown barrel-shapped eggs are laid singly on the leaves and stems and hatch in about a week. On hatching, the nymphs start sucking the sap from the plants and become adults in about three weeks. Often there are a number of generation during a single season.

Control:-

1. Collection of bugs by hand-nets and their destruction is a common practice.

2. In the early stages of attack, dusting the crop with 5% BHC at the rate of 15 lbs. per acre may be found effective.

3. Spraying pyrocolloid 1-400 in early stages repeat as necessary.

APHIDES

This group of insects are pests on several crops and in different seasons all over the Nepal. Some species are known to feed on jowar and groundnut in the Kharif season, while those on cabbage, cauliflower and safflower become abundant in the Rabi season. Among the cultivated crops, the following are known to get infested with them: Jowar, Maize, groundnut, wal, mung, udid, bhendi, chavali, beans, lucerne, cotton and avala in the Kharif season and cauliflower, cabbage, knolkhol, peas, safflower, brinjal, tondli and wheat in the Rabi season. Some fruit trees like the citrus also suffer from certain species of aphides.

Marks of identification:- Except for the species feeding on safflower which is black, most of the aphides are generally light green or slightly yellow in colour. They all are very sluggish insects, and do not move much in their wingless stage and generally remain stationary after inserting their minute beaks in the leaf tissue. They are soft-bodied, minute, about one to two mm. in length, and oblong in shape and, due to their stationary shape and, due to the stationary habits and small size, they are often confused by laymen as "eggs" of some insects. When found in abundance, scores or more may be found on the under-surfaces of leaves. In the case of jowar, they may be common in whorls also. On microscopic examination, one can observe two tubes arising out of the latter half of their body. These are called cornicles. They are mostly wingless but later in the season or at the maturity of the crop, winged adults are also found. Their wings are transparent, sometimes with black lines on them, and are retained in a roof-like position.

Nature of damage:- The aphides have a sucking type of mouth parts in the form of a beak whose inside part they insert into the leaf tissue and suck the cell sap. The presence of a number of aphides which generally remain on the undersurfaces of leaves and their continued feeding lead to the general yellowing of leaves and subsequent drying. As they take an excessive amount of cell sap, they also excrete a large amount of sugary solution which comes to lie on the leaf surface. On this sugary solution develop black sooty moulds which blacken the surface of the leaf on which the pest feeds. This is frequently seen on the infested leaves. The sooty mould is not parasitic on the plant but remains as a saprophyte on the surface but its presence in excessive amounts interferes with the photosynthetic activity of the plant.

These insects are known to transmit virus diseases of certain crops like cardamom and papaya, which may also cause symptoms of the disease.

Life history:- In Tropical Areas, the pest does not reproduce by laying eggs, but mature winged and wingless individuals lay young ones. All the individuals normally seen are the females, while the males are not very common or are almost absent in our climatic conditions. Each female can produce scores of individuals. The young ones develop into mature females and thus continue the life-cycle. The rate of reproduction is very rapid and the pest increases in abundance within a few weeks, resulting in the presence of hundreds of these small greenish and roundish individuals appearing on the under surfaces of leaves. At the end of the season as the crop approaches maturity, winged individuals appear from the wingless ones and they migrate to other crops to continue their life-cycle.

Very often, red ants appear on the plants infested with aphides. These ants come to feed on the sugary solution secreted by aphides. In return they protect the aphides. The presence of ants themselves generally does not cause damage to the plants, but by their habit of protecting and encouraging the aphides, they are indirectly harmful. Hence getting rid of these ants tends to discourage aphis population, though it will not prevent the presence of the aphides entirely.

Control measures:- This pest can be successfully controlled by using any of the following insecticides.

1. 40% nicotine sulphate under various trade names is readily available in the market. It is to be diluted at the rate of 1 part in 800 parts of water and about 3 to 4 lbs. of soap are dissolved in the mixture for enhancing its effect. About 80 to 100 gallons per acre are necessary. The application of the spray may be repeated if necessary at an interval of 7 to 10 days.

2. Tobacco decoction may be used. It is prepared by soaking overnight 1 lb. of tobacco waste (Dhus) of good quality in a gallon of water and is subsequently boiled for an hour. When the liquid is boiling, half a pound of bar soap should be added and, after it is dissolved, the resultant liquid should be strained through a cloth and allowed to cool. It may be stocked in this form until required for use. For spraying, the liquid is diluted with 6 to 8 times its volume of water. About 80 to 100 gallons of the diluted decoction are required per acre. If necessary the treatment may be repeated after a period of 10 days.

3. Fish oil rosin soap is also used. Half a lb. of fish oil rosin soap is also is dissolved in 4 gallons of water. The solution is stirred vigorously till a good lather appears. About 80 to 100 gallons of spray are required for one acre.

4. Pyrethrum extract is another agent commonly used. A concentrated form of pyrethrum flowers sold under various trade names is also used as spray against aphides after diluting one part of it in 1,000 parts of water. About 80 to 100 gallons per acre may be required, depending on the stage of development of the crop.

5. Pyrocolloid 1 part in 1000 parts of water at rate of 80 gallons per acre.

IV-CUCURBITS
(Melons)

Such common vegetables as the pumpkin, ridge gourd, bottle gourd, cucurbit, etc., have certain pests common to them. But they are not equally injurious to all. Thus, for example, the fruit fly is the most serious pest of tondli, while other cucurbits are not as attractive hosts. Similarly, Epilachna is common on Kareli, but is not of much significance in the case of some other vegetables. This fact must always be borne in mind while dealing with pests of cucurbits and their control. They are: (i) the red-and-black pumpkin beetle, (ii) the fruit fly, (iii) the Epilachna beetle, (iv) aphides, and (v) the banded blister beetle.

Even after DDT and BHC have become common insecticides, the control of cucurbit pests has not become easy; this is so because the new halogenated insecticides are highly toxic to cucurbit plants and, therefore, cannot be used for control of pests on these crops. It is most important to remember that DDT and BHC in any form should not be used for treating cucurbits.

THE RED-AND-BLACK PUMPKIN BEETLE

Marks of identification:- The beetles are red-and-black coloured and about a third of an inch long. The grubs are small and yellowish white, with a brownish head and, when full-grown, measure about half an inch in length.

Host plants:- All cucurbits. The extent of damage is different in case of different hosts.

Nature of damage:- The beetles eat the green part of leaves and thus create irregular holes on their surfaces. The grubs remain in the soil and bore into the roots and stems as well as the fruits which come into contact with the soil.

Life history:- Yellowish-brown, elongated eggs are laid in the soil below the plants and they hatch in a period of 6 to 15 days. On hatching, the grubs feed on young roots of plants and become

full-grown in 2 to 3 weeks. The total period of their life-cycle is 4 to 7 weeks. There are 3 to 5 generations in a season. The pest partially hibernates in winter in the adult stage and is active from March to October but in winter also it causes some injury, which is noticeable.

Control:-

1. Collection of beetles by hand and their destruction offer the simplest method.

2. Treating the crop with lead arsenate or calcium arsenate is also found useful. Cryolite, after dilution with two parts of talc, has also given a satisfactory degree of control.

FRUIT FLY
Order: Diptera

There is probably more than one species of fruit fly attacking melons but the habits are usually the same. The female deposits her eggs just beneath the skin of the fruit. These hatching two or three days and the maggots begin to tunnel and feed throughout the fruit. Bacteria soon enters the hole and the fruit begins to rot, resulting in complete loss of the fruit. After about seven days of feeding, they emerge from the fruit, drop to the ground and pupate. The pest is active all year round in warm climates, feeding on different plants.

Control:-

1. Attacked and rotten fruit should be collected and destroyed by burying deep in the ground.

2. For added protection a layer of lime may be placed over the buried fruit before covering with dirt.

3. The fields should be thoroughly plowed and harrowed to dislodge and destroy the hibernating pupae. This should be done during the winter season.

APHIDES
(Refer to Cruciferous plants)

Epilachna Beetles

(Refer to Brinjal)

V-POTATO

Cut worms
Order: Lepidoptera

Cutworms are often a major pest of potato. The insect hides during the day under stones or higher pieces of soil and is active only during the night. They cut the plants a little above the soil and pull these towards their burrows (holes) for eating. In the morning these cut stems of the leaves are seen on the ground. The damage occurs because the larvae cut much more than what they can consume.

The adult of this larvae is a moth that is heavy bodied and gray brown in color. It has a wing span of two inches. Likewise there are blackish gray patches on the wings.

Life history:- The eggs are laid on the underside of the leaves or on the stems. Eggs are dome shaped and about $\frac{1}{2}$ mm. wide. They are creamy white in color. One single moth may lay as many as 300 eggs. The egg stage last for about three to eight days depending upon the temperature. The larvae upon hatching moves about in a semi-loop manner. It will curl up on the slightest touch and fall to the ground. This stage last for about 19 to 24 days. As a mature larva it is almost 50mm or two inches in length with a dark gray green color. The pupal stage which takes place in the ground last for about 11 to 18 days.

Control:-

1. Expose the soil to attract birds to feed on the caterpillars.

2. Clean cultivation prevents cutworm attacks.

3. Heaps of green vegetables or grass put in the fields in the evening and collected in the morning gives a large number of caterpillars that hide under the green matter.

4. Dust the crop with three to five percent BHC.

5. Spray the crop with 0.2% or 0.3% DDT.

POTATO TUBER MOTH
Order: Lepidoptera

This is a serious pest where potatoes are grown and attack the stored tubers as well as the those in the fields. The adult is a small moth, brown in color with a fringe of hairs on the posterior margin of the hind wings.

Life History and Nature of Damage:- The adult moths are night fliers and they lay their eggs on the eyes of the tuber. The eggs are

pale and oval and hatch in five to six days. Immediately the young larva starts to bore into the tuber. Here the larva feeds and tunnels until it is ready to pupate. More than one larva is usually found in one tuber. When a badly infested tuber is cut, it will be found to be full of tunnels and frass. When mature the larva is about $\frac{1}{2}$ inch in length with a deep red anterior portion behind the head. Pupation occurs inside the tuber and last for about six days. Potatoes with sunken eyes are attacked more often that those with superficial eyes as the Simla Potato.

Control Practices:- In the fields the ridges should not be narrow as exposed tubers are infested daily. After harvest the tubers should not be left exposed in the field for a long time. In storing the tubers should be dusted with 5% DDT or BHC.

EPILACHNA BEETLES

A serious pest of Potato (Refer to under Brinjal)

VI- ONION AND GARLIC

Thrips

Order: Thysanoptera

The onion thrips are very small in size and are often called the onion louse. It causes an injury which is called the 'white blast' or the white blight or silver top. This species often ruins the entire fields of onion. The adults and the larvae feed on the leaves often hidden from the view and in flowers and the thrip infestation is bad on the late varieties. The thrips feed by gashing the outer walls of the opidermis and when the juice oozes out they apply their mouth and some juice is sucked. Sometimes they may cause sterlity. The leaves of the attacked plants show streaks and the tips dry up. The size and the quality of the bulb is lowered. Leaves are often curled and wrinkled. The females lay kidney shaped eggs in the slits made in the leaves of the food plants. The eggs hatch in 5 to 9 days or more. The nymphs feed on the leaves and are full fed in 8 days. They descend to the ground and pupate in the soil. The pupal stage lasts for about four days.

Control:-

1. Spray pyrocolloid 1-1000
2. Spray nicotina sulfate
3. Spray 0.1% DDT or BHC (1 lb. 50% DDT or BHC per 50 gallons of water). Do not spray within three weeks of laryesting if leaves are eaten.

VII-CHILIES

Thrips

Refer to Onion and Garlic

INSECTS PESTS OF FRUIT
I-CITRUS

Shoot and Bark Borer
Order: Lepidoptera

Status:- Occassionally serious.
Nature of damage:- The caterpillar borer into the stems and under the bark and make winding galleries of powdery matter webbed together. They attack the shoots also.

Life history and habits:- The parent moth lays eggs under the loose bark of the trees. The caterpillars on hatching bore into the stem and bark and moves about in the galleries. It may enter the side shoots also. Full fed caterpillar is about 1/1/2 inch in length has a dirty pale brown colour with the head region dark. The larva pupates in the gallery and is short and reddish brown. The life history occupies quite a long period. The moth is short stout built of a pale brown in colour with grey markings on the wings.

Control:-

1. When single branches are attacked these can be cut.
2. Injecting the borer solution containing 2 parts of carbon-bi-sulphide with one part of choloroform or creosote is found it kill the larvae of the borer quite effectively.
3. Sometimes the bark is sprayed with Paris green.

THE WHITE FLY

Order: Hemiptera

Identification:- The adult is a yellow minute insect measuring about ½" in length having white or greyish wings and red medially-constricted eyes. Nymphs and pupae are oval-shaped and yellow-bodies, with marginal bristles like fringes. The nymphs remain stationary once they have settled down.

Host plants:- There are several species of white flies infesting different varieties of citrus, cotton, coffee, banana, caster and some ornamental plants.

Nature of damage:- The damage caused is of two types. Firstly, the nymphs and adults suck the sap from leaves, as a result of which the leaves wither and later turn brownish, and fruit-setting is affected. Secondly the nymphs secrete a honey-dew which attracts fungus, whichir turn gives the tree a blackish appearance.

Life history:- The female white fly lays about 150 to 200 yellowish eggs on the underside of tender leaves. These hatch out in about 10 days. The freshly hatched nymphs crawl about on the leaves till they find a suitable place to settle in. In their early stages they are called crawlers and nymphs, they become full fed in about 3 to 10 weeks when they change to oval pale yellow (or sometimes dark) pupae whose bodies are margined with fringes or tooth-like division with the middle part coloured orange-yellow. The pupal period lasts about 16 to 22 weeks.

Control measures:-

1. The pest can be controlled reasonably well by two applications of a good spray of rosion compound at intervals of a week.

2. 2 lbs. 50% DDT (water dispersible) in 100 gallons of water.

3. Pyrocolloid 1 part in 400 parts water.

THE CITRUS APHIS
Order: Hemiptera

Identification:- The adult is a small minute, oval, dark-brown lice-like insect, measuring about 1/10" in length with or without wings and is found in clusters or colonies on tender shoots. It has two short or long tube-like structures called cornicles on the lateral side of the latter half of the abdomen on the dorsal side. These structures are the characteristics of aphides.

Host plant:- Mainly found on tender leaves and shoots of citrus.

Nature of damage:- Both adults and nymphs feed on the sap of growing shoots and leaves. As a result, the leaves become badly curled and at times etiolated. In severe cases of attack, the vigour of the tree declines and the ripening of the fruit is adversely affected.

Life history:- Like all other species of aphis this species reproduces without fertilization and lays young ones and not eggs. In the early part of the season, only those without wings are produced. As the season comes to an end, winged ones appear which migrate to other host plants.

Control:

1. Pyrocolloid 1 part in 800 or 1 lb. Nicotine sulfate and 4 lbs soap in 80 gallons water sprayed at weekly intervals untill pest is controlled.

THE LEAF MINER
Order: Lepidoptera

Indentification:- The adult is a tiny little silvery white moth with white hind wings measuring 1/4" when expanded and brown striped fore wings having a prominent black spot near the tip, both pairs fringed with hairs. The fullgrown caterpillar is slender and yellowish green in colour with brownish mandibles and is found inside the gallery formed in the leaf tissue.

Host plants:- Although the larvae prefer to feed on the leaves of varieties of citrus, they are also reported to mine the leaves of jasmine and cinnamon.

Nature of damage:- The larvae mine specially the tender leaves and feed on the inner tissue of leaves, leaving the outer skin intact and thus give rise to transparent, zigzag galleries characteristic of miner damage. As a result, the leaves turn pale, curl badly and eventually dry off. The mined leaves are also suspected of aiding infection by bacteria which cause citrus canker. Sometimes, the larvae mine the outer layer of skin of young green twigs also.

Life history:- The eggs are usually laid singly on the underside of leaves near the midrib. They hatch out in about 3 to 6 days. On hatching, the young larvae enter the leaf tissue at once and start mining. The larval period may range from 1 to 2 weeks, depending upon the season.

Control measures:-

1. The pest is extremely difficult to control particularly after infestation has taken place, since the larvae are internal feeders. However, some relief may be obtained by an application of a spray containing 1 lb. nicotine (40%), 4 lbs. soap, 4 lbs. of 50% wettable DDT in 80 gallons of water. This may kill the adults, moths and the newly hatched caterpillars before they penetrate the leaf tissues.

2. Clip and destroy all attacked leaves.

THE FRUIT-SUCKING MOTH

Order: Lepidoptera

Identification:- The adults are largesized moths having about a 3-inch wing expanse, and stout bodies measuring an inch in length. Their forewings are usually grey or reddish-brown with a greenish patch, the hind wings being orange or yellow with black spots or marginal dark bands and a strong elongated mouth for puncturing the rind of fruits. The larvae is a cylindrical stout bodied semilooper, having a dark-brown, velvety colour with cryptic markings. It is found usually on weeds belonging to the natural order of menispermaceae and not on citrus.

Host plants:- Moths generally puncture the rinds of all varieties of citrus. However, in Bombay State the damage is particularly serious on grape fruits and mosambi.

Nature of damage:- The moths not only cause direct damage to citrus fruit but through their feeding injury open the way for bacteria which make the fruit rot quickly.

Life history:- The female lays about 200 to 300 eggs on certain weeds. on hatching the larvae feed on their foliage and enter the soil for pupation after maturity. The eggs require 3 to 4 days for hatching, the larval stage may extend from 13 to 17 days and the pupal period may last 12 to 18 days.

Control measures:- This is a very difficult pest to control. Adults or moths have not been found to be controlled by insecticides; hence bagging of fruits is at present the only reliably method of control. Attracting the moths to fermented poison baits and to torches and then killing them are the other methods for detecting the moths and killing them. Removal of wild hosts at the caterpillar stage will also help to reduce damage.

THE RED ANT

Order: Hymenoptera

Identification:- The wingless ants or the workers, measuring about half an inch long resemble household ants, except that they are slightly longer. The workers are orange-red. The male and female ants are greenish in colour.

Host plants:- Although these ants do not feed on any plant they spread all over the trees and build nests of leaves, thereby causing great nuisance. They are commonly found on such fruit trees as mango, citrus, chikoo and guava.

Nature of damage:- They do not cause direct damage to plants but protect noxious insects like coccids, aphides, scales, etc. for getting honey-dew from these harmful insects. Frequently these harmful insects are found where red ants are present. Their enormous numbers and wandering on trees hinder harvesting of fruits and cause great nuisance.

Life history:- Eggs are laid by the female and tended by the workers in the nest. The larvae and pupae are found in galleries in the nest. The nests are composed of leaves spun together by silken threads excreted by the larvae.

Control measures:- 5% DDT sulphur dust (1:1) or 5% BHC-sulphur (2:1) or either of these insecticides alone as 5% dust has been found to be very effective in controlling this pest. While dusting, the tree trunks

and space around them upto a radius of about 5 feet should be first dusted. Then the whole tree should be dusted. The dust may be also pushed inside nests after piercing them by the fore end of the dust gun.

This treatment may be repeated after about 2 or 3 weeks.

THE SCALE INSECT AND THE MEALY BUG

Order: Hemiptera

Identification:- The scale insects are small 1/10" in diameter or smaller stationary, some of them are circular and other oblong and usually brownish in colour. When present in large numbers, the leaves and grass stems have a spotted appearance. The female of the adult mealy bug is usually wingless with a flattened soft body covered with a white mealy powder; the male is, however, winged and has two blackish wings.

Host plants:- Different species are found on a wide range of host plants.

Nature of damage:- They suck the sap from the tissues of leaves and shoots. As a result, the leaves and shoots get deformed and sometimes twisted into knots and loops in which the insects live.

Life history:- Detailed life history of many species is not yet known. In some cases reproduction takes place parthenogenitically (without sexual union). The young ones which are crawlers move about for some time and settle down to feed, grow and reproduce. Once having settled down the scale insects do not move, while the mealy bugs, though mobile, are sluggish.

Control measures:-

1. The pest can be controlled by two or three applications of heavy spraying of Rosin compound at weekly intervals.

2. Pyrocolloid 1 part in 400 parts water.

THE CITRUS MITE

Identification:- The adult is a small oval-bodied, red-coloured or pale yellow quick-moving creature and measures about 1/25" in length and has 8 legs. A greshly hatched larva has only three pairs of legs and, in the subsequent stage, the fourth pair of legs is seen.

Host plants:- Many species of mites attack cultivated crops such as mango, potato, betelvine and diffirent varieties of citrus, guava, etc.

Nature of damage:- The mites generally feed on the underside of leaves and also on tender fruits, As a result, a characteristic pale-yellow depression is seen on the attacked leaves and fruits. Due to infestation by some species, the surface of the fruit initially becomes silvery and later turns brownish. The fruits fail to develop properly and fetch lower prices due to their ungainly appearance.

Life history:- The details of their life history have not yet been investigated. The females of some of these may lay about 40 to 50 eggs which hatch out within a week or tow. The nymphal stage may range from 2 to 3 weeks or less in which period the nymph passes through 3 to 4 moults, before it becomes an adult which is wingless. The symptoms of damage like silvery and browinish patches are generally notified after the pest has disappeared. In the initial stage, the damage is seen in dots and later the whole surface becomes similarly affected. Timely observation is, therefore, essential to ensure protection.

Control measures:- Application sulphur dust or lime sulphur wash is one of the surest remedies to control this pest. For doing this, the damage must be detected as early as possible. At present this is the only satisfactory method of control. Though certain other insecticides have now been developed to control mites, they are not yet much in vogue in India.

II-BANANA

Banana Root Weevil
Order: Coleoptera

Status:- Sometimes serious.

Identification:- Weevils are small narrow, elongate and dark coloured. There is a white spot on the scutellum. Mouth parts formed into long curred shout.

Life history and habits:- The eggs of the weevil are laid either near the root stock or in the leaf sheaths. They are cylindrical. No wound is made but eggs are simply pushed under the sheath. The legless dirty white grub is 1/2 inch in length with a reddish brown head. Usually a number of grubs occur together in one root stock. The total duration of life history is two months. The pest is active all the year round.

Control:- The pest is distributed from one locality to another through infested root stock and so at the time of planting great care should be taken to see that no damaged sets are used. All the old stumps should be periodically taken and burnt.

Aphides
Order: Homoptera

Status:- It is present all over and attains big populations in the costal tracts and in Kanara.

Nature of damage:- The aphid is found in large numbers under the sheaths. They simply insert their mouth parts into the tissue and stay there bathed in water. In warm weather the aphid also is found in large colonies on the crown of the plants. Due to the heavy suction of the sap by the adults the vitality of the plants is very much lowered and the new leaves may be discoloured.

Life history and habits:- The life history of the aphid is typical of this insect group. There is no sexual stage and reproduction all the year goes on by the females through viviparity. Males are never seen and no eggs are laid. The distribution of the pest occurs through the winged females that are always being produced. During favourable conditions the multiplication of the aphides is most rapid.

Control:

1. Spray pyrocolloid 1: 800

2. Spray nicotine sulfate

In both cases spray fluid should run down freely from the crown into the sheaths.

Importance:- This aphid has been found to be the ve[illegible] of 'Katte' disease of cardamons and of 'Bunchy top of banana'. Wh[illegible]ver these two virus diseases are found steps should be taken to s[illegible]ay the plants regularly.

ILL-MANGO

Mango Hopper
Order: Hemiptera

Identification:- The adult is a wedge-shaped insect measuring 1/8 inch length, with a greyish body having three dark brown spots on the head. It has a band in the middle and two black sports on pronotum with a shield or plate having triangular black spots and a central longitudinal narrow dark streak dilated anteriorly and posteriorly. The nymph is, however, smaller than the adult.

Host plants:- The mango and chickoo.

Nature of damage: The nymphs and adults desap the collective flower of trees. As a result, the flower withers and drops without bearing fruit. They also secrete a sugary substance called honey-dew, which later permits development of sooty mould and thus imparts a black appearance to plants.

Life History:- With the onset of the cold season, the adult female starts laying eggs singly in the tissue of flowers, unopened flowers and young leaves from December to February. The eggs hatch into nymphs

within 8 to 10 days. The nymphs turn into adults within 15 to 20 days. The breeding of the pest also takes place during the monsoon when egg-laying takes place in the midrib of young leaves.

Control measures:- The pest can be effectively controlled by two applications of 5% DDT sulphur dust mixed in the proportion of 1:1 or 1:2. The initial dusting is to be given after the first flush of flowering is complete. The second dusting should follow about two weeks after the first application if the infestation continues. In some areas, only one dusting may check the pest for the rest of the season, while in other a second treatment may be found necessary.

THE STEM-BORER

Identification:- The adult is wellbuilt, conspicuously long, and has brownish yellow colour, and measures about 2 inches long. It has orange yellow spots on the back and has hard upper wings. The larva is also conspicuous. When full grown, the grub is yellowish white, fleshy, and measures about 4" x 3/4" with a dark brown head having strong jaws.

Host plants:- The mango, fig, rubber and jack.

Nature of damage:- The grubs bore and tunnel through the stem. As a result, the affected branches start drying up and masses of refuse exude from the bored hole. In severe cases of attack, the branches may collapse and the tree may die.

Life history:- The female beetle deposits eggs singly under the loose bark, or in the crevices of stems. The eggs hatch out in about 7 to 14 days. The grubs tunnel directly into the bark and take about 3 to 6 months to mature into full-grown larvae. Later, they pupate in the stem and remain in the pupal stage for 4 to 6 months, after which they emerge as adult beetles.

Control:-

1. The infested branches should be cut and the grubs inside killed

2. Beetles found in the garden should be killed.

3. When external symptoms of attack are visible, the grubs should be taken out with a bent wire and killed by injecting in the holes borer solution consisting of one part of Carbon bisulphic, and one part chloroform. If it is not at hand then dilute kerosine oil may be put in.

4. The dead trees in the garden should be immediately cut and used for fuel.

RED ANTS

Order: Hymenoptera

Status:- Indirectly a serious pest as they attack the workers in the mango orchards and cause great annoyance.

Nature of damage:- They do not cause direct damage to the plants but indirectly trouble the fruit three workers and also harbour noxious insects in their nests like coccids etc.

Food:- Caterpillars, beetles, flies and ants.

Life history:- Typical ants, only they live in colonies that are not so elaborate as of other ants.

Control:-

1. Nests can be burnt at night.
2. Dust a mixture of 5% BHC in combination with Sulphur in the proportion of 2:1 or Pyrodust 1500 or 5% DDT-sulphur (2:1) will be good.
3. While dusting pierce open the nests.
4. After dusting and removing all nests, paint the tree trunks with some sticky substance.

Mango Weevil
Order: Coleoptera

Status:- Not a serious pest as a rule. A small proportion of fruit is spoiled by the weevils boring out of the fruit on exit from pupa.

Identification:- The adult is 1/3rd inch long dark grey in colour with a series of spots on the elytra. The snout is curved under the body.

Nature of damage:- The grubs of the weevil feed inside the mango stone and also pupate inside. The weevil on emergence has to bore its way out and the entire fruit is spoiled. Sometimes the fruits fall down and are a total loss. People do not eat the fruits with weevil.

Life History:- There is only one brood in the year and the period of activity is May to June. Life history has not been fully worked out. Eggs are laid in the young fruit into which the newly hatched grub bores, taking up its position inside the embryo mango stone whose interior it devours. When full fed the grub pupates inside the stone and the weevil bores its way out. The beetles survive as adults till the next mango season.

Chiefly sweet varieties of mango are attacked. Though the insect develops inside the fruit, the injury to the pulp is not so marked since the incision made for egg laying becomes closed up as the fruit develops. It has not been found to attack any other fruit.

Control:- The proper disposal of all refuse seed and fallen mangoes, destruction of weevils when seen in the garden and general clean conditions in the garden will go long way to check the pest.

Mango Fruit Fly
Order: Diptera
Refer to Fruit Fly discussion under Guava.

GUAVA

Amongst the many pests of guava, there are a few which are very important. These are in the fruit fly, the shoot borer and the scale insects. Information on scale insects has already been given under pests of citrus.

The Fruit Fly
Order: Diptera

Identification:- The adult is a small insect measuring 1/5" in length as in the case of the housefly but characterised by traingular yellowish brown abdomen and transparent, out-stretched wings with a brown spot on the tip. Brown patches on wings distinguish these flies from others. The maggot which is found in fruits is a small yellowish white-bodied legless larva measuring about ½" in length and tapering at one end.

Host plants:- Besides guava, the fruit fly is reported to infest fruits of citrus, gourds, mango, melon, tendli, etc. A species also affects her fruits severely.

Nature of damage:- The flies lay eggs just under the rind of the developing fruit. The maggots, on hatching, bore into the fruit and feed on its pulp. The infested fruits can be recognized by the presence of a rotten patch round the place of oviposition. As the maggots grow, this patch extends and ultimately the fruit falls down. The incidence of this pest is more in late-maturing varieties of the guava.

Life history:- The female fruit fly deposits eggs singly or in batches on the developing fruits by first making a little depression by its ovipositor. Eggs hatch in about 3 to 5 days and the maggots are full-grown in about one or two weeks, by which time the fruit drops and the larvae leave the fruit and pupate in soil but sometimes in the fruit also. The adult fly emerges within 8 or 10 days. There are a number of generations in a year.

Control measures:- Sanitation in the orchards is the most important measure against fruit flies. Daily removal and complete destruction of fallen and badly infested fruits should be done by burning them in small deep pits. Spot spraying with a spray bait containing 1 oz. tartar emetic, 24 ozs. jaggery and 20 lbs. of water may help to check the pest. The efficacy of organic insecticides has not yet been throughly investigated, but frequent spraying by 0.1% DDT water dispersible (1 lb. of 50% water dispersible DDT in 50 gallons of water) helps to check the pest by killing the adult flies. The adjoining hedges may be sprayed where the adult fly often takes shelter. However, these chemical measures are not fully and finally established for controlling fruit flies and hence the emphasis on sanitary measures.

The Shoot-and-Bark Borer
Order: Lepidoptera

Identification:- The adult is a short, stoutly built moth, with a wing expanse of about one inch, having grey marks on wings. The larva is a caterpillar measuring about 1½" in length and dirty brown in colour withdarkish head region.

Host plants:- Guava, citrus, pomegranate, mango and casuarina.

Nature of damage:- The freshly hatched larva bores into the stems and bark. It moves in a gallery of powdered bark and silk, feeds on the bark and also enters the stem. As a result, the tree puts on a sickly appearance and ultimately it may die. Its presence can be readily detected by the appearance of frass-covered areas on the bark.

Life history:- The female moth lays eggs on the bark. The larvae on hatching feed on the bark and enter the stem where they pass their larval and pupal stages.

Control measures:- Injecting the borer solution containing 2 parts carbon disulphide with one part each of chloroform and creosote is found to control the larvae of the borer effectively. Before injecting the solution, the galleries and webbings are to be scraped off and the live burrows ascertained.

PESTS OF POMEGRANATE

The Fruit-Borer or Anar Caterpillar
Order: Lepidoptera

Identification:- The adult is a mediumsized, greyish-violet-coloured butterfly with a wing expanse of about 2 inches. The female butterfly has a conspicuous orange-coloured patch on the forewing. The full-grown larva is a short, stout, darkish brown caterpillar with hairs and whitish patches on the body.

Host plants:- Besides the pomegranate, it is known to attack fruits of the wood apple, guava, palm and tamarind.

Nature of damage:- The larvae usually enter when the fruits are small and tunnel into the developing fruits and then cause rotting and bring about their premature fall.

Life history:- The female butterfly lays shining white eggs singly on flowers or tender fruits. The larvae hatch out within a week and enter the fruit by boring a hole and burrow into the fruit till about 4 weeks when they pupate. Pupation mostly takes place inside the fruit and lasts for about 3 weeks.

Control measures:- Two to three applications of a spray containing 1 lb. of 50% water dispersible DDT powder in 25 gallons of water, given at three weekly intervals during the flowering season has been found to control the pest to some extent. The treatment should start when the fruits are just beginning to form. As use of spraying with insecticide is not yet finally established, bagging of fruits with cloth or paper bags is also being practised with cloth or paper bags is also being practised with considerable success, though it is a rather laborious method.

INSECT PESTS OF STORED GRAINS AND THEIR CONTROL

One of the serious problems that we have to face in storing grains in large quantities is the danger of attack by insect pests. It is now fully recognised that the preservation of foodgrains from all avoidable waste and deterioration especially by insect pests is the paramount need of the hour.

Although more than a dozen insect pests have been recorded and are known to infest stored grains, only seven may be classed as major pests. These are the pests that we come across in the farmers' granaries in the villages and in the warehouses and godowns in urban areas. Most of these have gained entry in almost every country in the world on account of their minute sizes that enable them to conceal themselves in a crevice or a crack in the grain.

The following are the pests more commonly met with in the granaries and godowns where grains are stored for varying periods:

1. Rice or black weevil
2. Lesser grain borer.
3. Khapra beetle.
4. Rust-red flour beetle.
5. Pulse weevil
6. Angoumois grain moth
7. Rice moth.

Rice or Black Weevil
Order: Coleoptera

This pest, popularly known as the rice weevil, is undoubtedly the most destructive of the stored grain pests in the world. Indeed this weevil and its friend and ally Sitophilus granarius Linn. are classed among true weevils, as the mouth parts of these pests are prolonged into an elongate beak or snout crowned by a pair of stout mandibles, their chi f weapon to cause destruction. Some entomologists believe India to be the original native home of this weevil. Be that as it may, the pest is now found all over the world and in countries blessed with a temperate or sub-tropical climate it is the predominant insect pest of stored grains. It is a small beetle, reddish brown in colour, and is about one-eighth of an inch long. It is capable of short flights. It has sometimes been observed to fly from the granaries to the field where the grains lie harvested. So in such cases the infestation starts from the field itself.

In India it has been observed only as a primary pest in the granaries and godowns. Both the adults and larvae are voracious feeders and although it is known as the rice weevil it feeds on all kinds of cereals and their products in India. The female weevil bores a small hole in the grain with her powerful sharp mandibles and lays in the cavity thus made an egg and bestows a measure of motherly protection on the future progeny by covering the egg by means of a gelatinous fluid. The egg is oval in shape, transluscent and white in colour and measures 0.7 mm. long and 0.3 mm. broad. One female is capable of laying as many as 250 eggs. The eggs usually hatch in about three days during the monsoon months beginning from July to September. The tiny grub after hatching bores its way into the kernel of the grain and makes a meal of it for its growth and development. The grub is white in colour with a small yellowish brown head and biting jaws. The grub stage lasts for about three weeks to a month. The full-grown grub pupates inside the hollow grain. The pupal period lasts from three to six days. The adults that emerge, mate almost immediately and new generation starts. The adults that emerge in spring and summer are short-lived. Their longevity does not extend to more than a month or a month and a half. Those that emerge in winter live long sometimes to several months. The duration of the lifecycle and the number of generations in a year depend to a considerable extent on the prevailing temperature and humidity conditions. In India four to five generations occur in one year especially in the North. The number of generations is probably more in the South where there is no clear cut winter.

Lesser Grain Borer
Order: Coleoptera

This pest commonly known as the lesser grain borer is only second in importance to S.oryza in the extent of damage and destruction caused to stored grains. It is a major pest of nearly all cereals and has been recorded and reported from the U.S.A., Argentina, New South Wales and

many other countries outside India. In addition to its destructiveness to stored grains, it feels at home in flour also and breeds readily in it. A dark brownish black beetle of about one-eight of an inch in length, this pest is readily distinguished from the other grain pests by its slender form and comparatively smaller size. The beetle is capable of flying longer distances than S.oryza.

Although both the adults and the larvae cause colossal destruction to a variety of grains reducing them to mere papery shells or converting the flour into a tangled mass of web and excreta, it is only the adults than can directly bore into the healthy grain. The larvae are weak and are unable to accomplish this feat of their parent and so they go in search of soft corners or minute holes made for them either by their own parents or by the stronger counsins of their own age. The female lays eggs on the grain singly or in clusters near the embryo. Sometims eggs are laid on bags, walls and among other foodgrains lying in the store. A single female is capable of laying as many as 500 eggs. The eggs are pear-shaped and white in colour. The incubation period is four to six days in summer and a little longer during the winter months. The newly hatched grub is whitish in colour and is very active. They complete their growth either within the grain or in the grain dust that that lies about and transform themselves into white pupae. The larval stage lasts from four to six weeks. Adults emerge from these pupae in about a week or so. The whole life-cycle occupies about two months. Five generations have been observed in a year in the North and the number is probably more in the South.

Khapra Beetle
Order: Coleoptera

This pest is known as khapra in the towns and villages of India and has been observed to feed on a variety of grains like wheat, rice, oats, jowar, maize, and sometimes even pulses. Wheat, however, is its principal food. This pest is probably the hardiest amongst the little monsters that infest stored grains in the Indian Union. Outside India it has been reported from the European countries. In the U.S.A. it has not established itself so far. Unlike the other two pests that have been described above, only the grub stages are destructive in the case of khapra. The adults are completely harmless. Even the adults cannot bore into the grains so well as the preceding two pests and it is only the upper surfaces of grains that are nibbled at the damaged as a result of the attack.

The adult is about one-tenth of an inch long and has a characteristic oval shape. They mate soon after emergence and the preoviposition period is from five to six days. Eggs are usually laid among the grains. One female is capable of laying as many as 125 eggs. They hatch in about a week under humid conditions and the period is longer under dry conditions. The freshly-hatched grubs are brownish white in colour with the body covered with reddish brown hairs that form a broom like tail at the posterior end. These grubs generally feed on the floury debris in food grains but sometimes attack the embryo point of sound grain also. If the infestation is heavy the grubs enter the grains and feed inside and are seen in a

crescent shape form under the epidermis. If there are crevices or holes present in the grains, these grubs take advantage of these weak points and gain easy access to the kernel and consume it entirely. The larval period lasts for about 50 days under optimum conditions. When conditions are unfavourable this period is oftentimes very very long and in rare cases may even last upto one, two or even three years. Thepupal stage lasts from 6 to 17 days during the humid months. The longevity of the adults is about a month under favourable conditions.

Rust Red Flour Beetle
Order: Coleoptera

This insect belongs to the category of such beetle pests of stored grains that are not primary pests but feed on broken grains, grain dust or grains damaged by other pests. So the appearance of this pest in the granaries and godowns may be considered as secondary following closely the footsteps of its other comrades. Indeed the grains that are partially damaged by the true grain beetles afford a welcome opportunity for this pest to complete the work of destruction begun by them. It is a small reddish brown beetle about one-eight of an inch long and is commonly known as the rust-red flour beetle. The pest is distributed all over the world. Unlike S.oryza and R.dominica in whose evil company it is oftentimes found associated, this beetle cannot damage sound grains either in the adult or larval stages. It is primarily a pest of prepared cereal products like atta, maida, suji, etc. When there is heavy infestation, the products turn yellow and become mouldy with frass and excreta of the grubs and the adults rendering the foodstuff totally unfit for human consumption. The female lays on an average 400 to 500 eggs, dropping them at random in the flour or other foodstuffs. The egg is tiny, slender and cylindrical in shape and white in colour. It hatches in about 5 to 12 days depending on the temperature and humidity conditions. The newly hatched grub is worm-like in appearance, slender, cylindrical and wiry. The fullgrown grub is about quarter of an inch in length and pale yellowish in colour. The larval period lasts from 27 to 90 days depending on the availability of food and the prevailing ecological conditions. The larvae generally pupate on the surface of the food. The pupal period lasts from six to nine days. The life-cycle from egg to adult may be as short as six weeks but oftentimes it is longer.

Pulse Weevil
Order: Coleoptera

This is a very serious pest of stored pulses in the Indian Union. There is another closely allied species, Bruchus analis F. that is found in association with this pest. As C. chinensis is more common of the two, the life-history of this pest is described here. In America, the pest is popularly known as the cowpea weevil. The adult is a small roundish beetle about one-eight of an inch in length, generally brownish in colour and flecked with white, black and greyish

patches. All kinds of pulses are attacked by this pest and bags of pulses stored in a godown may be completely destroyed by these hungry weevils whose voracious appetite is almost insatiable. Neat circular holes cut on the body of the grains are very characteristic of the damage caused by this beetle pest. The females lay eggs singly but usually many eggs are laid on one grain. These eggs look like white dots on the surface of the grains and areusually glued on to the epidermis. The eggs hatch out in four to five days and the tiny yellowish grub that hatches out of the egg burrows into the grain. The entrance hole is so minute that it escapes the notice unless one's eyes are trained to spot damages of this kind. The larvae go on feeding inside the grain without any outside indication and the grain apparently looks healthy. The larvae are full-grown in about three weeks in summer. During this period the larva has consumed a fairly good proportion of the grain from inside and then forms already a tunel in a carved state. The pupal period usually lasts from three to four days during summer. This period is considerably longer during winter. The adults when they emerge push through the exit holes thoughtfully formed in the larval stage. If undisturbed the adults remain on the top of the grains. Mating then follows and yet another cycle is started afresh. This pest has a number of generations in a year governed by the twin ecological factors of temperature and humidity.

Angoumois Grain Moth
Order: Lepidoptera

This species is commonly known as the Angoumois grain moth and is one of the most destructive pests of unmilled grain. It is cosmopolitan in distribution and is found all over the world. It is not uncommon to see small buff coloured moths flying or crawling on the surface of bags or bins filled with grains in granaries and godowns. One or two minute holes are present in the samples of grains infested by this pest. As a rule greater damage occurs on the upper surface of grains in bags or bins. It is oftentimes difficult to detect this pest in early stages of its infestation as the damage occurs inside the grains. When only the moths emerge in large numbers from the pupae that are formed inside the grains, we realise that the grain has been infested by this pest. The adult moth is very delicate and measures about half inch with the wings expanded. They mate soon after emergence and the female moth lays several hundred minute white eggs. A maximum of 400 eggs has been observed to have been laid by a single female. Eggs are laid singly or in clusters and are usually deposited in depressions, cracks or holes in the grain or sometimes midst the grain. Each egg measures about 0.5 mm. long with both ends rounded. The egg hatches in about one week and the tiny wormlike larva at once burrows into the kernel of the grain and feeds on the kernel. The larva feeds thus for about two to three weeks until it pupates inside the grain under a silken cocoon. The pupa is brown in colour. Moths emerge from these pupae in about a week. The pest is very susceptible to cold weather conditions and die in large numbers or become benumbed during the winter months. Breeding is continuous throughout the year when warmth and other favourable conditions prevail. At least four broods have been observed in our country.

Rice moth
Order: Lepidoptera

This pest is commonly known as the rice moth and is a serious pest of stored paddy, rice and other cereals. It has been reported from almost all parts of the world. This moth is comparatively bigger in size as compared to S. cerealella. This pest thrives well only on broken foodgrains and this applies more in the case of the tiny larvae that hatch from the eggs. The full fed larvae can to a certain extent bore their way into the whole grain. The female moth within a couple of days of its mating lays eggs amidst the grains. A single female has been observed to lay a maximum of 200 eggs. As in the case of the grain moth, eggs are laid on bags, walls or among grains, either singly or in small clusters. The egg is white in color and oval-shaped and each measures 0.5 mm.long and 0.3 mm. broad. The egg hatches in four to five days. The tiny larva is creamy white in colour and moves about actively and feeds on the broken grains. When full-fed the larva spins a tough silken cocoon insile which it pupates. The pupa is of light brown colour. The larval period lasts about a month. Moths begin to emerge from the pupae after about ten days and the cycle is repeated.

CONTROL MEASURES

There is a popular myth that the infestation of stored grains by insect pests cannot be avoided. This is a fallacy which cannot stand a moment's scrutiny.

Insects multiply in the artificial conditions that we ourselves create for them. In the case of insect pests of storage early neglect is fatal, for neglect makes multiplication easy. It is a well known scientific fact that the development of the insect pests of stored grains depends on the water content of the foodgrains. Dryness which is an essential factor for preserving the quality of foodgrains is unfavourable for the growth and multiplication of insect pests of stored grains. So it is extremely necessary that we should see that the grains are well-dried before they are stored in bins. It is also essential that there should be no initial infestation. In a country like India where solar energy is both bounteous and plentiful at all times it can be utilised for drying grains soon after harvest and before their storage. If to this we can give a light fumigation by any of the fumigants like carbon disulphide or Killoptera, infestation can be completely avoided.

There is danger of infestation from July to October and it is during this period that we have to be very careful. A number of fumigants are available in the market but the most effective and harmless from the point of view of the viability of the grains intended for seed purposes is the fumigant sold under the name of Killoptera which is mixture of three parts of ethylene dichloride and one part of carbon tetrachloride.

The mixture is obtained in a liquid form but vaporises on exposure to air. All that is to be done is to cover up the infested grains under an air-proof cloth and pour this compound on a shallow dish on the top of the grain at the rate of about 4 lb. per 100 maunds of the grain. The exposure period is 24 hours. Fumigation of grains intended for food can be carried out with carbon disuphide, methyl bromide, hydrocyanic acid gas, etc. But these fumigants can only be handled by the dexterous hands of a well-trained entomologist. So it is recommended that Killoptera is the safest fumigant to use.

For storage of grains meant for seed purposes, dressing of the seed grains by 10 per cent DDT dust at the rate of 2 oz. per 135 lb. of grain will give very satisfactory results. Researches carried out in the Division of Entomology at the Indian Agricultural Research Institute have shown that treatment of the seed grains by 10 per cent DDT dust does not affect the viability of seeds at all. Moreover, it keeps the seed grains free from the attack of insect pests. Pyrethrum is a harmless insecticide and its use to prevent infestation of both food and seed grains can be safely recommended. But unfortunately, the insecticide is expensive today. When Pyrethrum flowers are grown in larger quantities and the extraction of the insecticide standardized, this insecticide will be a boon not only for the control of insect pests of storage but pests of agricultural crops in general. For we shall then be handling an insecticide non-toxic to warm-blooded animals and human beings but highly lethal to insect pest.