Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

Leland R. Brown

Clark O. Eads

INSECTS AFFECTING ORNAMENTAL CONIFERS IN SOUTHERN CALIFORNIA

CALIFORNIA AGRICULTURAL
EXPERIMENT STATION

BULLETIN 834

HOW TO USE THIS BULLETIN

For the person not trained as an entomologist, a few suggestions may be helpful.

First: Identify the insect or its damage to the coniferous plant. Compare the insect at hand with the main categories in the Contents. Use the photographs to assist in this identification.

Second: Read about the insect on the indicated page in the text. This should confirm the identity as well as supply interesting points about the insect's habits and necessary information on control.

Third: Consult specific directions for combating the insect, beginning on page 67.

CONTENTS

NOTE: For a general discussion of sucking, leaf-consuming, and boring insects, and of the principles and practices of treating large shade trees with insecticides, see University of California Agricultural Experiment Station Bulletin 810, "A Technical Study of Insects Affecting the Oak Tree in Southern California."

OCTOBER, 1967

THE AUTHORS:

Leland R. Brown is Associate Professor of Entomology and Associate Entomologist in the Experiment Station, Riverside.

Clark O. Eads is Laboratory Technician IV in the Experiment Station, Riverside.

Insects Affecting Ornamental Conifers in Southern California[1,2]

THE CONE-BEARING plants are among the most common and useful of landscaping plants. They are often used to impart a note of formality in a garden or park. Included are many shrubs and trees, ranging in size from the small, root-pruned, bonsai plant in a dish to that largest of all living things, the giant sequoia. Compared to the flowering plants, the conifers are not a large group but many of them are used for ornament and shade. Among them are the pines, cedars, firs, cypresses, junipers, redwood, arborvitae, yew, araucaria, and also such lesser-known conifers as ginkgo, podocarpus, and the sago palm (cycad). In addition to the many native and imported natural species of the conifer genera, the number of horticulturally developed hybrids and varieties (i.e., cultivars) is very large in some genera. Mathias and McClintock (1963) list, for example, 123 valid names under *Juniperus* as used in California alone. Some of our common, native forest trees are used for ornament in landscaping—that is, for uses other than lumber production—around mountain homes, summer cabins, in parks and picnic areas, and in our low-elevation urban areas.

A great many different insects attack conifers and feed exclusively on them—many more than the relatively few discussed in this bulletin. Listed here are those commonly encountered in southern California, and those with which we have had some original experience. Many of these insects will harm the conifer to some degree, some may be truly devastating, as for instance the bark beetles, but most of them are of secondary importance compared to such a primary problem as drought in this arid region. For insects not covered in this bulletin, we suggest such works as Essig (1926 or 1958), Doane *et al.* (1936) or Keen (1952).

SUCKING INSECTS

Western pine spittlebug

Although the western pine spittlebug, *Aphrophora permutata* Uhler (Homoptera: Cercopidae), has been found on species of 16 widely different families of plants (DeLong and Severin, 1950), Severin (1950) suggests that this common name is appropriate. Essig (1926, 1958) calls it the "rhubarb spittlebug." Kelson (1964) suggests that many of the recorded host plants are frequently near stands of pine, which is the favored host plant genus. Great quantities of sap are sucked from the plant by the immature insect to form the frothy mass in which it lives (figures 1 and 2). The adult also sucks considerable amounts of sap and defecates much honeydew, but is not confined to the mass of froth or spittle. Although enormous quantities of sap are lost to the pine tree it is difficult to assess the damage done otherwise; the loss of sap is likely to be serious in the presence of other limiting factors, such as drought. The spittle

---

[1] Submitted for publication January 8, 1966.

[2] The authors began these studies on the Los Angeles campus of the University of California in 1949 and continued them on the Riverside campus beginning in 1960.

Western pine spittlebug. Fig. 1. Top: Aleppo pine cone covered with spittle. 1.1×. Fig. 2. Bottom: Aleppo pine twig covered with spittle; note nymphal cast skins on some needles. 1.1×.

masses, the falling spittle, and the flying adults, however, are a nuisance, and many people want them controlled.

The western pine spittlebug is found throughout the western United States, and, according to Kelson, may be found with a related species, *Aphrophora canadensis* Walley, in some locations. We have found the spittlebug in southern California on both Monterey pine and aleppo pine—as did DeLong and Severin (1950)—but only along the coast or in areas under coastal influence.

Kelson (1964) reports that the egg of the western pine spittlebug ranges from pale yellow, when first laid, to dark purple near hatching time. It is tapering on each end, slightly curved, with one end slightly sharper, and about 1.7 mm long. The eggs are deposited serially in the pine needle; this manner of insertion is similar to that of the diprionid sawflies. Some of the eggs may be completely submerged in the needle tissue, others may be partially protruding from the egg slit, and some may be almost completely out of the needle tissue and adhering only by one end. Kelson states, and Severin (1950) infers, that all of the newly hatched spittlebug nymphs drop to the ground and complete their development on nearby herbaceous plants, particularly on the bristly ox-tongue, *Picris echioides* (Compositae). However, this habit does not explain our observations here that the spittle masses (produced only by and surrounding the immature instars) may be found throughout the spring on both the pine (figures 1 and 2) and the low-growing herbaceous plants surrounding the tree. In southern California at least, the immature instars may develop on both the pine and surrounding herbaceous plants. However, Kelson notes that in the San Francisco Bay region the associated species, *Aphrophora canadensis*, does complete its development on pine; so it is possible that some of our observations may have confused the two species. Kelson notes that *Aphrophora* species have five nymphal instars, before the single adult instar. The first four instars of *A. permutata* have the head and thorax dark brown and the abdomen a light pink, except for the last segment which is dark. The fifth instar is uniformly dark with some lighter spots on the thorax and head. The most obvious difference of the fifth instar of *A. canadensis* is that the first six abdominal segments continue to be light colored.

Severin (1950) describes the molting to the adult stage: The fifth instar nymph crawls out of the spittle mass to the tip of the needle (figure 2) and attaches the tip of the abdomen to the needle with spittle which dries. Eventually the dorsum of the head and thorax splits and the adult crawls out, but remains attached to the cast skin by the tip of the abdomen until the appendages

Fig. 3. Western pine spittlebug adults. 6.8×.

and other parts of the exoskeleton are hardened and darkened. The adult (figure 3) is 9 to 12 mm long, brownish-orange to dark brown, with an indistinct white line diagonally crossing the middle of the elytra. As with all cercopids, the distal end of the hind tibia is ringed with stout spines, whereas the leafhoppers, which have a somewhat similar appearance, have a double row of spines along the length of most of the hind tibia.

Ball (1920) states that cercopids in central California have only a single generation per year. Severin (1950), studying *A. permutata* in San Mateo County, reports two generations, with the nymphs of the first generation on herbaceous plants, and the whole cycle of the second generation going through on pine. Kelson (1964), studying in a comparable locality, suspects that Severin confused the nymphs of *A. permutata* with those of *A. canadensis,* the latter occurring somewhat later and on pine. He concludes that there is only a single generation annually of either of these species. In southern California, we observed immature spittlebugs on pines and the surrounding herbaceous plants in the middle of October. Granting the possibility that we, too, may have confused these two species, we would suspect that one or both of these species may have a partial second annual brood in southern California. Here the spittle masses are much more commonly seen in the spring, with the individual mass being particularly large in late May, when the nymphs are largest and likely defecating the most honeydew. Kelson, who made his observations in the San Francisco Bay region, indicates that overwintering occurs in the egg stage, with hatching beginning in February, in the case of *A. permutata.* The initial hatch of *A. canadensis* begins in early April. Adults of *A. permutata* begin to appear in late May, and those of *A. canadensis* not until early July.

Several insecticides have been used successfully against this and other spittlebugs. Thorough coverage sprays of dieldrin have given excellent control. Methoxychlor, lindane, malathion and carbaryl have controlled various spittlebugs.

Pine bark aphid

The pine bark aphid, *Pineus strobi* (Hartig) (Homoptera: Adelgidae), is a relatively common pest throughout southern California. We have found it on several species of yellow and white pines, including both native and imported species. This insect is commonly found beneath the woolly waxen masses it secretes on the twigs (figure 4), or beneath the wax protruding from the trunk cracks of thick-barked pines (figure 5), or thickly covering the limbs and trunk of immature pines or of thin-barked species (figure 8). Sometimes these waxy masses are so thick on the twigs that the tree appears like a Christmas tree decorated with cotton. These heavy infestations of the bark aphid definitely weaken the growth of the twigs, and the cottony masses, often largely covered with black sooty mold, give the limbs a dirty, unkempt appearance.

By carefully pulling back the cottony wax, the wingless, soft bodied, purplish-black female may be seen under the dissecting microscope, often almost completely covered by the mass of relatively large eggs she has laid (figure 7). She is about 1 mm long. In the photograph some strands of cottony wax may be seen protruding from her dorsum or back. If such a female adelgid is cleared with potassium hydroxide, mounted on a microscope slide, and examined under a compound microscope, numerous chitinous, multipored, wax-secreting plates can be seen on the dorsum (Annand, 1928; Essig, 1942). A large plate unites the top of the head and thorax, and several rows of smaller plates exist on the posterior parts, these rows corresponding to the segmentation of the insect. According to Doane (1961), when these clumps of wax pores of the pine bark aphid, particularly those just behind the ocelli, are examined under high magnification, the pores are close together, giving the border of each pore an angular appear-

Pine bark aphid. Fig. 4. Right: Cottony masses on pine twigs and needles; sooty mold is on needle base at right. 3.0×. **Fig. 5.** Below: Heavy infestation indicated by cottony masses protruding from cracks in pieces of pine bark. 1.1×. **Fig. 6.** Bottom: Three winged females on pine needle; their abdomens have collapsed from the laying of egg masses behind them. 18×.

ance. Also the aperture of the pore presents a granulated appearance as compared to the clear aperture of closely related adelgids. The adelgids have a pair of tarsal claws on each leg, as compared to a single claw in coccoid scales, some of which have been confused with the pine bark aphid. Apparently the apterous forms (as in figure 7) are much more common than the somewhat rare winged forms (figure 6). The wingless forms reproduce parthenogenetically (no males), whereas the winged forms may be sexual (males and females). Both types of females only lay eggs, in contrast to the true aphids, some forms of which bring forth living young. Also the bases of the cubital veins in the winged forms are separated, whereas in the closely-related Phylloxeridae they are together or stalked. According to Doane, winged adults are common only in certain years (in the New England states) and it is in this form that they fly from the pine to the spruce which is the alternate host. Spruce (*Picea*) is not part of the natural flora of southern California and is rarely planted as an ornamental here. The eggs are elongate, oval, 0.2 mm long and yellowish-pink.

Adelgids, like the true aphids (Aphididae), may have a rather complicated life cycle, with a multiplicity of forms possible during the year (Essig, 1942 and Imms, 1960). We are not certain how many generations of the pine bark aphid may occur annually in southern California. Herrick (1935) indicates that there are three generations in New York. We have noticed large numbers of crawlers (figure 8) hatching in April and May, with some as early as February and some as late as September. From the point of view of insecticidal control, a spray during heavy crawler hatch is best.

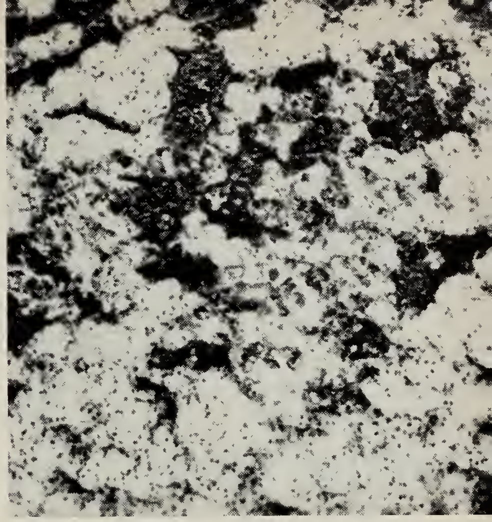


Fig. 8. Many crawlers appear like pepper grains on the numerous cottony masses covering pine bark aphid females on the trunk bark. 3.3×.

Malathion or lindane sprays have yielded fairly good control but recent experiments show that diazinon sprays are better. Additional wetting agent, such as X-77, in the spray increases the effectiveness; the relatively high dosage of 1 pint of wetting agent per 100 gallons of spray gave the best control. It is essential that the force of the spray be directed in a solid stream at the trunk and limb bark, with particular attention given to the growing tips, or candles. See section on Control.

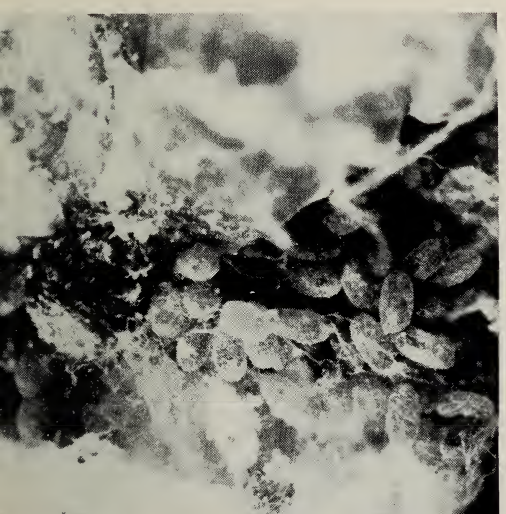


Fig. 7. Cottony mass opened to expose wingless pine bark aphid female (left of center); she laid the large mass of eggs to the right. 21.9×.

Deodar aphid

In deodar-planted parkways it is common to find wet spots on the pavement beneath the tree. Cars parked beneath the trees may be liberally sprinkled with small drops of a clear, sticky liquid. The lower sides of the tree limbs, from the trunk outward to the tips, may be seen thickly covered with large, long-legged aphids, which are one of the species of *Cinara* (figure 9). These frequently have been identified as *C. curvipes* (Patch) (Homoptera: Aphididae: Lachnini), although the specimens described below may not be this species. Almost all of these giant aphids will be found with their mouthparts inserted into the bark, sucking the sap, and frequently defecating droplets of excess water and sugar from their posterior end. Not only is the falling honeydew a nuisance, but honeydew on the tree becomes black from a smut fungus; also, the extracted sap weakens the tree and undoubtedly reduces the luxuriant growth of the deodar cedar. This tree often suffers from drought in this area, and such heavy aphid infestations cause water loss that the tree can ill afford. Insecticidal control measures of this aphid are usually warranted. Apparently, these lachnine aphids are highly specific as far as their host is concerned. (See Gillette and Palmer, 1931; and Essig, 1926 and 1958).

Aphids of the tribe Lachnini are relatively large compared with others of the family, this particular aphid (figure 9 for example) having a body length of 4 to 5 mm. It is purplish-black or brownish-black, and the abdomen and part of the thorax are usually covered with a gray powdery wax. The cornicles, extending horn-like from the back of the abdomen in most aphids, are shiny black, low, ring-like cones on this *Cinara*. Fine hair is on the cornicles. The legs, particularly the hind pair, are conspicuously long and amber colored. Both winged and wingless forms may be present, and all the variety of forms and habits found in

A giant conifer aphid. Fig. 9. Two wingless and one winged form from the deodar cedar; note dark conical cornicles on upper left specimen. 5.1×.

other aphid species are presumably also found in this genus and species (Essig, 1942). When the limb is slightly jarred, all the deodar aphids shift their pea-size bodies in unison, without moving their attachment to the limb, in perfect synchronization of movement. The limb must be jarred most vigorously for the aphids to interrupt their feeding and withdraw their mouthparts. The annual number of generations is not known, but breeding is continuous throughout most of the year.

Lindane, malathion and diazinon have for some time been used in sprays for controlling this and other of the true aphids. Dimethoate and Meta-Systox-R, both systemic insecticides, are showing promise on various aphids. See section on Control.

Arborvitae aphid

Like the deodar aphid, the arborvitae aphid, *Dilachnus tujafilinus* (Del Guercio) (Homoptera: Aphididae: Lachnini), is another of the lachnine aphids that affects coniferous plants. It commonly infests arborvitae (*Thuja* species) and almost all of the cypresses (*Cupressus* species and *Chamaecyparis* species) grown in southern California. The trees commonly turn brown from the copious feeding of the numerous gregarious colonies, and often turn black from the smut fungus in the honeydew. Individual limbs have been killed from such concentrated attacks.

The aphid colony in figure 10 is typical of the wingless form, which is the one most commonly found. The aphid body is pear-shaped, with the head at the smaller end. The broad conical cornicles are at the sides of the wide part. The integument is shiny brown with grayish powdered wax covering all of the body except those parts appearing as dark lines on the aphids in figure 10. The longest specimen in the photograph is 2.7 mm.

As with other aphids, insecticides such as lindane, malathion and diazinon are effective against this species. See section on Control.

Monterey pine aphid

The two preceding aphids are almost always found feeding gregariously on the bark of conifers, but the Monterey pine aphid, *Essigella californica* (Essig) (Homoptera: Aphididae: Lachnini), feeds on the pine needles and is frequently found alone running about rapidly on them. Its populations, however, are seldom heavy. It often feeds heavily on pine needles early in the season, then disappears, so that the common yellowing of needles found later is difficult to diagnose as to cause. Burke (1937) also noticed that it feeds in early spring. We have found it on Monterey pine, ponderosa pine, and Coulter pine in various parts of southern California.

Essig (1926 or 1958) on page 229 shows drawings of the winged and apterous forms. Gillette and Palmer (1931) have a detailed description of the genus and species. Characteristic features of the aphid are its long, almost cigar-shaped body, its almost total lack of cornicles, the green color, the relatively long legs, and the speed with which it runs about on the needles. It is relatively small (1.5 mm long) compared with some aphids.

Insecticidal controls may be applied in the spring. The usual insecticides are effective—lindane, malathion or diazinon. See section on Control.

◀ **Arborvitae aphid.** Fig. 10. A colony of wingless specimens. 4.5×.

Podocarpus aphid

This aphid, *Neophyllaphis podocarpi* Takahashi (Homoptera: Aphididae: Callipterini), is occasionally found on podocarpus nursery stock. Its presence on the leaves is usually detected by the whitish cottony wax that comes from wax glands at its posterior end. So far as we know, infestations of this aphid do not curl the leaves, as do some closely related genera and species. The aphid is restricted to this genus of plants, and if cottony wax is noticed on the leaves the presence of this aphid can be suspected. Beyond some honeydew secretion and black smutting of the leaves, it is difficult to judge the economic significance of this species.

According to Gillette and Palmer (1931), besides the presence of wax glands, the slightly elevated cornicles are mere rings on a low conical base, the forewing radial sector is slightly curved and the media two-branched. The hind wings have both a media and cubitus.

The usual insecticidal controls for aphids are effective against this species. For spot treatment with small, compressed-air sprayers, additional wetting agent in the spray, to aid in wetting the cottony wax, may be necessary. See section on Control.

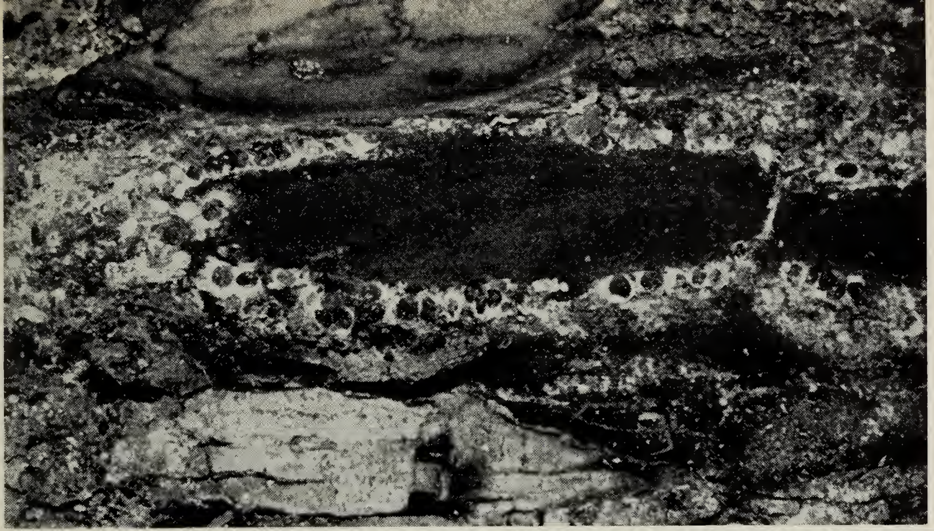
Monterey pine mealybug

The specimens of mealybugs shown in figure 11 are very likely to be *Dysmicoccus aciculus* Ferris (Homoptera: Pseudococcidae). They are not common, seem to be associated with the Monterey pine, *Pinus radiata*, but are of questionable economic importance. A fair degree of honeydew and sooty mold may be found with the infestation. Feeding occurs on the tender wood at the base of the needle fascicles of the pine growing tip.

The mealybug is about 3 mm long, and rather evenly covered with powdery wax, but with some slight indication of the segmentation. The peripheral wax filaments are all toward the posterior of the body and are relatively short. Apparently no egg case is made. Ferris (1950) states that there is a single generation per year and that it may be very heavily parasitized; therefore it is likely to be a native species.

Two or more sprays are needed. Malathion or diazinon are generally suggested. Additional wetting agent in the spray may be necessary. See section on Control.

Monterey pine mealybug. Fig. 11. White mealybug contrasts with black sooty mold on needles of Monterey pine. 4.4×.



Cypress bark mealybug. Fig. 12. Removal of a bark plate reveals a colony in the form of an oval. 2.3×.

Cypress bark mealybug

Ehrhornia cupressi (Ehrhorn), (Homoptera: Pseudococcidae) has also been called the "cottony cypress scale" (Essig, 1926) and "cypress bark scale." Ferris (1953), however, places it among the mealybugs. In figure 12 a piece of bark has been removed to expose the inner bark where numerous mealybugs are wedged tightly around the attachment of the bark piece. This insect seemed to have been very prevalent and injurious to various cupressaceous plants, particularly Monterey cypress and incense cedar, in the San Francisco Bay region. Herbert (1920) noted many hedges and individual plants—heavily infested with this cottony, wax-shrouded insect—that turned chlorotic and eventually died. In southern California we have seen this insect only infrequently in the last decade, perhaps because it is less prevalent now and the preferred host plants are less common here than in the San Francisco Bay region. But, where found in the south, it has been serious enough to warrant control measures.

The female of the cypress bark scale is about 1.5 mm long, hemispherical, and reddish-brown. She is immersed in the cottony mass of glistening wax strands and, along with other females, inserts herself tightly and permanently into cracks of the bark. Infestations are suspected by the cottony wax protruding from the bark cracks. The male scale (Herbert, 1920) is similar to other coccoid males, has a reddish-brown body, a pair of whitish, almost veinless forewings (the hind pair is reduced to halteres), and a pair of long, white waxen filaments extending to the rear. It develops, like other coccoid males, in a small, white, sac-like cocoon. Herbert notes that, although there is only a single generation annually, the immature, mobile forms may be found from April into November and suggests an insecticidal spray in August or September.

Although our experience in controlling this insect has been limited, sprays of malathion or diazinon should be successful. It may be necessary to apply a second spray two or three weeks after the first. Very thorough coverage with the spray gun is needed, with particular attention to getting the spray forcefully beneath the cracks in the bark. Additional wetting and emulsifying agent may be necessary. See section on Control.

Anderson mealybug. Spilococcus andersoni. Fig. 13. Dorsal and lateral view of mealybug (left) and its long, white egg sac (right); lower egg sac is opened to show eggs. 13.8×.

Anderson mealybug

This mealybug, *Spilococcus andersoni* (Coleman) (Homoptera: Pseudococcidae), is not particularly common in southern California, but the insect and its egg sac are distinctive on its cupressaceous hosts. In some restricted locations in Santa Barbara and Ventura counties we noticed fairly heavy infestations on big-cone cypress, but its economic damage was questionable. The top specimen in figure 13 is typical of the appearance on the cord-like twigs and leaves of this plant. The female on the left is dark green, the color being almost obliterated by the heavy dusting of the white, powdery wax. She is about 2.5 mm long. Extending to the right is the typical egg sac, which is elongate, rather convex in cross-section, and has a slight furrow along the top. The lower specimen in figure 13 has the thin ovisac opened to expose the yellowish eggs. We have noticed heavy egg-laying and construction of the egg sacs in June. For a detailed morphological and taxonomic treatment, see Ferris (1950).

Control, where warranted, will be accomplished with a spray or two of malathion or diazinon, applied with a fair degree of force. Additional wetting agent in the spray may be necessary. See section on Control.

Golden mealybug. Fig. 14. Colony on twig of the star pine. 3.6×.

Golden mealybug

The golden mealybug, *Nipaecoccus aurilanatus* (Maskell) (Homoptera: Pseudococcidae), is a fairly common pest in southern California on the plant genus *Araucaria*. This commonly includes *A. bidwillii,* the bunyabunya, and *A. heterophylla* (= *excelsa*), the star pine or Norfolk Island pine (figure 14). It has also been recorded on the closely related genus *Agathis*. The insect was evidently imported into California on these hosts from Australia and New Zealand (Essig 1926). Usually infestations are very heavy, with the wood of the younger twigs being almost covered with the insects. Considerable honeydew is defecated and smutting of the limbs occurs. Growth of younger twigs is retarded by such attacks.

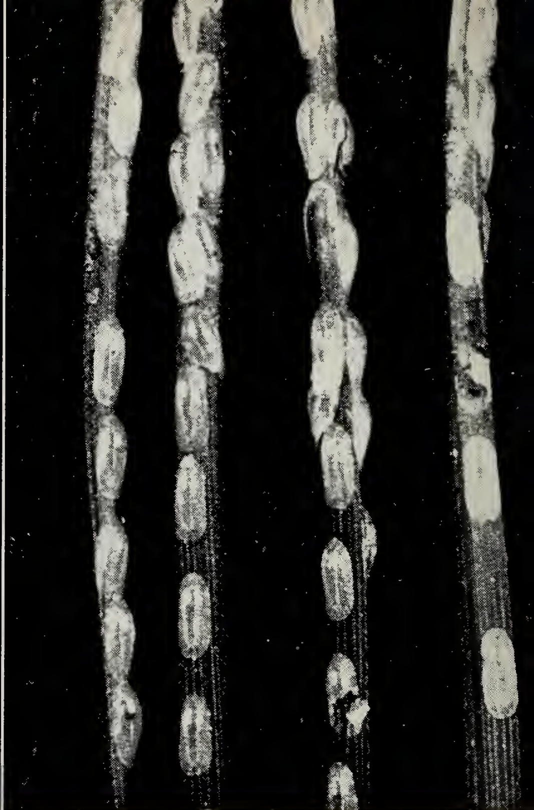
This is one of the most strikingly colored of the mealybugs: the body is purple, and the wax is yellow. The wax is located around the periphery of the body —in broad short points, and in a broad line down the middle of the back; several clumps of wax (corresponding to the segments of the body) may be found also on each side of the midline. The mature mealybug is about 3 mm long. The eggs are also purple, and are laid in a thin white cottony web (Ferris, 1950).

Insecticidal control is similar to that for preceding mealybugs—one or more sprays of malathion or diazinon. See section on Control.

Monterey pine scale

The Monterey pine scale, *Physokermes insignicola* (Craw) (Homoptera: Coccidae), is one of two members of this family that may be found infesting Monterey pine in southern California. It heavily infests the young twig at the bases of the needle fascicles (figure 15). The shiny-surfaced, very dark, hemispherical female scale may be seen, but more often its surface is encrusted with honeydew and smut fungus. Such heavy amounts of sap sucking have killed the twigs (Burke, 1932). The male spends its immature instars on the pine needles, and like most other male scale insects has a pair of wings, a pair of long anal filaments of white wax, and a reddish-brown body. Egg-laying occurs in mid-April and hatching is shortly thereafter (Burke, 1937). In our experience this scale is not nearly as common in southern California as the next species, nor is it as common here as we have seen it in the San Francisco Bay region. See the next species for discussion of control measures.

Monterey pine scale. Fig. 15. Numerous adults clumped on twigs. 1.9×.



Irregular pine scale. Fig. 16. Left: Adult females on twig of Monterey pine. 5.1×. Fig. 17 Right: Male cocoons on needles of Monterey pine. 6.2×.

Irregular pine scale

The most common and injurious coccid scale on pines in southern California is the irregular pine scale, *Toumeyella pinicola* Ferris (Homoptera: Coccidae). The females are found on the twigs at the base of the needle fascicles (figure 16), and the males are in cocoons on the needles (figure 17). This insect is a copious sap sucker. Large colonies are usually found on small branchlets, often two or three deep. They are usually covered with honeydew and sooty mold, and numerous ants are crawling about. The needles on such heavily infested branches are more yellowish than normal and many needles may be killed. There is little question that the pine tree is weakened by these attacks. We have observed the scale in southern California most commonly on Monterey pine in coastal areas. It may infest other pines.

The adult female scale (figure 16) is about 5 to 6 mm long, quite hemispherical, rather turtle-shaped, and with the derm roughened. It is yellowish-white, with much gray and brown showing, and even some tints of pink; it appears like a small pebble of marble. The male is similar to other coccoid males. The male cocoon on the needles (figure 17) is somewhat distinctive in being elongate oval, rather flattened, and with a raised central ridge extending from one end to the other. It is about 1.8 mm long and is made of smooth, shining, semi-transparent wax.

Hatching of the crawlers occurs commonly in this area in February and

March and hatching may extend through May. There is only a single generation per year.

Insecticidal control is most effective when the crawlers are hatching. According to Koehler *et al.* (1965) thorough-coverage sprays of carbaryl (Sevin) or malathion are effective; two sprays applied two to three weeks apart are necessary. See section on Control.

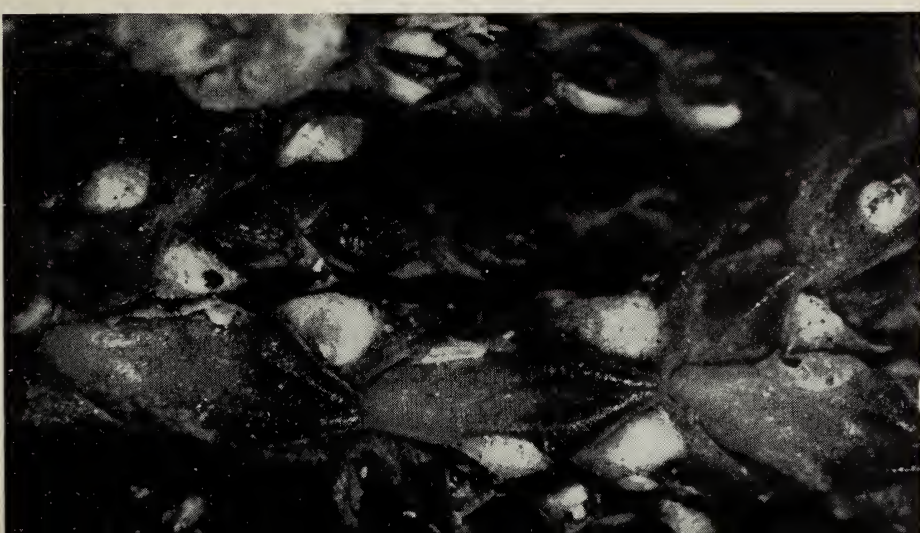
Juniper scale

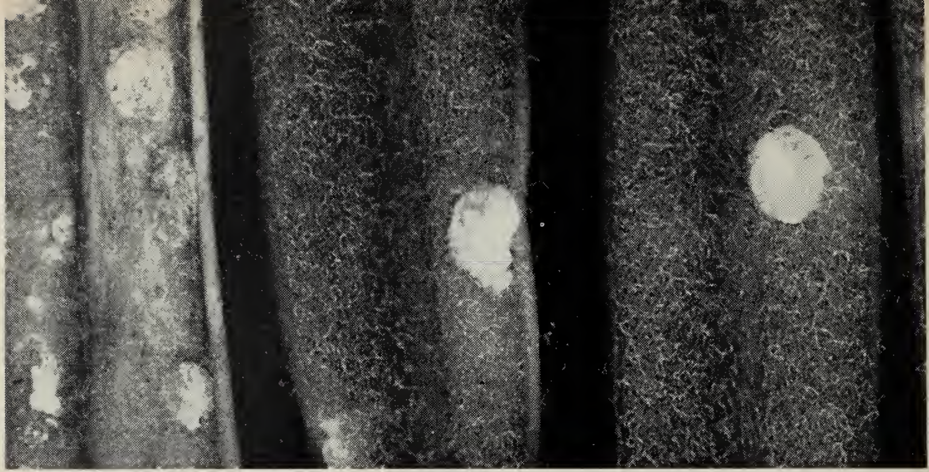
This is one of several armored (diaspid) scale insects infesting coniferous plants in southern California. The armored scales have a waxen, paper-like layer (the armor) over and separate from the body of the scale. This shell-like covering also includes the cast skins (exuviae) which form the "nipple." The juniper scale, *Carulaspis visci* (Schrank) (Homoptera: Diaspididae) (= *Diaspis carueli* Targ.), commonly and seriously infests cupressaceous plants (figure 18) including the junipers, cypresses, cedar, and arborvitae. This armored scale evidently has a great reproductive potential as it settles in very large numbers on the leaves, twigs, limbs, and cones of the host plants. Its sap sucking has caused a weakening of the plants in southern California but it is not as destructive here as in some areas of the world where it has killed long stretches of hedges. None of the armored scales secrete honeydew, as do the preceding scales and many other sucking insects.

The armor of the female juniper scale (figure 18) is rather circular, sometimes slightly oblong, and quite convex in sideview. It is whitish-gray. The nipple or exuviae is slightly off-center, and is dull yellow. The female body is brown. The armor of the male is smaller, elongate, and with three ridges along the top. It, too, is whitish-gray, with the yellowish exuviae at one end of the armor. In southern California, the yellowish eggs are noticed beneath the female armor in March and April. The minute yellow crawlers hatch during this period, crawl from beneath the female, and migrate to a suitable, tender place on the plant to settle down and feed. Once settled, the scale remains attached by its mouthparts. There is at least one generation annually and very likely several are produced.

Insecticidal sprays will be most effective if applied when the crawlers are hatching and migrating. Two thorough-coverage sprays of malathion or diazinon, applied 10 days to two weeks apart, will be necessary. See section on Control.

Juniper scale. Fig. 18. Adult females and males, most of them partially under the leaflets of this juniper twig. 13.9×.





Cycad scale. Fig. 19. Whitish scales on undersides of several leaflets. 6.4×.

Cycad scale

The cycad scale, *Furchadiaspis zamiae* (Morgan) (Homoptera: Diaspididae), is frequently found infesting the so-called "sago palm" (figure 19). The scale is almost always found on the hairy undersides of the leaflets. Visible from both the top and underside of the dark green leaflets is a pronounced chlorosis, or yellowing, in the area of the scales, which on a heavily infested plant detracts considerably from its ornamental value. A heavy infestation very likely impedes the growth, but on such a slow-growing plant this is difficult to detect. Most nurserymen and other plantsmen want the cycad freed of this pest.

The slightly convex armor of the female scale is almost round in outline, about 2 mm in diameter, and whitish or yellowish-white. The yellow exuviae or nipple is usually near the edge. There is a well-developed ventral armor, beneath the soft, yellowish insect body and the leaf. According to Ferris (1938) the male is unknown.

Thorough-coverage sprays of malathion or diazinon are effective against the cycad scale, and are safe on the sago palm. See section on Control.

Black araucaria scale. Fig. 20. Scales on needles of coast redwood; note that armor falsely appears transparent (see text). Soft, reddish body is exposed at left. 15.4×.

Black araucaria scale

The black araucaria scale, *Lindingaspis rossi* (Maskell) (Homoptera: Diaspididae), heavily infests *Araucaria* species and also may be found in great numbers on the coast redwood (figure 20). Heavily infested and chlorotic leaves or needles do not grow as vigorously as those uninfested, and insecticidal control is frequently warranted. We have found this insect throughout southern California wherever these host plants are grown. Both Ferris (1938) and Essig (1926) list many other hosts of this insect, mostly as recorded in other countries.

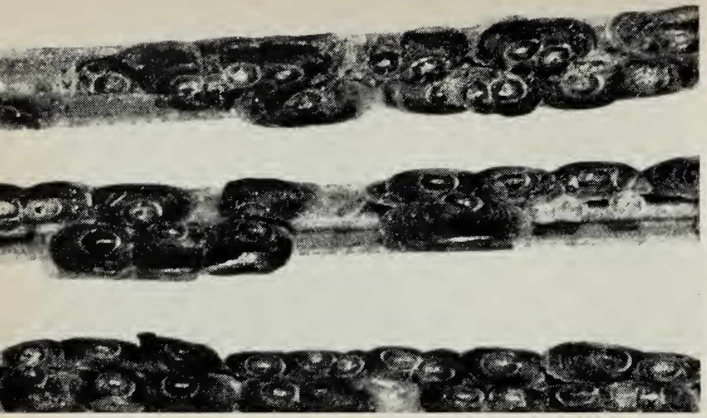
The female armor is about 2 mm in diameter and is generally round, as on the wider araucaria leaf, but may be somewhat oval in adapting to the more narrow redwood needle. The color varies from light chocolate brown to dark brown, with the nearly central nipple or exuviae being somewhat darker. As on other diaspid scales there may be a small point of white, cottony wax—the "white cap"—at the peak of the nipple. In heavy, closely packed infestations the nipple may be almost marginal. The armor is relatively flat. In figure 20 the strip of white wax spots on the redwood needle appears to be visible through the armor; that is, the armor gives the illusion of being transparent, but really is opaque. Evidently, as the armor is being secreted by the wax pores on the tail end of the insect's body, this wax is placed at the edge of the armor and beneath the external wax layer produced by the leaf. A relatively thick white ventral armor is laid down between the insect body and the leaf, except for a small area surrounding the hair-like mouthparts issuing near the center of the body. When the armor is lifted the body comes with it, being retained by the ventral armor. A white spot remains on the leaf. The scale body (see at middle left in figure 20) is reddish-pink. The armor of the male is smaller and oval.

Some infestations have a large percentage of the scales with parasitic wasp emergence holes in them (see upper left in figure 20). If parasite control is inadequate, or if no parasites are present, thorough-coverage sprays of malathion or diazinon applied during crawler hatch in the spring will be effective. Two sprays two or three weeks apart may be necessary. Because mature araucaria or redwood may be huge trees, a suitable large-capacity sprayer and spray guns will be necessary. See the section on Control.

Black pine leaf scale

The black pine leaf scale, *Nuculaspis californica* (Coleman) (= *Aspidiotus californicus* Coleman, *A. pini* Comstock) (Homoptera: Diaspididae), is the most destructive of the armored scales affecting pines in southern California. This scale insect is also called the "hemlock scale" in much of the readily available literature (Essig, 1926; Doane *et al.*, 1936). We have observed it commonly and seriously infesting several of the yellow pine species in this area, but Ferris (1938) lists it also on white pine and Douglas fir, and Doane *et al.* note it on hemlock as well. It is one of the commonest scales on *Pinus ponderosa* needles in the resort and summer cabin areas of southern California mountains. As seen in figure 21, the scales thickly cover the needles, and soon these needles become yellow and die. The twigs and smaller limbs may also be killed, and it is common to see young seedling trees killed by infestations of this scale insect (Doane *et al.*).

The scale or armor of the female (figure 21) is about 2 mm long, and on the restricted needle surface tends to be elongate oval. One side is more flattened and this usually coincides with the straight edge of the needle. The armor is fairly convex with the exuviae near the middle, or frequently nearer the flat side. The female armor is dark gray or



Black pine leaf scale. Fig. 21. Typically heavy infestations on needles of western yellow pine. 9.5×.

black. The male armor is similar to that of the female, but is smaller and darker. The insect bodies are bright yellow, and compared to the soft, flexible bodies of most diaspid scales, the derm of this scale is sclerotized or hardened. According to Keen (1952) crawler hatch is very early in the spring, and there may be from one to three generations in a year.

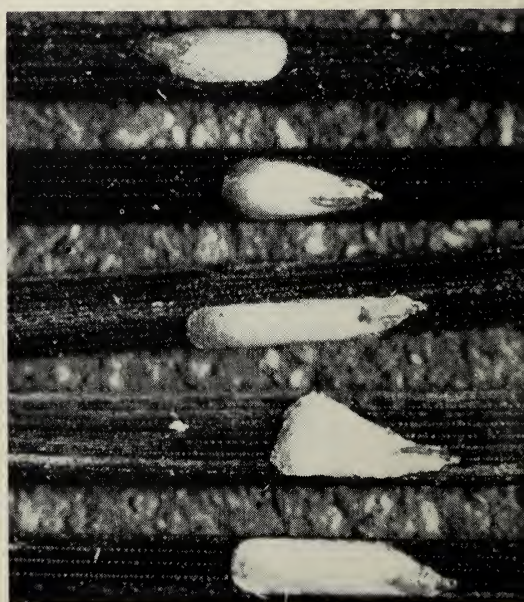
On trees not too tall to be sprayed, malathion or diazinon thorough-coverage sprays are effective in the spring.

White pine needle scale

This armored scale insect, *Phenacaspis pinifoliae* (Fitch) (= *Chionaspis*) (Homoptera: Diaspididae), is perhaps the most commonly found insect of its type on pine in southern California. It frequently is found on pines along roadsides or other dusty locations, in such large numbers that the plant appears as though whitewashed. Usually many scales cover each needle. In some locations small trees so infested have been killed, and on larger trees needles and smaller twigs have died. The insect attacks all types of pines found here: native and imported, yellow and white. Others (Essig, 1926; Doane *et al.*, 1936) have recorded infestations on Douglas fir and cedar, as well as spruce and California nutmeg in other locations. It may be found in situations varying from formal landscaped areas to pines in the wilderness. Large numbers of both male and female scales are present.

The armor of the female scale (figure 22) is conspicuously white on the dark needles. It is about 2.7 mm long and the shape varies with the space available

White pine needle scale. Fig. 22. The variable shape of the white armor is apparent on these scales infesting needles of Monterey pine. 9.5×.



for it to occupy. On long, narrow, flat areas of the needle the armor will be long, narrow and parallel-sided, whereas on the broader areas the armor may be acutely triangular. Two light yellowish, oval exuviae are at the pointed or oldest ends of the armor. Figure 23 shows armor lifted with a pin, exposing the elongated, scallop-edged, dark orange-colored female. In this figure the tail-end (pygidium) is to the left, and careful inspection will reveal minute strands of whitish wax issuing from the many wax glands present there. By moving the tail-end from side to side the insect forms the wax strands into the armor. Sometimes when the female armor is lifted, the reddish eggs (figure 24) may be seen, with the female body appearing in a collapsed state. The armor of the male scale is less than half as long as the female armor, and is also white and parallel-sided, but it has three ridges running lengthwise of the top of the armor (tricarinate).

Cumming, in her very detailed study (1953), indicates that there is only a single annual generation in Canada, although two generations have been recorded in the United States. Burke (1932) notes that the scale is said to have two generations annually, but this was questionable for California conditions (in the Sierra Nevada Range, presumably). In southern California we have observed eggs and hatching crawlers under the female armor as early as late March, and crawlers and new settlers have been commonly observed during May and June.

Thourough-coverage sprays of malathion or diazinon, applied in the spring at the time of crawler hatch, will offer adequate control. A second spray three or four weeks later may be necessary. See section on Control.

Fig. 23. Top: The white wax armor is lifted to expose the yellowish female body of the pine needle scale; wax-secreting tail end is to the left. 25.4×. Fig. 24. Bottom: The armor of lower specimen is lifted to show the reddish eggs; female is to the right in that armor. 12.7×.

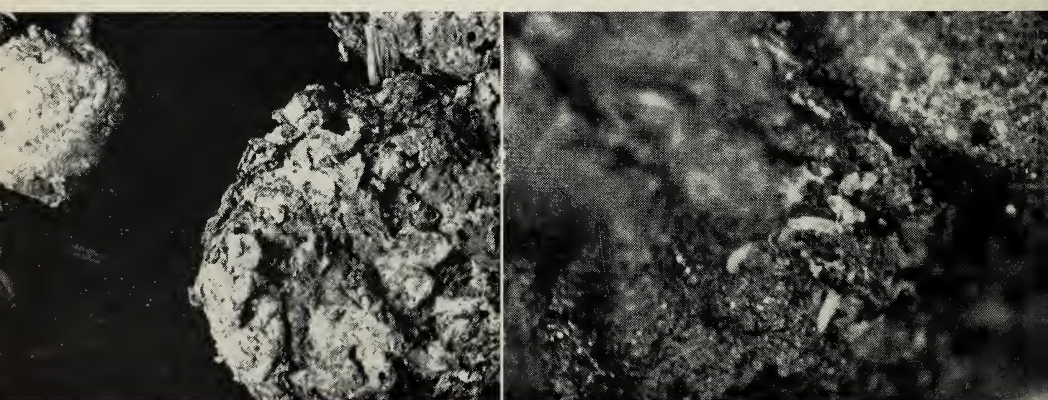
A redwood gall mite

In April, 1942, H. H. Keifer, the Eriophyid mite specialist of the California State Department of Agriculture, identified mites associated with galls on coast redwood (figures 25 and 26) as *Trisetacus pini* (Nalepa) (Acarina: Eriophyidae) (= *Phytoptus*, = *Eriophyes*). However, Keifer (1952) listed *pini* Nalepa as affecting only *Pinus* species, generally as an external feeder on the needles, but also mentioned the formation of twig enlargements on *Pinus sylvestris* in Europe. Just preceding *pini* Nalepa, Keifer (1952) lists *Trisetacus cupressi* Keifer (originally described in 1944), which forms small galls on the tips of cypress twigs, and also feeds on juniper. With neither of these eriophyid mites does he mention coast redwood, nor does he mention the genus *Sequoia* with any other mite in this rather complete and detailed bulletin of California eriophyid mites. Therefore, the reader must consider our use of *Trisetacus pini* as provisional until this matter is settled.

If the naming of this eriophyid is somewhat obscure, the galls it causes to form are not. They are quite conspicuous, in some situations appearing like bark-covered, misshapen balls covering the trunk from top to bottom. In the same situations other galls—the more tender ones usually containing the living mites—may be found on the young twigs and branches (figure 25). The owner of the redwood tree naturally is concerned about the effect of the galls on the tree, but so far as we have been able to observe there is very little adverse effect. The galls evidently do not seriously involve the vascular tubes of the tree, an involvement which conceivably could restrict the flow of fluids and result in death of tissue. Furthermore, we have observed such galled redwoods in only a few locations in southern California. These galls sometimes have an appearance similar to redwood burls which are so prized by wood workers. With the gall there is a woody, nonliving core covered with tender, living tissue, which in turn is covered with thin, peeling bark. Beneath these bits of bark and on the tender tissues the mites and eggs (figure 26) can be found. Other galls may not have any living tissue or mites, that is, they appear completely dead. In some of these dead galls lepidopterous larvae have been found, and from one infested batch of galls we were able to rear adults of *Symmoca signatella* (Gelechiidae), which we have noticed scavenging on a variety of ornamental plants.

For anatomical drawings and a systematic treatment of the eriophyid mites, see Keifer (1952). Eriophyids are very small, elongate mites having four legs at their front end. This redwood gall mite (figure 26) is about 0.1 mm long, and its egg is about 0.03 mm long. They are probably invisible to the naked eye of most people, and are difficult to see even with most hand lenses. The mite belongs to that group of the Eriophyidae that are bud and gall mites, and that are wormlike, soft-bodied and with the beak exposed above. It has three shield setae and subdorsal abdominal setae that can be seen under a compound microscope on specimens prepared on microscope slides.

Diazinon, chlorobenzilate, or malathion have given effective control on a variety of other eriophyid mites, thus it is reasonable to expect that these materials would control this mite also. In applying a thorough-coverage, high-pressure spray to the tree, special attention should be given to getting the spray beneath the bark plates of the galls on the trunk and limbs. See section on Control.



A redwood gall mite. Fig. 25. Left: Galls, one old (right) and one newly formed (left), on twigs of coast redwood. 1.3×. Fig. 26. Right: Eggs and adults (the elongate forms) on the tender tissue of newly formed redwood twig gall. 77×.

LEAF-CONSUMING INSECTS

Cypress tip miner

Argyresthia cupressella Walsingham, the cypress tip miner (Lepidoptera: Hyponomeutidae), is one of the common insects affecting cypress-like plants. The larvae typically mine the minute terminal twigs and leaves of cypresses, junipers, and arborvitae, which causes the death of these tips. In heavy infestations, such browned tips (figure 27) may cover the whole plant so that from a distance it may appear dead. It is doubtful if even heavy infestations will actually kill the plant, but the ornamental value of the plant is reduced considerably. The net effect of repeated heavy infestations on these relatively slow-growing plants is to eliminate any apparent growth of the plants. For these reasons, even under light infestations, most people consider insecticidal control measures desirable. We have observed the cypress tip miner or its damage many times in southern Califorina areas under coastal influence; but it also may be found elsewhere in any area where the host plants will grow. The readily available literature (Burke, 1932; Doane *et al.*, 1936: Keen, 1952) notes two closely related species that may occur with the cypress tip miner and do similar damage: *Argyresthia trifasciae* Braun and *A. franciscella* Busck. For an excellent discussion of the bionomics of another closely related species, the Monterey pine needle miner, *A. pilatella* Braun, see Jessen (1964).

According to Burke (1932) the eggs of the cypress tip miner are oblong-oval and are laid singly in the crevices between the leaf scales. The larva, if like *Argyresthia pilatella* (see Jessen, 1964), probably has a total of 6 instars. The earlier larval instars are yellowish-green, whereas the last instar (figures 29 and 30) is reddish-pink, with a black head and brownish pronotal shield, and 5 to 6 mm long. The abdominal prolegs are relatively slender with the uniordinal crochets (minute hooks) in almost a complete circle, except on the anal prolegs where they are in a band. Abdominal setae IV and V (Forbes, 1923) (or L2 and L1, MacKay, 1959) are distant from each other. The larva spends its life mining the relatively thick leaves and the small tender stems of its cupressaceous host plants. As it gets older it mines into somewhat larger and more hardened twigs, and at maturity chews an exit hole in the twig (figure 29). It crawls on the surface of the twigs and soon spins an irregular, whitish, paper-like cocoon (figure 28) between the stems. In the cocoon it transforms to the brownish-black pupa with a greenish abdomen. The pupa (figure 31) is about 3 mm long. About two weeks are spent in the pupal stage,

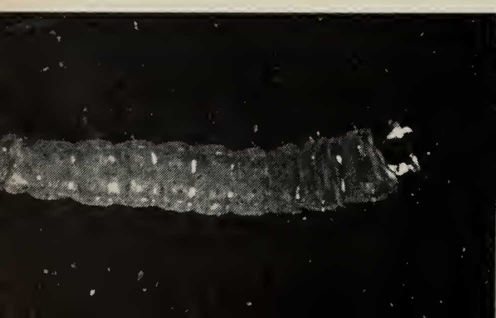
Cypress tip miner. Fig. 27. The lighter foliage at the tips of these arborvitae branchlets is dead as a result of twig mining.

Fig. 28. Left: The pupal cocoon is spun between the leaflets. 11.3×. Fig. 29. Right: To pupate the miner leaves its tunnel in the small twig. 12.7×.

and as adult emergence approaches, the pupa pierces the cocoon head-first. The pupal cuticle splits on the back of the thorax and the adult emerges. In southern Califorina most moths emerge during April, extending into May, but some appear in early March. The adult moth (figure 32) has a wing spread of 7 to 9 mm, and is generally covered with pale golden-yellow scales, and a pattern of spots of golden-brown scales. There is a minute black spot, composed of a few black scales, at the tip of each forewing. The hind wing is typical of the micro-Lepidoptera—dagger-shaped and with a wide fringe of hairs on the hind margin; the hind wing is pale gray. The head is tufted with white scales, and the filiform antennae are composed of segments with both brown and whitish scales, so that they appear ringed. The right specimen in figure 32 is in a typical resting posture. There is only one generation per year.

Thorough-coverage sprays of DDT in late March or early April have given good control. Because the mature larva comes out of the mine to pupate, the adult is external to the plant, and the pupal stage is relatively short, it is logical to use a long-lasting residual insecticide, such as DDT. See section on Control.

Fig. 30. Left: The miner larva is reddish, with a black head and prothoracic shield, and is devoid of conspicuous hairs. 12.7×. Fig. 31. Right: The cocoon is opened to show the blackish pupa with a greenish-brown abdomen. 11.0×.



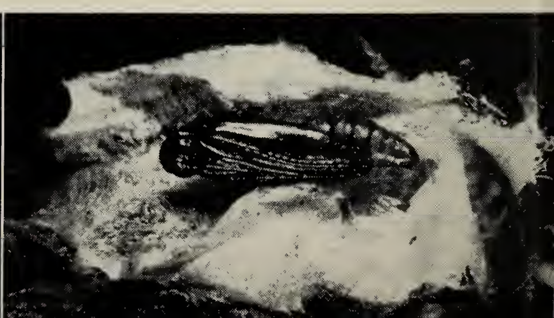


Fig. 32. Pinned cypress tip miner adults; specimen at right shows appearance at rest. 11.6×.

Cypress webworm

This is the first of two insects in southern California that has been called "cypress webber." It is *Herculia phoezalis* Dyar (Lepidoptera: Pyralidae); the other, *Epinotia subviridis*, is discussed next. *Herculia phoezalis* is found frequently in southern California, and seems to be particularly fond of cypress foliage. However, the larvae have also been found on arborvitae, catalpa, cedar, cotoneaster, hydrangea, olive, orange, and pepper tree. They feed on the foliage of cypress and tie the foliage and branchlets together with silk. This causes the tree to have a ribbed or clumped appearance (figure 33). If a clumped and tied branchlet is cut out of the tree (figure 34), it will be found that much of the webbing and dead and dying foliage—cut from near the tips—is down around the larger twigs, away from the tips. If this "nest" is pulled apart, considerable webbing is found, much of which is in the form of flimsy tunnels, and in these as many as a dozen dark larvae may be found (figure 35) living somewhat gregariously. The

Cypress webworm. Fig. 33. A cypress with dead, webbed and clumped branchlets.

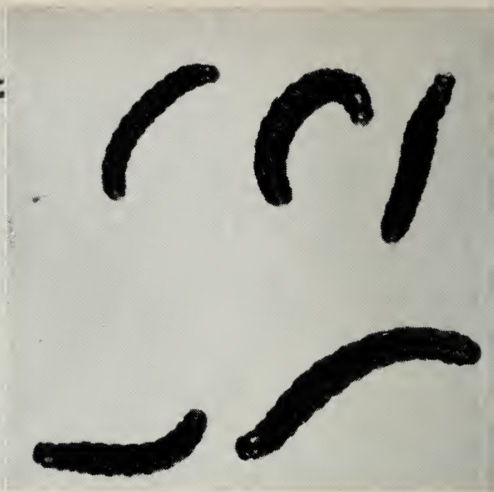


Fig. 34. Left: The clumped, webbed and dead appearance is more apparent when the branchlets are separated. Meandering through these "nests" are loosely woven tunnels. Fig. 35. Right: In the loosely woven silken tunnels are these black webber larvae; they feed on bits of the living and dead leaves. 2.2×.

nests may persist for several years after the larvae have gone. Thus much foliage is lost on a heavily infested cypress, growth is retarded, and this brown clumping is unattractive. In such situations, most cypress owners want the insect controlled. We have found this insect in many southern California locations, most frequently in areas under coastal influence, but also elsewhere—wherever the host plants are grown.

We have not observed the eggs of this cypress webworm, but very probably they are similar to those of other pyralids (see Essig, 1926), being laid on the foliage singly or in small groups, sometimes shingle-like, and being oval, flattened, slightly reticulated, and light colored. The mature larva (figure 35) is about 18 mm long, with a brownish-black head and prothoracic shield. The body integument is uniformly shiny black, somewhat wrinkled and naked except for the inconspicuous setae in positions typical of the pyralids. A whitish silken cocoon (figure 36) is spun in the debris nest, incorporating fecal pellets and chewed leaf bits on the outside. The pupa is about 10 mm long and shining brownish tan. The wingspread of the adult (figure 37) varies from 17 to 25 mm. The forewings are dark brown with two indefinite transverse, sinuous white lines. The first line is at one-third of the distance from the wing base and the other at two-thirds, the latter having its origin in a triangular, white costal spot. The first line is bordered on the outside and the second on the inside with darker brown scales. These wavy lines are apparently a variable character, with little more than the triangular white costal spot remaining on some specimens. The fringe scales of the forewing are

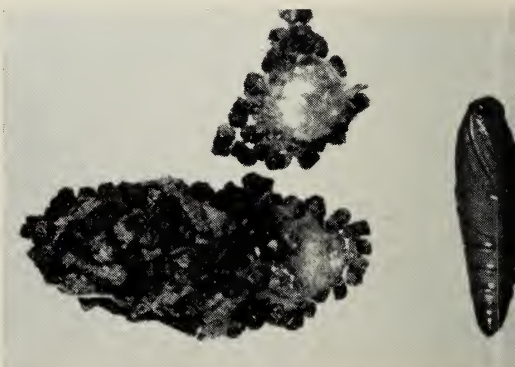


Fig. 36. Also in the nests can be found the silken webworm cocoons which are covered in frass; the pupa is light brown. 3.2×.

Fig. 37. Pinned webworm adults; right specimen represents appearance at rest. 4.6×.

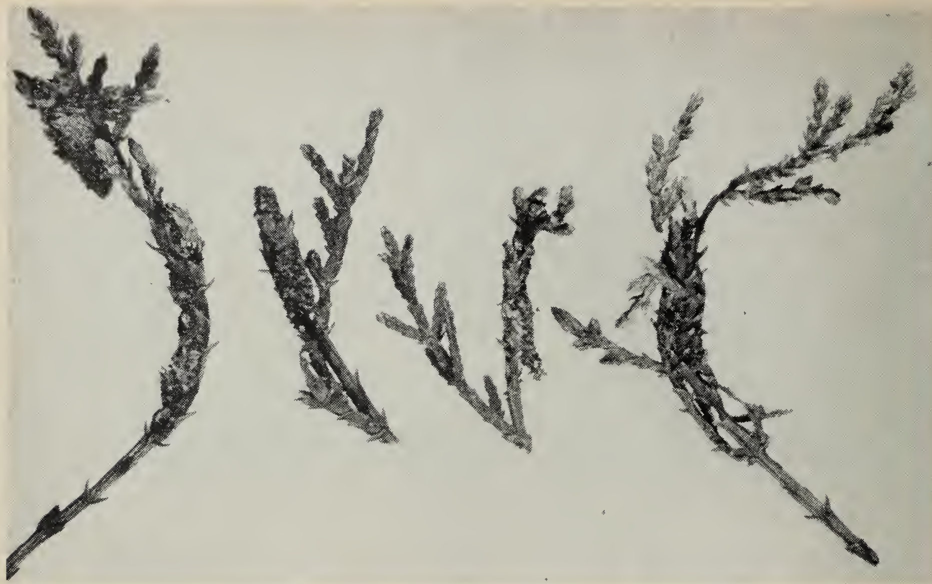
variously banded with white and brown. The hind wing has similar dark brown scales as the forewing but, being fewer in number, the wing appears lighter. A faint white line curves outward from three-fourths of the way along the costa to the cubital region. The fringe scales are similar to those of the forewing, and are perhaps more clearly marked. In common with other pyralidoid moths, the hind wing, when cleared of scales, shows the combined subcostal-first radial vein further combined with the radial sector vein for a short distance beyond the discal cell. The right specimen (figure 37) shows the appearance at rest.

The cypress webworm produces a single generation per year. Emergence of adults from the cocoons occurs from May into July, with a peak usually in June. Emergence of pyralid moths from the pupal integument occurs within the cocoon, according to Imms (1960). (Contrast this with another commonly found cypress webbing insect—an olethreutid moth—in figure 40.) The larvae continue to feed throughout our relatively mild winter. The pupal stage takes about three weeks.

Thorough-coverage sprays of DDT in March or April for the larvae or in mid-May for the emerging adults, will give control of the cypress webworm. Sufficient pressure and volume of spray to penetrate into the webbed nests of debris among the larger branchlets are desirable not only for control of the insects but also to rid the tree of these unsightly masses. See section on Control.

Cypress leaf tier

Like the cypress webworm, the cypress leaf tier, *Epinotia subviridis* Heinrich (Lepidoptera: Olethreutidae), has also been called "cypress webber" (Burke, 1932, 1936; Herrick, 1935; Schuh and Mote, 1948; and Keen, 1952). It seems appropriate that these two silk-spinning, cypress-infesting insects should have more definitive common names assigned to them. The larva of *Epinotia subviridis* gnaws into the tips of the foliage and this usually results in the death of the part beyond, or distal to, the injury, thus making the tip brown. As the larva moves about, it spins some webbing and the larval (figure 38) and pupal cocoons; this webbing frequently ties together the dead and living tips. The webbing may



Cypress leaf tier. Fig. 38. Small cypress twigs with silken cocoon-like tunnels incorporating frass and dead leaf bits on the surface. 1.7×.

also incorporate fecal pellets and bits of dead plants parts. Such injury causes the plant to appear as if it had been scorched by fire, especially in the spring when infestations are heavy. The larva may also appear boring in cones of cypresses. In southern California this insect is most commonly found on cypress, although arborvitae, cedar, false cypresses, and juniper have also been injured. It occurs in Pacific coastal areas from the Mexican border up into Canada.

The translucent white, disk-like eggs are laid singly on the scale-like leaves of the cypress according to Burke (1932). The mature larva (figure 39) is approximately 10 mm long, and is blackish-pink with five dark seta-bearing tubercles on each segment. The head is reddish-brown with the labrum and other mouth parts black; the pronotal shield is light brown with a black yoke posteriorly. The thoracic legs are black. The crochets on the abdominal prolegs are biordinal and in a circle. The larvae are usually found in tubular silk-lined cocoons (figure 38 and 39), which incorporate frass and chewed plant parts externally, and are attached to the twig terminal. Both ends of the cocoon are open and the larva may protrude from either end to feed. Nearing pupation, the larva seals the ends of the cocoon with silk and pupates in it. The pupa (figure 40) is brownish-pink and about 8 mm long. When adult emergence is about to occur the pupa, by

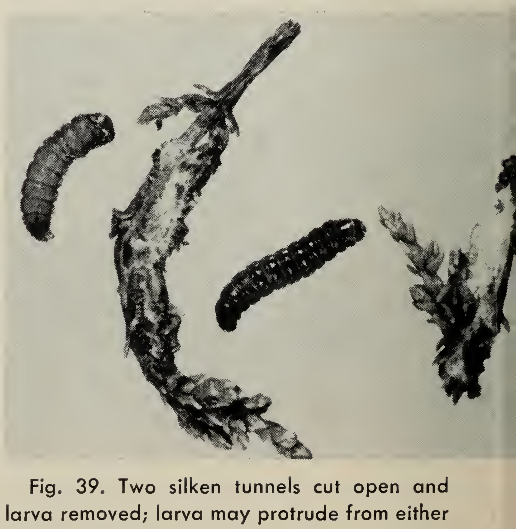


Fig. 39. Two silken tunnels cut open and larva removed; larva may protrude from either open end and feed on cypress leaflets. 2.8×.

Fig. 40. Pupal skin from closed silken tunnel (covered with frass) and newly emerged adult. 6.5×.

vigorous wriggling, pierces the end of the cocoon, and thus protruding, the pupal integument splits and the adult emerges. The adult wings are completely expanded at emergence; its appearance at rest is shown in figure 40. Wingspan of the spread adult (figure 41) may be from 16 to 20 mm. First impression of the spread forewings is alternating light and dark rectangular areas, in a checkerboard effect. Dark gray scales uniformly cover the darker areas, which are bordered by broad black lines, and the latter are bordered by narrow brownish-orange lines. The lighter areas of the forewing are an uneven mixture of dark gray, creamish-white and brownish-orange scales. Specimens in figure 41 illustrate the possible variation in depth of wing color. Both of these specimens are paratypes at the U. S. National Museum, the lower from California and photographed 60 years after it was collected, and the upper from British Columbia 51 years after collection. The living adult in figure 40 was newly emerged at Pasadena, California, when photographed.

Adults have been noticed from late March into September, and in most numbers during April to June. There are possibly two overlapping broods per year. The pupal stage requires three to four weeks in the spring. There is some evidence that the first instar larva bores in the small twig and tip, but all of the later larval instars are spent as external feeders on the foliage. Tubular cocoons are constructed and larval feeding occurs from these. The larva may leave the cocoon to feed, and it may abandon several cocoons

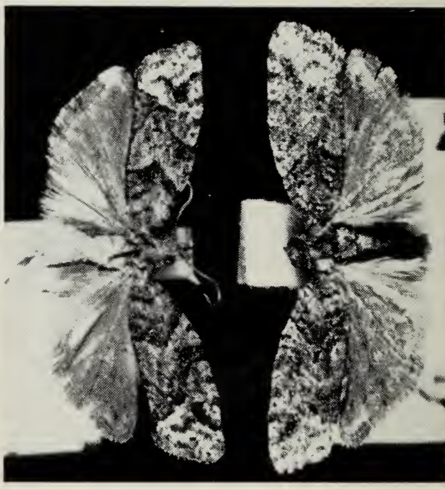
Fig. 41. Pinned and spread leaf tier adults; these are paratypes. 3.0×.

during its movement to newer and fresher tips. Most of the larval feeding is done in the early spring, and a browning of the foliage is mostly reported in late spring.

Thorough-coverage sprays of DDT during March and April, when the damage is becoming quite noticeable, will give good control of the larvae. Such sprays about one month later will control the adults although most people will prefer to control the damaging larvae. Carbaryl (Sevin) gives excellent control of the larvae. See section on Control.

Epinotia hopkinsana var. *cupressi* Heinrich

This insect (figure 42) is a close relative of the cypress leaf tier. It also affects cypresses and its habits are similar to *E. subviridis.* The specimens in figure 42 show a faint checkerboard pattern, much more indistinct than on *E. subviridis. E. hopkinsana* is much less common in southern California than *E. subviridis;* according to Burke (1932, 1936) *E. hopkinsana* is relatively more common in the San Francisco Bay region. Presumably the same control measures would be effective against this species.



Epinotia hopkinsana cupressi. Fig. 42. A moth whose larvae attack Monterey cypress and arborvitae; right specimen is a paratype. 3.2×.

Orange tortrix

The very common and widespread orange tortrix, *Argyrotaenia citrana* (Fernald) (Lepidoptera: Tortricidae), has been found occasionally infesting the Monterey pine in southern California. The young larva feeds at the base of the needle fascicles of the terminal and lateral buds (Lange, 1936; Keen, 1952), and thus may be confused with the Monterey pine tip moth (see page 46), and the Monterey pine bud moth (see page 39). Lange (1936) and Burke (1937) note that orange tortrix larvae web the needles together to form small nests in which they feed, and cause the needles to die. Such nests of dead needles detract from the ornamental value of this widely planted pine. The orange tortrix is an omnivorous feeder and has been found on many other host plants (Basinger, 1938). Our few observations of this species on pine have been made in southern California areas under influence of the ocean.

Orange tortrix. Fig. 43. Live adult; this insect and its damage may be confused with the Monterey pine tip moth and the Monterey pine bud moth. 6.2×.

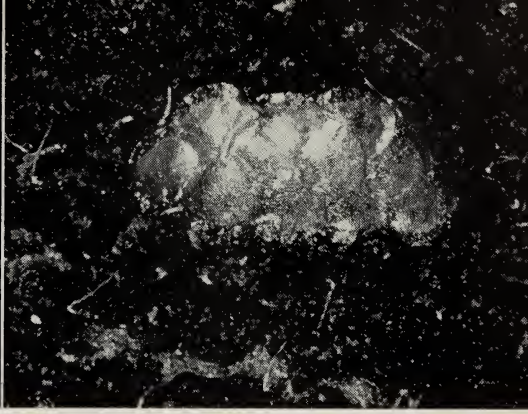


Fig. 44. Left: Live larva of the orange tortrix; this almost hairless larva appears much like the Monterey pine tip moth larva. 4×. Fig. 45. Right: A mass of eggs laid shingle-like; in contrast the Monterey pine tip moth lays eggs singly. 12.7×.

The eggs are laid on the needles or smooth areas of the growing tips, in overlapping, shingle-like masses (figure 45), and the individual egg is disk-like, about 1 mm in diameter, and reticulated. The mature larva (fifth or sixth instar) varies from 11 to 16 mm long (figure 44) and, when feeding on green needles, is whitish-green, with a darker line down the middle of the back. The head capsule, prothoracic shield and anal plate are translucent green to light brown. The setae project from whitish tubercles. Abdominal setae IV and V (Forbes, 1923; L2 and L1, MacKay, 1959) are adjacent, and ninth abdominal segment setae II (D2) are closer together across the top than those setae on preceding segments. Seta I of ninth abdominal segment is about the same distance from II and III. The dark brown pupa is in a slight amount of webbing in the dead leaf nest and is about 8 to 10 mm long. The pupa, like many related Lepidoptera, has two transverse rows of spines on the top of each abdominal segment. The adult (figure 43) is brownish or buff-colored, with a more-or-less regular dark brown stripe beginning about one-third out on the costal margin of the forewing and continuing obliquely toward the anal angle; a triangular dark spot is about two-thirds out on the costa. These dark marks vary in density from one specimen to another. The hind wing is silvery white with a similar fringe. At rest the adult varies from 9 to 12 mm long, and when the wings are spread the span averages about 16 mm. From figure 43 the outline of the moth can be seen to resemble an elongated bell, this characteristic being typical of members of the Tortricid family, which are commonly called the "bell moths."

For a complete discussion of the seasonal biology, and most other aspects of the orange tortrix, see Basinger (1938). He notes that inland two generations occur per year, the first completing its development from mid-February to mid-May, and the second from mid-May to mid-February. This insect prefers the cooler seasons of the year, and is almost in a state of aestivation in the hot summer and fall months. In cooler, coastal situations development is rather continuous, with considerable overlapping of broods.

Insecticidal control of the orange tortrix on pines and most other plants requires a thorough-coverage spray with considerable driving force to penetrate the nests (that is, adequate pressure and volume). DDD has given very good control for many years (Atkins, 1952), and carbaryl (Sevin) gives excellent control. Apply when larval injury is first noticed.

Magdalis species

These dark weevils (figure 46) are seen occasionally on the needles of yellow pines in the mountainous areas of southern California. From accounts in Doane *et al.* (1936), Essig (1926) and Keen (1952), it is probable that the specimen illustrated is *Magdalis lecontei* Horn (Coleoptera: Curculionidae), whose larvae are borers in the twigs of the yellow pines. The adults are said to feed slightly on the needles. Including the snout the weevils are about 9 mm long, and are black. Apparently very little more is known about these weevils. Controls listed for other leaf-consuming insects should be adequate for this insect. See section on Control.

***Magdalis* species.** Fig. 46. This weevil feeds on pine needles, whereas its larva bores in the twigs. 4.5×.

Rusty pine needle weevil

Although Burke (1937) calls *Scythropus ferrugineus* Casey (Coleoptera: Curculionidae) the "Monterey pine needle weevil," "rusty pine needle weevil" is a more appropriate common name. The beetle is rusty-red and affects pines in addition to Monterey pine. The damage caused by this weevil is distinctive (figure 47): the needle is chewed almost in half intermittently along its length, giving it a saw-like appearance. The needles die beyond the injured areas. Sometimes, but not usually, individual trees may assume an overall brownish hue because of this needle damage. Other beetles of this genus may also do similar damage to various pines in this area (Essig, 1926; Doane *et al.*, 1936). Although apparently all pines may be affected we have noticed this weevil only on the yellow pines in the mountainous areas of southern California.

Rusty pine needle weevil. Fig. 47. Typical feeding injury to pine needles by this weevil. 3.7×.

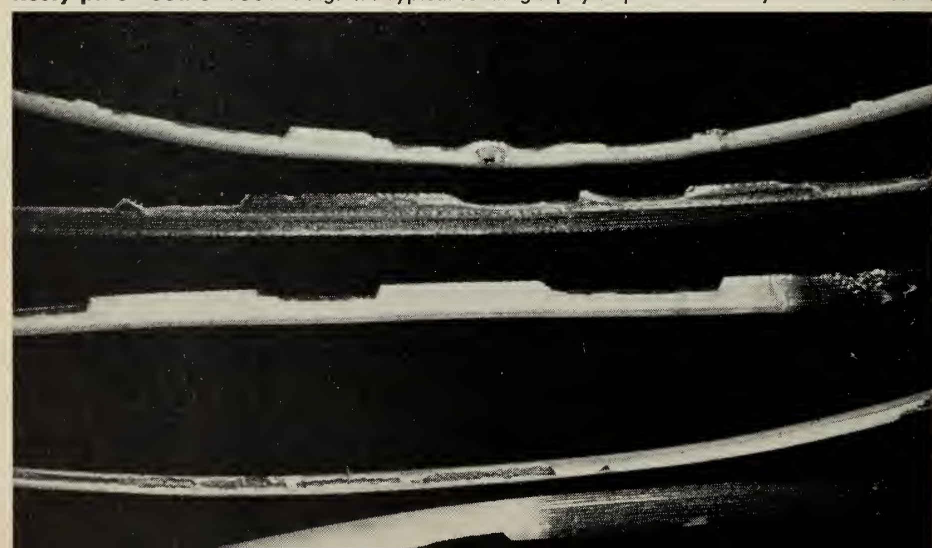


Fig. 48. Living adult of this broad-nosed weevil, on a needle it has been eating. 10.5×.

The adult (figure 48) ranges from 6 to 8 mm long. The integument is very dark brownish-black, but because of its almost complete coverage with shiny, cream-colored scales, the overall appearance is rusty red. This beetle is in that branch of the weevil family which has the short, broad snout, or extension of the head, and in which the mandibles have a small appendage on the anterior edge which soon breaks off, leaving a small oval scar. For this reason the group is often referred to as the "scarred snout beetles." According to Burke (1937) the legless, grub-like larvae live in the soil and possibly feed on the roots of the pines. This habitat is similar to that of other members of this branch of the weevils. We have noticed the adults feeding in southern California areas only in the spring, particularly in April.

A thorough-coverage spray of lindane or DDT applied early in the spring, is likely to give control where warranted.

Cypress sawfly

The cypress sawfly is *Susana cupressi* Rohwer and Middleton (Hymenoptera: Tenthredinidae). Although Burke (1932) called this an undescribed species of *Neodiprion* (Hymenoptera: Diprionidae), he was doubtless referring to *Susana cupressi* (see also Burke, 1933). *S. cupressi* was described originally, both genus and species, by Rohwer and Middleton (1932). Burke's calling it a Diprionid instead of a Tenthredinid (a closely related family of sawflies) is understandable, because most externally feeding sawflies on coniferous plants are Diprionids, and only rarely Tenthredinid species. The larvae of the two species are difficult to differentiate. In adults, the antennae of Tenthredinids (figure 50) are thread-like and have 10 segments or less, whereas those of Diprionids (figure 56) are saw-tooth-like or comb-like, and (in America) are composed of 13 or more segments (Borror and Delong, 1954). The genus, *Susana*, is named after the location where several of the type specimens were collected—the Santa Susana Pass area in northern Los Angeles County. The specimens shown in figure 50 were collected by Burke, in 1933 in Palo Alto, California, and were deposited in the U. S.

Cypress sawfly. Fig. 49. Larva adhering to plant in a manner typical of the externally feeding sawflies. 4×.

Fig. 50. Pinned sawfly adults; side view of male, top view of female. 4.7×.

National Museum with the type specimens.

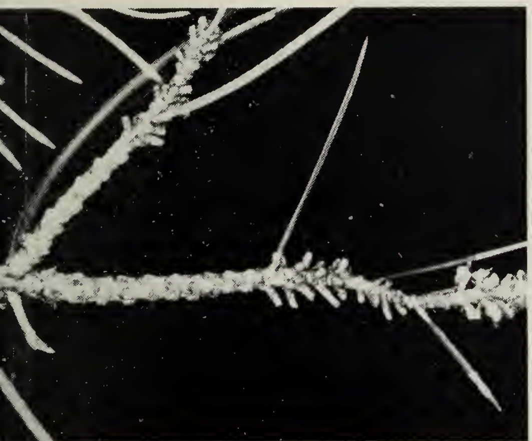
At times the larvae (figure 49) have been very serious defoliators of cypresses in southern California. All species of cypress have been attacked, as well as some species of juniper and arborvitae. Evidently the insect is found throughout southern California wherever these plants are grown. It has been reported many times in Los Angeles County, both in the city and at higher elevations.

The eggs are whitish, lima bean-shaped, about 1 mm in diameter, and are inserted in slits sawed in the young tender cypress tips and leaves. The larva near maturity (figure 49) on the foliage is about 16 to 20 mm long, grayish-green with longitudinal stripes of white spots, and has a wrinkled body surface. The head is light brown with a dark brown ocellus forming the eye spot. It has three pairs of thoracic legs which are segmented and black and white, and seven pairs of fleshy abdominal prolegs, which do not have the small hooks (crochets) on them, as do lepidopterous larvae. It is characteristic of the externally feeding sawfly larvae to curl their tail-end around the leaf or twig, as shown in figure 49. The last instar (probably sixth) larva drops to the ground and burrows into the debris and soil; this is also typical of mature sawfly larvae. In the soil an oval cell is hollowed out and a tough, brown, paper-like cocoon is spun around the larva late in the spring, usually late May or during June. The larva then lapses into a state of diapause, and remains so until early the next spring. Then pupation occurs and this stage probably requires about two weeks. The pupa is at first all white and then near emergence becomes pigmented like the adult; the pupal appendages are loose from the body, not being cemented to it like lepidopterous pupae. The adult (figure 50) emerges in the pupal cell and digs its way to the surface of the soil. The female (on the right) is about 8 mm long and the male (on the left) about 6 mm. The adult male is all black except for a prominent yellow band around the middle abdominal segments, and yellow on the femur of the legs. The wing veins are dark brown. The antenna is thread-like with relatively thick basal segments. The female is similar, but more robust, and has yellow marks on the prothorax, and thinner antennae.

The adults fly to the leaves after emerging from the soil. This is during February and through mid-March in southern California (apparently about a month earlier than in the San Francisco area). Mating and oviposition follow in short order. From oviposition to hatching requires a week or so (Burke, 1932). Development of the larvae is relatively rapid and by late April they are becoming conspicuous, and all during May they are very common and injurious. Then they drop to the soil and the overwintering pupal cell is formed. There is only the single generation per year.

Very good control of the larvae of this sawfly has been achieved with thorough-coverage sprays of DDT applied in early April. A similar spray applied earlier (mid-February) will kill the adults. See section on Control.

The type localities of the pinyon pine sawfly, *Zadiprion rohweri* (Middleton) (Hymenoptera: Diprionidae), are Swarthout Valley (near Wrightwood) in San Bernardino County, California (holotype) and Mesa Verde National Park in Colorado (paratype). Since its initial description (Middleton, 1931), it has been reported as a pest in many other places in the Great Basin Area of the western United States (U. S. Department of Agriculture 1960–1964), and in other locations along the north side of the San Gabriel Mountains (part of the southwestern boundary of the Great Basin Area). The specimens shown in figures 51 through 56 were collected by us in the New York Mountains, near the California-Nevada border in San Bernardino County. The single-leafed pinyon pine (*Pinus monophylla*) and the two-leafed pinyon pine (*P. edulis*) evidently are the only pines attacked, although in the laboratory the sawfly larvae feed readily on deodar cedar (*Cedrus deodara*), and have been raised to adults on this coniferous plant. Evidently on *Pinus edulis* this sawfly may be confused with *Neodiprion edulicolis* (U. S. Department of Agriculture 1965 *a*, *b*).



The single-leafed pinyon twig in figure 51 shows only the older needle bases remaining after feeding by the larger sawfly larvae. In contrast, the younger larvae (figure 53) feed also on the needles, but only on the tender tissue, leaving the harder, central, thread-like core. The larvae are gregarious, living in colonies (figures 52 and 53), so that a single limb may be completely denuded while the rest of the tree remains relatively free of injury. Many smaller trees, however, have been completely defoliated.

The eggs are inserted singly into slits sawed serially along the needles, usually

Pinyon pine sawfly. Fig. 51. Above: Pinyon pine twig showing most of needles cut off by older larvae. 1.1×. Fig. 52. Right: Typical gregarious larval colony on pinyon twig. 1.5×.

Fig. 53. Above: Colony of young pine sawfly larvae; note only tender outside needle tissue is consumed leaving harder center tissue. 4.9×. Fig. 54. Right: Very tough, waterproof cocoons, usually found in debris and soil beneath the pinyon pine. 5.1×.

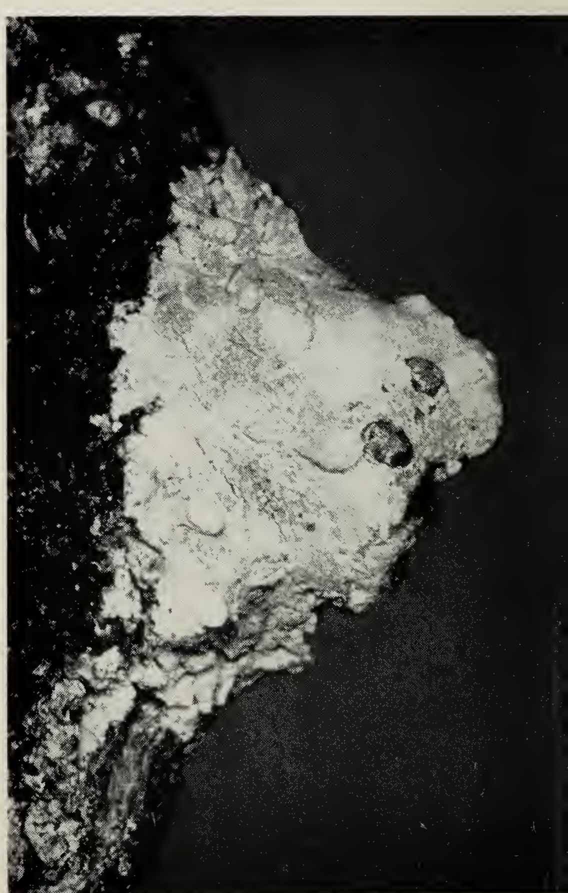
in those newer needles at the tip of the branch. This causes these needles to have a crusty brown appearance along the oviposition sites. On hatching, the young larvae (figure 53) crawl back to those needles away from the tip and feed in a gregarious clump. These young larvae are almost completely yellow, except for the black thoracic legs, and the light brown head. The mature larva (figure 52) appears naked, wrinkled, and is almost completely black except for the eight pairs of whitish, crochet-less prolegs, most of the whitish underside, and yellowish-white parts of the thoracic segments. The head capsule is reddish-brown with a black eye spot inside of which is a single ocellus. Some apparently mature larvae may appear lighter with little more than a black stripe down the middle of the back. The length of the mature larva varies from 18 to 23 mm. The larvae, like all externally feeding Diprionid sawflies, curl their tail-end around the needle. The diapausing, prepupal larva in its soil cocoon (figure 55) is all yellow, except for a row of black spots down the side; the head is slightly darker yellow. The cocoon (figure 54), enclosing the diapausing larva and the pupa, is brown and of a tough, paper-like material. It may be found in the soil or the needle debris around the base of the tree. The pupa has the appendages free from the body. It is light yellow and, nearing adult emergence, is yellowish-brown for the larger females, and almost black for the smaller males. Living adult females (figure 56) are uniformly shining yellowish-brown (only in dead specimens could we see a greenish tinge mentioned in the original description) except for the brownish-black compound eyes and ocelli, the black wing veins and brownish glassy, hyaline wing cells, the small inverted "V" over the middle ocellus, a brownish-black "V" converging back from the head and impressed in the mesonotum. At the point of this "V" is a smaller, blacker, and more deeply impressed "V" diverging widely backwards. The female antennae are slightly serrate (sawtoothed) and usually have 22 segments. Body length varies from 8.5 to 10 mm. The wings of the male are similar to those of the female. The body of the male is completely black, except for the legs, which are light yellow for the most part, and the light tan mouthparts. The most striking difference from the female is the male feather-like antenna, composed of 24 or 25 segments. The male body is about 6 mm long.

From reports of others (U. S. Depart-

Fig. 55. Above: Pine sawfly cocoons cut open to show overwintering and diapausing mature larvae, sometimes called prepupae. 5.1×. Fig. 56. Right: Dead adults; males are smaller, darker and with feathery antennae. 3.8×.

ment of Agriculture, 1960–1964) two generations per year can be inferred for the pinyon pine sawfly, the first brood of larvae from mid-March to mid-April and the second from mid-August to late October. For this type of sawfly, generally the larva completes its development in three to five weeks (Craighead, *et al.*, 1950). Our own developmental information on this species is very meager; it stems from a single collection of young and mature larvae in the New York Mountains in early September, 1959. Bringing these back to the laboratory (kept at about 72°F), and after the supply of pinyon foliage was gone, we found that the larvae readily fed on needles of *Cedrus deodara*. All larvae matured on this latter host plant and spun cocoons. Late in the following January they were still in the prepupal condition, shown in figure 55. (This was probably also their condition under field conditions, because overwintering of many Diprionid sawflies is as diapausing, prepupal larvae.) At that time part of the cocoons were placed at 40°F for two months, and from this batch females began emerging in late July, 1960, and males in late August and September. The batch of cocoons at a constant 72°F had produced only a very few adults. About this time the whole culture was destroyed.

We have never attempted insecticidal control of this sawfly, but it is probable that a thorough-coverage spray of DDT, applied when the larvae are first noticed, would give successful control.



Pitch moth. Fig. 57. Pitch mass on yellow pine limb, an indication of larval tunnelling in inner bark. 1.5×.

BORING INSECTS

Sequoia pitch moth

Occasionally on yellow pines there appears to be a rock stuck to the limb (figure 57). On chipping into the mass a glassy-clear, yellowish, hard concretion of pitch is exposed. The effects of the weather on the surface of the mass causes it to appear dull like the surface of a rock. Sometimes such masses are still forming and when the surface is pressed it breaks and moves like congealed syrup. On digging further into the pitch mass and into the cambium area of the wood the irregular, pitchy tunnels and sometimes the larva of the sequoia pitch moth, *Vespamima sequoiae* (Edwards) (Lepidoptera: Aegeriidae), are exposed. Besides the loss, and messiness of pitch exudation, larval tunnelling (Doane, *et al.*, 1936) can be extensive enough to cause weakening or death of limbs. The adult clear-wing moth is all black except for bright yellow bands on the abdomen, three such bands on the female and four on the male. According to Doane *et al.* (1936) the moths emerge from mid-June through July, and a single generation requires two years. Burke (1937) suggests scraping off the pitch mass and killing the larva, presumably in small infestations. If infestations are more extensive, thorough-coverage sprays of a long-residual insecticide (such as DDT or dieldrin), applied when the adults are flying, possibly would be effective.

Monterey pine bud moth

Monterey pine bud moth. Fig. 58. Pinned adults; specimen on the top is a paratype. 5.1×.

The Monterey pine bud moth, *Exoteleia burkei* Keifer (Lepidoptera: Gelechiidae), is one of two common insects likely to be found boring in Monterey pine buds or tips in southern California. The other is the Monterey pine tip moth (see page 46). Either of these two insects, or orange tortrix (see page 30), may be found boring in the needle fascicle as shown in figure 70. The adult moths of these various species (figures 43, 58 and 73) are quite distinctive, but the larvae are easily confused. The best way to identify the insect, therefore, is to rear the adults.

Larvae of the Monterey pine bud moth make small mines in the center of the new buds and developing tips, causing them to wither, die and become brown. In heavy infestations most of the shoots are killed, and the ornamental value of the tree is decreased. Injury differs from that of the Monterey pine tip moth (figures 68 and 69) in that the tip injured by the bud moth continues to grow for 6 or 7 inches before dying, whereas the tip moth larva (or larvae), being a larger insect, removes most of the inside of the developing tip causing the growth to stop abruptly and the tip to die. There seems to be some tendency for one tree to be very heavily infested with the bud moth while a neighboring tree will have only a light infestation. Finnegan (1965) noticed that the closely related *Exoteleia pinifoliella* tends to oviposit in branches from which it emerged, which concentrates damage on the infested tree. We have noticed this bud moth only on the Monterey pine, and distributed generally in the area where this host tree is grown.

The fully grown larva of the Monterey pine bud moth is about 5 to 6 mm long, and is brownish-yellow with a black head and brownish prothoracic shield and anal plate. Abdominal setae IV and V (Forbes, 1923) (or L2 and L1, MacKay, 1959) are near together. Ninth abdominal segment setae II (or D2) are as far apart across the top as those setae on the preceding segments. The brownish pupa is only slightly shorter than the mature larva. The adult moth (figure 58) has an 8 to 10 mm wing spread. The antennae are distinctly and alternately ringed with brown and white. The head and body are quite dark. The forewings are grayish-brown and marked by three irregular transverse whitish bands, which are edged with a few black scales; there are some bright brownish-orange scales between these white marks. The hind wings are uniformly covered with brown scales, and like other micro-Lepidoptera, they show a wide fringe of hairs on the rear edge of each hind wing.

There is only a single generation annually. The moths are commonly seen in late April, throughout May and into June in southern California. Apparently they lay their eggs singly at the base of buds that will be shoots the next year (Burke, 1937). These buds are entered by the newly hatched larvae and a certain amount of tunnelling is done by these minute larvae during the remainder of the year. *Exotelia burkei* is probably similar to a close relative in eastern North America, *E. pinifoliella*, the pine needle miner (Finnegan, 1965), in spending the winter as a fourth-instar larva. Apparently not until the next spring does the larval tunnelling become extensive and damaging enough to be noticed externally. As the spring season becomes warmer the tunnelled shoots begin to wilt. Pupation usually takes place in the tunnel of the dried shoot, most often near an exit or entrance hole. The pupal stage occupies a relatively short period, apparently only two or three weeks, after which the adults emerge, thus completing the single annual cycle.

Probably as a result of the single-brooded condition, and adult emergence over a relatively short period, thorough-coverage sprays of DDT or DDD, applied in late April, have given fairly good control of this insect. See section on Control.

Juniper twig girdler

The juniper twig girdler, *Periploca nigra* Hodges (1962), (Lepidoptera: Gelechioidea: Cosmopterygidae or Walshiidae), is a common and important insect pest of cultivated junipers in southern California. It is one of those rare insects that became well-known before it had a scientific name. In our records, the typical plant damage and larval stage go back to 1952. The low growing and widely planted Tam juniper (*J. sabina*) is a preferred host, but Koehler and Tauber (1946*a*) note several other commonly planted juniper species that may be attacked. Infestation of a juniper hedge is noticed, especially late in the summer, by a browning, death, or "flagging" of the smaller limbs. Before the very warm weather the affected limbs are yellow, much in contrast to the normal green of the healthy limbs. Affected plantings may present an unsightly checkerboard of green and brown limbs, and are considerably retarded in growth. Tracing down a brown flag beyond the leaves, a sort of flaring of the bark plates on the

Juniper twig girdler. Fig. 59. Above: Typical appearance of twigs at point of girdling. 2.0×. Fig. 60. Right: Twigs with bark removed to show larval girdling. 3.4×. Fig. 61. Below: Larva in tunnel of girdled twig. 4.2×.

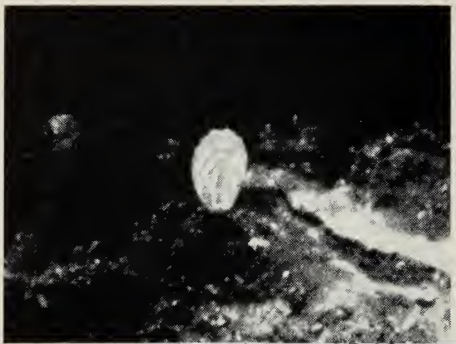
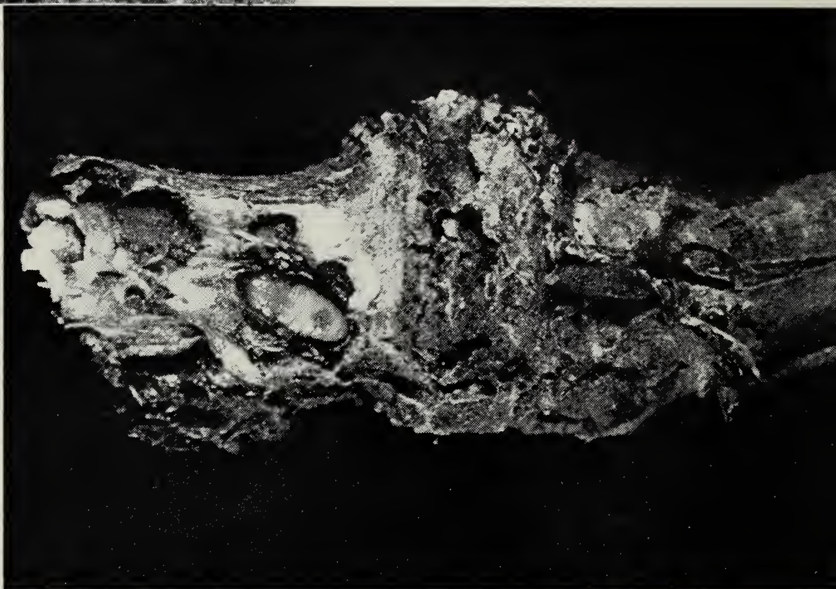


Fig. 62. Left: A twig girdler egg laid on tender part of bark. 30.2×. Fig. 63. Below: Newly formed pupa (dorsal view) in exposed tunnel next to a girdle. 4.4×. Fig. 64. Bottom: An almost black adult; lighter areas on wing are reflections from metal-like scales. 12.7×.



stem may be seen (figure 59), and when the bark is stripped from that area the girdling tunnels of the larvae (figures 59, 60 and 61) are found. The twig above the girdle is usually thickened. Frequently one or more of the girdler larvae (figure 61) may also be seen. The larval tunnelling cuts into the wood and through the fluid-conducting tubes of the stem, and may extend completely around a small stem or only partially around a larger stem. Koehler and Tauber (1946*a*) note an average of seven larvae per twig in the San Francisco Bay area, with a high of 33 larvae in one stem. We have noticed the typical flagging wherever these plants are grown in southern California, although most of our observations have been made in areas under coastal influence. Koehler (in a personal communication) notes that a similar flagging may be caused by other agents, such as girdling by mice; the latter cause a different type of girdling of the stem, however, which is readily apparent on close inspection. Although an insect relatively new to science, the juniper twig girdler is widespread in California, and may even be native here, or introduced many years ago on juniper in the nursery trade.

The egg (figure 62) is rather pear-shaped and attached by the smaller end to the tender bark. The egg is about ½ mm high, yellowish-white, shiny surfaced, and with longitudinal rows of small bumps. The mature larva (figure 61) is yellowish- or whitish-pink, with the brownish-pink gut contents visible as a line down the back. The shining head capsule is brown, the back part being recessed into the prothorax and visible as two black crescents through the transparent and shining prothoracic shield. The mature larva is 6 to 7 mm long. The pupa (figure 63) in the tunnel is 4.5 mm long, and has the shining black wing pads and antennae extending almost to the ventral tip of the shining brown abdomen; as with all Lepidoptera the appendages of the pupa adhere to the body. The adult (figure 64) is dark brownish-black overall with the front end being somewhat darker. The scales are so shiny they appear almost metal-like. The outward part of the antenna and the hind edge of the forewing (along the dorsal midline at rest) are honey-colored. The adult at rest is 6 to 7 mm long from head to wing tip.

There is a single generation per year. In southern California the adults emerge over a relatively long period—March, April and May, and a few in February and June. Hodges' (1962) types (from the San Joaquin and Sacramento valleys) emerged early in the year: January, February and March. However, Koehler *et al.* (1946*b*) noted emergence in the San Francisco Bay region primarily in June and July. The only adults we have observed have been reared in the laboratory, and as Koehler and Tauber (1946*a*) note, the adults are very secretive in the field and possibly fly at night. The eggs are laid relatively soon after emergence and the young larva mines for the most part into the thickened and apparently nutritious callus tissue from previous girdles of the stem, and into the new terminal growth. Larvae may be found throughout the rest of the year and into the first months of the next year resting and slowly extending their meandering or girdling mines. In January, February and March the mature larvae enlarge the tunnel into a kind of cell extending down into the wood of the stem and pupate therein. Evidently the pupal stage requires three to four weeks in our area, and then the dark adult emerges, thus completing the cycle.

This insect may be controlled with insecticides, but considerable experience has shown that the larval stage is not the appropriate part of the life cycle to attack. As with most boring insects, a stage outside of the plant tissue—in this and most other cases the adult—can be controlled most effectively. As suggested by Koehler *et al.* (1964*b*), a single spray of lindane (at the rate of ½ pound of active ingredient per 100 gallons of water) when adult emergence is nearing its maximum will give effective control. In southern California this would be in late March or early April. In heavy infestations, or when adult emergence cannot be determined easily, possibly two sprays would yield the best results: the first spray somewhat before that suggested above, and the second three or four weeks later. Dieldrin sprays have also yielded satisfactory results in southern California. It is necessary to thoroughly wet the stems and leaves of the plants to achieve control. According to Koehler *et al.* (1964*b*) small, compressed-air sprayers, or hose-end sprayers, may be used effectively. As these chlorinated hydrocarbon insecticide sprays may cause a mite build-up, it is desirable that Kelthane or Tedion be included in the spray. It will be necessary to prune out the dead stems for the best appearance of the juniper plantings. See section on Control.

Other Boring Lepidoptera

Some moth larvae, discussed under Leaf-consuming Insects, may also be found boring in their conifer hosts. As younger instar larvae the cypress leaf tier, *Epinotia subviridis* Heinrich (Lepidoptera: Olethreutidae), occasionally may be found boring in the tender tips of various cypress species. The same is true for the closely-related *E. hopkinsana.* For the biology and control of these species, see the appropriate section under Leaf-consuming Insects.

Cypress bark moth

The cypress bark moth, *Laspeyresia cupressana* (Kearfott) (Lepidoptera: Olethreutidae), is one of the more common insect pests affecting cypresses all along coastal southern California and extending to the San Francisco Bay region. The larvae tunnel into the bark and phloem areas (figure 65) causing the bark to become roughened, and covered with reddish-brown, sand-like frass and oozing drops of pitch. Heavy infestations circling the limb may be a factor in its death, but coryneum canker may be even more important. Numerous limbs have been weakened and killed in cypress hedgerows when associated with these agents. Also the dripping, sticky syrup-like pitch is a nuisance when falling on articles beneath the tree. Although the cypress bark moth larvae chewing into the resin ducts can cause this pitch exudate on the surface, they are not the

Cypress bark moth. Fig. 65. Cypress limb showing roughened area with frass, and drops of pitch forming. 0.7×.

Fig. 66. Above: Living bark moth adult on cypress cone and protruding pupal skin from which it emerged. 6.1×. Fig. 67. Below: Trunk of cypress tree swollen, roughened and covered with frass and dripping pitch from repeated infestations. 0.2×.

only cause (Wagener, 1936); the coryneum canker, a fungus disease in the same areas, is associated with this resinous drip. We have shown, too, that a knife cut exuding pitch on the otherwise healthy bark is attractive to the moths, and that eventually such artificial injuries can become infested with the larvae, which accentuate the dripping problem. Thus, many areas that eventually become infested probably were originally dripping from some other cause.

Figure 67 shows a cypress trunk that had been infested repeatedly for several years; the trunk was severely roughened, enlarged, and the whole tree severely weakened. Eventually it was cut down. Also favored for attack are the cones of the cypress (figure 66); Doane *et al.* (1936) even call the insect the "cypress cone moth." Such tunnelling in the cone destroys the seeds, thus affecting the natural reproduction of these plants; Keen (1958) estimates that 25 per cent of attacked cones die before maturing.

The eggs are oval, flattened, about 1 mm in diameter, and are laid singly on the bark, usually near resinous exudate, or on the cones. The mature larva, like others of the genus (Keen, 1958), is about 12 to 15 mm long, pinkish- or grayish-white, and with brownish-yellow head capsule, prothoracic shield and anal plate. On the prolegs there are uniordinal crochets in a circle; abdominal setae IV and V (Forbes, 1923) (or L2 and L1, MacKay, 1959) are adjacent to each other. Ninth abdominal segment setae II (or D2) are closer together across the top than those on preceding segments. The pupa is shining brown and is in a whitish silk, frass-covered cocoon, which is in the burrow near the entrance (figure 66). The pupa, like many other boring Lepidoptera, has rows of spines on the back of the abdominal segments, which, with wiggling, aid the pupa to protrude from the cocoon and burrow. The forepart of the adult (figure 66) is covered with grayish scales, while the forewings are covered with black scales, the tips of which are white. This gives the impression of minute, alternating white and black bands of varying widths. The predominantly wide white band near the middle of the resting adult consists of individual scales that are mostly white. The darker bands on the wings are formed of scales that, viewed from some angles, appear brass colored. The hind wings are uniformly dull brown. At rest the adult is approximately 8 mm long.

Burke (1936) and Keen (1958) state that there are two overlapping broods annually; our findings confirm this. The spring brood of emerging moths may appear in southern California over the extended period of March to July, most of them probably in April. The second brood also has an extended emergence period; we have noticed newly emerged moths from early August to early November. As is common in many other members in the family, overwintering occurs in the larval stage.

A residual insecticide spray (as DDT or Sevin), applied in early April and again in early September, will give some control of the moths. Cutting out the larvae, opening up their tunnels, and dressing these wounds with slurries of various insecticides (DDT, lindane, or dieldrin) has given a degree of control of larval infestations, but such a great amount of work is impractical except on expensive specimen trees. Controlling the dripping of the sticky resin is a much more difficult problem, because dripping may also result from coryneum infection or other causes. Any cutting—as in dressing the wounds—opens resin ducts and may result in dripping. A liberal painting of the dressed wound with an asphalt pruning compound does seem to lessen the dripping. See section on Control.

Monterey pine tip moth

Monterey pine tip moth. Fig. 68. Several whitish-brown growing tips killed by larval tunneling; some whitish pitch exudate can also be seen.

The Monterey pine tip moth, *Rhyacionia pasadenana* (Kearfott) (Lepidoptera: Olethreutidae), is a fairly common boring pest of the growing tips of the Monterey pine all along coastal southern California. The larva hollows out the newly developing bud and tip, causing their abrupt death (figures 68 and 71) (compare with Monterey pine bud moth, page 39). The needles on these dead tips are conspicuously light brown in contrast to the normal dark green of healthy needles. Sometimes an exudation of whitish pitch further accentuates the light appearance of the dead tip. The death of the growing terminal bud causes one or more lateral buds to develop (figure 69), resulting in a stunted bushiness of growth and—if this happens over the whole



Fig. 69. Left: Growing tip of Monterey pine killed by tip moth larval tunnelling; for the picture the mature needles were removed to show the proliferation of the lateral buds, which causes an undesirable bushiness of growth on the limb. 0.7×. Fig. 70. Right top: Young larva with its head protruding from the mined needle fascicle. 10.3×. Fig. 71. Right bottom: A dead Monterey pine terminal bud showing an exit hole of the larva; the larva may go to another terminal bud, enter, and kill it also. 3.6×.

tree—detracting considerably from its ornamental value. The newly-hatched larvae usually first burrow into the needle fascicle and may appear to be boring in the needles (figure 70); such injury is a mild forerunner to the severe damage and death of the tip. Although relatively large trees are attacked by this insect, it seems most common and destructive on young, newly-planted Monterey pines, or on those in nursery plantations. We have seen this insect only on the Monterey pine in southern California, but Lange (1937) mentions that it also attacks Bishop and shore pines. Some of the paratype specimens are from Pasadena, thus the scientific name of the species. Other paratypes (figure 73) and the holotype are from Alameda and Monterey counties.

The egg is like others in the family—yellowish-white when first laid, somewhat flattened, and slightly less than 1 mm in diameter. According to Lange (1937) the eggs are laid singly or in groups of two to ten on the needle or on the woody tip (Koehler and Tauber, 1964*b*). Considerable evidence by these latter writers show that the younger instars of the majority of the larvae feed primarily on the needles (figure 70), and that the later instars bore into the bud (figure 71) and down into the growing tip after causing a "tent" of pitch to form

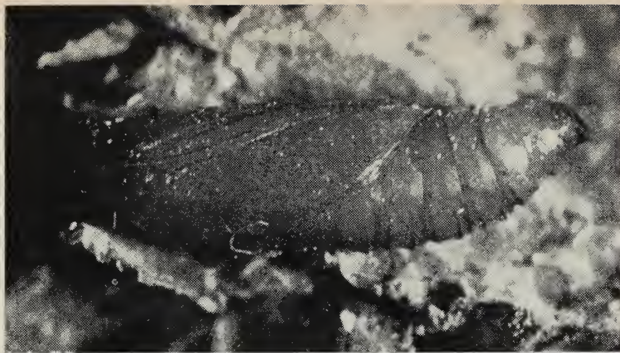


Fig. 72. Top: The tunnel in a terminal bud has been opened to show the yellowish-brown tip moth pupa; this is the site where this stage of the insect occurs. 10.3×. Fig. 73. Bottom: Pinned and spread adults; specimen on right labeled: "cotype." Forewings are gray with reddish scales toward tips. 3.6×.

at the site of entry. These writers also show that several larvae (an average of about five) work in a single tip, which helps explain the rather extensive hollowing out of the tip. They indicate too, as did Lange, that the larvae come out of the shoot and may be found crawling about on the outside of the shoot, or going to new shoots to injure them. The mature larva (6th instar) is 9 to 10 mm long, a whitish-orange color, and has the head capsule, prothoracic shield, and anal plate dark brown. Abdominal setae IV and V (Forbes, 1923; or L2 and L1 of MacKay, 1959) are adjacent to each other, and ninth abdominal segment setae II (or D2) are closer together across the top than those on the preceding segments. Seta I, on ninth abdominal segment, is closer to III than to II. The yellowish-brown pupa (figure 72) is 6 to 7 mm long, and has a double transverse row of spines dorsally on most of the abdominal segments, a character in common with many other families of boring Lepidoptera. Pupation occurs in the hollowed-out, silk-lined tip. When the adult is about to emerge, the pupa, by wiggling its abdomen, moves to a hole previously made in the bud (figure 71), and when it protrudes through this to the outside the pupal skin splits and the adult emerges. At rest the adult is 8.5 to 9.5 mm long and, when mounted (figure 73), has a wingspan of 15 to 16 mm. The adult has a reddish-brown head and black eyes. The forewing is gray with reddish-brown scales, being mostly red in the outer third and intensely red at the outer border. There are several (to five) indistinct transverse gray lines equidistant along the forewing. There is a reddish-gray fringe with a white inner border. The hind wing is silvery brown with darker veins, and has a silvery fringe with a brown basal line. The base of the cubital vein on the top of the hind wing has a fringe of long hairs.

Moth emergence in southern California has been observed from late January throughout March, with the most appearing in early March. Here, only a single brood of moths emerges. But the rather extensive data of Koehler and Tauber (1964*b*) suggest that there is a partial second brood in the San Francisco Bay area (in November). Therefore it should not be surprising to find some moth emergence also in southern California, perhaps in October or November. However, Koehler and Tauber note the preponderance of moths in the spring (peaking in mid-April), although emergence is over a relatively long period. This is the brood of economic significance. We have noticed larval activity in southern California externally on the tips in January and February.

Thorough-coverage sprays of long-residual insecticides, such as DDT or lindane, applied during the last half of March, have controlled this insect successfully in southern California. As Koehler *et al.* (1964*a*) note, the spraying date will be progressively later the farther one goes north, and may be late May near San Francisco. See section on Control.

California flatheaded borer

In recent years the California flatheaded borer, *Melanophila californica* Van Dyke, (Coleoptera: Buprestidae), has been one of the most common and destructive insects to yellow pines in the southern California mountains. The larvae tunnel in the phloem area beneath the trunk bark, often in large numbers, causing a girdling that hastens the decline and death of the pine. In commercial timberlands it is considered so serious that when mature larvae are found in the trunk of the tree, it is cut down and the bark surface treated with insecticides. This is to protect the surrounding uninfested trees. But to the owner of a mountain cabin or year-round home with surrounding pines this is a drastic measure he is reluctant to take. See Lyon (1958) for an excellent account of this insect.

California flatheaded borer. Fig. 74. Living adult; one of the most common and injurious insects of western yellow pines. 5×.

Likely victims of the flatheaded borer are drought-weakened pines as well as those not getting enough water for other reasons, such as trees on rocky slopes. When the bark is loosened the flattened, meandering, frass-filled tunnels are seen, particularly on the inner surface of the bark, and with a corresponding slight engraving in the wood. The dark brown frass is packed tightly in the tunnel, often in alternating, crescent-shaped marks and ridges. The tunnel width varies from 10 to 15 mm. Some tunnels are so regular in depth and width as to appear made by a router. The foliage of heavily infested trees is more yellow and thinner than that on healthy trees, and eventually it turns brown as the tree dies.

The larva in the tunnel, like many other buprestids, is shaped somewhat like a horseshoe nail. The prothorax is broad (the so-called "flat head") with the head sunken into it. The body tapers posteriorly, with the abdominal segments being somewhat flattened and bead-like. The larva is legless, yellowish-white, and about 25 mm long at maturity. Pupation occurs in a cell at any depth in the bark. The adult beetle (figure 74) varies from 7 to 11 mm in length, and is brownish-black and bronzed above, and greenish metallic below. Although some of the adults are as in the figure, more of them have one to three yellow spots on the elytra (wing cover).

The adults emerge from their pupal cells in the bark primarily in June and July (Lyon, 1958). A generation will go through in one year in a tree that is sufficiently weakened. Those larvae in more vigorous trees develop more slowly, and a generation may take 2, 3 or 4 years, and a great many such larvae die. This gives a clue to what could be a practical control measure for the small property owner: keep the trees vigorous. Such invigorating measures can include supplementary irrigation — important in drought-ridden southern California, and judicious fertilization. Secondarily, insecticidal sprays (lindane, DDT or dieldrin) could be practical for the small property owner with smaller yellow pines. Such trunk and large-limb sprays should be applied when the adults are emerging. See section on Control.

Sculptured pine borer

Although nowhere near the economic importance of the preceding species, the sculptured pine borer, *Chalcophora angulicollis* (Leconte) (Coleoptera: Buprestidae), is commonly seen, usually as shown in figure 75, sitting quietly on the bark. Several times we have verified Keen's observation (1952) that we first notice these beetles when searching the bark quite closely, and one suddenly takes noisy flight right by our face. He also notes that this is the largest of the western members of the family; the adult is about 25 mm long. It is a coppery chocolate color, with distinctive sculptured marks. The larvae attack dead —or nearly dead—pines and firs, and are especially noticeable around stumps. In a sense then, the insect could be considered of benefit in helping to reduce the debris in the forest. If insecticidal control is considered necessary, those measures suggested for the preceding species will probably be adequate for this beetle. We have noticed the beetle most commonly from May to July, with the most appearing in June, when oviposition in *Dendroctonus brevicomis* holes and in bark crevices was observed.

Sculptured pine borer. Fig. 75. Living adult resting on western yellow pine bark; a common insect in western forests. 2.5×.

Roundheaded borers or longhorned beetles

Many roundheaded borers or longhorned beetles (Coleoptera: Cerambycidae) attack ornamental coniferous trees, and many more attack forest conifers. A few may be of economic significance to the healthy plant, but the vast majority attack only conifers that are seriously weakened, or dying or dead from some other cause. Usually, by the time the cerambycids attack the tree it is too late to save it. Good, general accounts of the longhorned beetles are available in Craig-

Roundheaded borers or longhorned beetles. Fig. 76. Above: Ventral view of apparently legless larva, probably Ergates species; normally yellowish-white, this specimen darkened in the preserving solution. 2.0×. Fig. 77. Left: Longhorned beetle (probably Oeme costata Leconte). Its larvae commonly mine beneath the bark of the trunk and limbs of western yellow pines. 4.0×.

head (1950); Keen (1952); Essig (1958); Doane *et al.* (1936). Here we shall briefly mention only two representatives of this beetle family.

Ponderous borers, *Ergates* species (figure 76), attack only dead or dying pines, including the Monterey pine. They bore in the sapwood and along the junction of the bark and sapwood, making nearly round (in cross-section), frass-packed burrows. The larvae are large (the specimen shown is 57 mm long), practically legless, with the thoracic legs being like small, segmented spines. The segments taper gently backward, not abruptly as in the flatheaded borers. The specimen shown darkened when put in preserving fluid; normally this borer (and all other cerambycid larvae) is light, yellowish-white.

Another longhorned beetle (probably *Oeme costata* Leconte) is shown in figure 77; its eggs are illustrated in figure 78. The larvae are common borers in various dead and dying yellow pines (including the Monterey pine) throughout southern California. The larvae make extensive, meandering, frass-packed burrows at the bark-wood junction and into the sapwood. Sometimes the tunnelling is so extensive that almost all of this junction is mined. Frequently the burrows of the California flatheaded borer (see page 49), a buprestid, may be in the same area of the trunk, and confused with those of this cerambycid. The buprestid tunnels

Fig. 78. Eggs laid in a glass jar by the beetle in fig. 77. 4.5×.

are more oval in cross-section. The adult of this cerambycid (figure 77) is olive-brown, shows the long antennae typical of the family, and is about 24 mm long. The grayish-white, elongate eggs (figure 78) are about 2.8 mm long and are laid in the bark crevices.

The primary defense against attacks of the longhorned beetles is prevention—maintenance of the conifer in a vigorous state of growth so that it will not be attractive to the insect. Judicious watering and fertilizing will accomplish this. Secondarily, thorough-coverage sprays of insecticides (DDT, lindane, or dieldrin) may be used when the adults are emerging. With *Oeme costata* this is during May and June. See section on Control.

Bark beetles

This family (Coleoptera: Scolytidae) contains the most devastating and economically most important insects that attack coniferous plants. This is true for our forests, and almost equally true for our ornamental coniferous plants. All bark beetles readily attack conifers that for one reason or another are not getting enough water into their systems. The two most common causes are inadequate rainfall or irrigation, but it also may be that the water-absorbing or -conducting capacity of the coniferous plants may be impaired. Reasons for this may be: rocky slopes; compacted soil; root-rot infection; blocking or cutting of the water-conducting vessels above the roots, through fire damage, or an infection plugging the tubes, or a cutting or crushing of the vessels, as by cars and cultivating equipment, or intentional cutting by irresponsible persons. The boring activities of the bark beetles themselves further cut these vessels, and hasten the death of the conifer. Some bark beetles have been recorded as attacking healthy coniferous plants, when sufficiently high populations of these insects develop.

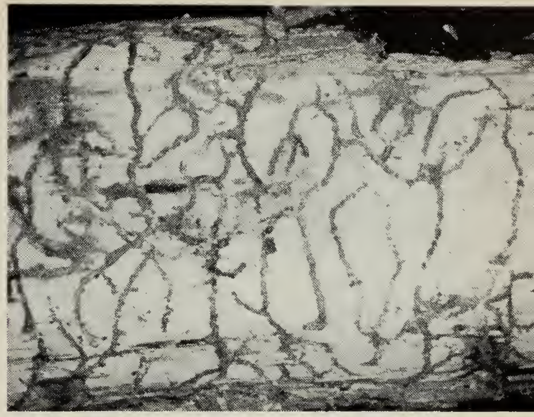
In each of the following bark beetle accounts, and insofar as shade and ornamental coniferous plants are concerned, a primary control measure suggested is prevention of bark beetle attack by keeping the plant invigorated, as by judicious irrigation and fertilization. Secondarily, insecticidal sprays are suggested.

Western pine beetle

The western pine beetle, *Dendroctonus brevicomis* Leconte (Coleoptera: Scolytidae), is the most destructive insect of yellow pines in the western United States (Whiteside, 1951; Keen, 1955). These authors estimate a loss of more than $100,000,000 worth of timber caused by this insect in the period 1921–1945. The person living in the mountains of southern California, as well as the city-dweller with a mountain cabin, should know of this important insect. This is necessary, not only to help protect the yellow pines on his own property, but also to understand and support the forestry officials in their difficult job of controlling this beetle in our forests.

One of the first signs that a tree is being attacked is a slight yellowing of the foliage. Such a dying tree is called a "fade" by foresters and it stands out clearly among its healthy, green neighbors. In the forest such trees may be cut down, and the bark stripped and burned. The trunk bark will show reddish-brown, flour-like frass caught in the crevices, and the 2 mm holes (figure 83), from which the frass came. If the tree still has a certain amount of vigor, the entry hole may be surrounded by some pitch that the adult beetle has pushed out of the tunnel. When a section of bark is stripped off, the typical meandering, frass-packed tunnels (figure 79) can be seen in a crisscrossing, net-like pattern. A few other *Dendroctonus* species working in yellow pines can be confused with *D. brevicomis,* as adult beetles, but the typical tunnelling damage done by the western pine beetle is unique. Most scolytid beetles show both adult and larval tunnelling at the bark-wood junction, frequently in a centipede-like pattern. The western pine beetle, however, almost always shows only adult tunnelling at the junction where the bark and wood separate (see figure 82 for a rare case of a larval tunnelling). The larval stage of the western pine beetle is usually found in the bark, outward from the bark-wood junction. This is why the beetle usually does not attack those yellow pines where the bark is thin, as on younger trees, or on the smaller limbs of mature trees. The trunk of large, mature ponderosa or Coulter pines, is most likely to be attacked. This beetle is commonly found throughout the mountains of southern California, wherever these pines are found.

As the adult of the western pine beetle chews its meandering tunnel (figure 80), it lays pearly-white, ovoid eggs along the sides of the tunnel (similar to figure 91). Small depressions are chewed out for the eggs, which are then covered with bits of chewed wood. On hatching the larvae may tunnel laterally from the adult egg-laying tunnel (figure 82) along the bark-wood junction, and then out into the bark, but are much more likely to tunnel directly into the bark toward the outside of the tree. The larvae, when full-grown, are 6 to 7 mm long, and, like all scolytid larvae, are legless, fat, curved, whitish and wrinkled. As Keen (1955) states, they appear like grains of rice when one slices halfway through the bark of an infested pine. The larva slightly enlarges a part of the tunnel in the bark and pupates there. The pupa is whitish, with the appendages mostly free from the body, and the elytra curved around



Western pine beetle. Fig. 79. Typical meandering tunnels on underside of bark. 0.3×.

the abdomen and ending on the ventral side. As the pupa nears adult emergence it becomes black or dark brown. The adult (figure 81) emerges in the pupal cell and chews its way to the outside of the bark, leaving a round hole in the bark (figure 83). The adult is 4.5 to 5.5 mm long, black or dark brown, and shining on most parts, except the elytra which have longitudinal grooves and roughened areas between the small grooves. Numerous short hairs are on the elytra. The front part of the prothorax is not so constricted as other closely related *Dendroctonus* species. The adults have a groove

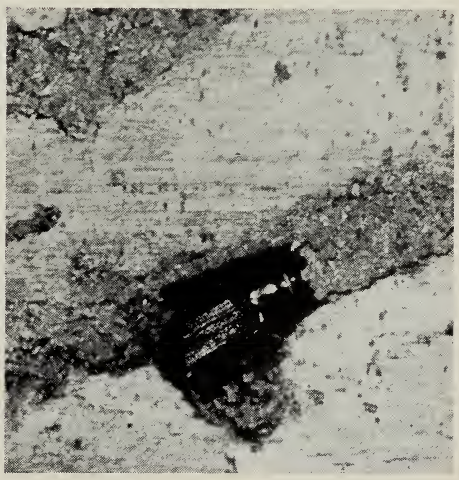


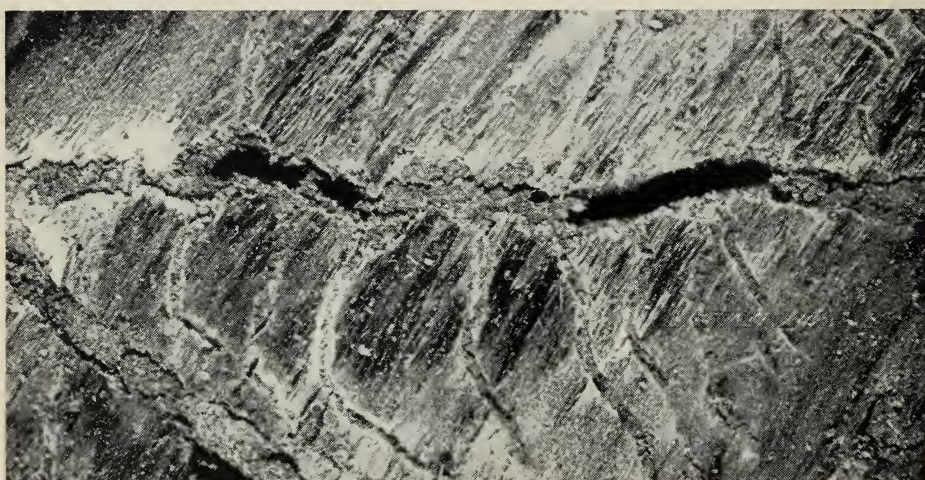
Fig. 80. Adult western pine beetle in frass-filled tunnel. 4.4×.

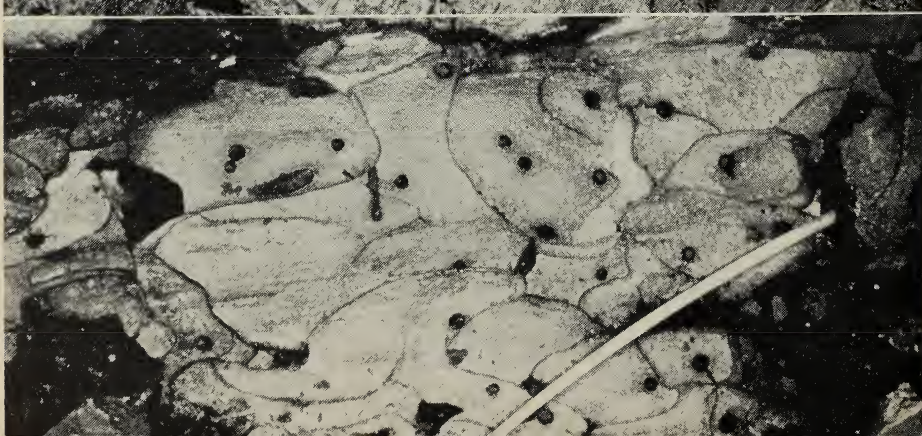
Fig. 81. Lateral, dorsal and ventral views of dead western pine beetles. 4.7×.

on the front part of the head, which is most apparent in the male (figure 81, lower right). Observing only the adult beetles, usually only a specialist can distinguish between *D. brevicomis* and other closely related species, but knowing the host pine and seeing the typical tunnelling damage helps in the identification of the western pine beetle.

In southern California at least two broods of the western pine beetle emerge per year. The first brood adults may be

Fig. 82. Top below: Large, partially frass-filled adult egg-laying tunnel and smaller, frass-filled larval tunnels radiating from it. Such larval tunnels by this species is uncommon but—as shown here—do occur. 1.5×. Fig. 83. Numerous adult emergence holes in the external bark plates of Coulter pine; most of the holes show an adult just within the opening; a pine needle is lying diagonally on the bark. 1.1×.



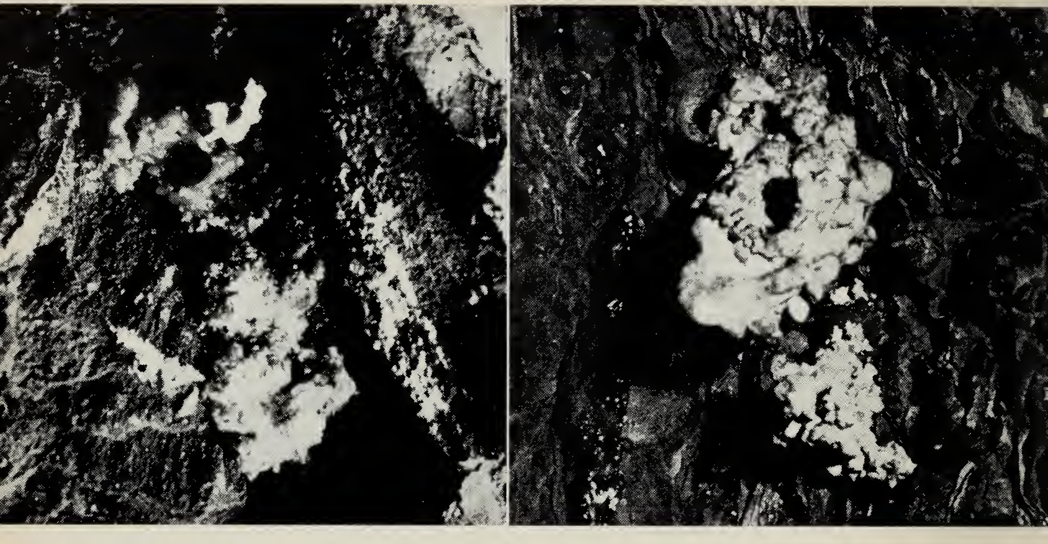


found on the bark during April, May and June, and the second in August and September. The broods overlap considerably, especially later in the year when any stage of the beetle can be found. Keen (1955) notes that there may be three or even four generations in some years, because of their almost continuous development in the relatively mild winter conditions in our mountains. Adults shown in their tunnels in figure 83 probably represent the third brood as the photograph was made in early December.

In southern California forest recreation areas, more than a decade of trials (Hall and Pierce, 1965) has shown that the sanitation-salvage management method can significantly reduce the overall beetle population. The method consists of the cutting down, and removal for lumber, of those relatively few trees (i.e., "high risk" trees) that are weakened and very likely to become infested. Although this seems drastic treatment from the shade and aesthetic points of view, it has proved economically feasible over the relatively large recreation areas. In smaller areas of private lands, or public campsites, further measures may be economically feasible. Foremost in such measures is deep but infrequent irrigation to supplement the less-than-normal rainfall of previous years. This can be done in the spring and fall, when the rains normally come. Irrigation in these periods should interfere less with the public's use of the area. Series of sprinklers probably duplicate most closely the conditions of rainfall. On some particularly valuable trees, thorough-coverage trunk sprays of residual insecticides (such as lindane or DDT) are desirable when the beetle adults are on the bark. Other measures may also be warranted depending on an analysis of the situation. If soil compaction is a problem—in a high-use area for example—it may be desirable for a few years to exclude, by fencing, human and grazing animal traffic from beneath the pines. We suggest that the property owner consult the local forestry officials before a particular control method is begun. See section on Control.

Red turpentine beetle

The red turpentine beetle, *Dendroctonus valens* Leconte (Coleoptera: Scolytidae), is another well-known bark beetle. Chamberlin (1939) lists 17 species of pine attacked by this beetle, as well as species of spruce, fir, larch and Douglas fir. Most species of pines native to southern California are included in his list, including the commonly planted Monterey pine. In addition we have noticed the beetle several times on *Pinus canariensis*, the Canary Island pine, which is imported into this area. We have found the insect in locations ranging from the seashore to the mountains. This beetle attacks only the lower trunk area, most sites being below 6 to 8 feet in height. Keen (1952) notes that it commonly attacks pine stumps in logging operations, as well as those pines left standing. Many conifer-attacking scolytid beetles push out some resin or pitch (or oleoresin) from their entry holes, particularly when a vigorous tree is attacked. This habit is particularly well-developed in the red turpentine beetle: one of the first symptoms noticed is the pitch tubes (figures 84 and 85) oozing down from the entry hole—a dozen or more pitch tubes may be found on the lower trunk. The first pitch is reddish, being mixed with the reddish sawdust-like bark frass; the later pitch (nearest the hole) is more nearly creamy-white. Such large amounts of pitch result not only from the tidy nature of the adult beetle, but from the larval habit of feeding gregariously in a common chamber as contrasted to the usual scolytid habit of feeding separately in a frass-filled tunnel. Removal of the pitch is necessary—in a relatively vigorous tree the beetle can be "pitched out," as the foresters say, that is, it is physically pushed out by the pitch, or engulfed and killed by it in the egg-laying tunnel. This tunnel is linear, with the eggs deposited in clumps along the sides of the tunnel (most scolytids lay them singly) as the adult female progresses, usually down the trunk from its entry hole. Or the eggs may be scattered in clumps in the common chamber. The bark over the common larval chamber in the bark-wood junction dies, cracks,



Red turpentine beetle. Fig. 84. Left: A pitch tube just as it is beginning to form on the external bark surface; the pitch collects in the egg-laying chamber and is pushed to the outside by the adult. 1.5×. Fig. 85. Right: An older pitch tube as it is commonly found on the lower few feet of the trunk; the dark opening for the adult entrance is visible in the center. 1×.

and eventually sloughs off the tree, leaving girdling scars. Usually, weakened trees are attacked, and such girdling further weakens the tree. We have noticed many planted Monterey pines affected in this manner in parks and other landscapes at lower elevations. According to Chamberlin (1939) the red turpentine beetle is further distinguished for two reasons: it is the largest of all the scolytid beetles, and it is the species most widely distributed in North America. California is the type locality, that is, Leconte's original description is based on specimens from this state, but it is questionable whether its presently known far-flung distribution stems from this area.

The eggs, larvae and pupae of the red turpentine beetle are not noticeably different from other scolytids except that they are possibly slightly larger than most. The larva has blunt spines on the sclerotized dorsum of the eighth and ninth abdominal segments (Thomas, 1965). The adult (figure 86) varies from light yellowish-red to dark reddish-black, with the elytra frequently being darker than the rest of the body. Adult size also varies considerably, from 6.5 to 9.5 mm. Some relatively long hair is on the basal part of the elytra, and the frontal groove is missing from the head (compare with the western pine beetle). The front part of the prothorax is moderately constricted. Often the adult is liberally covered with pitch.

Red turpentine beetle specimens from California in the U. S. National Museum were collected every month of the year but January, February and March, with most specimens appearing in July and October. These represent many elevations and locations within the state.

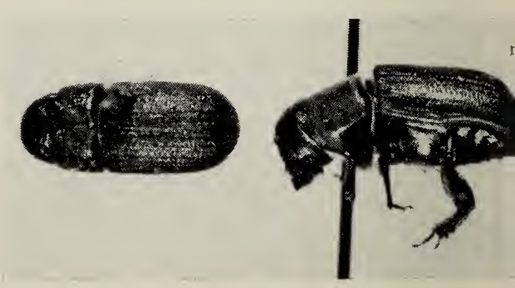


Fig. 86. Dorsal and lateral views of the red turpentine beetle; this largest of all scolytid beetles is native to southern California. 3.8×.

From our observations there are apparently at least two generations of this beetle in southern California. Keen (1952) says there may be one or more generations annually, depending on the locality and season, and that in the more southerly range it can be found in all stages of development at nearly any season of the year.

On trees having relatively few specimens, cutting out the damaged bark at the site of the pitch tube is often adequate to control this insect. Keen (1952) and Chamberlin (1939) note that carbon bisulfide squirted into the entrance hole (presumably with an oil squirt can), has given control. We have achieved control by painting the trunk with slurries of lindane or DDT. The basic problem is to invigorate the tree, if possible, so that it will not be attractive to the beetle. Deep irrigation and appropriate fertilization are the usual methods of invigoration. See section on Control.

Pine engravers, *Ips* species

The pine engraver beetles, *Ips* species (Coleoptera: Scolytidae), are easily recognized by their conspicuous concavity (called the "declivity") on the elytra at the posterior end of the body (figures 90 and 93). On the lateral margin of this concavity, and depending on the species, are three to six stout spines, while the lower margin forms a spadelike extension beyond the elytral border. The *Ips* beetles are generally smaller than the foregoing *Dendroctonus* beetles, and frequently their attacks on pines will follow after *Dendroctonus* has weakened the tree. Generally *Ips* prefers the tree tops and the younger, thinner-barked limbs as contrasted to the *Dendroctonus* species that often prefer the older, thicker-barked trunk and larger limbs. It is not uncommon to see a yellow pine with the bottom half green and the top half brown —the latter killed by an *Ips* attack. The engraver beetles will attack pines weakened by other factors also, drought being common in recent years. Slash—the residue of lumbering—is commonly attacked, as are felled trees.

According to Chamberlin (1939) the pine engraver, *Ips pini* (Say) (= *I. oregoni*, see Hopping, 1964), is the most abundant species of this genus in the pine forests of the western United States. We have noticed its damage many times in the mountain recreational areas of southern California, particularly to Jeffrey pine and other yellow pines. It may be a primary pest—the sole insect responsible for the death of weakened pines (Doane *et al.*, 1936); more commonly, it is secondary to the attacks of *Dendroctonus brevicomis* or *Melanophila californica*.

Pine engravers. Fig. 87. Several typical engravings of the pine engraver Ips pini on the inner bark surface of Jeffrey pine; note the central nuptial chamber with several egg-laying tunnels radiating (more or less with the wood grain) from it. A few small beginning larval tunnels can be seen at right angles to the egg-laying tunnels. 0.7×.

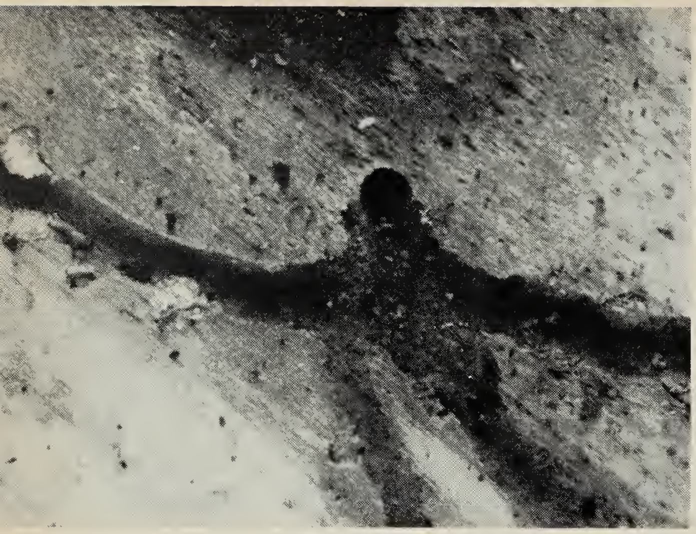


Fig. 88. The inner bark surface of Jeffrey pine showing the adult pine engraver entrance hole, a small chamber, and four egg-laying tunnels; in the left tunnel several egg niches can be seen covered with pieces of chewed wood. 4.5×.

When the bark from the pine trunk is stripped (figure 87), most of the engraved tunnels of *Ips pini* come off with the bark, and only a slight amount of engraving is in the sapwood. The yellowish-white inner bark is discolored a light or dark brown around the tunnels. A small central, nuptial chamber can be seen, with a single entry hole from the outside of the bark, and several (three to five) egg-laying tunnels radiating from the chamber, the latter tunnels being more or less with the grain of the wood (figure 88). If there are only three tunnels they may be in the form of a "Y," either upright or inverted. This species is polygamous (Chamberlin), with one male and three to five (Keen, 1952, says 1 to 7) females. The male makes the initial entry hole and the females follow. Chamberlin

Fig. 89. Left: Pine engraver at the end of an egg-laying tunnel; bits of frass can be seen on the whitish inner bark surface. 14×. Fig. 90. Right: The same pine engraver removed from its tunnel; note elytral declivity. 14×.

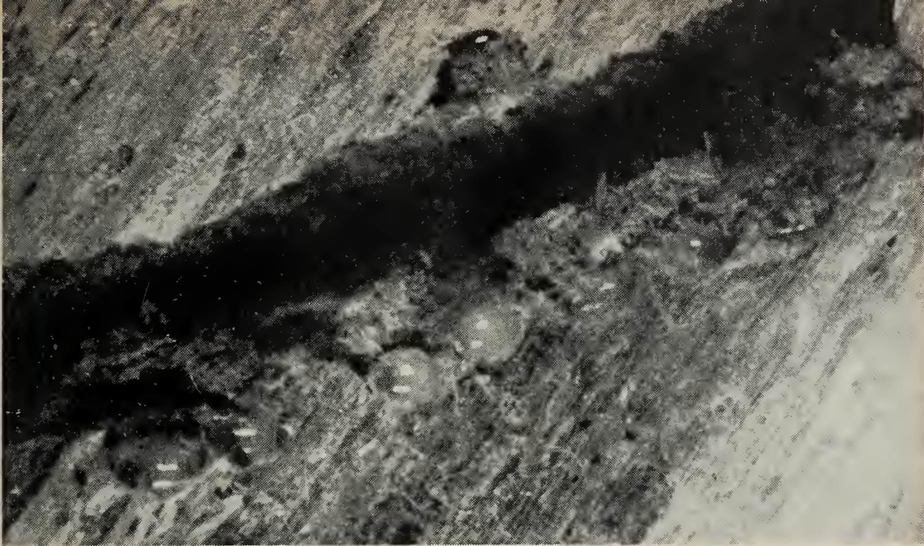
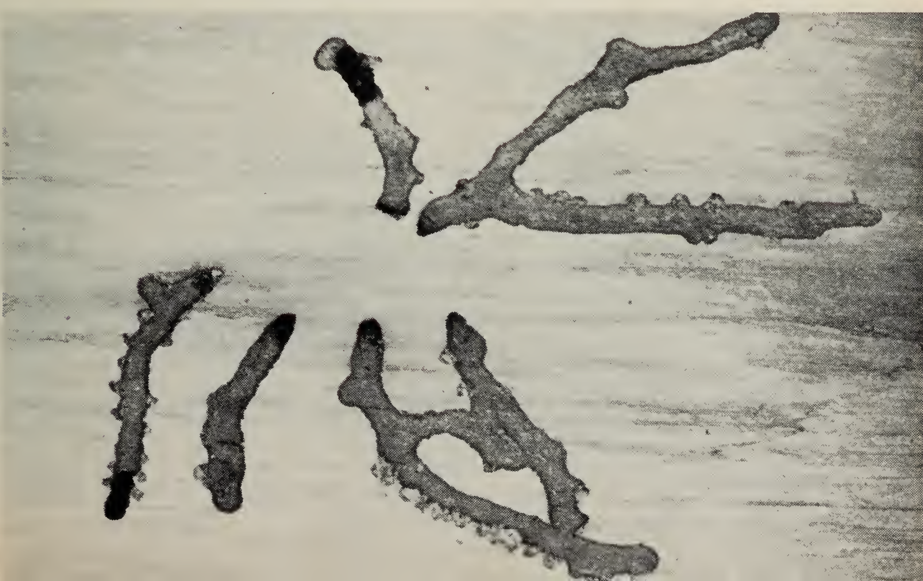


Fig. 91. Several eggs of the pine engraver in niches covered with sawdust-like frass; most scolytid beetles oviposit like this. 13.2×.

also notes the adults may leave the tunnels and construct a second, or even a third similar engraving.

This type of engraving, according to Doane *et al.* (1936), is readily confused and may be together with that of other *Ips*, most commonly with *I. confusus* (Leconte), the California five-spined engraver (see figures 88 and 92). The reddish-brown to black *Ips pini* adults (figures 89 and 90) may be distinguished however, by having only 4 spines on the elytral declivity. The first spine (dorsal) is nearer the junction of the two elytra than it is to the second spine, the latter being broadly triangular and on the same ridge as the more slender third spine. The third spine of the males is longer and slightly crooked compared to that of the females. The fourth spine of both sexes is small and near the shovel-like ridge just preceding the apex of the elytra. Like other *Ips* species, *I. pini* has the wood-rasp-like spines on the front

Fig. 92. Six adult tunnels (possibly of Ips pini or I. confusus) being initiated on heavily infested Monterey pine; numerous eggs in their niches can be seen in these tunnels. 2.6×.



part of the pronotum, the latter hiding the head when viewed from above. Instead of being straight, the sutures of the antennal club bend three times; the middle bend is acute. Adults are 3.5 to 4.5 mm long, the males being somewhat smaller than the females. The eggs (figures 88, 91 and 92) are similar to those of other scolytids, and are laid in niches along the sides of the tunnels. The pupal stage is in a cell only slightly removed from the bark-wood junction.

According to Keen (1952) there are from two to four generations per year in southern California, probably four or more. Considerable overlapping of the generations occurs later in the year. This beetle's habit of coming out of the initial mine and making a second or third mine, complicates the determination of the number of broods.

Another similar and relatively common scolytid is the Monterey pine engraver, *Ips mexicanus* (Hopkins) (= *I. radiatae,* see Hopping, 1963). We have seen it only on Monterey pine wherever it is grown in southern California, but Chamberlin (1939) records it also on Bishop, knobcone, lodgepole, Jeffrey, and whitebark pines. *Ips mexicanus* is 4 to 5 mm long, and has the sutures of the antennal club strongly and evenly arched. The punctations on the rear of the pronotum are more pronounced than on most *Ips.* It has three pairs of spines on the elytral declivity, only one of which—the third—is long and conspicuous (figure 93). The engraving at the bark-wood junction is distinctive: when only one female enters the entry hole she makes a "U" shaped mine, with the upright portions being parallel with the wood grain. If two females make entry, the second constructs a similar gallery in the opposite direction, so that the combined mines have the form of an "S." Along the outside curve of the mine, relatively large pockets are excavated and an average of four eggs is laid in each pocket. As the larvae develop, their mines fan out in all directions at the bark-wood junction. Pupation is at the bark-wood junction (figure 94). Keen (1952) suggests there are three broods annually with overwintering occurring as adults and larvae. Specimens at the U. S. National Museum (from most of the western United States) have collection dates for every month of the year except January through March.

Control of the pine engraver beetles is the same as for the other economically important scolytid beetles. Primarily, maintaining the vigor of the ornamental pines will prevent attacks by these

Fig. 93. The Monterey pine engraver from several aspects: posteriorly, on the left, showing the elytral declivity; dorsally, above right; and laterally, below right—note the prominent tooth extending backward from the elytral declivity. 13.4×.

Fig. 94. Three pupae of the Monterey pine engraver in or near their pupal chambers in the bark. 6.7×.

beetles, as well as others whose work predisposes the pines to attack by this species. Stark and Borden (1965), Moore (1957), Lyon (1959) and others have demonstrated the effectiveness of lindane against *Ips* species. Thorough-coverage sprays of this insecticide, however, should be considered as secondary to tree-invigorating procedures, such as deep and infrequent irrigation and judicious fertilization. See section on Control.

Cypress bark beetles

As Keen (1952) indicates, almost any bark beetle working in the inner bark of cedar-like trees (includes the cypresses, redwoods, and others) is almost certain to be a species of *Phloeosinus* (Coleoptera: Scolytidae). Two species attacking southern California cypresses are very common and destructive: *P. cristatus* (Leconte) (figure 95), the interior cypress bark beetle, and *P. cupressi* Hopkins (figure 96), the coast cypress bark beetle. Burke (1932) suggested these common names because *cupressi* is usually restricted to the Pacific coast, attacking the Monterey cypress in its native habitat, whereas *cristatus*—which may also be found along the coast—ranges more commonly in the inland California areas, and has also been reported in Arizona. Both species attack almost all the many true cypresses grown for ornament in southern California, as well as the false or blue cypresses, cryptomeria, arbor-

Fig. 95. Left: Dorsal and lateral views of mounted interior cypress bark beetles; note two rows of spines on elytral declivity of left specimen. 8.7×. Fig. 96. Right: Dorsal and lateral views of mounted coast cypress bark beetles; note four rows of spines on elytral declivity of left specimen. 8.6×.

vitae, and cedar. Not only do these bark beetles cause their engraving type of injury on the trunks and larger limbs—being like most scolytids in this respect—but the newly emerged adults tunnel in the small twigs. These twigs are completely hollowed out, leaving only a shell of the bark for support, which results in the death of the tips, or a "flagging." These weakened twigs break off and fall in the wind. The trunk and larger limb engraving looks like a centipede—the adult egg-laying tunnel is straight and parallel with the grain of the wood, and the larval tunnels fan out across the grain. Both adult and larval tunnels include about equal amounts of sapwood and bark. Heavy infestations have killed healthy trees, and trees weakened from other causes are more commonly killed. Drought in southern California has been an important factor in the weakening of cypresses.

The cypress bark beetles (figures 95 and 96) are small (3 to 4 mm long), dark brown to black scolytids, whose antennal club is elongate-oval, and the elytra are roughened by having longitudinal rows of granulations. The elytral declivity is convex and has longitudinal rows of short, stout spines, appearing like saw-teeth. As Edmonston's drawings clearly illustrate (reproduced in Burke, 1932; Doane *et al.*, 1936; and Chamberlin, 1939), *Phloeosinus cupressi* may be distinguished by its four complete or partial rows of these stout spines on the declivity, whereas *P. cristatus* has only two such rows (see also left specimen in figures 95 and 96). The sexes of these species may be identified as follows: *cupressi*—females with all four rows complete, and males with two center rows only partially complete; *cristatus*—females with two rows of very small spines in the center, while these are lacking in the male. The eggs, ovipositional habits, larvae and pupae are similar to the other scolytids discussed in the preceding pages.

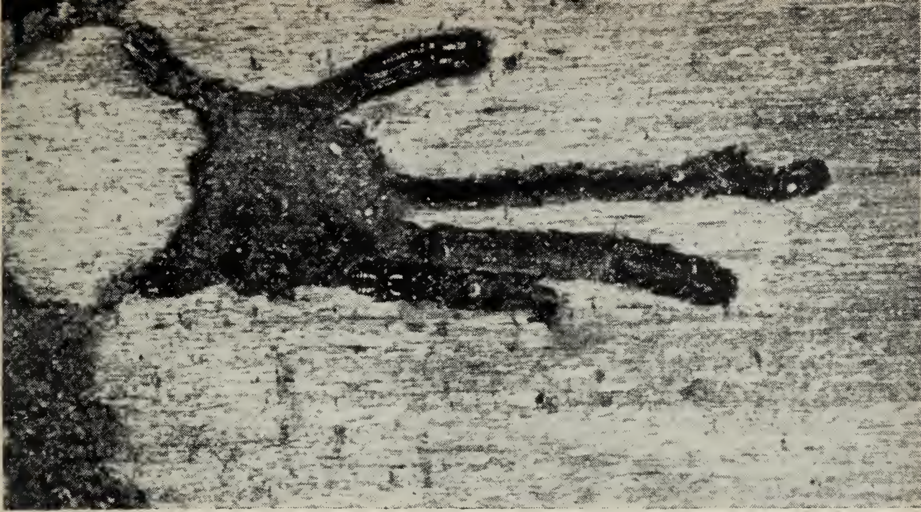
Burke (1932) and Chamberlin (1939) note that *P. cristatus* has one and a partial second generations per year. Adult specimens in the U. S. National Museum (in September, 1955) were collected in every month of the year, except March, with the most appearing from April to June and again from August through November. Our collection data tend to bear out these museum data. *P. cupressi*, Burke notes, has "several generations each year." National Museum data show collections from September to March, with none during the warm April-through-August period; again, our data bear this out. It is evident that this latter insect prefers a cool climate, which helps explain its restricted coastal distribution.

Another *Phloeosinus* which we have seen in huge numbers and doing much damage, is *P. rubicundulus* Swaine. It affects many young specimens of the big tree, *Sequoia gigantea,* in the Balch Park area of Tulare County. These trees were apparently healthy preceding attack, but possibly may have been suffering from drought. Limbs of mature *gigantea* are also attacked. For two consecutive years we have noticed that adult emergence was exceedingly heavy in early July. This species is very similar to *P. cupressi.* Since it is one of the very few scolytids affecting the big tree, its identification can be reasonably certain.

Control of these *Phloeosinus* species uses the same methods mentioned for the preceding scolytid beetles: primarily, tree invigoration to prevent adult attack, and secondarily, thorough-coverage sprays of insecticides to kill the adults when they emerge. DDT and lindane have proved to be excellent insecticides for these scolytid beetles. See section on Control.

Pondersosa pine wood engraver

Pityogenes carinulatus (Leconte), called the ponderosa pine wood engraver (Coleoptera: Scolytidae) by Doane *et al.* (1936), is a small, polygamous beetle closely related to the genus *Ips* (see page 57). This insect is a secondary pest attacking various yellow pines that have been weakened by something else, such as attacks by other bark beetles or drought. The relatively thin-barked twigs are most often attacked. The beetle frequently will go to felled trees and the slash left from logging. The adult male makes the initial entry hole into the bark and hol-



Ponderosa pine wood engraver. Fig. 97. Central nuptial chamber with several egg-laying tunnels being extended by several females, more or less with the grain of the ponderosa pine inner bark surface. 6.2×.

lows out a chamber (figure 97) at the bark-wood junction. Then one or more females (as many as ten, according to Chamberlin, 1939), enter the hole and bore egg-laying tunnels radiating out from the central nuptial chamber. The number of females associated with each male is indicated by the number of oviposition tunnels; each female makes her own tunnel. When completed the tunnel may be as long as 2 inches. After mating with the male in the central chamber she backs into the tunnel and lays her eggs along each side, like most other scolytids. We have noticed the typical engravings on both ponderosa and Jeffrey pines in the mountainous recreational areas of southern California.

The adults (figure 98) are about 3 mm long, dark brown to black, shining, and with the elytral declivity much less concave than found in the genus *Ips*. The shallow concavity is bordered laterally, in the female, with three small, widely-spaced teeth, whereas the male has only two such teeth, the top tooth being enlarged and elongated backwards into a downward curving hook. The elytra are sparsely covered with stiff hairs, with the bottom of the declivity having a fringe of such hairs. On the front of the female head is a depression, which is absent in the male. The rasp-like spines (asperities) are apparent on the front of the pronotum, as in *Ips*.

From data on U.S. National Museum specimens, June through July appears to be the most likely period for adult emergence. However, for the closely-related *Pityogenes hopkinsi* in the cooler eastern United States, Blackman (in Chamberlin, 1939) lists one and a half to two broods per season. Our own data on development are too scant to be conclusive.

Control of this species is similar to that for preceding scolytid species—primarily, tree invigoration, and then insecticide sprays. See section on Control.

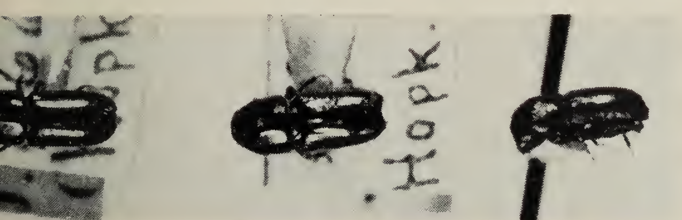
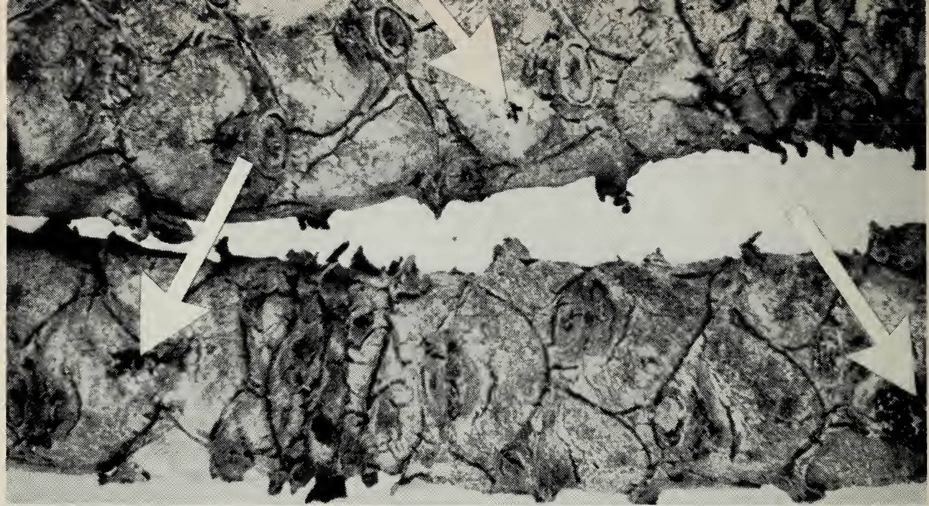


Fig. 98. Dorsal and lateral views of ponderosa pine wood engraver. 6.2×.



Torrey pine twig beetle

Burke (1932, 1937) called *Pityophthorus carmeli* (Swaine) (Coleoptera: Scloytidae), the Monterey pine twig beetle. He observed it in the central Califorina coastal region heavily infesting the Monterey pine. In southern California we have observed it only in recent years and only on Torrey pines in and near the Torrey Pine State Park near San Diego. The infestations were extremely heavy, causing concern.to park officials because the Torrey pine is a comparatively rare tree. Both Doane *et al.* (1936) and Chamberlin (1939) note that this scolytid infests both Monterey and Torrey pines all along coastal California. Although this small beetle in many ways is similar morphologically to the preceding species of *Ips, Phloeosinus,* and *Pityogenes,* in habit it seems to attack only the smaller twigs of its pine host (figures 99, 100, and 101). Such pines have almost always been weakened by drought or attacks of other bark beetles, such as *Dendroctonus.* The gallery and polygamous habit of the Torrey pine twig beetle are similar to those of *Pityogenes* (see figure 97) in having a central nuptial chamber and radiating egg-laying tunnels constructed by separate females. In a heavily infested, small twig, however, the adult and larval tunnels are so entwined that the bark seems to be a loose shell around the wood. Besides the large amount of fine powder-like frass on the outside of the twigs, one of the first signs of infestation that may be noticed is the small yellowish, granular pitch tube (arrows in figure 99). In its initial entry the male must cut through the resinous ducts in the twig bark, and the pitch oozing into the entry tunnel is pushed to the outside, thus forming the small pitch tube. In a vigorous twig the pitch flow may be great enough to overwhelm the beetle and so prevent its damaging attack. But despite these seemingly damaging attacks, injury by this bark beetle is a secondary manifestation of a more fundamental difficulty, such as drought often coupled with dry, hot winds.

The adults (figure 102) are small bark beetles, about 2.5 to 3.3 mm long. They are shining and dark reddish-brown with lighter brown legs. The elytral declivity is steeply inclined and almost flat, rather than concave, and the union of the elytral margins is raised into parallel ridges. There is almost no evidence of teeth on the margin of the declivity, as in the preceding bark beetle species. The rasplike spines (asperities) on the front of the pronotum are separate and not united. A punctate depression on the front of the head is especially pronounced in the females. The head of the female has an eye shade-like fringe of yellow hairs projecting just below the pronotal margin. The other stages are similar to the preceding scolytid beetles.

Burke (1932) states that this twig beetle has several generations each year; Keen (1952) indicates beetles of this genus generally have two or more annual generations. We have found adults every month of the year at Torrey Pines State Park.

As with other scolytid beetles, the

Fig. 102. Lateral, ventral and dorsal views of the Torrey pine twig beetle. 10.5×.

Torrey pine twig beetle. Fig. 99. Top: Two Torrey pine twigs showing several adult entrance holes (arrows), made more prominent by the frass and pitch surrounding them. 3.2×. Fig. 100. Center: Relatively large piles of frass that accumulated beneath two adult entrance holes; the twig was lying on a table. 2.7×. Fig. 101. Bottom: In a twig still relatively green a tunnel is cut open to show three adults. 5.1×.

primary control is prevention of attack by tree invigoration, such as irrigation and fertilization. A program of supplemental sprinkler irrigation at the Torrey Pines Park is causing reduced populations of this twig bark beetle. Pruning and burning of affected twigs further reduce the beetle populations, and enhance the appearance of the tree. As a secondary measure, thorough-coverage sprays of insecticides (such as lindane or DDT) can be used. See section on Control.

Behrens' horntail

This wood wasp, *Sirex behrensii* (Cresson) (Hymenoptera: Siricidae), is typical of several on pine trees. We found it commonly throughout southern California attacking Monterey or Jeffrey pines. See Middlekauff (1960) for identification and biology of the Califorina species of these primitive wasps. Ordinarily, when this or other siricids are seen on or in a pine tree, the tree is considered beyond help, as far as keeping it in a living and healthy state. This horntail is attracted to felled trees and standing trees that have been severely injured by other factors such as drought, fire, or bark beetle attack. The larvae bore throughout the heartwood making tunnels that, in cross-section, are almost perfectly circular; they are about ¼ inch in diameter. The adults make similar tunnels as they bore from the pupal stage in the wood to the outside of the tree. Such tunnels probably do little harm to the living tree, but lumber cut from the tree can be down-

Behrens' horntail. Fig. 103. Top: Living adult female; extending to the rear is the awl-like ovipositor; between this and the wing tips is the horn to which the common name refers. 2.9×. Fig. 104. Bottom: Living adult male. 2.9×.

graded. Middlekauff notes that horntail adults can emerge from lumber after it has been incorporated into a building, even boring through plaster, hardwood flooring or carpeting.

The adults are elongate, cylindrical insects, with the female being the larger. In figure 103 the female is 22.5 mm long and the male in figure 104 is 13.5 mm long. These measurements are from the front of the head, excluding the antennae, to the tip of the abdominal horn, but considerable variation in length has been noticed. The horn (on both sexes) is typical of the family and is the reason for the wasp's name. According to Middlekauff (1960), the outline shape and area of roughness of the female horn can be used to differentiate the California species of the siricids. The female of *Sirex behrensii* has a reddish-brown abdomen—except for the two blackish basal segments—with the horn shouldered at about the middle and then drawn to an acute and roughened point. The head is uniformly roughened and blackish across the top. The thorax is also darkened. The hard, awl-like ovipositor is capable of inserting the egg deep into the bark or hardwood. The larvae of the family are slightly "S" shaped, yellowish-white, with only minute thoracic legs.

Siricids may vary in the length of their life cycles. Some may require only one year (Craighead, 1950). Middlekauff notes that one species (*Sirex cyaneus*) may take three years or longer to complete the life cycle. *S. behrensii* were most commonly collected in October and November, and some in May (possibly indicating a one-year cycle). We have collected many adults of this species in August and September in southern California.

As siricids attack only severely weakened trees, the obvious method of control is to keep the tree invigorated and free of attack by primary insect pests, as the bark beetles. Chlorinated hydrocarbon insecticides would probably be effective, secondarily, in protecting such weakened trees, and also in protecting fallen and cut logs. See section on Control.

CONTROL OF CONIFER PESTS

The following recommended insecticide dosages for the control of conifer pests are listed roughly in the order of length of experience with the material, and also according to its insecticidal effectiveness, and its harmfulness to plants and higher animals. No doubt some materials lower on the list will replace materials higher on the list when more is learned of their use. Consult the section on a specific insect for timing of sprays. All dosages are amounts per 100 gallons of water, or, more accurately, 100 gallons of finished spray. Unless otherwise stated, all recommendations are for thorough-coverage, conventional, high-pressure spraying.

Note on control of sucking pests: Oil sprays in amounts of 1 gallon or more per 100 gallons of water are used for the control of scale insects on many plants. But *oil sprays are not recommended on conifers*, because in too many cases the oil has injured the plant, even where relatively small amounts of oil are used in combination with other insecticides. In emulsifiable concentrate formulations small amounts of oil are used in combination with other insecticides, but here the amount of oil is so small that, according to experience, plant damage is not likely. Wettable powder formulations, of course, have no oil in them. With any formulation, irrigate the plants well before spraying, and avoid spraying on hot, dry, or smoggy days.

Note on control of boring pests: With most of these pests, use insecticidal control only as a secondary measure. *In-*

vigorate the plant to help it resist insect attack. Supplementary irrigation to overcome the effects of drought is of primary importance in much of southern California. Judicious use of fertilizer may be necessary. Ask your Farm Advisor.

INSECTICIDE DOSAGES FOR CONTROL OF SUCKING INSECTS

Insecticide and formulation	Dosage/100 gal water	Remarks
1. Malathion, wett. powd. (25%), *or* emuls. conc. (8 lb/gal)	4 lb 1 pt	All sucking insects; time for crawler hatch; More wetting agent needed for forms with cottony wax
2. Diazinon, wett. powd. (50%), *or* emuls. conc. (4 lb/ gal)	1 lb 1 pt	Same as above
3. Carbaryl (Sevin), wett. powd. (80%)	1¼ lb	Same as above; excellent for coccid scales
4. Lindane, wett. powd. (25%)	1 lb	An alternate for aphids
5. Chlorobenzilate, wett. powd. (25%)	1 lb	An alternate for gall mites
6. Dieldrin, wett. powd. (50%), *or* emuls. conc. (1–1½ lb/gal)	2 lb 2½ qt (= 5 tsp/1 gal water)	For ants feeding on honeydew; spray on tree trunk

INSECTICIDE DOSAGES FOR CONTROL OF LEAF-CONSUMING INSECTS

Insecticide and formulation	Dosage/100 gal water	Remarks
1. DDT, wett. powd. (50%)	2 lb	Treat at first notice of injury
2. Carbaryl (Sevin), wett. powd. (80%)	1¼ lb	Same as above; preferred near fish-ponds
3. DDD, wett. powd. (50%)	2 lb	Treat at first notice of injury
4. Lindane, wett. powd. (25%)	2 lb	Same as above

INSECTICIDE DOSAGES FOR CONTROL OF BORING INSECTS

Insecticide and formulation	Dosage/100 gal water	Remarks
1. Lindane, wett. powd. (25%)	4 lb	Timing of spray essential; good for most beetles and moths
2. DDT, wett. powd. (50%)	2 lb	Same as above
3. Dieldrin, wett. powd. (50%)	1 lb	Timing of spray essential
4. Carbaryl (Sevin), wett. powd. (80%)	1¼ lb	Same as above

WARNING ON USE OF PESTICIDES

These recommendations for pest control are based on the best information currently available for each pesticide listed. Treatments based upon these recommendations should give adequate control and not cause any serious hazard if the applicator follows all directions on the insecticide package label with respect to dosage levels, number of applications, and precautions for the user as well as those for fish and other wildlife.

The applicator is legally responsible for treatments on a given property as well as for problems caused by drift from original property to other properties or crops.

LITERATURE CITED

Annand, P. N.
1928. A contribution toward a monograph of the Adelginae (Phylloxeridae) of North America. Stanford Univ. Publ., Univ. Series, Biol. Sci. **6**(1):1–146, 31 figs.

Atkins, E. L.
1952. Fruit tree leafroller. Calif. Agr. **6**(6):5,15.

Ball, E. D.
1920. The life cycle in Hemiptera, Ann. Ent. Soc. Amer. **13**:142–55.

Basinger, A. J.
1938. The orange tortrix, *Argyrotaenia citrana*. Hilgardia. **11**(11):635–69.

Borror, D. J., and D. M. DeLong
1954. An introduction to the study of insects. New York: Holt, Rinehart and Winston. 1030 pp., 634 figs.

Brown, L. R., and C. O. Eads
1965. A technical study of insects affecting the oak tree in southern California. Univ. Calif. Agr. Exp. Sta. Bul. **810**, 106 pp., 145 figs.

Burke, H. E.
1932. Summary of shade tree insect activities in California for 1931. Calif. Dept. Agr. Monthly Bul. **21**:358–69.
1933. Some important insect enemies of shade trees in central and southern California. National Shade Tree Conf. Proc. 9:49–59.
1936. Important insect enemies of cypress trees. Western Shade Tree Conf. Proc. 3:70–79.

1937. Important insect enemies of the Monterey pine. Western Shade Tree Conf. Proc. 4:21–31.

Chamberlin, W. J.

1939. The bark and timber beetles of North America, north of Mexico. Corvallis, Oregon: Oregon State College Coop. Assoc. 513 pp., 321 figs.

Craighead, F. C.

1950. Insect enemies of eastern forests. U. S. Dept. Agr. Misc. Pub. **657**, Washington, D.C. 679 pp., 197 figs.

Cumming, M. E. P.

1953. Notes on the life history and seasonal development of the pine needle scale, *Phenacaspis pinifoliae* (Fitch) (Diaspididae: Homoptera). Canadian Ent. 85(9):347–52.

DeLong, D. M., and H. H. P. Severin

1950. Spittle-insect vectors of Pierce's disease virus. 1. Characters, distribution and food plants. Hilgardia. **19**(11):339–56.

Doane, C. C.

1961. Taxonomy and biology of *Pineus strobi* (Hartig) and *P. coloradensis* (Gillette) (Homoptera, Adelgidae). Canadian Ent. **93**(7):553–60.

Doane, R. W., E. C. Van Dyke, W. J. Chamberlin, and H. E. Burke

1936. Forest insects. New York: McGraw-Hill Book Co. 463 pp., 234 figs.

Essig, E. O.

1926. Insects of western North America. New York: Macmillan Co., 1035 pp., 766 figs.

1942. College entomology. New York: Macmillan Co. 900 pp., 308 figs.

1958. Insects and mites of western North America. New York: Macmillan Co. 1050 pp., 766 figs.

Ferris, G. F.

1938. Atlas of the scale insects of North America. Stanford University, Calif.: Stanford Univ. Press. Series II, serial 137–268.

1942. Atlas of the scale insects of North America. Stanford University, Calif.: Stanford Univ. Press. Series IV, serial 385–448.

1950. Atlas of the scale insects of North America. Stanford University, Calif.: Stanford Univ. Press Series V (Part I). 1–278, 108 figs.

1953. Atlas of the scale insects of North America. Stanford University, Calif.: Stanford Univ. Press. Vol. VI (Part II). 279–506, figs. 109–193.

Finnegan, R. J.

1965. The pine needle miner, *Exoteleia pinifoliella* (Chamb.) (Lepidoptera: Gelechiidae), in Quebec. Canadian Ent. **97**(7):744–50.

Forbes, W. T. M.

1923. The Lepidoptera of New York and neighboring states. Ithaca, N.Y.: Cornell Univ. Agr. Exp. Sta. Mem. **68**. 729 pp., 439 figs.

Gillette, C. P., and M. A. Palmer

1931. The Aphididae of Colorado. Part I. Ann. Ent. Soc. Amer. **24**(4):827–934.

Hall, R. C., and J. R. Pierce

1965. Sanitation treatment for insect control. U. S. Dept. Agr., Forest Service. 21 pp., 7 figs.

Herbert, F. B.

1920. Cypress bark scale. U. S. Dept. Agr. Bul. **838**. 22 pp., 5 figs., 6 plates.

Herrick, G. W.

1935. Insect enemies of shade trees. Ithaca, N.Y.: Comstock Pub. Co. 417 pp., 321 figs.

Hodges, R. W.

1962. A review of the genus *Periploca* with descriptions of nine new species (Lepidoptera: Gelechioidea). Pan-Pacific Ent. **38**(2):83–97.

Hopping, G. R.
1963. The North American species in group I of *Ips* DeGeer (Coleop., Scolytidae). Canadian Ent. **95**(10):1091–96.
1964. The North American species in groups IV and V of *Ips* DeGeer (Coleop., Scolytidae). Canadian Ent. **96**(7):970–78.

Imms, A. D.
1960. A general textbook of entomology, 9th edition. London.: Methuen and Co. 886 pp., 609 figs.

Jessen, E.
1964. Life history of the Monterey pine needle miner, *Argyresthia pilatella.* (Lepidoptera: Yponomeutidae). Ann. Ent. Soc. Amer. **57**(3):332–41.

Keen, F. P.
1952. Insect enemies of western forests. U. S. Dept. Agr. Misc. Pub. **273**, Washington, D.C. 210 pp., 111 figs.
1955. The western pine beetle. U. S. Dept. Agr., Forest Pest Leaflet **1**. 4 pp., 4 figs.
1958. Cone and seed insects of western forest trees. U. S. Dept. Agr. Tech. Bul. **1169**. 168 pp., 57 figs.

Keifer, H. H.
1952. The Eriophyid mites of Califorina. Univ. Calif. Insect Surv. Bul. **2**(1):1–123.

Kelson, W. E.
1964. The biology of *Aphrophora permutata* and some observations on *Aphrophora canadensis* attacking Monterey pine in California (Homoptera: Cercopidae). Pan-Pacific Ent. **40**(3):135–46.

Koehler, C. S., L. R. Brown, C. O. Eads and M. D. Davis
1965. Irregular pine scale. Univ. Calif. Agr. Ext. Ser. One-Sheet Answer **166**.

Koehler, C. S., C. S. Davis, L. R. Brown, and C. O. Eads
1964*a*. Monterey pine tip moth. Univ. Calif. Agr. Ext. Ser. One-Sheet Answer **164**.

Koehler, C. S., C. O. Eads, L. R. Brown and M. D. Davis
1964*b*. Juniper twig girdler. Univ. Calif. Agr. Ext. Ser. One-Sheet Answer **165**.

Koehler, C. S., and M. Tauber
1964*a*. *Periploca nigra,* a major cause of dieback of ornamental juniper in California. Jour. Econ. Ent. **57**(4):563–66.
1964*b*. Seasonal activity and control of the Monterey pine tip moth. Jour. Econ. Ent. **57**(6):825–29.

Lange, W. H.
1936. The biology of the orange tortrix, *Eulia* (*Argyrotaenia*) *citrana* Fern. Calif. Dept. Agr. Monthly Bul. **25**(2):283–5.
1937. Califorina pine tip moths of the genus *Rhyacionia*. South. Calif. Acad. Sci. Bul. **36**(1):25–34.

Lyon, R. L.
1958. California flatheaded borer. U. S. Dept. Agr., Forest Pest Leaflet **24**. 7 pp., 4 figs.
1959. Lindane, a better insecticide for pine engraver beetles. U. S. Dept. Agr., Forest Ser. Misc. Paper **29**. 2 pp., 2 figs.

MacKay, M. R.
1959. Larvae of North American Olethreutidae (Lepidoptera). Canadian Ent. **91**, supplement 10. 338 pp., 161 figs.

Mathias, M. E., and E. McClintock
1963. A checklist of woody ornamental plants of California. Univ. Calif. Agr. Exp. Sta. Manual **32**, 65 pp.

-ekauff, W. W.
The siricid wood wasps of California. Univ. Calif. Insect Surv. Bul. **6**(4):56–77. 20 figs.

Middleton, W.
1931. A new species of sawfly of the subgenus *Zadiprion* with a description of the male of *N.* (Z.) *vallicola* Roh. and a key to the species of the subgenus. Ent. Soc. Wash. Proc. **33**(7):165–70.

Moore, A. D.
1957. The relative toxicity of DDT, toxaphene, lindane and isodrin to *Dendroctonus brevicomis* Lec. and *Ips confusus* (Lec.). Jour. Econ. Ent. **50**(5):548–50.

Rohwer, S. A., and W. Middleton
1932. Descriptions of five nearctic sawflies of the tribe Hemichroini. Ent. Soc. Wash. Proc. **34**(6):93–97.

Schuh, J., and D. C. Mote
1948. Insect pests of nursery and ornamental trees and shrubs in Oregon. Oregon Agr. Exp. Sta. Bul. **449.** 164 pp., 83 figs.

Severin, H. H. P.
1950. Spittle-insect vectors of Pierce's disease virus, 2. Life history and virus transmission. Hilgardia. **19**(11):357–82.

Stark, R. W. and J. H. Borden
1965. A field test of lindane for prevention and control of attack by *Ips confusus* (LeConte) (Coleop., Scolytidae) in slash. Jour. Econ. Ent. **58** (5):994–96.

Thomas, J. B.
1965. The immature stages of Scolytidae: the genus *Dendroctonus* Erichson. Canadian Ent. **97**(4):374–400.

U. S. Department of Agriculture, Plant Pest Control Division
1960. Cooperative Economic Insect Report **10**(11):158.
1961*a*. Cooperative Economic Insect Report **11**(33):784.
1961*b*. Cooperative Economic Insect Report **11**(34):807.
1962*a*. Cooperative Economic Insect Report **12**(15):372.
1962*b*. Cooperative Economic Insect Report **12**(35):974.
1963*a*. Cooperative Economic Insect Report **13**(14):351.
1963*b*. Cooperative Economic Insect Report **13**(34):993.
1964. Cooperative Economic Insect Report **14**(44):1191.
1965*a*. Cooperative Economic Insect Report **15**(21):514.
1965*b*. Cooperative Economic Insect Report **15**(23):580.

Wagener, W. W.
1936. The cypress bark canker and other cypress diseases. Western Shade Tree Conf. Proc. **3**:79–85.

Whiteside, J. M.
1951. The western pine beetle, a serious enemy of ponderosa pine. U. S. Dept. Agr. Circ. **864,** 11 pp., 7 figs., 1 color plate.

ACKNOWLEDGMENTS

Many people have made contributions to these studies, particularly the following persons: at the U. S. National Museum, Washington, D.C.: J. F. G. Clarke, W. H. Anderson, and C. F. W. Muesebeck; in the U. S. Department of Agriculture, Plant Pest Control Division: the late Kelvin Dorward, and Joe Gentry; in the U. S. Forest Service: John Pierce; in the Los Angeles County Agricultural Commissioner's office: Donald Ferrell; William Griffin, of Griffin and Morgan Co., Santa Barbara; Harold Mitchell, of J. Harold Mitchell Co., San Gabriel. The interest and support of C. S. Koehler and Howard McKenzie, of the University of California, are gratefully acknowledged.

10*m*-10,'67(H3468)J.F.