Insect Pests of Maize

A guide for field identification

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Preface

Maize is among the world's three most important cereal crops, the other two being wheat and rice. It possesses great genetic diversity and is grown in a wide range of environments, from the equator to about 50° north latitude and 42° south latitude and as high as 3800 meters above sea level. The factors that limit maize production are also diverse, some of the most important being insects and closely related organisms such as mites. From the high valleys of the tropics and subtropics to the tropical lowlands and temperate regions, these pests can infest maize at any stage of crop development and in storage and attack any part of the plant, often causing severe damage.

The moth group (which includes cutworms, armyworms, earworms, borers, and grain moths) is the most damaging to maize worldwide, followed by the beetles (rootworms, wireworms, grubs, grain borers, and weevils). Next in importance is the group of insects that serve as carriers (vectors) for disease agents (viruses, micoplasms, bacteria, and fungi), among which the sap-sucking bugs (leafhoppers and aphids) are the greatest problem.

Field guides like this one generally offer little in the way of specific recommendations for control of such pests. The aim of these tools, rather, is to help readers recognize pests, an important first

step toward effective protection of the crop against them. Focusing mainly on the tropics and subtropics, this guide attempts to provide that knowledge by several means, chiefly through color photographs with descriptions of the damage, appearance, life cycle, and geographical distribution of selected major insect pests. In the middle of this guide, the reader will find a table that groups the major insect pests according to the plant parts they attack and the stage in plant development at which attack occurs. With each insect name is given the page number on which the description of that insect appears. The list of insects in the table of contents is also ordered according to the plant parts attacked and the stages in crop development at which pest damage is most important.

The principle of knowing insect pests has an important corollary: being able to recognize the beneficial insects that prey on or parasitize them. The ability to identify beneficial insects correctly can be just as important as recognition of damaging ones, since this ability can be used to enhance the effectiveness of pest control. For that reason, a separate field guide to the beneficial insects would be extremely useful. Until one can be prepared, though, a brief and selective list of those insects is included here, accompanied by color photographs.

Though it is beyond the scope of this publication to provide recommendations for control of particular insect pests, a section has been included that describes some general principles and outlines various approaches to pest control. Also, in the reference section at the back of this guide, the reader will find listed a number of publications that cover control methods, among other relevant topics, in greater detail.

The author and other CIMMYT staff hope that this guide will prove useful to researchers, technicians, and farmers in developing countries, as well as to others who are concerned with maize production in the Third World, and welcome any suggestions, information, or color transparencies that might be useful in the preparation of future editions of this publication.

Acknowledgments

I wish to extend my gratitude and recognition to the staff of CIMMYT's Information Services program. Special thanks are due to Nathan Russell, science writer/editor; Miguel Mellado, graphic artist and production manager; Rafael de la Colina F., José Manuel Fouilloux B., and Bertha Regalado M., graphic artists; and Silvia Bistrain R. and Maricela A. de Ramos, typesetters.

Alejandro Ortega C.

Introduction to Insect Pests

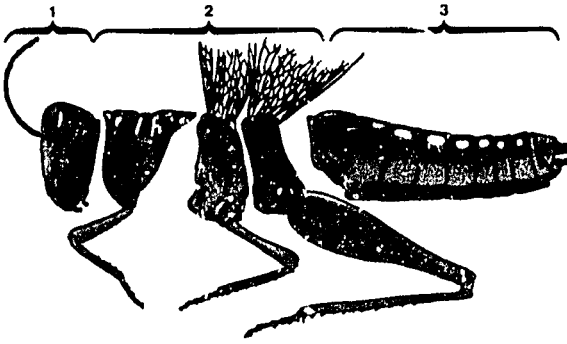
Arthropods, the group of joint-limbed animals to which insects belong, have been evolving for about 350 million years, compared to less than two million for human beings. Insects have been such successful inhabitants of the earth because of their tremendous reproductive potential, survival capacity, small size, and diversity. They have come to occupy almost every imaginable ecological niche and in many instances are beneficial to human activity. Relatively few species are harmful to people and their animals, crops, and stored products.

Adult insects are characterized by an external skeleton, and their bodies are divided into three parts: head (1), thorax (2), and abdomen (3) (see drawing on page 3). The head bears antennae, eyes, and mouth parts, which may be adapted for chewing, piercing-sucking, chewing-lapping, or other functions. The thorax is divided into three segments, each of which usually possesses a pair of jointed legs; winged forms have pairs of wings on the second and third segments. Among some flying insects the pair of wings on the third segment of the thorax is modified to serve as a balancing organ. The external reproductive organs are carried on the abdomen.

Insects usually pass through four developmental stages: egg, larva or nymph, pupa, and adult (shown in that order clockwise from the right, with egg mass greatly enlarged, in drawing on page 3). In the immature stages (larva or nymph),

insects do not have wings, and some may lack legs and other typical structures, giving them an appearance totally different from that of the pupa and adult forms. The primitive, wingless insects are an exception: the young appear very similar to the adults, and instead of passing through distinct stages of development before reaching adulthood, they simply molt and increase in size until they attain sexual maturity. This guide, however, is concerned mostly with the insects that undergo metamorphosis. That process of change is sometimes gradual (as in the development of nymphs into adult grasshoppers, leafhoppers, and bugs), and only in some groups is it complete (as with the moths, beetles, and flies, which pass through all stages from larva to adult). In a few cases (aphids, for example), the mature parthenogenetic female—one that reproduces without fertilization—gives birth to living nymphs, though it may also eventually produce eggs.

The larvae have different names, depending on the insect group they belong to: in the moth group they are referred to as worms, the larvae of flies are maggots, and grubs are the larval stage of beetles. The larval or nymphal form, which undergoes several changes (instars), is the feeding stage, the pupa is the resting and transformation stage, and the adult the reproductive stage.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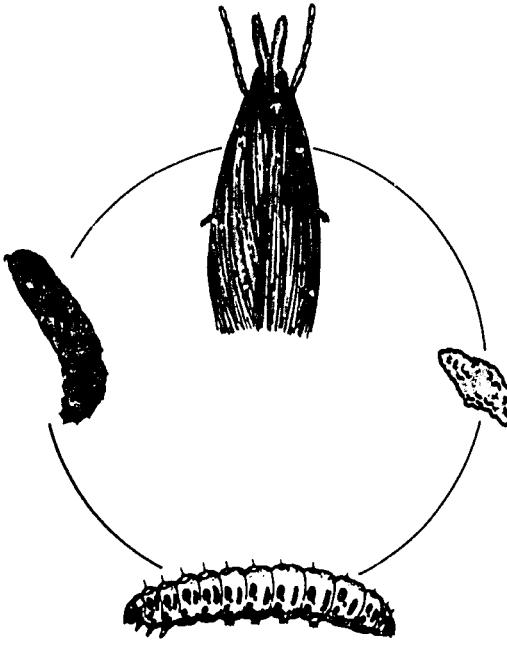

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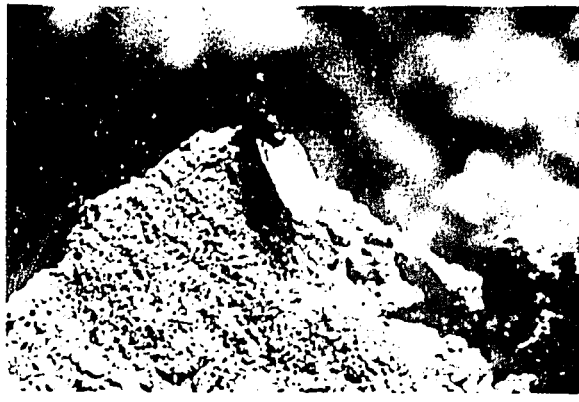

Seedcorn Maggots

Hylemya (=*Cilicrura*) *platura* and *Hylemya* spp.

Nature of damage: The principal indications that maize seed has been damaged by maggots are gaps in the plant stand throughout the field and weak, wilting plants. Similar symptoms are caused by other insects inhabiting the soil. Outbreaks of this insect are favored by wet, cool weather in spring, which slows germination, leaving seeds vulnerable to attack for a longer time.

Description and life cycle: Maize seeds into which *Hylemya* spp. have burrowed will contain legless, whitish or yellowish, slender, conical maggots. When fully grown these may range in length from 2 or 3 mm to over 0.5 cm. After hatching, the larva feeds for about three weeks and then develops into a white, soft pupa inside a brown shell in the soil. The adult, a grayish fly about 0.5 cm long, lays its eggs in moist soil near germinating maize seeds (1). Flies are particularly attracted to seeds in fields that have been heavily manured or for other reasons are high in organic matter.

Geographical distribution: Seed corn maggots occur in the temperate regions and tropical highlands of North America.

Wireworms

Many species of the families Elateridae (*Melanotus, Agriotes*, and *Dalopius* are among the important genera) and Tenebrionidae (*Eleodes* spp.)

Nature of damage: Patchy seedling emergence, wilting and tillering of seedlings, and lodging of older plants are signs of wireworm injury, although these symptoms may also be associated with other soil insects. In pastures, hay crops, and cereal crops, large wireworm populations may develop, injuring the base of the stem, cutting the roots, and boring into the larger roots of older plants (2). Heavy infestations will reduce the root system and cause plants to lodge.

Description and life cycle: A careful search of the soil surrounding wireworm-damaged seed or seedlings will expose segmented, thin, cylindrical worms, which when recently hatched are small (10 mm long), soft, and white and when mature are 40 mm long, shiny, smooth, sluggish, deep yellow or brownish, and hard but flexible (3). After hatching, the larvae begin searching for and feeding upon seeds and roots. Within several months to several years, the larvae develop into white, soft pupae inside cells in the soil, from which they eventually emerge as adults. These are sometimes referred to as "click beetles" because, when turned upside down, they make an audible clicking sound in flipping themselves back over. The beetles are active fliers, have a hard, elongated, somewhat flat shell, and are brownish to almost black and from 0.5 to 2 cm in length. Female beetles burrow into the soil to lay eggs.

Geographical distribution: Wireworms are found in virtually all maize-growing areas of the world.

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Fernando Rios Rosillo, Bayer, Mexico

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Flea Beetles and Flea Beetle Rootworms

Chaetocnema pulicaria and *Chaetocnema* spp.

Nature of damage: On recently emerged seedlings, the main symptom of attack is white, thin, elongated lesions (injured areas) along the upper leaf surface, which are the result of scratching between the leaf veins by the beetles (5). They may continue to cause this type of damage as long as there is green tissue in maturing plants and will occasionally perforate the leaf as well. The worms feed on the roots, sometimes causing maize plants to lodge.

In temperate climates the beetles are important vectors of Stewart's wilt bacteria. This disease is of no economic importance in the tropics, however. Recently, these insects have also been reported to be vectors of maize chlorotic mottle virus (MCMV).

Description and life cycle: The small (1- to 2-mm), shiny, black beetles (5) deposit their eggs in the soil, where the tiny rootworms develop into white, delicate pupae. The adults can fly and typically have swollen hind legs that are well adapted for jumping.

Geographical distribution: These insects occur all over the world.

Diabrotica Beetles and Diabrotica Rootworms

Diabrotica balteata, D. virgifera, D. longicornis, D. speciosa, and *Diabrotica* spp.

Nature of damage: Root clipping and tunneling by the worms may result in tilted, curved stems or lodged plants. Lodging may begin around the midwhorl stage and continue to maturity. In seedlings the beetles eat portions of the leaf margins (6, shows *D. balteata*), leave irregular holes in the tender leaves, and occasionally cut the plant at the base. Leaf feeding on older plants seldom has economic significance. At flowering, however, the beetles (which are active fliers) feed on green silks (7, shows *D. balteata*) and pollen, leading at times to poor seed set. *D. virgifera* and *D. longicornis* were recently reported to be vectors of maize chlorotic mottle virus (MCMV) and Stewart's wilt bacteria.

Description and life cycle: In the soil around infested plants and in their root systems, one can find the white or creamish colored, thin, soft, small worms (8). These have three pairs of legs, brown heads, and a dark brown plate at the end opposite the head and vary in length at maturity from 2 or 3 mm to about 1 cm. After three molts the larvae develop into soft, white pupae inside cells in the soil, from which the beetles emerge. These vary in size (6 to 9 mm) and color pattern according to species. They lay most of their eggs at soil depths of up to 10 cm. The number of generations in a year (ranging from one to three or four) varies with the species and latitude.

Geographical distribution: These insects are restricted to the Americas, *D. balteata* being found in the tropics and subtropics and *D. virgifera, D. longicornis,* and *D. speciosa* in temperate areas.

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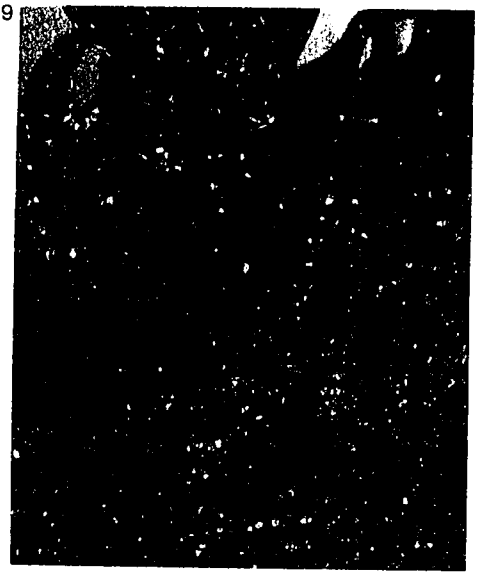

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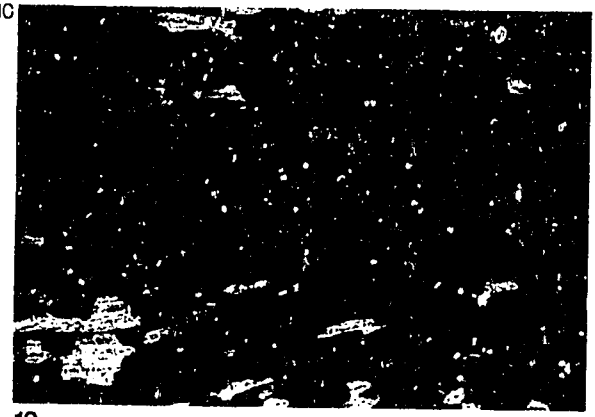

Maize Billbugs and Maize Billbug Grubs

Nicentrites testaceipes, lesser maize billbug; *Geraeus senilis*, large maize billbug

Nature of damage: Leaves show white specks, which grow together under severe infestation. The specks are an indication of feeding by billbugs in the whorl, where they scratch small, irregular sections of the epidermis without puncturing it (9). As the leaves unfold, the specks become visible. The grubs feed on the roots of maize plants, which, as a result, become prone to lodging. Damage in fields where maize is preceded by forage or cover crops may be particularly severe.

Description and life cycle: From the early or midwhorl stage to near tasseling, one can observe in the whorl abundant, grayish, lesser billbugs 3 to 4 mm long and large billbugs 5 to 7 mm long (10). When disturbed these drop into the whorl or onto the ground and remain motionless for some time. These insects pass through four stages: egg (white and bean-shaped), larva (white, legless, humpbacked grubs with brown heads), pupa (white and soft), and adult (referred to as weevil, snout beetle, or billbug).

Geographical distribution: Damage by these insects can have economic significance mainly in the highlands of the Neotropics (which include northern South America, the West Indies, and tropical North America).

White Grubs

Phyllophaga spp. and *Cyclocephala* spp. (annual white grubs)

Nature of damage: Root damage by white grubs is evidenced first by wilting seedlings and later by poor stands and patches of tilted, curved, or lodged plants that show uneven growth. Injured plants can easily be pulled out of the ground. Feeding of adults on leaves of maize or other plants is of no economic significance.

Description and life cycle: Inspecting the soil surrounding the damaged root system will expose the white C-shaped grubs 2 or 3 mm to nearly 3 cm in length (11). When mature these are somewhat swollen and semitransparent. They have brown heads, three pairs of legs, and abdomens with a shiny tip (12). After molting several times, the larvae develop into soft, white pupae inside cells in the soil, from which beetles emerge. These are pale yellow to dark brown, range from 1.5 to 2 cm in length, and are active night fliers. The females (often referred to as June beetles or chafers) deposit their spherical, white eggs in weedy fields or grasslands several centimeters below the soil surface.

Geographical distribution: These insects are distributed worldwide.

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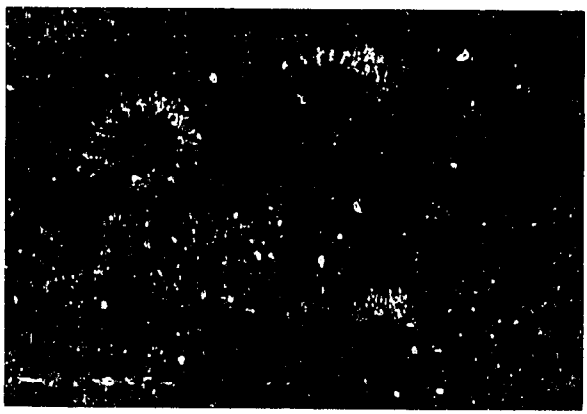

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Cutworms

Agrotis ipsilon, Agrotis spp., *Peridroma saucia, Chorizagrotis auxiliaris*, and many other species

Nature of damage: Young cutworms (and some other species) cut maize seedlings at or a little below ground level, make small holes along the initial leaves, or remove sections from the leaf margins (13). The so-called army cutworms also feed on the foliage and at the base of young plants. On older plants large cutworms feed on the stems just below the surface, leaving cavities that cause the plants to wilt and eventually die. Most cutworm feeding takes place at night. Some may occur during the day, but cutworms generally remain sheltered below the ground at that time.

Description and life cycle: Removal of the soil around the cut or injured seedlings or older plants will expose two or three young, small cutworms 0.5 to 1.0 cm in length or a single, oily or greasy, large (4- to 5-cm-long), grayish, brownish, or black worm. When disturbed the larvae curve their bodies into a "C" and remain motionless for a short period (14). After molting six times, they develop into brown pupae in cells prepared by the larvae a few centimeters below the soil surface. The adults are 2 to 3 cm long and dull brown, gray, or black with markings on the front wings. The wing markings of the adults, which are strong fliers, vary according to the species. Females deposit their eggs on plant stems or on the surface of moist soil. Depending on the species and latitude, one to three or four generations may occur in a year.

Geographical distribution: These insects are distributed worldwide.

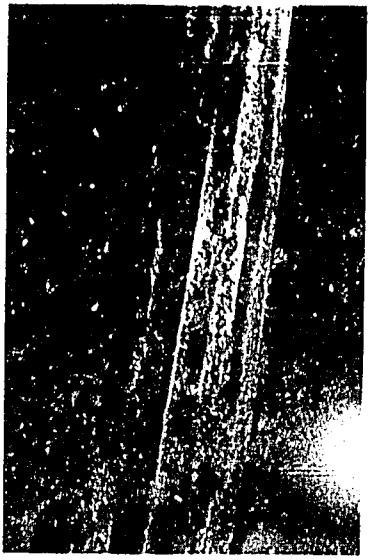
Thrips

Frankiniella spp., *Anaphothrips* spp., *Hercothrips* spp., and *Caliothrips* (=*Hercothrips*) *phaseoli* (soybean or black thrips)

Nature of damage: Lower leaves of damaged seedlings have a silvery, mottled appearance. Upon close examination one can observe thin longitudinal streaks made by the rasping and sucking of the thrips (15). These insects also cause drying, stunting, yellowing, and leaf rolling or twisting.

Description and life cycle: Careful unfolding of the leaves will expose thrips at early development stages (16, shows *Frankiniella* spp.). These insects go through two larval and two pupal instars, the last of which is inactive in the soil. The adults, commonly found under the fully expanded leaves of seedlings, are 1.0 to 1.5 mm long and pale yellow to light brown, and have featherlike wings. They deposit their eggs in the whorl. Development of large thrips populations is favored by dry weather. The soybean or black thrips lives in large colonies on the underside of the lower leaves of seedlings and disperses rapidly when disturbed.

Geographical distribution: Thrips are widely distributed in the Americas.



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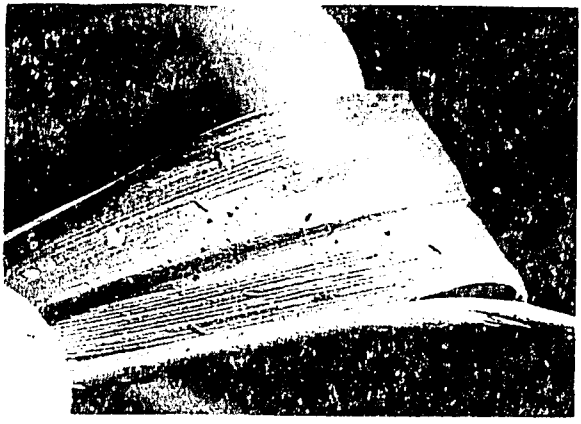

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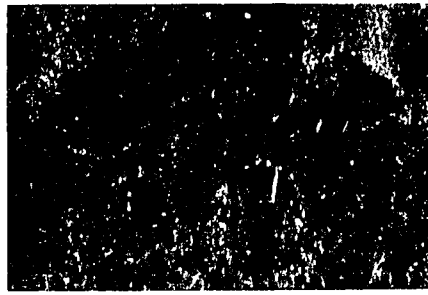

Ricardo Ramírez Huerta, CIANO, Mexico

Lesser Cornstalk Borer

Elasmopalpus lignosellus

Nature of damage: Early damage to the seedling produces a series of holes that become visible as leaves unfold (17). Later indications of attack by the lesser corn borer are wilting, tillering, and stunting of seedlings (18).

Description and life cycle: Close inspection of the seedlings reveals a gallery or tunnel at or slightly below the surface of the soil. Attached to the entrance of the tunnel is a silk-webbed sack covered with soil particles. The sack is made by the bluish or greenish, striped larva, which has distinct brown bands and when disturbed jerks and skips (19). Full-grown larvae (25 mm long) pupate in the soil. The adult form is a small, light-brown moth, which lays its greenish white eggs on young seedlings.

Geographical distribution: This insect is occasionally a serious pest of maize in the Americas.

Corn Stunt Leafhoppers

Dalbulus maidis and *Dalbulus* spp.

Nature of damage: Several leafhopper species feed on the developing maize plant (by piercing and sucking) but do not inflict economically significant damage in this way. More serious is the indirect damage these insects cause by serving as vectors of corn stunt spiroplasma (Rio Grande strain), corn stunt mycoplasma (Mesa Central strain), and maize rayado fino virus.

Maize plants are most severely damaged by corn stunt when infected by leafhoppers at the seedling stage. Four to six weeks after infection of susceptible plants, small, yellow spots develop at the base of the leaves and fuse along the veins in succeeding leaves. In addition, the whorl may turn yellowish, much as it would if there were a deficiency of a minor element. As the plant ages, old leaves turn a reddish purple, and stunting becomes evident (20). If the plant develops tassels, these will be small. Any ears produced will have very poor seed set. Another common symptom at this stage is proliferation of tillers or axillary shoots (21).

When plants are infected at the midwhorl stage, the initial disease symptoms are a yellowing of the whorl leaves and gradual shortening of the internodes. By flowering time plants will be stunted and may be sterile, having small and sometimes distorted tassels. Other common symptoms are tillering and axillary proliferation, reddish purple leaves, and poorly developed ears.

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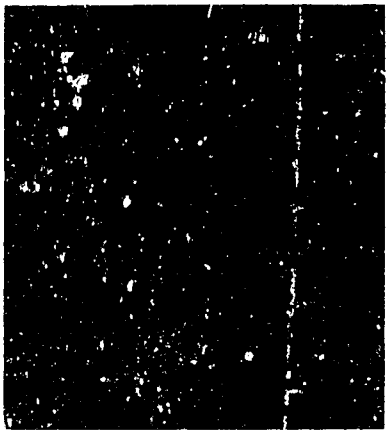

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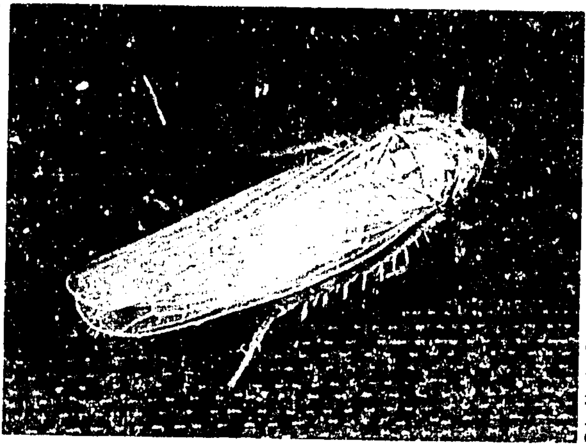

R.L. Nault, Ohio Agric. Res. and Dev. Center, U.S.A.

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Most plants infected at the late whorl stage or later will mature without expressing any of the symptoms described above. Some, however, may show stunting and reddish purple upper leaves.

Description and life cycle: The 3-mm-long adult leafhopper, which is a pale straw color, inserts its eggs into the midveins of the leaves of young maize plants (22, shows *Dalbulus maidis*). After hatching the nymphs go through five instars before becoming adults (23).

Geographical distribution: Two of the pathogens for which this leafhopper is a vector, the corn stunt spiroplasma (Rio Grande strain) and maize rayado fino virus, are distributed throughout the tropical and subtropical belts of the American continent. The third, corn stunt mycoplasma (Mesa Central strain), is apparently restricted to the Mexican highlands.

Maize Streak Virus Leafhoppers

Cicadulina mbila and *Cicadulina* spp.

Nature of damage: This insect does not cause economically significant damage through its feeding but transmits the maize streak virus (harbored by several wild and cultivated graminaceous plants), which itself can cause severe injury to maize. The initial symptoms of the disease are small, whitish spots, which become colorless streaks running parallel to the veins along the entire length of the leaf (24). When the plant is infected at the seedling stage, this streaking appears on all but the lowest leaves. Moreover, the plants become stunted and, though they produce tassels, do not silk. If infection occurs later, the plant will produce smaller than normal ears.

Description and life cycle: Either nymphs or adults, both of which may be found feeding and resting in leaf whorls, can transmit the maize streak virus. The leafhopper is straw yellow and 3 mm long and has a pair of black dots between its eyes (25, shows *Cicadulina mbila*). Adults insert their eggs into the midvein of the leaves.

Geographical distribution: Maize streak virus, and its leafhopper vector are found in sub-Saharan Africa.


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Z.T. Dabrowsky, IITA, Nigeria

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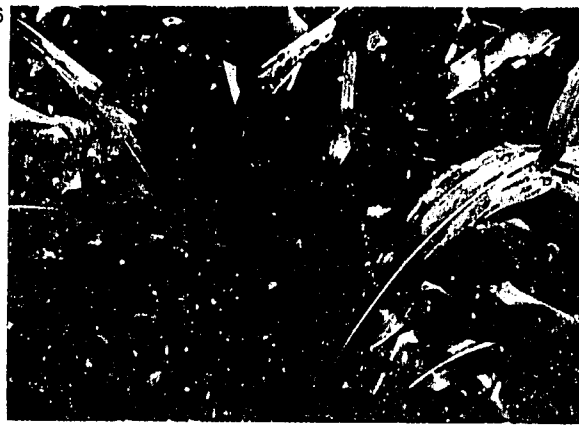

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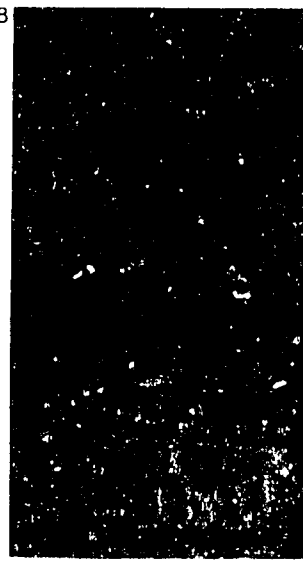

Fall Armyworm

Spodoptera frugiperda

Nature of damage: Extensive leaf damage, which becomes quite noticeable as the leaves unfold (26), is caused by the small, dark-green worms. Upon hatching they begin to feed by scraping the leaf epidermis (27) and later migrate to the whorl, where they feed voraciously. Late infestation of the whorl damages the tassel (28) and all the ear parts in a manner similar to that of the corn earworm (see plate 73). In hot, dry weather, full-grown larvae that have dropped to the ground before pupation will begin to feed at the base of the plant, cutting the tender stalk.

Description and life cycle: Usually, only one full-grown armyworm is found in the whorl, since at the second or third larval instar it starts to show cannibalistic tendencies. After six larval instars, the full-grown (3-cm-long), grayish brown worm

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drops to the ground and pupates in an earthen cell a few centimeters below the soil surface. The adults, dark-gray moths, 20 to 25 mm long with a conspicuous white spot on the extreme tip of the hind wings, lay fuzz-covered clusters of a few to several hundred, white, pinkish, or light-green eggs usually on the underside of leaves (29) Larvae emerge from the eggs simultaneously, at which point their mortality rate is extremely high as a result of factors such as rain, predators, and parasites (30).

Geographical distribution: This insect is one of the most important pests of maize in the Americas, causing damage from the early seedling to the prematurity stages. Species closely related to it are found in Africa and Asia.

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Armyworms

Spodoptera spp. and *Pseudaletia* spp.

Nature of damage: As newly emerged larvae begin feeding on the leaves, they scrape the surface but do not actually perforate it, creating a "window-pane" effect (31). Later, this feeding is more damaging. Starting at the margins and moving inward, larvae may eat entire leaves, leaving only the midribs (32). Under severe infestation, the entire young plant may be consumed.

Description and life cycle: When full-grown (4 to 5 cm long), the black or dark-green larvae (33) turn into reddish dark-brown pupae below the soil surface. The adult is a grayish dark-brown moth with variegated forewings 1.5 to 2.0 cm long. This moth lays its eggs on maize leaves in nearly spherical, yellowish white, fuzz-covered clusters that become dark as the time for hatching approaches.

Geographical distribution: These insects are widely distributed in the tropics and subtropics throughout the world.

Spider Mites

Tetranychus spp., *Paratetranychus* spp., and *Olygonychus* spp.

Nature of damage: Mites can damage maize from the seedling stage to maturity. The presence of small, faint, yellow blotches on the lower leaves is an indication of spider mite injury, wnich is inflicted through piercing and sucking of the foliar tissue. As the colonies of mites increase in size, they cause the lower leaves of the maize plant to become dry (34); the mites then migrate to the upper leaves.

Description and life cycle: On the underside of damaged leaves, one can observe tiny green to reddish brown mites protected by a delicate web secreted by the adults (35, shows *Paratetranychus* spp.), whose eggs have a pearl-like appearance. Mites (which are more closely related to spiders than to insects) go through a larval and two nymphal instars and multiply very quickly in hot, dry weather.

Geographical distribution: Spider mites are distributed throughout the world.

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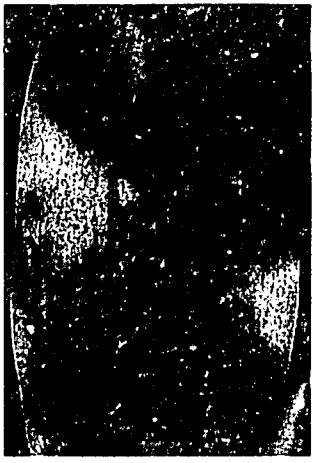

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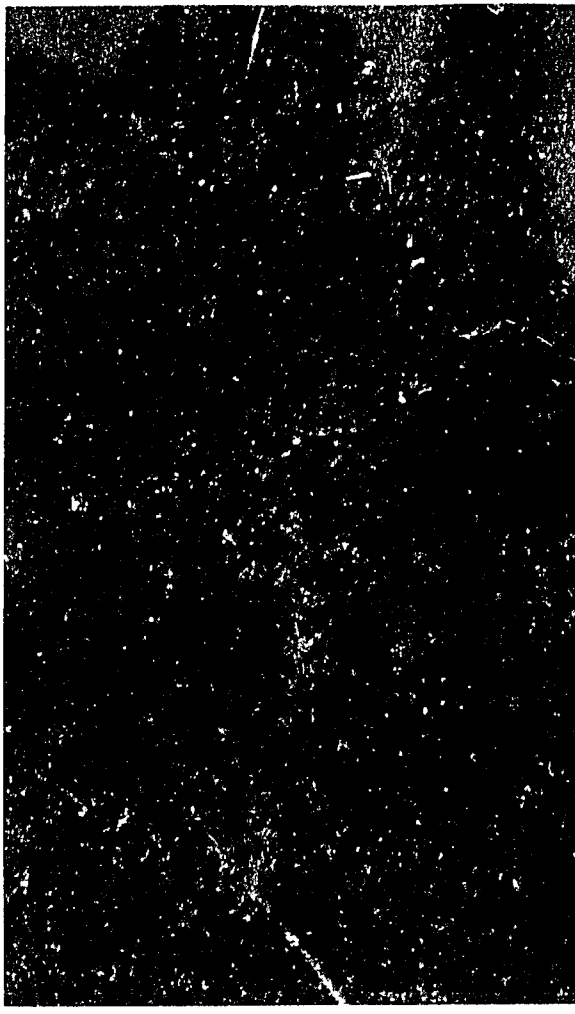

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Corn Leaf Aphid

Rhopalosiphum maidis

Nature of damage: The role of this insect as a vector of the sugarcane mosaic virus, maize dwarf mosaic virus, and maize leaf-fleck virus makes it a pest of considerable economic importance. Diseased plants may become stunted, show a conspicuous yellowish mottling, and turn reddish as they mature. Young plants that have been infected seldom produce ears.

Piercing of the leaves and sucking of plant fluids by the insect causes some yellowish mottling, but this damage is seldom of economic importance. Sugary droplets excreted by the aphids favor the development of black molds and make the plants sticky. These insects usually attack maize plants at the end of the midwhorl stage. Their colonies may completely cover emerging tassels and the surrounding leaves, preventing pollen release (36). In severe outbreaks the ear shoot is also infested, and seed set may be affected.

Description and life cycle: The small, greenish blue adult females do not lay eggs but give birth to living nymphs. In crowded colonies winged forms are produced that eventually migrate to other plants. Skins that have been shed give the colonies a whitish appearance.

Geographical distribution: This insect is distributed worldwide.

Maize Whorl Maggots

Euxesta spp.

Nature of damage: This minor pest and others can cause "deadheart," which is a wilting and drying of the central leaf. The damaged central leaf can easily be pulled loose from the plant. Injured young plants produce side tillers (37). Larvae may damage the ear shoot.

Description and life cycle: Dissection of the whorl of an infested plant will expose the white or cream-colored maggot, which is 12 to 15 mm long when full-grown (38). The adult form is a fairly large fly with alternating black and transparent bands on its wings (39).

Geographical distribution: This pest occurs in the lowland tropics of Mexico and other countries in the Americas.


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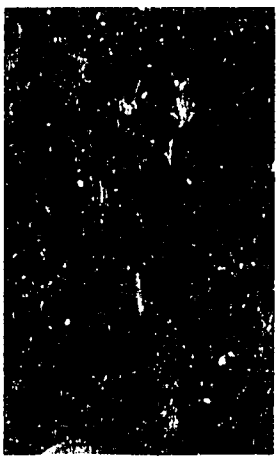
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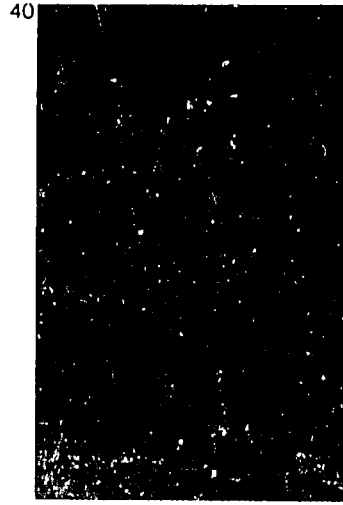
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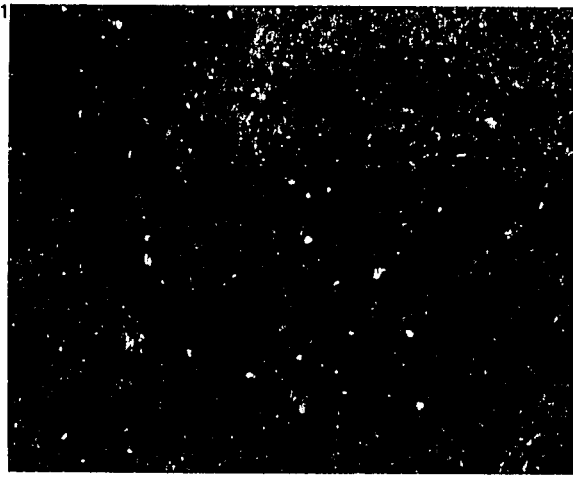
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Sugarcane Froghoppers

Aneolamia spp. and *Prosapia* spp.

Nature of damage: Distinct, whitish yellow blotches on the leaves are a symptom of infestation by this insect, which is of minor importance in maize (40). It introduces toxins into the leaves as it pierces and sucks fluids fro them. The damaged areas of a leaf gradually dry. If the infestation is severe, these lesions grow together, and whole portions of the leaf die.

Description and life cycle: The adults (41, shows *Aneolamia* spp.), which are strong flyers and can also disperse themselves by jumping, deposit their eggs in the soil. The nymphs, also known as spittle bugs, feed at the base of grass and sugarcane plants, in which their damage can have economic significance.

Geographical distribution: These pests occur in the tropics and subtropics of the Americas.

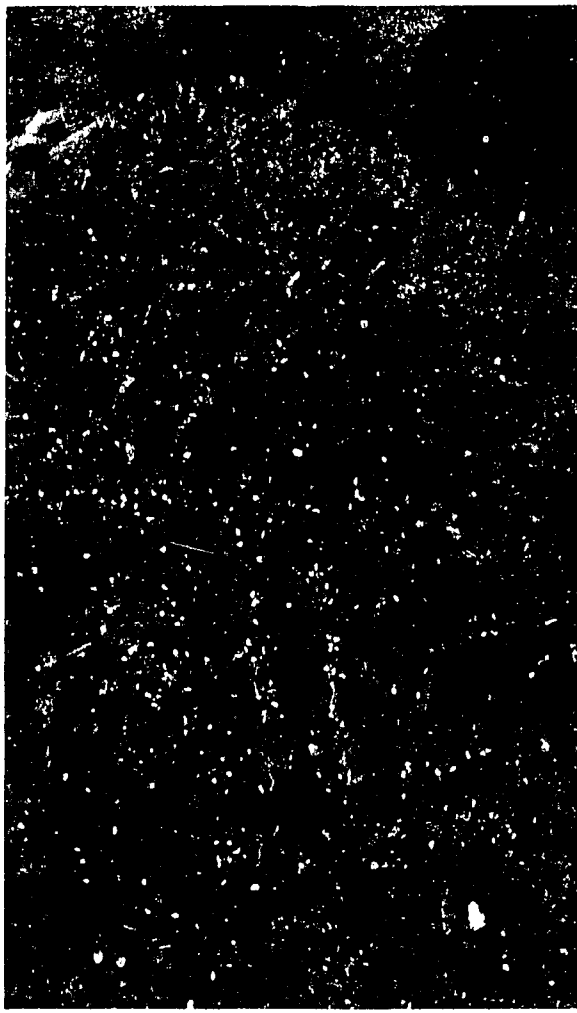
Chafers

Macrodactylus spp.

Nature of damage: These beetles damage maize leaves, silks, and tassels. Although the foliage and tassel injury is seldom important, pruning of the silks can affect seed set.

Description and life cycle: The grayish to brownish beetles are about 1.5 cm long and have spiny legs. They are strong flyers, congregate in large numbers on the host plant (42), and lay whitish, nearly spherical eggs. The larvae (white grubs) are root feeders. The life cycle of this insect is completed in one to several years.

Geographical distribution: These insects, close relatives of the June beetles, are restricted to the Bajío and central plateau of Mexico.



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Grasshoppers

Melanoplus spp., *Schistocerca* spp. and *Sphenarium* spp.

Nature of damage: These insects attack maize from the midwhorl stage to maturity and consume every part of the plant.

Description and life cycle: Many sedentary and migratory species have been described (43). Most species can fly long distances, but those having short wings disperse only by jumping. Adults deposit their eggs in the soil of grassy areas or pastures. Nymphs go through five or seven instars, depending on the species.

Geographical distribution: Devastating grasshopper or locust attacks have occurred in almost every arid or semiarid region of the world.

Key for Identification of Insect Pests

	Germination	Seedling
Tassel		
Ear		
Stem		
Foliage		Cutworms (p.17) Thrips (p.18) Flea beetles (p.9) Diabrotica beetles (p.10) Leafhoppers (p.22,26) Lesser cornstalk borer(p.21) Fall armyworm (p.29) Spider mites (p.34) Maize whorl maggots (p.38)
Roots		Wireworms (p.6) Flea beetle rootworms (p.9) Diabrotica rootworms (p.10) Maize billbug grubs (p.13) White grubs (p.14)
Seed	Seedcorn maggots (p.5) Wireworms (p.6)	

Early whorl (4-6 leaves)	Midwhorl (7-9 leaves)
	Borers (p.55-72)
Cutworms (p.17) Thrips (p.18) Flea beetles (p.9) Diabrotica beetles (p.10) Leafhoppers (p.22,26) Lesser cornstalk borer (p.21) Fall armyworm (p.29) Spider mites (p.34) Maize whorl maggots (p.38) Maize billbugs (p.13)	Thrips (p.18) Flea beetles (p.9) Leafhoppers (p.22,26) Fall armyworm (p.29) Spider mites (p.34) Maize billbugs (p.13) Borers (p.55-72) Grasshoppers (p.45) Chafers (p.42) Sugarcane froghoppers (p.41) Corn leaf aphid (p.37)
Wireworms (p.6) Flea beetle rootworms (p.9) Diabrotica rootworms (p.10) Maize billbug grubs (p.13) White grubs (p.14)	Wireworms (p.6) Flea beetle rootworms (p.9) Diabrotica rootworms (p.10) Maize billbug grubs (p.13) White grubs (p.14)

Identification Key, Continued

Late whorl (10-12 leaves)	
Tassel	
Ear	
Stem	Borers (p.55-72) Termites (p.52)
Foliage	Flea beetles (p.9) Fall armyworm (p.29) Spider mites (p.34) Maize billbugs (p.13) Borers (p.55-72) Grasshoppers (p.45) Chafers (p.42) Sugarcane froghoppers (p.41) Corn leaf aphid (p.37)
Roots	Wireworms (p.6) Flea beetle rootworms (p.9) Diabrotica rootworms (p.10) Maize billbug grubs (p.13) White grubs (p.14)

	Flowering
	Fall armyworm (p.29) Borers (p.55-72) Corn leaf aphid (p.37) Diabrotica beetles (p.10)
	Armyworms (p.29, 33) Corn earworms (p.79) Borers (p.55-72) Ear maggots (p.76) Corn leaf aphid (p.37) Stink bugs (p.80)
	Borers (p.55-72) Termites (p.52) Maize stem weevils (p. 75)
	Flea beetles (p.9) Spider mites (p.34) Maize billbugs (p.13) Borers (p.55-72) Grasshoppers (p.45) Chafers (p.42) Corn leaf aphid (p.37)
	Wireworms (p.6) Flea beetle rootworms (p.9) Diabrotica rootworms (p.10) Maize billbug grubs (p.13) White grubs (p.14)

Identification Key, Continued

	Maturation
Tassel	Borers (p.55-72)
Ear	Armyworms (p.29, 33) Corn earworms (p.79) Borers (p.55-72)
Stem	Borers (p.55-72) Termites (p.52) Maize stem weevils (p. 75)
Foliage	Flea beetles (p.9) Spider mites (p.34) Maize billbugs (p.13)
Roots	Wireworms (p.6) Flea beetle rootworms (p.9) Diabrotica rootworms (p.10) Maize billbugs grubs (p.13) White grubs (p.14)

Preharvest	Postharvest
Borers (p.55-72)	
Armyworms (p.29, 33) Corn earworms (p.79) Borers (p.55-72) Grain weevils (p.87) Angoumois gr. moth (p.83) Grain borers (p.88)	 Borers (p.55-72) Grain weevils (p.87) Angoumois gr. moth (p.83) Indian meal moth (p.84) Grain borers (p.88)
Borers (p.55-72) Termites (p.52) Maize stem weevils (p. 75)	Borers (p.55-72) Termites (p.52)

Termites

Microtermes spp., *Macrotermes* spp., *Allodontermes* spp., and *Odontotermes* spp.

Nature of damage: Termites occasionally cause partial or total defoliation of maize seedlings but are principally damaging to maturing or mature plants. After about three months of plant growth, termites begin to attack the main root system, prop roots, and stems and eventually pack the stems with soil and cover them with galleries or tunnels made of thin sheets of soil (44). As plants mature the amount of damage increases rapidly and so does the likelihood of lodging, brought about directly by termite injury or by wind. Severely damaged plants may lodge and be completely destroyed by termites. The longer a field has been cultivated, the greater will be the yield losses caused by these insects.

Description and life cycle: These soft-bodied insects, often referred to as "white ants," occur in various forms. The sexual forms, the "queen" and her cohort, have four wings extending beyond the abdomen, which are lost after pairing. Once the queen is established in a nest, her abdomen becomes enlarged, and she produces thousands of eggs, from which nymphs emerge. These either become soldiers, which protect the termite colony, or workers, whose function is to feed members of the colony. Both of those forms are sterile.

Geographical distribution: Termites occur in sub-Saharan Africa, especially the savanna and semiarid zones, and in India.

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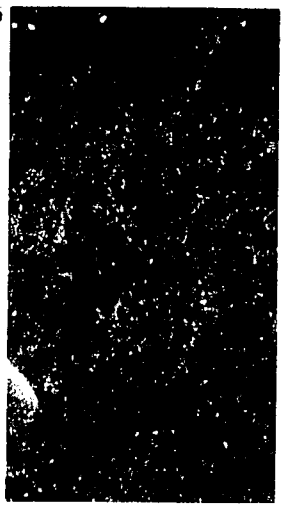

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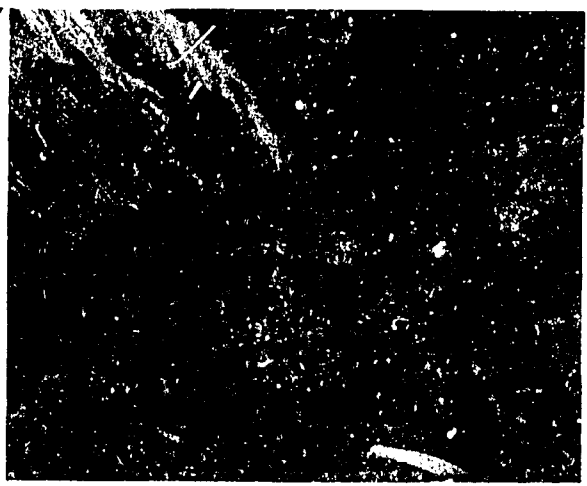


Sugarcane Borer

Diatraea saccharalis

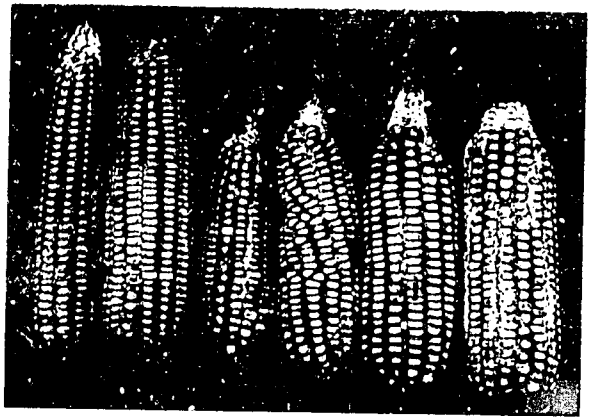
Nature of damage: The first indications of borer attack are rows of pinholes that become visible as leaves unfold during the midwhorl stage (45). Some larvae bore deep enough into the whorl to kill the growing point and cut the central leaves at the base. Eventually, these leaves wilt, die, and turn white, a symptom commonly referred to as "deadheart." During later stages of plant development, borers cause other types of damage, including tillering and stunting. Older larvae bore into the stem, usually where the leaf blade and leaf sheath are joined (46). They may also tunnel in the midribs and feed on the collar. Heavily infested stalks become riddled with tunnels and will easily break and lodge. At flowering the second-generation worms feed on the tender tassels and bore into the stem, causing it to break (47). They may also penetrate ear shanks and ears, which drop from the plant if damage is

(Continued)

intense (48). In addition to this direct injury, borers open avenues for the entrance of stalk- and ear-rotting fungi.

Description and life cycle: Removal and careful inspection of young whorls will reveal small, whitish, black-headed worms of the first generation feeding on the tightly rolled leaves of the whorl. At later stages of plant development, splitting the stem will reveal white or creamish, spotted worms with brown heads, tunneling throughout the stem and depositing their sawdustlike excrement (49). Summer larvae are spotted; overwintering larvae lose their dark-brownish spots and become creamy white. The larvae undergo several molts before developing into brown pupae. Pupation takes place wherever the larvae happen to be feeding (on the stem, ear shanks, or ears). Full-grown larvae feeding on the stem prepare for the exit of the moth by making a circular "window" at the end of the gallery. The straw-colored moths, which have two oblique, dark lines and a central dot on their forewings (50), deposit clusters of white, oval, scalelike eggs in overlapping rows, usually on the smooth undersides of leaves. As the eggs near hatching, they turn from reddish to black.

Geographical distribution: The genus *Diatraea* is associated with the Gramineae of the Americas. This insect occurs from the southeastern United States to the Argentinian corn belt.



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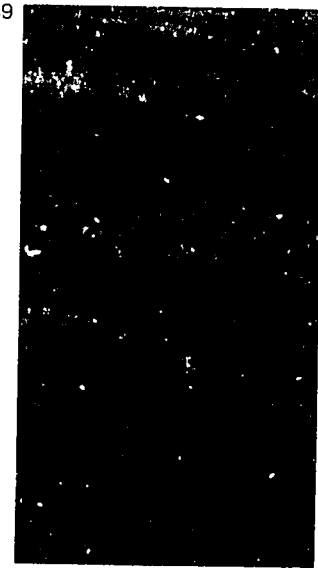

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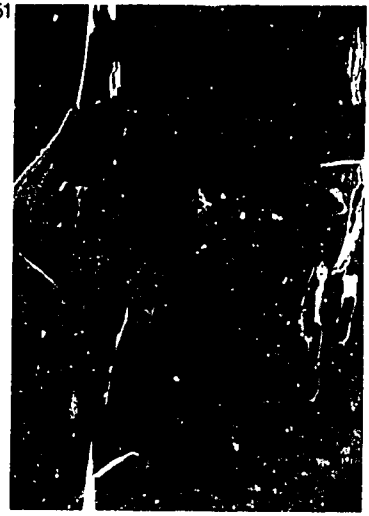

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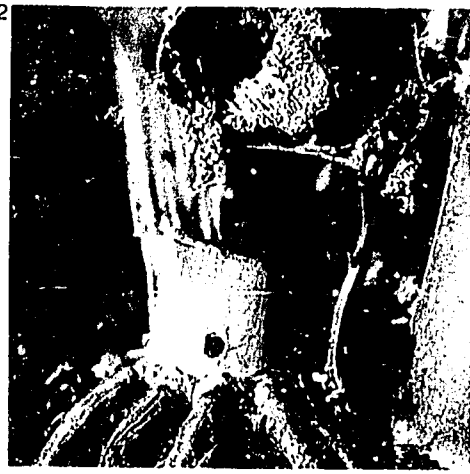

Southwestern Corn Borer

Diatraea grandiosella

Nature of damage: This borer, like the sugarcane borer, makes pinholes in the young leaves of the whorl. It damages other plant parts (such as the midrib) in much the same manner as the sugarcane borer as well (51). One distinctive feature of injury by the full-grown, overwintering southwestern corn borer is that it girdles the maize stalk from inside near the soil surface (52). The worms remain at the base of the stalk below the girdled section until spring. Girdled stalks are prone to lodging.

Description and life cycle: Although the life cycle of the southwestern corn borer is similar to that of the sugarcane borer, there are noticeable differences in the appearance of the two species at various stages. Full-grown southwestern corn borers, for example, are larger than sugarcane borers and possess conspicuous black spots on each body segment, as do the neotropical corn borers (see plate 53). Overwintering larvae of this species are whitish and, like sugarcane borers, do not have spots. The straw-colored moth of the southwestern corn borer is much larger than the sugarcane borer moth and has wing markings like those of the neotropical corn borer (see plate 55).

Geographical distribution: This subtropical borer occurs in the United States and Mexico.

Neotropical Corn Borer

Diatraea lineolata

Nature of damage: The injury caused by this borer to maize leaves early in plant growth and to other plant parts later is similar to that inflicted by the sugarcane borer and southwestern corn borer. Unlike the latter species, however, the neotropical corn borer does not girdle the base of the maize stalk.

Description and life cycle: The development stages of this borer—larva (53), pupa (54), and moth (55)—resemble those of the southwestern corn borer.

Geographical distribution: The neotropical corn borer occurs in eastern Mexico, Central America, and the Caribbean region.

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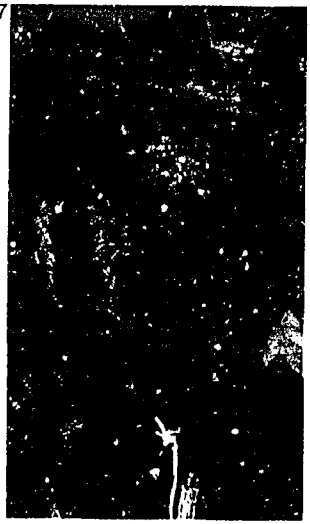

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Oriental Corn Borer or Asian Maize Borer

Ostrinia furnacalis (=*Pyrausta salentialis*)

Nature of damage: The first signs of infestation appear at the early or midwhorl stage as young larvae begin feeding on the leaf around the egg mass and later within the whorl. Older larvae bore into the stalk behind the leaf sheath, usually at the node (56). An easy way to detect this type of damage is to check for larval excrement accumulating at the leaf axil. The larvae also bore into and damage developing tassels, ears, and midribs (57). Under severe attack stalks and tassels are commonly broken.

Description and life cycle: The young borers are pinkish or yellowish gray and have black heads; the older ones are whitish and spotted. Pupation occurs in whatever plant part the full-grown larvae are feeding on (58). The adults, brownish or straw-colored moths, deposit their oval, light-yellow, overlapping, scalelike eggs in clusters of variable sizes on the upper side of leaves or on the husk. As the time for hatching approaches, the eggs turn black.

Geographical distribution: This borer is widely distributed in Asia and is very closely related to the European corn borer, *Ostrinia nubilalis* (Hübner). The two species overlap in their range of distribution in central Asia.

Spotted Sorghum Stem Borer

Chilo partellus (=*C. zonellus*)

Nature of damage: The initial symptom of infestation on young plants is rows of oval perforations in leaves of the unfolding whorl (59). This damage is caused by the feeding of the young larvae. As they develop, the larvae tunnel into the leaf midribs, damage the growing point (causing a condition referred to as "deadheart"), or bore into the stem (60).

Description and life cycle: The young stem borers are small, spotted, and yellowish. When full-grown they are 20 to 25 mm long and spotted, with colored stripes along the back of the body. Before developing into pupae, the larvae prepare an exit for the adult by leaving intact at the end of their tunnels only the thin exterior wall of the stem. The straw-colored or yellowish brown moths, which are about 15 mm long, deposit white, scalelike eggs in overlapping rows, usually on the underside of leaves.

Geographical distribution: This borer is associated with the Gramineae of Australia, East Africa, and Southeast Asia. Closely related species occur in North America.

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W.R. Young, Rockefeller Foundation

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African Maize Stem Borer or African Sorghum Stem Borer

Busseola fusca

Nature of damage: The larvae feed very little or not at all where the eggs have been laid but migrate into the leaf whorl, where they begin scraping the tender leaves. As they unfold, the leaves show perforations (61). Deep feeding in the whorl destroys the growing point, causing a symptom referred to as "deadheart." Medium-sized larvae migrate down the stem, bore into it, and as they do so expel a dust from the interior. Second-generation larvae, like those of other species, feed on tassels, ear shanks, ears, and stems (62) and may there enter a period of dormancy and become nonpigmented.

(Continued)

Description and life cycle: The full-grown borer is about 3 cm long and has a pinkish body with a brown head. It prepares an exit for the adult (a dark-brown moth) by leaving intact the thin outer wall of the stem, which serves as a lid for the round exit. The moths (63) deposit their nearly spherical, light-yellowish eggs between the stem and lower leaf sheaths, as do the adults of the African pink borer (see plate 65).

Geographical distribution: This insect is regarded as the most important pest of maize in sub-Saharan Africa at altitudes of 500 m and above. It is rarely found in the continent's thorn savanna and has not been observed in the forest areas. In Africa the noctuid borers prevail over the pyralid borers, which are predominant in the Americas, Asia, and Europe.

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M. Barrow, Pioneer, South Africa

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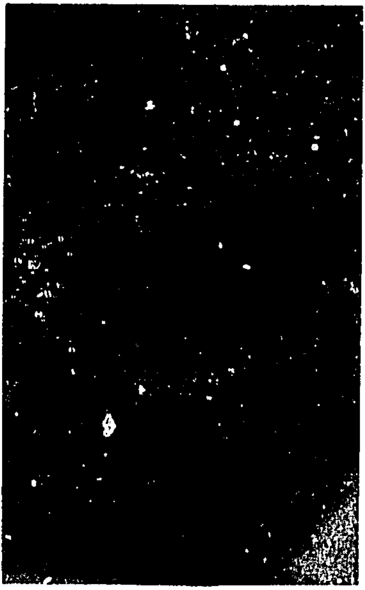

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African Pink Borer

Sesamia calamistis

Nature of damage: Newly hatched larvae remain in a group behind the leaf sheath and begin chewing on the stem and inner side of the sheath (64). Later, some larvae migrate to neighboring leaf sheaths, while others penetrate the stem, expelling a dust from within. Severe damage causes the stem to break. Like other species of borers, these also feed in the whorl, tassels, and ears. If larvae invade the whorl, unfolding leaves will have rows of oblong holes. Moreover, because of wilt brought on by damage at the base of the plant, the central leaves of the whorl may be easily detached, a symptom of what is referred to as "deadheart."

Description and life cycle: The full-grown (3- to 4-cm), pinkish larvae usually pupate at the base of the stem or within a cocoon in an old leaf sheath. The adult form has light-brown forewings with dark stripes and silvery white hind wings. This moth, like that of the African maize stem borer, deposits nearly spherical, white eggs in rows between the stems and inner surfaces of the bottom leaf sheaths of two- to four-week-old plants (65). On full-grown plants, the moths place their eggs in the leaf sheaths next to the developing ear. As the time for hatching approaches, eggs become pinkish and then turn brown.

Geographical distribution: This borer is an important pest in the warmer coastal areas of Africa. Closely related species occur in Asia, southern Europe, and the Middle East.

African Sugarcane Borer

Eldana saccharina

Nature of damage: The larvae damage maize stems (66), ears (67), and tassels.

Description and life cycle: When full-grown the larvae are 20 mm long and have red bristles and yellowish legs. They pupate inside the plant within a cocoon. The pale rose-brown female moths have two dark spots in the center of their forewings, are about 15 mm long, and lay their eggs on the leaf sheaths.

Geographical distribution: This insect occurs throughout sub-Saharan Africa.

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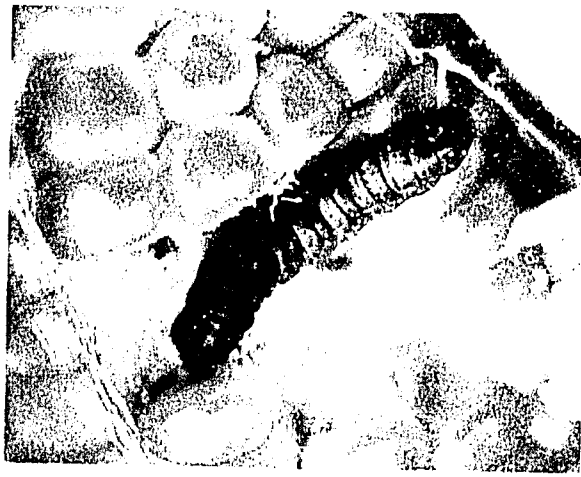

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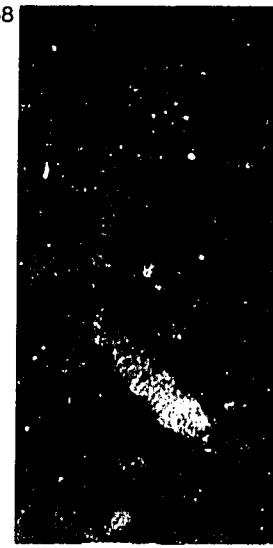

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Maize Stem Weevils or Corn Stem Weevils

Sphenophorus spp. (= *Calendra* spp.)

Nature of damage: Grubs, feeding inside the stems (68), make small, round or slightly elongated exit holes on the internodes of maize plants near flowering to maturity (69). The grubs also actively disseminate fusarium stalk rot. The weevils feed at the base of young plants. This feeding results in excessive tillering and creates a series of holes in the leaves, which become evident as the leaves unfold.

Description and life cycle: The grubs are tiny and white. The weevils are shiny black, clearly striped, and slightly larger than the maize grain weevil.

Geographical distribution: This insect is distributed throughout the Americas.

Ear Maggots

Euxesta spp.

Nature of damage: The larvae feed on decaying silks and destroy developing kernels (70).

Description and life cycle: Removal of the husks will expose creamish white maggots, about 1 cm long when full-grown, that flip vigorously when disturbed. The larvae pupate inside a brownish red to dark-brown cocoon in the silk channel (71). The adults, flies about 0.5 cm long, have banded wings, which they slide together with quick strokes as they move on the foliage of the maize plant (72). These flies, often found in pairs, lay their tiny, white, elongated eggs in the silk channel.

Geographical distribution: This insect is distributed throughout tropical America and, together with the corn earworm, can cause serious damage in the highland valleys of the Andean region.


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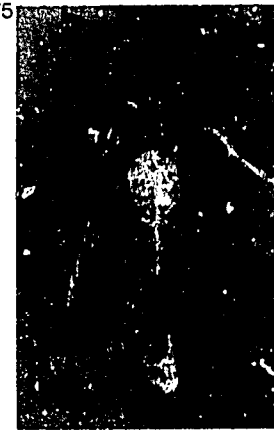

Corn Earworms

Heliothis zea and *H. armigera*

Nature of damage: Although they may occasionally feed in the leaf whorl or on the tender tassels, the larvae principally damage the maize ear (73). They begin feeding soon after emergence, concentrating on the silk channels. In addition to causing direct injury to the kernels, they open avenues for infection by ear-rot pathogens.

Description and life cycle: Upon carefully inspecting fresh maize silks or young husks, one may find the tiny, white eggs, which have a shiny appearance (74) and are laid by robust, brownish moths (75, shows *Heliothis zea*). Developing and mature larvae vary widely in color, from brown or red to green or some combination of those colors. Because the larvae are cannibalistic, seldom does more than one remain in the ear. Full-grown larvae (4 to 5 cm long) drop to the ground and pupate in earthen cells a few centimeters below the soil surface.

Geographical distribution: This insect occurs throughout the world and poses a serious problem in the high valleys of the Andean region.

Stink Bugs

Nezara viridula, southern green stink bug; *Acrosternum marginatum*, green stink bug; *Euschistus servus*, brown stink bug

Nature of damage: Both the adults and nymphs have a beak, with which they pierce and suck fluids from the plant, usually on the leaf collars and developing ears. The most conspicuous symptom of stink bug damage is a twisting of young ear shoots (76). As the ear develops, this twisting becomes more noticeable, and the husk leaves separate, exposing the ear. Exposed ears are subject to ear-rotting fungi, stored grain insects, field infestation by other insects, and bird damage.

Description and life cycle: The light-green egg clusters, which turn pink as the time for hatching approaches, can readily be found on the upper leaf surfaces (77). As nymphs pass through five instars, their color changes from reddish brown to green. The scent glands on both sides of the abdomen of the nymphs and adults emit a liquid that has an offensive smell. The green or brownish adults are strong flyers (78, shows *Euschistus servus*).

Geographical distribution: This insect is widely distributed throughout the Americas.

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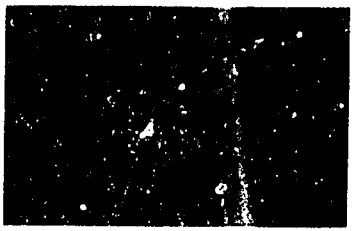

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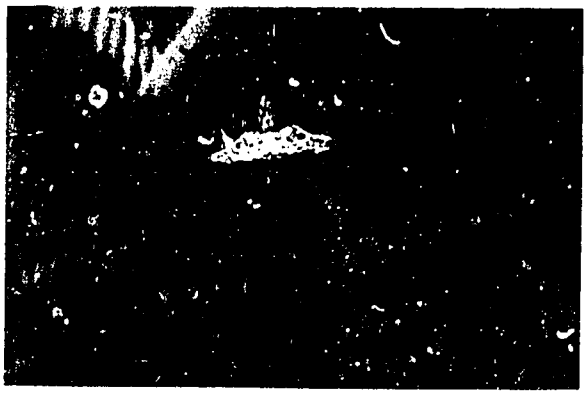

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Angoumois Grain Moth

Sitotroga cerealella

Nature of damage: Young worms penetrate and feed inside maize grain. This insect may also infest the crop in the field prior to harvest.

Description and life cycle: Small, yellowish or straw-colored moths, which are nearly a centimeter long and have a fringe along the posterior margin of their wings, can be observed flying around infested grain stores (79). Their presence is especially evident if ears or shelled grain are disturbed. The moths tend to lay clusters of scalelike eggs, which turn from white to red near hatching, between two close surfaces (for example, between the kernel and the reduced glumes at the base of the kernel). The young larvae are tiny and whitish. In their last larval instar, just before pupation, the larvae prepare a round exit hole for the moth, leaving the outer seed wall only partially cut as a flap over the hole.

Geographical distribution: This insect occurs all over the world.

Indian Meal Moth

Plodia interpunctella

Nature of damage: This insect is a pest only of stored grain and does not infest maize in the field.

Description and life cycle: Moths about 1 cm long, which have three bands (a narrow reddish brown one and a wider one of the same color separated by a whitish band), can be observed flying around infested grain stores (80). The moths lay their eggs on the surface of the maize grain. Upon inspecting the surface of stored ears or stored grain, one can find a dense silken webbing produced by light-yellowish larvae, which eventually acquire a greenish or pinkish tint (81). Full-grown larvae leave the inside of the grain and pupate in white, silken cocoons on the outside of the infested grain mass.

Geographical distribution: This insect is distributed worldwide.

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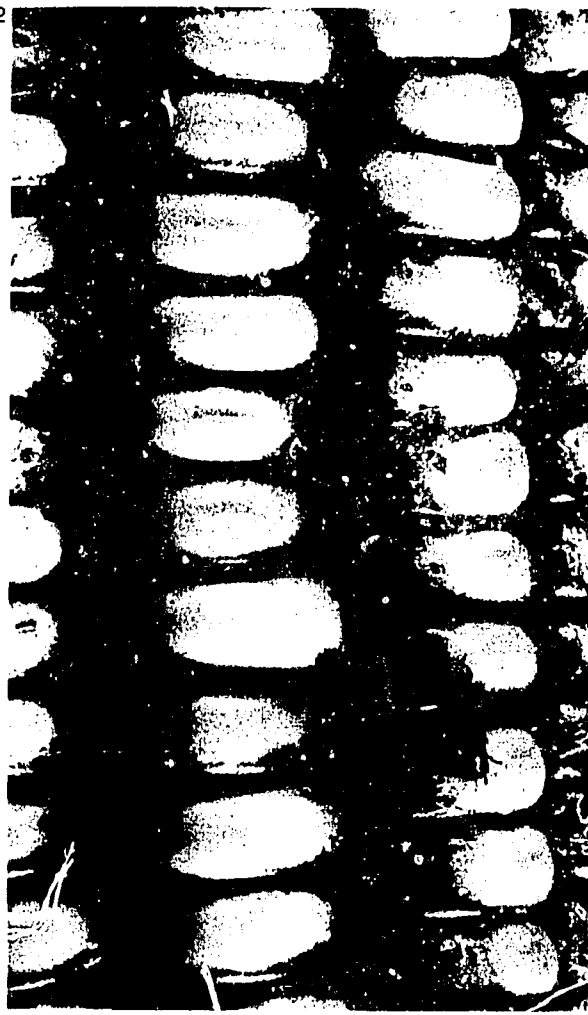

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Grain Weevils

Sitophilus zeamais, maize grain weevil; *Sitophilus oryzae*, rice weevil; *Sitophilus granarius*, granary weevil

Nature of damage: These insects may infest stored grain or maize ears before harvest.

Description and life cycle: Removal of husks in the field will reveal weevils and the irregular punctures they make in kernels during feeding or egg laying (82, shows *Sitophilus zeamais*). The rice weevil, smallest of the three species, rarely flies but is otherwise similar to the maize weevil, which is a strong flier. The granary weevil also resembles the maize weevil, but cannot fly and lacks its four reddish spots on the wing covers. In kernels dislodged from the cob, one can readily observe thread-like galleries made by the the legless, stout, whitish grubs as they feed inside the kernels. The larvae develop into pupae inside the kernel.

Geographical distribution: These weevils occur throughout the world.

Grain Borers

Rhyzopertha dominica, lesser grain borer; *Prostephanus* (=*Dinoderus*) *truncatus*, larger grain borer

Nature of damage: These insects infest both stored grain and maturing maize ears in the field. In a very short time, the adults produce large quantities of floury dust as they bore into and feed on the grains. Damaged grains can readily be identified since they are usually covered by a film of this dust.

Description and life cycle: The small, nearly cylindrical beetles are reddish brown to dark brown; their head is turned down and appears to be covered by a hood (83, shows *Prostephanus truncatus*). The larger grain borer is 1 to 2 mm longer than the lesser grain borer and has a smoother surface. Both are capable of flying. The beetles lay their eggs on the grain or in the floury dust. The tiny, whitish grubs, which have swollen anterior and posterior ends, feed on the dust or crawl into and feed on slightly damaged kernels. Pupation takes place inside the kernels, and emerging adults then cut their way out of the kernels.

Geographical distribution: These insects occur primarily in the tropics and subtropics, but can survive in temperate regions in warm grain stores.

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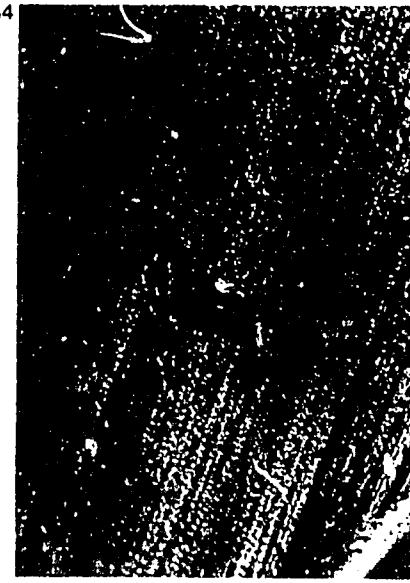

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Beneficial Insects

Many insects are regarded as beneficial because they prey on or parasitize other insects that damage crops and stored products. Preying insects, such as the hunters and assassin bugs, seek out and destroy pests and then immediately move on to other prey. Parasites may also kill their host insects, but only after having developed in or on the host for some time. By far, the most important beneficial forms are the parasites, of which there are 64 genera of wasps and 37 of flies. Among the predators the Coccinellidae beetles (7 genera) are the most abundant.

It is important for farmers and others involved in crop production to be able to recognize these insects and understand their role in regulating pest populations. That knowledge can enable them to take advantage of beneficial insects in overall pest control strategies. What follows are descriptions and illustrations of some of the most important genera (with their family and order names) of beneficial insects.

Pirate Bugs or Flower Bugs, *Orius* spp. (Anthocoridae, Heteroptera). These minute bugs (along with their nymphs) prey on thrips, mites, aphids, insect eggs, and newly hatched larvae (84).

Lacewings, *Chrysopa* spp. (Chrysopidae, Neuroptera). Lacewings and their larvae prey on aphids, thrips, insect eggs, mites, and very young larvae (85). One distinctive characteristic of this genus is that the females prooduce their eggs at the tip of a sturdy filament.

Black Hunting Wasps, *Polibia* spp. (Vespidae, Hymenoptera). This wasp and those of the genus *Polistes* are effective hunters of armyworms (86).

Assassin Bugs, *Castolus* spp. and *Zellus* spp. (Reduviidae, Heteroptera). Nymphs and adults of these insects prey on beetles, froghoppers, and worms. Here a *Castolus* adult is preying on a fall armyworm (87).

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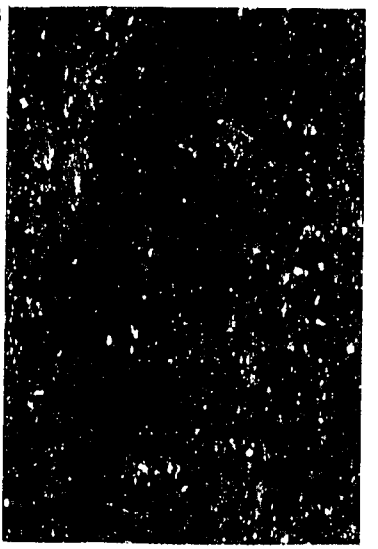

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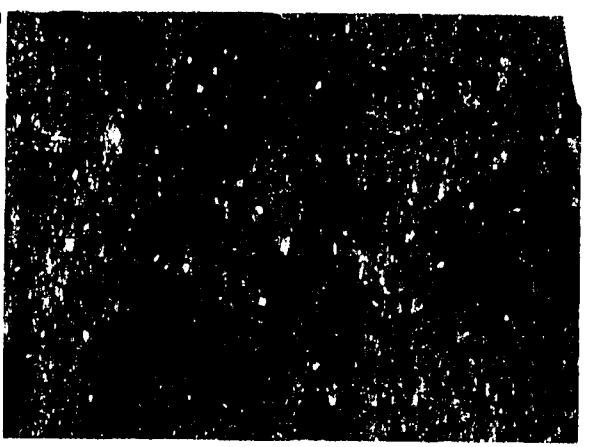

Lady Beetles, *Hippodamia* spp. and *Ceratomegilla* spp. (=Coleomegilla) (Coccinellidae, Coleoptera). These beetles and their larvae are voracious predators of aphids, mites, insect eggs, small insect larvae, and hoppers. Here a *Ceratomegilla* beetle is preying on a larva of the sugarcane borer (88).

Aphid Wasps, *Aphidius* spp. (Braconidae, Hymenoptera). This wasp parasitizes aphids, which then turn yellowish or brownish and become swollen and mummified. Also shown here are syrphid fly larvae (*Syrphus* spp., Syrphidae, Diptera) feeding on the corn leaf aphid (89).

Tiny Wasps, *Chelonus* spp. (Braconidae, Hymenoptera). These wasps parasitize armyworm eggs (90).

Minute Wasps, *Trichogramma* spp. (Trichogrammatidae, Hymenoptera). These tiny wasps parasitize stem borer moth eggs, causing them to turn black (91). The wasps are also effective parasites of the eggs of corn earworm moths.

Slim Orange Wasps, *Iphiaulax* spp. (Braconidae, Hymenoptera). This is a common parasite of sugarcane borer (92).

Bracon wasps, *Apanteles* spp. (Braconidae, Hymenoptera). Here the full-grown wasp larvae have completely consumed a sugarcane borer larva and begun to form a white cocoon (93, p. 98).

Tachina Flies, *Paratherecia* spp. (Tachinidae, Diptera). This insect parasitizes sugarcane borer larvae. A puparium of the parasite is shown here, from which a fly (similar to a housefly) will emerge (94, p. 98).

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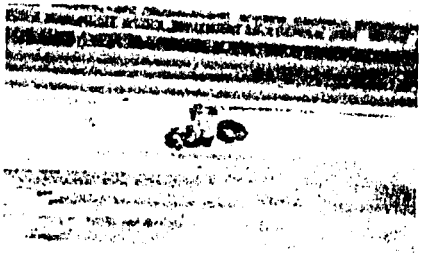

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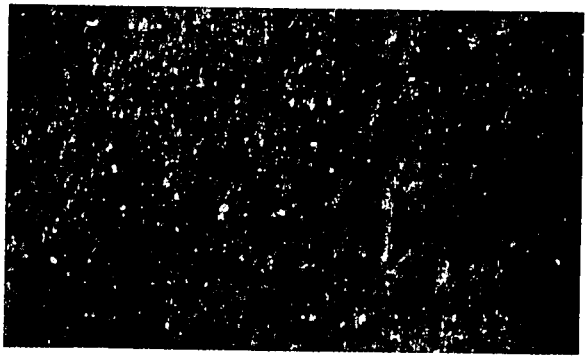

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Insect Pest Control

The size of insect populations in a maize-growing environment is regulated by a number of factors: seasonal and cyclical variations in weather; tillage practices; the quantity and quality of the insects' food supply; inter- and intraspecific competition; epidemics of viruses, bacteria, and fungi; and size of predator and parasite populations.

Insects become pests in crop production when their numbers and/or damage have surpassed the level, referred to as the "economic threshold," at which they begin to threaten farmers' return on investment. At any given time, the economic threshold should be roughly uniform across an environment where the farms and farmers' practices are similar. Even so, the economic threshold is not static for a given insect pest but differs from one growing environment to another. Even within an environment, it may be altered as changes take place in the cultivars or plant varieties farmers grow and the agronomic practices they use, as commodity and input prices rise or fall, and as the size of parasite and predator populations fluctuates. The threshold will also vary according to the socioeconomic circumstances of farmers, being quite different for subsistence farmers than for those engaged in commercialized agriculture.

It is important to be aware of variations in the economic threshold because of its value in planning pest control measures. One should be particularly alert to fluctuations in the populations of pests and their natural enemies where multiple cropping or conservation tillage are being implemented. These changes in the cropping system may call for adjustments in pest control strategy.

Once an insect has reached the economic threshold, it is usually necessary to apply insecticides. Chemical controls should be targeted accurately so that they reduce pest populations while doing a minimum of harm to beneficial insects. Achieving such precision requires careful choice and placement of the insecticide and proper timing in its application. Timing should be based on routine field surveys, and the products chosen should, if at all possible, be those which will have the least disruptive effect on beneficial insects in the particular ecology. It may also be a good idea to use granular insecticide formulations (which are placed in the maize whorl) or seed coatings of the appropriate pesticide. Neglecting to take such measures leads to indiscriminate use of insecticides, which may disrupt the balance between insect populations, causing nonpests or secondary pests to become primary ones.

More specific information can be found in most developing countries, where national maize scientists, with assistance from the international pesticide industry, are developing up-to-date recommendations for insecticide use.

There are a number of other approaches to pest control, some of them quite novel, such as the use of stations baited with some kind of lure—synthetic chemicals, for example, or pheromones (chemicals produced by an insect that elicit behavioral responses in other insects of the same species). Another approach, one more likely to be the basis of future pest management models, is the development of genetically resistant maize germplasm that is acceptable or superior in agronomic performance. Though not nearly as far advanced as development of resistance to plant diseases, research on insect resistance is moving forward in some national and international organizations. As this work is intensified and progresses, our ability to deal effectively with insect pest populations, particularly where pesticides are not widely available, should be much improved.

For More Information

Baur, F.J., ed. 1985. *Insect Management for Food Storage and Processing*. Saint Paul: American Association of Cereal Chemists.

Blair, B.D., ed. n.d. *Corn Pest Management for the Midwest: A Guide for Pest and Problem Diagnosis*. North Central Regional Publication No. 98. Columbus: The Ohio State University.

Bottrell, D.G. 1979. Guidelines for integrated control of maize pests. Plant Production and Protection Paper No. 18. Rome: Food and Agriculture Organization of the United Nations.

Clausen, C.P. (1940) 1962. *Entomophagous Insects*. Reprint. New York: Hafner Publishing Co.

Commonwealth Institute of Entomology. n.d. *Distribution Maps of Pests*. Slough, England: Commonwealth Agricultural Bureaux.

Cotton, R. 1952. *Insect Pests of Stored Grain and Grain Products: Identification, Habits, and Methods of Control*. Minneapolis: Burgess Publishing Co.

Dicke, F.F. 1977. The most important corn insects. In *Corn and Corn Improvement*, edited by G.F. Sprague. Agronomy Series No. 18. Madison, Wisconsin: American Society of Agronomy.

FAO. 1971. *Crop Loss Assessment Methods: FAO Manual on the Evaluation and Prevention of Losses by Pests, Diseases, and Weeds*. Ed. L. Chiarappa. Slough, England: Commonwealth Agricultural Bureaux.

Geier, P.W., R.D. Hughes, and R.F. Morris. 1967. *The Ecology of Insect Populations*. London: Methuen and Co.

Kranz, J., H. Schmutterer, and W. Koch. 1977. *Diseases, Pests, and Weeds in Tropical Crops*. Berlin: Verlag Paul Parey.

Lindblad, C., and L. Druben. 1977. *Small Farm Grain Storage*. 3 vols. Washington, D.C.: Action/Peace Corps.

Mallis, A. 1982. *Handbook of Pest Control*. Cleveland: Franzak Foster Co.

Martin, H., and C.R. Worthing, eds. 1977. *Pesticide Manual: Basic Information on the Chemicals Used as Active Components of Pesticides*. Nottingham: British Crop Protection Council.

Meister, R.T., ed. Published annually. *Farm Chemicals Handbook*. Willoughby, Ohio: Meister Publishing Co.

Metcalf, C.L., and R.L. Metcalf. 1951. *Destructive and Useful Insects: Their Habits and Control*. New York: McGraw-Hill.

Perrin, K.R., D.L. Winkelmann, E.R. Moscardi, and J.R. Anderson. 1979. *From Agronomic Data to Farmer Recommendations: An Economics Training Manual*. Information Bulletin 27. Mexico, D.F.: CIMMYT.

Ramirez, G.M. 1966. *Almacenamiento y Conservacion de Granos y Semillas*. Mexico City: Compañia Editorial Continental.

Teetes, G.L., K.W. Seshu Reddy, K. Leuchner, and L.R. House. 1983. *Sorghum Insect Identification Handbook*. Hyderabad: International Crops Research Institute for the Semi-Arid Tropics.

York, A.C., ed. Published annually. *Insecticide and Acaricide Tests*. College Park, Maryland: Entomological Society of America.

List of Insect Pest Names*

Acrididae (Orthoptera)
Grasshoppers: *Melanoplus* spp., *Schistocerca* spp., and *Sphenarium* spp.

Anthomyiidae (Diptera)
Seedcorn maggots: *Hylemya* (=*Cilicrura*) platura (Meigen) and *Hylemya* spp.

Aphididae (Homoptera)
Corn leaf aphid: *Rhopalosiphum maidis* (Fitch)

Bostrychidae (Coleoptera)
Lesser grain borer: *Rhyzopertha dominica* (Fabricius)
Larger grain borer: *Prostephanus* (=*Dinoderus*) truncatus (Horn)

Cercopidae (Homoptera)
Sugarcane froghoppers: *Aneolamia* spp. and *Prosapia* spp.

Chrysomelidae (Coleoptera)
Diabrotica beetles: *Diabrotica balteata* (Le Conte), *D. virgifera* (Le Conte), *D. longicornis* (Say), *D. speciosa* (Germ.), and *Diabrotica* spp.
Flea beetles: *Chaetocnema pulicaria* Melsheimer and *Chaetocnema* spp.

Cicadellidae (Homoptera)
Corn stunt leafhoppers: *Dalbulus maidis* (Delong and Wolcott) and *Dalbulus* spp.
Maize streak virus leafhoppers: *Cicadulina mbila* (Naudé) and *Cicadulina* spp.

Curculionidae (Coleoptera)
Lesser maize billbug: *Nicentrites testaceipes* (Champion)

* The headings under which the common and scientific names of the insect pests are listed contain the family and order (in parentheses) names.

Large maize billbug: *Geraeus senilis* (Gyllenhal)
Maize stem weevils or corn stem weevils: *Sphenophorus* spp. (=*Calendra* spp.)
Maize grain weevil: *Sitophilus zeamais* Motschulsky
Rice weevil: *Sitophilus oryzae* (Linnaeus)
Granary weevil: *Sitophilus granarius* (Linnaeus)

Elateridae (Coleoptera)
Wireworms: *Melanotus* spp., *Agriotes* spp., *Dalopius* spp., and other genera

Gelechidae (Lepidoptera)
Angoumois grain moth: *Sitotroga cerealella* (Olivier)

Noctuidae (Lepidoptera)
Cutworms: *Agrotis ipsilon* (Hufnagel), *Agrotis spp., Peridroma saucia* (Hubner), *Chorizagrotis auxiliaris* (Hbn.), and many other species
Fall armyworm: *Spodoptera frugiperda* (J.E. Smith)
Armyworms: *Spodoptera* spp. and *Pseudaletia* spp.
African maize stem borer or African sorghum stem borer: *Busseola fusca* (Full.)
African pink borer: *Sesamia calamistis* Hmps.
African sugarcane borer: *Eldana saccharina* Walker
Corn earworms: *Heliothis zea* (Boddie) and *H. armigera* (Hubner)

Otitidae (Diptera)
Maize whorl maggots: *Euxesta* spp.
Ear maggots: *Euxesta* spp.

Pentatomidae (Heteroptera)
Southern green stink bug: *Nezara viridula* (Linnaeus)
Green stink bug: *Acrosternum marginatum* (Pal. de Beau.)
Brown stink bug: *Euschistus servus* (Say)

Pyralidae (Lepidoptera)
Lesser cornstalk borer: *Elasmopalpus lignosellus* (Zeller)
Sugarcane borer: *Diatraea saccharalis* (Fabricius)
Southwestern corn borer: *Diatraea grandiosella* (Dyar)
Neotropical corn borer: *Diatraea lineolata* Walker
Oriental corn borer or Asian maize borer: *Ostrinia furnacalis* (Guenée) = *Pyrausta salentialis* (Snellen)
Spotted sorghum stem borer: *Chilo partellus* (Swinh.) = *C. zonellus* (Butl.)
Indian meal moth: *Plodia interpunctella* (Hübner)

Scarabaeidae (Coleoptera)
White grubs: *Phyllophaga* spp. and *Cyclocephala* spp.
Chafers: *Macrodactylus* spp.

Tenebrionidae (Coleoptera)
False wireworms: *Eleodes* spp.

Termitidae (Isoptera)
Termites: *Microtermes* spp., *Macrotermes* spp., *Allodontermes* spp., and *Odontotermes* spp.

Tetranychidae (Acarina)
Spider mites: *Tetranychus* spp., *Paratetranychus* spp., and *Olygonychus* spp.

Thripidae (Thysanoptera)
Thrips: *Frankiniella* spp., *Anaphothrips* spp., *Hercothrips* spp., and *Caliothrips* (=*Hercothrips*) *phaseoli* (Hood)

The International Maize and Wheat Improvement Center (CIMMYT) is an internationally funded, nonprofit scientific research and training organization. Headquartered in Mexico, CIMMYT is engaged in a worldwide research program for maize, wheat, and triticale, with emphasis on food production in developing countries. CIMMYT is one of 13 nonprofit international agricultural research and training centers supported by the Consultative Group for International Agricultural Research (CGIAR). The CGIAR is sponsored by the Food and Agriculture Organization (FAO) of the United Nations, the International Bank for Reconstruction and Development (World Bank), and the United Nations Development Programme (UNDP). The CGIAR consists of 40 donor countries, international and regional organizations, and private foundations.

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