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ORCHARD INSECTS OF THE PACIFIC NORTHWEST AND THEIR CONTROL

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Orchard Insects of the Pacific Northwest and Their Control

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In the orchards of the Pacific Northwest insects take a toll of many million dollars a year. In Washington and Oregon alone the value of the annual fruit crop is about 100 million dollars, and the cost of combating insect pests and the losses due to infested fruit amount to about one-tenth this figure. Knowledge of the insects found in these orchards—their life history and habits and how to control them—is of vital interest to fruit growers. This circular gives such information about the most important insects found in the orchards of Oregon, Washington, Idaho, and western Montana. Many of these insects also occur in Utah and California.

APPLE AND PEAR INSECTS

CODLING MOTH

The codling moth² is present in all the apple-growing districts of the West, having been accidentally introduced from Europe into the Eastern States and then transmitted to the Pacific coast.

This insect is injurious only in the larval, or worm, stage. The young worms crawl to the fruit nearest them, burrow into it, and produce the familiar wormy apple or pear. Many worms enter through the calyx end, where the calyx protects them and they can easily obtain a foothold; others enter at a point where two fruits touch, or where a leaf touches a fruit; and still others burrow into the exposed side of the fruit. The worm penetrates the skin and within an hour excavates a small cavity. It remains near the surface for a few days and then burrows to the center of the fruit, usually feeding on the seeds and core. When full-grown the worm tunnels to the surface and leaves the fruit. Wormy fruit is of small commercial value, as it will not keep long, and the laws of some States forbid its shipment except to byproducts plants.

Another form of injury known as the sting (fig. 1) is caused by a worm that begins to burrow into the fruit and then dies, usually from feeding on a slow-acting poison spray on the fruit. Large

¹The assistance of staff members of the Yakima, Wash., laboratory of the Bureau of Entomology and Plant Quarantine, and of members of the various experiment stations in the Pacific Northwest, is gratefully acknowledged.

²The scientific names of the insects included in this circular are listed on page 56.

Figure 1.—Stings made by codling moth worms on an apple.

stings may cause the fruit to be classified as culls, and small stings, if there are many of them, will lower its grade.

LIFE HISTORY

The codling moth winters as a worm in a cocoon (fig. 2, *A*) about three-fourths inch long. The cocoon may be under the loose bark of the trees, in cracks and crevices on the trunks, attached to the trunk just below the surface of the ground, or in protected places in

Figure 2.—Codling moth: *A*, Larva and pupa in cocoons; *B*, adult. Enlarged.

boxes, sacks, and packing sheds. The worm just about fills the cocoon and is dirty white or pinkish, with a brown head. The last brood of worms that leaves the fruit before it is packed, and a part of the preceding brood, hibernate. In the spring the worms construct tubes of silk, transform to pupae, and later to moths, which escape through these tubes. The first moths appear about the time Winesap apple trees are in bloom, and the largest numbers are flying late in May or early in June. The moths (fig. 2, *B*) are rather inconspicuous, having a wing spread of about three-fourths inch. The front, or upper, wings are brownish gray, crossed with lines of lighter gray, with a bronze band at the tip. The hind wings, which are covered when the moths are at rest, are grayish brown. The moths live for about 2 weeks. They lay most of their eggs between sundown and 9 or 10 p. m., but lay few eggs if the temperature is below 60° F. Most of the eggs are laid during the second, third, and fourth evenings after the moths have emerged, but in the spring, cool weather may prevent egg laying for a week or more. The eggs (fig. 3) are pearly white, about the size of pinheads, and resemble thin convex disks. A red ring appears in the egg a few days after it is laid, and the day before the worm hatches a black spot, the head of the worm, is easily seen. Most of the first-brood eggs are laid on the leaves surrounding the small fruits.

Usually the weather is cool when the first eggs are laid, and the worms do not hatch for 12 to 14 days. As the temperature increases, the incubation period becomes shorter, the minimum being 5 days. Worms are hatching and entering the fruit for about 5 weeks, and are most numerous

Figure 3.—Codling moth eggs: *A*, Natural size on apple leaf; *B*, single egg, greatly enlarged.

during June. These worms feed in the fruit for about 3 weeks and then leave it and spin cocoons. About 75 percent of them develop into pupae and moths, but the others remain in the cocoons until the following season. The worms that transform pass through the pupal period in about 2 weeks, and the first individuals of the second brood of moths appear early in July.

After this time moths are present in large numbers until cool weather, and the first stormy weather in September usually ends their activities for the season. Many eggs of the second brood are laid on the fruit, and during July and August they ordinarily hatch in 6 or 7 days. The worms often remain in the fruit for more than a month in the fall,

and many of them are still there when it is picked. They may leave the fruit before it is packed, and large numbers of cocoons may be found in picking boxes and packing sheds.

The codling moth is sensitive to variations in temperature. In warm localities there is often a partial third generation, but at higher elevations and along the coast there is no third generation and the second generation is smaller than elsewhere. In any locality the yearly abundance of worms varies greatly, as it is dependent on weather conditions. Temperatures of -15° F. or colder kill some of the overwintering worms. Probably the effect of temperature is most evident during May and June, when large numbers of first-brood eggs are laid if the weather is warm, but the number is greatly reduced if it is cold or rainy. Thus an early warm season produces many worms, but a late cool season has the opposite effect. The fruit grower should therefore study weather conditions as well as conditions in his orchard and plan his spraying schedule accordingly.

CONTROL

Although lead arsenate and cryolite have been used for many years to control the codling moth, the most effective means at present consists in spraying the trees one or more times with DDT. Other organic insecticides may be developed for this purpose, and a material that will not leave objectionable residues on the fruit or in the soil is needed. For apples two to four cover sprays of DDT, about 3 or 4 weeks apart, will give excellent control. The 50-percent wettable powder should be used at the rate of 2 pounds to 100 gallons in the first cover spray, and at 1 to

2 pounds to 100 gallons in later applications. A calyx spray is unnecessary if DDT is used. The first cover spray should be applied as soon as large numbers of moths begin to fly, usually 2 to 3 weeks after the petals fall, as DDT not only kills many of the moths but also destroys any worms that might develop.

Bartlett pears can often be protected for the season with a single cover spray applied just before the first eggs hatch. Usually winter pears must be sprayed more than once.

Attractive baits, containing fermenting solutions of sugar or molasses, with or without an aromatic chemical, are useful for determining the periods when the moths are abundant in the orchards. Information obtained from traps is of value in timing spray applications. The numbers of moths caught, however, are not great enough to aid materially in control.

SAN JOSE SCALE

The San Jose scale is capable of doing more damage than any other insect occurring in the orchards of the Pacific Northwest. Besides rendering the fruit unmarketable, it kills the twigs and limbs, and if not controlled it may eventually kill the tree or at least so weaken it that it is worthless. Actually the San Jose scale does little damage, because control is easy and fruit growers generally know the danger and keep the scale under control.

This insect sucks the plant juices from the twigs and larger branches and from the fruit and foliage. It causes small reddish spots, particularly on the fruit, which often are the first indication that the scale is present (fig. 4, A). The red discoloration also occurs on scale-infested leaves and in the bark.

It cannot be seen on the surface of the bark, but is disclosed by cutting into infested twigs or limbs. The bark has a roughened and grayish appearance (fig. 4, B), and if it is scraped a yellowish liquid, coming from the crushed bodies of the insects, appears. Infestations are also manifested by dead twigs scattered about the tree and by the tendency of the leaves on infested branches to remain on the trees during the winter. In irrigated districts, however, apple leaves often remain on uninfested trees for at least a part of the winter.

Although present methods of control are adequate and are keeping the scale in check, an infestation should not be regarded lightly. If spraying is neglected, the scales can become numerous in a surprisingly short time, as a single female may produce several million progeny in one season. Laws in some States prohibit the marketing of infested fruit except for making byproducts, and quarantine regulations prohibit the entrance of infested fruit into certain foreign countries.

The San Jose scale is present in practically all the fruit districts in the United States. It does most harm to apple and pear trees but is at times a serious pest of sweet cherry, peach, and prune. It also attacks other deciduous fruit trees, as well as nut trees, berry bushes, and many kinds of shade trees and ornamental shrubs, among them the mountainash, currant, dogwood, elm, gooseberry, hawthorn, lilac, linden, poplar, snowberry, willow, and the ornamental flowering varieties of fruit trees. Many of these plants grow in the gardens or about the houses in fruit-growing districts, and unless they are inspected regularly and sprayed, if infested, they may be troublesome centers of infestation for orchards nearby.

Figure 4.—San Jose scale: *A*, Apples spotted by scales; *B*, bark encrusted with scale; *C*, scales magnified.

LIFE HISTORY

The San Jose scale remains in one place during most of its life. Almost all stages may be found on the trees in the fall, but only those that are about half-grown survive the winter, and in severe winters many of them succumb. Temperatures of -15° to -20° F. kill approximately two-thirds of the half-grown scales, and 90 percent or more are killed if the temperature gets as low as -25° or -30° .

In the spring the surviving scales continue their growth and mature in May or June. The males

develop wings and are active, although they do little flying. The females have no wings. They remain where they develop and produce several hundred very small, louselike, yellowish, active young. These young insects crawl considerable distances during the first few hours of their lives, and spread about at that time. Often they are carried to other trees by the wind, on the feet of birds, on the clothing of men working in the orchards, or on horses or farm implements. Ordinarily they settle down within a few hours on the bark or on leaves or fruit, insert

their long, threadlike beaks into the plant tissue, and begin feeding.

Almost at once they begin to secrete a waxy material, which soon forms a circular, scalelike covering. The covering of the full-grown female is about the size of a pinhead and grayish, with a dark, central nipple-like projection, whereas that of the male is elongated (fig. 4, *C*). Underneath these coverings the delicate, bright-yellow, saclike bodies of the insects may be seen. Growth is completed in about 6 weeks, and there are two or more generations in a season.

CONTROL

Ordinary infestations may be controlled with a single thorough application of lubricating-oil emulsion or liquid lime-sulfur during the dormant season. More than 1 year may be required to bring very heavy infestations under control.

The material to use depends on what other insects are on the trees at the same time. Oil sprays are effective against the eggs of red spiders, trechoppers, and the fruit tree leaf roller, and against newly hatched aphids, and should be used if these eggs or insects are numerous; otherwise the lime-sulfur is just as satisfactory. It is often desired to control the pear leaf blister mite on pear trees, and for this purpose lime-sulfur is preferable. This material is safer than oil emulsion for use during the delayed dormant period, although a sudden onset of warm weather after its application may cause the fruit buds to drop. These materials should be applied only while the trees are dormant (fig. 5). If the spray is applied after the trees have been pruned, less material is required. The most heavily infested limbs may often be removed before spraying.

On medium or heavy infestations of the San Jose scale, an emulsion containing about 4 percent of lubricating oil must be used. For very light infestations a 3-percent emulsion may be sufficient. The diluted liquid lime-sulfur must test at least $4\frac{1}{2}^{\circ}$ Baumé for most infestations (see table 1, p. 60). Very light infestations may be held in check with a solution testing at least $3\frac{1}{2}^{\circ}$ Baumé.

Figure 5.—Apple buds in stage of development for dormant spray.

A mixture of oil emulsion and liquid lime-sulfur is often useful for controlling the San Jose scale; 1 percent of actual oil and 3 percent of lime-sulfur is effective. If it is desired also to control the apple aphids (see p. 15) or to destroy orchard mite eggs (see p. 12) 2 percent of oil should be used. Only the paste or flowable types of oil emulsion should be employed, and the mixture should be applied when the trees are dormant.

OYSTERSHELL SCALE

The oystershell scale is found throughout the Northwest, but it is most common west of the Cas-

cade Mountains. It is readily distinguishable from other scale insects by its characteristic shape (fig. 6, *A*). The apple is a favorite food plant, but this scale also

Jose scale, and heavily encrusted trees or limbs may be killed.

LIFE HISTORY

If the old scales on the bark are turned over during the winter, they will be found filled with small pearly white eggs (fig. 6, *B*). Often there are nearly 100 eggs beneath a single scale. The eggs hatch shortly after the apple trees bloom, and the minute, whitish young crawl out and settle in a few hours on some living part of the plant. They develop slowly, increasing the size of the scale covering as they grow. The covering of the female is about one-eighth inch long when completed, dark brownish gray, and shaped somewhat like oyster-shells. The covering of the male is smaller and oval, and the mature males emerge from the scales with fully developed wings. The females spend their entire lives beneath the scale coverings, depositing eggs under them in the fall before they die.

CONTROL

The dormant-season application of liquid lime-sulfur is not so effective against the oystershell scale as against the San Jose scale. However, its annual use keeps this scale insect in check. Oil emulsions, at the dilutions recommended for dormant spraying (p. 59), are more effective and should be used for severe infestations. The mixture of oil emulsion and lime-sulfur recommended for controlling the San Jose scale (p. 6) is particularly effective against the oystershell scale.

COTTONY MAPLE SCALE

The cottony maple scale sometimes becomes numerous on Winter Nelis and Anjou pear trees, but it does not seem to thrive on the Bartlett variety and is seldom seen on

lives on many other fruit trees, as well as shade trees, ornamental shrubs and plants, and on native trees, such as willow and dogwood. Its effect on the tree and fruit is similar to that of the San

Figure 6.—Oystershell scale: *A*, Twig encrusted with the scale; *B*, old scale turned over to show eggs. Enlarged.

apple trees. This scale is primarily a pest of maple trees (fig. 7), but it also lives on grape, apricot, boxelder, blackberry, and various other plants. It is a native of Europe, and came to the United States over 100 years ago.

Figure 7.—Cottony maple scales on a maple twig. Enlarged.

The insect is easily recognized by the cottony egg sac the female produces early in the summer. About 3,000 eggs are laid in this sac, and they hatch during June and July. The young scales settle on the undersides of the leaves, where the male insects mature. The partly grown females, which are oval, flattened, and greenish or yellowish, migrate to the twigs in the fall and hibernate there. They complete their growth in the spring. At this time they are brown, convex, and about one-eighth inch in diameter. The egg sac is formed gradually, as the eggs are laid, and the females die when oviposition is complete. There is only one generation in a year.

Applications of oil emulsion or liquid lime-sulfur during the dor-

mant season, as recommended for the San Jose scale, control this insect very well. In July, after the young have settled on the leaves, they may be killed with nicotine sulfate, three-fourths pint to 100 gallons of water, to which is added 2 or 3 pounds of soap dissolved in water or 1 pound of casein spreader.

FRUIT TREE LEAF ROLLER

The fruit tree leaf roller feeds primarily on the fruit and foliage of the apple, but also on those of most of the other deciduous fruit trees. The small caterpillars, hatching when the buds begin to open, feed on the unfolding leaves, webbing them together and forming a protection for themselves (fig. 8). This webbing often

Figure 8.—Apple foliage showing injury by leaf rollers.

covers the blossom buds, preventing normal blooming. As the caterpillars become larger, they roll up one or more large leaves and include some of the fruit in the

webbing, making a sort of nest. They feed within this enclosure, eating large, irregular holes in the fruit (fig. 9) and foliage. In ex-

hatch the following spring as soon as the buds begin to open.

The caterpillars are active, crawling backward about as rapidly as forward, and often drop to the ground on a thread if disturbed. They become full-grown

Figure 9.—Apples eaten by larvae of the fruit tree leaf roller.

treme cases they practically defoliate the trees and destroy the entire crop. Where much spraying is done for the codling moth and the San Jose scale, the fruit tree leaf roller has not been an important pest, but occasionally serious outbreaks have occurred elsewhere. The insect has periodically become of prime importance in the Pacific Northwest, remained so for a few years, and then again subsided into relative unimportance. It is a native insect which originally fed on a number of wild plants.

LIFE HISTORY

The fruit tree leaf roller winters in the egg stage. The eggs are laid during June and July, each female depositing her eggs in a single mass (fig. 10, A), unless disturbed. The egg masses, each containing 100 or more eggs, are rather inconspicuous, oval, grayish or brownish patches, nearly one-fourth inch long, on the limbs, twigs, and trunks of the trees. The eggs

Figure 10.—Fruit tree leaf roller: A, Egg mass; B, adult moth and leaf curled around cocoon, with empty pupal skin attached. Enlarged.

in June. At that time they are about three-fourths inch long and green with black heads. They transform to brown pupae in the rolled-up leaves, and the moths (fig. 10, *B*) emerge about 10 or 12 days later. They are a little larger than codling moths, the expanded wings measuring about three-fourths inch across, and are cinnamon brown, with two or three light-yellowish markings.

CONTROL

The most effective means of controlling the leaf roller is to apply an oil spray in the spring before the eggs have hatched. Any of the emulsions that are satisfactory for scale control may be used for this purpose. Light infestations may be treated with an emulsion containing 4 percent of oil, but for serious outbreaks, when large numbers of eggs are on the trees, the emulsion should contain 5 or 6 percent of oil. Spraying should be done during the first period of settled mild weather and before the eggs have begun to hatch. It should not be done just before a rain or when the temperature is likely to drop below 25° F. within a few days.

For severe infestations that have not been sufficiently controlled by this means, a lead arsenate or DDT spray may be applied as soon as the buds begin to separate in the clusters. To make 100 gallons of spray 4 pounds of lead arsenate or 2 pounds of 50-percent DDT wettable powder is used.

ORCHARD MITES

Orchard mites do great damage to fruit trees, much of it difficult to measure. They feed by withdrawing the contents of the leaf cells, including the chlorophyll, thus causing a whitening or mottling of the leaves, which finally become browned or bronzed. In

nonirrigated orchards complete or partial defoliation frequently results. However, any foliage injury reduces the vitality of the tree, and consequently the size of the fruit, even if it does not cause the leaves to drop off.

LIFE HISTORY

Four important species of mites infest orchards in the Pacific Northwest. Two are of European origin and the others are native.

Figure 11.—Pacific mite: *A*, Egg; *B*, adult. Greatly enlarged.

The Pacific mite (fig. 11, *B*) causes more injury than the others, and in some orchards it is the most serious pest the grower has to deal with. The webbing it spins often collects dust and gives the foliage a dry and dusty appearance. This species winters as an adult in leaves and trash on the ground, and in mild winters some individuals are able to survive on the trees in crevices of the bark. In the spring the mites migrate into the trees, first attacking the foli-

age nearest the ground and gradually extending their operations to cover the whole tree. The mites are usually greenish or yellowish while feeding, often with two dark spots on the body. The eggs, which are almost colorless, are laid in the webbing (fig. 11, A). The young look like the adults, but have only six legs instead of eight. The mites develop from egg to adult in a week or 10 days, and there are several generations in a year. They can therefore become exceedingly numerous in one season. Late in July or in August, particularly if the infestation is severe and the mites are crowded, many of the adults cease feeding, become reddish or orange, and migrate to their hibernating places. Since this migration is downward, many of them collect around the calyx ends of apples, where they spin webbing that takes on the appearance of cellophane. This species thrives on many kinds of fruit trees and also on a milkweed (*Apocynum*) that grows in the orchards, but it is especially injurious to apple.

The Willamette mite is particularly injurious to apple and pear trees in the Hood River and Rogue River Valleys of Oregon. It looks something like the Pacific mite but spins less webbing.

The European red mite lays bright red overwintering eggs on the twigs and branches of fruit trees (fig. 12), and when these eggs are numerous they are noticeable as reddish patches on the bark. They are also found in the calyx end of mature apples (fig. 13). These eggs hatch in April just before the blossoms open. The mites feed on the foliage, usually on the underside, and spin little webbing. They are more easily seen than the Pacific mite, being velvety or brownish red, with conspicuous whitish, curved

spines on the back. During the summer the eggs are laid on the leaves, and there are seven or eight

Figure 12.—Overwintering eggs of the European red mite.

generations in a season. This species is seldom found except on deciduous fruit trees.

Figure 13.—Winter eggs of the European red mite in the calyx end of an apple. Enlarged.

The clover, or brown, mite (fig. 14) also winters in the egg stage. The eggs are slightly larger and rounder than those of the European red mite but not distinguishable from them with the naked

eye. They hatch about a week earlier; otherwise the habits and life history of the two species are much alike. The brown mites spin no webbing. They congregate in roughened places on the twigs and branches during the day, and migrate to the leaves at night to feed. This habit of feeding at night and the lack of webbing make them in-

Figure 14.—Adult clover mite. Greatly enlarged.

conspicuous, and usually the whitening of the leaves caused by their feeding is the first evidence of their presence. The adults are dull reddish or greenish, and are flatter and have longer legs than those of the European red mite. They are found on deciduous fruit trees and on clover and other forage crops.

CONTROL

The method of controlling orchard mites depends somewhat on the species. Irrigation, where practiced, is an important factor in reducing mite injury, and in facilitating control by spraying. Thrifty, adequately irrigated trees are damaged less by mites than are trees that are dry and in poor condition. Defoliation, which is always serious if it occurs before

September, may force the trees to send out new leaves or blossoms in the fall and materially reduce the following year's crop. It also affects the fruit buds and the size of the current crop.

Spraying or dusting is practically the only direct means of controlling orchard mites. It must be done before July to be of much value. Dormant-season sprays containing 4 percent of oil emulsion, as used for scale insects or for the leaf roller, destroy the overwintering eggs of the European red mite and the brown mite. A mixture containing 2 percent of oil and 3 percent of liquid lime-sulfur is also effective. The spray should be applied before March 15, as the trees are sometimes injured by late-dormant sprays. Lime-sulfur alone is relatively ineffective against these eggs. Sprays of lime-sulfur, however, made with 2 or 3 gallons (see table 1, p. 60) to 100 gallons of water, as used for combating apple powdery mildew or apple scab, are valuable in destroying young mites. These sprays should be applied just before the blossoms open and again as a calyx application.

Neither the dormant-season sprays nor sprays used for controlling mildew can be depended on to control the mites for the entire season. However, orchard mites can be controlled with summer sprays, even though the earlier applications have not been made. They are the only sprays that are effective against the Pacific mite and the Willamette mite, since these species are usually not on the trees when the earlier sprays are applied.

A number of chemicals that can be used in summer sprays are toxic to orchard mites. Chief among these are parathion and rotenone. Either of these materials may be added to DDT ap-

plied for control of the codling moth, or they may be used alone. The concentration of the acaricide, or mite-killing material, should be as follows for 100 gallons of spray:

Parathion (15 - percent
wetable powder or
equivalent) ----- $\frac{1}{2}$ to 1 pound
Rotenone:

1- or 1.5-percent
liquid ----- 1 pint
plus summer-
oil emulsion_ 2 quarts
(or) 1- or 1.5-percent
wetable
powder ---- 1 pound
plus summer-
oil emulsion_ 2 quarts

These quantities may be increased when used in air-carrier machines. Other acaricides, such as the dicyclohexylamine salt of dinitro-*o*-cyclohexyl phenol and tetraethyl pyrophosphate, may be employed advantageously, and the manufacturer's directions should be followed carefully. Toxaphene (50-percent emulsible material or its equivalent), 1 to $1\frac{1}{2}$ pints to 100 gallons of spray, is also effective when added to DDT applied for control of the codling moth.

Some of these acaricides are available as dusts. If used in this form, the quantity of active ingredient applied per tree should be the same as when the material is applied as a spray. Most acaricides are effective for 3 weeks or a month when used as sprays, and for a shorter time when used as dusts. Therefore, it will be necessary to repeat the applications at such intervals. The final application should be made at least 30 days before harvest to avoid having excessive residues on the fruit at that time.

Caution.—Extreme caution must be used in handling, storing, and applying parathion and tetraethyl pyrophosphate. (See p. 59, for details.)

Summer spraying or dusting for orchard mites must be thorough, as the mites infest the entire tree,

and portions not covered often harbor enough mites to reinfest the tree in a short time.

PEAR LEAF BLISTER MITE

The pear leaf blister mite lives in the buds, foliage, and fruit of apple and pear trees. It produces small galls or blisters on the leaves. At first these galls are greenish or reddish, but later they turn brown and cause dead areas. These areas may be distinguished from apple scab by the small round holes on the under surface of the leaf approximately in the center of each blister (fig. 15, A).

Figure 15.—Pear leaf blister mite: A, Infestation on an apple leaf; B, deformed and russeted apple; C, adult mites.

Since the mites begin feeding in the leaves before they are fully opened, the new leaves show the blisters at once; and if the mites are numerous, many of the leaves later dry and drop off. The fruit of the apple is more seriously affected than that of the pear; it is attacked when it is young, and the injuries cause mature fruit to be russeted or deformed (fig. 15, *B*) and sometimes to crack open. The mites also injure and deform the blossoms.

There is some evidence that the mites attacking apple and pear are distinct species. Often apples will be injured but pears on adjacent trees will show no injury. The mite that attacks the apple apparently comes from the wild snowberry, since a mite that seems to be identical is found on that plant, and apple orchards in canyons and along foothills near wild growths of the snowberry are most often infested. The form found on the pear tree is evidently the same as the species occurring in Europe, and undoubtedly came from there.

LIFE HISTORY

The adults winter under the scales of fruit and leaf buds. They are exceedingly small, less than one one-hundredth inch long. Under a lens they appear as elongated, whitish, wormlike creatures, with four legs near the head end (fig. 15, *C*). Often hundreds of them can be found in a single bud. In warm spring weather when the buds begin to swell the mites lay eggs in them, and the young burrow into the unfolding leaves and form the characteristic blisters. They feed entirely within the blisters, and a succession of generations develop, practically out of the reach of sprays. With the approach of cold weather the mites migrate to

the buds, where they hibernate beneath the scales.

CONTROL

The pear leaf blister mite can be controlled easily with liquid lime-sulfur used as a dormant spray at the same strength as for the San Jose scale—that is, testing $4\frac{1}{2}^{\circ}$ Baumé (table 1, p. 60). If the San Jose scale is not present, the lime-sulfur need test only $3\frac{1}{2}^{\circ}$ Baumé. Spraying should be completed in the spring before the buds have begun to open, for the mites get into the leaves soon after that and cannot be reached with the spray. Good control may also be obtained by spraying in the fall, as soon as the leaves have dropped. Oil emulsions are not effective unless applied just as the buds are swelling noticeably; the weather must be warm so that the oil will penetrate into the buds and kill the mites.

APPLE RUST MITE

A very small mite, not unlike the pear leaf blister mite, is often found on the under surfaces of apple and pear leaves as well as on prune leaves. This is the apple rust mite, so named because its feeding gives the leaves a rusty appearance. It also causes the leaves to roll lengthwise. The fruit may be attacked and become russeted.

The apple rust mite is so small that it can scarcely be seen with the naked eye. Under a lens it is found to be shorter and more triangular than the pear leaf blister mite. Instead of producing blisters, this mite feeds on the leaf surface during the growing season and hibernates in the buds. It may be controlled by the same means used for the blister mite. Contact sprays, such as those used for control of orchard mites (p. 12), applied during the summer

will control this mite if the undersides of the leaves are sprayed thoroughly.

ROSY APPLE APHID

The rosy apple aphid feeds only on apple and on its alternate summer host, the plantain or ribgrass. It curls the leaves, particularly those on the fruit spurs, and infests the young fruit, causing it to become stunted and distorted (fig. 16). These aphid apples do not

Figure 16.—Apples stunted by the rosy apple aphid.

thin out normally during the June drop, and in the fall clusters of them are often conspicuous, especially on the lower and inner parts of the trees. At times they are sufficiently numerous to cause a distinct reduction in the marketable crop. This aphid was probably introduced from Europe.

LIFE HISTORY

The rosy apple aphid winters in the egg stage on apple trees, and the eggs hatch in the spring when the buds begin to swell. The

young start feeding in the unfolding fruit buds, causing the leaves to curl as they develop. Several generations of aphids are produced on the apple, and these feed on the leaves and the fruit. The species may be distinguished by its purplish or rosy-brown color and by its habit of curling the leaves and deforming the fruit. As the weather becomes warmer, brownish-green winged individuals develop and migrate to the plantain. Most of the aphids have left the apple trees by early in July. They do not migrate to other apple trees, and therefore trees not bearing winter eggs remain free of infestation. On the plantain several generations of yellowish-green aphids occur, and in the fall winged forms again develop and fly back to the apple trees, where they produce a wingless generation of aphids. These aphids deposit eggs on the twigs, in the axils of the buds, and in crevices in the bark. At first the eggs are pale green but later they become shiny black.

CONTROL

The rosy apple aphid should be controlled before the leaves have been curled, as it is difficult to accomplish afterward. A spray containing 4 percent of oil destroys many of the young aphids gathered on the buds if it is applied just after the eggs have hatched. A mixture containing 2 percent of oil emulsion and 3 percent of liquid lime-sulfur, applied when the trees are still dormant, is effective, but the dormant-season application of lime-sulfur alone is less effective. Better control will result from using nicotine sulfate (40 percent nicotine), three-fourths pint to 100 gallons of water, in combination with the oil emulsion or the lime-sulfur. This application must be completed be-

fore the tips of the leaves have begun to separate (fig. 17). If neither the oil nor the lime-sulfur is used, nicotine sulfate three-fourths pint, with soap 2 or 3

Figure 17.—Apple bud at stage of development to spray for aphids.

pounds or casein spreader 1 pound, to 100 gallons of water at this time will give good control. Parathion, one-half pound of a 15-percent wettable powder to 100 gallons of water, is also effective.

Caution.—Extreme caution must be used in handling and storing parathion. (See p. 59 for details.)

APPLE APHID

The apple aphid, formerly known as the green apple aphid, lives on apple trees throughout the year and feeds mostly on the succulent terminal twigs (fig. 18), curling the leaves and stunting the growing shoots. It is thus injurious chiefly to nursery stock and to young trees, although it may become sufficiently numerous on bearing trees to hinder normal growth. It is occasionally found on pear trees. This aphid, which came from Europe, is now found in the United States wherever apples are grown.

LIFE HISTORY

The apple aphid winters in the egg stage, in the same manner as the rosy apple aphid, although the eggs are more likely to be found on water sprouts than on other parts of the trees. The eggs hatch at about the same time as do those of the rosy apple aphid, and there may be from 9 to 17 generations in a year. Young and adults are green with black legs, and some have yellowish heads. Some of the adults are winged, and these migrate to other apple trees, thus spreading the infestation during the season. The eggs are green when deposited in the fall, but later become glossy black.

Figure 18.—Apple aphids on apple foliage.

CONTROL

The control measures recommended for the rosy apple aphid are also effective for this species. Since it remains on the trees throughout the season and mi-

grates from tree to tree, additional sprays may be necessary, particularly on young trees or on nursery stock.

WOOLLY APPLE APHID

The woolly apple aphid attacks the roots as well as the upper parts of the trees. Above the ground it is found chiefly on the trunks, limbs, and twigs in wounds caused by pruning or cultivating implements, and wherever the bark is tender (fig. 19). Twigs become somewhat swelled and knotted from its attacks. The aphids are occasionally found on the fruit stems and in the calyx ends of apples. In the arid, sandy areas of the Northwest roots are not often injured, the injury being usually limited to exposed roots. In the coastal sections, particu-

some honeydew excreted by the insects, hangs in festoons, smears the fruit, and makes picking a disagreeable job. In districts where the perennial canker disease occurs, aphids feeding above ground apparently prevent the healing of cankers. The woolly aphid is found in practically all apple-growing districts.

Figure 19.—Aerial colony of the woolly apple aphid.

Figure 20.—Nodular apple roots resulting from attack by the woolly apple aphid.

LIFE HISTORY

The woolly apple aphid hibernates on the roots of apple trees, and many of those on the upper portions of the trees also survive mild winters. Infestations above ground may thus come from wintering forms already present there or from migrants from the roots. Heavy infestations are likely to follow mild winters. The aphids multiply rapidly, and new colonies are established by winged forms flying to other apple trees or by young aphids carried from tree to tree by the wind or by other means.

CONTROL

The establishment of a parasite, *Aphelinus mali* (Hald.), in the Pacific Northwest has made it unnecessary to use sprays for the

larly in heavy soil that may crack, the aphids penetrate to the roots, causing swellings and other deformities (fig. 20) that may hinder the growth of the tree. The colonies of aphids appear as bluish-white, woolly patches, which are composed of the reddish insects covered with woolly masses of wax. When the aphids are numerous, this waxy material, which contains

control of the woolly apple aphid in most orchards. However, the use of DDT for controlling the codling moth reduces the *Aphelinus* parasites to the point where they become ineffective, and insecticides must be resorted to. Benzene hexachloride, 2 pounds of material containing 10 to 12 percent of a gamma isomer to 100 gallons of spray, is very effective against the woolly apple aphid. It should be added to the first DDT spray applied for control of the codling moth. If used later than this, benzene hexachloride may impart an off-flavor and objectionable odor to the fruit. If parathion or toxaphene is used in subsequent applications for controlling orchard mites, the woolly apple aphid will usually be held in check sufficiently so that special applications will be unnecessary.

It is extremely difficult to control aphids on the roots. The most practical method is to keep the trees in a thrifty, vigorous condition, by means of proper cultivation and fertilization, so that they can withstand the attacks of these insects. Applications of tobacco refuse about the roots, fumigation with carbon disulfide, and other remedial treatments have been tried, but they are not always successful. Paradichlorobenzene, recommended for controlling the peach tree borer, has been used with some success against the woolly aphid, particularly on old trees. It should be applied in the same manner as for the peach borer (p. 38), at any time during the summer or fall, at the rate of $\frac{3}{4}$ or 1 ounce per tree.

PEAR PSYLLA

The pear psylla was first found in the United States in Connecticut in 1832, evidently having come from Europe. It has been a pest of pear east of the Mississippi

River for many years, but was not found in the Pacific Northwest until 1939. It has now spread throughout eastern Washington, northern Oregon, and northern Idaho wherever pears are grown, and in time may infest the other pear-growing areas of the West. Injury is limited to pears. Honeydew secreted by the insects runs down over the foliage and fruit, and a sooty fungus grows in it (fig. 21). The skin of the fruit becomes scarred and blackened where the honeydew occurs, and

Figure 21.—Pear damaged by the pear psylla.

the foliage develops brown spots. Severe infestations may cause partial defoliation of the tree, reducing its vitality, and may prevent normal formation of buds. The honeydew is also a great inconvenience to pickers.

LIFE HISTORY

The pear psylla (fig. 22) winters as an adult in crevices and in the bark or under leaves on the ground. The adults (fig. 22, A) are about one-tenth inch long, dark reddish-brown, with transparent wings that slope down over the body, giving the insect somewhat the appearance of a miniature cicada. They may become ac-

tive at any time during the winter when temperatures are above 40° F. In March they start depositing eggs (fig. 22, *B*) in the small

on the foliage during the summer, most of them on the under surface along the midrib.

CONTROL

An application of oil emulsion, as used for the San Jose scale, in the early spring when the trees are still dormant kills many of the adults and their eggs, and usually prevents a summer infestation from developing before July. The summer broods may be controlled readily with one of the following sprays (quantities for 100 gallons of spray) :

Nicotine sulfate three-fourths pint plus summer-oil emulsion 2 quarts.

Rotenone (1 percent) 1 pound plus summer-oil emulsion 2 quarts.

Parathion (15 percent) one-half pound.

Toxaphene (50 percent water-miscible) 1½ pints.

Parathion and toxaphene should not be used with oil. (See Cautions, p. 59.) All these insecticides except the nicotine will also control any mites that may be on the trees. One or two thorough applications should suffice for the season. Dusting is less effective than spraying.

TREEHOPPERS

Young orchards containing alfalfa or clover cover crops are subject to the attacks of several species of treehoppers, the most injurious being the buffalo treehopper, the green clover treehopper, and the dark-colored treehopper (fig. 23). The injury consists of wounds and scars made by the female when laying her eggs in the bark of the trees (fig. 24). The female cuts slits, roughened and ragged or clean-cut, with her ovipositor, the type of injury depending on the species. The injury rarely extends more than 6 or 8 feet above the ground, and young

Figure 22.—Pear psylla: *A*, Adult; *B*, eggs; *C*, large nymphs. (Photograph furnished by New York Agricultural Experiment Station.)

crevices about the buds, and after the foliage is out they deposit them on the leaves. Each female may deposit as many as 500 eggs. These are small and elongated, and whitish or yellowish. They hatch in 10 to 30 days and the young nymphs migrate to the axils of the leaves and to the leaves themselves to feed. The nymphs (fig. 22, *C*) are yellowish and flattened, and soon cover themselves with droplets of honeydew, which they secrete. They pass through five immature stages, becoming greenish as they grow larger, and finally brownish-black in the last, or "hard-shell," stage. Often these "hard-shells" congregate in large numbers on the water sprouts and other tender growth. There are at least four broods a year. The adults deposit eggs almost entirely

Figure 23.—Treehoppers: *A*, Buffalo treehopper; *B*, green clover treehopper; *C*, dark-colored treehopper. Enlarged.

trees are most often attacked. Frequently the growth of such trees is seriously retarded. Injury is practically confined to the current season's growth and to 1-year-old wood, but the old scars persist for some years. Apple and pear trees are the most subject to injury, although peach, cherry, plum, and quince are affected occasionally.

LIFE HISTORY

The whitish, cylindrical eggs of the treehoppers are about one-tenth inch long, and from 6 to 20 of them are placed side by side in each slit, the ends usually being visible. They are deposited from July to September and hatch the following April or May. The young, or nymphs, drop to the ground and feed chiefly on alfalfa, where they are most often found

in the center of the crowns. Growth is completed in July. The adults are about three-eighths inch long, grayish or greenish, and triangular, and the commoner species have projecting pronotal horns, suggesting the appearance of a buffalo.

CONTROL

Clean cultivation is the most obvious and practical control method and should be practiced in young orchards whenever possible. As the trees become older, cover crops may be planted, for the injury is less severe on older trees. Many of the worst-scarred twigs can be pruned off during the winter, and should be burned to destroy the eggs. A thorough application of a dormant spray containing 4 percent of lubricat-

Figure 24.—Apple twig scarred by green clover treehoppers in laying eggs.

ing-oil emulsion kills most of the eggs in the twigs and may reduce the infestation the following year.

LYGUS BUGS

Lygus bugs sometimes cause considerable injury to pears (fig. 25) and Delicious apples. For a

Figure 25.—Young pears injured by *lygus* bugs.

description of these bugs and for methods of controlling them, see page 50.

BOXELDER BUGS

Occasionally clusters of flat bugs, black with red lines and about one-half inch long, are

Figure 26.—Boxelder bugs feeding on an apple.

found feeding on the maturing fruit of apple and pear trees (fig. 26). These are boxelder bugs

which occur chiefly in the vicinity of boxelder trees. They are sometimes mistaken for *lygus* bugs, but may be distinguished by their large size and conspicuous coloring. The adults hibernate in swarms in crevices about trees and buildings, and the young, which hatch from eggs laid in the spring, feed on the boxelder trees.

Control consists mainly in prevention. Boxelder trees are of two kinds, those that bear seeds and those that do not, and only the latter should be planted, as the bugs live mostly on the former kind. Seed-bearing trees in the vicinity of orchards should be replaced with other kinds of shade trees if possible. The hibernating adults may be destroyed with a spray of kerosene or strong oil emulsion.

CLIMBING CUTWORMS

Apple and pear trees are occasionally attacked by climbing cutworms, although they injure peaches chiefly. For a description of these insects and methods of control, see page 50.

GREEN FRUITWORMS

Related to the cutworms are the green fruitworms. When young these worms feed on buds and

Figure 27.—Green fruitworm feeding on an apple.

leaves and are not often noticed, but when about half-grown they begin feeding on the fruit (fig. 27). They are then smooth green

worms, an inch or so long, which eat large holes in the developing apples or pears. They are most often seen during May and June. The fruit that is attacked may drop off, or if the cavities are shallow they heal over and result in russeted scars. When the worms are full-grown they make cells in the ground, where they transform to brown pupae in a manner similar to that of the cutworms. The moths emerge late in the fall or early in the spring and lay eggs singly on the trees. Control measures are not often needed, as the sprays applied for the codling moth usually prevent the fruitworms from becoming very injurious. Most of the damage is done early, and affected fruits may often be thinned off without much loss.

EYE-SPOTTED BUD MOTH

The eye-spotted bud moth occurs chiefly in Idaho, eastern Washington, and the region west of the Cascade Mountains. The injury to the fruit, which is caused by the young, consists of irregular surface feeding or a series of small holes in the skin (fig. 28). Sprays

Figure 28.—Holes in an apple made by larvae of the eye-spotted bud moth.

used for controlling the codling moth on apple and pear usually prevent this insect from becoming a serious pest on these fruits (p. 3). If additional control is necessary, lead arsenate, 3 pounds to 100 gallons, may be added to the

pink spray of lime-sulfur, which is often used for scab or mildew, or the lead arsenate may be used alone at this time.

FLATHEADED BORERS

Two species of flatheaded borers, the flatheaded apple tree borer and the Pacific flatheaded borer, occur

Figure 29.—Flatheaded apple tree borer: A, Adult; B, larva. Enlarged.

in the orchards of the Pacific Northwest. They are similar, the adult beetles (fig. 29, A) being flattened, and dark greenish blue or dark bronze with coppery spots. The larvae, or borers, are most often injurious to young trees, particularly those weakened from sunburn or other causes. They are waxy white, about an inch long when full-grown, legless, and with

the fore part of the body broad and flat (fig. 29, *B*). The beetles emerge in the spring and lay eggs on the tree trunks, preferably in the sun. The young borers burrow into the bark and require a year or more for complete development. Both species are native American insects.

Trees should be kept in a healthy condition, as the young borers are unable to thrive in vigorous trees with strong-flowing sap. If the trunks of young trees are protected with whitewash, or if a board or stave is placed so that it will shade the trunk, danger of injury will be reduced.

SHOT-HOLE BORER

In the coastal area small, round holes, looking like shot holes, are sometimes found in the trunks of apple and pear trees. They are made by a small, black scolytid beetle known in the Pacific Northwest as a shot-hole borer. Usually only unhealthy trees are attacked.

For further information about these insects, see page 51.

BRONZE APPLE TREE WEEVIL

The bronze apple tree weevil attacks weakened apple and prune trees, making several small holes in a patch in the bark. These holes are egg punctures, and the grubs hatching from the eggs feed beneath the bark, causing a sunken, discolored area about the size of a silver dollar. The adult beetles, which are small, bronzy or black, and have snouts, emerge the following spring. Attacks of this weevil may be prevented and controlled in the manner described for shot-hole borers.

PEAR THRIPS

The pear thrips is found on pears, but in the Pacific Northwest it is more serious as a prune pest, and it is therefore discussed under

that heading (p. 39). The recommendations given there also apply to pear trees.

APPLE LEAFHOPPERS

The leafhoppers, like orchard mites, are sucking insects feeding exclusively on the foliage of apple trees. They withdraw the chlorophyll and other cell contents, leaving the foliage with a whitened or mottled appearance. Slight foliage injury by leafhoppers and mites is of no consequence, but as soon as the foliage is reduced below the amount required for the crop, the fruit and buds are directly affected. The fruit fails to reach normal size and the buds are weakened so that they may not set fruit the next season. It is therefore important to guard against extensive injury.

LIFE HISTORY

Two species of leafhoppers are prevalent in the Pacific Northwest, both native to the United States. The more common and important of these is the rose leafhopper, a slender, active, whitish insect about one-eighth inch long. It winters in the egg stage in the bark of the trees. The eggs hatch in April and early in May, and the small white hoppers begin to feed at once on the new foliage, remaining in the pubescence of the underside of the leaves. Growth is attained in 3 to 6 weeks, and the adults live for 2 months or more. Eggs are laid in the tissue of the leaves from June to August, and hatch in about a month. The second brood of young thus appears late in July and August, and adults are present again from August to November. These lay wintering eggs in the bark, where they appear as small raised blisters.

The apple leafhopper has only one generation a year, beginning

with the wintering eggs, which are usually laid in the bark of wood 2 or 3 years old. The eggs hatch in April or May; and the young, which are light green instead of white, feed in the same manner as do the rose leafhoppers. The green adults appear in May and June and some are still present in July. Most of the eggs are deposited in June and July, and these remain in the bark until the following April. As it has only a single generation annually, this leafhopper does not become so numerous as the white species.

CONTROL

The standard method of controlling leafhoppers has been to use nicotine sulfate, one-half pint to 100 gallons, together with an oil emulsion, 2 or 3 pounds of soap dissolved in water, or other type of spreader. (See Caution, p. 60.) DDT controls leafhoppers, and if this material is used for controlling other pests special applications against leafhoppers will be unnecessary. It is best to spray the trees when the young are on them, as the adults are too active to be reached with a contact spray. The application should therefore be made in May for control of the green leafhopper or the first generation of the rose leafhopper, and in late July or August for the second generation of the latter. The lime-sulfur spray, which is used in May in some districts for apple scab or powdery mildew, constitutes an excellent control for leafhoppers, and when it is used other sprays should not be needed.

SYNETA LEAF BEETLE

The syneta leaf beetle seldom injures apples, but may reduce the pear crop by 50 percent or more. The injury consists of scars and deformities on the fruit caused by the beetles when feeding. The

beetle also chews the fruit stems (fig. 30), and causes some of the fruit to drop. Practically all the injury is done during April and May. The life history of the beetle is discussed on page 34.

Figure 30.—Young pears injured by the syneta leaf beetle.

CONTROL

Beetles on apples and pears may often be controlled by a single thorough application of lead arsenate, 3 pounds to 100 gallons of water, used as a calyx spray. If the infestation is severe, a second application may be made 10 days or 2 weeks later. Dusts containing 30 percent of lead arsenate or 5 percent of DDT are also effective.

WESTERN TENT CATERPILLAR

The western tent caterpillar is practically limited in its depredations to the region west of the Cascade Mountains. The caterpillars appear in May and June, constructing tents of webbing in the crotches or about the smaller twigs and leaves of the trees. The tents are similar to those of the eastern tent caterpillar shown in figure 31. The caterpillars feed voraciously during the day, de-

vouring all the leaf tissue except the midribs, and retire at night to the tents, or collect in masses on the larger limbs. These caterpillars occur sporadically and in some years are numerous enough to defoliate not only fruit trees but wild growth and shade trees as well.

Figure 31.—Nest of the eastern tent caterpillar.

LIFE HISTORY

The insect winters in the egg stage. The eggs are laid in masses surrounding the twigs, each mass containing several hundred eggs covered with a frothy, waterproof material. The young caterpillars appear about the time the apple buds begin to open. The group hatching from a single egg mass constructs a small silken nest or tent, and as the caterpillars grow this nest is enlarged to provide adequate protection for the colony. The caterpillars are somewhat hairy, tawny brown, with a row of blue spots flanked by orange spots along the back. When full-

grown they are nearly 2 inches long. As the caterpillars become larger they tend to scatter, and their cocoons may be spun in various sheltered places, such as under loose bark, in curled leaves, or under projecting eaves of nearby buildings. The cocoons are tightly woven of yellow silk, surrounded with a loose mass of silk. The moths emerge in June or July and soon deposit the overwintering egg masses.

CONTROL

Many of the egg masses may be found and destroyed when the trees are pruned. If the small caterpillars are numerous, a spray containing lead arsenate or 50-percent DDT wettable powder, 2 pounds to 100 gallons, applied just before the trees bloom is very effective. If the spraying is done later, the quantity of lead arsenate should be doubled, as the larger caterpillars are more resistant to the poison. Often the tents can be pruned out and destroyed, or burned out with a torch; care should be taken to move the flame rapidly so as not to injure the tree. The tents should be destroyed at night when most of the caterpillars are congregated in them.

FALL WEBWORM

Although the habits of the fall webworm are somewhat similar to those of the tent caterpillar, the two insects can be easily distinguished. As the name implies, the fall webworm appears late in the summer and constructs a loose and unsightly nest of webbing about a number of twigs (fig. 32). These nests are extended as the caterpillars grow and often enclose entire branches. The caterpillars feed within the webs, devouring the leaves and fruit. When full-grown the caterpillar is about $1\frac{1}{4}$ inches long, covered with long,

whitish hairs, and has a dark band along the back. It constructs a flimsy, brown cocoon in trash on the ground; from this cocoon the moth emerges late in the spring. The moth is usually pure white or dotted with dark-colored spots. It lays pale-green eggs in a flat mass on a leaf, covering them with white hairs from its body. The eggs hatch in about 10 days.

Figure 32.—Nest of the fall webworm.

There is only one brood annually in the Pacific Northwest. The insect occurs in the area west of the Cascade Mountains and in Idaho.

Apple and pear trees sprayed regularly with arsenicals are not harmed by the fall webworm, as the caterpillars appear after some of these sprays have been applied, and the small worms succumb readily to the poison on the foliage. On shade trees or fruit trees not ordinarily sprayed, a spray containing lead arsenate or 50-percent DDT wettable powder, 2 pounds to 100 gallons, is effective if applied while the caterpillars are still small. The caterpillars may also be destroyed in their webs by burning, as suggested for

the tent caterpillar. This may be done during the day.

TUSSOCK MOTHS

The rusty tussock moth and the western tussock moth are leaf-feeding insects found chiefly west of the Cascade Mountains. The first species winters in the egg stage in dry leaves or on tree trunks or twigs. The caterpillars appear in April and subsist mainly on the foliage, but occasionally damage the fruit. They may be found on many different kinds of trees and shrubs. They feed for a month or more, and when full-grown are about 1 inch long, hairy, blackish or bluish, with several thick tufts of hairs along the back. The male moth has rusty-brown wings, but the female is practically wingless. She deposits her eggs in a mass on the cocoon from which she emerged. A second brood of caterpillars appears late in July and produces moths in September; these in turn deposit the overwintering eggs. The western tussock moth has similar habits, except that there is but a single brood each year, the eggs laid in July hatching the following spring. Special control is seldom necessary, since sprays applied for other leaf-feeding caterpillars keep these insects in check. Many of the egg masses may be found and destroyed when the trees are pruned.

APPLE LACEBUG

A lacebug is a pest of apples in Washington and Oregon. The young and adult feed on the lower surface of the leaves, usually in groups. They dot the leaves with black spots of excrement, and as the insects suck out the juices the leaves become yellowed and eventually drop. The adults are about one-eighth inch long, grayish, flattened, with lacelike wings. Eggs

are deposited on the leaves, and there are probably two or more generations annually. Fair control may be effected with three-fourths pint of nicotine sulfate to 100 gallons of water, to which is added some soap or spreader. (See Caution, p. 60.) The underside of the leaves must be sprayed thoroughly.

APPLE LEAF MINERS

In western Oregon and in the Hood River Valley the apple leaf miner may be found in apple leaves and also in leaves of the wild hawthorn. It constructs blotchlike mines in the leaf (fig. 33) between

forming the mine. When full grown it pupates within the mine, and the moth emerges soon after. There are probably two broods in a season. In the fall the worms make silken hibernacula in the mines, where they spend the winter in the fallen leaves.

The apple leaf trumpet miner sometimes causes a trumpet-shaped injury on apple foliage in western Oregon. These pests are of minor importance. Any cleaning up or cultivation that destroys or buries the leaves late in the fall would prevent many of the moths from emerging the following spring.

APPLE AND THORN SKELETONIZER

Another larva that injures the foliage of apple and pear in the western parts of Oregon and Washington is the apple and thorn skeletonizer. It also feeds on cherry and hawthorn. The adult is a small, dark-brown moth, which hibernates and deposits eggs early in the spring. The small caterpillars feed on the under sides of leaves first; later they feed on the upper surfaces and construct shelters by drawing the leaves together with silk. The injured leaf becomes a mass of webbing and frass. There are several generations in a year. Spraying the trees with lead arsenate or DDT as for other leaf-feeding insects is an effective means of control.

PEAR-SLUG

The pear-slug feeds on the foliage of pear and cherry trees, skeletonizing the leaves by eating the upper surfaces (fig. 34). The larvae are slimy and sluglike in appearance, olive green or almost black, and about one-half inch long when full-grown. When they are numerous the whole tree becomes brown, as though swept

Figure 33.—Apple leaf injured by the apple leaf miner. (Photograph furnished by Oregon Agricultural Experiment Station.)

the large veins and causes the leaf to become somewhat misshapen. The adult is a very small, silvery moth that lays eggs on the leaves. The young worm burrows between the upper and lower leaf surfaces,

by fire. This should not be allowed to happen to valuable trees, as the reduction in the leaf surface seriously interferes with the growth of the fruit and the development of fruit buds. This insect is widely distributed in the United States, having come in from Europe.

Figure 34.—Pear-slug and its injury to a leaf. Enlarged.

LIFE HISTORY

The adults are glossy black, four-winged flies, about one-fifth inch long. They are known as sawflies because they cut slits in the upper surface of the leaves, in which the eggs are laid. The eggs in the leaves look like small blisters. The young slugs hatch in a week or two and feed almost altogether on the upper surface, usually avoiding any leaves that may have been attacked by aphids

or blister mites. Just after molting the slugs are yellow, but they soon secrete a slime which gives them the characteristic olive green or black color. Their bodies are somewhat enlarged in front and taper behind. The slugs complete their growth in less than a month, drop to the ground, and form cells in the soil, within which they transform to adults in a couple of weeks. The second brood of slugs appears on the trees in August, and these, when full-grown, spend the winter in earthen cells from which the adult sawflies emerge the following spring.

CONTROL

The pear-slug is easily controlled and does not become a pest if arsenicals are used on pear trees in the spring for other insects. If the slug is the only insect present, a spray containing lead arsenate in the proportion of 2 pounds to 100 gallons of water is very effective, or lead arsenate or hydrated lime may be used as a dust. If it is necessary to spray for the second brood in August, and the fruit is still on the trees, a nicotine spray should be used. This spray should contain three-fourths of a pint of nicotine sulfate plus 2 or 3 pounds of soap in solution to 100 gallons of water. If the fruit has been harvested the lead arsenate spray may be used. (See Cautions, p. 60.)

PEAR LEAF WORM

Holes one-fourth inch or more in diameter are sometimes found in pear leaves late in April or in May. A close examination will usually show a green worm stretched along the edge of each hole, feeding on the leaf (fig. 35). This is a pear leaf worm, which occurs throughout the Pacific Northwest and in California.

LIFE HISTORY

The adult insects are sawflies similar in appearance to those of the pear-slug, but more slender and with some yellowish markings. They emerge from the ground early in April and cut slits in the lower surfaces of the partly unfolded leaves, in which the eggs are laid. The wounds often cause the leaves to become deformed. The small green worms hatch in 10 days or 2 weeks and feed as described above.

Figure 35.—Pear leaf worm: A, Injury to leaf; B, egg in tissue and young larva feeding (enlarged); C, full-grown larva (enlarged).

CONTROL

The pear leaf worm is easily controlled with lead arsenate at 2 pounds to 100 gallons of water, applied just after the petals have fallen.

DOCK SAWFLY

Apples are occasionally found in the fall with round holes in them resembling those made by full-grown codling moth larvae. If the fruit is cut open, a bright-green worm may be found inside (fig. 36). This is the larva of the dock sawfly, an insect that has come in from Europe. The adult

sawfly lays eggs in the leaves of dock, wild buckwheat, sheep sorrel, and related plants, which grow along ditch banks and in moist places in orchards. The young feed on these same plants, and when full-grown they search for suitable places in which to transform to adults. Usually they burrow into the dry, hollow or pithy, stems of alfalfa or mustard, or

Figure 36.—Larva of the dock sawfly in an apple.

into the stems of their food plants. But if apples are near by, and particularly if they are hanging low in the cover crop, the worms may construct cells in the apples instead of in the plant stems. The injury caused by this insect is ordinarily negligible. If it should become serious, it can be reduced by keeping the orchard free of dock and related plants or by propping up low-hanging branches, and by banding the

props and the tree trunks with cotton or some sticky substance in August and leaving the bands on until after the fruit has been harvested.

ANTS

Orchards of the Pacific Northwest are sometimes troubled by ants, particularly the large, pugnacious red ants (*Formica* spp.), that build nests in the ground, often covered with rather conspicuous heaps of dried stems and twigs of plants. These ants are attracted to the trees primarily to feed on the honeydew excreted by aphids. At times the ants may chew the blossoms and cause direct injury. If the nests are not adjacent to the trees or other valuable plants, the ants may be eradicated or greatly reduced in numbers by placing about an ounce of granular calcium cyanide in the center of the hill or nest, several inches below the surface, and covering it with dirt. This material is dangerous to use near growing plants, and in such cases some control may be obtained by drenching the nests with water containing pyrethrum extract. The extract should be used at the highest strength recommended by the manufacturer (usually about 1 gallon to 200 gallons of water). A thorough dusting of the nests with DDT or parathion dust is also effective. (See Caution, p. 59.)

CHERRY INSECTS

SAN JOSE SCALE

The San Jose Scale is not often injurious to sour cherries, but it does a great deal of damage to sweet cherries. As these trees usually grow large, the tops are difficult to spray thoroughly. Dead leaves sometimes seen clinging to the upper branches of large sweet cherry trees during the

winter usually indicate the presence of this scale. Treatment is the same as for scale on apple and pear trees (p. 6). The tops of large trees may be reached by climbing into the trees and spraying the tops first.

BLACK CHERRY APHID

The black cherry aphid is a large, shiny, black aphid which occurs on the young foliage of cherry trees and often interferes with the terminal growth. It is found much more often on sweet cherry trees than on the sour va-

Figure 37.—Cherry foliage injured by the black cherry aphid.

rieties, and is particularly injurious to young trees and to nursery stock. The leaves of infested trees are severely curled (fig. 37) and covered with a sticky honeydew. This aphid is a European species that has become prevalent in the United States.

LIFE HISTORY

The winter eggs, which are tucked in among the buds, hatch at about the time the buds burst. The young develop rapidly on the new growth, curling the leaves and feeding within the protection thus afforded. There are several generations. Winged adults develop in the middle of the summer and

migrate to water cress, pepper-grass, and other plants of the mustard family. A later generation returns to the cherry in the fall and produces wingless individuals, which lay the overwintering eggs.

CONTROL

Very good control may be obtained by spraying just as the buds are breaking. Spraying after the leaves are curled is of little use. Nicotine sulfate may be used at three-fourths pint to 100 gallons of water, with soap or casein spreader, or added to dormant sprays of lime-sulfur or oil. Parathion is also very effective, but should not be added to oil. (See Caution, p. 59.)

ORCHARD MITES

On cherry trees the Willamette mite and the Pacific mite are usually more injurious than other species. They hibernate beneath the fallen leaves or in other trash and migrate into the trees in the spring as soon as the new leaves have appeared. They are not often seen before June and do their most serious injury after the fruit has been picked. Cherry trees are frequently neglected at this time and allowed to become dry; this condition aggravates the injury caused by the mites and may materially reduce the succeeding year's crop by weakening the fruit buds. If cherry trees have a dry and dusty appearance late in the summer, it may be suspected that mites are on the trees. Closer examination will reveal the webbing, in which the small greenish or yellowish mites are running about. More complete descriptions of these and other mites will be found on page 10.

CONTROL

Since no stage of the web-spinning mites is on the trees during

the winter, dormant-season sprays are of no value. In the coastal valleys, where control of the brown rot is often necessary, the sulfur sprays used for this purpose should also be adequate for keeping the mites in check. Otherwise it is better to delay the spraying until after the fruit has been picked and then to spray the trees thoroughly with $1\frac{1}{2}$ gallons of oil emulsion, 2 gallons of liquid lime-sulfur, or 3 to 5 pounds of colloidal sulfur, to 100 gallons of water; or with one of the organic insecticides suggested on page 13. If the brown mite is present, it may be controlled with a dormant-season spray containing 3 or 4 percent of oil emulsion, as used for scale insects, or with one of the summer sprays just mentioned.

CHERRY FRUIT FLY

The maggots of the cherry fruit fly are injurious to cherries in Oregon and in parts of Washington, Idaho, and Montana. The injury is especially severe in years when the cherry crop matures late, as a late season apparently delays the fruit more than it delays the flies, and gives them the opportunity to infest the main crop of cherries. In normal years the maggots live chiefly in seedlings and late varieties.

The young maggots begin to feed about the cherry pit, and the flesh of an infested cherry may be separated from the pit very easily. This feeding may be done before there are any outward signs of infestation, and often before the maggots are large enough to be seen easily. Later the cherry begins to shrivel on one side, the flesh is more or less decayed, and small holes appear in the skin. At this stage the white, nearly full-grown maggot may readily be found in the fruit; usually there is only one, but sometimes two or more.

Although the maggots are more easily seen in the dark-meated varieties of cherries, such as the Lambert and the Late Duke, careful examinations have shown that the white cherries are often infested just as much as the black ones. The infestation at times amounts to 75 to 90 percent of the crop. This insect is a native of the Eastern States.

LIFE HISTORY

The maggots winter in the soil, in small, hard, brown cases. These cases, known as puparia, are produced by the shrinking and drying of the outer skin of the maggot. The flies (fig. 38) emerge from the

Figure 38.—Cherry fruit fly. Enlarged.

ground during June or July, and fly about in the sun for some days, feeding on any moisture or honeydew that may be on trees. After a few days the females lay eggs in the cherries, piercing the skin of the fruit with their ovipositors and depositing the eggs in the flesh. The small white maggots, about one-fourth inch long, hatch in a week or less and immediately begin to feed around the pit. Feeding continues for about 2 weeks, and when full-grown the maggots drop to the ground and form their puparia a few inches beneath the surface. They remain there until the following spring.

CONTROL

Thorough cultivation undoubtedly destroys some of the puparia in the soil, but it does not reach enough of them to be of much value. As the maggots hatch within the fruit and are protected by it while they are feeding, there is no satisfactory means of poisoning them. Neither has any effective way of killing this pest by means of chemicals while it is in the soil been found. Effective measures may be employed against the flies only during the short period when they are feeding on honeydew and other moisture before laying their eggs.

If cherries are to be sold as fresh fruit, an application of a 10-percent lead arsenate dust at 40 pounds per acre may be made as soon as the first flies emerge. This treatment should be followed by successive applications of rotenone, either a 0.75-percent dust or a spray containing 3 pounds of a 4-percent rotenone preparation. If the cherries are to be canned, several applications of lead arsenate, 3 pounds to 100 gallons, may be made. The rotenone should be applied at intervals of a week or 10 days, and the lead arsenate every 2 weeks until the fruit is harvested. An application of the lead arsenate spray immediately after harvest, particularly to trees still having some fruit on them, will help reduce the numbers of flies appearing next season. Local information should be obtained as to the time to begin using these control measures.

PEAR-SLUG

The pear-slug, sometimes called the cherry slug, frequently skeletonizes the leaves of cherry trees. If it is not controlled, the trees may be almost completely defoliated, as the skeletonized leaves die and

drop off. This condition seriously affects the development of fruit buds for the following year's crop. The slugs may be controlled on cherry trees in the same manner as on pear trees. Control measures and the life history are given on page 28.

CHERRY FRUITWORM

The cherry fruitworm is the larva of a small moth found in western Washington and British Columbia. It is a native insect that originally lived on the wild cherry. The larvae bore into the green cherries and feed about the pit. Injured cherries are often misshapen.

LIFE HISTORY

The cherry fruitworms winter as full-grown larvae in the stubs of pruned branches or in cells cut into the corky bark. The small gray moths appear in May or early June and deposit eggs singly on the cherries, usually in the suture or at the stem end. The eggs are opalescent, circular, flattened, and smaller than the eggs of the codling moth. They hatch in about 10 days and the larvae immediately bore into the fruit. The pinkish larvae are about three-eighths inch long and mature in about 3 weeks. There is only one brood a year.

CONTROL

The measures used for controlling the cherry fruit fly (p. 32) also control the cherry fruitworm; therefore special sprays are usually unnecessary.

DESTRUCTIVE PRUNE WORM

The destructive prune worm is sometimes a pest of cherries, particularly in Oregon. Information on its habits and control will be found on page 42.

PANDEMIS MOTH

The pandemis moth has been present in the Pacific Northwest for many years, but only occasionally does it become a pest. It is similar in appearance and habits to the oblique-banded leaf roller, which also occurs in the same area, and also to the fruit tree leaf roller. (See p. 8.) The caterpillars feed on apple, apricot, cherry, plum, and prune, but apparently not on peach.

LIFE HISTORY

There are two broods of this insect in a year. It winters as a small larva hiding in trash or in a web constructed on the tree trunk at the surface of the ground. The larvae crawl up the trees in the spring, as soon as the leaves are out, and feed on the foliage. They mature in May, spinning loose cocoons in the leaves. The moths appear in late May and in June. The light green eggs are deposited in flat clusters of 90 to 150 on the smooth upper surface of the leaves (fig. 39, A), and they hatch in about 2 weeks. The small larvae start feeding on the tender foliage at the tips of the branches or along the midribs of the leaves, and develop slowly. Later, they feed on the fruit. On cherries they are most often found feeding about the stem end, and some of them may burrow into the fruit (fig. 39, B). On apricots, a single larva may feed on all fruits in a cluster, making large holes in the sides. Feeding on plums and apples is similar. This second brood matures late in July or August. Moths from this brood are flying in August and September, and the young larvae coming from their eggs feed until cold weather and then hibernate. In California they sometimes feed on the buds during the winter.

CONTROL

Not much is known about controlling the pandemic, but a small quantity of 10-percent DDT dust, placed about the base of the tree, as recommended for climbing cutworms (p. 50), might prevent the larvae from getting into the trees

Figure 39.—A, Egg masses of the pandemic moth; B, cherries injured by pandemic worms.

in the spring. Sprays or dusts of lead arsenate, DDT, or parathion (see Cautions, pp. 58 and 59), if thoroughly applied, should also be effective against the young larvae. They should be used in April or May, as soon as worms are found in the trees.

SYNETA LEAF BEETLE

The syneta leaf beetle is a common pest of cherry west of the Cascade Mountains. Apparently it is a native insect that has found congenial living conditions in cultivated orchards. The beetles eat the skin and flesh of the immature fruit (fig. 40). This injury

causes scars and deformities on the mature fruit. The beetles also feed on the stems, causing some of the fruit to drop, and on the buds, blossoms, and leaves.

Figure 40.—Immature cherries injured by syneta leaf beetles.

LIFE HISTORY

The beetles emerge from the ground just before the trees begin to bloom. They are about one-fourth inch long, and light gray, dirty white, or yellowish (fig. 41).

Figure 41.—Syneta leaf beetles, male and female. Enlarged.

They begin feeding in the trees at once and may be found in the orchards for about 2 months. They remain between the buds or among the foliage but fly out in

warm weather if the trees are shaken or sprayed. Eggs are simply dropped to the ground, where they are difficult to find because of their small size. The eggs hatch in 2 or 3 weeks, usually just after a rain or in damp weather, as the young grubs find it difficult to survive in dry soil. The grubs burrow into the ground, where they feed on the fine fibrous roots of the trees and do a certain amount of damage. Feeding continues throughout the summer and fall. The grubs remain in the soil during the winter, forming small cells early in the spring. Within these cells they change to pupae and then to beetles.

CONTROL

The injury caused by these beetles may be greatly reduced by spraying the trees twice thoroughly with lead arsenate at the rate of 4 pounds to 100 gallons of water, to which is added 4 pounds of hydrated lime. A dust containing 30 percent of lead arsenate or 5 percent of DDT may be used instead. The first application should be made just before the blossoms open, that is, when the tips of the white petals are beginning to show, and the second just after the petals have dropped. In severe infestations a third application may be made as soon as the husks have fallen. The application made just after blooming is the most effective of the three, and if the trees are sprayed only once, the spraying should be done at that time. A fungicide for controlling brown rot may be used with any of these sprays.

SHOT-HOLE BORERS

Cherry trees are sometimes attacked by one of the shot-hole borers which make small round holes in the trunks or small limbs. At times these insects attack

healthy trees, boring into the twigs just beneath the buds and killing the buds. For more information on these insects and their habits, and for methods of preventing their attacks, see page 51.

PEAR THRIPS

The pear thrips is sometimes injurious to cherries in western and northeastern Oregon and in western and southeastern Washington. Its habits and control on cherry trees are much the same as on prune trees (p. 39).

PRUNE AND PLUM INSECTS

SAN JOSE SCALE

The San Jose scale is an important pest of prune and plum trees. For a description of this insect and treatment see pages 4 to 6.

EUROPEAN FRUIT LECANIUM

The European fruit lecanium, also called brown apricot scale, occasionally appears in the irri-

Figure 42.—European fruit lecanium.

gated valleys. It is a large, hemispherical, more or less wrinkled, brown, scale insect (fig. 42) occurring on the twigs and limbs of

prune, apricot, and peach trees, and also on other fruit and shade trees. It winters as a nearly mature insect, laying eggs beneath the shell in the spring. The eggs hatch from May to July, and the young settle on the twigs and leaves. There is only one generation a year. This scale may be controlled with the usual dormant-season applications of lime-sulfur (table 1, p. 60) or oil emulsions, the oil being more effective.

APHIDS

Four or five species of aphids occur on prunes and plums in the Pacific Northwest. All have similar habits and may be controlled in the same manner. One of the commonest species is the hop aphid, which is a serious pest of hops but spends a part of the year

Figure 43.—Mealy plum aphids on plum foliage.

on prune trees. Planting hops near prune orchards should therefore be avoided, if possible. This green aphid often covers the under surface of the leaves of prune trees early in the season. The mealy plum aphid is bluish-green with a whitish, powdery covering (fig. 43). It frequently becomes

exceedingly abundant on the under surface of the leaves. The thistle aphid, a leaf-curling plum aphid, and the green peach aphid also occur on prune and plum trees, and occasionally become abundant. These aphids are green or reddish and they curl the leaves considerably. All these species are of European origin.

LIFE HISTORY

The life histories of these aphids are similar. Wintering eggs are laid on the trees and hatch early in the spring before the buds have swelled appreciably. The young feed within the opening buds and on the leaves. After several generations have developed on the prune trees, winged forms develop and fly to the summer host plants, and later generations return to the trees in the fall. During the summer the hop aphid is found on the hops, the mealy plum aphid on reed grasses and cattails, the thistle aphid on thistles, chrysanthemums, and other plants, and the other two species on many kinds of wild and cultivated plants.

CONTROL

Ordinarily a dormant-season application of oil emulsion containing 4 percent of oil is fairly effective in controlling aphids on prune and plum trees. If lime-sulfur is used, nicotine sulfate should be added to it at three-fourths pint to 100 gallons of water. If the dormant spray has not been applied, and the infestation becomes serious, one of the contact materials, such as nicotine or parathion, may be used effectively as a spray or dust. (See Cautions, p. 59.)

ORCHARD MITES

Prune and plum trees are often seriously affected by orchard mites. The foliage is bronzed, and de-

foliation may occur in nonirrigated orchards, frequently accompanied by the dropping of some of the fruit. Injury by the mites may prevent the fruit buds from forming, or at least may weaken them, causing a small crop or small fruit the following year. This injury is often much more serious than is apparent. The species most commonly found on these trees are the clover mite, the European red mite, and the Pacific mite.

CONTROL

Control of orchard mites on prune and plum trees is similar to that on apple (p. 12) and peach trees (p. 45). If it is necessary to use sulfur sprays for controlling brown rot, special applications against orchard mites should not be needed.

APPLE RUST MITE

The apple rust mite causes prune leaves to curl longitudinally and become russeted or silvered. The fruit may also be russeted. Control is the same on prune trees as on apple and pear trees (p. 14).

LEAFHOPPERS

Leafhoppers often become numerous on prune trees. A species found in the Yakima Valley, *Typhlocyba prunicola* Edw., and the rase leafhopper may be controlled on prune trees in the same manner as on apple trees (p. 24). The materials mentioned for orchard mites (p. 12) will also control leafhoppers.

PEACH TREE BORERS

The peach tree borer and the western variety of the same species are both found in the Pacific Northwest. These borers are serious pests of prune and peach trees, as well as of apricots and plums and occasionally cherries. The injury occurs chiefly in the crown

and roots of the trees, where the borers tunnel beneath the surface, feeding on the inner or growing layer of bark. Young trees may be completely girdled and killed (fig. 44), and older trees are frequently so weakened that they become subject to other insect pests or to diseases. The presence of borers in the trees is often first indicated by a quantity of gum at the base of the trunk, mixed with dirt and frass. Poor condition of the trees may also indicate that the borers are present. Trees should be examined periodically for borers, es-

Figure 44.—Base of young peach tree severely injured by peach borers.

pecially if they are not making good growth or do not appear to be thrifty. The borers are most commonly found west of the Cascade Mountains, but sometimes become injurious elsewhere.

LIFE HISTORY

The adult is a steel-blue moth with a wing expanse of more than an inch. The wings of the male moth are clear, except for the margins, but the forewings of the female are opaque. The female of the eastern form has an orange band about the abdomen, whereas the whole abdomen of the western variety is steely blue. The male

moth of the eastern form has several narrow yellow bands on the abdomen and yellow markings on the wings; these do not appear on males of the western variety. Otherwise the two forms are similar in appearance and their habits are the same.

The moths appear in the orchards in July and August, flying about actively during the warm part of the day. Each female lays several hundred oval, cinnamon-brown eggs, singly or in groups on the tree trunks. The eggs hatch in about 10 days, and the young borers crawl down the trunks and enter the damp bark just beneath the surface of the soil. At once they begin feeding on the inner bark and continue doing so until late in the fall, remaining quietly in the burrows during the winter. In the spring feeding is resumed, and the borers become full-grown in May and June, when they are about 1 inch long, yellowish white or cream-colored, with brown heads. They construct cocoons of silk and frass at the surface of the soil, either in the tunnel or close to the trunk, within which they change to pupae and several weeks later to moths. There is only one generation annually.

CONTROL

An effective control measure for peach tree borers is ethylene dichloride or propylene dichloride, or paradichlorobenzene placed about the tree trunks in the fall to kill the young borers. These materials may also be used in the spring, but are more effective in the fall. Ethylene dichloride or propylene dichloride are used in the emulsion form, the concentration and quantity of which should be varied with the age of the trees. Paradichlorobenzene, which comes in the form of white crystals and produces a gas that is heavier than

air, should be applied at the rate of $\frac{1}{4}$ to $1\frac{1}{2}$ ounces per tree. When properly used, these materials kill practically all the borers without injuring the trees, and they are not harmful to man or animals. Specific directions for their use should be obtained from the State Extension Service.

The ground should be leveled off, and the chemical placed around the tree trunk in a ring 1 or 2 inches wide about $1\frac{1}{2}$ inches from the trunk (fig. 45). Care should

Figure 45.—Paradichlorobenzene placed at the base of a peach tree to control the peach borer.

be taken not to let the chemical come in contact with the tree trunk lest it injure the tree, but if the ring is more than 2 inches away, it will be less effective. The ring should be covered with several shovelfuls of earth, which should be packed down with the back of the shovel. The material should be applied between August 15 and September 15, while the borers are small and easily killed.

OTHER BORERS

Flatheaded borers are often found in the trunks of prune trees, particularly in unhealthy trees. A darkened area of bark indicates the presence of these borers. The shot-hole borers also attack unhealthy trees, making round, shotlike holes in the trunks. These pests are discussed on pages 22 and 23.

PEAR THRIPS

The pear thrips causes more injury to prune trees in the Pacific Northwest than to pears or other fruits. The insect occurs in west-

ern and northeastern Oregon, in southeastern Washington, and in western British Columbia. Apparently it has been introduced from Europe. There are three types of injury. The most serious injury is that caused by the adult thrips, which emerge from the ground in the spring, feed in the developing buds, and cause deformed leaves and blossoms (fig. 46), and thus a reduction of the crop. Later the adults lay eggs in the stems of the fruit and foliage. Both the young and the adults feed by rasping the surface and then sucking out the plant juices.

LIFE HISTORY

There is only one generation of the pear thrips annually. The adults are less than one-twentieth inch long, and slim and dark brown. They emerge when the fruit buds are swelling and beginning to show green. After feeding for about 3 weeks they begin egg laying, which lasts another 3 weeks. The eggs are very small, whitish, and kidney-shaped, and they hatch in less than 2 weeks. The young are white and similar to the adults in shape (fig. 47). They develop for about 3 weeks, then drop to the ground, burrow into the soil, and construct small cells a few inches to 3 feet from the surface. Here they remain dormant, changing late in the fall to adults, which emerge the following spring. The pear thrips is thus active on the trees for only about 2 months in spring and is dormant in the ground the rest of the year.

CONTROL

The pear thrips may be controlled by thoroughly spraying the trees during the first warm weather after the buds have begun to show green. Additional sprays may be needed when the blossom

Figure 46.—Prune twig showing deformed leaves and poor set of fruit caused by the pear thrips.

buds begin to show white and just after the blooming period. The trees should be examined some days after the first spray has been applied: if there is an average of one or more thrips to each bud at this time, the later sprays are advisable. For prune and plum trees a spray consisting of 1 pint of an oil emulsion containing 25 percent of DDT, or 2 pounds of 50-percent DDT wettable powder,

well as on some other plants. It is a cool-climate insect, occurring chiefly in Oregon and Washington west of the Cascade Mountains, in northern Idaho, and in British Columbia. It is also a pest in the Eastern States, in Canada, and in Europe, which was its original home. It causes the most injury to the expanding buds, which are devoured by the partly grown, hungry caterpillars that have hibernated on the trees. Crops are reduced by this bud-feeding habit, and injury to the terminal shoots causes a bushy growth (fig. 48). Later the insects eat the foli-

Figure 47.—Larva of the pear thrips. Greatly enlarged.

in 100 gallons of water should be used. A dust containing 5 percent of DDT with sulfur or inert materials may be used instead. There is also a possibility that thrips can be controlled with insecticides applied to the soil. Information on this method may be obtained from your State Extension Service.

EYE-SPOTTED BUD MOTH

The eye-spotted bud moth damages prunes and plums in the Pacific Northwest, but may be found on all the orchard fruits, as

Figure 48.—Bushy terminal growth of prune caused by injury by bud moth.

age, and a new generation feeds on fruit, often attaching a leaf to it and feeding in the shelter thus formed.

LIFE HISTORY AND HABITS

The partly grown dark-brown larvae of the bud moth winter in small silken nests, or hibernacula,

attached to the twigs, often in a crevice or crotch. These nests are made of pieces of leaves or bark held together with silk and are difficult to find on the trees. The larvae leave them in April, or whenever the buds begin to swell appreciably, and burrow into the expanding buds and into the terminal shoots, feeding from the inside. Nests of silk are formed in

olive-brown with black heads (fig. 49, *A*). They transform to pupae in the nests of webbed leaves, and the moths appear about 3 weeks later. These are somewhat smaller than codling moths, ashy gray, with a cream-white band across both wings (fig. 49, *B*). The flattened eggs, similar to those of the codling moth, are deposited on the leaves and hatch in a week or so. The young larvae feed on the leaves, protecting themselves with silk, and often eat small holes in the fruit. In the fall these larvae build the hibernacula in which they spend the winter. There is only one generation a year.

CONTROL

A spray of lead arsenate, 3 pounds to 100 gallons of water, should be applied just as the tips of the leaves are pushing out of the buds. If the infestation is serious, a second application may be made a week or 10 days later.

LESSER APPLEWORM

The lesser appleworm has recently been discovered in eastern Oregon, where it has been causing considerable injury to prunes. It has also occurred for some years in British Columbia, and is known as a serious pest of apple in sections of the eastern parts of the United States and Canada. The egg, larva, and adult moth are somewhat similar in appearance to the corresponding stages of the codling moth, except that they are smaller. The habits of the insect are also similar. For controlling this insect basic lead arsenate at the rate of 4 pounds to 100 gallons of water, to which is added 3 quarts of summer-oil emulsion, is recommended. This spray should be applied when the moths first appear. If later applications seem to be necessary, the State Extension Service should be consulted.

Figure 49.—Eye-spotted bud moth: *A*, Full-grown larva; *B*, adult.

the opening leaves, and as the foliage surrounding them dries the larvae go outside to eat leaves or blossoms, retiring to the nests when not feeding. These webbed nests are often the first indication of the presence of the insects. The larvae become full-grown in June or early in July, when they are

DESTRUCTIVE PRUNE WORM

The destructive prune worm has become a rather serious pest of prune and cherry trees in southern Idaho and in parts of Oregon. Its habits are somewhat like those of the bud moth. The partly grown brown worms winter in small hibernacula woven of silk and placed in the smaller crotches or in crevices in the bark. These worms emerge in the spring before the flower buds are open and bore into the buds, feeding entirely on the inside and destroying many blossoms. They become full-grown in 2 to 4 weeks, when they drop to the ground and spin loose cocoons. The moths emerge from these cocoons in June, and lay eggs singly on the lower surfaces of the leaves. The worms hatching from these eggs burrow into the green prunes or into the cherries and cause considerable injury by feeding on the fruit. This second brood of worms becomes full-grown late in July or early in August and produces a second brood of moths. Worms coming from eggs laid by these moths feed for a time in the maturing prunes or on the foliage and then leave it and spin silken nests in which they hibernate. There are thus two complete generations in a season.

No satisfactory measure for controlling this pest has been worked out, although an early application of DDT, before the trees bloom, may be effective.

SNOWY TREE CRICKET

The snowy tree cricket occurs throughout the Pacific Northwest, but has been of economic importance chiefly in southern Idaho, where it sometimes does considerable harm to prunes by eating holes in the ripening fruit (fig. 50, A). Early in the season the young feed on the foliage, but this

Figure 50.—Snowy tree cricket: A, Prune injured by snowy tree crickets; B, female (enlarged) and section of twig, showing egg. (Photograph for A furnished by Idaho Agricultural Experiment Station.)

injury is of little consequence. Much of the injured fruit drops prematurely and the remainder is unfit for market. The adult crickets are slightly more than one-half inch long, and light green or yellowish. The female (fig. 50, B) has narrow, transparent wings, and the male has somewhat broader wings. There is but one generation a year, and the adults may be found in the orchards from July until frost occurs.

CONTROL

The injury caused by the snowy tree cricket may largely be prevented by poisoning the crickets while they are still feeding on the leaves and before they have begun to eat holes in the fruit. In southern Idaho this may be done between July 15 and August 1. The trees may be sprayed with lead arsenate, 2 pounds to 100 gallons of water, to which is added 1 pound of spreader.

SYNETA LEAF BEETLE

The syneta leaf beetle ordinarily does not injure prunes so severely as it injures pears and cherries (pp. 24 and 34). Most of the prunes grown in the area where this beetle occurs are sold in the dried form and the smaller injuries are of less consequence than those on fruit that is to be marketed green or fresh. Large russeted areas on the prunes detract from the appearance of the dried product (fig. 51) and make the fresh fruit unmarketable.

CONTROL

Lead arsenate, 3 or 4 pounds to 100 gallons, will control this beetle on prunes. It is most effective if used just before and just after the blooming period; it may

be added to the fungicides used at that time for the control of brown rot. A third application when the husks have fallen may be necessary if the infestation is severe.

Figure 51.—Dried prunes: A, Russeted by syneta leaf beetle; B, uninjured.

CATERPILLARS

The caterpillars of various moths often become injurious to prune trees in western Oregon and Washington. They are most likely to be the tent caterpillars, fall webworms, or caterpillars of tussock moths. A discussion of these insects will be found on pages 24 to 26.

PEACH TWIG BORER

Prune trees are attacked by the peach twig borer in much the same manner as are peach trees. The brown worms bore into the tender new growth, causing the leaves to wilt, and later they feed in the fruit. The life history and control of this pest are given on page 46.

PEACH AND APRICOT INSECTS

GREEN PEACH APHID

Peach crops are sometimes seriously reduced by large numbers of green peach aphids (fig. 52) in the

Figure 52.—Green peach aphids on pear foliage.

opening blossoms. These sucking insects remove the juices from the newly formed fruit, causing it to drop. They also curl the leaves badly and prevent them from developing normally. It is important, therefore, that control measures be taken early, as little or no injury occurs later. The green peach aphid came from Europe and is common in all the peach-growing districts of the West.

LIFE HISTORY

The glossy black wintering eggs may be found on the twigs, in the axils of the buds, and in the crevices of the bark. They hatch early in the spring, and the pinkish young begin feeding at once on the

opening buds, pushing their way into the unfolding blossoms and between the developing leaves. The second and third generations are green, and the latter acquire wings and migrate to summer food plants, which include many of the common vegetables and ornamental plants, such as cabbage, cucumber, lettuce, potato, tomato, turnip, carnation, chrysanthemum, snapdragon, and violet. In the fall winged forms return to the peach and produce a wingless generation that lays the overwintering eggs.

CONTROL

An emulsion containing 4 percent of oil, as used for the San Jose scale, affords good control of the green peach aphid, if applied just as the buds begin to swell. It must be used after the eggs have hatched and before the buds have opened. If lime-sulfur is used for the peach twig borer, nicotine sulfate should be added at three-fourths pint to 100 gallons of spray, as lime-sulfur does not control the aphids. (See Caution, p. 60.) The addition of oil to the late dormant application of lead arsenate for the peach twig borer (see p. 46) usually also gives control of the aphids. Since most of the damage occurs during and shortly after blossoming, later treatments are of little value.

BLACK PEACH APHID

The black peach aphid is occasionally seen in the Pacific Northwest, having been introduced from the Eastern States, where it is native. It feeds on the roots and leaves of peach and apricot trees, as well as on the young trees, and is therefore potentially a pest of considerable importance, since root-feeding forms are often more diffi-

cult to control than those above ground.

LIFE HISTORY

The black wingless forms live on the roots throughout the year, and in the spring some of them migrate to the new growth above ground where they increase rapidly (fig. 53). As they become

CONTROL

If the root-feeding form is numerous enough to affect the growth of the trees, it should be controlled with paradichlorobenzene, used as recommended for the peach tree borer (p. 38). The aerial form may be controlled readily with the usual nicotine sprays.

ORCHARD MITES

Orchard mites, including the clover mite, the two-spotted spider mite, and the European red mite, injure peaches, but are rarely found on apricots. The two-spotted spider mite also attacks hops, beans, and many other crops, as well as weeds that may be growing in the orchards. It is similar in appearance to the Pacific mite and spins a great deal of webbing. For a description of the other species, see page 10.

CONTROL

Control of the mites on peaches is to some extent the same as on apples and pears. (See p. 12.) Dormant-season sprays are effective against the clover mite and the European red mite, and lime-sulfur solution, used before blossoming, is also very effective. For summer sprays 1 gallon of lime-sulfur to which is added 2 or 3 pounds of wettable sulfur, or wettable sulfur alone at 4 to 6 pounds, to 100 gallons of water may be used. Parathion and rotenone are also effective, as on apples and pears, but toxaphene should not be used on stone fruits as it may injure them. (See Caution, p. 59.)

PEACH TWIG BORER

Ripening peaches are sometimes wormy, and this worminess may be associated with a split pit. The brown worms in these peaches are peach twig borers, so named be-

Figure 53.—Black peach aphids on peach shoot.

crowded winged forms develop, which fly to other trees and establish new infestations. The aerial forms usually disappear by mid-summer.

cause early in the spring the young worms burrow into the tender terminal growth of the trees and cause the rapidly growing twigs to wilt (fig. 54). In this way they

Figure 54.—Peach shoot injured by the peach twig borer.

composed of silk and tiny pieces of bark, which is difficult to see without a lens. The small worms leave these winter quarters as soon as twig growth has begun and burrow into the new shoots, where they feed on the pith and inner bark and cause the shoot to wilt. Frequently a single worm injures several twigs in this manner.

By May the worms are mature, nearly one-half inch long, and reddish brown. They spin loose cocoons in rough places in the bark or in curled leaves, and the small, inconspicuous, grayish moths emerge in June. These lay minute eggs on the bark, and the tiny worms hatching from them attack the fruit as well as the new growth. They usually burrow into the peaches near the stem end and feed around the pit; or, if this is still soft, they enter it and feed on the kernel. This second brood of worms also produces a brood of moths that lay eggs, and the young worms hatching from these eggs build the silken burrows in which the winter is spent.

interfere with the development of new growth. Their presence in the peaches causes a direct loss of fruit. The peach twig borer also attacks prune and apricot trees, and the twig injury is especially serious on nursery trees or in young orchards. The species originated in Europe and has been in the United States for many years.

LIFE HISTORY

The young peach twig borers winter in small silk-lined burrows, known as hibernacula, in the bark. These are usually constructed in the folded bark found in the crotches of the younger branches. Each burrow has a characteristic projecting tube or "chimney,"

CONTROL

The peach twig borer is easily controlled on peaches with applications of liquid lime-sulfur as used for the San Jose scale (p. 6), but this material may be injurious to apricots. If there is no scale infestation, a dilution testing $3\frac{1}{2}^{\circ}$ Baumé is adequate (table 1, p. 60) and may be applied at any time in the spring before the pink stage of the blossom buds. Oil sprays at this time are much less effective and should not be used if the twig borer is at all serious. Sprays containing 3 pounds of basic lead arsenate to 100 gallons, or nicotine sulfate at three-fourths pint to 100 gallons of water, with soap or spreader, are also effective if used before the trees are in full bloom.

Oil emulsion at the rate of 2 gallons to 100 gallons of spray may be added to the lead arsenate to control aphids. If the worms have not been controlled before the blossoms open, basic lead arsenate may be applied at the rate of 4 pounds to 100 gallons after the petals have dropped.

ORIENTAL FRUIT MOTH

The oriental fruit moth (fig. 55) was discovered in the District of Columbia in 1916, having been brought in from Japan in shipments of flowering cherry, peach, or other fruit trees. It seems to

Figure 55.—Adult oriental fruit moth. Enlarged.

have been introduced into Japan about 10 years earlier from other parts of the Orient. It has gradually spread throughout the United States until now it is present in most of the peach-growing districts. Moths were first caught in baits in Idaho in 1944, and in Oregon and Washington in 1945. The

first infestation of any consequence in the Pacific Northwest was found in the lower Yakima Valley in the fall of 1948.

The only injurious stage of the oriental fruit moth is the larva, or worm. The young worms burrow into the rapidly growing twigs near the tips and feed on the cen-

Figure 56.—Peach twigs injured by the oriental fruit moth.

tral core (fig. 56). They also enter the fruit, particularly near the end of the season, either through the stem or through the side, and feed on the flesh around the pit (fig. 57). The worms usually leave through holes in the side and often considerable gum exudes from the holes. Injury to the twigs prevents the tree from growing normally, as it may send out several lateral twigs just below the injury. Injury to the fruit usually ruins it for consumption.

The oriental fruit moth attacks peaches primarily, but it also feeds on all the other deciduous fruits. In the Pacific Northwest it should

not be troublesome on the other fruits because they are harvested early or because of control measures applied for other insects.

Figure 57.—Oriental fruit moth larva in a peach.

LIFE HISTORY

The oriental fruit moth winters in much the same manner as the codling moth—that is, as a full-grown worm in a cocoon on the tree or in leaves or stems on the ground. The moths emerge in the spring shortly before the peach trees are in bloom and are flying for about a month. Eggs are usually laid singly on the upper surfaces of the leaves. There may be four or five broods a year in the Pacific Northwest.

CONTROL

In the eastern United States the oriental fruit moth may be controlled by applying several sprays or dusts of DDT in July and Au-

gust to kill the second and third broods of worms. In the Pacific Northwest good control may be obtained with two sprays of DDT applied in April or May, when the spring-brood moths are flying, the first one as soon as the petals start dropping from peach trees, and the second about 12 to 14 days later. A third application should be made in June when the next brood of moths appears. The spray should contain 2 pounds of 50-percent DDT wettable powder to 100 gallons of water. An acaricide should be added to the third application to prevent mites from developing. Only the first application is necessary for apricots. Dusting is less effective than spraying.

Some control of the oriental fruit moth with parasites has been obtained in the East, but because of the general use of DDT in the Pacific Northwest, this method would not be likely to succeed there.

PANDEMIS MOTH

The larva of the pandemis moth at times seriously injures ripening apricots. For a discussion of this insect and its control, see page 33.

SAN JOSE SCALE

The San Jose scale is not so injurious to peach as to apple and pear, and it seldom injures apricot. For a description of this insect and for methods of control, see page 4. The methods used against other insects, such as the peach twig borer or aphids, usually control this scale.

EUROPEAN FRUIT LECANIUM

The European fruit lecanium attacks peach and apricot trees, as well as prunes and other deciduous fruits. For a discussion of the life history and control of this insect, see page 35.

CLIMBING CUTWORMS

In the spring orchardists sometimes find that the opening buds on their trees are being eaten into and often entirely devoured, although no insects capable of causing the injury are visible (fig. 58).

Figure 58.—Peach buds showing holes made by climbing cutworms.

A careful search among the leaves or trash at the base of the tree will probably disclose the culprits. They are climbing cutworms, smooth, grayish-brown or blackish, greasy-looking worms, usually curled up but ranging in length from $\frac{1}{4}$ to $1\frac{1}{2}$ inches when stretched out. They lie

quietly just beneath the soil surface, under a leaf, or in a bunch of grass or alfalfa during the day, and climb into the trees at night to feed on the tender leaves and flower parts of the expanding buds. Frequently their presence is made known by many buds and portions of buds on the ground under the trees, dropped there by the worms as they feed. At times dozens and even hundreds of these worms may be found in the daytime under each tree, and such numbers cause severe damage.

In the Pacific Northwest several species of cutworms, including the spotted cutworm (fig. 59), are re-

Figure 59.—Spotted cutworms: A, Moth; B, larva extended; C, larva curled.

sponsible for most of the damage of this type done to fruit trees. Their habits are similar. Most of them spend the winter as small, partly grown worms. In the spring they come out of hibernation voraciously hungry. For a time the tender buds of fruit trees offer an attractive food supply, and most of the damage is caused over a short period. Later the worms feed on alfalfa and other ground plants. When full-grown they construct cells in the soil, where they pupate, and the orange-brown pupae are often turned up when the soil is plowed or spaded. The moths emerge at various times during the summer and are among the fairly large, dull grayish or brownish moths seen flying about

the lights at night. There may be one or more generations, but later generations are of little consequence, as vegetation is plentiful by the time they appear. Eggs are deposited in the fall on the trees or cover crops in patches of a hundred or more. After the eggs have hatched the small worms feed for a time before going into hibernation.

CONTROL

The best way to control cutworms is to place a small handful of 10-percent DDT dust on the lower trunk of the tree and on the ground about the base. The cutworms come in contact with the DDT as they climb into the tree, and are killed by it.

LYGUS BUGS

Lygus bugs (fig. 60, *A*) appear in the trees early in the spring and puncture the swelling fruit and leaf buds (fig. 60, *B*), sucking the

Figure 60.—Lygus bug: *A*, Adult (enlarged); *B*, adult on peach bud.

sap from them. Their presence is often first made known by the brownish drops of sap exuding from these punctures. This loss of sap causes the buds to dry, and in the case of fruit buds the blossoms may never open, or, if they do, they may be deformed. When the bugs are sufficiently numerous, the injury is severe and the entire crop may be lost. The degree of

injury depends not only on the number of bugs but on the weather. Continued settled warm weather in March or early in April, before alfalfa and other ground crops have developed, causes the bugs to feed in the trees; cold, rainy, or windy weather at this time prevents extensive feeding. Pears and Delicious apples, as well as peaches, are susceptible to this injury. The bugs also sometimes feed on the young (fig. 25) and maturing fruit and cause dry or corky and sunken spots. Lygus bugs occur throughout the Pacific Northwest; they are apparently native insects.

LIFE HISTORY

The adult lygus bugs are nearly one-fourth inch long, dirty grayish or greenish, with variable markings. They come out of hibernation during the first warm, sunny days of early spring and feed for a time on fruit-tree buds and the leguminous cover crops. They are active, flying readily or moving around to the opposite side of a twig or bud when approached, and are not easily seen. Eggs are laid in the tender shoots or in the flower heads of a number of plants, and the nymphs, which resemble the adults, except that they are smaller and have no wings, feed chiefly on cover crops and weeds. Growth is attained in less than a month, nymphs going through a series of molts as they increase in size. There are three or four broods during the season, and the bugs are often very numerous in the fall. Many bugs die when the first cold weather comes and the mortality among those hibernating is apparently high.

CONTROL

Lygus bugs are susceptible to DDT, and if the infested areas

are treated with a 10-percent dust early in the spring before the bugs have started feeding, damage should be avoided. Both the ground and the trees should be dusted at the rate of about 40 pounds per acre. This treatment may result in an increase of orchard mites.

Figure 61.—Trunk of tree injured by the shot-hole borer.

SHOT-HOLE BORERS

Two kinds of shot-hole borers occur throughout the Pacific Northwest. They attack the wood of all the deciduous fruit trees (fig. 61) preferring wood that is in an unhealthy or dying condition,

brought about by mechanical or winter injury, improper watering, or insects or fungus diseases. They will also attack the larger wood that has been pruned from trees, at least until it has dried out thoroughly. They seem to be particularly attracted to the souring sap, but under some conditions they will attack healthy wood. The beetles bore into the sapwood and make tunnels through it in which they lay eggs. The souring sap favors the growth of a fungus, and the young grubs feed on this fungus and not on the wood. There are two broods a year. In the fall the grubs of the second brood transform to beetles, which remain in the tunnels until spring, when they emerge and construct fresh tunnels. If the tunnels are numerous, the growth of the trees may be affected seriously. The beetle is sometimes found attacking the heartwood also. On healthy trees, the attack often takes place just below a bud, which is weakened and killed, even though the beetle may be repelled by a flow of sap before it has been able to deposit eggs.

To prevent attacks of this beetle, the trees should be kept in a healthy vigorous condition; if they are unhealthy, the cause should be determined and corrected if possible. A spray made with 2 pounds of 50-percent DDT wettable powder, or 1 pound of 15-percent parathion wettable powder, in 100 gallons of water, when the beetles become active, usually in late May and again in September, will prevent damage. (See Caution, p. 59.)

PEACH TREE BORERS

Although peach tree borers are serious pests of peach trees in California and the Eastern States, they do more injury to prune trees than to peach trees in the Pacific North-

west. For a discussion of this insect see page 38.

STONE FLIES

Stone flies or salmon flies occasionally injure the buds of peach, apricot, and plum trees in the

Figure 62.—Stone fly feeding on peach buds.

spring (fig. 62), particularly where these trees are growing near the Columbia River or some other large stream. The young insects live in the streams. The adult flies emerge early in the spring, when thousands of cast skins may be found among the rocks along the stream banks. The flies feed on the fruit buds mostly during warm, sunny weather, destroying many of the buds and injuring others so that they produce deformed fruit. If control is necessary, lead arsenate, 2 pounds to 100 gallons of water, should be effective if applied as soon as the insects appear.

EARWIGS

The European earwig has spread into many of the fruit-growing areas of the Pacific Northwest. It is most often seen in the adult stage (fig. 63) as a slender, shining brown insect, about two-thirds inch long, with a pair of conspicuous forceps on the posterior end. The insects hide under leaves and trash during the day and feed mostly at night.

They often climb into fruit trees, particularly apricot and peach trees, and feed on the ripening fruit. They also feed on various vegetables and flowers.

Figure 63.—Adult European earwig. Enlarged.

CONTROL

To keep earwigs out of fruit trees, the soil at the base of the trees and the tree trunks should be thoroughly dusted with 10-percent DDT about a month before the fruit ripens.

NUT INSECTS

FILBERTWORM

The filbertworm, also known as the Catalina cherry moth, is the most serious pest of filberts in western Oregon and Washington. It is generally distributed throughout the Pacific Northwest, but causes commercial loss only in certain localities. This worm is the larva of a pale to dusky moth having two coppery bands near

the tips of its forewings. Eggs are laid on the leaves near the nuts, or on the husks, and the young worms enter the nuts at the base. They mature after feeding for 3 or 4 weeks and leave the nuts to overwinter in cocoons formed in the ground, in trash, or in dried or rolled leaves on the ground. Pupation occurs from early in May through August.

The best control has been obtained by spraying with lead arsenate, at the rate of 3 pounds to 100 gallons of water, just before the young worms enter the nuts.

WALNUT APHID

The walnut aphid is the only important insect pest of walnut trees in the Pacific Northwest. It is a small pale-yellow, wingless or winged insect found on the underside of the leaves, often in considerable numbers. These aphids secrete a sticky liquid known as honeydew, which covers the leaves and nuts, and in which a black fungus grows. Syrphid flies, ladybeetles, and other natural enemies of aphids (p. 53) usually keep this pest in check so that artificial control is unnecessary. If these beneficial insects fail, the aphid may be combated with nicotine sulfate, $\frac{1}{2}$ pint to 100 gallons of water, to which is added soap or spreader, or with a 2-percent nicotine dust prepared from $2\frac{1}{2}$ pounds of nicotine sulfate to $47\frac{1}{2}$ pounds of hydrated lime. (See Caution, p. 60.)

BENEFICIAL INSECTS

Not all the insects found in an orchard are harmful. Many are of no importance because they are not sufficiently numerous or are not injuring the trees or the cover crop. Many others are beneficial because they feed on some of the insects that are harmful to the crops. The most conspicuous

beneficial insects and the ones most often seen in an orchard are those that prey on aphids. These insects kill the greatest number of aphids during warm weather.

Ladybeetles are nearly always abundant in orchards. Both the adults and young feed on aphids on the trees or in the cover crops. There are many species, one of the commonest being the convergent ladybeetle (fig. 64), a red beetle

Figure 64.—Convergent ladybeetle: A, Adult; B, pupa; C, larva. Enlarged.

with black head and black spots on the back. Some species are plain red and others are black with two or more red spots. There are also small black ladybeetles (*Stethorus picipes* Casey) (fig. 65) that feed

Figure 65.—A ladybeetle. Enlarged.

chiefly on orchard mites and scale insects. Most of these species lay yellow or orange-colored, cigar-shaped eggs, which stand on end in clusters. The larvae are usually

black or gray with red or orange markings. Some of them are covered with a white waxy secretion, giving them the appearance of mealybugs. Although most ladybeetles are conspicuous, they are not molested by birds, possibly because they have a disagreeable taste.

The larvae of syrphid flies are common enemies of aphids and are most often found in colonies of the woolly aphid. Frequently they destroy the colonies entirely. These larvae, or maggots, (fig. 66)

Figure 66.—Larva of a syrphid fly.
Enlarged.

are nearly one-half inch long when full-grown, yellowish or grayish, and often with a stripe down the back. The body is widest behind, and the narrow head is restlessly moved about as the maggot searches for food. No legs are evident. The adult syrphid flies (fig. 67) are usually black, striped with

yellow, and may be mistaken for wasps or bees. They fly and often poise in midair before darting

Figure 67.—Syrphid fly.

down to a colony of aphids to deposit their eggs. The eggs are elongated, dirty whitish, and are laid singly among the aphids.

Figure 68.—Young of a lacewing fly.
Enlarged.

The young of lacewing flies (fig. 68) are effective enemies of aphids, and also feed on other insects, such as orchard mites, newly hatched

codling moth larvae, and the young of leafhoppers. These larvae, known as aphid lions, are flat, elongated, tapering at both ends, with long legs and conspicuous sickle-shaped jaws. When mature they are about three-eighths inch long, grayish or yellowish, with red or brown markings. They spin spherical white cocoons, which are sometimes found in codling-moth bands, and from which the adults escape by cutting circular lids. The adults are light green with delicate transparent wings and golden eyes. They emit a disagreeable odor when crushed, and this doubtless protects them from birds and other enemies in the same manner as ladybeetles are

feed on orchard mites. In addition to these, there are hosts of small, inconspicuous parasitic insects, mostly related to the bees and wasps, that take their toll of the pests. One of these is *Aphelinus mali* Hald., a parasite of the woolly apple aphid (fig. 70), which

Figure 70.—Woolly apple aphids parasitized by *Aphelinus mali*.

Figure 69.—Eggs of a lacewing fly.

protected. The eggs are deposited in clusters, each egg on a long stalk (fig. 69); this is believed to prevent the eggs from being eaten by the young or by other insects.

There are also many predaceous bugs and beetles that prey on various insects, and there are small predaceous mites and thrips that

was introduced into the Pacific Northwest about 1930.

It is difficult to estimate the benefit done by predaceous and parasitic insects. The beneficial species prevent many potentially harmful insects from becoming numerous, and therefore should be encouraged in every way. Frequently, also, outbreaks of serious pests are stopped more completely by beneficial insects than is possible with artificial control measures. Unfortunately the beneficial forms often do not begin to be effective until after the harmful species have done much damage; therefore the fruit grower cannot afford to wait and must control the pests himself. The sprays applied to trees, particularly the contact sprays, destroy many of the beneficial insects. Some of these insects, such as the syrphid flies and the ladybeetles, withstand insecticides fairly well, but the *Aphelinus* and some of the predators of orchard mites are seriously reduced in numbers, particularly by DDT or parathion.

LIST OF ORCHARD INSECTS

Common name	Scientific name
Apple and thorn skeletonizer.....	<i>Anthophila pariana</i> (Clerck)
Apple aphid.....	<i>Aphis pomi</i> Deg.
*Apple lacebug.....	<i>Corythucha salicata</i> Gibs.
Apple leafhopper.....	<i>Empoasca maligna</i> (Walsh)
*Apple leaf miner.....	<i>Lithocolletis crataegella</i> Clem.
Apple leaf trumpet miner.....	<i>Tischeria malifoliella</i> Clem.
Apple rust mite.....	<i>Vasates schlectendali</i> (Nal.)
Black cherry aphid.....	<i>Myzus cerasi</i> (F.)
Black peach aphid.....	<i>Anuraphis persicae-niger</i> (Smith)
Boxelder bug.....	<i>Leptocoris trivittatus</i> (Say)
Bronze apple tree weevil.....	<i>Magdalis aenescens</i> Lec.
Buffalo treehopper.....	<i>Ceresa bubalus</i> (F.)
Cherry fruit fly.....	<i>Rhagoletis cingulata</i> (Loew)
Cherry fruitworm.....	<i>Grapholitha packardii</i> (Zell.)
Clover mite.....	<i>Bryobia praetiosa</i> Koch
Codling moth.....	<i>Carpocapsa pomonella</i> (L.)
Convergent lady beetle.....	<i>Hippodamia convergens</i> Guér.
Cottony maple scale.....	<i>Pulvinaria vitis</i> (L.)
*Dark-colored treehopper.....	<i>Ceresa basalis</i> Wlkr.
*Destructive prune worm.....	<i>Mineola scitulella</i> Hulst.
Dock sawfly.....	<i>Ametastegia glabrata</i> (Fall.)
European earwig.....	<i>Forficula auricularia</i> L.
European fruit lecanium.....	<i>Lecanium corni</i> Bouché
European red mite.....	<i>Paratetranychus pilosus</i> (C. and F.)
Eye-spotted budmoth.....	<i>Spilonota ocellana</i> (D. and S.)
Fall webworm.....	<i>Hyphantria cunea</i> (Drury)
Filbertworm.....	<i>Melissopus latiferreanus</i> (Wlsm.)
Flatheaded apple tree borer.....	<i>Chrysobothris femorata</i> (Oliv.)
Fruit tree leaf roller.....	<i>Archips argyrospila</i> (Wlkr.)
*Green clover treehopper.....	<i>Stictocephala inermis</i> F.
*Green fruitworms.....	<i>Graptolitha</i> spp.
Green peach aphid.....	<i>Myzus persicae</i> (Sulz.)
Hop aphid.....	<i>Phorodon humuli</i> (Schr.)
*Leaf-curling plum aphid.....	<i>Anuraphis helichrysi</i> (Kltb.)
Lesser appleworm.....	<i>Grapholitha prunivora</i> (Walsh)
*Lygus bugs.....	<i>Lygus hesperus</i> Knight; <i>Lygus elisus</i> Van Duzee
Mealy plum aphid.....	<i>Hyalopterus arundinis</i> (F.)
Oblique-banded leaf roller.....	<i>Archips rosaceana</i> (Harr.)
Oriental fruit moth.....	<i>Grapholitha molesta</i> (Busck)
Oystershell scale.....	<i>Lepidosaphes ulmi</i> (L.)
Pacific flatheaded borer.....	<i>Chrysobothris mali</i> Horn
Pacific mite.....	<i>Tetranychus pacificus</i> McG.
*Pandemis moth.....	<i>Pandemis albaniana</i> Wlkr.
Peach tree borers.....	<i>Sanninoidea exitiosa</i> (Say); <i>S. exitiosa</i> graefi Hy. Edw.
Peach twig borer.....	<i>Anarsia lineatella</i> Zell.
Pear leaf blister mite.....	<i>Eriophyes pyri</i> (Pgst.)
*Pear leaf worm.....	<i>Gymnonychus californicus</i> Marlatt
Pear psylla.....	<i>Psylla pyricola</i> Foerst.
Pear-slug.....	<i>Caliroa cerasi</i> (L.)
Pear thrips.....	<i>Taeniothrips inconsequens</i> (Uzel)
Rose leafhopper.....	<i>Typhlocyba rosae</i> (L.)
Rosy apple aphid.....	<i>Anuraphis roseus</i> Baker
Rusty tussock moth.....	<i>Notolophus antiquus</i> (L.)
San Jose scale.....	<i>Aspidiotus perniciosus</i> Comst.
Shot-hole borers.....	<i>Scolytus rugulosus</i> (Ratz.); <i>Anisandrus dispar</i> (F.)
Snowy tree cricket.....	<i>Oecanthus niveus</i> (Deg.)
Spotted cutworms.....	<i>Amathes c-nigrum</i> (L.); <i>Abagrotis barnesi</i> (Benj.); <i>Euzoa</i> spp.
*Stone fly.....	<i>Taeniopteryx pacifica</i> Banks

* Name does not appear in list of Common Names of Insects Approved by The American Association of Economic Entomologists.

Common name	Scientific name
*Syneta leaf beetle.....	<i>Syneta albida</i> Lec.
Thistle aphid.....	<i>Anuraphis cardui</i> (L.)
Two-spotted spider mite.....	<i>Tetranychus bimaculatus</i> Harvey
Walnut aphid.....	<i>Chromaphis juglandicola</i> (Kltb.)
Western tent caterpillar.....	<i>Malacosoma pluviale</i> (Dyar)
Western tussock moth.....	<i>Hemerocampa vetusta</i> (Bdvl.)
*Willamette mite.....	<i>Tetranychus willamettei</i> McG.
Woolly apple aphid.....	<i>Eriosoma lanigerum</i> (Hausm.)

*Name does not appear in list of Common Names of Insects Approved by The American Association of Economic Entomologists.

INSECTICIDES

Fortunately, most of the insect pests of fruit trees spend at least part of their lives where fruit growers can control them with insecticides. Annual crops may often be protected from serious insect injury by following certain practices of planting, harvesting, cultivating, and crop rotation, but with fruit trees these methods are usually out of the question. Spraying is expensive, but its cost is small compared with the value of the crop.

Insects feed in two ways. Some bite off and swallow portions of the fruit or foliage. Others have mouths in the form of a sucking apparatus, which they insert into the plant tissues and through which they draw out the plant juices. Many of the biting insects may be destroyed by keeping the trees covered with a poisonous material, which the insects eat with their food. The young of the codling moth and other moths, beetles, sawflies, grasshoppers, and crickets are biting insects. The insects with sucking mouth parts are not affected by poisons placed on the surface of the leaves or fruit. For their control contact insecticides, which poison the insects through their breathing pores or by a corrosive action on their bodies, must be used. The scale insects, aphids, leafhoppers, treehoppers, and the true bugs are sucking insects. Red spiders also feed in this manner, although they

are not true insects. Some materials may act both as stomach poisons and as contact insecticides.

The insecticides discussed in the following pages have been used extensively with success. The worth of others has not yet been proved although they may already be in practical use. As a rule the fruit grower will find that the standard materials, with known ingredients, are the most effective and economical. Products the ingredients of which are unknown should be avoided, as they are often worthless. The Federal Insecticide, Fungicide, and Rodenticide Act, which regulates the marketing of insecticides that are shipped from one State to another, requires that they bear a label giving the percentages of both active and inert materials. The States in the Pacific Northwest have similar laws governing the sale of insecticides. Growers should therefore refuse to buy any material offered for sale as an insecticide unless it is properly labeled.

Any insecticide residue on the harvested fruit in quantities large enough to endanger the health of the consumer must be removed by washing or wiping before the fruit is marketed. Usually it is not necessary to apply an insecticide so near harvest that dangerous residues will remain on the fruit.

Many insecticides are poisonous to bees and other insects that pollinate the blossoms of fruit trees. Therefore, do not apply insecticides when the trees are in bloom. If possible, also avoid spraying

when cover crops or weeds in the orchard are in bloom. Dusting is more likely to poison bees than spraying.

Many insecticides are available for application as dusts. In general dusts have not been so satisfactory as sprays, although in some instances they have been used successfully, particularly if more frequent applications were made. Dusting should only be done in calm weather.

PRECAUTIONS

DDT, toxaphene, benzene hexachloride, lead arsenate, cryolite, parathion, and nicotine are poisonous to man and animals and should be handled accordingly. Because parathion and nicotine are extremely poisonous to human beings, persons using these chemicals should follow the additional precautions given on pages 59 and 60. When mixing or applying insecticides, take extreme care to keep the materials out of the mouth and eyes and away from tender parts of the body. When spraying or dusting operations are long and continuous, keep the body well covered, even in the warmest weather, and wear goggles to protect the eyes. Wash the face and hands thoroughly after using any insecticide. After long exposure take a bath and change the clothes. Do not wear clothing on which spray residues have accumulated until it has been washed.

Containers in which insecticides are stored should be plainly marked "*Poison.*" Keep them tightly closed and preferably under lock, and well out of reach of children and others unfamiliar with their poisonous nature. Prevent domestic animals and livestock from feeding on treated vegetation, licking containers, or drinking contaminated water. Bury or burn empty packages because of the small quantity of insecticide remaining in them. Bury unused portions or discarded material at least a foot below the surface of the ground and away from water supply or drainage. Keep DDT and rotenone out of ponds. They kill fish.

DDT

DDT has come into widespread use both as a contact insecticide and as a stomach poison. It is valuable to the fruit grower for controlling a number of pests, including the codling moth, the oriental fruit moth, lygus bugs,

climbing cutworms, leafhoppers, and many aphids. DDT has failed to control the woolly apple aphid or the orchard mites, and it destroys many of their parasites and predators, so that it is necessary to use other insecticides for controlling these two pests.

With successive applications of DDT there is danger of building up a concentration in the soil high enough to interfere with the growth of plants. Therefore, no more than is necessary to control the insect should be used.

DDT is most commonly available as a 50-percent wettable powder and as a 5- or 10-percent dust. For spray applications the wettable powder is used at 1 to 2 pounds to 100 gallons of water for control of most fruit insects.

TOXAPHENE AND BENZENE HEXACHLORIDE

Toxaphene and benzene hexachloride may have limited uses in the orchard. Toxaphene preparations, which are available in both powdered and liquid forms, will control the pear psylla, aphids, and mites. The 50-percent powder should ordinarily be used at 1 pound, and the 50-percent liquid at 1 pint, to 100 gallons. Toxaphene should not be used on stone fruits, as it may cause injury. Benzene hexachloride may be used early in the season for controlling the woolly apple aphid. (See p. 18.)

PARATHION

Parathion is primarily useful as a contact insecticide and acaricide (miticide) for controlling aphids, mites, pear psylla, scale insects and small larvae. It is available as a 15- or 25-percent wettable powder and as a 1- or 2-percent dust. For spray applications the 15-percent powder is most commonly used at $\frac{1}{2}$ pound or more to 100 gallons of water.

Caution.—Parathion is highly toxic to human beings. It is extremely hazardous if swallowed, inhaled, or absorbed through the skin. Do not use it unless you are willing to continuously observe the recommended cautions. Handle it with great care and only in the open air or in well-ventilated rooms. Avoid breathing in the wettable powder while opening the bags or putting it into the spray tank. Avoid exposure to spray drift or dust clouds; wear protective clothing if so exposed. Wear a respirator of a type which has been tested in the Department of Agriculture while handling the wettable powder and during spraying and dusting operations. Never handle parathion spray and dust formulations with the bare hands. Wash the hands, arms, and face thoroughly with soap and water after handling parathion and before eating or smoking. Change the clothes and bathe at the end of work.

In case, through an accident, parathion spray materials strike the face or arms or the clothing becomes wet with it, remove the clothing immediately and wash thoroughly the exposed parts.

If headache, blurred vision, weakness, nausea, cramps, diarrhea, or discomfort in the chest develop while working with parathion, or in or about parathion-sprayed trees, stop work immediately, change the clothes and bathe. If the illness persists, call your doctor. Atropine in therapeutic doses is of value in relieving acute symptoms of poisoning from this insecticide. Morphine should never be given.

TETRAETHYL PYROPHOSPHATE

Tetraethyl pyrophosphate has uses similar to parathion but is not so lasting and therefore may have to be applied more often. It sometimes is useful as an emergency treatment put on shortly before the fruit is harvested. It comes in both liquid and dust forms. Like parathion, this material is extremely toxic to man and animals and must be handled with extreme care.

MINERAL OILS

Mineral oils are useful for controlling scale insects and other pests when the trees are dormant. They are customarily employed in emulsions containing 3 or 4 percent of oil, or at the rate of 1 or 2 percent of oil combined with lime-sulfur. The oil should have a viscosity of 100 to 120 seconds Saybolt, and an unsulfonated residue of 50 to 70 percent. The use of oil sprays during the summer has been almost entirely supplanted by various organic insecticides.

LEAD ARSENATE

Lead arsenate has been almost entirely supplanted by DDT and other organic materials, but it still finds some use as a stomach poison for controlling fruit insects. It comes as a powder. The acid lead arsenate is used on apples and pears, but the basic form is preferred for stone fruits, as there is less danger of injury. In this circular, unless the basic form is specified, the acid form is meant.

Caution.—Lead arsenate is very poisonous. The general cautions on the storage and use of such materials should be followed.

CRYOLITE

Cryolite (sodium fluoaluminate) may be used in place of lead arsenate for spraying apples and pears in the Northwest. Lime-sulfur or other materials of high lime content should not be mixed with cryolite.

LIME-SULFUR

Liquid lime-sulfur will control certain insect pests and fungus diseases of fruit trees. It may be used as a dormant spray and also, in a more dilute form, as a summer spray. In the latter case it is

TABLE 1.—*Dilution of liquid lime-sulfur for various strengths of spray*

Strength of liquid lime-sulfur		Quantity ¹ to make 100 gallons of spray			
Hydrometer scale (° Baumé)	Specific gravity	Dormant strength		Early spring strength for scab and red spider (1½° Baumé)	Spring or summer strength for mildew and red spider (1° Baumé)
		For scales (4½° Baumé)	For blister mite and twig borer (3½° Baumé)		
		Gallons	Gallons	Gallons	Gallons
36-----	1. 330	9½	7	2¾	1¾
34-----	1. 306	10	7½	3	1¾
33-----	1. 295	10½	7¾	3	2
32-----	1. 283	11	8	3	2
31-----	1. 272	11¼	8¼	3	2
30-----	1. 261	11½	8½	3¼	2
29-----	1. 250	12	9	3¼	2¼
28-----	1. 239	12½	9½	3½	2¼
26-----	1. 218	13½	10	3¾	2½
24-----	1. 198	14¾	11	4¼	2¾
22-----	1. 179	16½	12½	4½	3
20-----	1. 160	18¾	14	5	3½

¹ All quantities expressed in nearest quarter gallon.

valuable chiefly as a fungicide. The strength of the commercial product varies, and should be ascertained from the manufacturer or by means of the Baumé or specific-gravity scale on a lime-sulfur hydrometer. The quantities required to make 100 gallons of spray for various purposes are shown in table 1. Dry lime-sulfur is sometimes used to avoid transporting the heavier liquid material, but is less effective against the San Jose scale.

NICOTINE

Nicotine is an effective insecticide for sucking insects, as it not only destroys insects by coming in direct contact with them but also acts as a fumigant in hot weather, killing insects that do not contact the spray. This fumigating action is undoubtedly limited to a short distance, possibly only a fraction

of an inch. For this reason it is advisable to spray with nicotine on calm days when the temperature is above 80° F., if possible. Nicotine is sold in the form of free nicotine and also as nicotine sulfate (40 percent nicotine), the latter being used chiefly for orchard spraying. The dilution is usually ¾ to 1 pint to 100 gallons. If nicotine sulfate is used alone, 2 or 3 pounds of soap dissolved in water or 1 pound of casein spreader should be added to each 100 gallons of water, to cause the mixture to spread better and penetrate any waxy covering of the insects. The soap should be omitted if the nicotine is added to other insecticides, but the spreader may be used.

Caution.—Nicotine and its compounds are extremely poisonous and should be used carefully. Continued exposure to fumes or sprays causes acute nausea in

some persons. Protection against this effect can be obtained by use of a respirator provided with pads saturated with a solution of citric acid. Nicotine can be absorbed through the skin. If a concentrated solution is spilled on the skin, it should be washed off with water immediately.

ROTENONE

The ground roots of certain tropical plants, such as cube or derris, the insecticidal constituent of which is rotenone, are used for controlling the cherry fruit fly and occasionally for pear psylla, aphids, and orchard mites.

SPREADERS AND STICKERS

Many organic insecticides are so effective that there is little need to use spreaders or stickers with them in the Pacific Northwest. It is advisable to use soap or other spreader with nicotine sprays, and a protein spreader, such as casein, blood albumin, or soy flour, is often added to lead arsenate or cryolite.

METHODS OF APPLYING INSECTICIDES

Excellent control of the codling moth and other fruit pests has been obtained with air-blast machines, which carry the finely divided spray into the trees. Therefore, the air-moving capacity of the machine must be sufficient to displace all the air within the tree. It is often advantageous to increase the concentration of ma-

terial in the tank by 50 percent or more, and to decrease the quantity of spray applied to the trees.

Until the most effective and practical concentrations and quantities have been determined, the grower will find that if he applies approximately the same quantity of insecticide per acre with the new machines as he has been applying with spray guns, he is very likely to get good control of the pests. Thus, if it is desired to apply half as much liquid by the concentrate method as with spray guns, the concentration of insecticide in the liquid should be twice that used with spray guns.

In dust applications also the air in the trees must be displaced. Many dusting machines that have been used for insect control do not have such a capacity. Application by airplane or helicopter, or by machines drawn along the ground, may be thorough and effective if an adequate quantity of dust is applied and the dusting is done when atmospheric conditions cause most of the dust to settle in the trees. Otherwise it may be of little value. Care should be taken not to apply dust when it may drift on to other crops. Dusts have often been much less effective against well-protected insects, such as the woolly apple aphid, than against orchard mites and other more exposed pests. Their effects are not so long lasting as those of sprays, necessitating more frequent applications.

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