SUBTROPICAL FRUIT PESTS

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PART THREE

Biology and Control of Pests Affecting Noncitrus Fruits

Chapter 9. Avocado Pests

The cultivated varieties of avocado are native to Mexico and to Central and South America. Besides growing both in the wild and cultivated state in the regions of their origin, they are now cultivated in California, Florida, the West Indies, and in various other subtropical areas throughout the world. California has about 20,450 acres of avocados, and it is estimated that in Florida there are about 9,000 acres, nearly all in Dade County.

This chapter deals primarily with the biology and control of the avocado pests of the United States. However, beginning on page 310, a brief account is given of the principal avocado pests in other countries. This is followed by a check list of all insects feeding on the avocado throughout the world, so far as it has been possible to prepare such a list from available sources of literature and through correspondence. Although many of these insects are not serious pests of the avocado where they now occur, it cannot be concluded that they will not eventually better adapt themselves to the avocado or that they would not be serious pests under the new environmental conditions they would encounter if accidentally introduced into California.

AVOCADO PESTS IN THE UNITED STATES

The commercial growing of avocados in California was not seriously considered until about 1910. As is usually the case when a fruit industry is newly established in a region, there was an initial period of relative freedom from serious pests. Certain native species became established on the avocado in California, however, and others were introduced. At present, the avocado can be said to have its share of insect pests, although fortunately they are more easily controlled than those attacking certain other subtropical fruits. The natural enemies of avocado pests also seem to be more effective in keeping pest populations down to subeconomic proportions than they are on the other important subtropical fruit crops.

In Florida, the dictyospermum scale has been one of the most important avocado pests, especially in the south and on young trees. In the north and central parts of the state, the pyriform scale is the most important scale pest. In Florida, both the greenhouse thrips and the red-banded thrips are pests of avocados. The avocado red mite is a pest during the winter season in Florida, while in California the closely related avocado brown mite reaches its greatest population density in the summer and fall.

Several very serious pests of avocados occur in Mexico that have not yet become established in California or Florida.

Stubby Root Nematode

According to Sher (1955), the stubby root nematode, *Trichodorus* sp., an important pest of many crops in Florida, is often found around the

roots of avocados where there has been a history of poor growth. However, its relationship to diseased avocado trees is unknown. Greenhouse investigations showed that this species multiplies around avocado seedlings, and radioactive tracer studies indicate that it feeds on avocado roots. It never enters the root, but feeds from the outside with its cell-puncturing spear.

Soil fumigation is being investigated where the stubby root nematode is abundant, in order to study the possibility of freeing the soil of infestations and determining what effect this would have on the health and vigor of the tree.

Eight other nematode species have been found around avocado roots, and tests are being made to determine whether or not they are injurious.

European Brown Snail

The European brown snail, *Helix aspersa* Müller (pl. I, 1), has been discussed as a pest of citrus (see page 139, chapter 7). On avocados, the snails feed on the foliage, blossoms, and very young fruit, causing scars on the latter. During the late winter and early spring months, which is the period when the snails are most active, they can be controlled by poison bait scattered under the trees as recommended for citrus (see chapter 7). In California, geese or ducks are often allowed to run loose in avocado orchards to keep the snails under control by eating them.

Avocado Red Mite

This mite, *Oligonychus yothersi* (McGregor), is the most common pest of the avocado in Florida, where its damage attracted the attention of growers as early as 1909. Its attacks are most severe on the tender West Indian avocado varieties, which are common in Florida. It causes severe defoliation and weakening of the tree. Besides attacking the avocado, this mite attacks the mango and has been recorded from camphor and eucalyptus in Florida and from elm, oak, and pecan in South Carolina.

Description. According to Moznette (1922*a*), the egg is globose, smoky amber, and bears a stalk at its apex. Occasional eggs have guy fibrils radiating to the leaf. The eggs are deposited singly and are found at first along the midrib but later scattered quite generally over the entire leaf. The globular, light-yellow larvae possess six legs and conspicuous carmine eyes. They become darker after feeding awhile. Another pair of legs is gained in the protonymph stage, these appearing behind the legs of the larva. The body color darkens still further. The deutonymph becomes larger and more elongate than the protonymph, resembling more the adult.

The adult female is oval, rusty red in color, and averages 0.30 mm. in length. The body, including the legs, is covered with conspicuous bristles. The male is smaller than the female, averaging 0.22 mm. in length, and its abdomen narrows posteriorly. The eyes are red and more conspicuous than in the female.

Life History. Unfertilized females can lay eggs, but these give rise only to males. There is no webbing, except for occasional fibrils attached to the eggs. Incubation of the eggs requires from 7 to 11 days. The average larval period is 2.58 days, the protonymph requires 2.8 days, and the deutonymph, 2.84 days. The average life cycle is 14.2 days. Heavy shedding of foliage in March and April results in a great reduction in avocado red mite population. Spring and summer rains also keep down the population by preventing the mites from establishing themselves on the foliage. The insects are most abundant in late fall or winter.

Injury. The avocado red mite feeds on the upper leaf surface, extracting the chlorophyll and causing myriads of tiny white spots to form. The infested area, however, gradually becomes reddish in color, especially adjacent to the midrib. If the mites are sufficiently abundant, the infested leaves may fall.

Predators. Moznette (1922*b*) considers that predators keep down avocado red mite population to some extent. He lists *Scolothrips sexmaculatus* (Pergande), *Chrysopa lateralis* (Guérin), *Scymnus utilis* Horn, *S. kinzeli* Casey, and *Leptothrips mali* (Fitch) as the most important of these predators.

Artificial Control. Sulfur dust is effective and practical, and should be used when no other pest problem is involved. A combination of avocado red mites and other pests might be controlled by adding some other material to the sulfur, or by using lime-sulfur. If scale insects are present, an oil spray would be effective for both mites and scale.

Avocado Brown Mite

This mite, *Oligonychus punicae* (Hirst), has been known to infest avocado trees in California for the last thirty years. It appears to have started in the Carlsbad region in San Diego County and to have spread rapidly from there. It now occurs throughout the coastal avocado area. This mite was believed to be the same as the avocado red mite

in Florida until McGregor, in 1941, showed that on the basis of a rather striking difference in the male genitalia, the California mite should be considered as a new species. This species is not known to occur outside of California.

Description. The stalked egg resembles that of *O. yothersi.* The immature stages are likewise similar, ranging from pale to increasingly darker hues with increasing age. The adult female (pl. IV, 7) is about 0.40 mm. long, and broadly ovate, being about a third longer than wide. Twenty-six strong, pale bristles are located dorsally, but do not arise from tubercles as is the case with the closely related citrus red mite. The cephalothorax is pinkish. The lateral area of the abdomen (and sometimes the median area) is occupied by many blotches of purplish or blackish brown. On older individuals, the abdomen may be quite solidly blackish brown. The forelegs and palpi are rusty pink, with the other legs pale.

The male is smaller than the female, averaging about 0.30 mm. in length. The body is narrow and tapers to a point behind. The color is paler than that of the female.

Life History. Observations made in the University of California experimental orchard at Los Angeles indicate that the duration of the various stages does not differ significantly, under similar temperature conditions, from that of the avocado red mite. In the summer, there may be two complete generations within a month. Under laboratory conditions, at a constant temperature of 77° F., only seven days are required to complete a generation, but at a constant temperature of 91.4° F. the mites died in all stages, including the egg (McGregor, 1941).

The drop of old leaves at the blooming period in the spring causes a heavy loss of overwintering mites. In Florida, summer rains keep down the mite population on the avocado, but in the drier summer climate of California, the population may build up rapidly and reach its highest levels in summer and fall.

Injury. The mites are found on the upper sides of the leaves, at first congregated along the midrib, then along the smaller veins, or even entirely over the upper leaf surfaces in heavy infestations. The area along the midrib, and finally along the smaller veins, becomes brownish. In addition to the typical discoloration of the leaf, an avocado brown mite infestation is characterized by the myriads of whitish hatched eggs and cast skins.

The destruction of chlorophyll no doubt reduces the value of the leaf to the tree. The green color returns if the mites are controlled. In severe infestations, there may be some defoliation. It appears that this species does not cause as much damage as one might expect when compared to the severe damage done by the six-spotted mite in similar numbers. Some growers have discontinued treatments for the avocado brown mite.

Control. In recent years, control measures have usually not been required in California, except where DDT has been used for the control of the greenhouse thrips or omnivorous looper, in which case the insect and mite treatments may be combined. The avocado brown mite is especially well controlled with sulfur, which is most economically applied as a dust. From a quarter to a half pound of sulfur is required per tree, depending on its size. Sulfur is only effective at temperatures above 70° F.

Six-Spotted Mite

The six-spotted mite, *Eotetranychus sexmaculatus* (Riley) (pl. IV, 7), has been an occasional pest of citrus in the coastal area of southern California for many years, but was not noticed on avocados until 1947 (Oldham and Thorne, 1947). The mite has caused sporadic damage to avocado trees since 1950.

The six-spotted mite has been described in chapter 7 as a pest of citrus. As on citrus trees, the mites are found on the underside of the leaf, but instead of being confined to definite areas they are considerably scattered about. However, an incipient infestations they are principally found along the midrib and larger veins of the leaf. The first indication of an infestation is a yellowish or brownish discoloration in these areas. In contrast to the effect of the avocado brown mite, a rather light infestation can cause a surprising amount of defoliation. Of the principal avocado varieties, the Hass, Anaheim, Nabal, Wurtz, and Carlsbad appear to be the most severely attacked.

Control is the same as for the citrus red mite (see page 147, chapter 7).

Other Mites

The broad mite, *Hemitarsonemus latus* (Banks) (fig. 9-1), is a minute, hyaline species (Hirst, 1921) that sometimes attacks the tips of avocado, guava, mango, and citrus seedlings in greenhouses, causing a severe crinkling and dwarfing of ter-

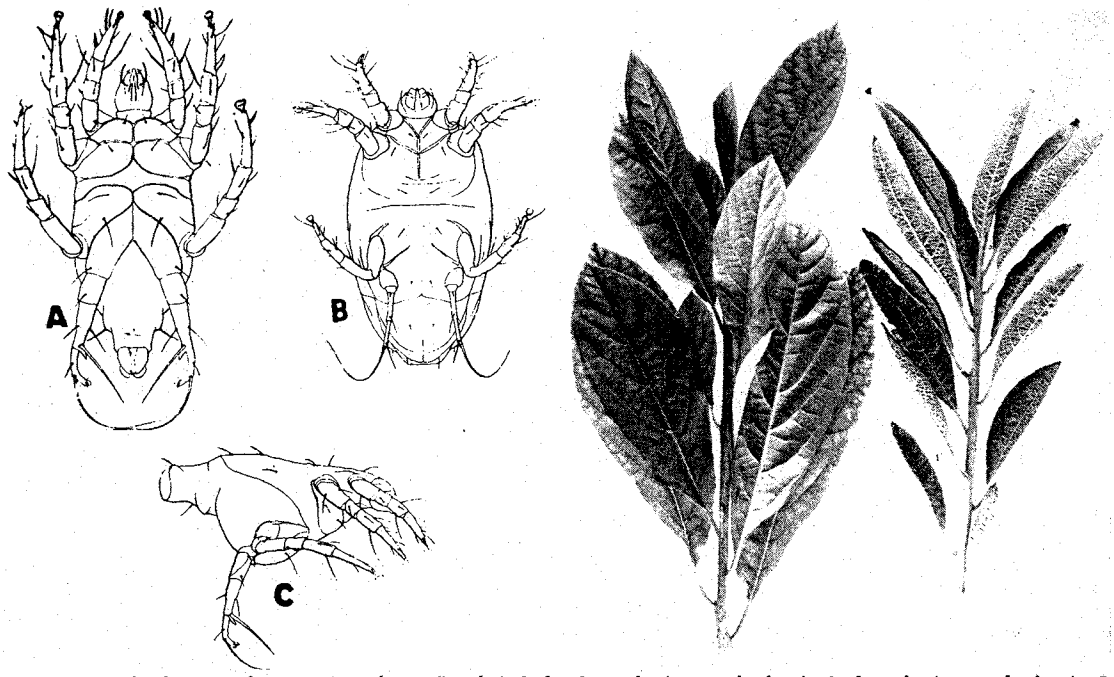

Fig. 9-1. Broad mite, *Hemitarsonemus latus* (Banks). Left: *A*, male (ventral view); *B*, female (ventral view); *C*, male (side view). (After Hirst, 1921.) Right: Normal foliage of an avocado terminal and dwarfed and crinkled foliage of a terminal infested with broad mite.

minal foliage (fig. 9-1). It is found on many varieties of plants throughout the country in greenhouses and is controlled with repeated applications of sulfur dust.

The platanus mite, *Oligonychus platani* (McGregor), was first found on avocado trees in 1952 (Fleschner and Ricker, 1952). It is believed to be generally distributed on avocados throughout southern California but is considered to be under satisfactory natural control.

The pallid mite, *Tydeus californicus* (Banks), is commonly confused with the six-spotted mite in field observations, although it is more whitish in appearance and has no black spots (Fleschner and Arakawa, 1953). It is abundant on avocado trees in some orchards. However, even heavy infestations appear to cause no perceptible injury, although the mite is undoubtedly phytophagous. In plots in which it had been controlled by spraying for two years, the trees appeared to be no more vigorous than adjacent trees with heavy infestations.

Brevipalpus australis (Tucker), the cause of citrus scaly bark or leprosis in Florida, was found on avocado foliage by C. A. Fleschner in the La Habra Heights area of Los Angeles County in 1953.

The avocado bud mite, *Epitrimerus myersi* Keifer, is a tiny eriophyid that was first found on avocado in 1938. It is quite widely distributed throughout the avocado-growing areas of California. The writer has found as many as 186 under the "button" of an avocado, but there is no evidence that the mites cause appreciable injury of any kind.

Calepitrimerus muesebecki Keifer is another eriophyid. It was found on avocado in Ventura County in 1954, and the infested orchard was sprayed in an attempt at eradication. This species had previously been known only in Florida.

Natural Enemies of Mites

Over forty species of mites and insects that are predaceous on avocado-infesting mites have been found (Fleschner and Ricker, 1953*a*). Some are general predators, such as the green and brown lacewings, the dusty-wings, and certain lady beetles, that feed on a wide variety of mites and insects. Others, such as the beetles *Stethorus picipes* (Casey) and *Oligota oviformis* (Casey) (=*Somatidium*), and the larvae of certain cecidomyid flies, as well as certain predaceous mites, confine their attention to plant-feeding mites (fig. 9-2). Fleschner and Ricker believe that by far the most important

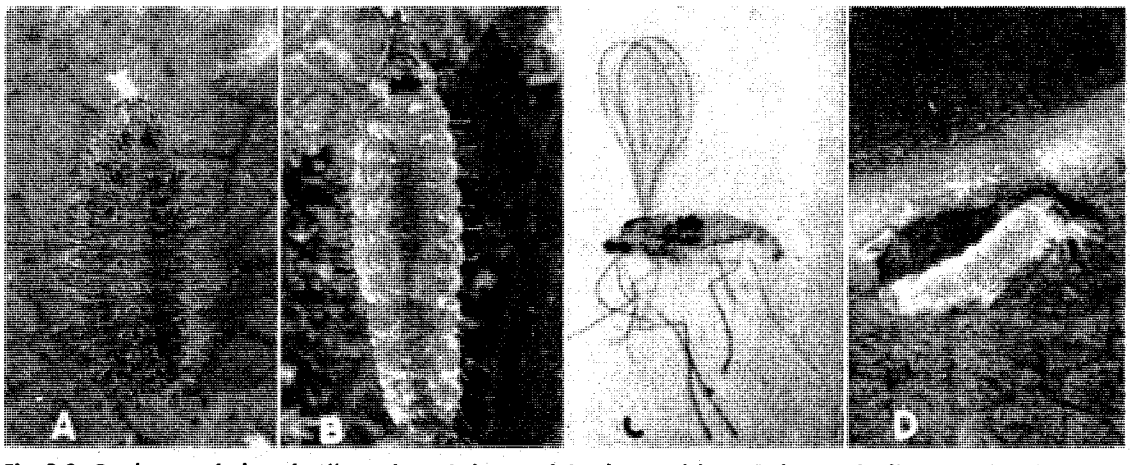

Fig. 9-2. Predators of plant-feeding mites. *A*, larva of *Stethorus picipes*; *B*, larva of *Oligota oviformis*; *C* and *D*, adult and larva of *Arthrocnodax occidentalis*. All larvae are feeding on six-spotted mites.

of the natural enemies of avocado mite pests are the predaceous mites of the genus *Typhlodromus* (fig. 9-3). The species involved are *T. finlandicus* (Oudemans) and another closely related species; also *T. longipilus* Nesbitt, *T. similis* Koch, and *T. conspicuus* (Garman). The last-named species is the only one of them that feeds and reproduces on *Tydeus californicus* (Banks), and apparently feeds only on this species. The mites can keep the pest population at extremely low levels and then survive on the eggs and immature stages of various insects and on honeydew and nectar.

Unfortunately, the typhlodromids, unlike the insect predators, succumb to most of the acaricides, and they are also susceptible to some of the

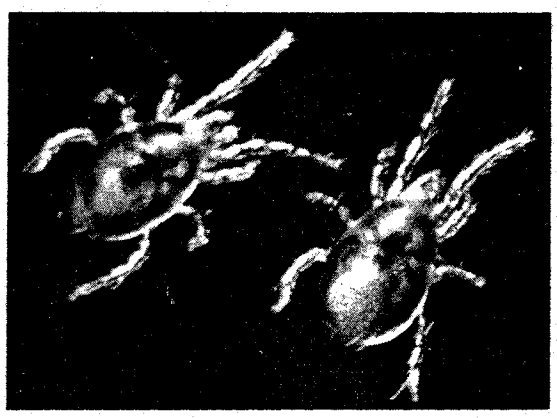

Fig. 9-3. Predaceous mites, *Typhlodromus finlandicus*. (Courtesy of C. A. Fleschner.)

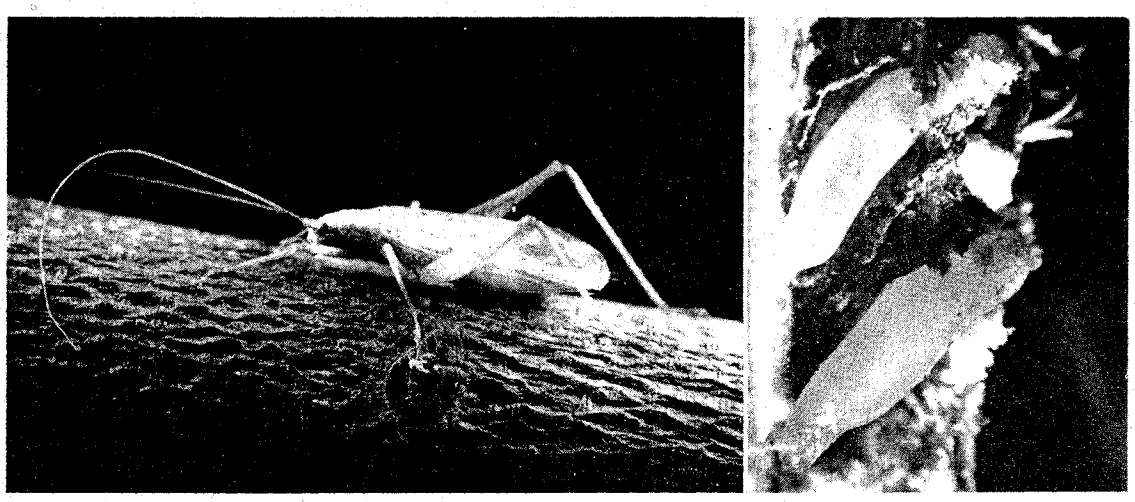

Fig. 9-4. The snowy tree cricket (left) and its eggs embedded in an avocado twig (right).

insecticides, such as DDT. Unlike the plant-feeding mites, they are adversely affected by road dust. Thus, the avoidance of insecticides and dust favors not only the work of insect predators, but also the most important of all the mite predators, which happens itself to be a mite.

Snowy Tree Cricket

The snowy tree cricket, *Oecanthus niveus* (De Geer), is a minor pest of the avocado. Green twigs of avocado trees are occasionally injured by the egg-laying punctures (fig. 9-4) of this insect. If the infestation is sufficiently severe, some small twigs may be killed, but apparently no damage of economic importance has ever been observed on avocados. Among the other subtropical fruit crops, these insects have been found attacking cherimoya trees, and on persimmon trees they are known to be carriers of a disease-causing fungus that attacks the twigs.

Greenhouse Thrips

The greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), is almost a cosmopolitan pest in tropical and subtropical regions and in greenhouses in temperate regions. In California and Florida, it occurs outdoors on avocado, citrus, and many other hosts. Except during years following winters of exceptionally low temperatures, the greenhouse thrips population may become so great, if uncontrolled, that from 50 to 90 per cent of some varieties of fruit may become scarred in coastal areas.

Hosts and Varietal Susceptibility. Other subtropical fruit crops attacked are the mango, sapote, cherimoya, guava, and grape. Among ornamental plants, the carissa, rose, arbutus, viburnum, statice, mandevilla, fuchsia, eugenia, hibbertia, myrtle, azalea, euonymus, saxifrage, vaccinium, rhododendron, cypress, eucalyptus, and mesembryanthemum are especially severely attacked. They should be removed as sources of infestation if they are growing adjacent to avocado plantings. Among the avocado varieties, the Mexican seedlings, such as Northrop and Puebla, are most severely attacked. Since they are of no commercial value and may serve as sources of infestation for commercial varieties, they should either be removed or treated at the first sign of thrips.

Among the least susceptible varieties are the Anaheim and Nabal. The Fuerte and Dickinson are also relatively resistant when compared with such highly susceptible varieties as Itzamna, Hass, Carlsbad, Benik, Queen, Panchoy, and Milly-C.

Description. The minute, white, reniform (kidney-shaped) eggs are inserted singly into the leaf tissue beneath the epidermis of either the upper or lower leaf surface or into the fruit (fig. 9-5). They continue to increase in size and become considerably swollen and distorted near the end of the incubation

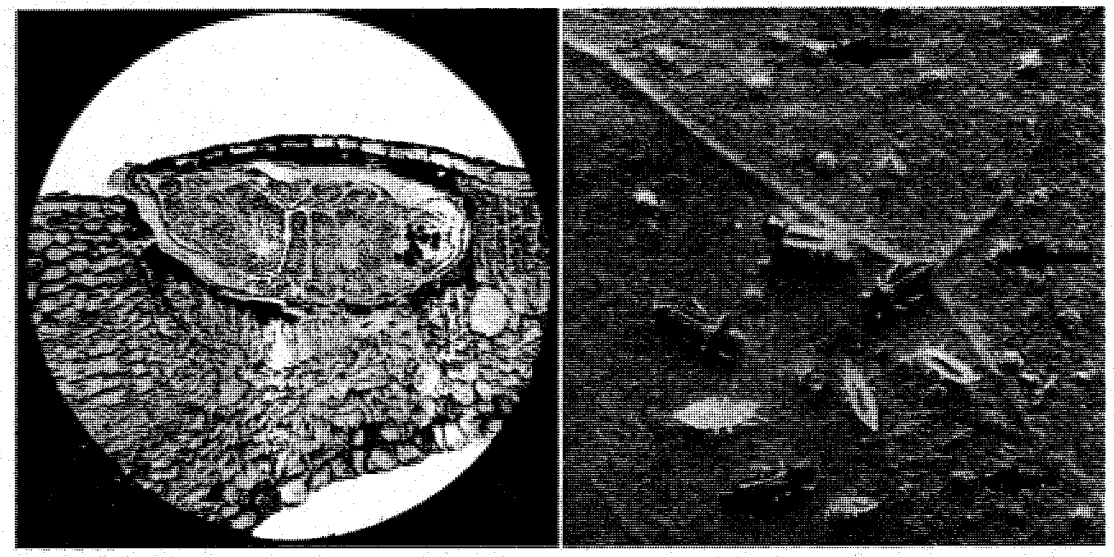

Fig. 9-5. Left, cross section of a greenhouse thrips egg inserted beneath the epidermis of an avocado leaf in the typical manner. Right, larvae, prepseudopupa, and adults of greenhouse thrips on carissa. Note "egg blisters," some with exit holes (arrows) of egg parasites.

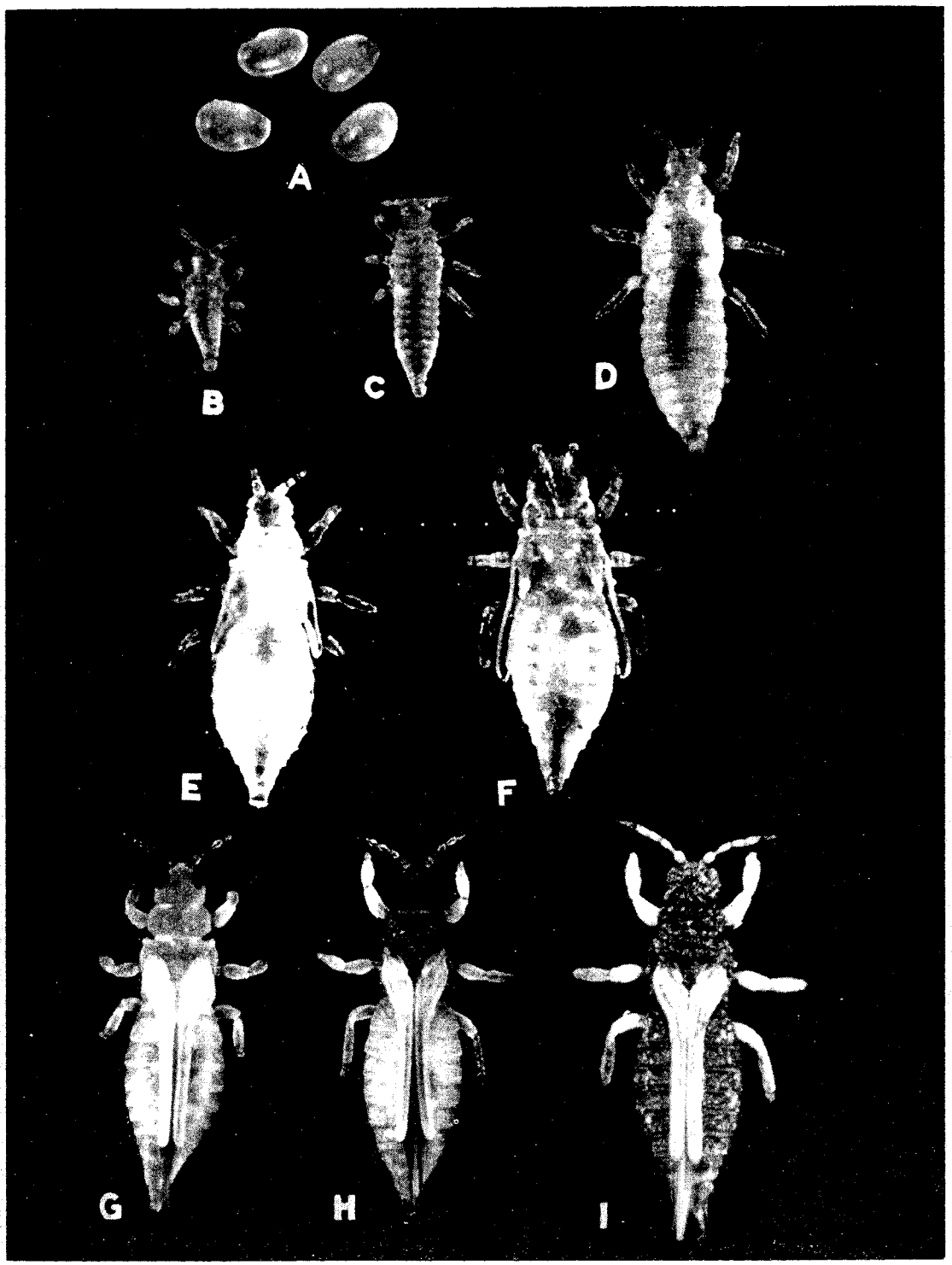

Fig. 9-6. Life stages of the greenhouse thrips. *A*, eggs in late stages of development; *B*, newly emerged first-instar nymph; *C*, fully developed first-instar nymph; *D*, second-instar nymph; *E*, prepseudopupa; *F*, pseudopupa; *G*, newly emerged adult; *H*, adult one hour old; *I*, adult several hours old.

period. This gradual increase in size causes a corresponding swelling of the leaf cuticle. The "egg blisters" (fig. 9-5) denoting the locations of the eggs are then readily seen with the aid of a hand lens, although when the eggs are first laid there is no outward evidence of their location.

The two nymphal instars (fig. 9-6, *B*, *C*, and *D*) are whitish to slightly yellowish; the eyes, as in the pupal stages, are red. The nymphs support on six anal setae a globule of fecal liquid, which is at first reddish and then becomes black. The globule of liquid increases in size until it falls off; then another begins to form. The result is a characteristic dotting of the infested areas with the black specks of fecal material.

The prepseudopupae and pseudopupae (fig. 9-6, *E* and *F*) are also whitish to slightly yellow. In the pseudopupae, the antennae are bent backwards. The mouth parts of both pseudopupal stages are nonfunctional and there is no feeding.

Immediately upon emerging, the adult is whitish throughout (fig. 9-6, *G*). It is about 1.25 mm. long. Within an hour, the head and thorax become black (fig. 9-6, *H*). In a few more hours, the entire body becomes black, with the exception of the legs and wings, which remain white (fig. 9-6, *I*). (See also pl. IV, 8.) All stages are sluggish, and the adults seldom fly. Males are practically unknown.

Life History. The parthenogenetic female makes incisions in the leaf or fruit surface with its strong, serrate ovipositor. During one experiment, adult females laid no more than one or two eggs (average 0.73) per day, or an average of 38.2 per female, of which an average of 46.5 per cent hatched (Ebeling and Pence, 1953*b*). In the experimental orchard at the University of California at Los Angeles, there were five generations from November, 1946, to November, 1947, and in Carlsbad, California, under milder climatic conditions, there were six.

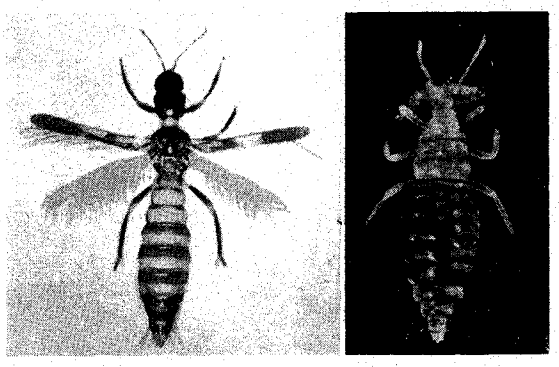

Fig. 9-7. *Franklinothrips vespiformis*, a predator of greenhouse thrips. Left, adult; right, nymph feeding on a greenhouse thrips.

Injury. Thrips injury on the foliage begins to become apparent, usually sometime in June, in the form of small, whitish, silvery, or ashy-gray patches on the upper leaf surfaces, where the thrips are found in greatest numbers. The greatest numbers or thrips are found inside and on the north side of the tree, away from the direct rays of the sun.

The whitish discoloration of foliage and fruit caused by early infestations changes to a brownish discoloration later in the season (pl. V, 1). The epidermis of both leaves and fruits becomes thickened, hardened, and cracked, and the characteristic black specks (see fig. 17-2) of thrips excrement become noticeable on the infested parts. It is not likely that much damage is done to the tree by extraction of sap and chlorophyll. The commercial damage consists mainly in the reduced value of the fruit owing to cullage of discolored, cracked, scarred, and decaying fruit.

Natural Enemies. What appears to be the most important natural enemy of the greenhouse thrips is a hymenopterous egg parasite, *Megaphragma mymaripenne* Timberlake. At times, more than half of the "egg blisters" seen on avocado leaves and fruit have the exit holes of this parasite (fig. 9-5), indicating that it may be of some importance in keeping down the thrips population.

A predatory thrips, *Franklinothrips vespiformis* (Crawford) (fig. 9-7), was found abundantly on Pike sapote trees in the university orchard in Los Angeles and was observed feeding on thrips on these, but not on avocado trees. Moulton (1932), however, states that the species is found on avocados and citrus in Florida, Texas, Cuba, Nicaragua, and Brazil. It has been reported as a predator of greenhouse thrips on citrus and avocado in British Guiana (Bodkin, 1917). E. A. McGregor found it on citrus in the Imperial Valley in 1926, the first record of the species in California.

Another predatory thrips, the black hunter, *Leptothrips mali* (Fitch), has been found sparingly under circumstances which indicate it may prey on greenhouse thrips. Another species, *Watsoniella flavipes* (Jones) (see page 297 of this chapter), attacks both the greenhouse thrips and the latania scale.

Artificial Control. Thorough spraying with 50 per cent DDT wettable powder at 2 pounds to 100

gallons or 25 per cent malathion wettable powder at 2 pounds to 100 gallons is suggested for the control of the greenhouse thrips. Since DDT increases mite infestations, a suitable acaricide should be added to the spray material if this insecticide is used.

Dieldrin would be the most effective insecticide if it were approved for labeling. However, it tends to increase mite, latania-scale, and omnivorous-looper populations.

Red-Banded Thrips

The red-banded thrips, *Selenothrips rubrocinctus* (Giard), has been described in detail by Russell (1912). It is an important enemy of cacao in the West Indies, whence it gained a foothold in Florida and now attacks avocados, guavas, and mangos, as does the greenhouse thrips. The most noticeable characteristic of this species, as the common name implies, is a bright-red band across the body of all the immature stages and nearly all adults (Franklin, 1908). The adult female is about the size of the greenhouse thrips, dark brown or black in color, except for the aforementioned reddish band covering the first three segments of the abdomen and the anal segment. The wings are dark. The male is much smaller and is rarely seen.

The life history of the red-banded thrips is similar to that of the greenhouse thrips and it causes similar injury. The heavy summer rains in Florida are said to cause the destruction of large numbers of this species.

Control measures are the same as for greenhouse thrips.

Avocado Blossom Thrips

The avocado blossom thrips, *Frankliniella cephalica* (Crawford), is another avocado pest in Florida (Moznette, 1922*b*). It is about 1 mm. long and pale yellow. It was first collected in the mountains near Guadalajara, Mexico, on a native acacia-like plant. Its mode of entry into Florida is not known. The thrips lay eggs in the stems bearing the flower cluster as well as in the petioles of the individual flowers. They frequently cause a considerable shedding of the bloom, but the principal injury is due to their feeding on the stamens and other floral parts.

Avocado Whitefly

This species, *Trialeurodes floridensis* (Quaintance), is much smaller than the citrus whitefly, but similar in habits. The adults are less than 1 mm. long, with pale-yellow bodies and white wings. It is a native insect found on avocados in Florida wherever they are grown. It also has been collected from papaya, banana, guava, annona, and citrus. The avocado whitefly is a pest both in the orchard and the nursery. It is responsible for the development of sooty-mold fungus. Affected fruit must be cleaned before it is packed.

Seasonal History. The avocado whitefly spends the winter in the pupal stage. Adults are found in great numbers on new growth in the spring, and the females mate and deposit about 100 eggs on the lower surfaces of the young leaves in March. The pearly-white eggs are usually placed in circles. The young are semitransparent and yellowish. There are three nymphal instars, requiring 5, 5 to 6, and 7 days, respectively, then a pupal stage of 15 to 30 days in summer, and from 3 to 6 months in fall and winter. There are three generations and sometimes a partial fourth.

Control. In Florida, an oil emulsion has been recommended in the fall at the time the avocado foliage begins to harden, and again in the spring after the fruit has set. The fall spray should be at 1.5 per cent and the spring spray at 1.25 per cent. This program will also result in the control of the dictyospermum scale (Moznette, 1922*b*). In Hawaii, sprays of 0.032 per cent parathion and 0.063 per cent EPN have given excellent control. Good controls were also obtained with DDT, methoxychlor, chlordane, toxaphene, dieldrin, and aldrin on beans.

Greenhouse Whitefly

The greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), is a general feeder. It has occasionally been found in appreciable numbers outdoors on the avocado, particularly on young nursery trees, which at times may be severely attacked. The stages one is most likely to find on the foliage are the nymphs and pupae. These are oval, thin, flat, and a semitransparent pale green in color. The pupae are distinguishable by the long filaments extending from their bodies.

Control. Various formulations of spray oil with nicotine or pyrethrum have been used with some degree of success in the control of the greenhouse whitefly. Oil plus DDT is effective against all stages. Excellent results have been obtained by spraying with 25 per cent parathion wettable powder at 1 pound to 100 gallons.

Aphids

Aphids apparently become sufficiently abundant to be injurious on avocado trees only when the latter are situated close to heavily infested citrus trees. In such instances, the species on avocado have been the same as those on the citrus trees from which they migrated, principally the spirea aphid, *Aphis spiraecola* Patch, and the melon aphid, *A. gossypii* Glover. On avocado trees isolated from citrus trees, the only species that have been found in California are the melon aphid, the dock aphid, *A. rumicis* L., and *Thoracaphis umbellulariae* Essig. Infestations of these species have been confined to an occasional succulent twig terminal. Nicotine sulfate, oil-rotenone, or TEPP (tetraethyl pyrophosphate) preparations, currently being used for the control of aphis on citrus, could also be used on avocado trees if required.

Long-Tailed Mealybug

The long-tailed mealybug, *Pseudococcus adonidum* (L.) (see fig. 7-21, *D*), is the most important of five species of mealybugs that may be found on avocado trees, the others being *P. gahani, P. maritimus, Phenacoccus colemani,* and *Planococcus citri.* The biology of the long-tailed mealybug is discussed on page 180, chapter 7.

The introduction of two hymenopterous parasites, *Tetracnemus peregrinus* and *Anarhopus sydneyensis,* into avocado orchards in San Diego County, California, in 1941, resulted in the control of once-serious infestations of long-tailed mealybugs. More recently, a new parasite, *Anagyrus kivuensis* Compere, three new lady beetles, *Scymnus quadrivittatus* Mulsant and undescribed species of *Pullus* and *Scymnus,* have been obtained from South Africa and liberated in avocado orchards in San Diego County. It is hoped that these species will further improve biological control.

In recent years, much grafting has been done in the coastal areas in California on varieties which have been found to be commercially unsuitable in these localities. Despite the generally good natural control of mealybugs on the average avocado tree, on grafted trees they may still be an important problem. The scions are covered with paper bags to keep the direct sunlight off the tender new foliage. The shade afforded makes it possible for the mealybugs to attack this foliage. Unless they are controlled, the mealybugs usually kill the scion. Predators and parasites are not able to control the mealybugs before they destroy the scions.

Control. In grafting, the trunk or several larger limbs of the trees are cut off, and usually two scions are placed in clefts at either side of the sawed-off area. After grafting is done, the top of the trunk or limb and the sides, or about six inches from the top, should be treated with chlordane or dieldrin to control ants.

Pyriform Scale

This scale, *Pulvinaria pyriformis* Cockerell, is a species that sometimes causes serious injury to avocado trees in Florida. It not only extracts the sap from the foliage, but excretes large quantities of honeydew which support the sooty-mold fungus. As the name implies, it is a pear-shaped scale. It is about 3 mm. long, and secretes from its margin curled, waxy filaments. The winter is spent by the female in a half-grown condition. The overwintering scales mature in the spring and lay eggs. The males emerge from scales that have no cottony secretions. There are several overlapping generations per year, infesting only the foliage.

Control. Control may be the same as that for dictyospermum scale, given later in this chapter. Parathion 15 per cent wettable powder at 1 pound to 100 gallons has been used successfully (Wolfenbarger, 1958).

Other Unarmored Scales

Among the unarmored scales that attack the avocado are the soft scale (*Coccus hesperidum* L.), hemispherical scale (*Saissetia hemisphaerica* [Targ.]), black scale (*S. oleae* [Bern.]), and the European fruit lecanium (*Lecanium corni* Bouché). These are all quite effectively controlled by parasites, and only rarely do they increase to more than a localized infestation in an occasional tree in the orchard.

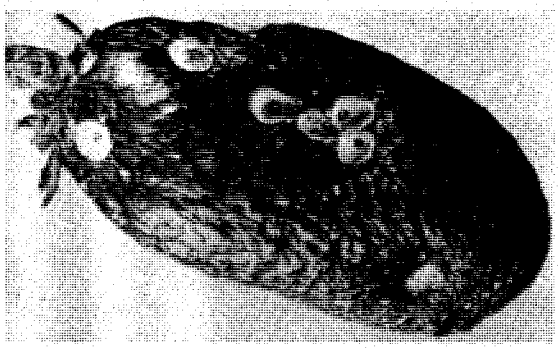

Fig. 9-8. A small avocado with latania scale.

Latania Scale

The latania scale, *Hemiberlesia lataniae* (Signoret), an armored scale, inhabits many regions of the world on a large number of hosts. In California, however, it was practically unknown until a survey made by state and county officials in 1928 revealed that it was the principal scale pest of avocado.

Description. The armor or scale covering of the adult (fig. 9-8) is removable at all times. It is circular, 1.5 to 2 mm. in diameter, and rather strongly convex. The armor can easily be confused with that of the oleander or greedy scales, being of the same gray color. The exuviae of the latania scale are central or subcentral and generally yellow or light brown in color.

The cleared and stained pygidium of the latania scale can be readily distinguished from those of the oleander and greedy scales (see fig. 7-35, *A*). The pygidium of the latania scale has only one pair of lobes, being similar to that of the greedy scale, although a microscopic examination will show definite differences. Circumgenital gland openings do

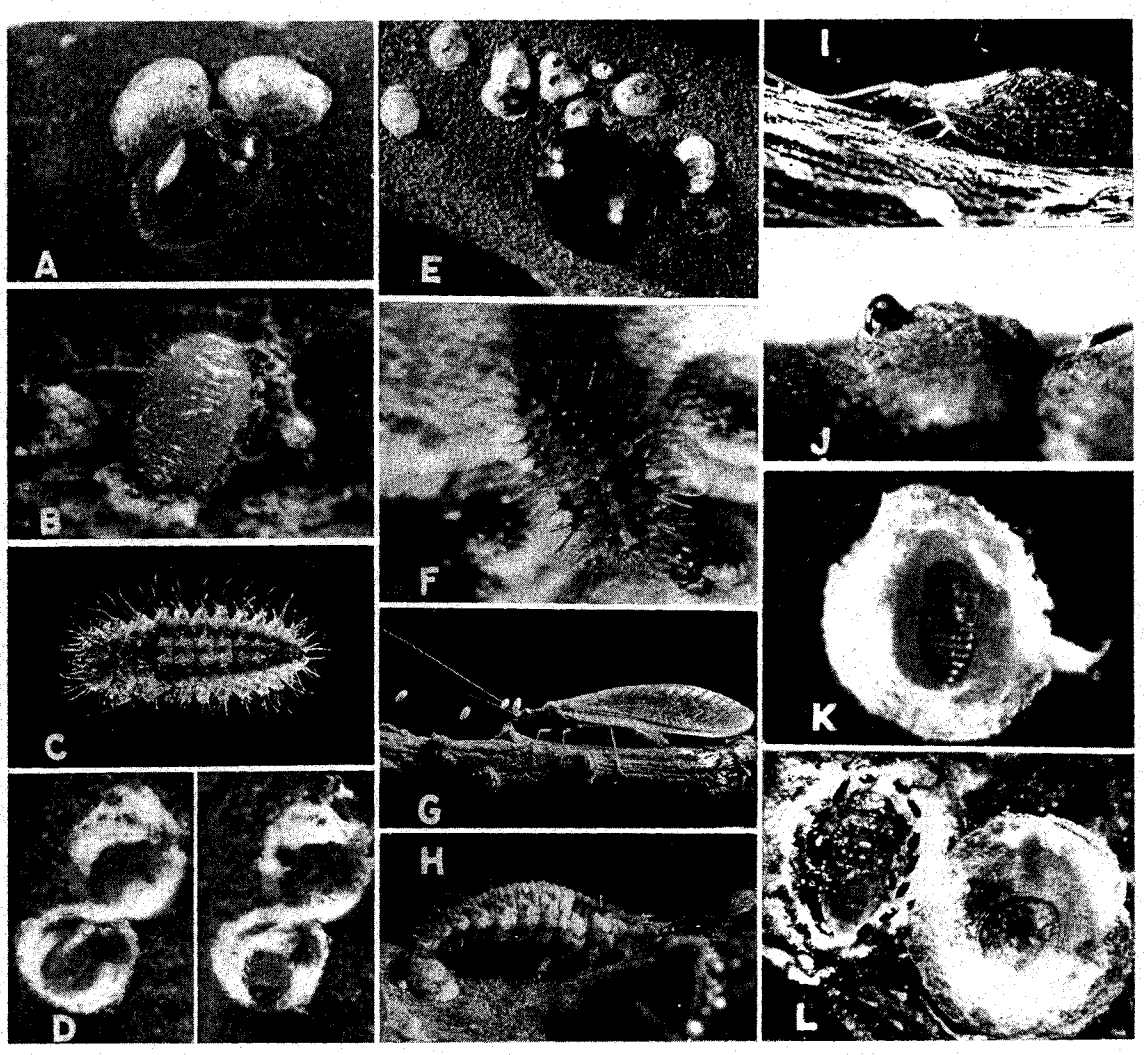

Fig. 9-9. Some natural enemies of the latania scale. *Lindorus lophanthae*: *A*, adult feeding on mature scales; *B*, pupa; *C*, larva; *D*, egg deposited under a scale (left) and hatching (right). *Chilocorus stigma*: *E*, adult feeding on mature scales; *F*, larva. *Chrysopa californica*: *G*, adult and stalked eggs; *H*, larva. *I*, adult of *Hemerobius pacificus*. *Thysanus* sp. nov.: *J*, adult emerging from a scale; *K*, pupa under scale armor. *L*, scale armor displaced to reveal pupa of the parasite, *Aphytis proclia*, surrounded by fecal pellets.

not occur on the pygidium of the greedy scale, but are present on the pygidium of the latania scale (McKenzie, 1935).

Life History. Upon turning over the scales, one may often find the yellow eggs, or the sulfur-yellow crawlers which hatch therefrom, within a few hours. The crawlers usually settle near the parent within a half a day after hatching, and like other armored scales, they start secreting the wax which forms the scale covering. In about 2 weeks, the insect undergoes its first molt, the process requiring 2 or 3 days. In 16 to 19 days afterward, the second molt occurs, and the insect enters the adult stage. Males have been recorded by several authors, but have not been found in California. Isolated females lay eggs, proving that they can reproduce parthenogenetically. In 26 to 30 days after the second molt, crawlers appear. In the summer, it has been found that the life cycle of the latania scale is 56 to 65 days in coastal San Diego County (McKenzie, 1935).

Injury. The scales are usually most abundant on the branches or twigs, but may appear on the leaves and fruit as the infestation increases. The smaller twigs may be killed. The fruit is degraded or culled because of the presence of the scales on the peel, although the quality of the fruit is not affected. On the Fuerte and possibly other thin-skinned varieties, the rostralis of the scale appears to cause an irritation in the flesh, as indicated by nodules adhering to the inside of the peel when it is removed. Corresponding depressions occur in the flesh of the ripe fruit. The Anaheim appears to be the most severely attacked of all varieties.

In former years, the latania scale was a much more important problem than it is today. In one packing house, the fruit was washed in a special solution and vigorously brushed to remove the scales. A considerable acreage was also fumigated or sprayed. At present, there are apparently no treatments being made for latania scale, although a small percentage of the fruit is infested in some orchards. The improved situation is apparently owing to the work of predators and parasites.

Natural Enemies. It appears that the most important predator of latania scale in California is the twice-stabbed lady beetle, *Chilocorus stigma* (Say) (fig. 9-9, *E*, *F*). This beetle is 4 to 5 mm. long, nearly hemispherical, and shining black, except for a red spot slightly anterior to the middle of each elytron (wing cover). The cylindrical, orange eggs are laid singly or in small groups in the crevices of the bark. The larvae are 5 to 7 mm. long and black, except for a yellow transverse band. They possess many long, branched spines.

Generally, a large percentage of adult latania scales have holes eaten into the armor (fig. 9-9, *E*) by the twice-stabbed lady beetles. The great destruction wrought by a relatively few beetles is very impressive.

Another predator, Blaisdell's lady beetle, *Lindorus lophanthae* (Blaisdell) (fig. 9-9, *A* to *D*), is 2 mm. long, reddish brown except for the shiny, black elytra, and has minute, white hairs densely covering the body. The full-grown larvae are 3.5 to 4 mm. long, and are dark-colored, except for a quadrangular whitish area on the dorsum of the first to fourth abdominal segments.

The blood-red lady beetle, *Cycloneda rubripennis* Casey, also occurs as a predator of the latania scale in avocado orchards. This and the above two species have the disadvantage of being effective only when the scales are so abundant as to be injurious to the trees. Seven other species of scale-feeding lady beetles have been introduced into avocado orchards in recent years (Bartlett and DeBach, 1952).

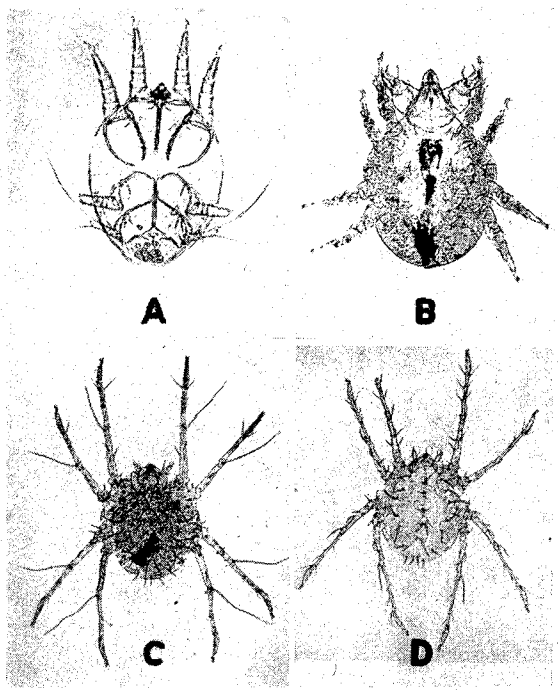

Fig. 9-10. Mites that attack latania scale. *A*, the "traveling form" of *Hemisarcoptes malus*; *B*, *Cheletomimus berlesei*; *C*, *Neophyllobius americana* Banks; and *D*, *N. agrifoliae* McGregor.

Besides attacking the latania scale themselves twice-stabbed lady beetles carry about, generall beneath their elytra, the "traveling form" (fig 9-10, *A*) of a parasitic mite, *Hemisarcoptes malus* Banks. These mites have the remarkable ability of clinging to the beetles, even being dragged about by the legs of the latter, and sometimes with only their long anal hairs as a means of attachment. Upon reaching the scales, the "traveling form" drops off and attempts to crawl beneath the armor of the latania scale. It can only enter after the newborn scale crawlers have started to emerge and have raised the waxy margin of the scale sufficiently to allow for their exit. After getting under the scale armor, the mite assumes a greatly different appearance, feeds on the underside of the scale, and lays great numbers of remarkably large eggs (fig. 9-11). This species was first noticed in avocado orchards in California in 1948 (Bartlett and DeBach, 1952). It was reported to be attacking the Florida red scale in Florida in 1947 (Mathis, 1947), and has long been known as an effective natural enemy of the oystershell scale in the northeastern states and Canada.

A predaceous mite, *Cheletomimus berlesei* (Oudemans)[1] (fig. 9-10, *B*), is found abundantly practically wherever latania scales occur. It feeds on the crawlers. This mite is circular, reddish, and about 0.5 mm. long. Its eggs are spherical and ruby-colored, and are held in position by a few guy threads. Certain species of caligonellid mites of the genus *Neophyllobius* (fig. 9-10, *C* and *D*) also attack the latania scale.

The well-known California green lacewing, *Chrysopa californica* Coquillett (fig. 9-9, *G* and *H*), which is a rather general predator and is found most frequently in aphid colonies, may occasionally be found feeding on all stages of the latania scale. In attacking the adult scale, the larvae force their mandibles under the armor, pierce the body, and suck the body contents. The brown lacewing, *Hemerobius pacificus* Banks (fig. 9-9, *I*), also feeds on latania scale, although it is more often found attacking mites and aphids.

A predaceous thrips, *Watsoniella flavipes* (Jones) (=*Cephalothrips errans* Moulton and *Karnothrips flavipes* [Jones]), is found in small numbers in avocado orchards in southern California. The adults are black, and less than 2 mm. long.

[1]The mites of the genera *Cheletomimus* and *Neophyllobius* were identified by E. W. Baker of the U. S. National Museum, Washington, D.C.

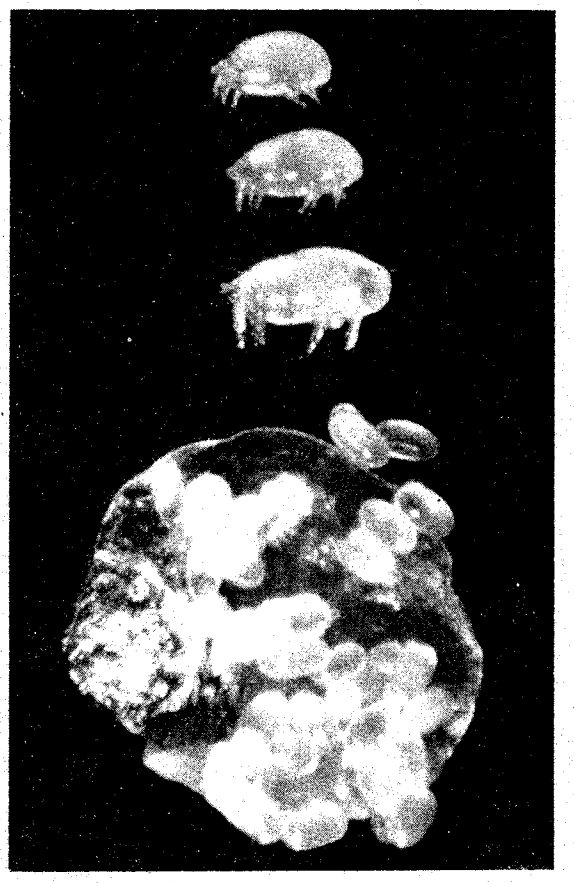

Fig. 9-11. A form of *Hemisarcoptes malus* found under the bodies of latania scales. Top, mites; bottom, eggs—all found under the scale shown.

They may be found under the scale coverings of latania scales, hiding under loose bark, or in the crevices of branches.

A small chalcid, *Aphytis proclia* (Walker) (=*Aphelinus diaspidis* Howard), attacks the latania scale. The larvae feed externally beneath the armor on the body of the scale (see fig. 6-2). They are broad and flattened against the body of the scale, are about the same color as the scale, and are not easily discernible. The pupae (fig 9-9, *L*) are surrounded by a ring of fecal pellets, known as "meconia."

Another hymenopterous external parasite, of the genus *Thysanus*, was found in the University of California experimental orchard in Los Angeles. The larvae are pale, taper toward each end, and are more elongate than are those of *Aphytis proclia*. The pupae (fig. 9-9, *K*) darken with age until they become a shining black. The adults (fig. 9-9, *J*)

are also a shining black. The members of this genus had previously been known only as hyperparasites.

An internal parasite, *Aspidiotiphagus citrinus citrinus* (Crawford), was also discovered in the University's experimental orchard within some early-instar latania scales. There appears to be no other record to date of this species parasitizing latania scales. The adults measure 0.7 mm. in length and are pale yellowish tan. The larva or pupa may be clearly seen through the body wall of the host (see fig. 6-3).

In recent years, five species of hymenopterous parasites have been introduced from foreign countries to prey on latania scale: an *Aspidiotiphagus* from China and four strains of *Aphytis* from China, Formosa, Egypt, and Iraq. It is hoped that these species will become permanently established and will be effective in very light infestations of latania scale (Bartlett and DeBach, 1952).

Control. In the infrequent cases in which the control of latania scale may appear to be justified, malathion 25 per cent wettable powder at 3 pounds, or the 50 per cent emulsifiable solution at 1½ pints to 100 gallons, is effective against this insect as well as the greenhouse thrips, orange tortrix, and soft scale, and it does not aggravate the mite problem.

Dictyospermum Scale

A California state survey in 1930 showed the dictyospermum scale, *Chrysomphalus dictyospermi* (Morgan) (see p. 199, ch. 7), to be quite abundant on avocado trees in residential properties in Whittier but very scarce in commercial orchards. After the known infestations of significant importance were controlled, this insect again appeared from time to time in appreciable numbers in a few avocado orchards. In Ventura County, the agricultural commissioner has records of two infestations of dictyospermum scale on avocados and twelve on citrus. These were all exterminated.

In Florida, the dictyospermum scale infests young trees more than mature ones. It attacks twigs and branches, and, in severe infestations, the foliage also. The branches at the base of young trees are the most severely attacked. The foliage-bearing twigs and branches may become so weakened that the entire tree eventually becomes weak and very sparsely foliaged. Severely infested branches and twigs become roughened and crack, allowing for entrance of destructive fungi. This pest has decreased in importance in Florida during the last decade.

Control. Two pounds of 15 per cent parathion wettable powder was found to be superior to the previously used oil spray (Wolfenbarger, 1951), but 1 gallon (or slightly less) of light-medium oil plus 1 pound of 15 per cent parathion wettable powder to 100 gallons is currently preferred.

California Red Scale

The California red scale, *Aonidiella aurantii* (Maskell) (see p. 189, chap. 7), if it is present on avocado at all, will usually be found only on occasional trees, generally in proximity to some more favored host, such as citrus (pl. II, 8). Sometimes a tree may be severely attacked while neighboring trees are completely uninfested. An exception to the generally spotty distribution of the red scale in an avocado orchard was a rather heavy infestation in a fifteen-acre orchard of the Fuerte and Ryan varieties at Monrovia, California. This infestation was sprayed with 1⅔ per cent light-medium oil, with good results, on January 25–26, 1946.

The Hass variety of avocado is believed to be particularly susceptible to infestation of California red scale. All Hass nursery stock shipped into Ventura County from areas where California red scale is known to occur is vacuum-fumigated at the Ventura County Fumatorium. This stringent measure is taken as a part of the general program to eradicate red scale in the county, where it has not yet become well established on citrus and other crops.

Tea Scale

The tea scale, *Parlatoria theae* Cockerell, was found infesting avocado trees at Point Loma, San Diego County, in 1948 and was eradicated by the San Diego County Commissioner's office in March of that year. This species probably had been introduced from the Orient, where it is a pest of the tea plant.

Harlequin Bug

This insect, *Murgántia histrionica* (Hahn), is a black pentatomid bug, with bright-red markings on the dorsum (pl. V, 2). It varies from 8 to 11 mm. in length. The cylindrical eggs resemble tiny, white barrels with black hoops. It is a serious garden pest throughout the United States. This species occasionally attacks avocado trees and may cause serious

damage. It may be controlled by dusting with toxaphene, DDT, or benzene hexachloride.

False Chinch Bug

The false chinch bug, *Nysius raphanus* Howard, is a small, light or dark gray lygaeid bug, 3 to 4 mm. long (pl. V, 2). The pale-gray nymphs, with reddish-brown abdomens, swarm from dry grasslands onto adjacent cultivated areas, attacking nearly any green plant. There are from four to seven generations per year. On a number of occasions, young avocado trees have been attacked and severely injured. Two per cent aldrin dust has controlled severe infestations on avocados more effectively than other insecticides that have been tried.

Avocado Lacebug

The lacebugs are small, flat bugs (family Tingidae), with a reticulated surface that is often lacelike in appearance. The avocado lacebug, *Pseudacysta perseae* (Heidemann), is about 2 mm. long, blackish brown with yellowish-white legs, and with iridescent wings (Moznette, 1922*b*). It is often found in large numbers on avocado trees in the dry winter months in Florida. It usually occurs in colonies on the undersides of the leaves and deposits its eggs in clusters. Yellowish areas, even as seen through the foliage from the upper side of the leaf, indicate the location of a colony of lacebugs.

Control. Nicotine sulfate at 1:800, with 2 to 4 pounds of fish-oil soap to 100 gallons of spray, has been recommended for control of avocado lacebugs. This may be added to a lime-sulfur solution in a combined spray for avocado red mites and lacebugs. In recent tests, benzene hexachloride, lindane, and parathion show promise.

Mirids

In recent years, there have been occasional severe infestations of plant bugs of the family Miridae, particularly *Rhinacloa subpallicornis* Knight and *Lygus fasciatus* Reuter, in avocado orchards in Florida. These are small, soft-bodied insects, not over 7 mm. in length. They attack the opening buds and cause the young fruit to drop or become malformed. Leaves are attacked while still in the bud. The punctured tissue becomes necrotic, so that when the leaves expand they contain many holes (Wolfe, Toy, and Stahl, 1946).

Control. It is important to treat promptly when the infestation is first observed. Nicotine sulfate, pyrethrum, or rotenone at high concentrations have been used in the past against the nymphs, for the adults are hard to kill. More recently, D. O. Wolfenbarger has found benzene hexachloride to be highly effective against these pests, but he believes their importance has usually been overrated.

Darkling Ground Beetle

Darkling ground beetles, *Coniontis subpubescens* Leconte, are shining black or brown tenebrionid beetles about 8 mm. long. They are recorded as being injurious to sugar beets in southern California. They are a native species that may migrate into cultivated areas from the surrounding hills in enormous numbers. About the middle of April, 1949, these insects were found attacking newly planted avocado trees in Ventura County. These trees were protected with shingles. The beetles climbed up the shingles and ate the foliage adjoining them, but did not appear to be climbing up the trunks of the trees. At least, no foliage was eaten that was not in contact with the shingles. The beetles were effectively combated with poison bran mash spread on the ground around the trees.

Branch and Twig Borer

Occasional examples of severe injury to avocado trees from the branch and twig borer, *Melalgus confertus* (Leconte), have been noted since the earliest days of the avocado industry in California. The borers leave unmistakable signs of their work and can therefore be readily located. The entrances to the burrows made by the adults on avocado trees are very conspicuous, for the sugary sap ("dulcitol") that exudes becomes flaky or powdery and turns white, as in the case of injury by orange tortrix. Infested branches are easily broken by wind.

This bostrichid beetle is black with brown elytra, cylindrical in shape, and 7 to 13 mm. long. The

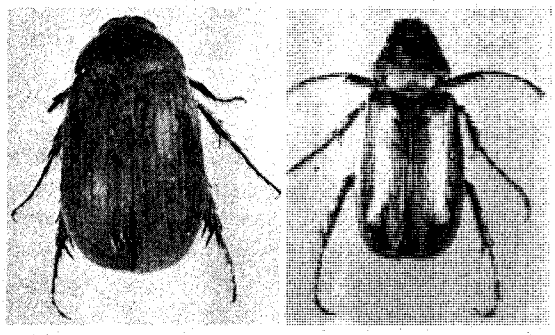

Fig. 9-12. June beetles. Left, *Serica fimbriata*; right, *Coenonycha testacea*.

adults burrow into the crotches or bud axils of native trees and of practically all kinds of fruit and nut trees in California and parts of Oregon. The robust, curved, whitish larvae burrow still farther, completely mining the heartwood.

Control. Apparently, the only effective control measure, especially since the infestations are so sporadic and unpredictable, is to cut and burn the infested branches or twigs. Native or cultivated trees in surrounding areas should be examined for possible sources of reinfestation.

June Beetles (Scarabs)

Of the June beetles attacking avocados, the species *Serica fimbriata* Leconte and *S. alternata* Leconte are the most familiar to the layman. They are found in practically any locality, and attack many trees and other crops besides the avocado. Both species are rather large and robust, *S. fimbriata* being 13 mm. and *S. alternata* 10 mm. long. The former is a smooth or velvety brown, with faintly striated elytra (fig. 9-12), while the latter is of a uniform shiny brown color.

June beetles are most injurious in young orchards planted near uncultivated land. They fly in from their breeding places in untilled fields and brushland and eat the foliage on the trees at night. They may completely defoliate hundreds of trees in a single orchard. During the day, they burrow into the soil to a depth of up to two inches, reappearing the following night to resume their feeding.

Coenonycha testacea Cazier (fig. 9-12) occurs over a wide area in California on certain species of native vegetation, but was first discovered on avocado trees in an orchard two miles south of Fallbrook, California, in February, 1946. Here the beetle did severe damage, stripping the foliage from young trees and completely destroying a small avocado nursery by feeding on the buds of newly budded seedlings. The beetle reappeared in the same orchard the following year, and also in neighboring orchards, and has been steadily increasing the range of its feeding on avocados in the Fallbrook area since 1946.

Coenonycha testacea belongs to the same family (Scarabaeidae) as the *Serica* beetles, but it is smaller and distinctly narrower. It measures about 10 mm. in length, approaches a rectangular shape in contrast to the broadly oval shape of *Serica*, and is proportionately narrower. *C. testacea* is shiny brown in color. This species first begins to feed on avocado foliage very early, about the first of February, and is found in appreciable numbers for only about a month. The *Serica* beetles appear about three months later, but the period of their activity is much longer.

Control. All three species discussed above are readily controlled with 5 per cent DDT dust. Control can be effected by applying the dust either to the foliage or to the ground beneath the tree.

Blossom Anomala

In Florida, another scarabaeid beetle known as the blossom anomala, *Anomala undulata* Melsheimer, may visit avocado blossoms in large numbers and cause serious injury (Moznette, 1922*b*). The adult varies from 7 to 9 mm. in length. It has a black thorax with a yellowish border, and the elytra are yellowish brown, sometimes verging on black.

The spikes are sometimes completely stripped of flowers by the blossom anomala, and they may even be completely cut off. The beetles feed at night and spend the day in the soil much as do June beetles, to which the anomala is closely related.

Control. The blossom spikes were in former years sprayed with lead arsenate, but it is likely

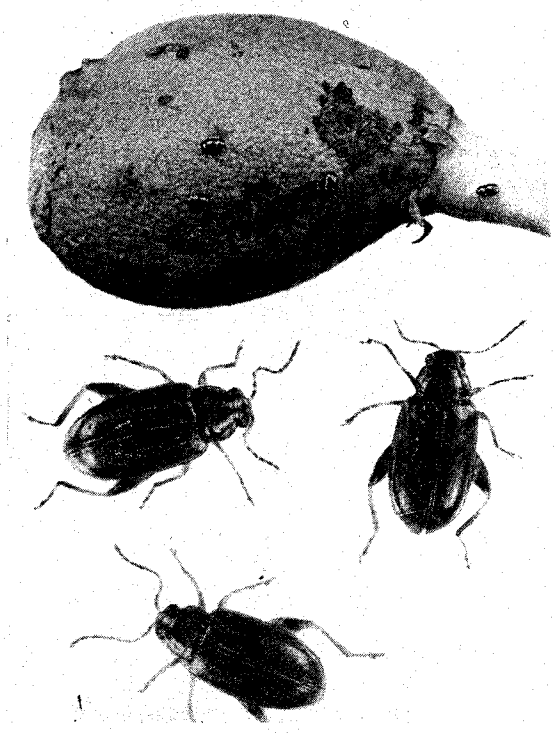

Fig. 9-13. Bronze willow flea beetles feeding on a young avocado (top) and enlarged (bottom).

that benzene hexachloride or some other of the organic insecticides would now prove to be a more effective remedy.

Bronze Willow Flea Beetle

This metallic-bronze chrysomelid, *Diachus auratus* (Fabricius), is only 3 mm. or less in length. It occurs in many parts of North and South America and is common on willow in New Mexico, Arizona, and California. It has caused damage to tender shoots of prune trees in California. In July, 1949, this beetle was found feeding on avocado fruits in an orchard near Santa Paula, California, causing a conspicuous scar on the peel (fig. 9-13). About 10 per cent of the fruit was affected.

These beetles also feed on tender avocado foliage, and could probably do much damage to seedlings or young trees. Infestations to date, however, have been found only in older orchards.

Control. A spray of 2 pounds of 50 per cent DDT wettable powder to 100 gallons was used with success in the control of the bronze willow flea beetle in one orchard.

Banded Flea Beetle

The banded flea beetle, *Systena blanda* Melsheimer (=*taeniata* [Say]), is of a yellowish or brownish color, and 3 to 5 mm. in length. It has a reddish head and two lateral black stripes on each wing cover, one bordering the inner margin. These beetles occasionally feed on avocado foliage and can seriously injure small trees.

This species occurs throughout the United States. The beetles lay their eggs on the host plants, usually near the ground. Among the hosts are various weeds, truck crops, grapevines, and the pear. The slender, white larvae live in the soil, where they pupate.

Fuller Rose Beetle

The Fuller rose beetle, *Pantomorus godmani* (Crotch), is about 10 mm. long and is a uniform pale brown (pl. III, 3). It feeds on the tender foliage of avocado trees and may at times do some damage to the younger ones. The feeding injury causes the leaves to have the same ragged appearance as injured citrus foliage. The characteristic appearance of this foliage is owing to the fact that these weevils feed from the margin of the leaf toward the midrib. On larger trees, foliage injured by Fuller rose beetles is ordinarily found only on the lower branches.

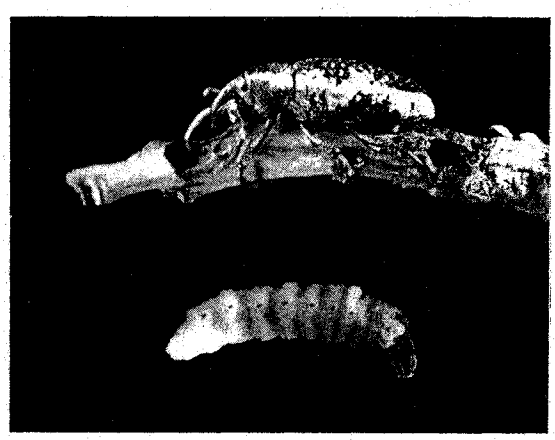

Fig. 9-14. Avocado tree girdler, *Heilipus squamosus*. Top, adult and holes in terminal twig caused by its feeding. Bottom, larva.

Details of the biology and control of the Fuller rose beetle are given on page 208. The vegetable weevil, *Listroderes costirostris obliquus* (Klug), which also occasionally feeds on avocado foliage, may be controlled in the same manner.

Adaleres Weevil

During the fall and early winter of 1949, newly planted avocado trees near Poway, San Diego County, were attacked by adaleres weevils, *Adaleres humeralis* Casey. The females of this species are about 13 mm. in length, while the males are somewhat smaller. These beetles are light to dark brown, with a grayish mottling on the elytra of some individuals. The elytra have rows of deep punctures. The weevils feed on the foliage and terminal buds, and their feeding can result in the death of young trees. Since they do not fly, they may be kept off the trees by means of sticky banding material.

Avocado Tree Girdler

This curculionid beetle, *Heilipus squamosus* Leconte, closely related to the avocado seed weevils of Mexico and Central America, was first recognized as a pest in southern Florida in October, 1947, although it is believed to have been in the region for at least 10 years before its discovery (Wolfenbarger, 1948). Among 512 trees in a young avocado planting, between 8 and 10 per cent of the trees were lost because of the attacks of this insect.

Description. The avocado tree girdler is about 13 mm. long and is black, with irregular white areas on its wing covers (fig. 9-14). It deposits its eggs on the bark at ground level. The pale-whitish

larvae become 13 to 16 mm. in length when full-grown. There appears to be one generation per year. The adults are most abundant in April, May, and June.

Injury. Masses of frass at the bases of the trees indicate the presence of the larvae boring within the trunk. In small trees, the larvae are nearly always found within six inches of the ground level. Only in large trees with twelve- to twenty-four-inch bases are they found up as high as two feet. The smaller trees are the more seriously injured. Yellowish leaves which fall prematurely are a symptom of injury that has been observed during February and March. Often, only a part of the tree shows this symptom. The adult beetles sometimes feed on young avocado fruits, eating away portions of about 4 to 13 mm. in diameter and up to 3 mm. deep. The fruit usually remains on the tree and scar tissue grows over the wounds. The adults also feed on terminal buds and other parts of the tender terminal twigs.

This weevil can be considered to be the most destructive avocado pest of southern Florida. It once caused considerable alarm, but has been decreasing in numbers in recent years.

Control. The larvae of the avocado tree girdler may be cut out of the trunk with a knife or other tool.

Seed Weevils

Seed weevils are among the most important pests of the avocado from Mexico to Panama, but no destructive species has been found in the United States. In California, a species of weevil known as the broad-nosed grain weevil, *Caulophilus latinasus* (Say) (fig. 9-15), may be found in avocado seeds, but only after they have fallen to the ground. It bores through the rotting flesh of the avocado and enters the seed. It has in a few instances attacked avocado seeds planted in nursery seedbeds. The resulting seedlings are less thrifty and may fail to reach adequate size for budding at the proper season.

The broad-nosed grain weevil is about 3 mm. long. It resembles the well-known granary weevil, *Sitophilus granarius* (Linnaeus), having the typical prolonged snout of the weevils, but is darker brown in color.

Ambrosia Beetles

Avocado trees which seem to be weak, and yet yield good crops and are commercially desirable,

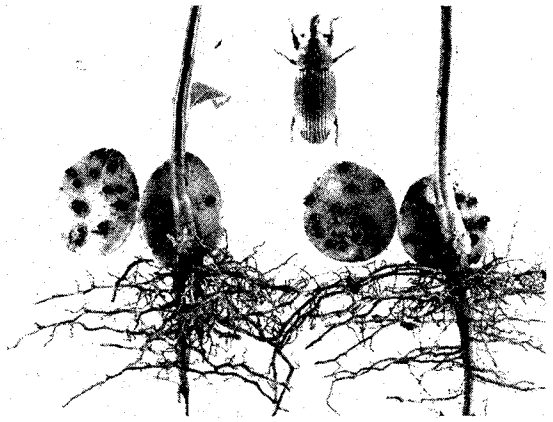

Fig. 9-15. Work of the broad-nosed grain weevil on planted avocado seeds. Inset: adult weevil.

are occasionally attacked by small beetles that cause the trunk and larger limbs to be riddled with small holes about 0.5 mm. in diameter. In one instance, these beetles were found to be small, cylindrical, brownish to black scolytid beetles, *Xyleborus xylographus* (Say) and *Monarthrum* sp., the former being the more numerous. These beetles infest many native trees in California. They often extend their brood chambers deep into the heartwood of the trees they attack. There they culture ambrosia fungi which serve as food for the larvae. In vigorous trees, the flow of sap drowns out the eggs and larvae. However, the working of these beetles may accelerate the death of weakened trees.

Control. An infestation may be controlled by applying a 5 per cent solution of DDT in kerosene on the surface of the infested trunk or branch by means of a paintbrush.

Fire Ant

Fire ants (*Solenopsis* spp.) (see p. 209, chap. 7) have girdled and killed young avocado trees in California and probably in other regions. Some believe the ants injure the bark in order to bring about a flow of sap, upon which they feed. The avocado tree "bleeds" copiously when injured.

Control. In California, a 5 per cent chlordane dust has been successfully used in the control of this pest.

Omnivorous Looper

As the common name implies, this insect, *Sabulodes caberata* (Guenée), feeds on a large number of plants. The term "looper" derives from the crawling habits that the larva shares with other

species of the family Geometridae. Members of this family are also called measuring worms, spanworms, or geometers, because of their looping method of locomotion. Prolegs are absent from the middle of the body and there are only two or three pairs at the posterior end, so the larvae must pull these up close to the true legs, thus looping their bodies, then firmly attaching the prolegs to the leaf and thrusting the fore end of the body forward.

Evidence of the presence of this native insect can be seen on almost any avocado tree in California, yet it seldom causes serious damage to foliage. However, in some orchards occasional trees may be severely attacked, and some varieties, like the Fuerte, are much more heavily infested than others. Although the omnivorous looper is distributed throughout California, it has not been recorded in any other western state.

Description and Life History. The eggs are ovoid, about 1.5 mm. long, and largest at the anterior end. They are deposited in clusters on the undersides of the leaves, each cluster consisting of from three to eighty eggs resting horizontally on the leaf surface. The eggs are at first metallic green but after two days turn to a chocolate brown (pl. V, 5). They hatch in eight or nine days.

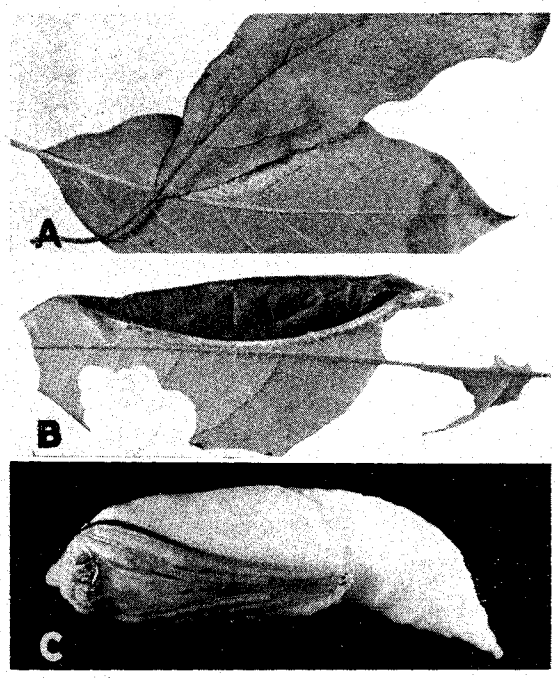

Fig. 9-16. Pupal stage of omnivorous looper. *A*, two leaves webbed together by larva for hiding during the day or for pupation; *B*, leaf folded for pupation; *C*, pupa in early period of development (it later becomes dark brown).

The first-instar larva is at first pale yellow and the same length as the egg. After the first instar, the larvae are yellow to pale green or pink, with yellow, brown, or green stripes on the sides and back. In addition, they have a number of black markings.

The second-instar larva is 7 mm. long, and has two dark bands along the sides of the body. The third-instar larva is about 13 mm. long, and has four dark bands along the sides of the body. The fourth-instar larva is a little more than 2 cm. in length, and has two black dots on the front of the head; otherwise, it is practically identical in appearance to the previous instar. The fifth and last instar of the larval stage (pl. V, 4) is 4 to 5 cm. long. The greatest damage is done by this instar. One individual may eat an avocado leaf in a single day.

The pupa may be found webbed between two leaves (fig. 9-16, *A*) or inside a leaf that has been folded and webbed together by the full-grown larva for the purpose of pupation (fig. 9-16, *B*). It is at first a pearly white (fig. 9-16, *C*), but becomes dark brown as the time for the emergence of the adult approaches. It is about 3 cm. long.

The adult moth is dull brown or yellow above and nearly white beneath. Two irregular, darker, transverse median bands cross the upper surface. It has a wing expanse of more than 4 cm. These attractive moths are seldom seen during the day because they cling to the undersides of the leaves with their wings spread, as shown in plate V, 3, and fly about only at night. They lay from 200 to 300 eggs.

The life cycle of the omnivorous looper requires about six weeks in summer in coastal San Diego County, and it appears that there may be five or six generations per year (McKenzie, 1935).

Injury. The first-instar larva eats only the epidermis of the upper surface of the leaf, leaving a characteristic brownish membrane (fig. 9-17). All the other larval instars eat all the way through the leaf. The figure also shows a necrosis of avocado leaves and the holes left in the leaves if and when the necrotic areas (shown by the arrows) drop out. The holes are bordered by a thin fringe of necrotic tissue that remains attached to the green portion of the leaf. This malady is commonly seen on avocado foliage, particularly on the inside leaves, but its cause is unknown. The injury is often confused with that caused by the omnivorous looper. How-

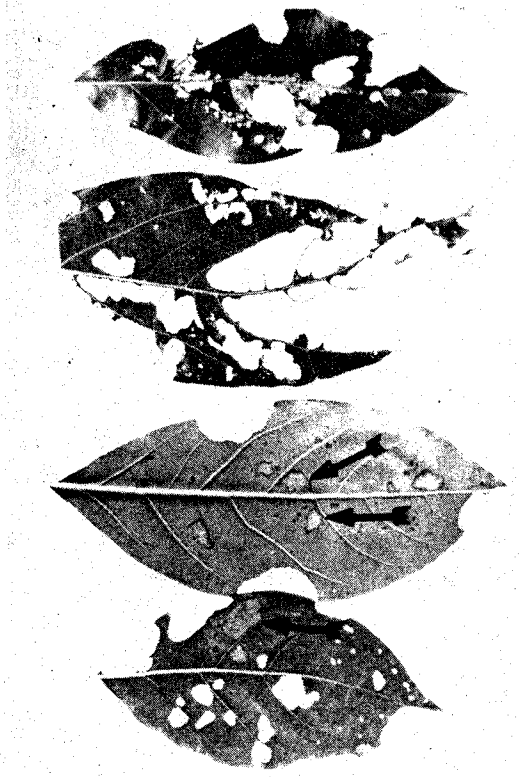

Fig. 9-17. Top, avocado leaf injury caused by omnivorous looper. Bottom, leaf necrosis of unknown origin having similar appearance to omnivorous-looper injury. Arrows point to necrotic areas.

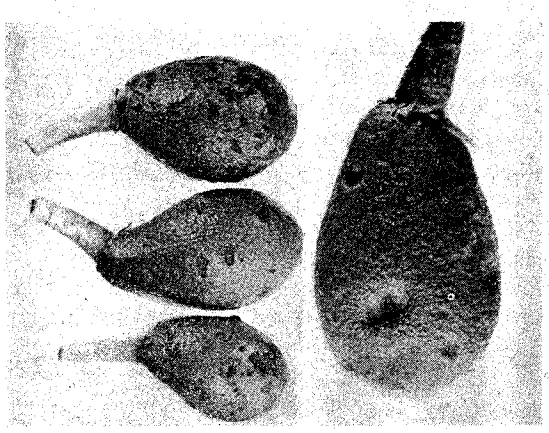

Fig. 9-18. Left, shallow grooves eaten out of young avocados by early instars of the omnivorous looper. Right, deep pits eaten out by later instars.

ever, several points of difference make the two easily distinguishable. The first-instar larvae leave skeletonized areas that are easily recognizable. The older larvae, although they will eat out some holes that appear similar to those caused by the necrosis, will also consume entire sections of foliage between the larger veins and along the midrib, leaving the veins and midrib exposed and giving the injured foliage a characteristic shredded appearance (Ebeling, 1955).

Injury by the omnivorous looper is usually confined to the foliage. If a sufficient percentage of the foliage is removed, the tree is weakened and the following year's crop is reduced. This degree of injury seldom occurs. Since the first record of extensive damage to fruit in 1949 (fig. 9-18), this type of injury by the omnivorous looper has become increasingly common, particularly on Fuertes in coastal areas. However, a year of heavy infestation is usually followed by a sharp decline in the looper population, owing to the activity of natural enemies. Consequently, often the very year the grower has decided he must treat his orchard to avoid further crop losses, the infestation is apt to be light, and artificial control measures are seldom employed.

Natural Enemies. McKenzie (1935) records that in 1932, at least 70 per cent of the omnivorous loopers in one area were parasitized by the hymenopterous parasite *Habrobracon xanthonotus* (Ashmead). More recently, in an avocado orchard in the Carlsbad area, Fleschner (1954) found 128 parasites emerging from 131 omnivorous-looper larvae—67 of these were *Meteorus* sp. and 61 *Apanteles* sp. (fig. 9-19). Since only one parasite emerged from each larva, 98 per cent of the larvae were parasitized. Only a few *H. xanthonotus* were found in the orchard. Two egg parasites (*Trichogramma minutum* Riley and *Telenomus* sp.) were found, but their importance was not ascertained. Muesebeck (1956) described two braconid parasites, *Meteorus tersus* and *Apanteles caberatae*, that were reared from the omnivorous looper.

Other parasites that could have emerged from either omnivorous looper or amorbia larvae collected by the writer were determined by N. L. H. Krauss to be *Coccygomimus sanguinipes* (Cresson), *Scambus aplopappi* (Ashmead), and *Cryptus* sp.

The spined soldier bug, *Podisus maculiventris* (Say), may occasionally be seen feeding on looper larvae. These pentatomid predators are 10 to 12 mm. long, yellowish or pale brownish, the dorsum

covered with small black specks. This species is a general feeder, however, and also attacks larvae of lady beetles and lacewings.

A fungus disease similar to the wilt disease of the silkworm attacks the third, fourth, and fifth instars of the larval stage. McKenzie (1935) found that all but two out of eighty-eight caterpillars used in an experiment were killed by this fungus. It is obviously an important factor in keeping the looper population down to its usual numbers. Viruses also aid in natural control.

Artificial Control. A thorough spray of DDT 50 per cent wettable powder at 1 pound to 100 gallons is effective in the control of the omnivorous looper. An acaricide should be added to prevent the outbreak of mites that would ordinarily follow a DDT treatment. DDT should be applied at least 30 days before harvest. Because of the adverse effect of DDT on natural enemies, the San Diego County Agricultural Commissioner's office recommends the use of 4 pounds of basic lead arsenate plus 6 ounces of blood albumin spreader to 100 gallons of water, applied with thorough coverage. To avoid arsenical residue in excess of the official tolerance, this spray must be applied after the fruit is picked.

Insecticide treatments should be avoided unless it is obvious that the insects will otherwise cause substantial economic damage, particularly by attacking the fruit. It may be advisable to allow a moderate degree of damage rather than to treat, for natural enemies usually cause a sharp reduction in the omnivorous-looper population sometime during the fall. The seasons of highest looper population are likely to be followed by a year of very light infestation. However, these insects are occasionally present in an orchard in injurious numbers for a period of two or three years before natural enemies can bring about a satisfactory control.

Cultural Control Measures for "Avocadoworms." Lepidopterous larvae feeding on fruit, such as the omnivorous looper and two tortricids to be discussed later, may be considered collectively as "avocadoworms." They are all favored by densely foliaged trees and by orchards in which there are large trees with interlacing branches, forming a continuous canopy of foliage. The Fuerte variety appears to be the most susceptible to attack.

Heavy infestations of avocadoworms in crowded orchards can be reduced to subeconomic levels by removing every second tree. Since Fuertes are not the best commercial variety in coastal areas, a grower may be justified in cutting every second tree to the trunk and grafting it to a variety of greater commercial value and with less susceptibility to avocadoworms, such as the Hass. As the latter increase in size, the remaining Fuerte trees can be removed.

Amorbia

The amorbia, *Amorbia essigana* Busck, is a tortricid (leaf-roller) moth which was first recorded as occurring in California by E. O. Essig in 1922. It is now distributed throughout the greater part of the avocado-growing area of California, and seems to prefer the avocado as a host. The biology of this insect was worked out by McKenzie (1935).

Life History and Description. The amorbia lays its eggs (pl. V, 5) on the upper surface of the avocado leaf, along the midrib. The greenish eggs are laid in flat masses of from 5 to 100, and from 400 to 500 eggs may be laid by a single moth. These hatch in from 13 to 15 days.

Although there may be as many as seven larval instars, pupation may take place after the fifth or sixth. The first-instar larva is small and yellowish

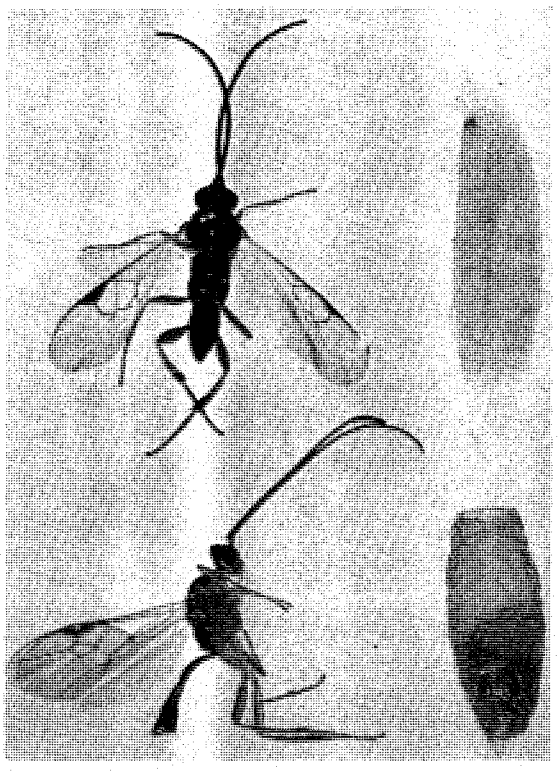

Fig. 9-19. Two common parasites of the omnivorous looper. *Apanteles* sp. (top) and *Meteorus* sp. (bottom), and their pupae. (Courtesy of C. A. Fleschner.)

green. The larvae of the remainder are darker green in color and are similar in appearance, except for size, the seventh-instar larva being from 2 to 3.3 cm. long. Larvae of all instars usually spend the day hidden between two leaves that have been webbed together, in this habit resembling the larvae of the omnivorous looper. The larvae wriggle violently and fall to the ground if the leaves are pulled apart. The duration of the larval stage, including seven instars, was found to be 63.6 days under outdoor temperature conditions late in the summer at Encinitas, California.

The pupa is from 1.3 to 2 cm. long. At first it is pale green, later changing to chocolate-brown. Like the omnivorous looper, the larvae web two leaves together to conceal themselves during pupation. The pupal stage requires an average of seventeen days in summer.

The adult has a wing expanse of 2.5 cm., being only a little over half the size of the omnivorous looper. The forewings of the female tend to be reddish brown, while those of the male tend to be a light brown or tan with a triangular, dark-brown marking about midway on the outer margin (pl. V, 6). However, there is considerable variation in the color and pattern of the forewings in both sexes. The moths when at rest have the bell-shaped outline so often seen in the tortricids. The apical points of the forewings are usually somewhat notched. The adults are nocturnal and rest on the undersides of the leaves during the day. The life cycle of the amorbia requires about two months in summer at Encinitas. There appear to be four or five generations per year.

Injury. On the older leaves, the amorbia larvae may cause injury similar to that of the omnivorous looper. However, they sometimes infest the small leaves of the twig terminals, webbing them together and feeding inside the leaf cluster. As the leaves unfold and increase in size, the holes caused by the amorbia larvae are revealed. This type of injury is typical of the species (fig. 9-20). In one avocado orchard in which more than half of the terminals were infested on trees of the Anaheim variety, about a fourth were infested on trees of the Hass variety, and only a few on Fuertes.

The injury caused by amorbia should not be confused with a similar injury to young foliage that is apparently physiological in origin. In the latter, the malformations of the leaves appear to originate from necrotic tissue that becomes apparent when the tiny leaves are first unfolding from the terminal clusters. This type of necrosis is mainly marginal, and influences the pattern of growth the leaf is to take in its subsequent development (Ebeling, 1955).

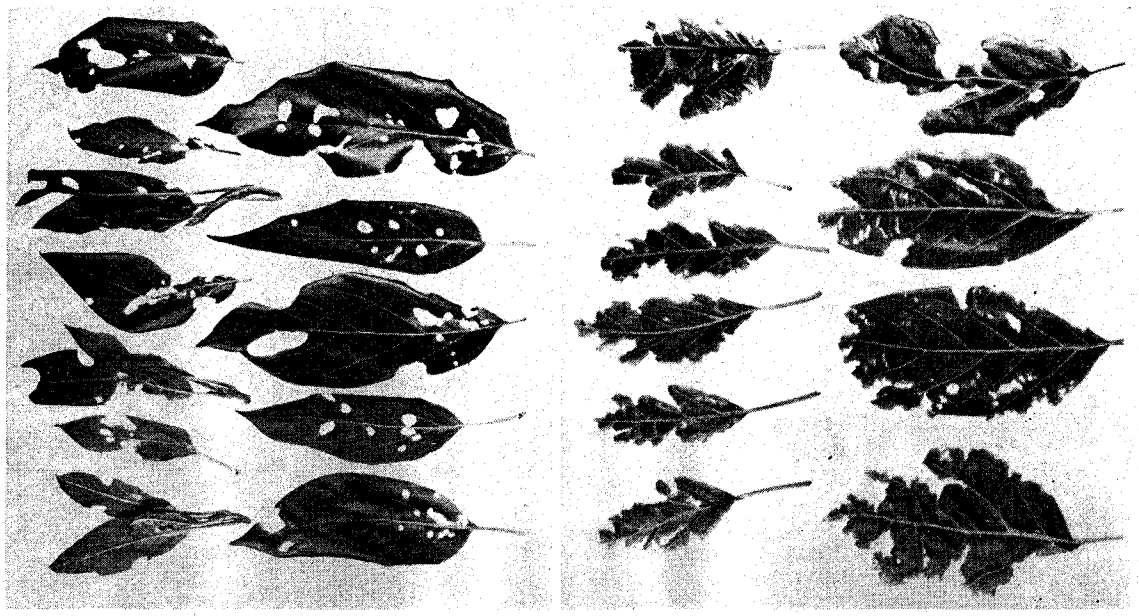

Fig. 9-20. Left, injury to young terminal foliage of the avocado caused by amorbia larvae; right, malformation of young foliage, apparently of physiological origin.

Although the amorbia is found more often on the leaves than on the fruit, the fact that it also feeds on the fruit (fig. 9-21) makes it of some economic importance when it is abundant. However, the larvae will feed on fruit only when they can conveniently web leaves against the fruit surface. The omnivorous looper, which can feed away from its hiding place at night, is therefore considered to be a more serious pest than the amorbia. Young fruits are sometimes attacked by amorbia larvae, and the scars caused by the feeding become enlarged and more conspicuous as the fruit reaches maturity.

In August, 1949, amorbia larvae, together with larvae of the orange tortrix, *Argyrotaenia citrana* (Fernald), were found to be destroying the buds of newly budded avocado trees. The larvae fed on the bark adjoining the inserted buds, on the buds themselves, and on any growth that had developed from the buds. The larvae were identified by E. L. Atkins, who also reared the moths from captured larvae.

Natural Enemies. Tachinid parasites, *Phorocera erecta* Coquillett (fig. 9-22, *A*), often destroy a high percentage of amorbia larvae. Other parasites of the larvae which have been identified by N. L. H. Krauss are *Lampronota lissonata*, *Bracon* sp., and *Hormius* sp. The egg parasite *Trichogramma minutum* Riley appears to be of small value.

Control. Control measures are the same as for the omnivorous looper.

Orange Tortrix

The orange tortrix, *Argyrotaenia citrana* (Fernald), is a small leaf-roller moth that has been known as an orange pest in California for many years. In 1949, this insect was found to be doing a limited amount of damage to avocados by feeding on green twigs and fruit. It appears to be increasing in abundance on the avocado. The appearance and life cycle of this moth are discussed on page 211, chapter 7, and the adult, larva, and pupa are shown in plate III, 4–5.

Injury. On avocados, the most frequent injury occurs near the periphery of the tree on terminal twiglets. The larvae feed on the green bark and often girdle the twigs (fig. 9-22, *C*), sometimes making holes down into the more tender ones. While feeding, the larvae are covered by crude "nests" of plant debris, similar to those shown in fig. 9-24 for holcocera, and it is these nests that attract attention

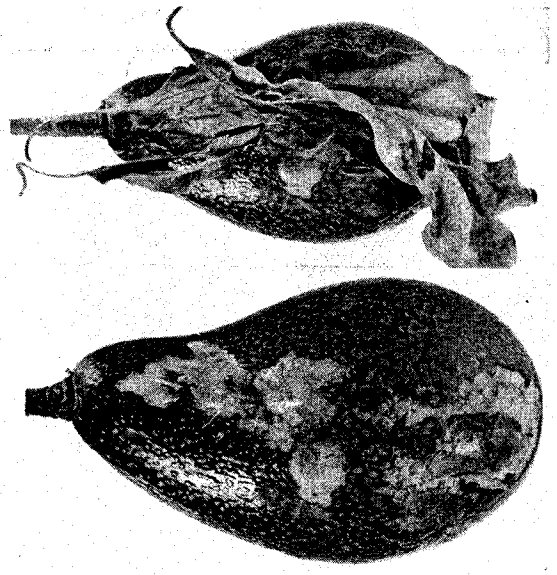

Fig. 9-21. Injury to an avocado caused by the amorbia. Top, before the adhering dead leaves are removed. Bottom, after removal of the leaves.

to the feeding. The bases of large twigs may be girdled at the point of their attachment to larger branches. The injured area in such cases is usually covered with a white sugar, called "dulcitol," that exudes from the wound.

During the blooming period, the tiny larvae are sometimes found inside the flowers, where they may feed on the developing embryo or the calyx. The same larvae may later form a nest of several flower

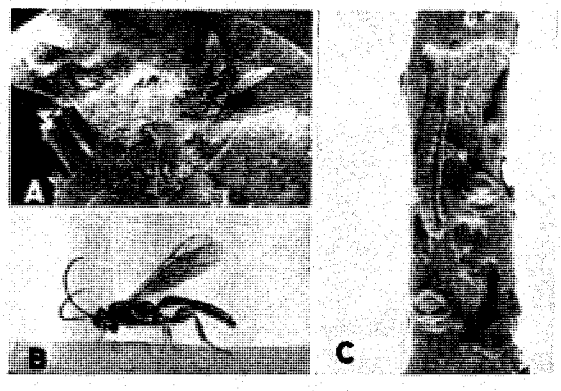

Fig. 9-22. *A*, adult tachinid fly, *Phorocera erecta* Coquillett (right) after leaving its pupal case (left), which is always found near the parasitized pupa of amorbia (center). *B*, *Exochus* sp. reared from an orange-tortrix larva infesting avocado. *C*, larva of the orange tortrix feeding on the green bark of an avocado twig from which the protective "nest" of debris has been removed.

heads and feed on the bases of the flowers or farther down in the long stems of the flower clusters. "Nests" of flower parts may sometimes be found at the point where several stems of the flower clusters are joined, and the larvae may be found feeding under the nests.

Like the amorbia, the orange tortrix may attack the terminal bud after tying together the tender terminal leaflets for a hiding place. It may also destroy the buds of newly budded trees. The tape holding the bud in place gives the same type of protection that is ordinarily afforded by the nests of debris.

The most serious injury to date has been the scarring of fruit caused by the feeding of the larvae. The injury appears much like that caused by the other lepidopterous larvae feeding on the avocado, except that occasional deep holes may be scattered about over the scarred tissue. Also, the orange tortrix has more of a tendency to make narrow, irregular grooves in the surface of the fruit and a greater amount of damage at the stem end than do the other moth larvae (fig. 9-23). As with the amorbia, the larvae feed only at the point of contact of two fruits or where the fruit may be in contact with a leaf or debris. Around the stem end, injury occurs when debris from the tree accumulates around the stem. The larvae sometimes feed in the stem itself, and the fruit drops. The writer has observed injury to Fuerte avocados in coastal San Diego County, California, amounting to as much as 38 per cent of the crop (Ebeling and Pence, 1957).

Parasites. The parasites of the orange tortrix, described on page 216, chapter 7, are usually effective in keeping the orange-tortrix population on avocados so low that no appreciable damage results. A hymenopterous parasite, *Exochus* sp. (see fig. 9-22, *B*), has been recovered most often from larvae reared from avocado twigs.

Artificial Control. Spraying with 2 pounds of 50 per cent TDE (DDD) wettable powder to 100 gallons is effective in controlling the orange tortrix, and the same treatment is also effective against the omnivorous looper and the amorbia. Cryolite may be used against the tortrix alone, and has the advantage of having a less adverse effect on natural enemies. However, it is not effective against the other lepidopterous pests, as noted in chapter 7. Only in a few instances have treatments been directed against the orange tortrix on avocados to date.

The crowding together of large avocado trees provides an ideal condition for the development of the orange tortrix, as well as other avocadoworms, as explained on page 305, just preceding the heading "Amorbia."

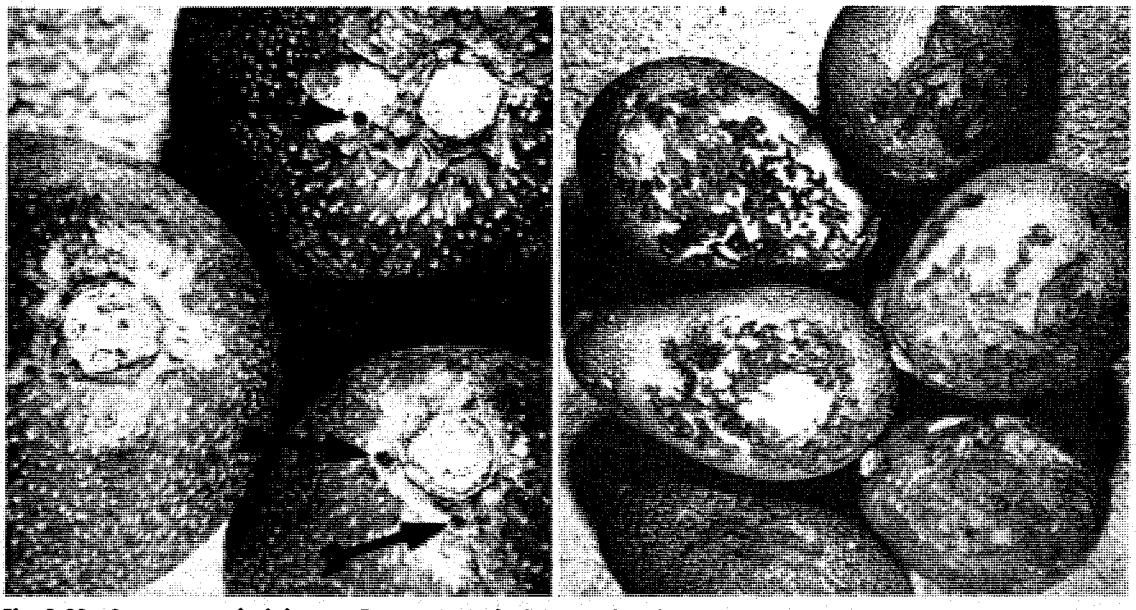

Fig. 9-23. Orange-tortrix injury to Fuerte avocado fruits. Left, injury to stem end of fruit, showing typical deep holes. Right, injury to sides of fruit, where they had been covered by foliage, with only occasionally a deep hole.

Fig. 9-24. "Nests" of *Holcocera iceryaeella* on twigs.

Holcocera

The holcocera, *Holcocera iceryaeella* (Riley), is a small, slender, grayish blastobasid moth (pl. III, 7), about 9 mm. in length. This moth and at least one other closely related species are primarily scavengers, but occasionally feed on live plant or animal material. Their nests (fig. 9-24) are larger and more carefully formed than those of the orange tortrix, but are not so numerous. Occasionally, they are attached to a leaf. The larvae when full-grown are on the average slightly longer than the moths. They are brownish, with broken, longitudinal stripes. They usually feed only on the debris in their nests, but will sometimes make a shallow channel in the green bark of the twig beneath the nest. Only rarely do they feed deeply into the twig. To date, they have proved to be of practically no economic importance on avocados.

Avocado Leaf Roller

This insect, *Gracilaria perseae* Busck, is a very small, grayish moth (family Gracilariidae), about 7 mm. in length, which deposits its eggs singly on the new growth of the avocado in Florida. The larva may feed as a leaf miner in the early instars, and later, on the undersides of the leaves. In the course of its feeding, it rolls the leaves back from the tip. Most of the "ragged" foliage of the avocado tree in Florida may be attributed to this insect. The full-grown larvae construct silken cocoons in the folds of the leaf and pupate within these folds.

Control. Lead arsenate at 3 pounds to 100 gallons has been found to be quite effective in controlling these pests.

Leaf Miner

A narrow, light-colored, serpentine pattern on the green twigs of avocado trees, and occasionally on the foliage and fruit, indicates the presence of a gracilariid leaf miner, *Marmara salictella* Clemens. The small, reddish larvae of these tiny moths bore beneath the epidermis, leaving characteristic serpentine markings. The native host of this species is the willow, and occasionally avocado trees growing near willows are rather heavily infested, although no economically important damage has ever been reported. The work of these leaf miners is most commonly seen in nurseries or young orchards. The insect is worthy of note here mainly because of the curiosity aroused by its markings on avocado or citrus twigs, leaves, or fruits.

Variegated Cutworm

The variegated cutworm, *Peridroma margaritosa* (Haworth), is one of the sporadic pests that occasionally attack young avocado trees, particularly near uncultivated areas. The adults are grayish-brown moths with dark-mottled forewings and a wing expanse of 4 to 5 cm. This is one of the night-flying noctuid moths ("millers") that are commonly attracted to lights.

The full-grown larvae are about 4 cm. long, variable in color, but usually gray or brown, mottled above with gray or darker lines, and often with oblique, gray areas on the sides. They feed on all kinds of vegetation.

Control. They may be controlled with commercially prepared poison baits. The bait should be scattered under the trees at dusk, as the larvae emerge from the soil at night to feed.

MAMMALIA

Rats

Partly devoured avocados are often found hanging in trees or lying on the ground. This damage is usually done by rats, and may at times reach serious proportions. Although space has not permitted a discussion elsewhere of rodents and other vertebrates as pests of the various subtropical fruits, an exception is made here because the problem pertains specifically to the avocado, and written information on the subject is almost entirely lacking.

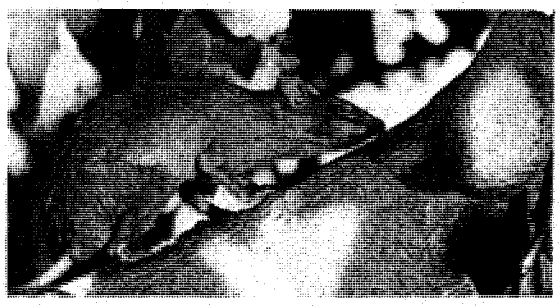

Fig. 9-25. Roof rat in avocado tree.

The principal species involved are the roof rat, *Rattus rattus alexandrinus* (Geoffroy), also known as the Alexandrine or gray rat (fig. 9-25), and the black rat, *Rattus rattus rattus* (L.), but especially the former. The black rat resembles the roof rat, except for its almost solidly black color. It is found only near salt water, such as at seaports and adjacent towns, but may be found in some coastal avocado orchards. The Norway rat, *Rattus norvegicus* (Erxleben), is a larger species with a shorter tail. It was once relatively unimportant as an avocado pest, but has become increasingly important in recent years. This species has a tendency to displace other species wherever it occurs, and will probably become a more serious pest in the future.

Control. Orchard sanitation aids in the control of rats, for they use woodpiles and piles of broken avocado limbs, boxes, or lumber as nesting places. Poisoning has long been successfully practiced by avocado growers, and is now coming into increasing favor because of the great success that has attended the use of the new poison, Warfarin. One advantage of this poison is that it does not require prebaiting. Also, it is not so poisonous to humans as some of the baits previously used.

Grains, such as oat groats, or any food eaten by humans may be used as bait. The poisoned bait in "bait boxes" is placed in locations that the rats are known to frequent. The bait boxes are left out several days, and the poisoned bait is renewed until feeding ceases. Several days may be required.

Since the advent of Warfarin as a rat bait, many growers who formerly controlled rats by trapping are now resorting to poisoning. In some counties, it is sold at cost by the county.

Other Rodents

The native wood rats, also known as "pack rats" or "trade rats," especially *Neotoma fuscipes* Baird, will eat avocados, but more serious damage results from their feeding on the bark, which sometimes results in the complete girdling and death of branches. These rats can readily be trapped in springtraps baited with rolled oats, peanut butter, raisins, or prunes. They should be handled in such a way as to avoid getting live fleas or ticks on the clothes or skin, for these may be carriers of disease.

The red fox squirrel, *Sciurus niger rufiventer* (Geoffroy), is an accidentally introduced species that now occurs in northern Los Angeles County and Ventura County. It feeds on walnuts, avocados, and oranges. This rodent has become less serious as a pest since the walnut orchards of the San Fernando Valley have been largely removed as the result of subdivision. Many walnut trees have remained as dooryard trees, but homeowners are about equally divided between those who regard the red fox squirrel as a pest and those who regard it as an attractive pet.

Meadow mice or voles (*Microtus* spp.) are injurious because they gnaw the bark and roots of avocado and citrus trees that are surrounded by grass and weeds. Their runways may be found in such locations. Mousetraps baited with oatmeal, rolled oats, or bits of apple or carrot may be set with their triggers across the runways. Mice running in either direction can thus be trapped. When large numbers of mice are present, it may be advantageous to poison them. Strychnine on alfalfa leaves or rolled barley has been used, or zinc phosphide on rolled barley or oats. A ground spray of endrin has been used successfully for control of mice in apple orchards in Virginia (Horsfall, 1956).

Pocket gophers (*Thomomys* spp.) are destructive to young avocado trees, and their control demands continuous vigilance on the part of the grower. Their presence is indicated by a series of rounded surface mounds. They are controlled by trapping or poisoning.

AVOCADO PESTS IN OTHER COUNTRIES

Potential menace to the avocado industry in the United States results from the presence in other parts of the world of insects that have proved themselves to be very injurious to the avocado. Their absence so far is probably owing primarily to quarantine regulations. The following section will be devoted to a discussion of these species.

Membracids (Treehoppers)

The avocado treehopper, *Metcalfiella monogramma* (Germar), is probably indigenous to Mexico.

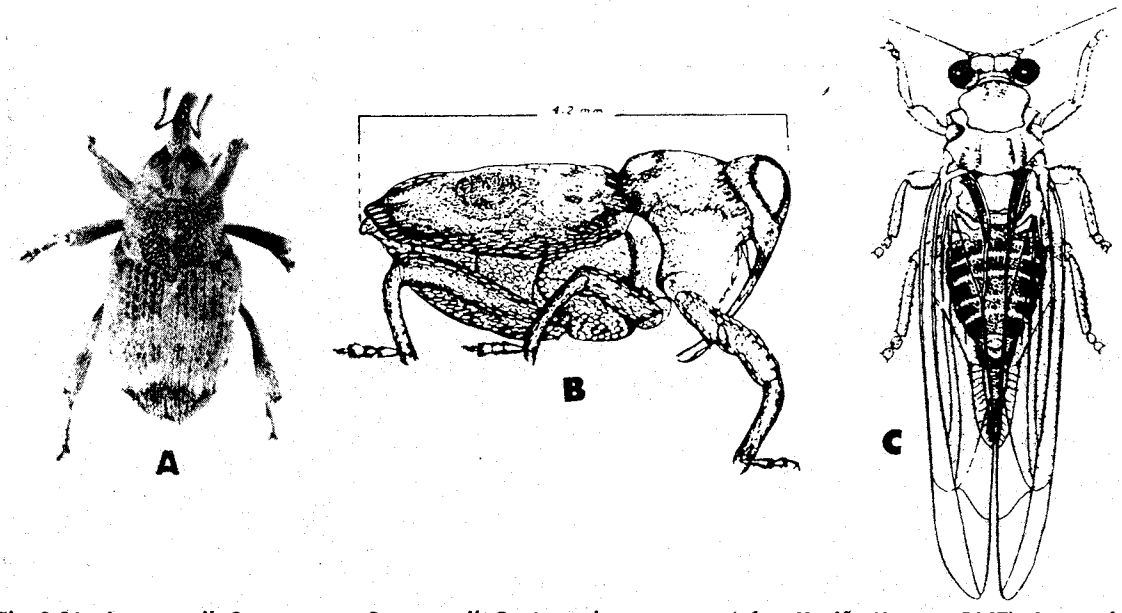

Fig. 9-26. ***A*, a weevil, *Copturus* sp.; *B*, a weevil, *Copturomimus perseae* (after Mariño Moreno, 1947); *C*, a psyllid, *Trioza anceps* (after Tinoco Corona, 1945).**

It is known as the *periquito del aguacate*, or by other terms commonly used for treehoppers, such as *saltón* or *torito*. The adults vary in color from a burnt red in the young adult to the brown or straw color of the older individuals, and some have a green prothorax. The females are 9 to 12 mm. long and 4.25 to 6 mm. wide; the males are 8 to 10 mm. long and 3.75 to 5.25 mm. wide (Ruiz Valencia, 1912; Camacho, 1944).

This insect attacks only avocados. In severe infestations, so many eggs are laid that the egg punctures alone cause the twigs to die. However, the principal damage ordinarily is from the extraction of sap by the nymphs. There appear to be no natural enemies.

Another membracid, *Platycotis tuberculatus* (Fairmaire), is at times extremely abundant in Haiti and seriously injures the terminal shoots of the avocado with its egg punctures and feeding. An undetermined trichogrammatid egg parasite has been reared from the eggs of this species.

Related to the membracids is an aetalionid, *Aetalion quadratum* Fowler (=*Polydontoscelis cintifrons* Ashmead) (fig. 9-27), which sometimes becomes abundant on the green twigs of the avocado in the state of Jalisco, Mexico.[2] This species is 1 cm. in length and has a light-green body with a few markings. The wings have prominent veins that are predominantly yellowish, but with some sections black.

A single individual of this species was captured in sweeping on a gallberry (inkberry) bush, *Ilex glabra* Gray, near St. Nicholas, Florida, in 1899 (Ashmead, 1899).

Psyllids

Perhaps the most spectacular injury caused by any avocado pest in Mexico and Central America is caused by a psyllid, *Trioza anceps* Tuthill (=*Trioza koebelei* Kirkaldy) (fig. 9-26, *C*), which deposits its tiny, oval, yellow eggs in punctures made in the epidermis of the upper leaf surface. Upon hatching, the nymphs produce a secretion that causes a rapid

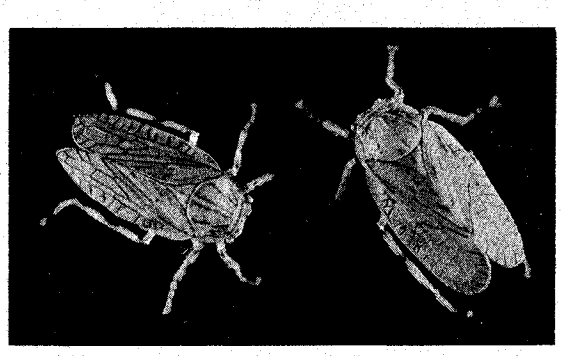

Fig. 9-27. A treehopper, *Aetalion quadratum*.

[2]The writer is indebted to Señor Victor E. Vuilleumier, Ciudad Guzman, Jalisco, Mexico, for specimens of this species.

Fig. 9-28. Galls of the psyllid Trioza anceps on avocado leaves. (Courtesy of Sr. Jacques de Choulot, Atlixco, Mexico.)

proliferation of cells followed by the development of an elongate gall (fig. 9-28) that may become 6 to 8 mm. long and 2 to 4 mm. wide. These are called *urnas* or *urnitas* by the Mexicans. The galls are at first green, but later become reddish at the terminal end. The trees are often covered with thousands of these galls. (See Tinoco Corona, 1945; Moznette, 1921.)

Inside the galls, the nymphs feed and reach the adult stage. The adult emerges on the lower side of the leaf through a circular hole made at the base of the gall.

The avocado tree can support a large number of psyllids with no apparent injury, but very heavy infestations result in defoliation. Some observers believe that even a moderate infestation will result in reduced production of fruit.

Citrus Blackfly

The citrus blackfly, *Aleurocanthus woglumi* Ashby, is one of the "whiteflies" (Aleyrodidae) but derives its common name from its black color. The young leaves of the avocado were stated by Ballou (1922) to be attacked by the citrus blackfly more severely than those of any other plant in Cuba. Although the blackfly is now held in check in Cuba by a parasite, *Eretmocerus serius* Silvestri, it has thrived in many sections of Mexico, where the same parasite is ineffective, apparently because of climatic conditions. Other parasites have been introduced in recent years, and blackfly populations have been greatly reduced, at least on citrus (see p. 232, chapter 8).

The biology and control of the citrus blackfly are discussed more fully in chapter 8.

Avocado Mealybug

Among the cosmopolitan mealybugs attacking the avocado, *Pseudococcus nipae* (Maskell) is the only species that has not been found in the avocado orchards in California, although it has been a serious pest in many avocado regions of the world.

Avocados, mangos, sapodillas, palms, and other ornamental plants were at one time heavily infested with the avocado mealybug in southern Florida, but it is no longer a serious pest in that state because of effective parasites. In 1924, this species was stated to be the most serious of insect pests of the avocado in Hawaii. Infested trees lost the greater part of their foliage and showed a loss of vigor, or, if young, were sometimes killed outright (Osborn, 1938). However, in April, 1922, parasites and predators of *P. nipae,* obtained in Mexico, were liberated in Hawaii. Included among these was the encyrtid parasite, *Pseudaphycus utilis* Timberlake. This parasite was remarkably successful and almost completely eradicated the pest. It never again became abundant in Hawaii after the parasites became established (Pope, 1924).

Long-Horned Beetles

The genus *Oncideres* of the Cerambycidae includes a number of species that girdle the branches and twigs of avocado and cause them to fall to the ground. Wille (1952) discusses three species, including *Oncideres poecila* Bates, that cause severe injury to avocado trees in Peru. *O. poecila* is a large species, measuring 3 cm. in length and 1 cm. in width. It is dark maroon in color, with a dense mat of yellow hairs and with numerous white dots distributed in four rows over each wing.

Avocado tree branches as large as 9 cm. in diameter can be girdled and killed by these beetles. They also attack many species of native trees.

The genus *Oncideres* has been injurious to avocados in Peru only in the Montaña (east of the Andes Mountains). As might be expected, certain species of *Oncideres* are also injurious to avocado in Brazil (Costa Lima, 1923).

Avocado Seed Weevils

Heilipus lauri Bohemann, known in Spanish America as *barrenador del hueso, picudo,* or *polilla,* is 12 to 15 mm. long and of a dark-brown color, with two incomplete, transverse, dorsal bands of

yellow on the elytra (fig. 9-29, *A*, and pl. VIII, 8). The typically grublike, legless larvae are 10 to 15 mm. long and of a dirty-white color (pl. VIII, 8). There is one generation per year, and the winter is spent in the adult stage. The elongate eggs, 1 to 2 mm. long, are deposited in May, June, or July under the epidermis of the developing fruit, by means of a "half-moon" puncture. The larvae make their way through the pulp to the seed, where they feed and spend their larval and pupal existence, although they sometimes leave fallen fruit and enter the soil to pupate. The larvae initiate a rotting of the pulp, principally near their tunnels, and a partial or total rotting of the seed, eventually resulting in the premature dropping of the fruit. The adult feeds on leaves, buds, sprouts, and in fruit that may offer some point of entry, as through a puncture or wound. (See H. S. Barber, 1919; Tinoco Corona, 1945.)

It is recommended that the infested and fallen fruits be collected and buried to a depth of at least one meter. Community action is required for best results.

Avocados grown at the higher elevations are not so susceptible to infestation as those grown in the lowlands.

Heilipus lauri is the avocado seed weevil that is responsible for the quarantine against Mexican avocados.

In Costa Rica, there is a weevil that is either another form of *Heilipus lauri* or another species, *H. pittieri* Barber (fig. 9-29, *B*). This weevil causes injury to avocados similar to that of *H. lauri*. In the Canal Zone, another species, *H. perseae* Barber (fig. 9-29, *C*), feeds on the seed, pulp, skin, young twigs, and leaves of the avocado. This species is 11 to 15.5 mm. long. When first emerging, the adults are reddish, with six prominent, yellow spots. The reddish color eventually becomes blackish (Dietz and Barber, 1920). These weevils are also controlled by orchard sanitation. The fallen fruits and seeds are gathered and burned or buried. In Guatemala, there is still another destructive weevil, *Conotrachelus perseae* Barber (fig. 9-29, *D* and *E*), with habits similar to those of *H. lauri*. It is a shiny, almost black beetle, the elytra of which are moderately clothed with a mixture of rose-red, pale brownish, and white hairs. It averages about 6 mm. in length. In Mexico, a species of *Cossonus* also attacks the seed, reducing it to a powder.

Other Weevils

In a number of localities in Mexico, especially in some avocado orchards near Atlixco, Puebla, the larvae of a curculionid beetle, *Copturus* sp. (see fig. 9-26, *A*), have caused great destruction of avocado trees by boring into branches and twigs, often causing them to break at the point where

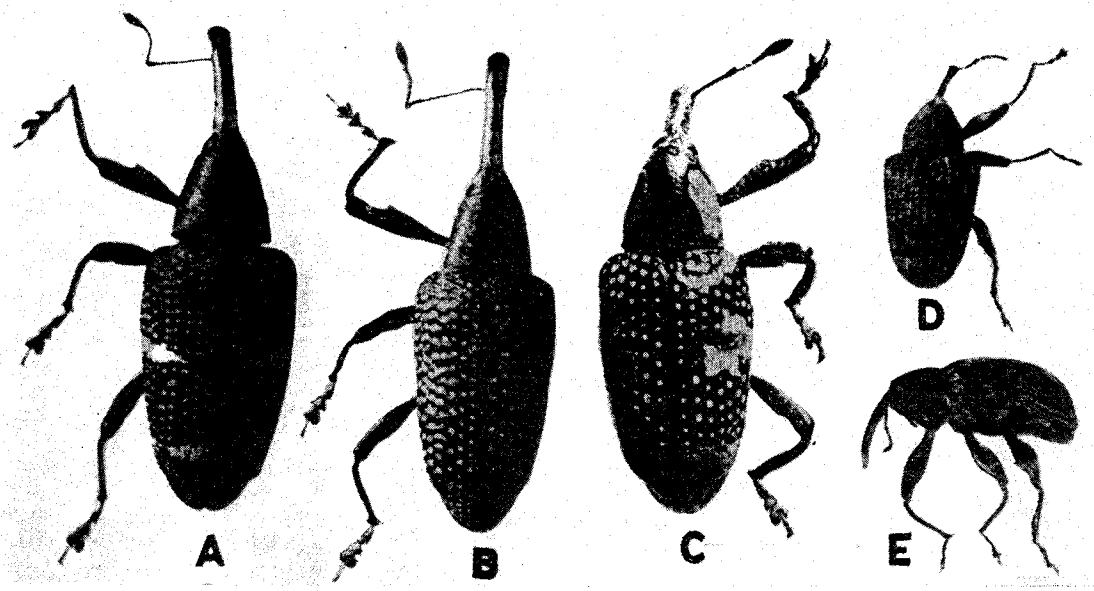

Fig. 9-29. Avocado seed weevils. *A, Heilipus lauri; B, H. pittieri; C, H. perseae; D* and *E, Conotrachelus perseae*. (Adapted from H. S. Barber, 1919, and Dietz and Barber, 1920.)

they are most extensively mined. Some trees that have been infested for a number of years are progressively reduced in size as the outer branches die back or break off. This insect is called *barrenador de las ramas*. It is 4 to 5 mm. long, grayish in color, with a broad, transverse band of white on the elytra. It is deeply punctate and rather densely covered with hairs.

Two specimens that were reared out of infested twigs taken near Atlixco were sent to L. L. Buchanan at the U. S. National Museum, who states that this species is probably undescribed. It differs from a "*Copturus*"[3] *perseae* Gunther, which attacks avocados in Costa Rica, or *Copturomimus perseae* Hustache in Colombia.

Copturomimus perseae Hustache (fig. 9-26, *B*) is similar to the preceding species in appearance and in the kind of injury it causes (Mariño Moreno, 1947). It has been controlled in Colombia with a spray having 3 per cent of "Geserol A-5," a preparation containing 5 per cent DDT. A 50 per cent wettable DDT powder would at present, of course, be the appropriate material to use, and at a much reduced concentration. The spray was repeated two or three times at monthly intervals. A five-gallon sprayer was carried up and down ladders to reach all parts of the tree. The beetles are susceptible to DDT because they do a great deal of crawling about over the surfaces of the twigs and branches. Possibly, *Copturus* sp. in Mexico could also be controlled with repeated DDT sprays.

Bark Beetles

Bark beetles (Scolytidae) have occasionally been serious pests in some avocado-growing regions. These beetles may girdle a tree by boring into the bark and sapwood, forming long, narrow "galleries." *Xyleborus morstatti* Hagedorn appears to be one of the most destructive, and has been a serious pest in Fiji, Mauritius, and the Seychelles (Lever, 1939–40). A complete gallery may contain as many as twenty-six individuals and cause enough injury to kill a tree. Lever states that *X. mutilatus* Blandford and *X. aplanatideclivis* Schedl are also found on avocado in Fiji. The tunnels made by *Xyleborus* are perpendicular to the surface, but sometimes bifurcate, and reach the central path, where they terminate in an enlarged cavity lined with fungal mycelium.

[3]This species is now believed to belong in the genus *Copturomimus*, thus making *C. perseae* Hustache a homonym.

In an experiment, a pad of cotton wool was soaked in a 2.44 per cent aldrin emulsion and lightly pressed against the entrance holes of the beetles, so that a little of the liquid was expelled. Nine out of ten adults and all of sixteen larvae in the infested branches were killed. The treatment was repeated in two and five weeks, with no injury to the treated trees.

In Hawaii, *Xyleborus kraatzi* Eichhoff (=*immaturus* Blackburn) often causes damage to avocado trees. These insects often enter the trunk or larger branches in wounds and may penetrate the live wood beneath the bark. The usual white, frostlike exudation ("dulcitol") on the surface of the bark indicates the presence of the beetles (Pope, 1924).

Ants

The leaf-cutting ant, *Atta sexdens* (L.) (see p. 237, chap. 8), is sometimes a serious pest of the avocado in South and Central America. Trees may be defoliated overnight (Wolcott, 1929). *A. insularis* Guérin causes similar damage to avocado trees in the West Indies.

Stenoma Moth

A stenomid moth, *Stenoma catenifer* Walsingham, is one of the most destructive pests of the avocado in many tropical and subtropical regions. The adults have a wingspread of about 2.5 cm. and are grayish brown in color, with twenty-five small, black dots arranged in a line like a letter S on each forewing.

The full-grown larva is a little over 2 cm. long. The young larvae are grayish white with brownish-black heads; their bodies later change to reddish purple (Wille, 1952).

Wille describes three types of injury in Peru: (1) The larva may bore into the terminal twigs, making tunnels up to 25 cm. long. The infested twigs wither and die, and if young trees are attacked, they may be killed. (2) This type of injury occurs if the larva bores into and cuts the stems or the bases of the small fruits. These fall to the ground, and sometimes a large part of the crop is lost. (3) This form of injury is found in the large and nearly mature fruit. On such fruits, the moth lays its eggs, and the resulting larvae eat through the flesh into the seed, expelling their excrement through the holes made when entering the fruit. They feed on the seed for three weeks or a month, then eat their way out through the fruit to pupate.

Busck (1919) has stated that in Ecuador, it is

almost impossible to buy a single avocado on the market which does not have at least one of the larvae, and more often two or three.

Wille (1952) believes that there are no parasites of *Stenoma catenifer* in Peru, but a hymenopterous parasite, probably *Apanteles* sp., is evidently an important factor in keeping this pest in check in Brazil, where Costa Lima (1923) has recommended that infested fruits be stored so that the parasite may be able to escape. The ichneumonid *Xiphosomella stenomae* Cushman has been recorded from *S. catenifer* in the Panama Canal Zone (Cushman, 1924).

Leaf Rollers

An olethreutid moth, *Olethreutes leucotreta* (Meyrick) (=*Argyroploce*), which is known principally as a pest of cotton and citrus in various parts of Africa, also feeds on the fruit of the avocado. In Sierra Leone, the larvae cause raised, black spots to form on the peel. They pupate beneath these spots and emerge when the fruit is ripe. As many as six larvae have been found in one fruit (Hargreaves, 1933).

The green caterpillar, *Amorbia emigratella* Busck, is a tortricid leaf roller that is a pest of the avocado in Central America. This moth has a wing expanse of 2.5 cm., and is of a brown color. Its green larvae occasionally injure the foliage of avocado trees, particularly young trees. They draw together the edges of the leaf, then retreat temporarily into the shelter thus formed. They emerge from this retreat to feed on the leaf. Arsenate of lead has been used for control (Pope, 1924).

Stericta Moth

An epipaschiid moth, *Stericta albifasciata* (Druce), infests the avocado in Central and South America (Araujo, 1939). The adult male has a wingspread of about 2.5 cm. It has a dark-gray thorax with shades of purple and olive, and the abdomen is of a very pale ocher color. The forewings are purplish, with some olive color, and have a white spot. The hindwings are whitish, with a purplish fringe and a pale, submarginal stripe. The female has a wingspread of 3 cm. It differs from the male in the absence of the white spot on the forewings and in having yellower hindwings.

The eggs are elliptical, slightly flattened, and are laid so as to overlap in a row along the midrib of the leaf. The larvae reach 5 cm. in length and are grayish green in color, with eight pale, parallel bands running longitudinally on the dorsum. The anterior part of the head and the metathorax are black.

The gregarious larvae destroy the blossoms and young leaves of the avocado. They live in nests made by webbing together the leaves and twigs. They may be destroyed by pruning off and burning the nests.

Lasiocampids (*Tent Caterpillars*)

The larvae of a lasiocampid moth, *Euglyphis fibra* (Schaus), sometimes cause severe damage to avocados in nurseries in Brazil. All the leaves are devoured except a few of the older ones that are webbed together to form shelters for the cocoons. Good control has been obtained from lead arsenate at 0.4 per cent or parathion at 0.01 per cent concentrations.

In Indonesia, *Suana concolor* (Walker) is a pest because of its urticating hairs.

Avocadoworms

The avocadoworm, *Turuptiana obliqua* Walker (family Arctiidae), is found in various parts of Colombia between 1,000 and 6,000 feet elevation. Avocados, sapotes, granadillas, grapes, and many other fruits are attacked by this pest, which is called *gusano del aguacate* (avocadoworm) or *gusano de cosecha* (harvestworm) (Luis Gallego, 1949).

The full-grown larvae are usually about 3 cm. long. They are of a maroon color and have maroon-colored tufts of hair on each segment. These tufts of hair are yellowish green in earlier instars, except for those of the central segments, which are nearly black.

The adult females have a wing expanse of 4.5 cm.; the males are somewhat smaller. They are of a dirty-white color, with a narrow, black margin and a transverse, narrow, black band on each forewing.

The larvae occur in colonies of about 200 individuals. One such colony can completely defoliate an avocado tree. Vigorous trees growing in good soil regain their foliage well in two or three months, but old or less vigorous trees in poor soil regain their foliage slowly and are severely debilitated.

Stomach poisons, or, while the larvae are small, a DDT spray, are recommended for control. Fertilization to increase the vigor of the defoliated tree is said to be highly beneficial.

In the Canal Zone, a saturniid moth of the genus *Hylesia,* principally a pest of the mango, also defoliates avocado trees (Howard, 1925).

Fruit Flies

Many species of fruit flies (Trypetidae) have been found infesting ripe avocados by various investigators. The Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (pl. VIII, 7), is a serious pest of the soft-skinned summer varieties of avocados in Israel, and often causes 80 to 100 per cent of the gruit to be damaged.[4] This species, and the oriental fruit fly, *Dacus dorsalis* Hendel (pl. VIII, 7), which has become established in Hawaii in recent years, are potential pests of certain avocado-growing areas of the United States. In Hawaii, a variety of avocado similar to the Fuerte, the most important California variety, was found to be 100 per cent infested in one orchard that was examined. There were as many as fifteen visible egg punctures on a single fruit. The egg punctures were characterized by the white, crystallized latex ("dulcitol") exuded from the wounds. This in itself would destroy the commercial value of the fruit, but even worse is the presence of larvae in the flesh. With thick-skinned varieties, the infestation is difficult to detect, even though the larvae may be present inside the fruit (Weybret, 1949).

The biology and control of fruit flies are discussed in chapter 8, starting on page 242.

CHECK LIST OF THE AVOCADO PESTS OF THE WORLD

In the following list, the avocado pests of the world are arranged according to order and family. Like the citrus pests listed on pages 276 to 284, chapter 8, they are placed not necessarily in the order of their importance, but in the order of the current consensus regarding their taxonomic relationships. The genera are alphabetically arranged.

An asterisk is placed before species known to be minor pests. They have been recorded as causing appreciable economic injury to the avocado, and possibly, in some cases, sporadic and localized severe injury. A double asterisk has been placed before species known to be major pests. The remaining species have been recorded as feeding on the avocado, but not in numbers to justify their designation even as minor pests. However, any species feeding on a fruit crop may within a few years assume major importance. Some of the species listed without an asterisk may therefore be of some importance as pests, although not known to be so now.

[4]Correspondence of November 1, 1949, from Dr. E. Rivnay, Division of Entomology, The Jewish Agency Agricultural Research Station, Rehovot, Israel.

Regions in which the pests have been recorded are indicated in the right-hand column. However, this list may lack certain areas, at least for some of the species listed. New data are constantly coming to light in this study.

In most regions where avocados occur, they are usually present only as dooryard trees or scattered about in orchards and fields devoted primarily to other crops. Nevertheless, the fruit is picked and can usually be found on the market. Severe pests in such areas cannot be considered as being of major economic importance. However, these may be starred in the present list to indicate their potentiality as pests if the avocado is ever developed as a commercial crop in the region indicated, or if the pest were to be accidentally introduced into areas where the avocado is commercially important, such as California or Florida.

The symbols for the regions indicated in the check list are as follows: A, Australia; Ar, Argentina; B, Brazil; BC, Belgian Congo; Ber, Bermuda; BG, British Guiana; CA, Central America; Cal, California; Cey, Ceylon; Ch, Chile; Col, Colombia; CR, Costa Rica; CZ, Canal Zone; Ec, Ecuador; Fla, Florida; Fo, Formosa; G, Guatemala; GC, Gold Coast; H, Hawaii; Hon, Honduras; In, Indonesia; Is, Israel; J, Japan; Mau, Mauritius; Me, Mexico; N, Nyasaland; P, Peru; Par, Paraguay; Ph, Philippines; R, Russia; Rhod, Rhodesia; SA, South Africa; SG, Spanish Guinea; SL, Sierra Leone; Sp, Spain; Tan, Tanganyika; Tr, Trinidad and Tobago; U, Uganda; and WI, West Indies.

STYLOMMATOPHORA

HELICIDAE (Snails)

- **Helix aspersa* Müller ..... Cal
- *Helix joppensis* Roth ..... Is
- *Helix seetzeni* Koch ..... Is
- *Theba pisana* (Müller) (=*Helix*) ..... Is

ACARINA

ERIOPHYIDAE (Blister Mites, Bud Mites)

- *Calepitrimerus muesebecki* Keifer ..... Cal, Fla
- *Epitrimerus myersi* Keifer ..... Cal

TETRANYCHIDAE (Spider Mites, Red Spiders)

- *Bryobia praetiosa* Koch ..... Ch
- ***Eotetranychus sexmaculatus* (Riley) ..... Cal
- *Oligonychus platani* (McGregor) (=*Paratetranychus*) Cal
- **Oligonychus punicae* (Hirst) ..... Cal
  (=*Paratetranychus coiti* McGregor)
- **Oligonychus yothersi* (McGregor) (=*major* Ewing) ... Fla
- *Panonychus ulmi* (Koch) (=*Metatetranychus*) ..... Ch

PHYTOPTIPALPIDAE (False Spider Mites)

- *Brevipalpus australis* (Tucker) ..... Cal, Fla, H
  (=*obovatus* Donnadieu)
  (=*papayensis* Baker)
  (=*phoenicis* Geijskes)

TUCKERELLIDAE
Tuckerella pavoniformis (Ewing) (on bark) ..... Fla
TARSONEMIDAE (Soft-Bodied Mites)
Hemitarsonemus latus (Banks) ..... Cal
TYDEIDAE
Tydeus californicus (Banks) ..... Cal

ORTHOPTERA

ACRIDIDAE (Grasshoppers)
**Eutropidacris cristata* (Linnaeus) ..... B
TETTIGONIIDAE (Katydids)
Elimaea punctifera (Walker) ..... H
GRYLLIDAE (Crickets)
Chremon repetinus Rehn ..... WI
Occanthus niveus (De Geer) ..... Cal
GRYLLOTALPIDAE (Mole Crickets)
Gryllotalpa gryllotalpa (Linnaeus) ..... Is

ISOPTERA

KALOTERMITIDAE
Neotermes castaneus (Burmeister) ..... Cal, Fla
RHINOTERMITIDAE
Coptotermes niger Snyder ..... CZ
Heterotermes tenuis (Hagen) ..... CZ
Schedorhinotermes lamanianus (Sjöstedt) ..... Tan
TERMITIDAE
Nasutitermes costalis (Holmgren) ..... Tan
Tenuirostritermes incisus (Snyder) ..... WI

THYSANOPTERA

THRIPIDAE (Thrips)
**Frankliniella bispinosa* (Morgan) ..... Fla, WI
(=*cephalica bruneri* Watson)
(=*cephalica masoni* Watson)
Frankliniella cephalica (Crawford) ..... Me, Fla
***Heliothrips haemorrhoidalis* (Bouché) ..... Cal, Fla, Me, CA, Tr, BG, R, A
Retithrips syriacus (Mayet) ..... Is
**Selenothrips rubrocinctus* (Giard) ..... Fla, SL, GC, CA, WI, B
PHLAEOTHRIPIDAE
Liothrips perseae Watson ..... WI

HEMIPTERA-HOMOPTERA

FULGORIDAE (Fulgorid Planthoppers)
Danepteryx robusta Doering ..... Cal
MEMBRACIDAE (Treehoppers)
Ceressa concinna Fowler ..... CR
Membracis mexicana Guérin ..... G
**Metcalfiella monogramma* (Germar) ..... Me
**Platycotis tuberculatus* (Fairmaire) ..... WI
Stictolobus minor (Fowler) ..... Hon
Stictopelta indeterminata (Walker) ..... Hon
AETALIONIDAE
**Aetalion quadratum* Fowler ..... Me
(=*Polydontoscelis cintifrons* Ashmead)
Aetalion reticulatum (Linnaeus) ..... Ar
CICADELLIDAE (Leafhoppers)
Agalliopsis sp. ..... G
Carneocephala dyeri (Gibson) ..... CR
Draeculacephala sp. ..... Hon
Empoasca dilitara DeLong & Davidson ..... Fla, WI
Empoasca papayae Oman ..... WI
Erythrogonia laudata (Fowler) ..... Hon
Homalodisca triquetra (Fabricius) ..... Hon
Hortensia sp. ..... CR
Idona minuenda (Ball) (=*Empoasca*) ..... Fla, WI
Idona minuenda clavigerana (Ball) (=*Empoasca*) ..... Fla
Idona minuenda moznettei (Ball) (=*Empoasca*) ..... Fla
Idona spp. ..... Me, Hon
Oncometopia sp. ..... Hon
Scaphytopius sp. ..... Me, G
Tettigella constans (Walker) (=*Cicadella*) ..... WI
Tettigella instrata (Fowler) ..... G
Tettigella miniaticeps (Fowler) ..... CR
Tylozygus fasciatus (Walker) ..... CR
Tylozygus sp. ..... Hon
PSYLLIDAE (Jumping Plant Lice or Psyllids; Gall Aphids)
Carsidara dugesii Loew ..... CR
**Trioza anceps* Tuthill (=*koebelei* Kirkaldy) ..... Me, CA
ALEYRODIDAE (Whiteflies)
**Aleurocanthus woglumi* Ashby ..... WI, Me, CA, CZ, Ph
Aleurodes insignis Bondar ..... B
Aleurodicus dugesii (Cockerell) ..... Me
Aleurodicus neglectus Quaintance & Baker ..... Tr
Aleuroplatus coronatus (Quaintance) ..... Cal
Aleurotrachelus sp. ..... B
Bemisia sp., possibly *inconspicua* (Quaintance) ..... G
Paraleurodes perseae (Quaintance) ..... Fla
Paraleurodes sp., near *goyabae* (Goeldi) ..... Me
Tetralicia sp. ..... Hon
**Trialeurodes floridensis* (Quaintance) ..... Fla, H
Trialeurodes similis Russell ..... Me
**Trialeurodes vaporariorum* (Westwood) ..... Cal
APHIDAE (Aphids)
Aphis gossypii Glover ..... Cal, Fla, WI, Ar, Me, CA, P
Aphis rumicis Linnaeus ..... Cal
Thoracaphis umbellulariae Essig ..... Cal
Toxoptera aurantii (Fonscolombe) ..... Fla
MARGARODIDAE (Margarodid Scales)
Drosicha contrahens (Walker) ..... Ph, Fo
Icerya montserratensis Riley & Howard ..... Me
Icerya purchasi Maskell ..... Cal, Fla, WI, CA, Me, Sp
Icerya seychellarum (Westwood) ..... Fiji
PSEUDOCOCCIDAE (Mealybugs)
Farinococcus olivaceus (Cockerell) (=*Pseudococcus*) ..... Me
Ferrisia virgata (Cockerell) ..... Fla, WI
Phenacoccus colemani Ehrhorn ..... Cal
Phenacoccus gossypii Townsend & Cockerell ..... Cal, WI, B
Planococcus citri (Risso) (=*Pseudococcus*) ..... Cal, Fla, WI, Me, CA, P, B, Ch, Tr
**Pseudococcus adonidum* (Linnaeus) ..... Cal, Fla, Me, WI, CA, B, Ch
Pseudococcus brevipes (Cockerell) ..... WI
(=*Dysmicoccus, Dactylopius*)
Pseudococcus comstocki (Kuwana) ..... Is
Pseudococcus gahani Green ..... Cal, Ch
Pseudococcus maritimus (Ehrhorn) ..... Cal, Fla
**Pseudococcus nipae* (Maskell) ..... Fla, Me, BG, Tr, H, B
ASTEROLECANIIDAE (Pit Scales)
Asterolecanium pustulans (Cockerell) ..... H
Cerococcus sp. nov. ..... G
COCCIDAE (Unarmored Scales)
Ceroplastes cirripediformis Comstock ..... Cal, Fla, WI, Me
Ceroplastes cistudiformis Townsend & Cockerell ..... Cal, Me
**Ceroplastes destructor* Newstead ..... A
Ceroplastes floridensis Comstock ..... Fla, WI, CA, B, Me, Is
**Ceroplastes rubens* Maskell ..... H, Cey, A

Ceroplastes rusci (Linnaeus) ..... Ar
Coccus hesperidum Linnaeus ..... Cal, Fla, WI, CA, Me, B, Is, A
Coccus mangiferae (Green) ..... Hon
Eucalymnatus tessellatus (Signoret) ..... Fla, WI
Lecanium corni Bouché ..... Cal
Platinglisia noacki Cockerell ..... B
Protopulvinaria longivalvata Green ..... B
Pulvinaria floccifera Westwood ..... CA
Pulvinaria mammeae Maskell ..... H
Pulvinaria psidii Maskell ..... Fla, WI, H
**Pulvinaria pyriformis* Cockerell (=*Protopulvinaria*) ..... Fla, WI, CZ, P, Par, Tr, Ber
Pulvinaria simulans Cockerell ..... Me
Saissetia formicarii (Green) ..... Cal, Fla, WI, CZ, B, Ph
Saissetia hemisphaerica (Targioni) ..... Cal, Fla, WI, Me, Ar, CA, CZ, Ch, Is
Saissetia nigra (Nietner) ..... Cal, Tr
Saissetia oleae (Bernard) ..... Cal, Fla, Ch, Is, Ar, A
Saissetia perseae Brain ..... SA
Solenococcus sp. ..... CA
Toumeyella liriodendri (Gmellin) ..... Fla
Toumeyella sp. ..... Hon

DIASPIDIDAE (Armored Scales)

Acutaspis albopicta (Cockerell) ..... CA
Acutaspis subnigra McKenzie ..... P
**Aonidiella aurantii* (Maskell) ..... Cal, Is, A
Aonidiella citrina (Coquillett) ..... Cal
Aonidiella orientalis (Newstead) ..... Fla, WI
Aspidiaspis arctostaphyli Cockerell & Robbins ..... Cal
**Aspidiotus destructor* Signoret ..... Fiji, CA, Fla, Tr
Aspidiotus hederae (Vallot) ..... Cal, Fla, Ch, A
Aspidiotus orientalis (Marlatt) ..... Fla (=*orientalis cocotiphagus* [Marlatt])
Aspidiotus spinosus Comstock ..... H, J, Cal (=*persearum* Cockerell)
Chrysomphalus agavis (Townsend & Cockerell) ..... Fla, Me
**Chrysomphalus aonidum* (Linnaeus) ..... Fla, WI, CA, H, Is, A
Chrysomphalus bifasciculatus Ferris ..... H
**Chrysomphalus dictyospermi* (Morgan) ..... Fla, Cal, Ar, B, Ch, CA, WI, H, SA
Chrysomphalus perseae (Comstock) ..... Fla, WI, Me, CA, B
**Chrysomphalus personatus* (Comstock) ..... CA, B, BG
Chrysomphalus pinnulifera diversicolor Green ..... Rhod
Chrysomphalus rossi (Maskell) (=*Lindingaspis*) ..... A
Chrysomphalus scutiformis (Cockerell) ..... Me, CA, B (=*Aspidiotus*)
Diaspis boisduvalii Signoret ..... CA
Diaspis sp., near *miranda* (Cockerell) ..... CA
Fiorinia fioriniae (Targioni-Tozzetti) ..... Fla, WI, H
Furcaspis biformis (Cockerell) (=*Targionia*) ..... CZ
Hemiberlesia cyanophylli (Signoret) ..... CA, Fla, Ar
**Hemiberlesia lataniae* (Signoret) (=*Aspidiotus*) ..... Cal, Fla, WI, CA, Tr, Ar, B, Is
Hemiberlesia palmae (Cockerell) ..... WI, CA, France (=*Aspidiotus palmae* Morgan & Cockerell)
Hemiberlesia rapax (Comstock) ..... Cal, Fla, CA, Is (=*Aspidiotus camelliae* Signoret)
Hemiberlesia sp., near *diffinis* (Newstead) ..... CA
Ischnaspis longirostris (Signoret) ..... CZ, B
Lepidosaphes beckii (Newman) ..... Ar
Lepidosaphes longula Leonardi ..... In
Lepidosaphes mimosarum Cockerell ..... CA
Lepidosaphes sp. ..... A
Lindingaspis floridana Ferris ..... Fla
**Mycetaspis personata* (Comstock) ..... Me
Neopinnaspis harperi McKenzie ..... Cal
Parlatoria proteus (Curtis) ..... Fla, B, Cey, H
Phenacaspis sandwichensis Fullaway ..... H
Pinnaspis rhombica Leonardi ..... J
Pinnaspis strachani (Cooley) ..... Fla, WI, H, B, Cey (=*Hemichionaspis minor* [Maskell])
Pseudaonidia duplex (Cockerell) ..... Fla, J
Pseudaonidia trilobitiformis Green ..... B
Pseudischnaspis alienus (Newstead) ..... Fla, WI
Pseudischnaspis bowreyi (Cockerell) ..... Fla
Pseudoparlatoria ostreata Cockerell ..... CA
Pseudoparlatoria parlatorioides (Comstock) ..... Fla, Is
Selenaspidus articulatus (Morgan) ..... Fla, WI, CA, B, P, CZ

HEMIPTERA-HETEROPTERA

PENTATOMIDAE (Stinkbugs)

Chlorocoris astrispinus Stål ..... Hon
**Murgantia histrionica* (Hahn) ..... Cal
Nezara viridula (Linnaeus) ..... Is

COREIDAE (Coreid Bugs)

Anisoscelis affinis Westwood ..... Hon
Burtinus notatipennis Stål ..... Me
Capaneus humerosus Distant ..... Me
Cebrenis robustus Stål ..... G
Chariesterus molestus Burmeister ..... Hon
***Homoeocerus* sp. ..... GC
Leptoglossus membranaceus (Fabricius) ..... SA
Leptoglossus phyllopus (Linnaeus) ..... Me
Leptoglossus stigma (Herbst) ..... Ar
Leptoglossus zonatus (Dallas) ..... G
Savius jurgiosus (Stål) ..... Hon

LYGAEIDAE (Lygaeid Bugs)

Lygaeus analis Dallas ..... Hon
**Nysius raphanus* Howard ..... Cal

PYRRHOCORIDAE (Pyrrhocorid Bugs)

Dysdercus obliquus (Herrich-Schaeffer) ..... Me
Dysdercus suturellus (Herrich-Schaeffer) ..... Fla
Largus cinctus Herrich-Schaeffer ..... Me

TINGIDAE (Lacebugs)

**Pseudacysta perseae* (Heidemann) (=*Acysta*) ..... Fla
Tigava pulchella Champion ..... Hon

MIRIDAE (Plant Bugs)

**Bryocoropsis laticollis* Schumacher ..... GC
**Helopeltis antonii* Signoret ..... SA, Ph
***Helopeltis bergrothi* Reuter ..... N
**Helopeltis lemosi* Ghesquière ..... BC
**Helopeltis maynei* Ghesquière ..... BC
**Helopeltis sanguineus* Poppius ..... BC
Horcias nobilellus (Berg) ..... B
**Lygus fasciatus* Reuter ..... Fla
**Rhinacloa subpallicornis* Knight ..... Fla
Taylorilygus arboreus (Taylor) (=*Lygus*) ..... U
Termatophylidea maculata Usinger ..... CR

COLEOPTERA

NITIDULIDAE

Brachypeplus pilosellus Murray ..... SL

CUCUJIDAE (Cucujids)

Ahasverus advena (Waltl) (=*Cathartus*) ..... CA

TENEBRIONIDAE (Darkling Beetles)

**Coniontis subpubescens* Leconte ..... Cal

LYCTIDAE (Powder-Post Beetles)
Lyctus parallelepipedus (Melsheimer) ..... Fiji
Tristiaria sp. ..... A
BOSTRICHIDAE (False Powder-Post Beetles)
Amphicerus cornutus (Pallas) ..... Cal, Ch
Apate monachus Fabricius (=*carmelita*) ..... WI, SL
Apate terebrans (Pallas) ..... GC, SL, WI
Dexicrates robustus (Blanchard) ..... Ch
Melalgus confertus (Leconte) (=*Polycaon*) ..... Cal
Micrapate neglecta Lesne ..... SL
Micrapate scabrata (Erichson) ..... Ch
Xylopsocus gibbicollis Macleay ..... A
Xylothrips religiosus (Boisduval) ..... H
ANOBIIDAE (Deathwatch and Drugstore Beetles)
Ozognathus cornutus (Leconte) ..... Cal
SCARABAEIDAE (Scarabs)
Melolonthinae
**Coenonycha testacea* Cazier ..... Cal
**Holotrichia mindanaona* Brenske (=*Phyllophaga*) ..... Guam, Ph
**Serica alternata* Leconte ..... Cal
**Serica fimbriata* Leconte ..... Cal
Trochalus carinatus (Gyllenhal) ..... SL
Trochalus gibbus (Fabricius) ..... SL
Trochalus pilula Klug ..... SL
Rutelinae
Adoretus saetipennis Ohaus (=*Chaetadoretus*) ..... B
Anomala denuda Arrow ..... SL
**Anomala undulata* Melsheimer ..... Fla
Platycoelia inflata Ohaus ..... Ar
Cetoniinae
Oxythyrea spp. ..... Is
CERAMBYCIDAE (Long-Horned Beetles or Roundheaded Wood Borers)
Acanthoderes jaspidea Germar ..... B
Anoplium inerme (Newman) (=*Elaphidion*) ..... Fla
Batocera rubus Linnaeus ..... WI, Cey
Derobrachus asperatus Bates ..... P
Lypsimena fasciata Leconte ..... Fla
Mecosaspis atripennis Hope ..... SL
Oncideres aegrota Thomson ..... Ar
Oncideres fasciata Lucas ..... Par
**Oncideres poecila* Bates ..... P
**Oncideres* sp. ..... P, B
Steirastoma marmorata Thunberg ..... Ar
Sthenias varius Olivier ..... Ph
**Stenodontes downesi* (Hope) (=*Mallodon*) ..... SG
Trachyderes subpilosus Waterhouse ..... Hon
Trachyderes succinctus Linnaeus ..... Ar
CHRYSOMELIDAE (Leaf Beetles, Flea Beetles)
Coptocycla sp., prob. *dorsoplagiata* Champion ..... Hon
Deloyala guttata (Olivier) ..... Me
Diabrotica balteata Leconte ..... Cal, Fla
**Diabrotica undecimpunctata undecimpunctata* Mannerheim ..... Cal
**Diachus auratus* (Fabricius) ..... Cal
Megalognatha sp. ..... Tan, U
Megalostomis pyropyga Lacordaire ..... Hon
***Monolepta australis* Jacoby ..... A
Monolepta bifasciata Hornstedt ..... Ph
**Monolepta lepida* Reiche ..... Is
Niphonoclea albata (Newman) ..... Ph
Niphonoclea capito (Pascoe) ..... Ph
Nisotra spadicea (Dalman) (=*Podagrica*) ..... SL
Ootheca mutabilis Sahlberg ..... SL
Phytorus lineolatus Weise ..... H
Phytorus pinguis Baly ..... Guam
Rhabdopterus bowditchii Barber ..... Fla
**Systena blanda* Melsheimer (=*taeniata* [Say]) ..... Cal
ANTHRIBIDAE (Fungus Weevils)
Araecerus fasciculatus (De Geer) ..... Fla, CA, SL
CURCULIONIDAE (Snout Beetles or Weevils)
**Adaleres humeralis* Casey ..... Cal
Apoderus tranquebaricus (Fabricius) (=*Strigapoderus*) ..... Cey
Apteromechus ferratus (Say) ..... Fla
Brachyrhinus cribricollis (Gyllenhal) ..... Cal
Caulophilus latinasus (Say) ..... Cal
***Conotrachelus aguacate* Barber ..... Me, CZ
***Conotrachelus perseae* Barber ..... Me, CA
**Conotrachelus serpentinus* Bohemann ..... Fla
***Copturomimus perseae* Hustache ..... Col
****Copturus* sp. ..... Me
**Cratosomus phaleratus* Perty ..... B
**Diaprepes abbreviatus* (Linnaeus) ..... WI
Diaprepes abbreviatus doublieri Guérin ..... WI
Diaprepes abbreviatus spengleri (Herbst) ..... WI
**Heilipus catagraphus* Germar ..... B
***Heilipus lauri* Bohemann ..... Me, CA
Heilipus montei Costa Lima ..... B
**Heilipus perseae* Barber ..... CZ
**Heilipus pittieri* Barber ..... CA
***Heilipus squamosus* Leconte ..... Fla, WI
Listroderes costirostris obliquus (Klug) ..... Cal
Pachnaeus azurescens Gyllenhal ..... WI
Pachnaeus costatus Perroud ..... WI
Pachnaeus litus (Germar) ..... Fla, WI
Pachnaeus psittacus (Olivier) ..... WI
**Pantomorus godmani* (Crotch) ..... Cal
Rhyephenes humeralis (Guérin) ..... Ch
Sitophilus oryza (Linnaeus) ..... CA
SCOLYTIDAE (Bark Beetles)
Crossotarsus externedentatus (Fairmaire) ..... H
Crossotarsus saundersi Chapuis ..... Fiji
Hypothenemus eruditus Westwood ..... H
Hypothenemus peritus Blandford ..... Fiji
Monarthrum sp. ..... Cal
**Pagiocerus frontalis* (Fabricius) ..... P
Pagiocerus rimosus Eichhoff ..... WI, CZ, Ch
Platypus sulcatus Chapuis ..... Ar
**Xyleborus aplanatideclivis* Schedl ..... Fiji
Xyleborus fijianus Schedl ..... Fiji
Xyleborus fornicatus Eichhoff ..... Cey
Xyleborus kraatzi Eichhoff (=*immaturus* Blackburn) ..... H
***Xyleborus morstatti* Hagedorn ..... Fiji, Mau, Fla
**Xyleborus mutilatus* Blandford ..... Fiji, Mau
Xyleborus saxeseni (Ratzeburg) ..... Cal
Xyleborus xylographus (Say) ..... Cal

HYMENOPTERA

FORMICIDAE (Ants)
**Atta insularis* Guérin ..... WI
***Atta sexdens* (Linnaeus) ..... P, B
**Crematogaster brevispinosa* Mayr ..... Tr
**Iridomyrmex humilis* (Mayr) ..... Cal
**Solenopsis geminata* (Fabricius) ..... Cal, Tr
**Solenopsis xyloni maniosa* Wheeler ..... Cal

MEGACHILIDAE (Leafcutting Bees)
Megachile davidsoni Cockerell ..... Cal
MELIPONIDAE
Melipona testacea cupira Smith ..... Me

LEPIDOPTERA

GRACILARIIDAE (Leaf Blotch Miners)
Acrocercops ordinatella Meyrick ..... Cey
Gracilaria perseae Busck ..... Fla
Gracilaria violacella Clemens ..... Fla
Marmara salictella Clemens ..... Cal
AEGERIIDAE (Clearwing Moths)
Synanthedron resplendens (Hy. Edwards) (=*Aegeria*) Cal
PSYCHIDAE (Bagworm Moths)
**Hyalarcta hübneri* (Westwood) ..... A
Thanatopsyche chilensis (Philippi) ..... Ch
HYPONOMEUTIDAE (Plutellid Moths)
Atteva punctella (Cramer) ..... Ar
BLASTOBASIDAE
Holcocera iceryaecella (Riley) ..... Cal
STENOMIDAE
***Stenoma catenifer* Walsingham ..... Me, CZ, Ec, P, B, Ar, H, CA
OECOPHORIDAE
Coptotelia perseaphaga Clarke ..... CR
COSSIDAE (Carpenterworm Moths)
**Duomitus punctifer* Hampson ..... WI
Langsdorfia valdiviana Philippi ..... Ch
Zeuzera coffeae Nietner ..... Tan, In, Cey, India
TORTRICIDAE (Leaf-Roller Moths)
**Amorbia emigratella* Busck ..... Me, H
**Amorbia essigana* Busck ..... Cal
**Argyrotaenia amatana* (Dyar) ..... Fla
**Argyrotaenia citrana* (Fernald) ..... Cal, B
Platynota stultana Walsingham ..... Cal
Sparganothis sp. ..... Fla
OLETHREUTIDAE (Olethreutid Moths)
Olethreutes leucotreta (Meyrick) ..... Rhod, SA, SL (=*Argyroploce*)
PYRALIDIDAE (Pyralid Moths)
Homalopalpia dalera (Dyar) ..... Fla
PYRAUSTIDAE
Dichocrocis punctiferalis (Guenée) ..... A
EPIPASCHIIDAE
**Stericta albifasciata* (Druce) ..... WI, B, Ec, P, BG, CA
LIMACODIDAE (Slug-Caterpillar Moths)
Sibine trimacula (Sepp) ..... Ar
GEOMETRIDAE (Geometrid Moths)
***Sabulodes caberata* (Guenée) ..... Cal
LASIOCAMPIDAE (Tent Caterpillars)
Euglyphis fibra (Schaus) ..... B
Suana concolor (Walker) ..... In
LYMANTRIIDAE (Tussock Moths)
**Hemerocampa vetusta* (Boisduval) ..... Cal
NOCTUIDAE (Phalaenidae) ("Millers," Cutworms)
Heliothis zea (Boddie) ..... Cal
Peridroma margaritosa (Haworth) ..... Cal
Prodenia eridania (Cramer) (=*Xylomyges*) ..... Fla
Pseudoplusia includens Walker (=*oo* Cramer) ..... Cal
ARCTIIDAE (Tiger Moths)
Estigmene acrea (Drury) ..... Cal
**Turuptiana obliqua* Walker ..... Col
SATURNIIDAE (Giant Silkworms)
**Hylesia* sp. ..... CZ
CITHERONIIDAE (Royal Moths)
Eacles imperialis (Drury) ..... Ar
HESPERIIDAE (Skippers)
Calpodes ethlius (Cramer) ..... WI
PAPILIONIDAE (Swallowtail Butterflies)
Papilio rutulus Lucas ..... Cal
**Papilio scamander grayi* Boisduval ..... B
Papilio thoas brasiliensis Rothschöld & Jordan ..... B, Ar

DIPTERA

MUSCIDAE (Houseflies, Stable Flies)
Atherigona orientalis Schiner (=*excisa* Thomson) ..... SL
TRYPETIDAE (Tephritidae)[5] (Fruit Flies, Trypetids)
**Anastrepha fraterculus* (Wiedemann) ..... Ar
Anastrepha ludens (Loew) ..... Me
Anastrepha serpentina (Wiedemann) ..... CA, WI
***Ceratitis capitata* (Wiedemann) ..... CA, H, In, Is
***Dacus dorsalis* Hendel ..... H, Fo, Guam, Cey
Dacus ferrugineus (Fabricius) ..... Cey
Dacus passiflora Froggatt (=*Chaetodacus*) ..... Fiji
***Dacus tryoni* (Froggatt) (=*Strumeta*) ..... A
Dacus xanthodes Broun (=*Chaetodacus*) ..... H, Samoa

MAMMALIA

ORDER MARSUPIALIA
Didelphis virginiana virginiana Kerr ..... Cal
ORDER RODENTIA
**Microtus californicus sanctidiegi* R. Kellogg ..... Cal
Neotoma fuscipes Baird ..... Cal
**Rattus norvegicus* (Erxleben) ..... Cal
**Rattus rattus alexandrinus* (Geoffroy) ..... Cal, Is
**Rattus rattus frugivorus* (Rafinesque) ..... Is
Rattus rattus rattus (Linnaeus) ..... Cal
**Sciurus niger rufiventer* (Geoffroy) ..... Cal
**Thomomys bottae bottae* (Eydoux & Gervais) ..... Cal
ORDER CARNIVORA
Canis aureus Linnaeus ..... Is
Procyon lotor psora Gray ..... Cal

[5]Injurious on thin-skinned varieties only; occasionally found on others.