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INSECTS AND OTHER PESTS ATTACKING AGRICULTURAL CROPS

E. O. ESSIG AND W. M. HOSKINS

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B. H. Crocheron, Director, California Agricultural Extension Service.

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CONTENTS

INSECTS AND OTHER PESTS ATTACKING AGRICULTURAL CROPS

E. O. ESSIG[1] AND W. M. HOSKINS[2]

FOREWORD

THIS CIRCULAR replaces those portions of Circular 265, *Plant Disease and Pest Control,* which deal particularly with insects, mites, and related animals, attacking agricultural crops in California. There are more ample publications on some of the subjects. A number of Experiment Station publications treating single insects or groups of insect pests are available and may be selected from a list of publications sent upon request by the College of Agriculture, Berkeley, California.[3] Consultations, publications, and other services of the College of Agriculture are free as far as possible.

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A. D. Borden, S. F. Bailey, J. E. Eckert, J. F. Lamiman, A. E. Michelbacher, L. M. Smith, R. H. Smith, and F. H. Wymore have collaborated in preparing this circular.

[3] Another valuable reference to such pests of crops and ornamentals in California is:

Essig, E. O. Insects of western North America. 1025 p. 766 figs. The Macmillan Co., New York. 1926. (Includes descriptions, illustrations, and control of all common insects west of the Rocky Mountains.)

Rodents are not included in this circular. They are discussed in:

Storer, T. I. Control of injurious rodents in California. California Agr. Ext. Cir. 79:1–55. 1933.

INSECT PESTS BY CROPS

ALFALFA

Alfalfa Caterpillar, *Eurymus eurytheme* (Bdv.).—The caterpillars are about 1 inch long and dark green with a distinct line on each side which is often pale yellow or white. They feed on the leaves and may entirely defoliate the plants. The yellow butterflies may be seen in great

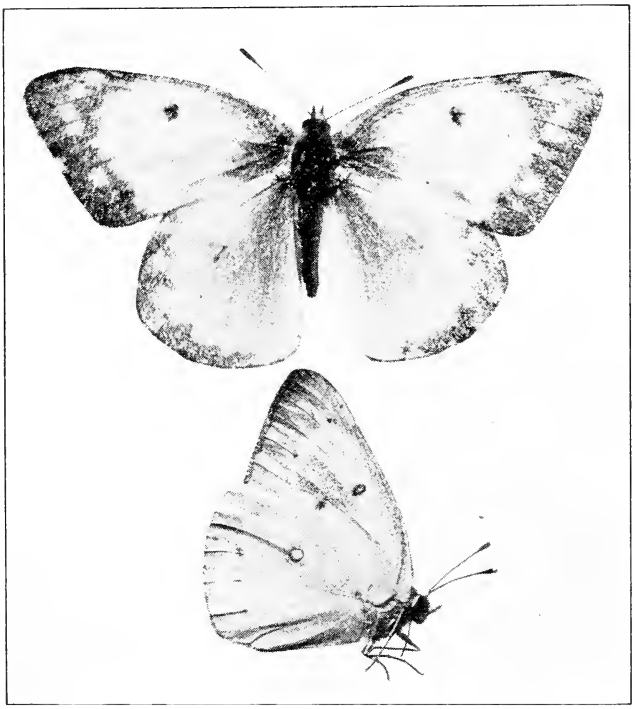


Fig. 1.—The alfalfa butterfly, the adult form of the alfalfa caterpillar.

numbers hovering over the fields. Cutting as soon as the caterpillars appear in destructive numbers, followed by irrigation, is the best method of control.

Alfalfa Weevil,[4] *Phytonomus variabilis* (Herbst).—The adult stage of this insect is a small brown weevil or snout beetle, 3/8 inch long, which feeds on the leaves of the alfalfa and related plants and lays its small, nearly globular, orange-colored eggs in the stems of the plants. The

[4] For further information, see: Essig, E. O., and A. E. Michelbacher. The alfalfa weevil. California Agr. Exp. Sta. Bul. 567:1–99. 1934.

mature larva is bright green, about ¼ inch long, with a small black head and a white strip down the back. Larvae are legless, but quite able to crawl over the plants upon which they feed. Although the stems are somewhat injured, the larvae are primarily leaf feeders and when enormously abundant may defoliate the plants. When mature the larvae spin thin lace-like cocoons in the debris at the bases of the plants and transform into pupae and eventually into adults. Serious injury to alfalfa by this insect can usually be prevented by keeping the crop growing vigorously and by timely cuttings. Great numbers of the larvae and pupae are killed by the heat of the sun after mowing.

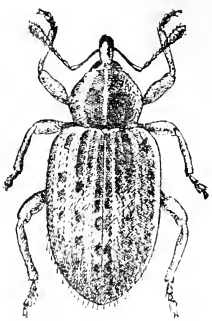


Fig. 2.—The adult alfalfa weevil. (After U. S. Dept. Agriculture.)

Whenever sufficiently injurious, it may be most cheaply controlled by dusting with a mixture of equal parts of commercial calcium arsenate and dusting sulfur applied at the rate of 4 pounds to the acre.

Armyworms and Cutworms.—See p. 89.

Clover Leaf Weevil, *Phytonomus punctatus* (Fab.).—The clover leaf weevil is very similar in appearance to the alfalfa weevil except that the

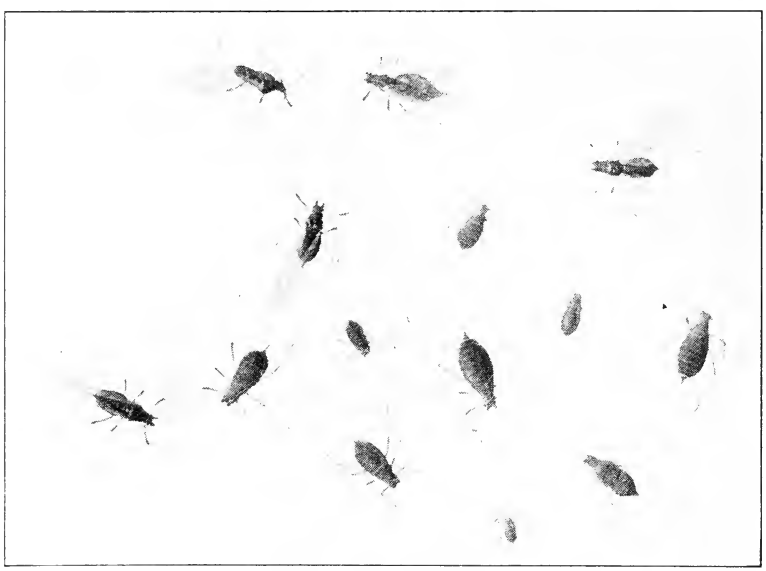


Fig. 3.—The pea aphid, often a serious pest of alfalfa and peas.

various stages are much larger. The larvae when small have the posterior half of the body pinkish, and when mature the pale strip down the back is bordered with pink lines. Although similar in habits it is much less

likely to prove a pest than the alfalfa weevil but may be controlled in the same manner.[5]

Clover or Almond Mite, *Bryobia praetiosa* Koch.—This mite, often known as the clover mite, may also appear in great numbers on alfalfa in the semiarid regions. Dusting with fine grades of dusting sulfur when temperatures are above 90° Fahrenheit is recommended only in cases of severe infestations. (See "Almond," p. 7.)

Clover Seed Chalcid, *Bruchophagus funebris* How.—The small white larva of this insect is just large enough to fill the seed. It occurs in sufficient numbers to reduce the seed crop greatly in most localities in the state. Destroying all the seed heads during winter and the straw after threshing will greatly reduce the infestation for the next year.

Grasshoppers.—See p. 94.

Pea Aphid, *Illinoia pisi* (Kalt.).—A large green aphid is often destructive to alfalfa in many parts of southern California. Spraying and dusting as suggested for this insect under "Pea," (p. 66) are usually impractical in alfalfa fields, but may be resorted to under certain conditions. Thorough irrigation following cutting; burning the stubble with an oil burner, as used for the destruction of foxtail and weeds; the application of granular cyanide under certain conditions; and the use of a chain drag to kill the aphids on the small plants may prove helpful in combating the pest. (See fig. 3.)

[5] Essig, E. O., and A. E. Michelbacher. The alfalfa weevil. California Agr. Exp Sta. Bul. 567:1-99. 1934.

ALMOND

Almond Mite, *Bryobia praetiosa* Koch.—The almond mite is the largest orchard mite, nearly the size of a pinhead; it is brownish or greenish with reddish legs, the front pair as long as the body and much longer than the other legs. The bright-red, globular eggs are laid in great numbers on the limbs and twigs of the trees, where they remain through the winter and hatch in the spring. They also occur on the twigs and leaves throughout the summer and fall. Spray the trees in the winter (January and February) with 1–10 lime-sulfur, or 4 per cent tank-mix oil spray, or 5 per cent commercial oil sprays to destroy the eggs. To control the mite during the growing period of the trees apply dry sulfur, wettable sulfur spray (formula 29, p. 137), 1–50 lime-sulfur plus 5 pounds of wettable sulfur, 1½ per cent commercial summer oil sprays, or 1½ per cent tank-mix oils (p. 127), as soon as the mites appear in the spring and as often as necessary during the summer and fall.

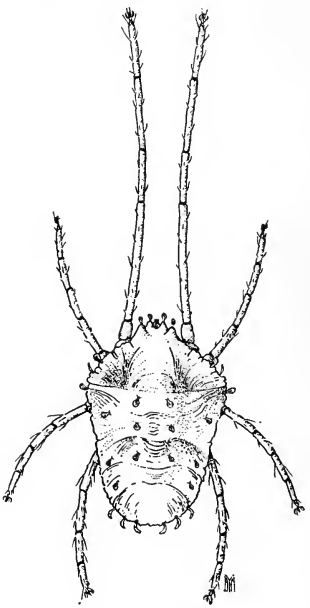


Fig. 4.—The adult almond mite. (After Quayle.)

The very finely divided dusting sulfurs, now available, have been giving very satisfactory control of this mite during the past few years. They should be thoroughly applied.[6] Keep plants well irrigated if possible.

Common Red Spider, *Tetranychus telarius* Linn., **and the Pacific Mite,** *T. pacificus* Mc. G.—See "Plum, Prune," p. 73.

Pacific Peach Tree Borer.—See "Peach," p. 67.

Peach Twig Borer.—See under "Peach," p. 68.

Red-humped Caterpillar.—See under "Plum Prune," p. 75.

San Jose Scale.—See "Apple and Quince," p. 8.

[6] See: deOng, E. R. The control of red spiders in deciduous orchards. California Agr. Exp. Sta. Bul. 347:37–83. 1922. (This bulletin is out of print, but may be consulted in many city and county libraries in California.)

APPLE AND QUINCE

Combined Spraying.—(See spray program under "Codling Moth," pp. 9–15.)

1. For serious infestations of scale insects, for removal of moss or lichens, and for a general clean-up, use 1–10 lime-sulfur, or 4 per cent tank-mix oil sprays or 5 per cent commercial oil emulsions particularly with caustic soda (formula 23, p. 129) during the winter.

2. For green, rosy, and woolly aphids, use nicotine and soap (formula 24, p. 132), or miscible oils, (according to recommendations of manufacturer), lime-sulfur, nicotine and oil emulsions (formula 22, p. 129), just as the buds are beginning to open. If only the first two are present and scab is a serious pest, substitute late dormant lime-sulfur, 1–10. This will assist in the control of the San Jose scale, if present. Combinations of oil sprays for insects, with lime-sulfur or bordeaux mixture for fungus diseases are often considered advisable, but for spring and summer application oil emulsions prepared with soap should not be used in combinations with, preceding, or following the application of lime-sulfur spray.

3. For codling moth and scab use 2 to 3 pounds of powdered, or 4 to 6 pounds of paste, standard arsenate of lead to 100 gallons of 1–35 lime-sulfur, when the petals are falling. For mildew, add 8 pounds of wettable sulfur paste to each 100 gallons of the above and ½ pint of Black Leaf 40 for green or rosy aphid. For later infestations of codling moth and scab, repeat this treatment and also that for mildew and aphid if these need attention.

In large apple-growing districts obtain advice of local horticultural authorities for modifications of the above.

4. For summer infestations of aphids use oil and nicotine (formula 21, p. 128, with summer oil) or nicotine and soap (formula 24, p. 132). For red spider use either a 1 per cent light oil emulsion or dusting sulfur.

Apple Skin Worm, *Tortrix franciscana* (Wlshm.).—The apple skin worm somewhat resembles the fruit tree leaf roller. The caterpillars are most numerous and destructive, however, in the fall of the year, when they feed on the skin of the fruit at points of contact or at the stem and blossom ends. If carried on the fruit into storage they will continue to injure the fruit unless it is subjected to cold-storage temperatures.

Best control has been obtained by destroying the egg masses. An early application of 2½ per cent lime-sulfur or 2 per cent winter oil emulsion or tank mix (p. 126) applied on the trunk and main limbs will destroy the egg masses occurring before blossom time. Two or three applications

of summer-type oil emulsion (2 gal.–100) on the foliage and fruit at intervals of 3 weeks after blooming will destroy later broods. Usually about three applications are sufficient.

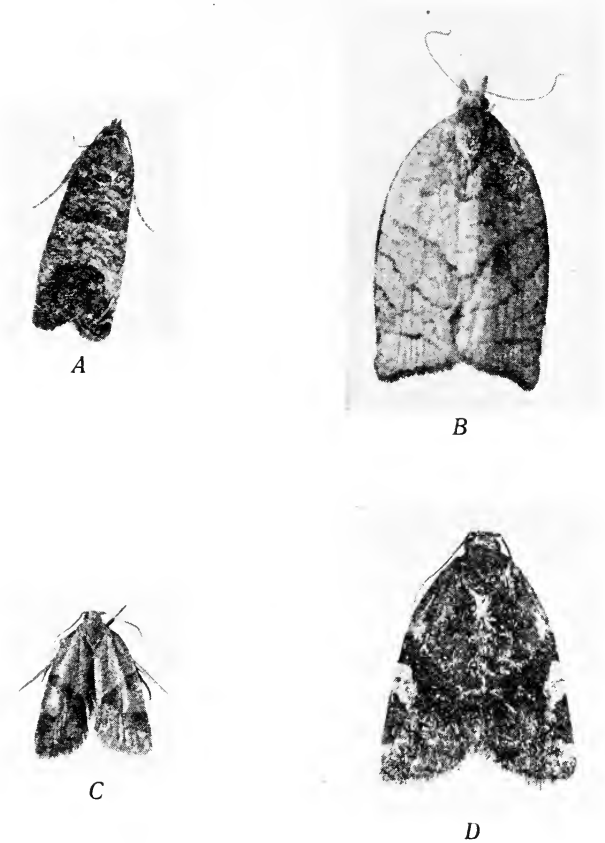


Fig. 5.—Apple insects: *A*, codling moth; *B*, pandemis moth; *C*, adult of the apple skin worm; *D*, adult of the fruit tree leaf roller. (After Borden.) Also see fig. 12.

Cankerworms.—See p. 92.

Codling Moth, *Carpocapsa pomonella* (Linn.).—The common white or pinkish worm or caterpillar nearly 1 inch long is found inside the fruit. For control, spray from two to five times as needed.

The most important problem confronting the apple and pear growers throughout the state is the control of the codling moth in an efficient manner which will at the same time leave very little spray residue at the time of harvest. In order to accomplish this it is advisable to guard against the past tendency to concentrate spraying efforts in the late summer months. Not only has late spraying failed to give the complete

control expected and desired, but it has resulted in objectionable amounts of spray residue remaining on the fruit when harvested.

After a discussion by representatives of the University of California, county agricultural commissioners, and the California State Department of Agriculture, the following recommendations were adopted as joint recommendations by these agencies.

JOINT RECOMMENDATIONS FOR CONTROL OF THE CODLING MOTH IN APPLES AND PEARS IN NORTHERN CALIFORNIA FOR 1934

I. Spray Schedule

1. Lead arsenate has proved to be the most effective in codling moth control. When powdered lead arsenate is used, best results will be obtained if this is mixed into a creamy paste with a small amount of water before placing in the spray tank.
2. Spreader. One-half (½) pound of dry protein-caseinate spreader should be used in each 100 gallons of dilute lead arsenate spray.
3. Calyx sprays. For effective control, calyx sprays are essential. Two such sprays are more effective than one.

   Formulas:

   First calyx spray:

   Standard lead arsenate.....3 pounds dry or 6 pounds paste
   Spreader.....½ pound
   Water.....100 gallons

   Second calyx spray:

   Standard lead arsenate.....4 pounds dry or 8 pounds paste
   Spreader.....½ pound
   Water.....100 gallons

   If only one calyx spray is to be used, 4 pounds of dry arsenate of lead or 8 pounds of paste should be used.

   Time of application: Applications of the first calyx spray should begin when 40 per cent of the petals have fallen. Application of the second calyx spray should begin immediately after the first is completed. Not more than 5 to 10 days should elapse between these sprays.
4. First cover spray.

   Formula:

   Standard lead arsenate.....3 pounds dry or 6 pounds paste
   Spreader.....½ pound
   Water.....100 gallons

   Time of application: Just after the first decided flight of moths as indicated by moths caught in bait pans (2 to 5 per pan). In no case should the first cover spray be delayed beyond three weeks after the start of the last calyx spray.
5. Second cover spray.

   Formula:

   Standard lead arsenate.....3 pounds dry or 6 pounds paste
   Spreader.....½ pound
   Water.....100 gallons

   Time of application: From June 10 to 20. The date of application should be governed by the catch of moths in bait pans.

6. Third cover spray.
   Formula:
   Standard lead arsenate.....3 pounds dry or 6 pounds paste
   Spreader.....½ pound
   Water.....100 gallons
   Time of application: A third cover spray will be essential over the major part of the Sacramento Valley. The time of application will vary, according to districts, from July 5 to 15.
7. Additional cover sprays. For late ripening varieties of both apples and pears, additional cover sprays may be necessary. The same amount of lead arsenate and spreader should be used and the increase in size of fruit and the presence of adult moths as shown by the bait traps should govern the time of application.
8. Alternate cover sprays. When mites or leafhoppers are present, oil may be used in the first and second cover sprays. The oil should have an unsulfonated residue of 90 per cent or above and be a light-medium class of spray oil.
   Formula:
   Standard lead arsenate.....2 pounds dry or 4 pounds paste
   Spreader.....½ pound
   Oil.....1 gallon
   Water to make.....100 gallons
9. Mineral oil should not be used in combination with lead arsenate within three (3) weeks of picking.
10. Mineral oil and nicotine sprays may be used as late cover sprays when bait pans show a decided flight of moths. When bait trap catches are continuous, applications of this combination should be made every ten days.
    Formula:
    Mineral oil, light-medium to medium grade 90, to 95 per cent unsulfonated residue.....1 gallon
    Nicotine sulfate 40 per cent.....¾ to 1 pint
    Water to make.....100 gallons
11. Fish oil should not be used at all.
12. Calcium arsenate, manganese arsenate, or other non-lead arsenical compounds have not as yet proved satisfactory.
13. Cryolite with spreader and without oil has shown some promise as a substitute for lead arsenate in the late cover sprays.
14. After picking, pears should not be dipped in a dilute oil. Pears so treated do not ripen well.

From this spray schedule a program may readily be selected which can be adapted to any particular area. Consult with the Agricultural Commissioner or the Farm Advisor for further information.

II. Sanitation

During years of poor prices and low returns a considerable portion of produced fruit is not marketed nor destroyed. Worms in these orchards complete their life cycle with resulting increase in numbers the following year.

Sanitary measures aimed at destruction of the worms in such fruit are recommended.

1. Windfalls and Dropped Fruit: Destruction of windfalls and cull fruits has proved an effective method of reducing the amount of wormy fruit the follow-

ing season. Removal of such fruit at periods not to exceed seven days is most effective. Such fruit should be buried, fed to livestock, or otherwise destroyed. After harvest cull fruits still hanging should be removed from trees and destroyed.

2. Packing-Shed Sanitation: Dipping field boxes in boiling water or passing over steam jets for one minute will kill many worms without harm to the boxes. These containers should be treated at the end of each season.

   Cull fruits should not be permitted to accumulate at packing-sheds.

   Many worms brought into the packing-shed may be trapped in burlap strips placed about the shed. Such strips and scraps of lumber, leaf, and other trash, in the packing-house should be burned as soon as packing is completed.

3. Dry-Yards: Cores and fruit trimmings should be removed from the cutting tables and destroyed at least once a day. Unsanitary dry-yards have been responsible for huge losses from worms in adjacent trees the following year.

III. Banding Trees

The greatest number of overwintering worms are found on the trees. Many of these may be trapped by bands around the trunks. For a long time the use of bands has been found effective in reducing the numbers of second-brood worms. At first burlap bands were recommended. To be effective these had to be removed and the collected worms destroyed every ten days. Corrugated paper bands treated with chemicals which kill the worms have been found more effective and removal is not necessary until the winter. These bands should be in place in time to trap the first-brood worms as they leave the fruit.

Chemically treated strips of corrugated paper may be purchased, or the bands may be made on the farm.

Specifications for the chemically treated bands are as follows:

Corrugated paper—Single face, low corrugation, 0.009 screenings and screenings. This paper may be purchased from most paper companies and comes in rolls 250 feet in length and 24 inches wide, which is cut into twelve 2-inch widths, making 3,000 linear feet of bands.

The solution into which the rolls of paper are dipped is made up from the following formula:

Red engine oil (300 sec. viscosity, 65–70 per cent unsulfonated residue)	1½ pints
Beta naphthol (crude or refined)	1 pound

Do not prepare the bands indoors or near buildings if an open fire is used, for both beta naphthol and the oil are inflammable but not explosive. Beta naphthol fumes are irritating to the eyes, skin, and mucous lining of the nose, and caution should be exercised in unnecessarily coming in contact with the fumes or material. Use gloves in handling the material and treated bands.

The dip is best prepared out of doors in a small tub over a hot fire. Put the proper proportions of oil and beta naphthol together in the tub, heat and stir until all the beta naphthol is dissolved, and continue heating until the solution reaches a temperature of 265° to 270° Fahrenheit. Maintain this temperature throughout the dipping process. If the temperature is too high not sufficient material will be absorbed and if too low the openings in the corrugated paper will clog.

The usual practice is to apply these bands early in June and leave them on until February. If not applied in June, considerable benefit may be derived by applying

them in September and October, before the rains, as there is often a migration to the tree trunks when the top soil becomes wet and cold. On pears the rough bark should be scraped from the tree trunk during the winter in a ring 4 or 5 inches wide and approximately 18 inches from the base. During the latter part of May or early June the band should be applied single thickness to this cleaned area. On apples all the loose bark on trunk and main limbs should be removed before applying the bands. The ends should overlap about an inch and be tight to the tree and held there by a small staple or tack.

These bands will discolor the bark but little, and little if any injury will occur if the bands are applied to different parts of the trunk in successive years. Bands should not be applied to the thin bark of young trees.

Fig. 6.—Codling moth bait trap suspended on a standard in a pear tree. (After Borden.)

Bait Traps.[7]—During the past few years considerable attention has been given to the use of bait traps in connection with the control of the codling moth. The bait consists of a fermented liquid made of 1 part of Diamalt and 19 parts of water, to which 1 yeast cake is added. This mixture is then poured into small shallow porcelain pans from 8 to 10 inches in diameter and 3 to 4 inches deep. By means of wires and strings these pans are suspended in the tops of the fruit trees; they are examined daily and refilled about once a week. The number of pans or traps used

[7] See: Borden, Arthur D. Codling-moth bait traps. California Agr. Ext. Cir. 63:1–13. 1932.

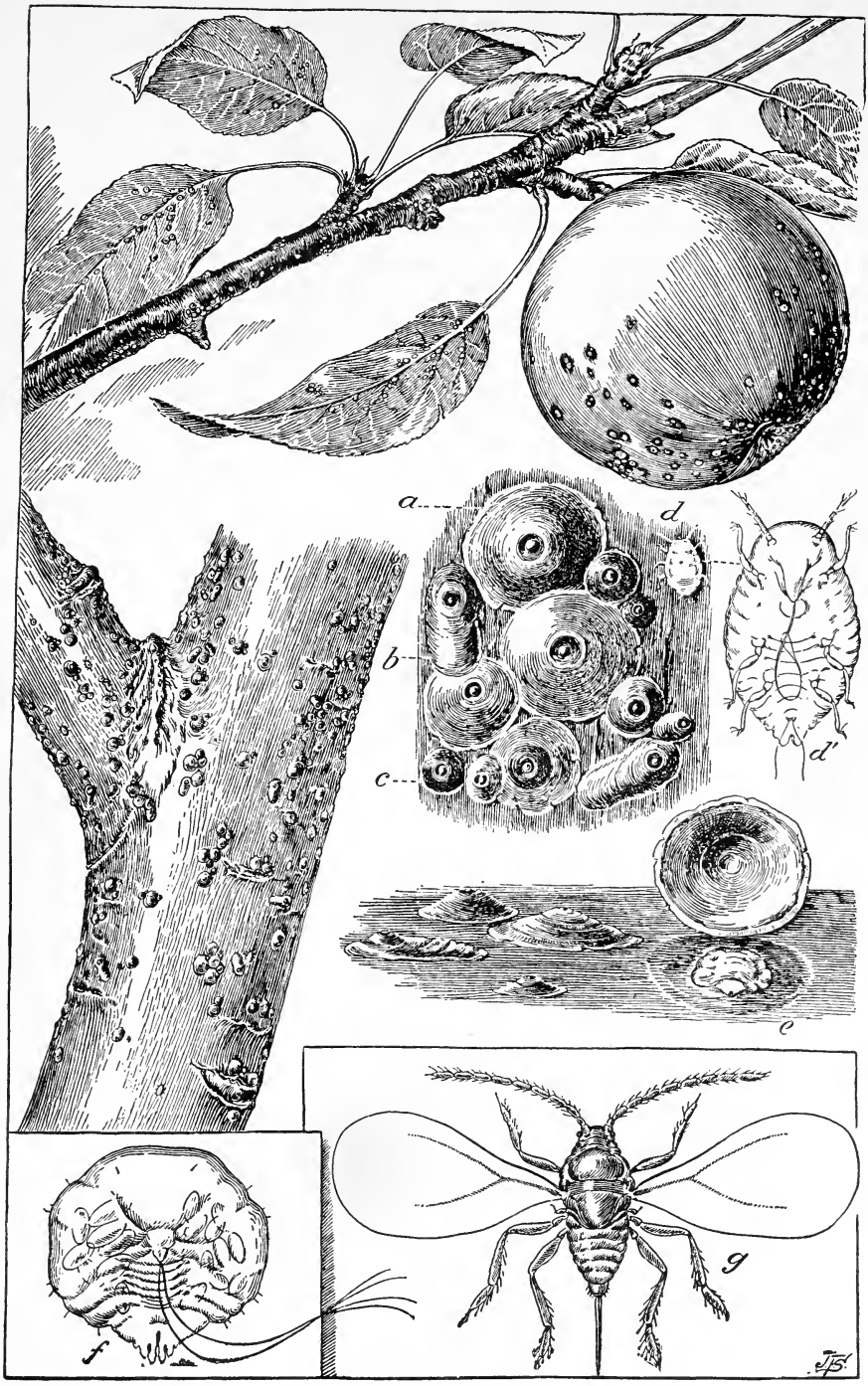


Fig. 7.—The San Jose scale: *a*, adult female scale; *b*, male scale; *c*, young scales; *d*, larva just hatched; *d'*, same, much enlarged; *e*, scale removed, showing body of female beneath; *f*, body of female insect, more enlarged; *g*, adult male. (After United States Department of Agriculture.)

depends upon the immediate conditions of the orchard and may vary from one pan to a tree to one for every two, three, or even six trees.

These bait pans serve several purposes: to determine the relative numbers of adults on the wing at a given time; to determine the appearances of the adults for the proper timing of sprays; and as a means of destroying the adults and thus reducing the number of eggs and worms.

Fruit Tree Leaf Roller, *Archips argyrospila* Walker.—The eggs are laid in small, flat, grayish or brownish masses, usually on two or three-year-old growth in the middle near the tops of the trees, in the fall. They hatch in the spring and the caterpillars draw the leaves together into compact rolls in which they live, and from which they wriggle violently if disturbed. When mature the larvae are nearly ¾ inch long, deep green, with the head and thoracic shield dark brown or black. The most satisfactory means of control is directed against the eggs and consists in the use of a 4 per cent miscible oil, 7 per cent commercial oil emulsions, or 4 per cent tank-mix oil spray (p. 126) during the winter. Great care must be taken to thoroughly drench the limbs and particularly the tops and outside branches. See fig. 12, p. 18.

Green and Rosy Apple Aphids, *Aphis pomi* DeGeer and *Anuraphis roseus* Baker.—These aphids are easily distinguished by their color and the characteristic curling of the leaves caused by their method of attack. Control measures are difficult and must be thorough to secure satisfactory results. Late dormant lime-sulfur, 1–10, applied just before the buds open, gives fair results in killing the eggs, but it is better to spray from the time of the bursting of the buds until the leaf buds are ½ inch long with nicotine and soap (formula 24, p. 132), or with nicotine and commercial oil emulsions or tank-mix oil sprays (formula 21, p. 128), or to dust thoroughly with 2 or 2½ per cent nicotine dust (see "Nicotine Dusts," p. 133). At this time the young stem-mothers may be destroyed as they hatch from the eggs.

Red-humped Caterpillar.—See under "Plum, Prune," p. 75.

San Jose Scale, *Aspidiotus perniciosus* Comst.; **Oyster-Shell Scale,** *Lepidosaphes ulmi* (Linn.); **and Other Scale Insects.**—The scales of the first are circular and gray; and those of the second are oyster-shaped and similar in color. They occur on all parts of the tree, the first causing a red or purplish stain on the bark and fruit. For the San Jose scale alone, spray with lime-sulfur, 1–10, and for all species use 3 per cent tank-mix oil of winter grade (p. 126), or with 5 per cent commercial winter oil emulsions. The lighter oil sprays are not so efficient as the heavier oil emulsions for the winter control of this insect. See fig. 7.

Tent Caterpillars.—See p. 100.

Tussock Moths: California *Hemerocampa vetusta* (Bdv.), **and Antique,** *Notolophus antiqua* (Linn.).—The caterpillars are brilliantly colored and clothed with tufts of white hair on the dorsum, and a single long black tuft at the rear and two in front, the last being responsible for the name "horn worms." The eggs appear as white, flat, felty masses on the old cocoons and on the limbs of the trees. They are deposited in late summer and fall, but do not hatch until the following spring. The female moths are wingless, while the males are normally winged.

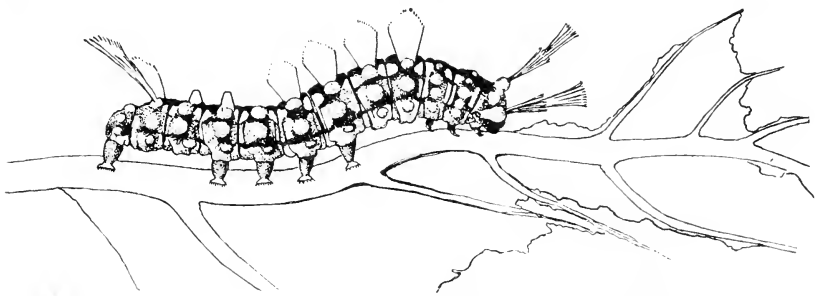


Fig. 8.—The larva of the California tussock moth. (After Volck.)

Control by removing the egg masses during the winter months. Great numbers of the caterpillars may be jarred from the trees and their reascending prevented by applying a band of cotton, wire screen, or tanglefoot around the trunks. Oil sprays applied shortly after the eggs hatch readily kill the young caterpillars. Such sprays are also of value in reducing the codling moth, skinworms, pandemis, cankerworms, bud moth, and other caterpillars. Poison sprays are of little use.

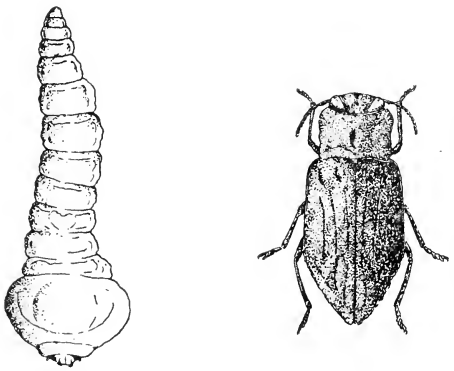


Fig. 9.—Western flat-headed borer, adult and larva. (After Woodworth.)

Western Flat-headed Borer, *Chrysobothris mali* Horn.—The full-grown larvae or borers are white or pale yellow and vary from ½ to 1 inch in length. The portion just behind the head is greatly enlarged and flattened, a character which is responsible for the common name. The adult beetles lay eggs on sunburned or other dead areas of the trunk exposed to the sun. Whitewash trunks to prevent sunburn and repel egg-laying. Avoid injuries and wounds. Dig out borers and paint

with asphaltum. Apply soap-naphthalene repellent (formula 17, p. 118) early in the spring when leaves start and repeat in 3 or 4 weeks.

Woolly Apple Aphid, *Eriosoma lanigera* (Hausm.).—This aphid is easily distinguished by its reddish body completely covered with white woolly wax. During the winter months spray with 2 per cent tank-mix spray (p. 126) or 2½ per cent commercial oil emulsions or miscible oil. For the root form, expose the crown of the roots and pour in 4 or 5 gallons of any of these spray mixtures and re-cover the roots. Carbon disulfide emulsion, diluted 1–200 and applied in quantities of from 5 to

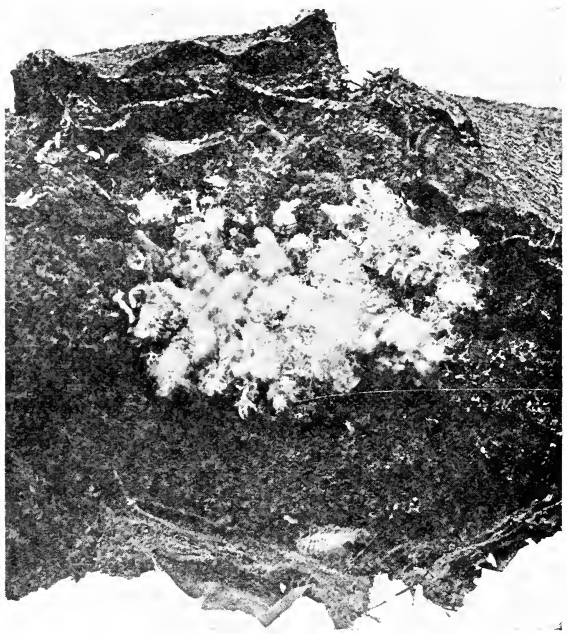


Fig. 10.—A colony of the woolly apple aphid.

10 gallons per tree during the late fall and winter months, is also effective in killing the woolly aphid on the roots. Nicotine and soap (formula 24, p. 132) is also effective, or refuse tobacco stems or leaves may be buried in the soil over the main roots during the rainy season. Use paradichlorobenzene during the fall. This material has killed young trees and must be used sparingly. Delicious and Northern Spy root-stocks are somewhat immune and are often used to avoid serious attacks of this pest. Of the two stocks, the former is the more vigorous and easily grafted but more susceptible to aphid attack. Summer infestations on the tops may be reduced by applying light summer oil emulsions or a combination of such emulsions with nicotine and soap (see formula 24, p. 132, plus summer oil).

APRICOT

Combined Spraying.—General clean-up may be accomplished by dormant oil sprays, 5 per cent commercial oil emulsion, 4 per cent miscible oils, or 4 per cent tank-mix oil sprays (p. 126). To control peach twig borer and brown rot, see the program recommended under "Peach Twig Borer," below.

Branch and Twig Borer, *Polycaon confertus* Lec.—A small elongated brown beetle, ¼ inch long, which bores clean round holes at the bases of buds, fruit spurs, and in the forks of small twigs. It often makes severe pruning necessary. The insect breeds in dead oaks and other native trees and in prunings of fruit and other trees. Clean up and burn dead brush and prunings around orchards. See fig. 62, p. 64.

Brown Apricot Scale, *Lecanium corni* Bouché, **and Black Scale,** *Saissetia oleae* (Bern.).—Immature scales of both species are brown or grayish, the latter having a distinct "H" on the back. They mature in May and June and are nearly hemispherical; the former, sometimes called "European fruit lecanium," is smooth and brown and the latter

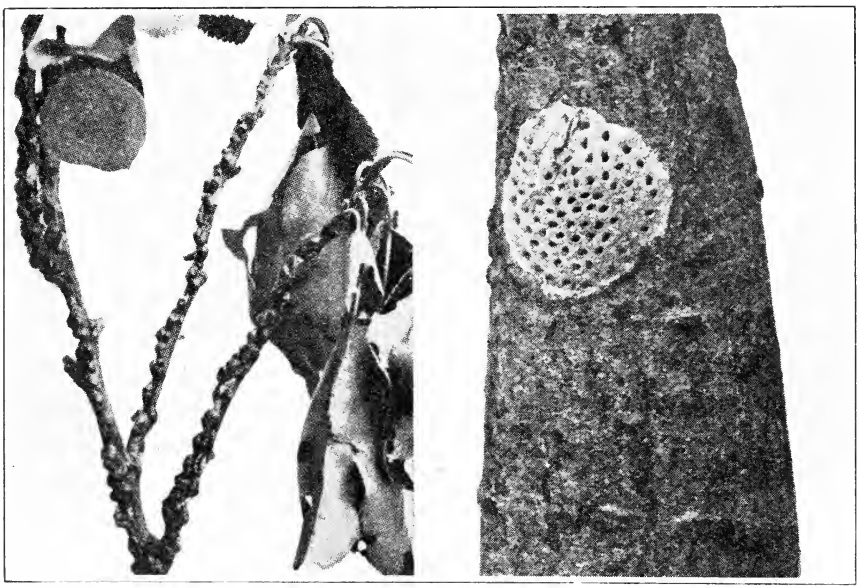


Fig. 11 Fig. 12

Fig. 11.—The brown apricot scale on small twigs of apricot, mature specimens. Only very small scales survive the winter and they occur on the new wood.

Fig. 12.—The egg-mass of the fruit tree leaf roller, showing the exit holes where the minute caterpillars emerged in early spring. Sprays should be applied in January and February before the eggs hatch. (See also fig. 5 *D.*)

black. Control is directed against the immature winter forms which occur on the new growth. Spray the trees when dormant, December to February, with 4 per cent commercial oil emulsion or 2 per cent tank-mix oil sprays (p. 126), or miscible oils, all of which give excellent control for both of these scales. Thoroughness of application is necessary.

Cankerworms.—See p. 92.

Fruit Tree Leaf Roller.—See "Apple," p. 8.

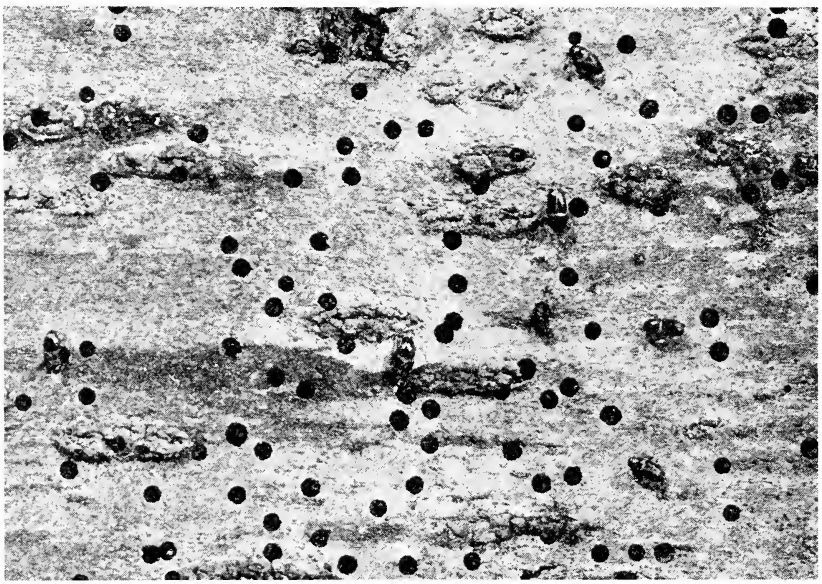


Fig. 13.—The shot-hole borer and exit holes on prune tree. (After L. M. Smith.)

Pacific Peach Tree Borer.—See "Peach," p. 67.

Peach Twig Borer, *Anarsia lineatella* Zeller.—See "Peach," p. 68, for a description of the insect. The following method of control is recommended by the University of California and the California State Department of Agriculture:

For apricots, where the use of lime-sulfur is likely to cause injury and where a combined insecticide and fungicide is desired to control the peach twig borer and brown rot (first spray), use bordeaux mixture 8–8–50 plus 3 pounds of dry basic arsenate of lead to every 100 gallons of the spray mixture. Apply this spray at the red-bud stage. Summer sprays with arsenicals should not be applied without consultation with competent authorities. See figs. 69 and 70, pp. 68 and 69.

Red-humped Caterpillar.—See under "Plum, Prune," p. 75.

Shot-Hole Borer,[8] *Scolytus rugulosus* Ratz., **and Lesser Shot-Hole Borer,** *Xyleborus saxeseni* (Ratz.).—These are very small brown beetles

[8] See: Smith, Leslie M. The shot-hole borer. California Agr. Ext. Cir. 64:1–13. 1932.

which bore into the sapwood and heartwood of different fruit trees, particularly prunes, plums, apricots, and cherries, preferring usually those in imperfect health. The white larvae of the shot-hole borer may be found during the winter months in the sapwood just beneath the bark, where they may completely girdle the trees. Keep trees well cultivated, fertilized, and irrigated throughout the year; prune out and burn all dead wood and trees to prevent spread; destroy all prunings immediately.

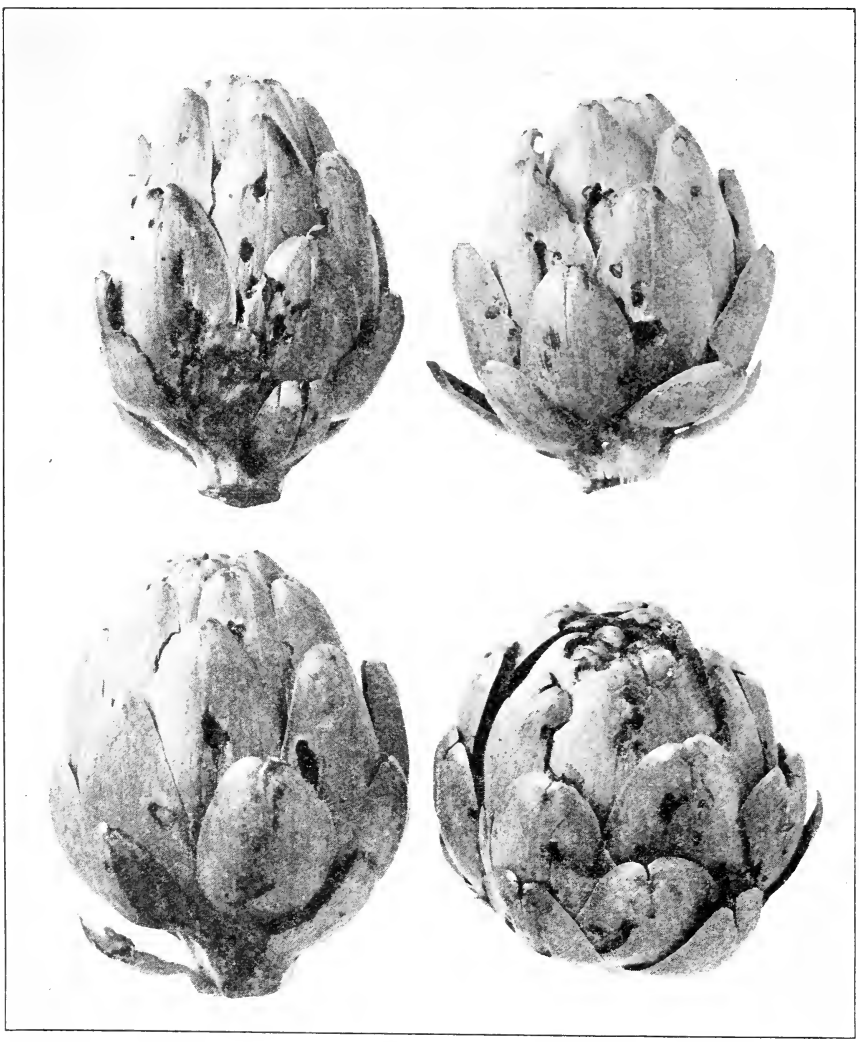


Fig. 14.—Artichokes showing the injury caused by the larvae of the artichoke plume moth.

ARTICHOKE

Artichoke Aphid, *Myzus braggi* Gill.—A green and black aphid often occurs in immense numbers on the heads and the undersides of the leaves. Dust with 2 per cent nicotine dust (see p. 133) or spray with nicotine and soap (formula 24, p. 132) or with pyrethrum or derris preparations.

Artichoke Plume Moth, *Platyptilia carduidactyla* (Riley).—This moth is 1 inch long, brown, and has narrow wings. The caterpillars are less than 1 inch long and yellowish with black heads. They feed chiefly upon the developing heads of the artichoke, making deep tunnels or eating through the bracts. They are very destructive and their work causes much loss every spring. See fig. 14.

Field sanitation is one of the best means of control. Infested heads should be removed at every picking and burned. Burning or deep plowing should be practiced to dispose of the old plants after cutting in May and June. Thistles and escaped or wild artichoke plants should be promptly destroyed to eliminate breeding places. Dusting with 2 per cent nicotine dust is recommended after each picking, until the attacks are reduced to a minimum.

The use of poisonous dusts, such as arsenate of lead, calcium arsenate, and fluosilicates, is to be avoided after the heads begin to form, because of possible danger to human health.

ASPARAGUS

Asparagus Beetle, *Crioceris asparagi* Linn.—The beetles are slender, ¼ inch long, metallic blue-black with red and yellow markings. The larvae are dull-brown or olive-green with black head and legs. They feed in great numbers upon the seedlings. Control by clean culture, by cutting and burning seedlings, or by spraying them with nicotine soap spray (formula 24, p. 132). A 2 per cent nicotine dust or 25 per cent calcium-cyanide dust also gives very efficient control. See fig. 15.

Garden Centipede,[9] *Scutigerella immaculata* (Newport).—The adults are small white, centipede-like animals, scarcely more than ¼ inch long. They live in the damp soil in great numbers and often seriously damage the young asparagus tips before they reach the surface of the soil. Clean culture, winter flooding, and crop rotation are the best control measures.

[9] See also: Wymore, F. H. The garden centipede. California Agr. Exp. Sta. Bul. 518:1–22. 1931.

Michelbacher, A. E. Chemical control of the garden centipede. California Agr. Exp. Sta. Bul. 548:1–19. 1932.

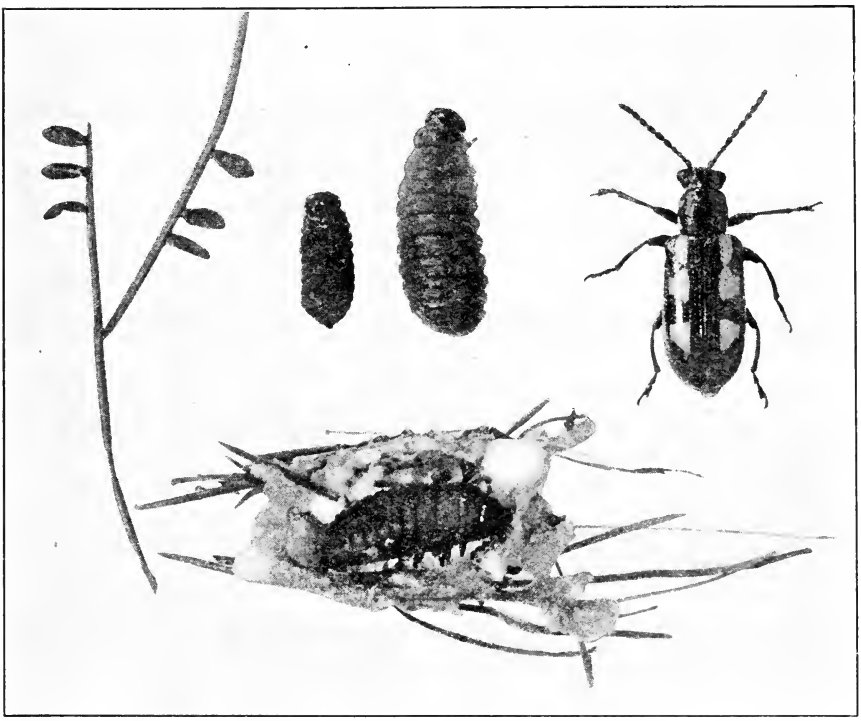


Fig. 15.—The asparagus beetle. Eggs attached to asparagus leaflets, larvae, adult, and larva in cell. (After Wymore.)

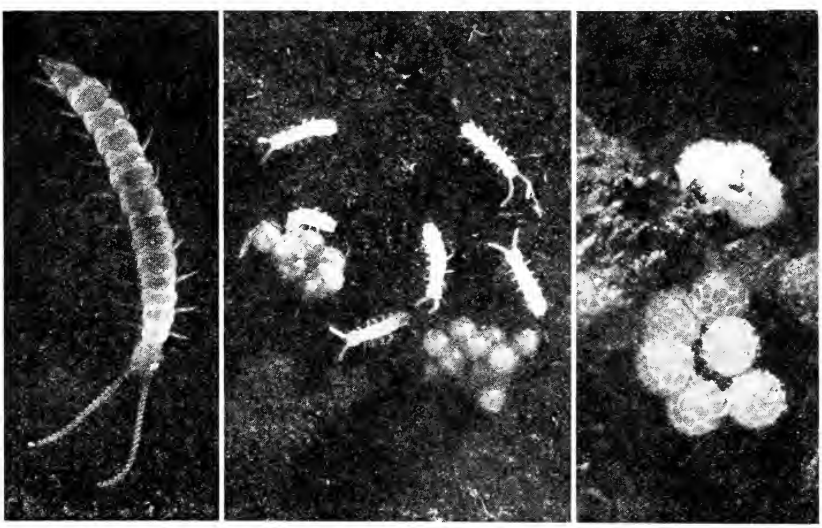


Fig. 16.—The garden centipede. Adult, eggs and newly hatched young, and eggs much enlarged. (After Wymore.)

ASTER, Callistephus chinensis (Nees)

Aster Root Aphid, *Anuraphis middletoni* (Thos.).—This dark green aphid often occurs in such numbers on the roots of aster plants as to kill them. Watering liberally with nicotine sulfate 40 per cent, diluted 1-600, or with carbon disulfide emulsion, 1-300, will control the pest. The aphids may be parasitized and then appear as pale inflated bodies.

Six-spotted Leafhopper, *Cicadula sexnotata* Fallén.—This leafhopper is about ⅛ inch long and yellow or yellowish green with black spots on the dorsal surface. It carries a disease of asters known as aster yellows, the symptoms of which are: the young leaves with transparent venation, erect; plants irregularly chlorotic (yellow), stunted, with abnormal branches; and flowers with part or all petals green. The disease is carried over not in the seed of the plants or the eggs of the insect, but in some diseased perennial plants. Numerous garden plants and weeds are affected. In lettuce it causes the white-heart disease. It was formerly rare in California though common in the East. No control is known. Herbaceous plants brought from the East should be watched, and suspicious ones destroyed. Any herbaceous perennials which appear abnormal should be destroyed. Other plants in California known to be subject to natural infection are: celery, California poppy, African marigold, Hamburg parsley, Short White carrots, White Belgian carrots, and zinnia.

AVOCADO[10]

Amorbia, *Amorbia essigana* Busck.—The eggs are laid in small, flat, greenish masses usually on the upper side of the leaf along the midrib. They hatch into small caterpillars that web the leaves together, and from which they wriggle violently if disturbed. The caterpillars are dark green and when mature attain lengths of from 1 to 1½ inches. Pupation occurs between two leaves that are webbed together. The moths are brown and are seldom seen in the daytime. Two or three dustings of basic lead arsenate will keep this insect in check.

Avocado Mite, *Paratetranychus yothersi* McG.—The mites are brown with a large pale area on the abdomen. They feed on the upper side of the leaf and spin very little web. The eggs are pale yellow and possess a single stalk. No guy threads are evident and yet small threads may be seen that tend to support the egg around the base. Dusting with sulfur gives excellent control.

Bean Thrips, *Hercothrips fasciatus* (Perg.), and **Greenhouse Thrips,** *Heliothrips haemorrhoidalis* Bouché.—These insects attack the leaves

[10] The paragraphs on amorbia, avocado mite, latania scale, and omnivorous looper, were prepared by H. L. McKenzie.

and fruit, causing a shiny, hard, discolored surface which has a tendency to check or crack, and which is covered with numerous fine specks of dark excrement. They are controlled by using a nicotine dust (see p. 133) or with commercially prepared nicotine and oil emulsion (formula 21, p. 128) or tank-mix spray (p. 127) with summer oil.

Branch and Twig Borer.—See "Apricot," p. 18. Sap collecting in the burrows produces, on evaporation, white powdery masses over the entrances, completely concealing them.

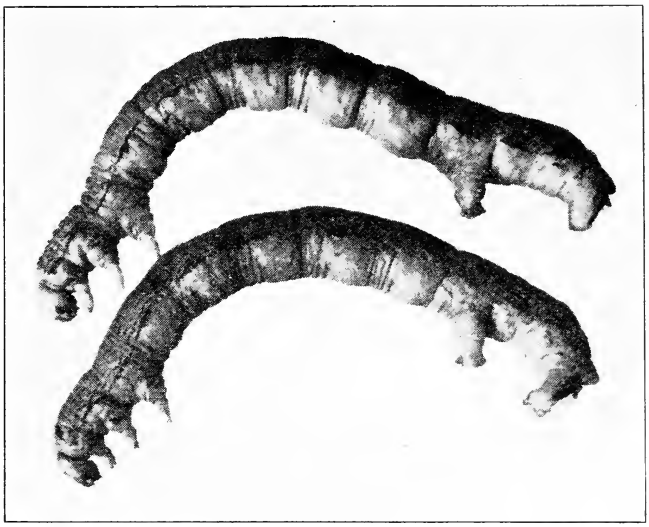


Fig. 17.—Mature caterpillars of the omnivorous looper. These insects are ravenous leaf eaters.

Latania Scale, *Aspidiotus lataniae* Sign.—A small, circular, flat, grayish-white scale occurs on the leaves, twigs, and fruit of the avocado. This scale increases rapidly and causes serious damage if allowed to reproduce without check. Fumigating with calcium cyanide dust gives good control. Where the trees become so large that a tent cannot be thrown over them, a medium oil, grade 4 (see p. 124), of 2 per cent is recommended.

Omnivorous Looper, *Sabulodes caberata* Gn.—The mature caterpillars are about 2¼ inches long and are usually brown with darker bands or stripes along each side and on the top of the body. They feed on the leaves and occasionally become abundant enough to strip the tree of practically its entire foliage. Pupation occurs between two leaves that have been webbed together. The moths are dull yellow and have a wing expanse of about 2 inches. They are nocturnal in habit and are seldom seen during the day unless disturbed from their resting places on the undersides of leaves. The eggs are laid in clusters on the undersides of

leaves. They are metallic green when laid but within 2 to 3 days turn to a chocolate brown. Two dustings with basic lead arsenate are fairly satisfactory in controlling this pest, the first is applied while the greatest number of individuals are in the young-caterpillar stage, the second at a time to reach the young caterpillars of the next generation.

Shot-Hole Borers.—See under "Apricot," p. 19.

Spanish Red Scale, *Chrysomphalus dictyospermi* Morgan.—A pale brown, circular scale infests all parts of the tree and is serious in greenhouses, and also in orchards in California. Control by hydrocyanic acid (HCN) fumigation, or if trees are too large, spray with summer or white oil sprays (2 per cent).

BARLEY

(See "Grain," p. 53)

BEAN

Bean Aphid, *Aphis rumicis* Linn.—A small black aphid collects in great numbers on the leaves and tender tips. Use 5 per cent nicotine dust or spray with nicotine-casein spray (formula 25, p. 132).

Bean Pod Borer, *Etiella zinckenella* (Treit.).—The larvae or caterpillars of this small gray moth burrow through the green pods of bush lima beans and feed upon the developing beans inside. No practical artificial control is now available. Some strains of the Hopi lima show resistance to its attacks.

Bean Thrips, *Hercothrips fasciatus* (Perg.).—This small dark thrips has black and white wings. The larvae are white and pinkish and appear in great numbers on the lower surface of the leaves. Treatment the same as for bean thrips as given under "Pear," p. 71.

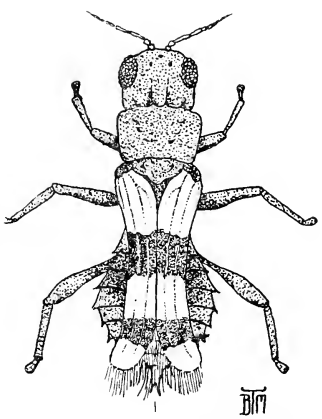


Fig. 18.—Adult bean thrips. (After Woodworth.)

Bean Weevil, *Mylabris obtectus* (Say).—The adults are short, robust, and about ⅛ inch long. The color varies from gray to brown with pale spots on the dorsum. The larvae work within the stored beans, from which the adults emerge through round holes. Breeding continues in storage. Fumigate in storage with carbon disulfide, 10–30 pounds to every 1,000 cubic feet of air space, the amount depending upon the tightness of the container; or with carbon tetrachloride or ethylene dichloride. The temperature should be above 70° Fahrenheit to secure satisfactory control by killing eggs, larvae, and adults.

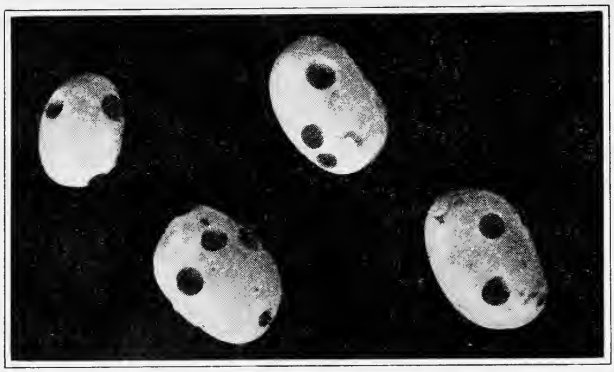


Fig. 19.—The work of the bean weevil on stored beans. (After deOng.)

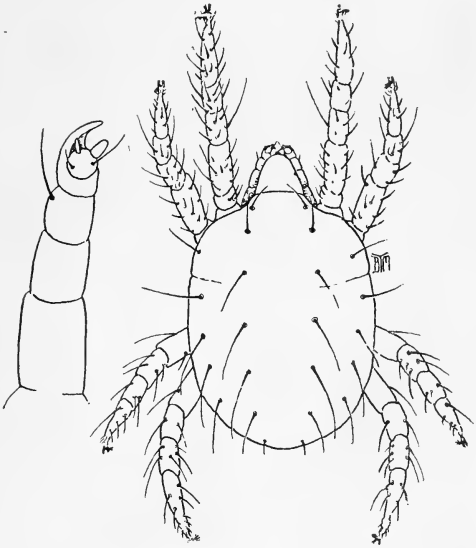


Fig. 20.—The adult red spider. (After Quayle.)

Red Spider, *Tetranychus telarius* Linn., **Pacific Mite,** *T. pacificus* McG., **and Two-spotted Mite,** *T. bimaculatus* Harvey. — These are very small, yellow, pale-green or reddish mites, the third with two large dark spots on the body. They feed on the undersides of leaves and often spin a considerable web. If possible keep the beans well irrigated and cultivated and in good healthy condition. Begin sulfuring as soon as the mites appear and continue throughout the summer, using 90 parts of dry sulfur to 10 parts of finely ground dry hydrated lime.

Root-Knot Nematode.—See p. 96. Black eyes and teparies are more resistant than other beans, but are sometimes badly infested.

Wireworms.—See p. 101.

BEET

Armyworms and Cutworms.—See p. 89.

Beet Leafhopper, *Eutettix tenellus* (Baker).—Curly top, sometimes called curly leaf or blight, is transmitted by the beet leafhopper. Leaf margins on affected plants curl inward or rarely outward and are much dwarfed and deformed; plants are stunted, and easily killed by drought and heat; young leaves show transparent venation (a clearing of the ultimate leaf vein branches); and a warty condition usually develops on

the backs of veins on old leaves. Roots often become hairy and show dark rings in cross section.

In the cool districts subject to ocean fogs, the insects do not reproduce abundantly and the disease when established is less injurious. Beets in all other parts of the Pacific slope and of the Rocky Mountains are liable to injury, but in certain regions have been observed to suffer less than

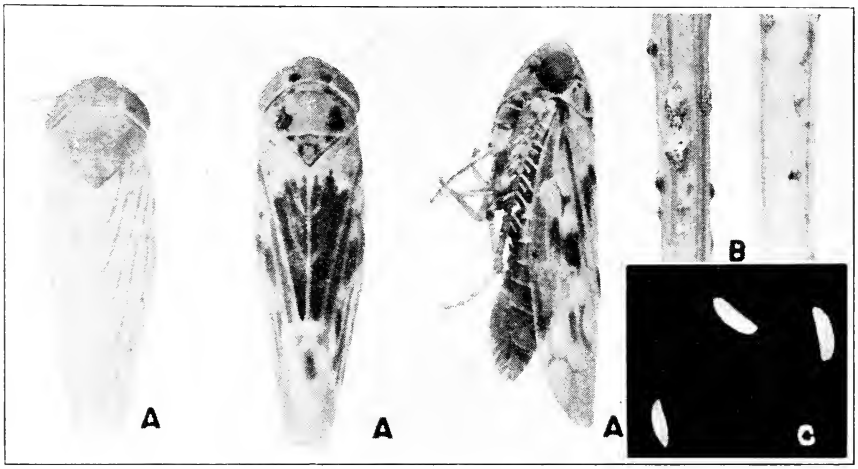


Fig. 21.—The beet leafhopper: *A*, light and dark color phases of the adults; *B*, egg punctures in the leaf petioles; *C*, eggs, much enlarged. (After Severin.)

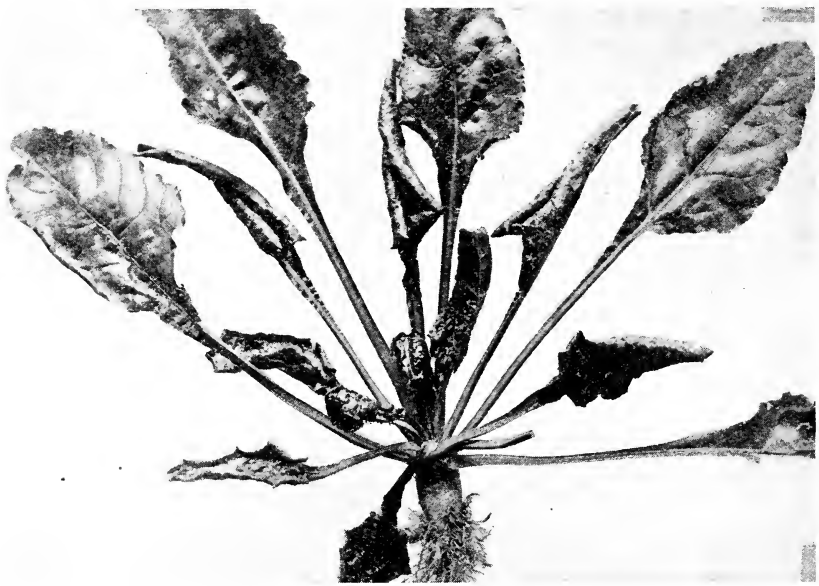


Fig. 22.—Young sugar beet infected with curly top disease. (After Severin.)

in others. Early planting (December to March 1 in interior regions) to bring the beet to a good size before the spring invasion of the insects from plains and foothills is generally successful except in years following early fall rains, which bring up filaree and other vegetation and cause a large number of insects to winter in the cultivated area. In the fog belt and coast valleys of central California early planting, then cessation, then resumption of planting in May and June is recommended.[11] Blighted stecklings do not produce seed successfully, although the symptoms may not always be apparent.

It has been shown that beans, beets (all varieties), spinach, Swiss chard, tomatoes, potatoes, peppers, cucumbers, squashes, varieties of melons, other garden plants, and many weeds, become stunted and unproductive from this disease in districts and seasons when it is severe.[12] The specific symptoms described for beets are not always developed, and the nature of the disease can be determined only by expert laboratory tests involving use of the leafhopper.

The beet leafhopper is wingless in the immature form and winged when full grown. The adults average about ¼ inch in length. The color varies with the season, those of the spring brood being pale green, those of the summer brood cream-colored, and the winter generations dark-colored with darker markings on the wing covers. The insects are to be found chiefly on the under surfaces of the leaves or between the stems near the crown, thus introducing the virus which causes the characteristic curly top. A pyrethrum-oil spray has been developed for the control of this insect in cultivated sugar-beet fields, but is likely to prove to be too expensive for practical purposes. Preparations of oil and pyrethrum are also used to kill the hibernating forms in the breeding grounds of the foothills.

Beet or Spinach Leaf-Miner.—See "Spinach," p. 80.

Grasshoppers.—See p. 94.

[11] See: Adams, R. L. The sugar beet in California. California Agr. Exp. Sta. Cir. 302:1–34. 1926. (This circular is now out of print but may be consulted in many city and county libraries in California.)

And also: Severin, Henry H. P. Curly top symptoms on the sugar beet. California Agr. Exp. Sta. Bul. 465:1–35. 1929.

[12] Further discussion will be found in the following papers, which are somewhat technical:

Severin, Henry H. P., and Charles F. Henderson. Some host plants of curly top. Hilgardia Vol. 3(No. 13): p. 339–393. (Out of print.)

Severin, Henry H. P. Additional host plants of curly top. Hilgardia Vol. 3(No. 20): p. 597–637. (Out of print; this and the preceding paper may be consulted at many city and county libraries in California.)

Severin, Henry H. P. Modes of curly-top transmission by the beet leafhopper, *Eutettix tenellus* (Baker). Hilgardia Vol. 6(No. 8): p. 253–276. 1931.

Severin, Henry H. P. Field observations on the beet leafhopper, *Eutettix tenellus*, in California. Hilgardia Vol. 7(No. 8): p. 281–360. 1933.

Larger Sugar Beet Wireworm, *Limonius californicus* (Mann.), **and the Ash-winged Click Beetle,** *Anchastus cinereipennis* (Esch.).—The larvae are the characteristic yellowish, smooth, shiny, worms found killing young beet seedlings, more particularly in the spring of the year. When fully grown they are from ½ to 1 inch in length. The adults are active, brownish or blackish click beetles. Practice clean culture, plant early, plow in the fall and stir ground thoroughly to kill immature forms in the soil. Baits are sometimes used, but are impractical for sugar-beet culture.

Nematodes.—See p. 96. The beet is attacked by two species, the root-knot nematode, *Heterodera marioni* (Cornu), which produces galls on a number of plants, and the sugar-beet nematode, *Heterodera schachtii* Schmidt, which is confined mainly to beets and does not produce galls.

BULBS (DAFFODIL, FREESIA, GLADIOLUS, NARCISSUS, TULIP)

Bulb Fly, *Merodon equestris* (Fabr.).—A large bee-like fly gives rise to large whitish or brownish maggots inside the bulbs of narcissus, amaryllis, hyacinth, eurycles, galtonia, habranthus, hippeastrum, Spanish iris, lilies, tulips, vallota, onions, and shallots. The control is by treating in hot water for two hours at 110° Fahrenheit or fumigating with hydrocyanic acid (HCN) after digging or before planting.

Fig. 23.—The maggot or larva of the bulb fly in a narcissus bulb. The entire heart of the bulb has been destroyed. (After Essig, *Insects of Western North America,* by permission of the Macmillan Co., copyright owners.)

Bulb Mite, *Rhizoglyphus hyacinthi* Bdv.—This is a whitish or yellowish, slow-moving mite often with brownish spots on the body. It is most abundant on rotting bulbs, tubers, rhizomes, roots, and decaying vegetable matter generally, and is responsible for carrying fungus disease, causing rot, from infected to clean bulbs in the soil and in storage. Only clean bulbs should be planted. After digging and curing, dip the bulbs in a 2 to 4 per cent commercial lime-sulfur solution, preferably heated in a large kettle to 125° Fahrenheit for not over one minute. Dry and then place in dry, well-ventilated storage. Small lots of bulbs may be effectively treated with a liberal amount of 2 per cent sulfur-nicotine dust in paper-bag containers which

may be securely tied and the dust allowed to remain until ready to plant. This will also kill mealybugs and aphids.

Gladiolus Thrips, *Taeniothrips gladioli* M. & S.—A small yellowish-brown thrips may cause considerable damage to gladiolus and to a lesser extent to tigridias, montbretias, and the torch lily or red-hot poker.

The feeding may result in a silvering and drying of the leaves and malformation of the flowers. Corms may also be infested in storage. For field control, not yet satisfactorily solved, see "Onion Thrips," p. 65. For bulb treatment put 100 bulbs in a paper bag with 1 ounce of naphthalene for 12 days or longer; or calcium cyanide fumigation, 5 ounces to 1,000 cubic feet, for 3 hours and repeat 3 times at intervals of 10 days; or dip in hot water at 110° Fahrenheit for 10 minutes.

Narcissus Stem Nematode or Bulb Nematode, *Tylenchus dipsaci* Kühn.—Raised, blister-like areas appear on the surface of the leaves, and badly diseased plants are lighter-colored and greatly reduced in vigor. The cut bulbs show discolored streaks and rings. Gradually enlarging areas of infestation develop in plantings left year after year without digging. Many imported bulbs are somewhat infected and new areas of infestation are being discovered from time to time. A hot-water treatment, in which bulbs are immersed for 3 hours in water kept at a temperature of 110°–111.5° Fahrenheit is recommended. It is possible that higher temperatures may be used with advantage. Diseased plants should be destroyed as soon as detected. The remaining bulbs in an infested field should not be sent to market. It is probable that the apparently sound bulbs from infested fields may be treated and grown in clean land and a clean crop produced. Infested land should not be used for bulbs for several years. This is a new problem in California and is still under investigation.

BUSH FRUITS (BLACKBERRY, LOGANBERRY, RASPBERRY)

(See also "Currant, Gooseberry," p. 48)

Blackberry Mite, *Eriophyes essigi* Hassan.—This is a small microscopic mite causing the redberry condition of the Himalaya, Mammoth, and other blackberries and loganberries throughout the state. Early varieties such as the Advance blackberry and the Gardena and Lucretia dewberries and possibly other varieties do not appear to be susceptible to the attacks of this mite. The mites attack the drupelets of the berries shortly after the flowers open and continue to work in the fruit, preventing ripening. The winter is spent in the buds, and the pest can be effectually controlled by spraying the infested vines after pruning in February or March, as the leaf buds are opening, with lime-sulfur solution, 5 gallons to 100 gallons of water.

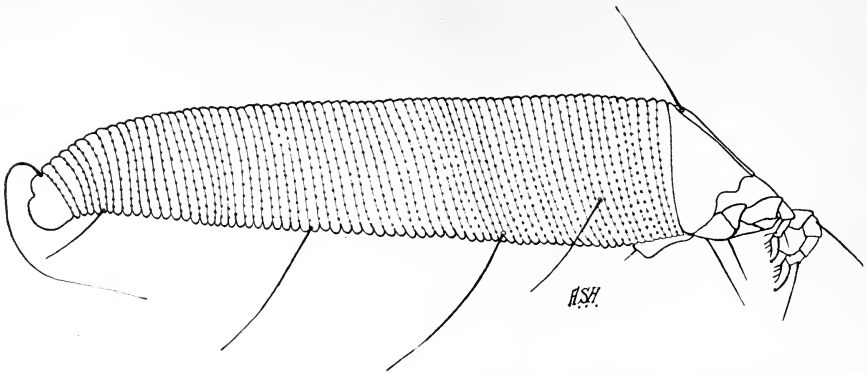


Fig. 24.—The blackberry mite, which causes the redberry disease of blackberries. Very greatly enlarged. (After Hassan.)

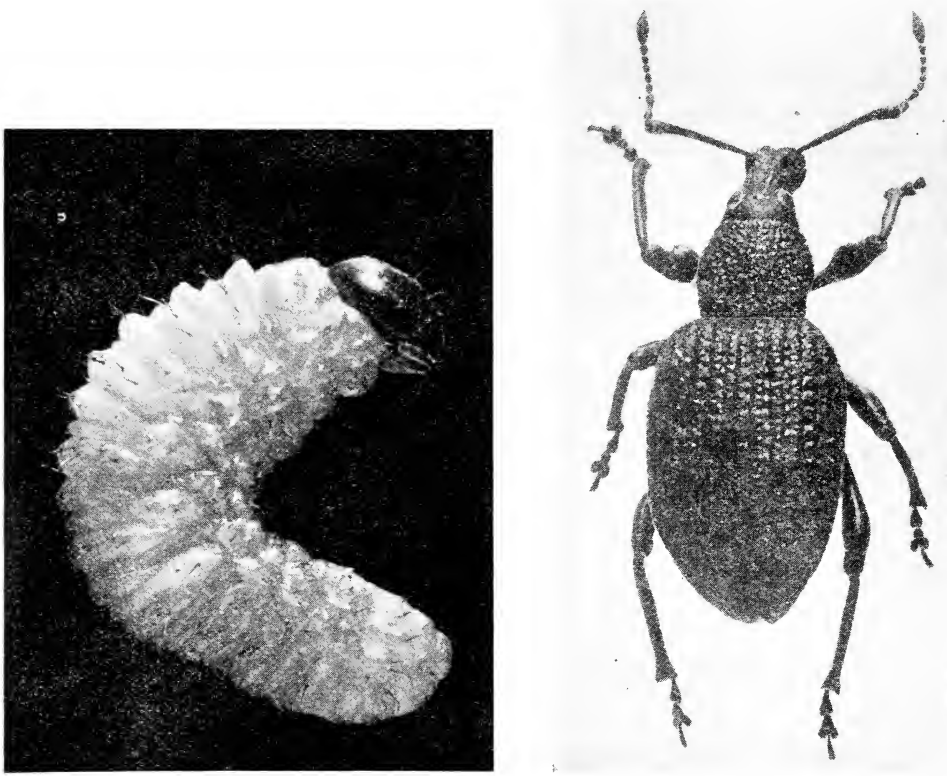


Fig. 25.—The larva and adult of the black vine weevil. The adults feed on the tops and the larvae on the roots of many plants. (After Leslie M. Smith.)

Good summer control is obtained in the Northwest by using lime-sulfur solution 1–40 applied about the middle of July, but this is not suitable for canning berries. Fall or winter control, if thorough, is sufficient.

Black Vine Weevil.—See p. 81 and fig. 25, p. 31.

Raspberry Horntail, *Hartigia cressoni* (Kirby).—The small white larvae are shaped somewhat like the letter "S" and when mature are nearly 1 inch long. They first attack the tender tips of the new canes and after girdling them and causing wilting they work down the pith to the roots, where they spend the winter. Cut off the young tips as soon as wilting is noticed so as to kill the larvae before they reach the roots. Remove all dead canes in winter, using care to dig out the borers at that time.

Rose Scale, *Aulacaspis rosae* (Bouché).—This is a pure-white scale often found in great numbers at the bases of the old canes. Spray in winter with 5 per cent commercial oil emulsions, with 4 per cent miscible oils or 4 per cent tank-mix oil spray (p. 126). Prune out old canes every year, because infestation spreads from them. The scale is serious only where pruning is not practiced every year. Lime-sulfur used as a fungicide also gives some control.

Snowy Tree Cricket,[13] *Oecanthus niveus* DeGeer.—A pale-green or yellowish cricket feeds on the buds, blossoms, and young fruit of the raspberry, often doing great damage to the second crop. Control measures are being completely revised and cannot be included at this time.

Strawberry Crown Moth or Cane Borer.—See "Strawberry," p. 82.

CABBAGE

Armyworms and Cutworms.—See p. 89. Scatter poison bran (formula 2 or 14, pp. 108 and 117) broadcast over the ground and plants in the evening.

Cabbage Aphid, *Brevicoryne brassicae* (Linn.).—This small green aphid entirely covered with fine whitish powdery wax is best controlled by liberal and repeated applications of nicotine-oil spray (formula 21, p. 128, with summer oil) or of nicotine soap (formula 24, p. 132). Nicotine dust gives only partial control.

Cabbage Maggot, *Phorbia brassicae* Bouché.—The small white maggots, ¼ inch long, are found tunneling the roots, which are often completely destroyed by them. The insect also attacks radishes, turnips, cauliflower, and other related plants. The most effective means of control is in the use of a repellent composed of 1 ounce of mercuric chloride to 8 gallons of water (formula 16, p. 118). Three applications should be made, using one cupful (½ pint) around the base of each plant, as follows: first application 3 or 4 days after transplanting; second applica-

[13] See: Smith, Leslie M. The snowy tree cricket and other insects injurious to raspberries. California Agr. Exp. Sta. Bul. 505:1–38. 1930.

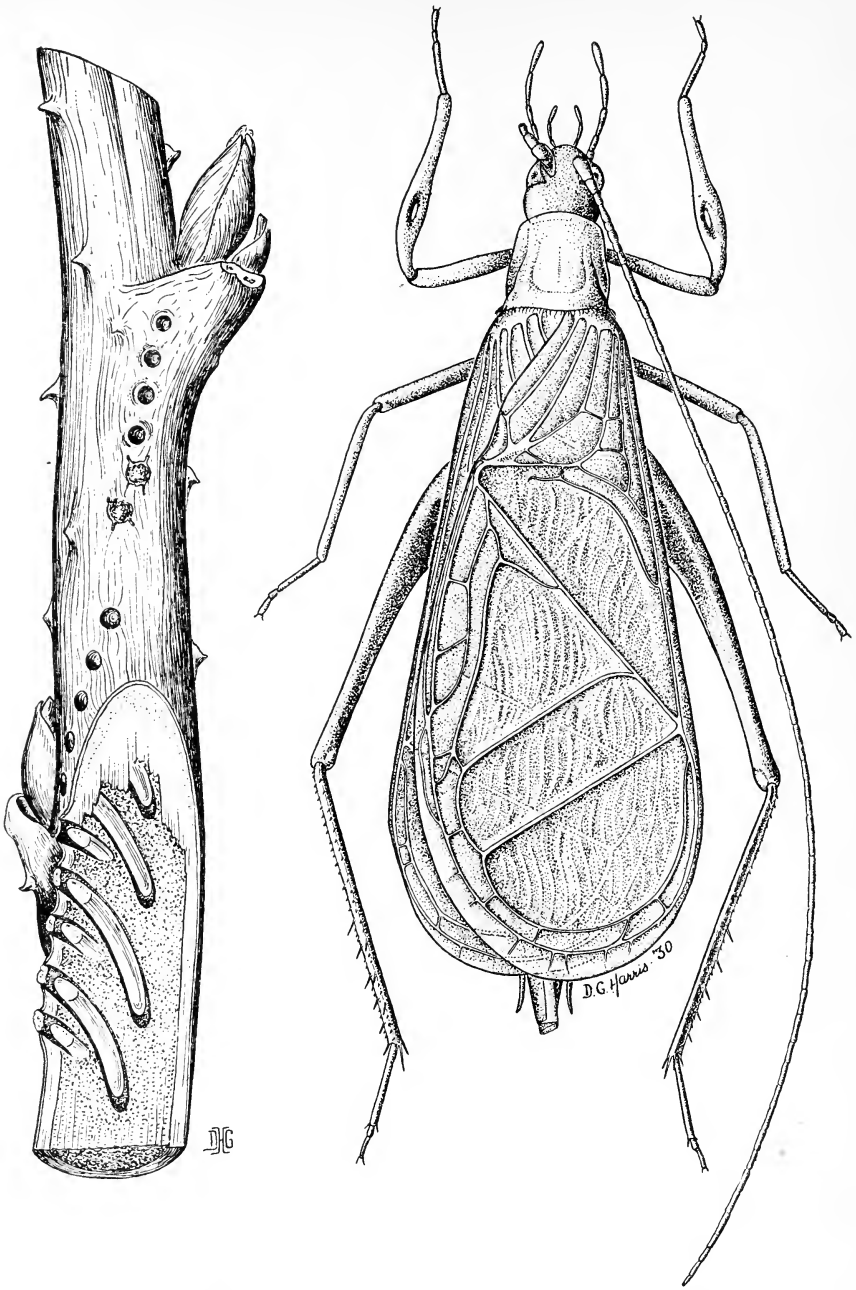


Fig. 26.—The snowy tree cricket: adult and egg-punctures and exposed eggs in a raspberry stem. Greatly enlarged. (After Leslie M. Smith.)

tion 9 or 10 days after transplanting; third application 19 to 20 days after transplanting. Later applications should not be made on account of the danger of poisoning. The material may be applied with a watering can suitably regulated. Clean up all refuse in the fall and plow and

Fig. 27.—The adult of the cabbage maggot.

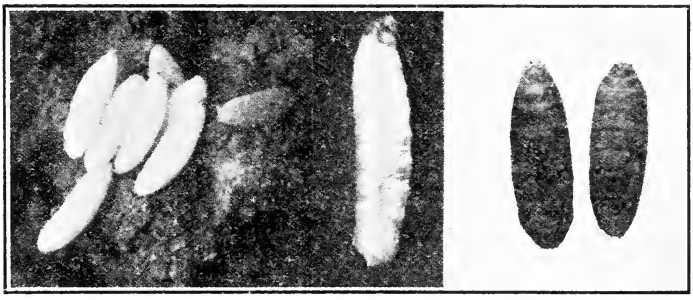


Fig. 28.—The eggs, larva, and puparia of the cabbage maggot.

cultivate thoroughly during fall, winter, and spring, before transplanting, to expose and kill overwintering pupae in the soil.

Cabbage Worm, *Pieris rapae* Linn.—A small green velvety worm, 1 inch long when mature, feeds upon the leaves and destroys the heads. The adults are white butterflies with dark spots on the front wings. Young cabbage plants may be protected by using arsenate of lead, 1 pound of powder or 2 pounds of paste, to 50 gallons of water. This should not be applied after the heads begin to form because of possible poisoning of humans. Later control may be accomplished by applying a nico-

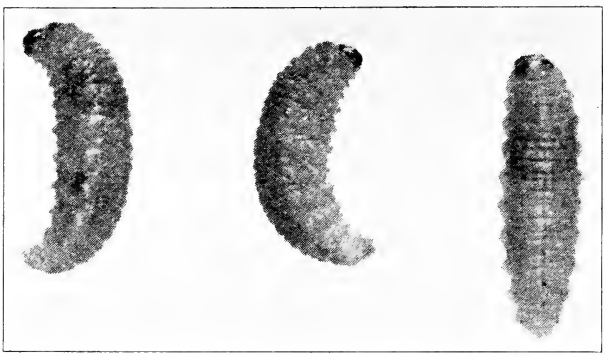


Fig. 29.—Larvae of the vegetable weevil, about four times natural size. (After Lovell.)

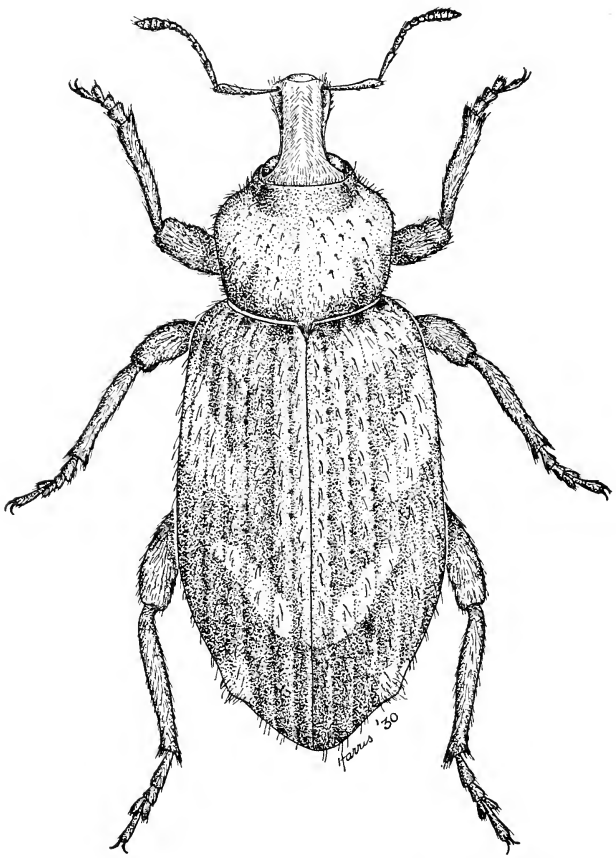


Fig. 30.—The vegetable weevil. Adult (greatly enlarged). (After Essig, *A History of Entomology*, by permission of the Macmillan Co., publishers.)

tine-soap spray (formula 24, p. 132). A 2 per cent nicotine dust (see p. 133) also gives very good control when liberally applied. Derris-clay dust of 0.5 per cent rotenone content, applied four times at about 15-day intervals, has given good control in eastern experiments.

CANTALOUPE

(See "Melons," p. 60)

CARNATION

Apple Skin Worm, *Tortrix franciscana* (Wlshm.). (See "Apple," p. 8.) The caterpillars frequently do considerable damage to the foliage and buds of carnations grown in greenhouses. In such cases spraying with arsenate of lead, 2 pounds of the powder to 50 gallons of water, will give control.

CARROT

Vegetable Weevil,[14] *Listroderes costirostris* Schoen., *(L. obliquus* Gyll.).—This insect is a brown or buff-colored snout beetle 3/8 inch long and with two rather prominent tubercles near the posterior end of the elytra. The larvae are legless, green grubs 1/2 inch long when mature. The larvae and adults feed on the foliage of carrots and turnips and on the tops of a number of other vegetables and the larvae may also feed on the roots, particularly of turnips and carrots, during the winter and spring months. Dusting with fluosilicate dusts 70 per cent to 80 per cent strength, at the rate of 30 to 40 pounds per acre, if foliage is dense, and at the rate of 15 to 25 pounds if the foliage is thin, as soon as the larvae begin to appear in the winter, will give satisfactory control. In such cases the tops should not be used for food, either for humans or domesticated animals, for fear of poisoning. See figs. 29 and 30, p. 35.

CASABA

(See "Melons," p. 60)

CAULIFLOWER

(See "Cabbage," p. 32)

CELERY

Aphids, *Myzus perisicae* (Sulz.) and *Cavariella capreae* (Fab.).—Green aphids attack the stems and leaves of the plants. Spray with nicotine and soap (formula 24, p. 132) or dust with 2 per cent nicotine dust (see p. 133).

[14] Lovell, Oliver H. The vegetable weevil, *Listroderes obliquus.* California Agr. Exp. Sta. Bul. 546:1–19. 1932.

Celery Caterpillar, *Papilio zolicaon* Bdv.—The caterpillars are beautifully marked, green black and orange, and feed upon the leaves. Hand pick, or spray with 3 pounds of powdered basic arsenate of lead to 100 gallons of water, not later than three weeks before harvest (formula 7, p. 112). Spraying celery with poisons is a dangerous procedure which should not be done without the advice of experts.

Celery Leaf-Tier, *Phlyctaenia ferrugalis* Hbn.—The caterpillars are pale green with white or yellow stripes and the adults pale fawn. The larvae web and devour the foliage and are frequently serious pests. Control is the same as for the celery caterpillar.

CHERRY

Black Cherry Aphid, *Myzus cerasi* Fabr.—A shiny black aphid with long honey tubes appears in spring and early summer and causes severe curling of the leaves. Spray with nicotine and soap (formula 24, p. 132) or dust thoroughly with 2 per cent nicotine dust (see p. 133) as soon as aphids appear and before the leaves curl. See fig. 31, p. 38.

Cankerworms.—See p. 92.

Cherry Fruit Sawfly, *Hoplocampa cookei* (Clarke).—The small white larvae work within the partly developed fruits of the cherry and plum and are at times responsible for much damage. Their presence is indicated by the dropping of fruit and by the small round exit holes in fruits which are hardly half-grown. The best treatment is the application of basic arsenate of lead (formula 7, p. 112) just when the petals are opening. See fig. 32, p. 39.

Cherry Slug, *Eriocampoides limacina* Retzius.—This name applies to the small dark green or blackish slug-like larvae which are nearly ½ inch long and which feed upon the leaves in great numbers, almost defoliating the trees in some years. Because of their slimy covering, they are readily killed by the application of various dusts, such as finely ground hydrated lime, ashes, road dusts, etc., but are best controlled by the applications of 0.8 per cent to 2.0 per cent nicotine dust (see p. 133). The regular basic lead arsenate sprays (formula 7, p. 112) are also good.

Poison sprays should not be applied from the time the fruit is half-grown until after it is harvested. Usually the most opportune time is either in early spring or after harvest. See fig. 33, p. 39.

Pacific Peach Tree Borer.—See "Peach," p. 67.

Pear Thrips.—See under "Pear," p. 73.

Red-humped Caterpillar.—See under "Plum, Prune," p. 75.

Tent Caterpillars.—See p. 100.

Fig. 31.—The black cherry aphid. Colony in curled leaf of cherry. In this condition it is beyond control for the season.

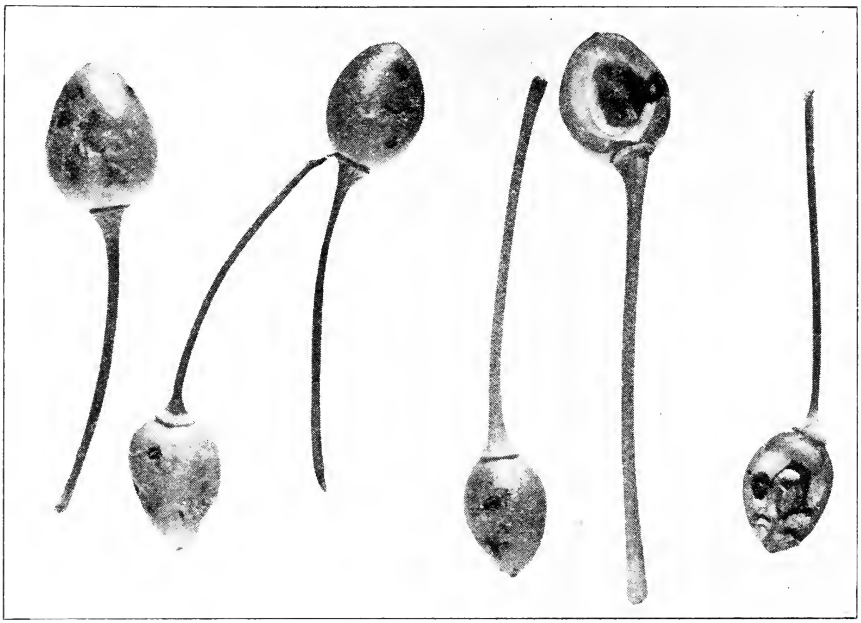


Fig. 32.—Work of the larvae of the cherry fruit sawfly on young cherries. The soft seed is completely devoured and the fruit ruined.

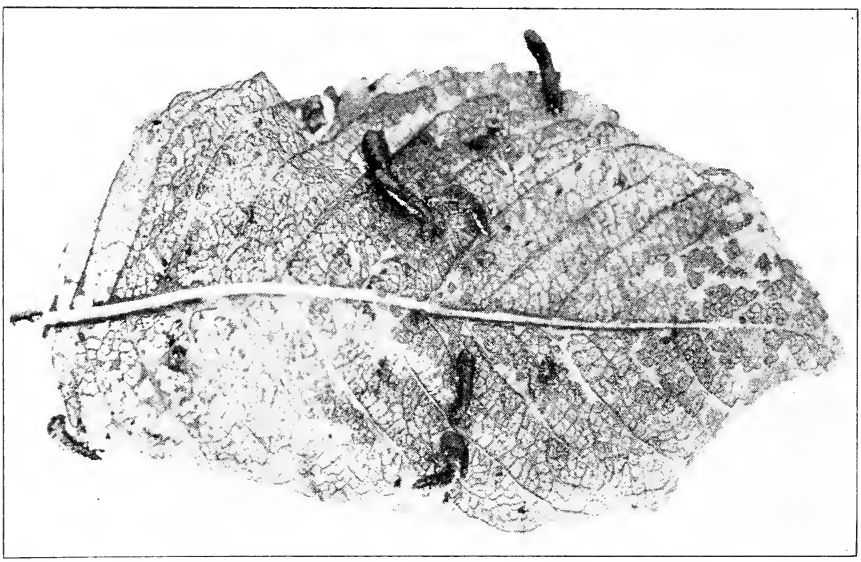


Fig. 33.—The cherry slug and characteristic feeding injury to the leaves of cherry trees. The first brood appears in the early summer and the second brood in the fall.

CHRYSANTHEMUM

Aphids (Various Species).—Spray with nicotine and soap (formula 24, p. 132) or dust with 2 per cent nicotine dust (see p. 133) when the insects appear. See "Aster," p. 23.

Chrysanthemum Gall Fly, *Diarthronomyia hypogaea* (Löw).—The small yellowish or white larvae cause numerous pointed galls on the leaves and stems and seriously injure the terminal buds. Great numbers of minute slender red eggs are laid on the plants in the spring and early summer, and these may be readily killed by repeated applications of nicotine and soap (formula 24, p. 132). Trim the plants to the ground in the spring to eliminate holdover forms.

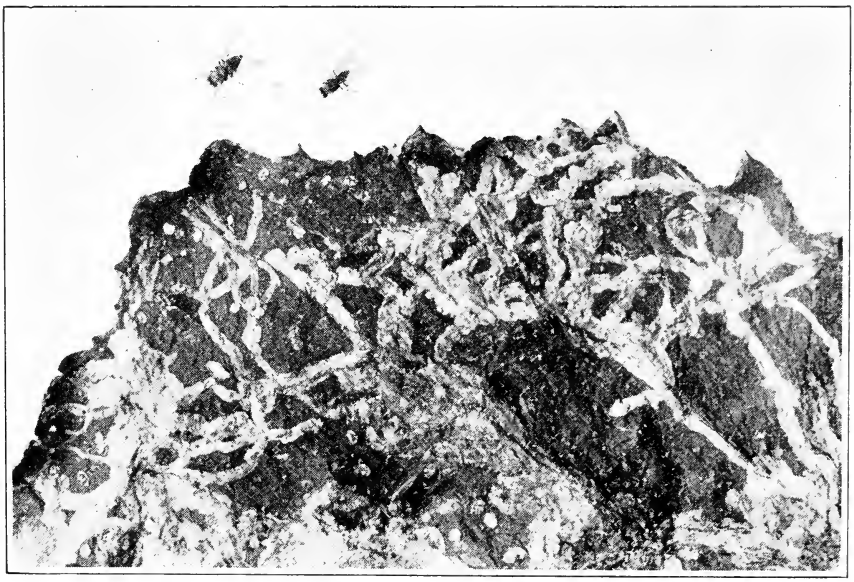


Fig. 34.—Adults of the chrysanthemum leaf miner and mines of the larvae in the leaf.

Chrysanthemum Leaf Miner, *Phytomyza chrysanthemi* Kow.—The injury due to this insect consists in numerous mines on the upper side of the leaves just under the epidermis. These are made by the small whitish maggots, which are easily killed within their burrows by applying one part of 40 per cent nicotine sulfate to 600 parts of water.

CINERARIA

Chrysanthemum Leaf Miner.—See "Chrysanthemum," above.

CITRUS FRUITS (GRAPEFRUIT, LEMON, ORANGE)[15]

Aphids (Various Species).—Use nicotine and soap (formula 24, p. 132) or summer oil sprays (2 per cent), or a 2 per cent nicotine dust (see p. 133).

Armyworms and Cutworms.—See p. 89.

Citrus Red Spider, *Paratetranychus citri* (McG.), **and Two-spotted Mite,** *Tetranychus bimaculatus* Harvey.—The first is bright cardinal

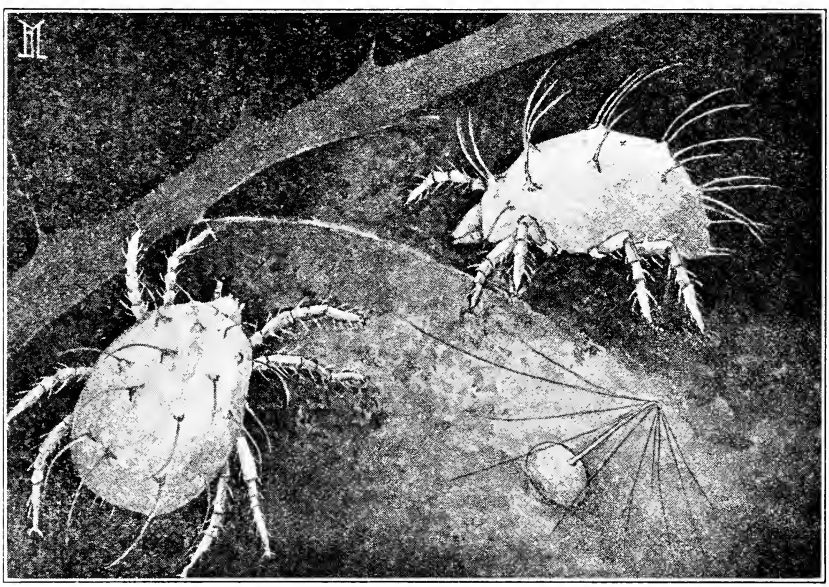


Fig. 35.—The citrus red spider and a single egg. (After Quayle.)

red, while the two-spotted mite is yellow, pale green, or reddish, and often has two or six dark spots on the dorsum. Dust with sulfur or spray with lime-sulfur 1–50 or wettable sulfur (formula 29, p. 137), or commercial sulfur paste 10 pounds to 100 gallons of water, or summer oil emulsions (1½ per cent). The summer oil emulsion spray is the control most used now.

Citrus Thrips, *Scirtothrips citri* (Moult.).—This small pale-yellow insect, less than $\frac{1}{30}$ inch long, works on leaves and fruit. It is most satisfactorily controlled by a 2 per cent solution of commercial lime-sulfur. A combination of miscible oil and lime-sulfur is recommended by some for killing the gray citrus scale and the citrus thrips at the same time.

[15] See: Quayle, H. J. Biology and control of citrus insects and mites. California Agr. Exp. Sta. Bul. 542:1–87. 1932.

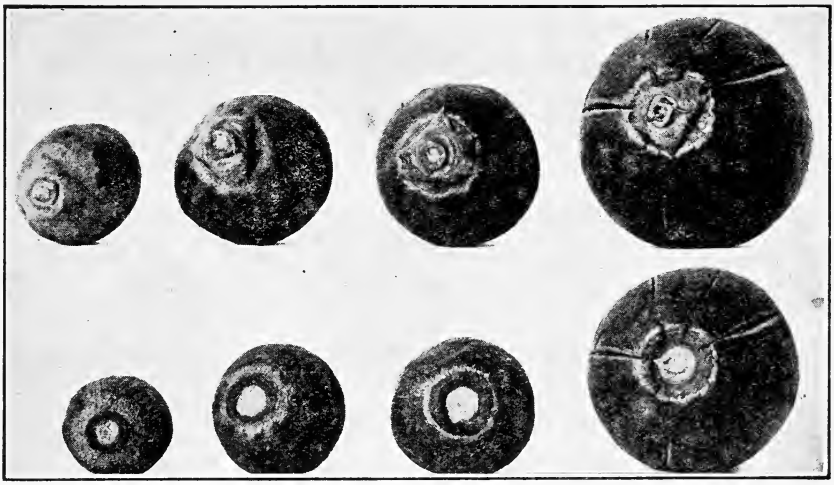


Fig. 36.—Characteristic scarred rings on oranges caused by the feeding of the citrus thrips. (After Quayle.)

Dusting with sulfur has also given good control of both insects in the San Joaquin Valley.

Fuller's Rose Weevil, *Pantomorus godmani* (Crotch).—A small gray snout beetle 3/8 inch long attacks young buds and foliage of citrus trees.

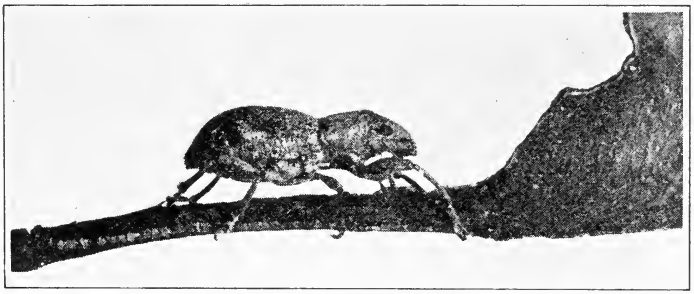


Fig. 37.—Fuller's rose weevil, adult and work on lemon leaf. The legless white larvae attack the roots of many rosaceous plants.

The adults cannot fly and may be kept off the trees by cotton or tanglefoot bands around the trunks.

Mealybugs, *Pseudococcus* spp.—These small, flat, oval insects, covered with white mealy material, are well known to most citrus growers. They are difficult to control, but may be most satisfactorily handled by liberal applications of summer oil sprays (4 per cent). Washing with water under heavy pressure has proved satisfactory under certain conditions. Hydrocyanic acid gas (HCN) fumigation is also often very

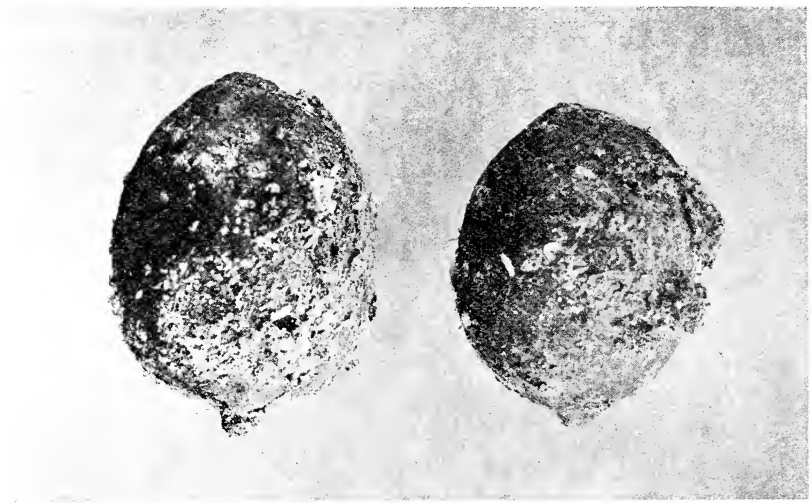


Fig. 38.—Citrus mealybugs on fruits of the lemon. (After Quayle.)

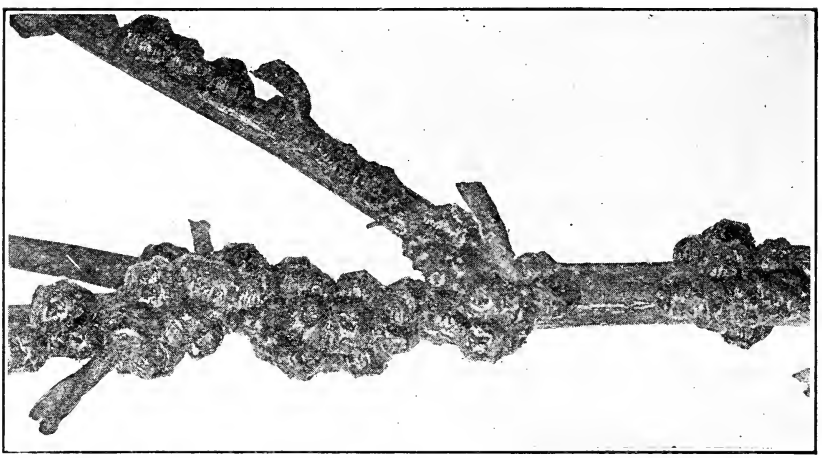


Fig. 39.—The black scale, a common pest of citrus, olives, oleander, pepper trees, and many other fruit and ornamental trees and shrubs. (After Quayle.)

effective where applicable. For the citrus mealybug, parasites are used with good results along the coast. The control of ants is necessary to secure beneficial results from parasites (see "Mealybugs," p. 94; and "Ants," p. 89).

Mediterranean Fruit Fly, *Ceratitis capitata* Wied.—This pest does not now occur in this country, and a strict quarantine is maintained against it.[16]

[16] For a description and list of the possible host plants of this insect, see:
Quayle, H. J. The Mediterranean and other fruit flies. California Agr. Exp. Sta. Cir. 315:1–19. 1929. (This circular is now out of print, but may be consulted in many city and county libraries in California.)

Orange Worms.—The orange tortrix, *Tortrix citrana* Fernald, is a small buff-colored moth, ½ inch long. The caterpillars are pale yellowish or greenish-white with pale head and, when mature measure ½ inch

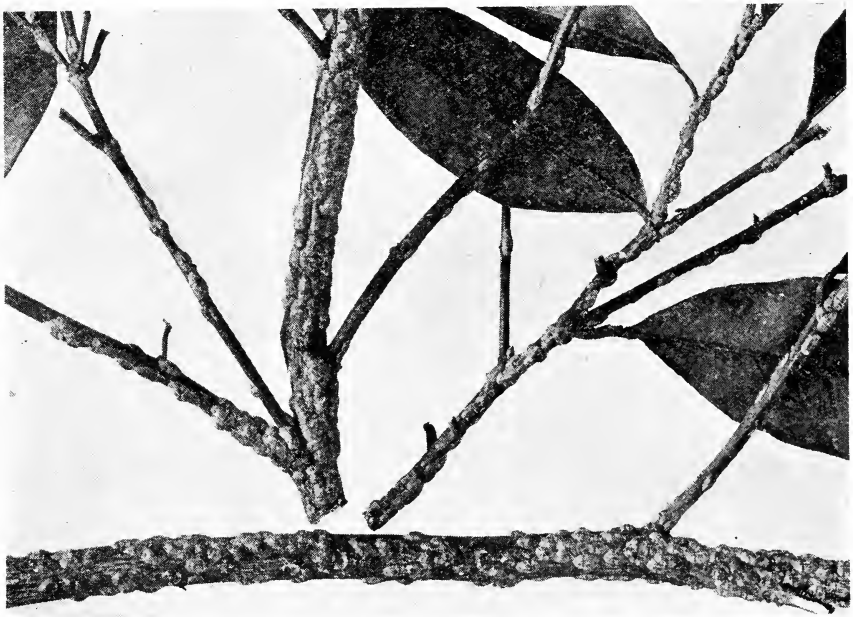


Fig. 40.—The citricola scale on orange twigs. (After Quayle.)

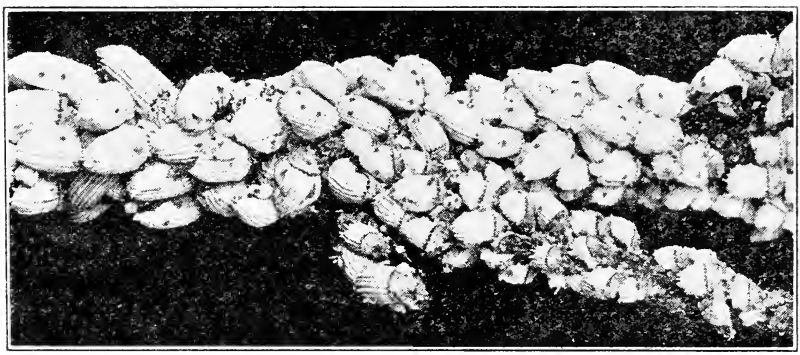


Fig. 41.—The cottony cushion scale. (After Quayle.)

in length. The disc-like greenish-yellow eggs are usually deposited in masses of 10 to 35 on the undersides of the leaves. The caterpillars burrow in the rind of the fruit, usually where fruits or fruits and leaves are in contact. *Holcocera iceryaella* (Riley) similarly injures the fruit, but only in the summer from April to November and is important only to Valencia oranges. The larvae are dark gray with black head and about

⅜ inch long. The adults are ashy-gray in color and approximately ⅜ inch long. Both of these moths are controlled by using either formula 12 or 13 (pp. 116–117).

Scale Insects (Many Species).—For control use fumigation with hydrocyanic acid gas or thorough applications of various strengths of commercial oil emulsions or tank-mix sprays.[17] For the cottony cushion scale secure ladybird beetles from Citrus Experiment Station, Riverside, California. See figs. 38–42.

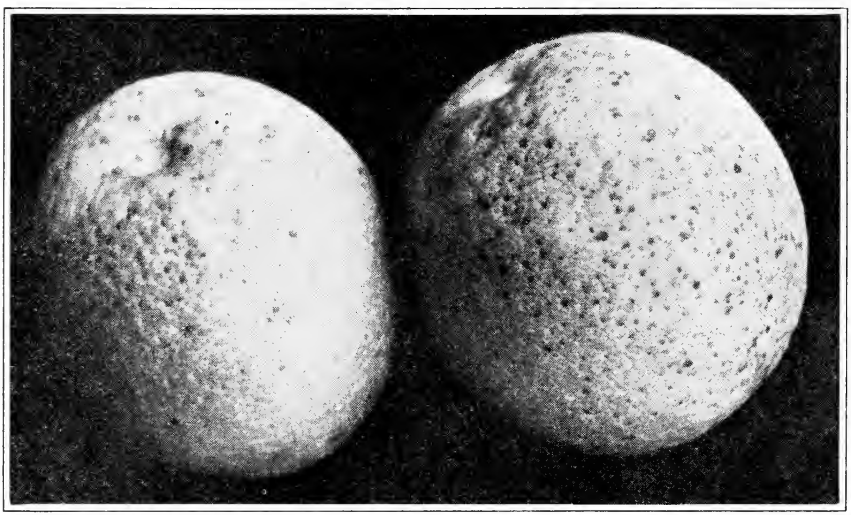


Fig. 42.—Red scale on oranges. (Courtesy of G. E. Woodhams.)

CORN

Angoumois Grain Moth.—See "Grain," p. 53.

Armyworms and Cutworms.—See p. 89.

Corn Earworm, *Chloridea obsoleta* (Fab.).—The larvae are nearly 2 inches long when full grown and vary in color from yellowish to brownish, with longitudinal gray and white stripes and with eight small dark tubercles on each segment. They work chiefly on the corn in the ear, but they may also attack the tassels and leaves. Clean up and burn refuse in the field. Plow in fall or early spring to expose and kill the pupae. Repeated dustings when the ears begin to form, with powdered sodium

[17] For more complete directions see:

Section on tank-mixture sprays for citrus trees. p. 123; or:

Smith, Ralph H. The tank-mixture method of using oil spray. California Agr. Exp. Sta. Bul. 527:1–86. 1932.

Quayle, H. J. Biology and control of citrus insects and mites. California Agr. Exp. Sta. Bul. 542:1–87. 1932.

fluosilicate, have given satisfactory control in certain areas. Owing to the varying sizes of corn plants no definite amount can be suggested. Some burning may result in the fog belt. The effects of such dusts on livestock, fed treated plants, is not known. Therefore, care should be exercised in using such dusted plants for fodder or silage.

Fig. 43.—The corn earworm and characteristic injury to sweet corn.

Granary and Rice Weevils.—See "Grain," p. 53.
Grasshoppers.—See p. 94.
Wireworms.—See p. 101.

COTTON

Armyworms and Cutworms.—See p. 89.

Bean Thrips.—See "Bean," p. 25. This insect usually appears on the cotton late in the season, when the injury may or may not be of sufficient importance to justify control. Lack of sufficient soil moisture is often responsible for the abundance and serious injury of thrips. Early infestation should be promptly dealt with, using dusting sulfur.

Corn Earworm.—See "Corn," p. 45. This insect attacks the cotton bolls. Sweet corn is sometimes planted as a catch crop. Dusting with powdered calcium arsenate or fluosilicates gives good results.

Cotton Leaf Perforator, *Bucculatrix thurberiella* Busck.—The larvae are pale or dark greenish and less than ½ inch long. When disturbed they wriggle violently. They perforate the leaves with very many holes

so as to consume them almost entirely. The larvae pupate in small, white-ribbed cocoons attached to the leaves or stems of the plants. The adults are white with black dots and other black markings.

This insect normally feeds upon wild cotton, but in recent years has invaded the cotton belt of the Southwest, and, while it prefers weak plants, it will attack perfectly healthy ones as well.

Parasites do much to keep the insect in check, but where severe infestations occur dust plants with calcium arsenate. From 20 to 30 pounds are sufficient for an acre of cotton.

Red Spider and Two-spotted Mite.—See under "Bean," p. 26.

CUCUMBER

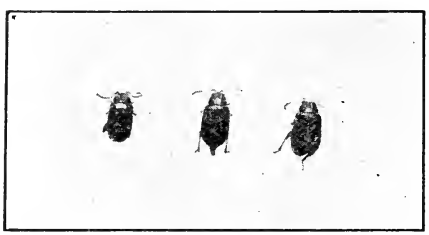


Fig. 44.—Adult flea beetles. These insects are very small and their ability to jump is responsible for the common name.

Flea Beetles (Various Species).—These are small flea-like beetles which jump quickly and eat small holes in the leaves. Bordeaux mixture (formula 10, p. 114) as a repellent is a good control measure. Also dust with 1 part of 2 per cent nicotine dust and 1 part of arsenate of lead or with 70 per cent sodium fluosilicate or other fluosilicate dusts.

Root-Knot Nematode.—See p. 97.

Melon Aphid.—See "Melons," p. 60.

Red Spider and Two-spotted Mite.—See under "Bean," p. 26.

Western Twelve-spotted and Striped Cucumber Beetles, *Diabrotica soror* Lec. and *D. trivittata* Mann.—The former is a small green beetle with twelve black spots on the back and is often mistaken for a ladybird; the latter is a brown beetle with three black lines on the dorsum. The adults may do considerable damage by eating tender leaves and blossoms. The white larvae feed upon the roots and may be controlled by pouring on the roots a cup of 40 per cent nicotine sulfate diluted 1 to 1,000 parts of water. Bordeaux mixture (formula 10, p. 114) is of considerable value as a repellent. Arsenate of lead (formula 6, p. 112) may also be used with good effect. The best insecticide now known for these beetles is 70 per cent sodium fluosilicate or other fluosilicate dusts, which must not be present in excess of the legal tolerance when the cucumbers are harvested. See fig. 45 and p. 146.

Fig. 45.—The western twelve-spotted cucumber beetle, or diabrotica, and work on leaves of watermelon.

CURRANT, GOOSEBERRY

Currant or Gooseberry Fruit Fly, *Epochra canadensis* Loew.—Small white maggots occur in the fruit at picking time. Cultivate thoroughly during the fall, winter, and spring months to expose and destroy the hibernating pupae.

Imported Currant Borer, *Aegeria tipuliformis* Clerck.—White caterpillars nearly 1 inch long work down the middle of the stalks and into the roots of the plants. Cut out and burn all dead and infested canes during winter and remove the borers.

Red Spider and Two-spotted Mite.—See "Bean," p. 26. Dust with sulfur or spray with wettable sulfur (formula 29, p. 137).

Fig. 46.—The currant or gooseberry fruit fly.
(After Whitney.)

San Jose Scale.—See "Apple," p. 15.

Western Flat-headed Borer.—See "Apple," p. 16.

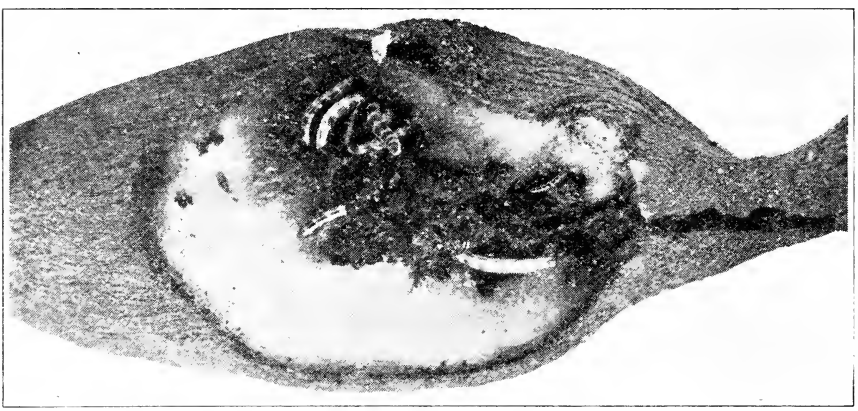


Fig. 47.—Wireworms in a dahlia tuber. These insects are most injurious in light sandy or humus soils. (After Essig, *Insects of Western North America,* by permission of the Macmillan Co., copyright owners.)

DAHLIA

Bean Aphid.—See "Bean," p. 25.

Western Twelve-spotted Cucumber Beetle.—See "Cucumber," p. 47.

Barium fluosilicate or cryolite dusts give some control, but no satisfactory method has been devised for adequately protecting choice individual flowers excepting screening with cloth.

Wireworms.—See p. 101.

DATE

Date Mite.—See "Citrus Red Spider," p. 41, and "Avocado Mite," p. 23.

Date Palm Scale, *Parlatoria blanchardi* (Targ.)—A small gray and white scale, less than 1/16 inch long, often occurs in great numbers on the leaves. It may be controlled by cutting away and destroying all the

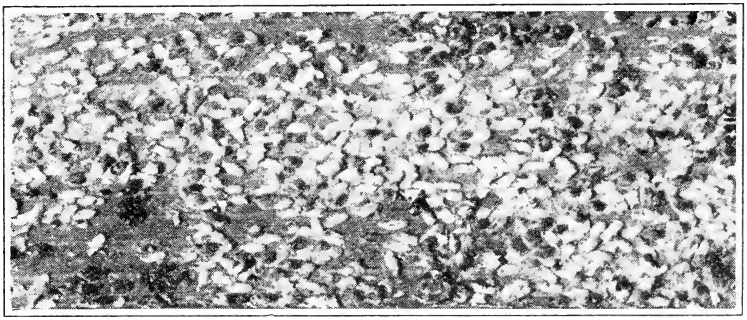


Fig. 48.—The date palm scale, a typical heavy infestation on leaf of date palm.

leaves and burning over the trunk with a gasoline torch. This insect is quarantined by the Bureau of Plant Quarantine, and young plants may be obtained only from uninfested territory.

Dried Fruit Beetle.—See under "Prune," p. 74.

Indian Meal Moth.—See "Prune," p. 74. This insect is a serious pest to dried dates, and to avoid infestation by this insect dates should be packed only in insect-proof containers.

Red Date Scale, *Phoenicococcus marlatti* Ckll.—A red-bodied, cottony covered scale, considerably larger than the date palm scale. It is found only between the unfolding leaves, the climatic conditions not permitting it to survive in the open in the Coachella Valley. It is not an important pest and many believe it does no injury to the palm.

FERNS

Aphids.—Aphids, or plant lice, often occur in considerable numbers on ferns growing indoors. Spray frequently with 40 per cent nicotine sulfate at the rate of 1 part to 1,000 parts of water.

Fern Moth, *Euplexia lucipara* (Linn.).—The adult is a rich velvety maroon moth which gives rise to both green and brownish-red caterpillars, which commonly feed upon ferns indoors and out. It can be controlled by using 2 pounds of arsenate of lead (dyed green if preferred) to 50 gallons of water.

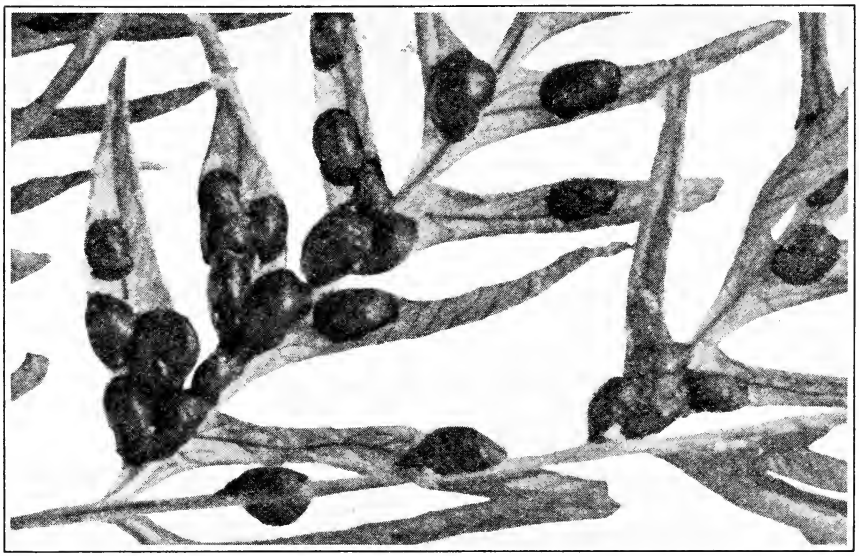


Fig. 49.—The mature forms of the hemispherical scale on fern.

Hemispherical Scale, *Saissetia hemisphaerica* (Targ.).—A brown, nearly hemispherical scale often appears in great numbers on the undersides of the fronds and on the stems. Spray or dip using a solution of nicotine and oil emulsion (formula 21, p. 128, with summer oil).

Mealybugs.—See p. 94.

Fig. 50.—The long-tailed mealybug on fern.

FIG

Branch and Twig Borer.—See "Apricot," p. 18.

Dried Fruit Beetle.—See "Prune," p. 74.

Mediterranean Fig Scale, *Lepidosaphes ficus* (Sign.).—Scales resemble small oysters and infest the limbs, twigs, leaves, and fruit. Spray with 4 per cent tank-mix oil (page 126), miscible oil, or 6 per cent commercial oil emulsion during the winter when the trees are dormant.

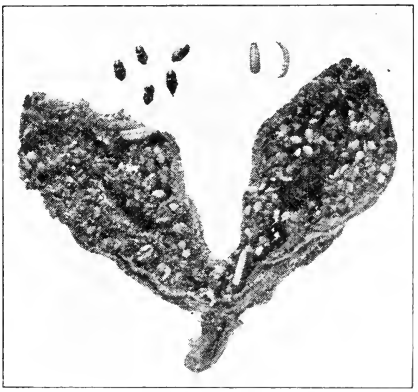


Fig. 51.—The dried fruit beetle: larvae and adults removed from dried fig. (Courtesy of Ralph E. Smith.)

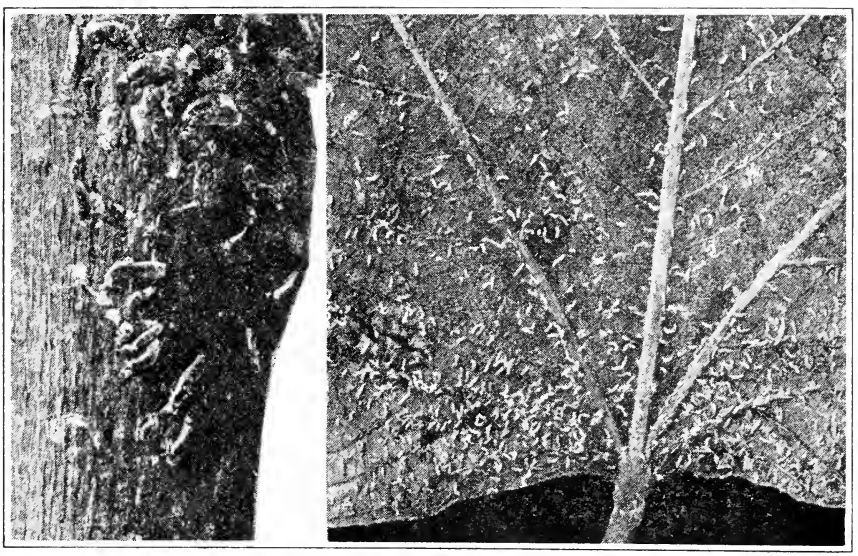


Fig. 52.—The Mediterranean fig scale on twig and leaf.

Nematodes.—These are becoming increasingly serious. No remedy is known. See p. 96.

Pomace or Vinegar Fly, *Drosophila ampelophila* Loew.—Small, slender, whitish maggots and brown or orange-colored flies 1/10 inch long, often occurring in great numbers in figs on the trees and on the drying trays. No practical method of control has yet been devised.

Red Spider—See "Pacific Mite," p. 73, under "Plum, Prune."

GRAIN (BARLEY, GRAIN SORGHUMS, MILLET, OATS, RICE, WHEAT)

(See also "Corn," p. 45)

Angoumois Grain Moth, *Sitotroga cerealella* Oliv.—A small tawny moth is found in granaries. The pale-yellow caterpillars feed within the kernels of stored grain and corn, escaping through a round hole. Control measures are the same as for the granary and rice weevils.

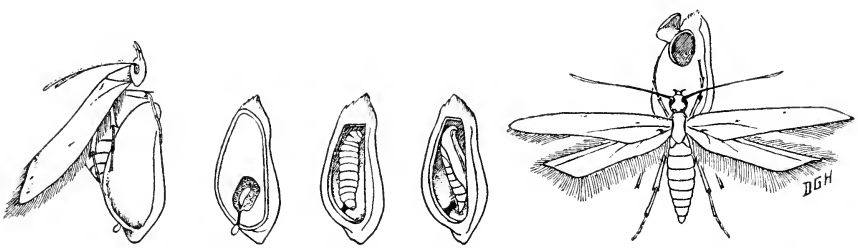


Fig. 53.—The angoumois grain moth and stages of development in stored wheat. (After the United States Department of Agriculture.)

Aphids (Many Species).—Aphids often seriously attack grain. Control methods are usually too costly to be practical. Cutting is often resorted to in order to save part of the crop.

Armyworms and Cutworms.—See p. 89.

Grain Mites, *Tyroglyphus* spp.—Pale-colored mites, smaller than the point of a pin, are frequently found in stored grain and by-products. When abundant, they appear as loose, fluffy masses of gray powder, for the cast skins are mingled with the living mites. Heat is the most effective remedy and should be used if practical (see "Heat As an Insecticide and Disinfectant," p. 145. Fumigation with carbon disulfide may also be used as directed for granary weevil. Screening or fanning may reduce the infestation to a satisfactory degree.

Granary Weevil, *Sitophilus granarius* (Linn.), **and Rice Weevil,** *S. oryzae* (Linn.).—Small brown or black weevils not over 1/8 inch in length, attacking the grain in storage. Fumigate with carbon disulfide 10 to 30 pounds to 1,000 cubic feet of air space, according to the tightness of the container. The temperature must be at least 70° Fahrenheit for satisfac-

tory results. Hydrocyanic acid gas (HCN) or carbon tetrachloride, and ethylene dichloride (singly or in combination) may also be used as a fumigant. Heating the grain to 125° Fahrenheit for several hours will kill all the weevils. Keeping the grain dry and well ventilated will largely prevent weevil attack in storage. Seed grain treated with copper-carbonate dust as recommended for smut will remain free from weevil attacks.

Grasshoppers.—See p. 94.

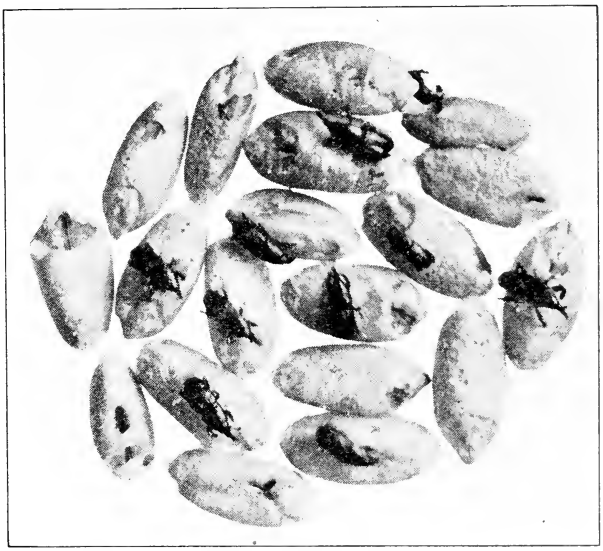


Fig. 54.—Adults of the rice weevil and work on stored wheat. This and the closely allied granary weevil feed on many kinds of cereals and cereal products.

Hessian Fly, *Phytophaga destructor* (Say).—A small gnat-like fly which lays very minute spindle-shaped eggs on the leaves of the wheat in the fall and spring months. The small white maggots feed on the stems and often do considerable damage to wheat in some localities. Deep plowing under of stubble immediately after harvest, summer fallow, or a rotation of crops will serve to keep the insect in check.

Straw Worms and Joint Worms, *Harmolita* spp.—These very small ant-like insects deposit eggs in the heart of the young plants and the minute, white, legless larvae live within the stems causing malformations of the joints or of the leaf-sheaths of wheat, rye, and wild grasses. Barley is not attacked and is a satisfactory rotation for any of the susceptible grains. Control same as for hessian fly.

GRAPE, RAISIN

Achemon Sphinx Moth, *Pholus achemon* (Drury).—The large caterpillars are green or pinkish with oblique whitish bars on the sides. They are often abundant and do great damage by stripping the vines. The adult moths are dull gray with brown marks and pink hind wings. Spray vines with arsenate of lead (formula 6, page 112), to which is added 1 pint of 40 per cent nicotine sulfate to every 200 gallons, or dust with powdered arsenate of lead, 1 part to 4 parts of hydrated lime or flowers of sulfur.

Armyworms and Cutworms.—See p. 89.

Fig. 55.—Work of the adults of the grape root worm on leaves and young fruit. (After Quayle.)

California Grape Root Worm, *Adoxus obscurus* (Linn.).—The adult beetles are black or brown and 3/16 inch long. They eat long slender holes in the leaves. The small white grubs feed on the roots of the vines. Cultivate thoroughly close to the vines during the winter to kill hibernating larvae. As soon as the beetles appear in the spring, spray with arsenate of lead, 6 pounds of paste or 3 pounds of powder to 100 gallons of water, or dust with 1 part of powdered arsenate of lead to 4 parts of hydrated lime or sulfur.

Dried Fruit Beetle.—These are frequently found on raisins; see under "Plum, Prune," p. 74.

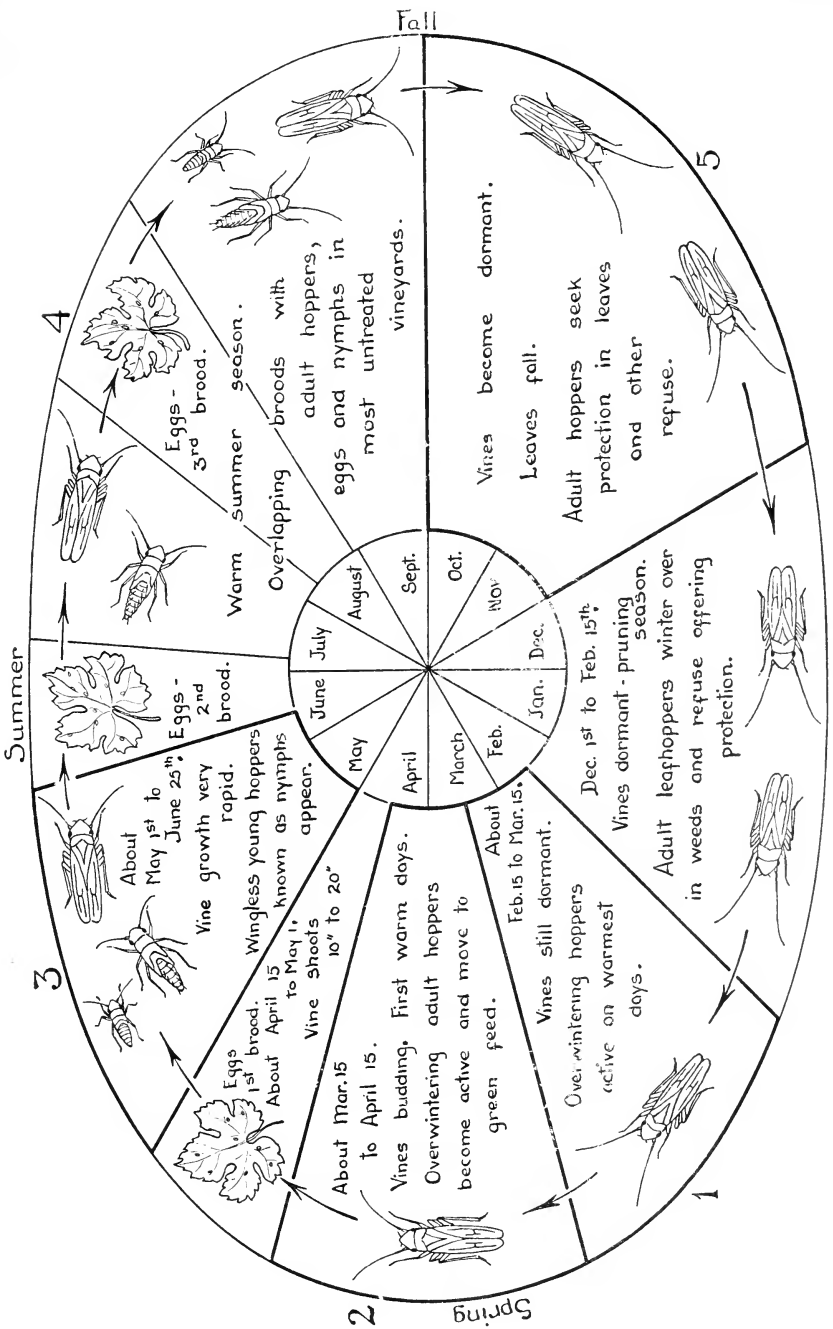


Fig. 56.—Chart showing the life history of the grape leafhopper. (After Lamiman.)

Grape Leafhopper,[18] *Erythroneura comes* (Say).—The immature forms or nymphs are white or pale yellow, while the adults are pale yellow with numerous small reddish marks all over the dorsum. All forms

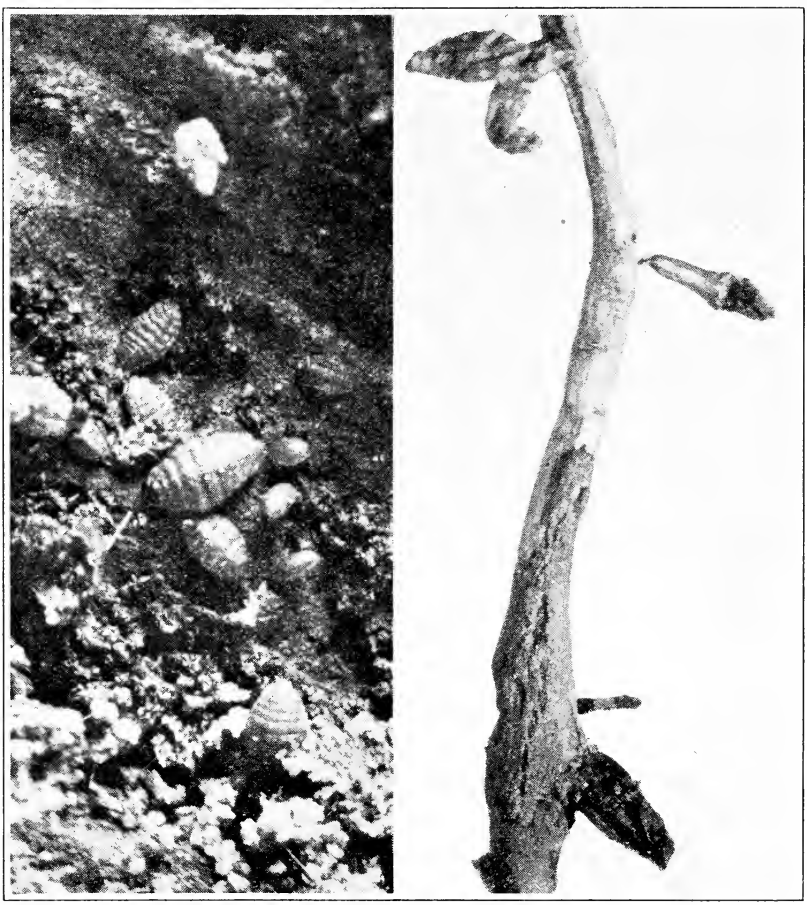


Fig. 57.—The grape phylloxera: colony, consisting of the adult female, eggs, and young on grape root at left; and galls on grape rootlets at right; greatly enlarged. (After Essig, *Insects of Western North America*, by permission of the Macmillan Co., copyright owners.)

feed on the underside of the leaves, causing them to turn yellow and drop prematurely. See fig. 56.

The following program represents a full season's control, which in total should seldom, if ever, be necessary, and indicates the most effective measures at various seasons of the year.

1. Clean cultivation followed by covercrops in the fall.
2. Planting of the trap crop and treating it with calcium cyanide dust

[18] See also: Lamiman, J. F. Control of the grape leafhopper in California. California Agr. Ext. Cir. 72:1–20. 1933.

or pyrethrum-oil sprays to destroy the overwintering adults before vine growth starts.

3. Early spring treatment of adults with calcium cyanide dust or pyrethrum-oil sprays (formula 18, p. 121) after movement to vines.

4. Two nymphal treatments with nicotine spray (formula 25, p. 132) or proprietary water-soluble pyrethrum extracts or nicotine dusts (formula 27, p. 133).

5. Treatment of first-brood adults with calcium cyanide dust or pyrethrum oil vapor spray (formula 18, p. 121).

6. Treatment of second-brood nymphs with nicotine dust.

7. Calcium cyanide treatment of adults at rate of 20 pounds granular material per acre before harvesting crop.

Treatments 3 and 4 are exceedingly effective, and one or both of them are usually sufficient, if thoroughly applied, for practical control.

Grape Mealybug, *Pseudococcus maritimus* Ehrh. (= *P. bakeri* Essig.)—This insect is easily distinguished by the small, oval, flat bodies covered with white cotton-like wax and by the cottony egg masses among the bunches of grapes. It is difficult of control, but best results have been obtained by using 3 per cent miscible oil sprays or 3 per cent tank-mix spray (see p. 126) during the winter months. See also "Mealybugs," p. 94, and under "Pear," p. 71.

Grape Phylloxera, *Phylloxera vitifoliae* Fitch.—The presence of the phylloxera is indicated by weak and dying vines. It usually occurs in small areas. The insect is a minute, yellow louse which feeds on the roots. To disinfect cuttings or rootings before planting, dip in hot water, 122° Fahrenheit, for 5 minutes. For permanently resistant vines, graft European varieties on certain American roots. See fig. 57.

Grasshoppers.—See p. 94.

Indian Meal Moth.—This moth sometimes attacks raisins; see "Plum, Prune," p. 74.

Pacific Mite.—See "Plum, Prune," p. 73. On table and juice grapes the only summer control is refined oils used before grapes are size of buckshot.

GRAPEFRUIT

(See "Citrus Fruits," p. 41)

HOLLYHOCK

Painted Lady Butterfly, *Vanessa carye* Hbn.—The yellowish or black spiny caterpillars which are about 1 inch long, feed on the leaves, which they draw together with webs for protection. Control is best accomplished by using 40 per cent nicotine sulfate, 1 part to 600 parts of water, and spraying the plants thoroughly.

HOP

Hop Aphid, *Phorodon humuli* (Schr.).—A pale-green aphid attacking the young shoots and leaves. Dust thoroughly and as often as necessary with 2 per cent nicotine dust (see p. 133) or spray until injury ceases with nicotine and soap (formula 24, p. 132).

Fig. 58.—The hop aphid on underside of plum leaf. From the plum and prune it migrates to hops.

Hop Flea Beetle, *Psylliodes punctulata* Melsh.—A small green or bronze metallic beetle, 1/10 inch long, attacks the foliage. It jumps quickly when disturbed. The most efficient method of control consists in putting tanglefoot bands around the bases of the vines and around the poles. These not only prevent the beetles from climbing the vines but also catch great numbers of them. Also dust with fluosilicate compounds.

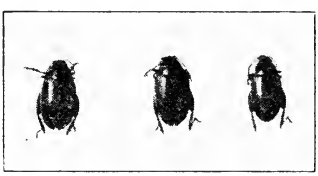


Fig. 59.—The adults of the hop flea beetle. Enlarged about four times.

Red Spiders and Two-spotted Mite.—See under "Bean," p. 26.

IRIS

Iris Root Aphid, *Anuraphis tulipae* (Fonsc.).—A pale-green or whitish aphid covered with fine whitish powder infesting the stalks, bases of the leaves, the crowns, and the bulbs of irises and also of tulips and gladiolas. Use summer oil and nicotine sprays (formula 21, p. 128, with summer oil) in the garden and fumigate infested bulbs with nicotine or cyanide dust before planting.

Iris White Fly, *Aleyrodes spiraeoides* Quaint.—The immature forms of this insect somewhat resemble soft scales, being oval, flat, and about 1/8 inch in length. They are often crowded in immense numbers on the leaves of the plants in late summer and fall. The adults appear as exceedingly minute, white, four-winged insects, often suggesting tiny moths.

As the insects do not become abundant and destructive until late in the year control is hardly necessary. Cutting the leaves will kill great numbers. Spraying with combinations of nicotine or pyrethrum and oil will also kill the immature forms.

LAWNS

Earthworms.—Earthworms or angleworms frequently cover golf greens with casts of earth, which are undesirable in such a place. To cause the worms to come to the surface, apply mercuric chloride, mixed as follows, and then sweep up the worms and remove them:

1 pound corrosive sublimate
1 gallon boiling water

Let cool for one hour; then add 4 gallons of cold water. Use 2½ pints of this solution to a barrel of water (50 gallons), and apply to greens with a sprinkler. See p. 118 for precautions in the use of mercuric chloride. This is a dangerous poison.

Satisfactory results have also been obtained by dusting the lawns with powdered arsenate of lead at the rate of 1 pound to 100 square feet and then watering it in. The worms ingest the poison with the surface soil and are killed.

Sod Worms, *Crambus leachellus* Zincken, *C. bonifatellus* Hulst, *C. cypridalis* Hulst, **and Other Species.**—The larvae are dusky, reddish-brown or grayish and live in the sod, where they may do great damage to lawns, golf greens, and similar grasslands. Dust thoroughly with 1 pound of arsenate of lead per every 100 square feet.

LEMON

(See "Citrus Fruits," p. 41)

LETTUCE

Armyworms and Cutworms.—See p. 89.

LOQUAT

Green Apple Aphid.—See under "Apple," p. 15.

San Jose Scale.—See under "Apple," p. 15.

MELONS (CANTALOUPE, CASABA, PUMPKIN, SQUASH, WATERMELON)

Flea Beetles.—See "Cucumber," p. 47.

Melon Aphid, *Aphis gossypii* Glover.—A small, very dark-green plant louse occurs in great numbers on the plants and does great damage. Destroy the first infested plants as soon as discovered in spring or spray with 40 per cent nicotine sulfate, 1 part to 1,000 parts of water. A 2 per cent nicotine dust (see p. 133) also gives very good results and is much more easily and quickly applied.

Nematode.—See p. 96.

Squash Bug, *Anasa tristis* DeGeer.—The young bugs are gray with black antennae, legs, and thorax; the adults of a uniform dull grayish-brown above, mottled yellowish beneath, and about ¾ inch long. Control measures should be directed against the immature forms, and consist in the use of 1 part of 40 per cent nicotine sulfate to 600 parts of water. A 50 per cent calcium cyanide dust is most effective. It should be applied

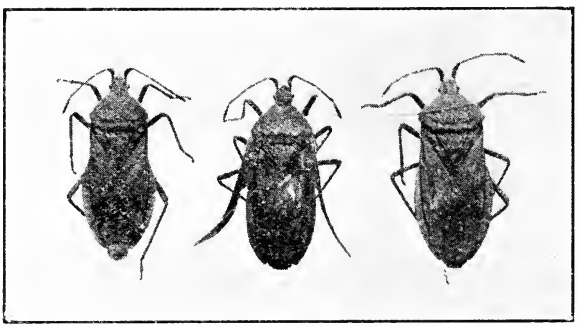


Fig. 60.—The squash bug.

only when the plants are perfectly dry or burning of the foliage will result. Hand-picking the adults in the spring is successful in small gardens.

Western Twelve-spotted and Striped Cucumber Beetles.—See "Cucumber," p. 47.

MUSHROOMS

Mushroom growing is a highly specialized industry which must take into consideration the elimination and control of pests from the very beginning. The sterilization of the compost and the spawn are of prime importance, and will prevent the establishment of most of the mites and insects which may spell ruin in the industry. The screening of doors, windows, and ventilators with fine wire gauze and adequate equipment for heating may add much to the success of the undertaking.

Mushroom Maggots, *Sciara* spp., and *Aphiochaeta* spp.—These maggots are serious pests of cultivated mushrooms, the small white maggots, or larvae, and the black gnat-like flies, or adults, fairly swarming in the mushroom houses. Here again clean compost and spawn are essential. The adults may be easily killed by frequent fumigations with nicotine smudges, and this of course eventually eliminates the larvae.

Mushroom Mite, *Tyroglyphus lintneri* Osb.—This mite is perhaps the commonest and most serious pest. It is a minute, transparently white, somewhat hairy, soft-bodied creature which moves slowly and awk-

wardly throughout the beds and attacks the mushrooms in all stages and causes serious damage or almost complete loss. Prevention is the only satisfactory cure and infested houses should be cleaned out and thoroughly disinfected. When once established it is most difficult to control. The use of carbon disulfide emulsion gives, at best, only temporary relief.

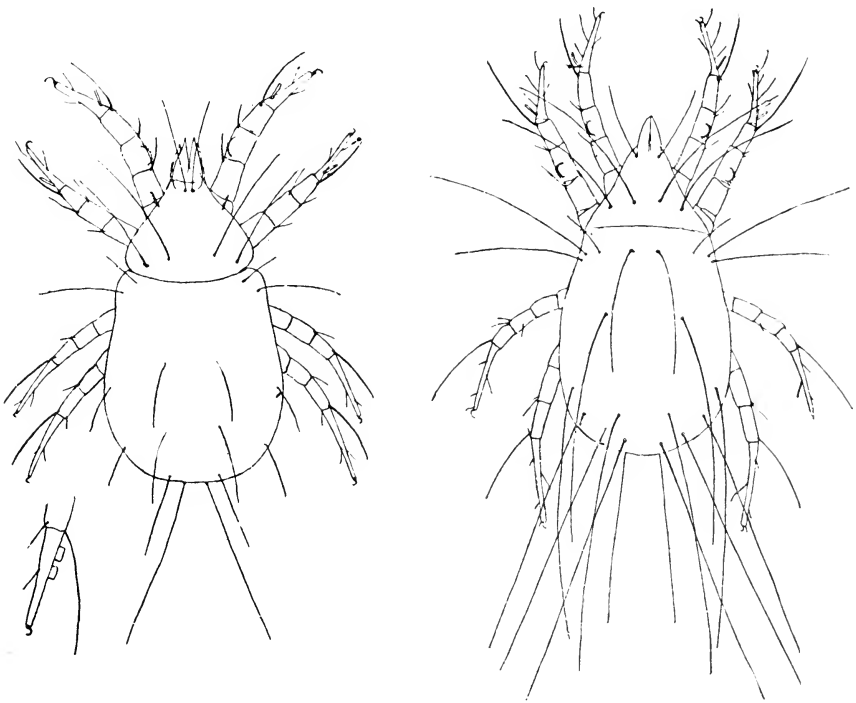


Fig. 61. The mushroom mite very greatly enlarged. After deOng and Roadhouse.)

Springtails, *Achorutes* spp., *Onychiurus* spp. **and Others.**—Springtails are minute white or dusky insects which live in the soil and which jump freely. They feed extensively on fleshy fungi and may often occur in considerable numbers in mushroom houses. As they often congregate near the surface of the beds they may be killed by fumigating the houses with calcium cyanide dust at the rate of 2½ ounces per 1,000 cubic feet. Placing cheap muslin over the infested beds and then sprinkling paradichlorobenzene rather thickly over the cloth, covering the whole with paper to prevent the upward escape of the gas, and allowing the fumigant to remain for a period of 48 hours, has also been successful in eastern houses.

NURSERY STOCK (DORMANT)

Borers and Other Insects on Deciduous Stock.—Fumigate with hydrocyanic acid gas. Rejecting infested stock is the only safe procedure.

Nematode.—Very carefully avoid planting affected trees. If a large percentage of a plot of trees is affected, those apparently healthy are of doubtful value. See p. 96.

Scale Insects.—For scale insects on citrus nursery stock, defoliate and fumigate with hydrocyanic acid gas (see p. 115), or dip in 5 per cent summer oil emulsions. Rejecting infested stock is the only safe procedure.

OAK

California Oak Moth, *Phryganidia californica* Packard.—The adult is a small pale-brown moth nearly 1 inch long. The somewhat flattened-globular white eggs are laid in masses on the leaves, limbs, and trunks of the trees in the fall of the year and again in summer—there are two broods a season. The caterpillars feed upon the leaves and may appear in such great numbers, especially in late summer, as to completely defoliate the oak trees. Pupation occurs on the trees or on any nearby objects. Control measures should be particularly directed against the first-brood larvae in April and May, but if neglected then the sprays should be applied as soon as the damage to the foliage is noted. Spray thoroughly with arsenate of lead at the rate of 3 pounds of the powder to 100 gallons of water. The addition of ½ pint of fish oil, as an adhesive, will add to the effectiveness of the spray in making it more resistant to rains.

OATS

(See "Grain," p. 53)

OLIVE

Black Scale, *Saissetia oleae* (Bern.).—See "Apricot," p. 18. This scale attacks chiefly the twigs. Spray with 3 per cent commercial oil emulsions, 3 per cent miscible oil or 2½ per cent tank-mix emulsions, December to February. See fig. 39.

Branch and Twig Borer, *Polycaon confertus* Lec.—See "Apricot," p. 18. This is often a serious pest of young olive trees. See fig. 62.

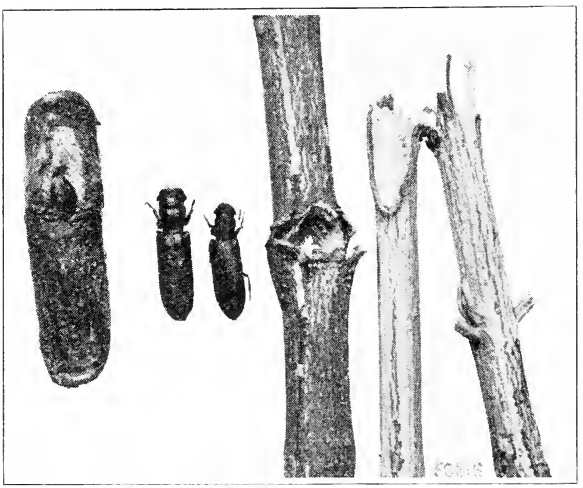


Fig. 62.—The branch and twig borer and work on small limbs of olive trees. The larvae are reared in dead dry wood.

Ivy or Oleander Scale, *Aspidiotus hederae* Vall.—A small circular, flat, gray scale occurs on the leaves and fruit, sometimes causing discolored spots on the ripening olives. Control as for black scale.

Fig. 63.—The ivy or oleander scale on olive leaf.

Olive Bark Beetle, *Leperisinus californicus* Swaine.—The small white larvae work in the cambium layer just under the bark and the adults bore small, round exit and entrance holes through the bark. It occurs in the southern part of the state. Burn prunings and remove all dead and infested portions of the trees.

ONION

Armyworms and Cutworms.—See p. 89.

Onion Maggot, *Hylemyia antiqua* (Meig.).—Small, white maggots attack the onions beneath the ground. Practice clean culture and destroy all refuse onions in the fall. Plow and cultivate thoroughly during winter

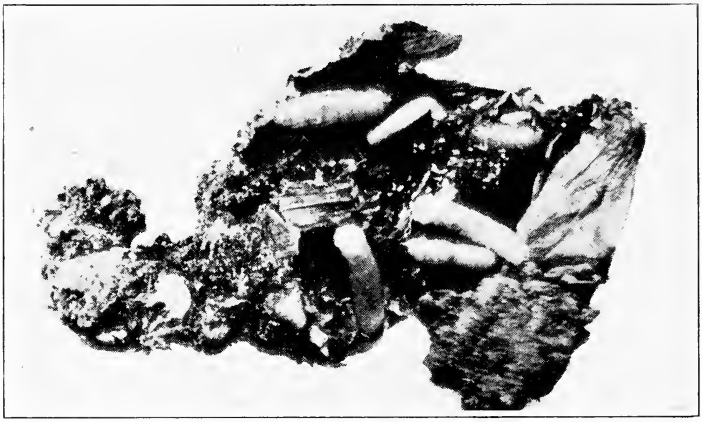


Fig. 64.—Decayed onion, a result of the attacks of the larvae of the onion maggot, also shown.

and spring. For control use mercuric chloride as recommended for cabbage maggot (see "Cabbage," p. 32).

Onion Thrips, *Thrips tabaci* Lind.—Minute, slender, grayish-brown adult insects and pale-yellow larvae occur in great numbers on the leaves, causing them to turn gray and wither. Spray with 1 part of 40

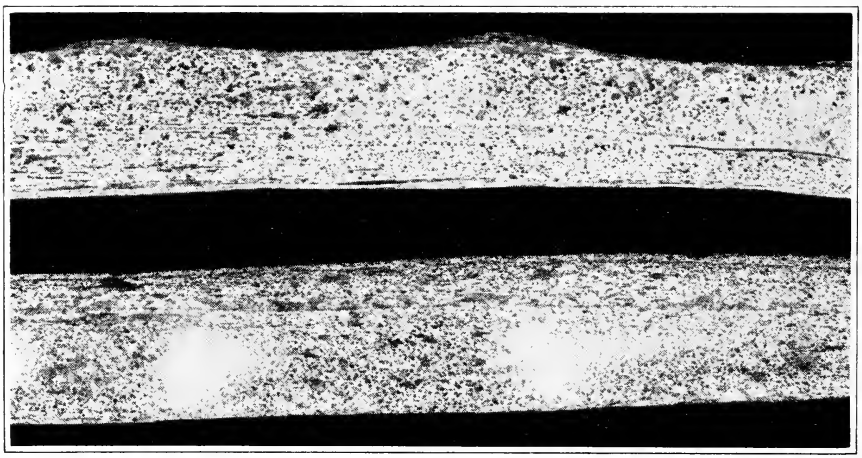


Fig. 65.—Onion leaves showing typical injury caused by the feeding of the onion thrips.

per cent nicotine sulfate (Black Leaf 40) to 800 parts of water at 250-300 pounds pressure or apply nicotine dust (2–4 per cent). Plant early maturing varieties and maintain vigorous growth.

Wireworms.—See p. 101 and fig. 47, p. 49.

ORANGE

(See Citrus Fruits," p. 41)

PALMS

(See "Date," p. 50)

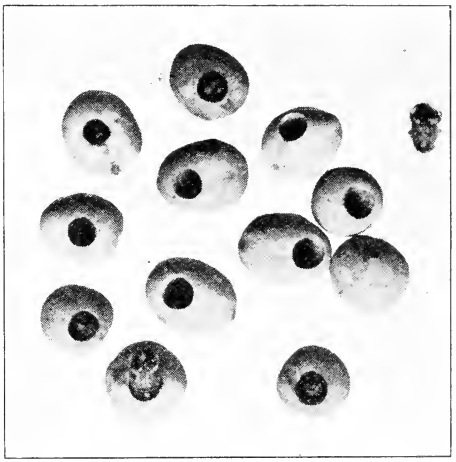


Fig. 66.—Dried garden peas showing the exit holes of and adults of the pea weevil. The larvae matured within the seeds.

PEA

Alfalfa Caterpillar.—See "Alfalfa," p. 4. The young caterpillars are often very destructive to garden and sweet peas. Dust with barium fluosilicate or cryolite or a mixture of equal parts of dusting sulfur and calcium arsenate.

Armyworms and Cutworms.—See p. 89.

Garden Centipede.—See "Snapdragon," p. 79.

Pea Aphid, *Illinoia pisi* (Kalt.).—This is a large green aphid which attacks the terminal shoots and leaves of the vines. It is difficult of control because of the expense involved, but may be killed by repeated applitions of a 4 per cent nicotine dust (see p. 133) or a nicotine spray (formula 25, p. 132), calcium cyanide dust, nicosulfur dust containing 2½ per cent nicotine, 30 per cent sulfur and the rest hydrated lime, may serve to control mildew also.

Pea Weevil, *Mylabris pisorum* (Linn.).—A small gray and white weevil attacks the pea, much as the bean weevil attacks the bean, but the

peas are infested in the field and the adult weevil does not emerge until the following spring. Unlike the bean weevil it never reinfests stored peas. Treatment is the same as for bean weevil (see "Bean," p. 25).

Red Spider.—See under "Bean," p. 26.

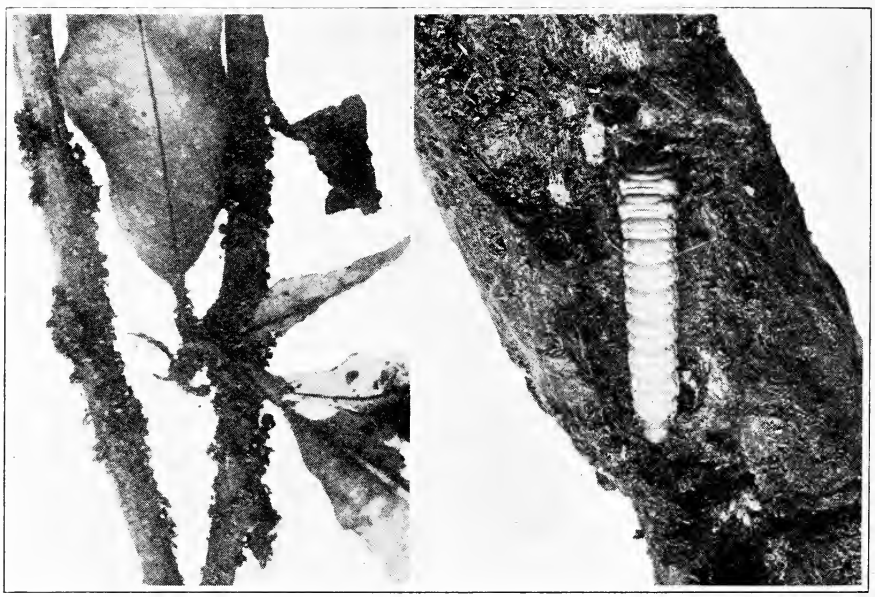


Fig. 67 Fig. 68

Fig. 67.—Peach twigs infested with the black peach aphid.
Fig. 68.—The larva of the Pacific peach tree borer, exposed to view by removing the bark of the tree.

PEACH

Black Peach Aphid, *Aphis persicae-niger* Smith.—A shiny black aphid sometimes occurs in great numbers on the young tender shoots. Spray with nicotine and soap (formula 24, p. 132) or dust with 2 per cent nicotine dust as soon as the insects appear.

Black Scale.—See "Brown Apricot Scale," under "Apricot," p. 18.

Branch and Twig Borer.—See "Apricot," p. 18.

Brown Apricot Scale.—See "Apricot," p. 18.

Cankerworms.—See p. 92.

Grass or Western Flower Thrips, *Frankliniella californica* Moult.—Control same as for bean thrips; see "Bean," p. 25.

Nematode.—See p. 96.

Pacific Peach Tree Borer, *Aegeria opalescens* Hy. Edw.—The white caterpillars, attaining a length of 1½ inches, burrow under the bark at the base of the trees, often extending their tunnels down into the bases

of the main roots. They are often serious, and may completely girdle the trees. Dig out the worms carefully in the fall and spring and paint over the wounds with a good asphaltum paint. Use paradichlorobenzene in summer and fall (see p. 129).

Peach Rust Mite, *Phyllocoptes cornutus* Banks.—A microscopic mite causes a silvering of the leaves. Spray in winter when the trees are dormant or when buds swell in the spring with lime-sulfur, 1–10, to kill mites hibernating in buds.

Peach Twig Borer, *Anarsia lineatella* Zeller.—A small, dark-reddish caterpillar, scarcely ½ inch long, burrows into and kills the young tender tips of the twigs and, later on, may infest the fruit to some degree. The minute young forms hibernate in small cells in the bark and are

Fig. 69.—Shoots and twigs of almond showing characteristic wilting and dying caused by the larvae of the peach twig borer. (After Duruz.)

effectively killed in the early spring of the year with lime-sulfur, 1–10, applied just as the blossom buds begin to open, which is before the larvae are able to enter the expanding leaf buds.

The following are the joint recommendations of the University of California and the California State Department of Agriculture:

Recent seasons have witnessed a decided increase in peach twig borer infestations in many of the large fruit-growing districts of California. Not only has greater injury occurred in peaches, but a growing hazard has developed in apricots, plums, prunes, and almonds. Not only have growers suffered heavy losses, but the wormy peach and apricot problem is also of particular concern to canners. To the end that twig-borer losses may be successfully checked, a vigorous campaign by growers is essential.

An effective control of the spring brood is fundamental for the control of peach twig borer. Failure to spray both bearing and nonbearing trees or carelessness in application will result in individual loss as well as damage to the industry as a whole.

The standard control for the peach twig borer has for many years been delayed dormant lime-sulfur *applied in the spring from the time the blossom buds are beginning to show pink until the first blossoms open.* This spray program still holds good

for most of the state as far as all stone fruits except apricots are concerned. In many orchards, however, considerable injury to the trees has been occasioned from the use of this spray, and complete control of the twig borer has not been obtained. Recent experiments have demonstrated that the combination of basic arsenate of lead and lime-sulfur has given more satisfactory control.

Program No. 1.—This program is intended especially for peaches and nectarines and serves as a combined spray for peach twig borer and peach leaf curl.

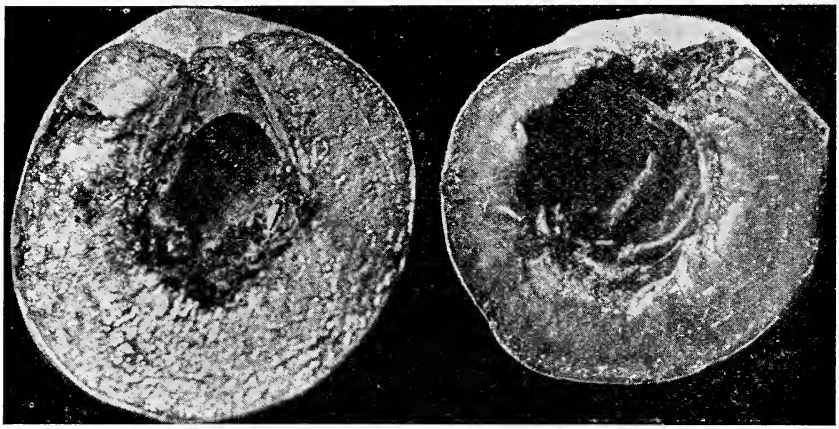


Fig. 70.—Larvae of the peach twig borer in fruit of the apricot. (After Clarke.)

Wherever lime-sulfur alone is desired as a spray for the peach twig borer, use lime-sulfur (standard or 32° Baumé) 8 gallons, or an equivalent amount of dry lime-sulfur, with water to make 100 gallons of spray.

Although this has been the standard remedy for the peach twig borer on peach trees for many years, recent careful investigations tend to show that it is really of little value in controlling the insect. A more satisfactory remedy is a spray composed of 3 pounds of basic arsenate of lead to 100 gallons of water as recommended in program No. 2 below. This spray should be applied when the petals of at least two-thirds of the blossoms have fallen in order to avoid poisoning the honeybees.

This program may also be used for almonds, plums, and prunes.

Program No. 2.—For apricots, the use of lime-sulfur is likely to cause injury. Use 3 pounds of dry basic arsenate of lead with water to make 100 gallons. Apply this spray at the red bud stage.

Important.—Summer sprays with arsenicals should not be applied without consultation with competent authorities.

Too much emphasis cannot be placed upon the necessity of proper spraying at the right time. It is essential to cover the entire surface of the tree, particularly the newer and outer portions of the branches. Use at least 175 pounds pressure, preferably 250 pounds.

All prunings should be collected and burned before spring, particularly the small and newer wood, because this material harbors the larvae.

Cull fruit should not be carelessly left about the orchard or packing-

house. All wormy fruit should be collected and properly disposed of. It should be fed promptly to pigs or other stock, or destroyed by burning or burying. A quick and simple manner of destroying worms in the cull fruit is to place the discarded fruit in a pile or in a trench, saturate with oil or cover with wood, and ignite. The heat resulting from the fire will be sufficient to kill the larvae in the fruit. Another means of destroying the larvae is to place the cull fruit in a caldron of boiling water for 15 minutes.

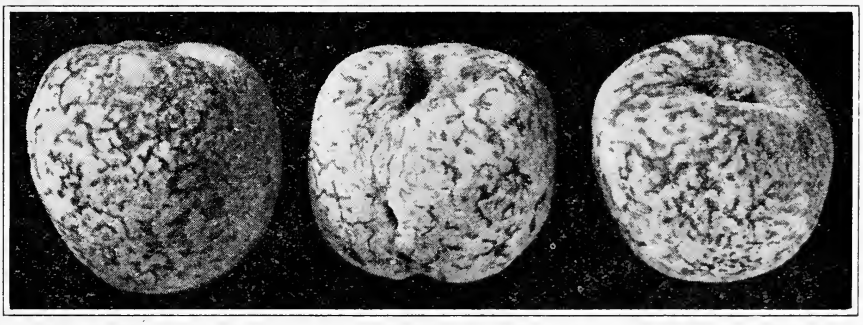


Fig. 71.—Peaches showing scarring caused by the feeding of the wheat thrips and the western grass thrips. (After Essig, *Insects of Western North America*, by permission of the Macmillan Co., copyright owners.)

Red Spider.—See "Plum, Prune," p. 73.

San Jose Scale.—See under "Apple," p. 15.

Shot-Hole Borer.—See under "Apricot," p. 19.

Tent Caterpillars.—See p. 100.

Western Flat-headed Borer.—See under "Apple," p. 16.

Wheat Thrips, *Frankliniella tritici* (Fitch).—This minute orange and yellow thrips often does considerable damage to the young fruit at blossoming time and later. Control as for pear thrips; see "Pear," p. 73.

PEAR

Combined Spraying.—1. For scale of any kind and for moss and a general clean-up, use a winter spray of lime-sulfur, 1–10, commercial oil emulsions, or tank-mix sprays (p. 126), or oil and caustic soda, formula 23, p. 129.

2. For scab and thrips use bordeaux mixture (formula 10, p. 114), or lime-sulfur 1-12 as cluster buds are opening, adding an extra 10 pounds of lime and 1 pound of 40 per cent nicotine sulfate to each 200 gallons of spray. Oil sprays may be mixed with lime-sulfur or bordeaux mixture for this purpose.

3. For scab and thrips, repeat "2" when first blossoms are about to open.

4. For codling moth and late scab infection, spray when petals are falling with 3 pounds of powdered standard lead arsenate in 100 gallons of 1–50 lime-sulfur or 100 gallons of 5–5–50 bordeaux mixture.

Bean Thrips, *Hercothrips fasciatus* (Perg.).—When the thrips appear in destructive numbers, spray with a highly refined commercial oil emulsion at 2 per cent concentration to which add ½ pint of nicotine

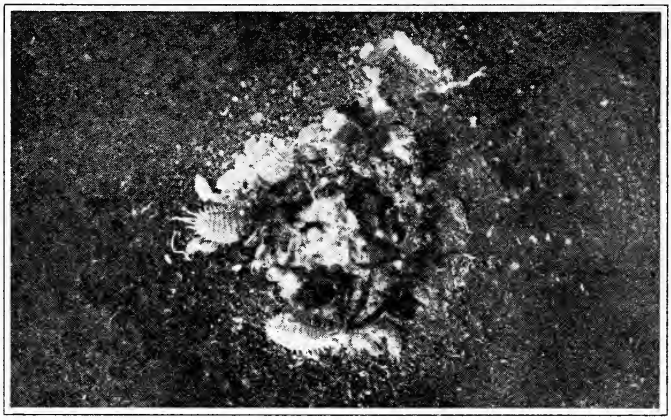


Fig. 72.—The grape mealybug clustered in the blossom end of a pear. (After Essig, *A History of Entomology,* by permission of the Macmillan Co., copyright owners.)

sulfate (40 per cent) to 100 gallons of the emulsion. Also tank-mix oil, nicotine, and ammonia (formula 21, p. 128, with summer oil) may be used. See "Bean," p. 25.

Branch and Twig Borer.—See "Apricot," p. 18.

Brown Apricot and Other Soft Scales.—See "Apricot," p. 18.

Cankerworms.—See p. 92.

Cherry or Pear Slug.—See "Cherry," p. 37.

Codling Moth.—See "Apple," p. 9. The control of this insect on pears is not so difficult as on apples, but thorough work is necessary to insure clean fruit, particularly in districts where large acreages of pears are grown.

Fruit Tree Leaf Roller.—See under "Apple," p. 15.

Grape Mealybug, *Pseudococcus maritimus* Ehrh. (= *P. bakeri* Essig). —This mealybug is a small, oval, flat insect less than ¼ inch long, and covered with white powdery wax and normally with several white, tail-like filaments nearly half as long as the body. The egg sacs look like small masses of cotton. The insects occur under the bark, on the underside of limbs, in cracks, wounds, and in the blossom end of the fruit. Control

measures are difficult and consist of repeated applications of 3 per cent miscible oil emulsions or the combination of oil and lime-sulfur (formula 20, p. 128) during the winter months and until the buds begin to open in the spring. Scrape the rough bark from the trunks and larger limbs so as to expose the mealybugs to the spray. If the fruit is infested, spray during the summer with water under heavy pressure to wash the mealybugs away.

Green Apple Aphid—See "Apple," p. 15.

Italian Pear Scale, *Diaspis piricola* (Del G.).—A small, gray, circular scale, the body being dark red, usually occurs under the moss or old bark; but it may cover the trunks and all of the main branches of the tree.

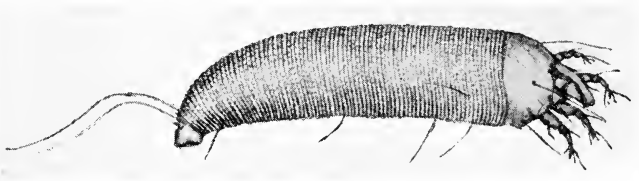


Fig. 73.—Adult of the pear leaf blister mite greatly enlarged. (After Parrott.)

It causes sunken areas in old limbs and greatly weakens the tree. Spray in the winter months, preferably in January and February, with heavy commercial oil emulsions (7 per cent) or with tank-mix oil sprays, using the heavier oils (4 per cent). Thoroughly drench the limbs and trunks.

Pear Leaf Blister Mite or Bud Mite,[19] *Eriophyes pyri* (Pagen.).—This microscopic mite causes pinkish and yellowish blisters or marks on the young terminal leaves and occasionally reddish blotches on the young fruit. Spray in late October or in November with a combination of 2 gallons of oil emulsion (viscosity 70 and unsulfonatable residue 90 or above) and 5 gallons of commercial lime-sulfur per 100 gallons of water, to kill the hibernating mites in the buds. November control is particularly recommended. If spring control is necessary, use 4 per cent commercial lime-sulfur in the cluster-bud stage or just before the blossoms open.

Pear Root Aphid, *Eriosoma languinosa* (Hartig).—This is a small dark aphid covered with white cottony material and greatly resembling the woolly apple aphid, but it attacks only the pear roots. For control see "Woolly Apple Aphid," under "Apple," p. 17. Eliminate young stunted trees and replant healthy ones. The Japanese root is much more resistant to this pest than the French. Use paradichlorobenzene in the fall (see p. 129).

[19] See: Borden, Arthur D. The pear leaf blister mite as a cause of fruit-bud injury. California Agr. Exp. Sta. Cir. 324:1–8. 1932.

Pear Thrips, *Taeniothrips inconsequens* Uzel.—Spray with oil emulsion (or tank-mix) and Black Leaf 40 (formula 21, p. 128). A 2½ per cent nicotine dust (see p. 133) is very effective against the larvae if the temperature is about 70° Fahrenheit or above and the air is still. Several applications are usually necessary. Destruction of forms in the soil is

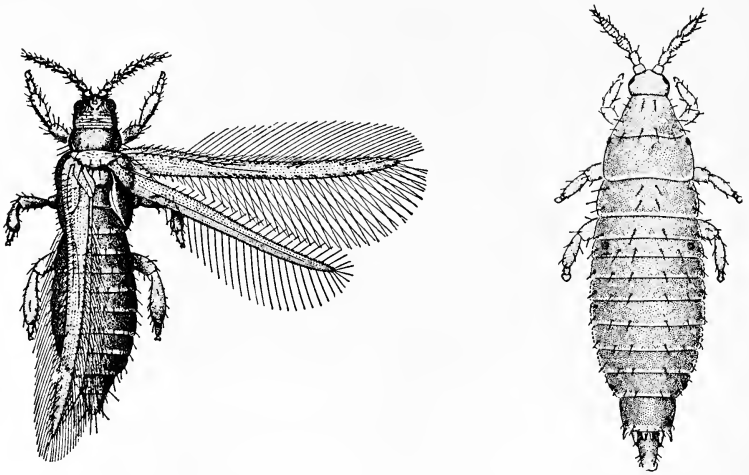


Fig. 74.—The adult and larva of the pear thrips; greatly enlarged. (After the United States Department of Agriculture.)

obtained by dry fall plowing (6–10 inches) with a moldboard or disk plow (single disk) as soon as the crop is out. Where possible, irrigation in October produces a high mortality of the pupae.

Red-humped Caterpillar.—See under "Plum, Prune," p. 75.

San Jose Scale.—See under "Apple," p. 15. Treatment for the Italian pear scale above will also suffice for this insect.

PLUM, PRUNE

Combined Spraying.—For scale, moss, and a general clean-up, spray in winter with heavy oil emulsions or tank mix (p. 126).

Almond Mite.—See "Almond Mite," under "Almond," p. 7.

Black Scale.—See "Brown Apricot Scale," under "Apricot," p. 18.

Brown Apricot Scale.—See "Apricot," p. 18.

Cankerworms.—See p. 92.

Cherry Fruit Sawfly.—See "Cherry," p. 37.

European Red Mite, *Paratetranychus pilosus* (C. & F.), **Common Red Spider,** *Tetranychus telarius* Linn., **Pacific Mite,** *T. pacificus,* McG., **and Two-spotted Mite,** *T. bimaculatus* Harvey.—Small, pale, green or yellow mites, the last with two dark spots on the back, appear in mid and late summer and do great damage to plum and prune trees by

causing the leaves to fall prematurely. Dusting and spraying as recommended for the almond mite should be done very thoroughly and continued until the first good rains occur in the fall. Avoid lime-sulfur or oil sprays on shipping plums.

Dried Fruit Beetle, *Carpophilus hemipterus* (Linn.).—This is a small black beetle less than ¼ inch long with a reddish spot near the middle of the dorsum. The adults and small yellowish or whitish larvae feed on the dried fruit and continue to breed indefinitely in storage. They may be controlled in storage by fumigation as recommended for grain weevil (see "Grain," p. 53). See fig. 51, p. 52.

Fruit Tree Leaf Roller.—See "Apple," p. 15.

Indian Meal Moth, *Plodia interpunctella* Hbn.—The caterpillars are white or pinkish and about 1 inch long. They feed on the dried fruit, through which they work their way to all parts, leaving behind a trail of excrement, webbing, and spoiled fruit. Their presence is usually first indicated by webbing on the fruit or around the sides of the container. The adults are small, slender, silvery gray moths with the apical ends of the wings coppery. This insect is controlled in the same way as the granary weevil (see "Grain," p. 53). Dipping the fruit in scalding water prior to packing kills all forms of this insect. Small packages of dried fruit should be made insect proof to prevent infestation in warehouses and storerooms.

Italian Pear Scale.—See under "Pear," p. 72.

Mealy Plum Aphid, *Hyalopterus arundinis* (Fabr.).—A pale-green aphid covered with a fine white mealy wax collects in great numbers on the underside of the leaves of tender shoots in May and June.

Fig. 75.—Prunes split at end owing to heavy infestations of the mealy plum aphid.

Best results in the control of this aphid are obtained by applying coal tar sprays, containing 2 per cent of actual tar distillate, during the dormant season to kill the eggs overwintering on the twigs. A spray consisting of 2 gallons of light summer oil and one-half pint of nicotine sulfate (40 per cent) per 100 gallons may be used when about 5 per cent of the blooms are out, or a nicotine and soap mixture (formula 24, p. 132) may be used during the spring and early summer.

Pacific Peach Tree Borer.—See "Peach," p. 67.

Peach Twig Borer.—See under "Peach," p. 68.

Pear Thrips.—See under "Pear," p. 73.

Red-humped Caterpillar, *Schizura concinna* (A. & S.).—The caterpillars are beautifully lined, reddish-black and yellow with a conspicuous red hump on the back. They feed in large colonies and may entirely defoliate individual limbs or entire trees during the spring and again in the fall of the year. They spin no webs, appear in the fall, and are not to be confused with the tent caterpillars, which appear in the spring. Control measures consist in cutting out and burning the entire colonies when small or in spraying with arsenate of lead as for codling moth, or, better, in dusting the infested trees with powdered standard arsenate of lead thoroughly mixed with equal parts of hydrated lime. The dusting may be effectively done with either a hand or power machine. See fig. 89, p. 87.

San Jose Scale.—See "Apple," p. 15.

Shot-Hole Borer,[20] *Scolytus rugulosus* Ratz., is a very small black beetle which attacks the limbs of prunes, plums, cherries, apricots, and other deciduous fruit trees and causes a copious flow of gum in summer and fall. The larvae mine in the sapwood and may kill branches or entire trees. The attacks of the insects are most severe in orchards deficient in soil moisture. Keep trees growing as vigorously as possible, promptly remove dead branches or dead trees, and burn all prunings.

Tent Caterpillars.—See p. 100.

Tussock Moths.—See under "Apple," p. 16.

Western Flat-headed Borer.—See under "Apple," p. 16.

POTATO

Combined Spraying.—Bordeaux mixture will not only repel the flea beetles but will also aid materially in subduing many fungus diseases.

Aphids (Various Species).—Dust thoroughly with 2 per cent nicotine dust (see p. 133) or spray with 1 part of 40 per cent nicotine sulfate to 800 parts of water. Destruction of aphids and other sucking insects helps to check the spread of mosaic diseases, virus diseases, and degeneration diseases, which are transmitted by these insects. Plants affected by these diseases show stunted, mottled, crinkled, or variously abnormal foliage, according to the specific kind of disease.

Armyworms and Cutworms.—See p. 89.

[20] See: Smith, Leslie M. The shot hole borer. California Agr. Ext. Cir. 64:1–13. 1932. See also fig. 13, p. 19.

Flea Beetles and Leaf Beetles.—See "Cucumber," p. 47. Use bordeaux mixture (formula 10, p. 114) as a repellent, or a nicotine-dust—lead-arsenate mixture or 70 per cent sodium fluosilicate or other fluosilicate dust. See fig. 44, p. 47.

Fig. 76.—Potatoes showing injury caused by the larvae of the western potato flea beetle.
(Courtesy A. J. Hanson.)

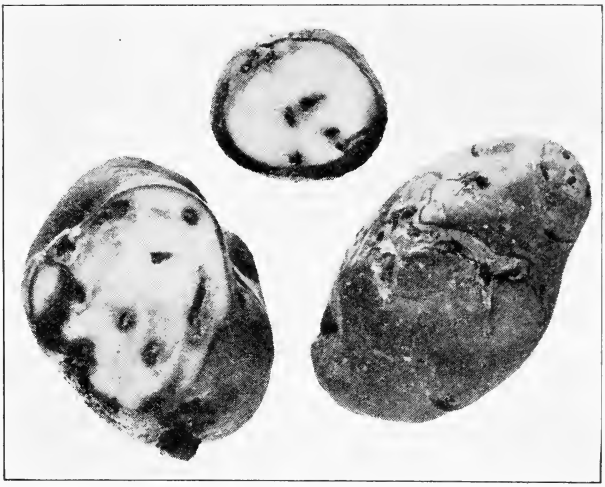


Fig. 77.—Characteristic work of the larvae of the potato tuber moth on potatoes.

Grasshoppers.—See p. 94.

Potato Stalk Borer, *Trichobaris trinotata* Say.—The larvae are small, pale yellow or white, and not over ½ inch long; they bore throughout the middle of the stalks, causing them to wilt and die. The adults hibernate in the old dry stalks, which should be raked up after digging and burned. This affords an almost perfect control if thoroughly done.

Potato Tuber Moth, *Phthorimaea operculella* (Zeller).—The full-grown caterpillars are white or pinkish and not over ¾ inch long. They make numerous burrows just under the skin and throughout the tubers, continuing to work as long as the tubers are available. Infestation may occur in the field or in storage. Hill up well around the growing plants and remove the potatoes as soon as dug to prevent infestation in the field. Store in a clean, uninfested place. If infested, fumigate with 20 to 30 pounds of carbon disulfide to every 1,000 cubic feet of air space at a temperature of 70° Fahrenheit or over. Plant only clean seed.

Root-Knot Nematode, or Eelworm, *Heterodera marioni* (Cornu).—This microscopic round worm produces a pimply or warty surface on the potato and small brown dots just beneath the skin. Plant only clean seed and avoid infested soil (see p. 97).

Tomato and Tobacco Worms.—See under "Tomato," p. 85.

Wireworms.—See p. 101.

PUMPKIN

(See "Melons," p. 60)

QUINCE

(See "Apple," p. 8)

RICE

(See "Grain," p. 53)

ROSE

Aphids (Various Species).—Two common aphids usually infest roses: the large green and pink *Macrosiphum rosae* (Linn.), which commonly attacks the tender tips and buds, and the small green *Myzaphis rosarum* (Walk.), which works on all parts of the plant and produces large quantities of honeydew, which results in the smutting of the plants. Both may be effectually controlled by dusting liberally with 2 per cent nicotine dust (see p. 133), by spraying with Black Leaf 40, 1 part to 1,000 parts of water, or with nicotine soap sprays (formula 24, p. 132), or by thoroughly hosing off the plants every two or three days with a strong water pressure and a coarse nozzle.

Bristly Rose Slug, *Cladius isomerus* Norton.—This slug is a small pale-green caterpillar-like larva which eats irregular holes in the leaves or completely destroys the foliage of rose bushes. The adults are small black sawflies which somewhat resemble diminutive bees. They lay their eggs on the petioles of the leaflets. Two broods of larvae appear, one in early summer and the second in the fall. Spray as soon as the injury is noted with arsenate of lead (colored green if preferred so as not

Fig. 78 Fig. 79

Fig. 78.—The rose aphid. This insect usually occurs on the tips of the new growth and buds.

Fig. 79.—The bristly rose slug, a green worm-like larva which skeletonizes the leaves of roses. (After Essig, *Insects of Western North America,* by permission of the Macmillan Co., copyright owners.)

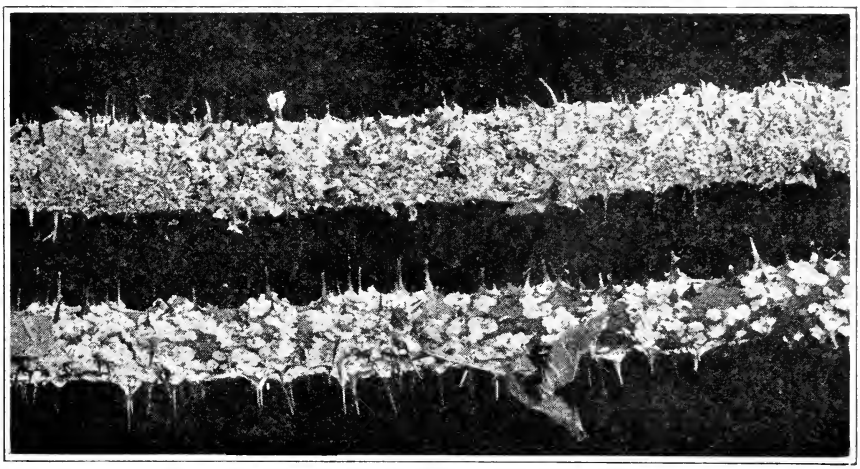


Fig. 80.—The rose scale, a white scale that attacks roses, blackberries, raspberries, and related plants. (After Essig, *Insects of Western North America,* by permission of the Macmillan Co., copyright owners.)

to be noticeable on the foliage) at the rate of 2 pounds to 50 gallons of water. One application applied in May or June is usually sufficient.

Fuller's Rose Weevil.—See under "Citrus Fruits," p. 42.

Raspberry Horntail.—See under "Bush Fruits," p. 32.

Rose Scale.—See "Bush Fruits," p. 32. Spray infested portions of the plants during the winter months with miscible oils.

Rose Snout Beetle, *Rhynchites bicolor* Fabr.—A small red and black snout beetle, scarcely ¼ inch long, which punctures the buds of roses, causing numerous holes in the petals when the flowers open. Jar beetles into a pan of oil in the early morning. A 4 per cent nicotine dust has given good control in some places. Arsenate of lead as recommended above for the bristly rose slug, applied as soon as the injury is noticed, also gives satisfactory control.

SNAPDRAGON

Aphids.—Dust thoroughly with 2 per cent nicotine dust. See "Rose," p. 77.

Garden Centipede, *Scutigerella immaculata* (Newport).—A small white centipede-like animal about ¼ inch long inhabits the soil especially in greenhouses, truck gardens, and home flower and vegetable gardens (see also "Asparagus," p. 21). It may often be present in immense numbers and feeds upon the germinating seeds, young rootlets, and underground stems of the plants. In greenhouses and lathhouses it is very destructive to snapdragons, sweet peas, asters, and other plants. Plants grown in raised benches under proper conditions of clean soil and fertilization are less liable to infestation, but plants grown in ground beds may be severely injured. Control is obtained by applying carbon disulfide emulsion 1–300 at the rate of 3 to 5 gallons per square yard.[21]

Snapdragon Plume Moth, *Platyptilia marmarodactyla* Dyar.—The small green larvae first mine the leaves and then burrow into the terminal shoots. Only by repeated applications of nicotine (formula 21, p. 128), pyrethrum (formula 28, p. 135), or arsenate of lead sprays (formula 6, p. 112) to kill the young larvae, can the damage be averted.

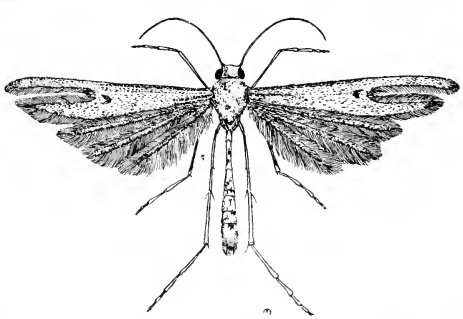


Fig. 81.—The snapdragon plume moth. (After Woodworth.)

[21] See: Wymore, F. H. The garden centipede. California Agr. Exp. Sta. Bul. 518:1–22. 1931.

Michelbacher, A. E. Chemical control of the garden centipede, *Scutigerella immaculata*. California Agr. Exp. Sta. Bul. 548:1–19. 1932.

SORGHUM, SUDAN GRASS, BROOM CORN, AND MILLET

(See "Grain," p. 53)

SPINACH

Armyworms and Cutworms.—Poison bran mash sown broadcast over the fields has proved very successful in completely protecting young plants. Because of the danger of poisoning due to the use of arsenicals and fluosilicates great care should be exercised to see that no such materials are used on the plants, except only on the very young ones. Mashes broadcast over the fields should be used only when the plants are young. On older plants sow the poison between the rows. See p. 89.

Beet or Spinach Leaf Miner, *Chortophila hyoscyami* Panzer.—Small white maggots mine the leaves and cause discolored areas. Keep down

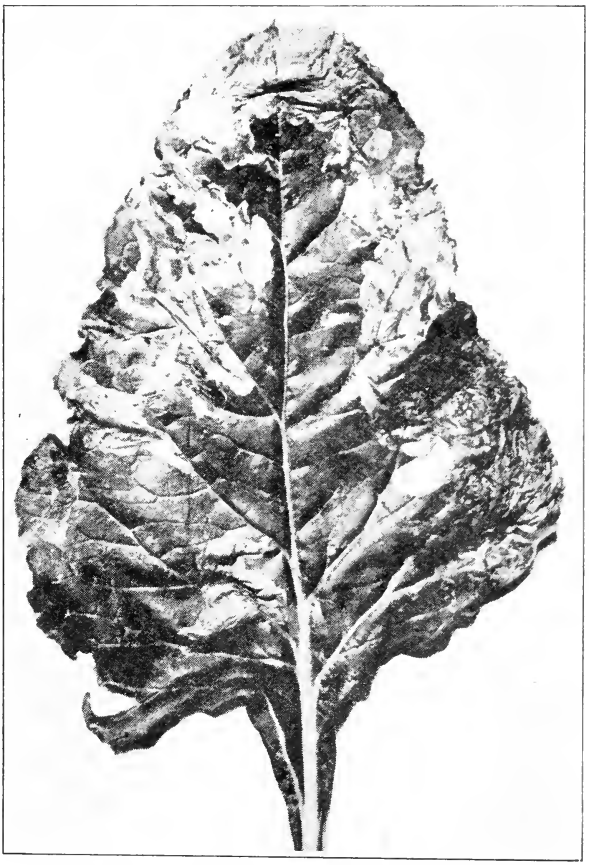


Fig. 82.—A beet leaf showing the injury caused by the mining habits of the larvae of the beet or spinach leaf miner.

all weeds about the fields, burn refuse tops, harvest as early as possible. Winter-grown spinach usually escapes the attacks of this insect.

Flea Beetles.—See "Cucumber," p. 47.

Grasshoppers.—See p. 94.

Melon Aphid.—See "Melons," p. 60.

SQUASH

(See "Melons," p. 60)

STRAWBERRY

Black Vine Weevil, *Brachyrrhinus sulcatus* (Fabr.), is a black snout beetle ⅝ inch long and the larvae are white, crescent-shaped, legless grubs with brown heads and when mature measure nearly ¾ inch in length. The adults feed upon the leaves and the larvae upon the roots of blackberries, raspberries, strawberries, and a number of ornamentals. For control use poison baits, commercial or formula 2, p. 108, or 15, p. 117.

Rough Strawberry Weevil, *Brachyrrhinus rugosostriatus* (Goeze).—This weevil is similar to the preceding species but is considerably larger and more robust in form. It is also more generally distributed in California, especially in parts of the San Francisco Bay region, where it appears so far to prefer the raspberry to the strawberry. For control use a commercial poison bait or a home-made substitute (formula 2, p. 108, or 15, p. 117).

Fig. 83.—The rough strawberry weevil. (After Leslie M. Smith.)

Strawberry Aphid, *Myzus fragaefolii* Ckll.—A very small pale yellow aphid occurs in great numbers on the undersides of the leaves, and often smuts the foliage. It transmits a serious strawberry disease known as xanthosis, yellows, or degeneration, which is very destructive to the plants. Defoliate the plants in winter. Dust liberally with 2 per cent nicotine dust (see p. 133) as soon as the aphids appear, applying it to the underside of the leaves with an upturned discharge pipe.

Strawberry Crown Moth, *Aegeria rutilans* H. Edw.—The white caterpillar, ½ inch long or less, bores into the crown of the plant, causing it to turn yellow and die. Remove and burn infested plants as soon as discovered. Be sure of clean nursery stock.

Fig. 84.—Caterpillar of the strawberry crown moth in a raspberry cane. (After Leslie M. Smith.)

Strawberry Flea Beetle, *Haltica ignita* Illiger.—A bright metallic, golden, green, or purplish flea beetle, 1/6 inch long, feeds upon the leaves of the plants. Use bordeaux mixture (formula 10, p. 114) as a repellent or dust with 70 per cent sodium fluosilicate.

Strawberry Leaf Beetle, *Paria canella* (Fabr.).—A small brown beetle with black markings on the dorsum and averaging ⅛ inch long. The adults eat numerous small irregular holes in the leaves, while the small white larvae attack the roots. It is a severe pest, and should be eradicated if possible, by destroying all infested vines and thoroughly sterlizing the soil by steam or carbon disulfide. Established infestations

may be reduced by thoroughly spraying with basic arsenate of lead (formula 7, p. 112), or by dusting with 1 part of basic powdered arsenate of lead to 4 parts of powdered hydrated lime.

Strawberry Mite, *Tarsonemus fragariae* Zimm.—A microscopically small white mite attacks the young growth and often does serious damage to the plants. It is a new pest, probably introduced from England,

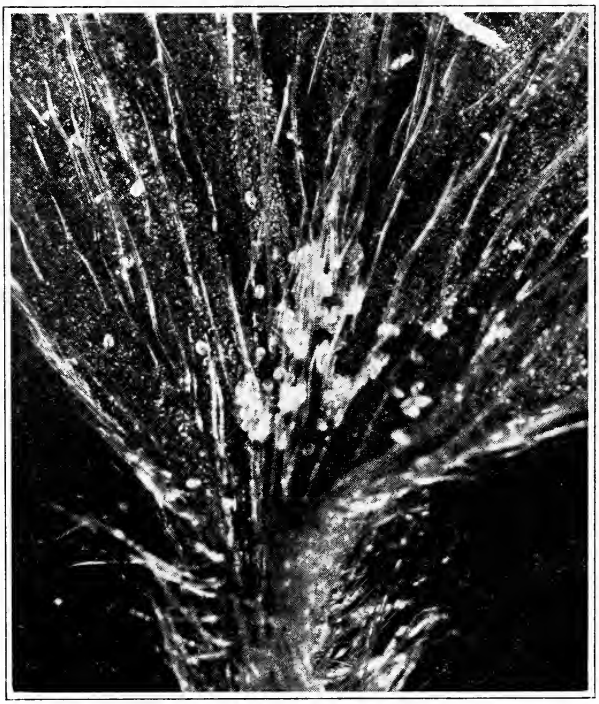


Fig. 85.—Eggs of the strawberry mite at the base of a young unfolding leaf. (Courtesy of Leslie M. Smith.)

and occurs in a limited area along the coast south of the San Francisco Bay region. As yet no successful field control has been worked out. Care should be taken to avoid infested plants in setting out new fields.

Strawberry Root Weevil, *Brachyrrhinus ovatus* (Linn.).—The adult is a small black snout beetle, 3/8 of an inch long, and the larva is white, crescent shaped, legless, and about the same length. The adults feed on the foliage and the larvae on the roots of strawberries and either or both stages may often do great damage. Fortunately the insect at present occurs only in limited numbers in some of the northern coast counties and has not been found in the large commercial plantings of the state. The insect is effectively controlled by the use of poison fruit baits

scattered in the fields. The commercial dried-apple bait ("Go West") and certain homemade baits (formula 2, p. 108, or 15, p. 117) may be used. They should be scattered broadcast or along the rows whenever the adults appear, but never on the vines when berries are being harvested.

Two-spotted Mite, *Tetranychus bimaculatus* Harvey.—See "Bean," p. 26, and "Prune," p. 73. Though this mite is ordinarily controlled with dry sulfur, this method cannot be used on strawberries because of the severe burning to the foliage. Very small amounts of sulfur in the ditches between the rows have afforded some relief. Highly refined commercial oil emulsions (1½ per cent) or tank-mix oil (1 per cent) have given good control without injury.

SWEET PEA

(See "Pea," p. 66)

TOBACCO

(See "Potato," p. 75, and "Tomato," p. 84)

TOMATO

(See also "Potato," p. 75)

Armyworms and Cutworms.—See p. 89.

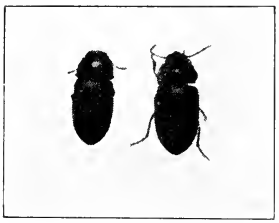


Fig. 86.—Adults of the small darkling ground beetle, which often occur in large numbers and severely injure newly transplanted tomatoes.

Darkling Ground Beetles, *Blapstinus* sp. and *Metoponium abnorme* (Lec.).—Small, dull-black or bluish-black beetles, scarcely more than ¼ inch long, living in the soil and responsible for much damage to young plants shortly after transplanting. Before resetting, wrap the stems of the young plants from roots to tops with waxed paper so as to have three or four thicknesses for protection, or scatter poison bran mash (formula 2, p. 108) over the ground at planting time.

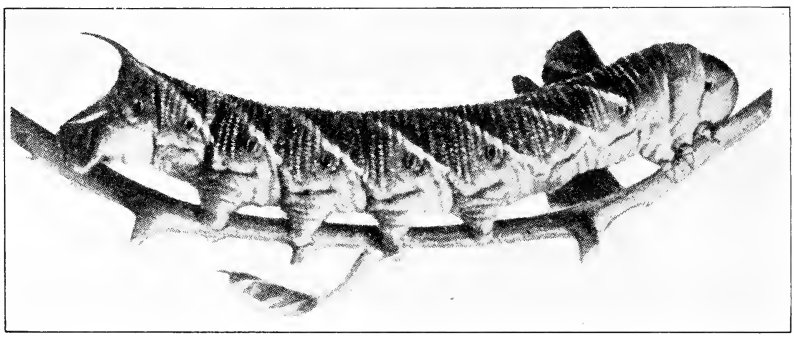
Flea Beetles.—Dust with powdered arsenate of lead, 1 part to 4 parts of dry lime, or sulfur-nicotine dust and arsenate of lead, or 70 per cent sodium fluosilicate dust, or spray with bordeaux mixture (formula 10, p. 114). See fig. 44, p. 47.

Grasshoppers.—See p. 94.

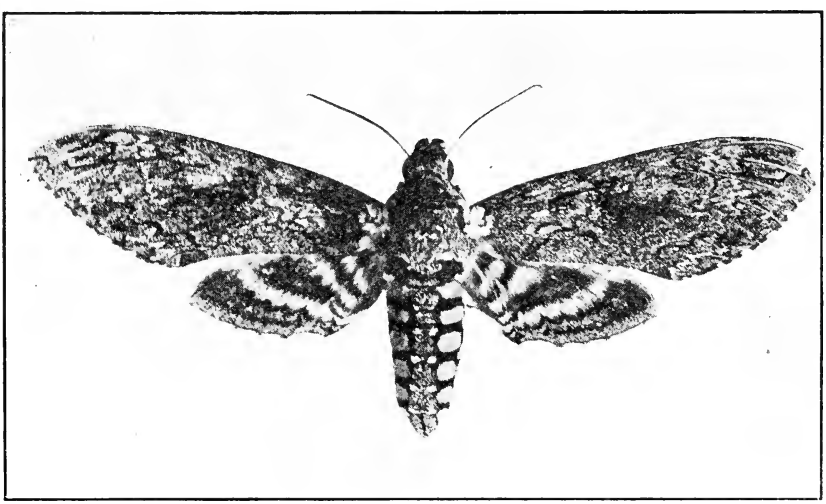
Root-knot Nematode.—See p. 97.

Tomato Pinworm, *Phthorimaea lycopersicella* Busck.—The very minute larvae bore small pinholes in the green fruit, which are often followed by decay. Applications of calcium arsenate dust have given only partial control. Such poison sprays cannot be used after the fruit is half grown for fear of injury to consumers.

Tomato Worm, *Protoparce sexta* Joh., **and Tobacco Worm,** *P. quinquemaculata* Haw.—These large green worms, often attaining a length of 4 inches, strip the leaves from the vines. The adults are known as humming-bird moths because of their large size and swift flight. They



A



B

Fig. 87.—*A*, Larva; and *B*, adult of the tomato worm. (Larva after Folsom.)

are gray with yellow spots on the sides of the body and have a wing expanse of 4 or 5 inches. The caterpillars may be controlled by hand picking, that is, cutting the worms in two with a pair of scissors, or by dusting the vines with 1 part of powdered standard arsenate of lead to 4 parts of finely ground hydrated lime; lead arsenate dusts should not be used after the fruit is half grown. Cryolite has recently been found to be more effective than arsenate of lead for the control of these insects.

WALNUT

Codling Moth, *Carpocapsa pomonella* (Linn.).—See "Apple," p. 9. This worm sometimes feeds on the green husks but usually bores directly into the kernel of the walnuts before they are mature, and also often works its way into the kernel after the shell becomes hardened by making an entrance in the suture at the base. It may be controlled by

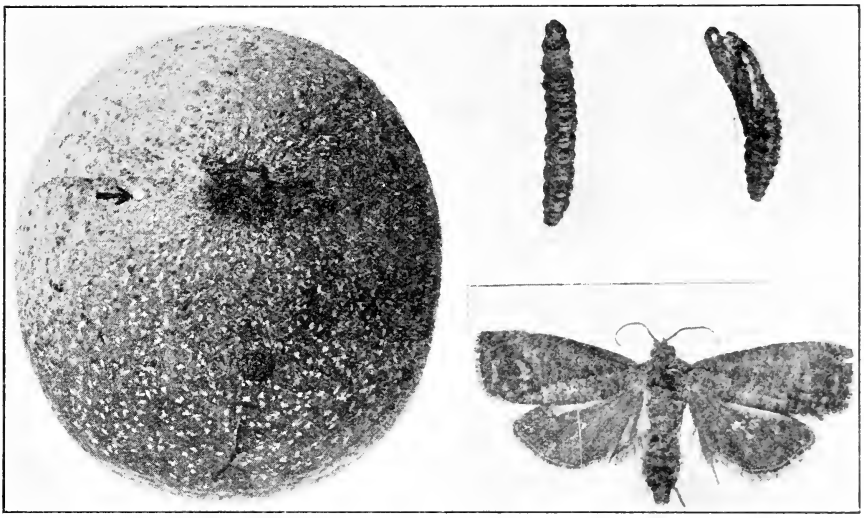


Fig. 88.—The codling moth and injury to green walnut caused by the larva. (After Quayle.)

spraying with basic arsenate of lead (formula 7, p. 112) when work on husks of nuts is first observed in May, June, or July, according to climatic conditions due to location near the coast or inland. Consult local horticultural officials. See also fig. 5*A*, p. 9.

Frosted Scale, *Lecanium pruinosum* Coq., **and Cherry or Calico Scale,** *L. cerasorum* Ckll.—Use same control as for brown apricot scale; see "Apricot," p. 18.

Indian Meal Moth.—This moth attacks walnuts in storage. See "Plum, Prune," p. 74.

Nautical Borer, *Xylotrechus nauticus* Mann.—The borers are small, fleshy, white or yellowish grubs, with slightly enlarged anterior end, and about ¾ inch long. The adult beetles are ½ inch long, dark with narrow, broken, yellow or whitish cross-bands on the elytra. The larvae work in the small twigs, limbs, and trunks of both healthy and sickly trees. Cut out and burn all infested portions. Destroy all dead oaks or prunings in the neighborhood to eliminate breeding places.

Red-humped Caterpillar.—See under "Plum, Prune," p. 75.

Two-spotted Mite.—See "Citrus Red Spider," etc., under "Plum, Prune," p. 73. Dust thoroughly with dry sulfur.

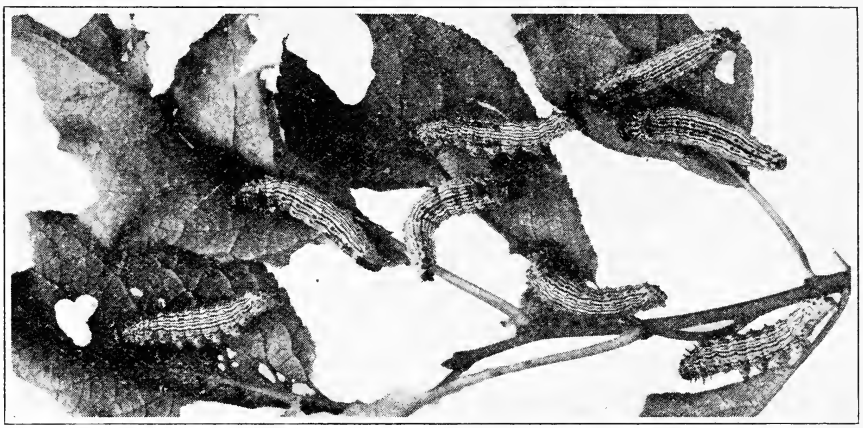


Fig. 89.—The red-humped caterpillar.

Walnut Aphid, *Chromaphis juglandicola* (Kalt.).—A small pale yellow aphid occurs in great numbers on the undersides of the leaves and produces great quantities of honeydew, which causes severe smutting of the foliage. (See "Mealybugs," p. 94.) Dust thoroughly

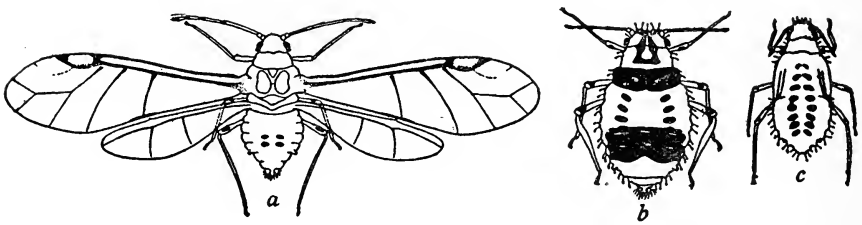


Fig. 90.—The walnut aphid: *a*, common winged form; *b*, egg-laying female; *c*, nymph or immature winged form; greatly enlarged.

with an 0.8 per cent nicotine dust (see p. 133) during the last week of May or the first part of June. Sometimes a second application is necessary in July or August.

Walnut Blister Mite, *Eriophyes tristriatus* (Nalepa) var. *erinea* (Nalepa).—A miscroscopic mite produces yellow or brown felt-like galls on the undersides of the leaves. It is not a serious pest, but may be cleaned up by spraying trees with lime-sulfur 1–10 in the spring when the buds are swelling. Control measures are not recommended except in extreme cases.

Walnut Husk Fly, *Rhagoletis completa* Cresson.[22]—This insect is a small fly, ⅛ to ¼ inch long, tawny in color with yellowish-white body markings and three parallel dusky bands across each wing. The maggots are yellowish white and about ½ inch in length. This insect occurs in parts of southern California and the maggots infest the green husks of the walnut. Certain varieties are more susceptible than others. The work causes internal decay in the husks which permanently blackens the shells of the nuts and results in inferior commercial grades. According to Boyce, control may be accomplished by the application of either a spray or a dust prepared as follows:

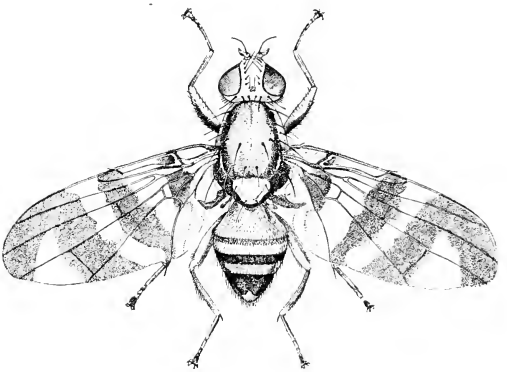


Fig. 91.—The walnut husk fly. (After Quayle.)

	Spray	Dust
Synthetic cryolite or barium fluosilicate	3 pounds	30 per cent
Mineral oil	1 quart	5 per cent
Water	100 gallons	.....
Diatomaceous earth	.....	65 per cent

Two treatments are recommended, the first when the emergence of the adult flies becomes regular, and the second approximately four weeks following the first. Interested growers are advised to consult the entomologists of the Citrus Experiment Station at Riverside concerning more specific information about this insect.

Yellow-necked Caterpillar, *Datana ministra* Drury.—A black, hairy caterpillar with numerous longitudinal yellow stripes on the back and sides and a yellow or orange-colored neck. It averages about 2 inches in length and is closely related and similar in habits to the red-humped caterpillar, and may be handled in the same way. See "Red-humped Caterpillar" under "Plum, Prune," p. 75.

WATERMELON

(See "Melons," p. 60)

WHEAT

(See "Grain," p. 53)

[22] Boyce, A. L. The walnut husk fly, *Rhagoletis completa*. Hilgardia. (In press.)

GENERAL SUBJECTS

ANTS

Among the several species of very tiny ants invading the pantry is Pharoah's ant or the little red ant; the very large, almost black native carpenter ant, nearly ½ inch in length, may also invade the house.

House-invading ants can usually be traced to their colonies out of doors in the lawn, dooryard, or under the house. Frequently much good can be accomplished by simply drenching the nest with boiling water, or kerosene. The distribution of ant poison in cans and other receptacles in the yard and around the foundation of the house must be done with some caution because of the danger to young children and domesticated animals. Sodium arsenite is the poisonous element used as a rule in ant syrups.

For the Argentine ant use formula 4 or 5 (p. 109), or buy special Argentine ant poison.

Homemade containers for the latter poison may be made by punching small holes around the tight-fitting tops of cans and then dipping in hot paraffine to prevent rusting. A sponge is placed in the bottom and thoroughly wet with the poison, the lid is securely fastened, the container marked "Poison" and then hung up under or in the house, or in the garden, away from the reach of children. Small fruit jars with holes punched in the lids may be used instead of cans, and if screwed on very tightly are less likely to be opened by children.

The Argentine ant frequently plays an important role in the orchard in relation to mealybug nurture, hence control here may be highly desirable. The same arsenical formula is recommended as above for this species, and the perforated cans may be hung in the lower branches or variously distributed both on the ground and in the trees.

ARMYWORMS AND CUTWORMS

General Life History.—The adult members of this family (Noctuidae) are practically all night-flyers. The caterpillars of many are known as armyworms and cutworms and are among the most destructive of insect pests. They often advance from field to field in great numbers, like an army, devastating as they go. Like the grasshoppers, they attack practically all kinds of plants, including field and truck crops, vineyards and orchards, flowers, and weeds.

The adults lay their eggs in spring and the larvae become exceedingly numerous in early summer, when most of the damage is done. The pupal

stage is passed underground, the light or dark-brown naked chrysalids being housed in small earthen cells. There are several broods a year. The winter is usually spent in the pupal stage, but some larvae and adults

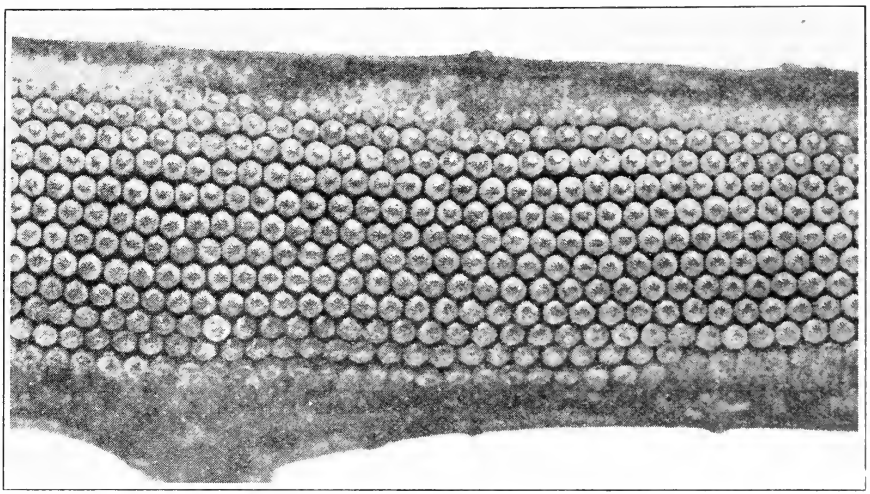


Fig. 92.—The eggs of the variegated cutworm, laid on the branch of a fruit tree. (After Essig, *Insects of Western North America*, by permission of the Macmillan Co., copyright owners.)

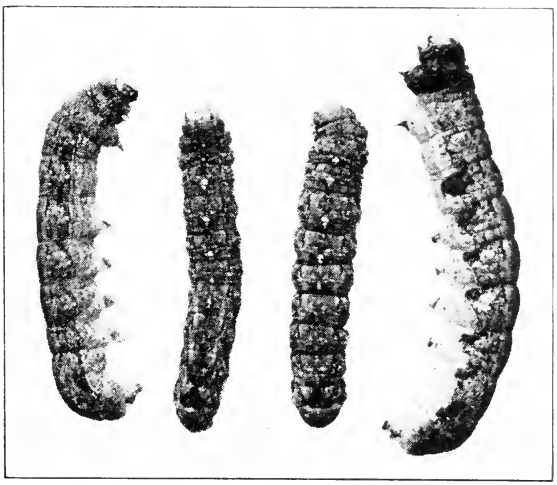


Fig. 93.—Larvae or caterpillars of the variegated cutworm.

hibernate. Hibernating larvae often seriously injure grapevines in the spring by eating the buds.

Control.—The control of these insects has been a difficult problem for years, and even today the methods worked out do not always give relief.

Clean culture in fall and thorough plowing of infested fields to kill the hibernating pupae in the cells is supposed to reduce the next year's broods greatly. This has been recommended as especially important in pea fields and gardens.

When the worms begin to march, trenches may be plowed across and ahead of their paths with a perpendicular wall in front of the advance.

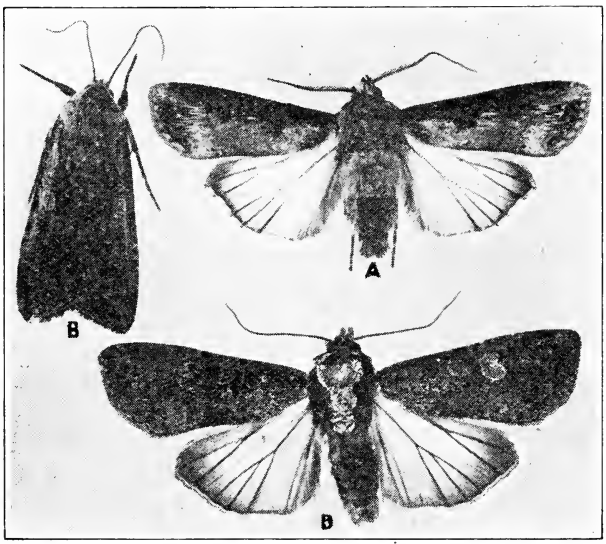


Fig. 94.—Millers or adult moths of cutworms: *A*, the variegated cutworm; *B*, the reaper dart. (After Essig, *Insects of Western North America*, by permission of the Macmillan Co., copyright owners.)

The worms, not being able to cross, will gather in great masses in these trenches and can be easily killed by spraying with crude oil or by crushing them with a narrow disk or roller.

Arsenical or fluosilicate sprays or dusts applied as soon as the larvae begin to appear will sometimes materially aid in protecting crops like potatoes, tomatoes, young trees, and grapevines, but are seldom practical for forage crops.

Poisoned baits (formulas 2, p. 108, and 14, p. 117) sown in the infested fields will kill countless worms, and these afford by far the most satisfactory means of killing these insects under all conditions. In fields, pastures, orchards, and gardens, the poisoned baits may be thinly sown over the plants. The armyworms and cutworms will eat the bait in preference to growing vegetation.

Attention must be called to the fact that great care should be exercised in applying poison sprays and baits to the foliage of plants consumed as greens and

such others as asparagus, artichokes, cabbage, cauliflower, lettuce, turnips, ripening tomatoes, etc., because of the danger of injuring consumers, who may be unaware of the presence of such poisons on the vegetables. Therefore, avoid the use of such materials except on young plants before the edible portions are formed. Under no conditions should such insecticides be applied on nearly mature or mature plants or the edible parts thereof. In many cases the poison bait may be scattered between the rows away from the plants.

Light traps are also used to capture the adults, but these have never seemed to lessen the attacks greatly, because large numbers of the moths captured have previously laid their eggs.

Natural Enemies.—By far the most important factors in the control of armyworms and cutworms are natural enemies. The parasitic tachinid flies kill countless numbers of them. Hymenopterous parasites of the family Ichneumonidae also prey upon the young. The predaceous ground beetles of the family Carabidae devour the worms and destroy great numbers. That armyworms and cutworms are not injurious every year is undoubtedly because of the work of these natural enemies.

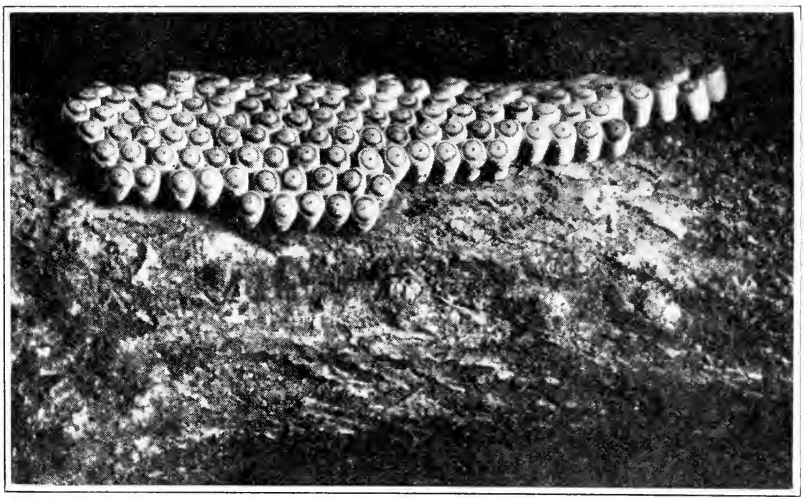


Fig. 95.—Eggs of the fall cankerworm on prune tree, fifteen times natural size.

CANKERWORMS

Cankerworms are small green or dark measuring worms less than an inch long, which feed upon the leaves and young fruit and drop down on a silken thread when the tree is jarred. The females are wingless and crawl up the trees in the fall or spring to lay their eggs on the limbs and small branches.

Egg-laying on the trees is prevented by placing tanglefoot, cotton, or permanent wire screen bands around the trunks of the trees in the fall in order to catch both the fall and spring worms. The caterpillars

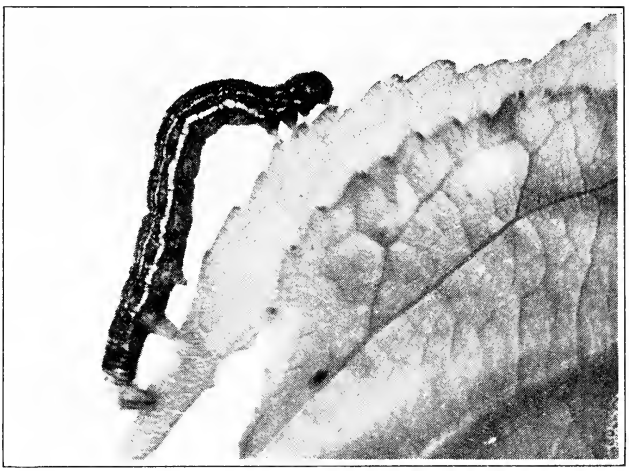


Fig. 96.—Larva or caterpillar of the fall cankerworm.

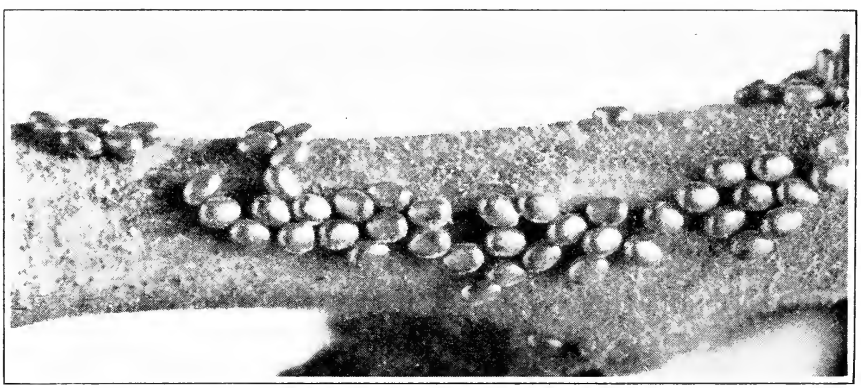


Fig. 97.—Eggs of the walnut spanworm, or cankerworm, on prune, fifteen times natural size. The insect often occurs on walnut also.

are easily jarred from the trees, but will crawl up again if not obstructed. Spraying with arsenate of lead (formulas 6 or 7, p. 112) will also give control. Pyrethrum or buhach powder, 2½ to 5 pounds soaked overnight in 5 gallons of cold water and then enough water added to make 200 gallons of spray, and commercial extracts of pyrethrum have given remarkable results in the control of the cankerworms.

GRASSHOPPERS

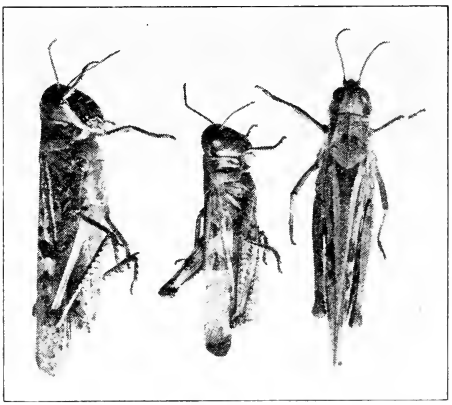


Fig. 98.—The clear-winged or pellucid grasshopper is a pest in many parts of the state.

Scatter poison bran mash or citrus bran mash freely (formula 2 or 3, p. 108). Be sure to mix the bran and poison thoroughly. Scatter in alfalfa fields about 4 o'clock in the afternoon and around orchard trees or other plants early in the morning. Concerning the danger of using poison baits on vegetables see "Armyworms and Cutworms," p. 89.

MEALYBUGS, *Pseudococcus* spp.

In California mealybugs are among the most serious enemies of many native and introduced plants, particularly subtropical fruits and ornamental flowering plants and shrubs. They infest all parts of the plants, including the roots, branches, leaves, flowers, and fruits, and often collect in compact colonies and deposit their eggs in masses of cotton-like waxy material which are most evident in late summer, fall, and winter.

The newly hatched insects are very minute and just visible to the naked eye. They are yellowish and as they grow they become covered with a whitish, powdery wax which extends as short rods around the margins of the body, and as longer filaments or tails posteriorly. The shape and length of these posterior filaments are useful in distinguishing the various species. The white waxy covering is responsible for the common name, mealybug. The males are minute two-winged insects which are often seen hovering about the infested plants during the late afternoons and evenings in the fall of the year.

Mealybugs, like many other scale insects and like aphids, excrete quantities of honeydew, which cover the infested plants like a thin coating of syrup. In cool and temperate areas, such as the coastal region of this state, a black-smut fungus grows on the honeydew, which is responsible for the dirty, smutty appearance of plants infested with these insects. To eliminate the smut it is necessary to get rid of the mealybugs or other insects which produce the honeydew. Ants are fond of this sweet excrement and protect the mealybugs to insure a constant

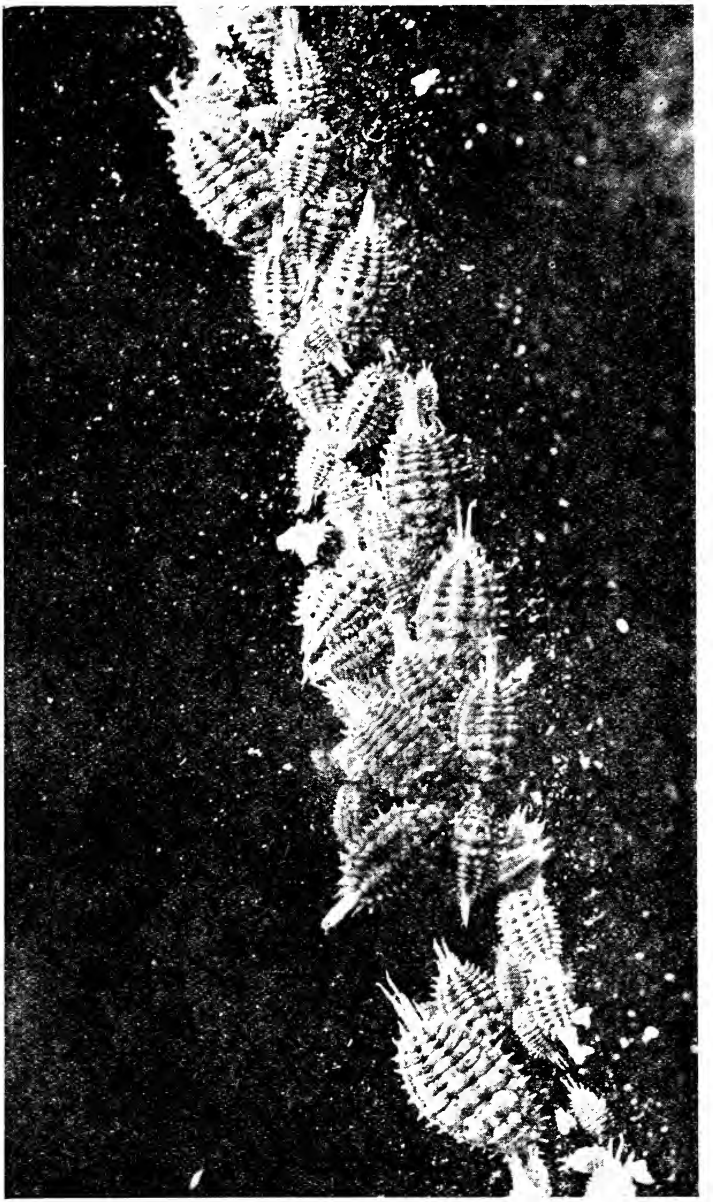


Fig. 99.—The citrophilus mealybug, a common pest of fruit, garden and ornamental trees, shrubs, and plants.

supply of it. Therefore, in connection with mealybug control it is always advisable to control the ants as well, using the poisons as recommended (formulas 4 and 5, p. 109).

Mealybugs are difficult of control, owing to the protection afforded

by the white waxy covering and their habits of collecting in dense colonies, depositing their eggs in large cottony masses, and feeding also underground. In the citrus orchards of southern California and in the vineyards of some parts of the Sacramento and San Joaquin valleys, ladybird beetles and minute parasites have been reared and liberated at a considerable cost to the growers, but often with much effectiveness. In the San Francisco Bay region, however, it appears to be too cool in certain sections for these natural enemies to thrive so that it is necessary to resort to sprays. A spray program recommended for mealybugs is given below.

Spring and Summer Control.—Thoroughly hose off the infested plants with a nozzle and as strong water pressure as is available. Hosing alone will sometimes control mealybugs. Spray shortly afterwards with any of the highly refined commercial oil sprays at a dilution of from 2 to 3 per cent or as indicated by the manufacturer, or 1½ to 2 per cent tank mix (see p. 127). Use as much force as possible and a coarse driving spray. Repeat applications of sprays every week until satisfactory control is obtained. Two or three applications may be necessary. Remove soil about roots and pour in a quantity of the diluted spray to kill mealybugs on the roots.

Irrigate infested plants a day or so before spraying them, because plants suffering for want of water are very susceptible to spray injuries, especially when oil emulsions are used.

Soap and nicotine sprays are of little value unless used in combination with oils. Homemade mixtures are likely to injure tender plants.

Winter Applications.—Dormant deciduous plants may be sprayed with any of the homemade oil sprays (e. g. formula 20, p. 128) or with miscible oil (3 per cent), or commercial oil sprays (5 per cent). Evergreen plants may be sprayed during the winter with the summer oils or more highly refined miscible oils and other oil emulsions. Homemade mixtures may also be used on the hardier plants. In other respects, conform to the recommendations given above.

NEMATODES (EELWORMS)

Microscopic worms of several species penetrate the tender tissues of plants.

Soil intended for greenhouse use should be taken from places where nematodes do not occur. The absence of nematodes is best determined by examining growing plants such as figs, peaches, melons, tomatoes, or nearly any soft-rooted vegetable. If it is not possible to get soil which is certainly free, it should be disinfected (see p. 145). Nematodes

are worse on sandy soils. They are frequently distributed in potatoes and rooted plants.

Beet Nematode, *Heterodera schachtii* Schmidt.—This nematode attacks beets and a few other plants, and where it occurs careful rotations should be followed with total exclusion of beets for many years. Alfalfa may be safely planted on beet-nematode soil.

Root-Knot Nematode,[23] *Heterodera marioni* (Cornu).—This nematode, called also the garden nematode, causes rounded irregular fleshy

Fig. 100.—Nodules on the small rootlets of sugar beet caused by the beet nematode. (After Severin.)

swellings or root knots on tender roots. If abundant, the roots may become much distorted and swollen, growth stops, and early rotting-off follows.

Do not attempt to grow susceptible crops on infested soil. Keep such areas clean-cultivated in summer or in a cereal crop. Grain may be grown in winter. Almost all important crops, except cereals and some fruit trees, are attacked by this nematode. Alfalfa is not seriously affected but carries it over to future crops.

[23] See also: Tyler, Jocelyn. The root-knot nematode. California Agr. Exp. Sta. Cir. **330**:1–34. 1933.

Recent experiments conducted by the Pomology Division at Davis indicate that certain rootstocks, such as apricot and the Bokhara and Shalil peach roots, are resistant to the attacks of nematodes.

Stem Nematode, *Tylenchus dipsaci* Kühn.—Stem nematode has recently attracted attention in various parts of the United states. It attacks many plants such as strawberries, alfalfa, clover, bulbs, grains, and many other plants. The parts just above the ground are infested (see under "bulbs," p. 30).

SLUGS AND SNAILS[24]

The slugs are close relatives of the snails but have the shell reduced and located internally so that the body is devoid of external protection. Three or more species of slugs are known to do damage to gardens in California. The enormous yellowish slugs (*Ariolimax*) of the northwestern humid portion of the state, from Monterey Bay northward, are occasionally reported as damaging gardens, but the chief offenders are three introduced species: the spotted slug (*Limax flavus*), yellowish or brownish in color, with bluish head, often 3½ inches in length, and with long narrow tubercles on the body; the large gray slug (*Limax maximus*) of gray body color with longitudinal stripes and spots of black; and the "gray" garden slug (*Agriolimax agrestris*) a small species under 1½ inches in length and variously gray, yellow, brown, or black. The first two are present from the vicinity of San Francisco Bay, southward, the third is present throughout the coastal portion of the state and inland at least to Sacramento and Kern counties, and is by far the most important garden pest other than insects.

The slugs are active chiefly by night and seek shelter by day in crevices in the ground and under boxes, stones, or other cover on the ground. They may sometimes be attracted to the arsenate-bran bait used for snails, but in the presence of green vegetation are less likely to seek the bait.

Control of slugs may be obtained by the use of a spray consisting of ¼ to ½ pound of ordinary alum (either potassium or ammonium alum) per gallon of water. The alum should be dissolved in hot water, the solution cooled, and then sprayed *at night* when the slugs are out. It is necessary actually to spray the slugs with the solution and both ground and plants should be well sprayed so as to reach all the slugs. The treatment should be repeated at intervals of two or three weeks in order to

[24] From Jones, H. A. The home vegetable garden. California Agr. Exp. Sta. Ext. Circ. 26:1–40. 1929.

See also: Basinger, A. J. The European brown snail in California. California Agr. Exp. Sta. Bul. 515:1–22. 1931.

kill adults missed at the first treatment and young which have emerged from eggs previously deposited.

Fluosilicate dusts applied to the plants are also effective. A 2 per cent nicotine dust is very effective in killing these pests if applied late in the evening, at night, or on dull days when the animals are at work on the plants. Trapping by means of boards or wet sacks and killing those taking shelter under them is effective in a small way. Liberal applications of dry bordeaux mixture as a dust on the ground and on infested plants acts as an effective repellent. Also use formula 2, p. 108. Chopped carrots rolled in white arsenic, paris green, or similar poison are also an effective bait.

SOWBUGS AND PILLBUGS

Sowbugs and pillbugs are small grayish flattened animals ¼ to ⅜ inch long, with many legs, occurring in damp situations and largely nocturnal in habit. They are often destructive to plant life. They are attracted to sweetened baits and are controlled by the use of a poison mash (see formula 2, p. 108), made by mixing together, dry, 1 pound of wheat bran and 1 ounce of paris green, which are then sweetened and moistened to the consistency of a mash by using 2 tablespoonfuls of

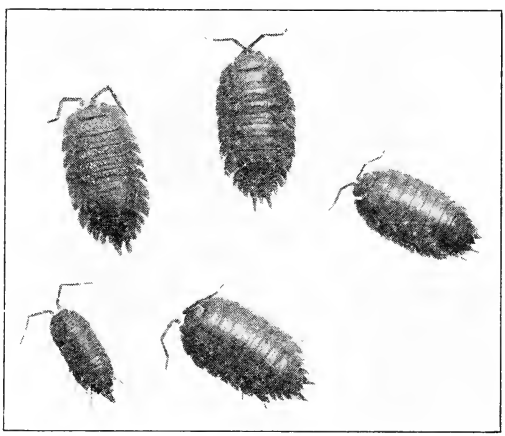


Fig. 101.—Sowbugs. Pillbugs are species of sowbugs which roll up into a ball when disturbed.

blackstrap molasses diluted in 1 pint of water. This bait is sown broadcast throughout the garden or placed in small portions under boards or inverted flower pots filled with straw where the sowbugs collect. It may also be used in greenhouses, but what appears to be more satisfactory under glass is a poison composed of five parts of granulated or brown sugar and one part of paris green, mixed dry and placed on small wooden

or tin plates throughout the beds, or poured on the frames of the beds of the greenhouse. This bait can be used outside also if protected from the rains and excessive soil moisture. It is, perhaps, wise to offer a word of caution regarding the use of the bran bait where poultry may pick

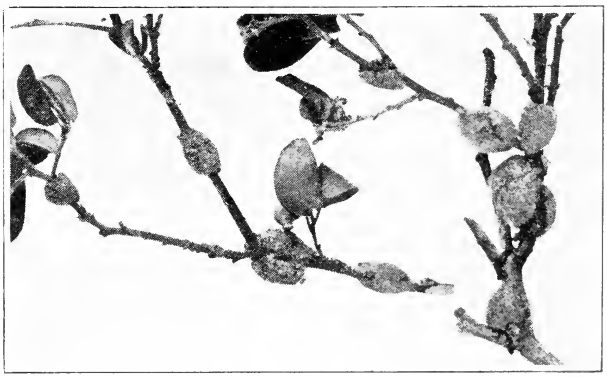


Fig. 102.—The egg-masses of the Great Basin tent caterpillar. They encircle the small twigs and are enclosed in a cement-like matrix. These eggs are laid in summer and hatch early the following spring.

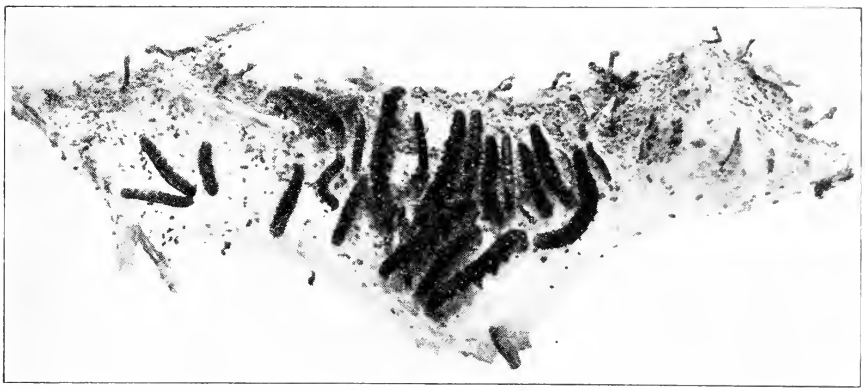


Fig. 103.—Tent caterpillars resting on the web or tent characteristic of these insects. They appear in the early spring.

it up and the use of the sugar and paris green in places frequented by children.

See also discussion on danger of using poison baits on vegetables under "Armyworms and Cutworms," p. 89.

TENT CATERPILLARS

The gray or brown, hairy caterpillars have a row of white spots on the back or pale bluish lines on sides and are from 1 to 3 inches long. They live either in compact colonies or in tightly woven webs or tents which

are conspicuous on many kinds of trees in the spring of the year. Entire colonies may be exterminated by cutting off infested branches and burning them, or by burning them on the tree with a torch, or by dusting infested portions with powdered basic arsenate of lead. The small dark egg masses encircling the smaller limbs may be pruned out when the trees are dormant and burned. Spraying with arsenate of lead (formula 6 or 7, p. 112) will control the caterpillars effectually. See figs. 102, 103.

WIREWORMS

Wireworms get their name from their smooth, round bodies, which are usually shiny, varying in color from pale yellow to dark brown. The common injurious forms are about 1 inch long. They live in the soil, preferring sandy loams rather than heavy soils, although they may be found in either. The larval stages last from one to three years, so that to be effective, control measures must cover the maximum period. The adult beetles are known as "click beetles" because of their ability to jump in the air with a clicking sound. They are mostly inconspicuous beetles of various shades of brown or entirely black, about ½ inch long. They are active and fly freely. See fig. 47, p. 49.

Control measures are difficult because of the underground habits of the larvae, and as yet have not been satisfactorily worked out for the different species. Clean culture and crop rotations are the most reliable practices, and much good comes from thorough cultivation. Trapping the adults with small piles of straw and burning them in fall and winter destroys large numbers. Replanting is often necessary with many crops such as potatoes, beans, peas, and melons. A teaspoonful of paradichlorobenzene in the soil near dahlia or potato tubers and bulbs has given very good protection but if it is used excessively, burning and injury results.

PESTS AND DISEASES OF IMPORTANCE IN THE APIARY[25]

Alfalfa Butterfly, *Eurymus eurtheme* (Bdv.).—This insect is said to extract sufficient nectar from alfalfa when very numerous to greatly reduce the yield of colonies. The caterpillars themselves do considerable damage to alfalfa and thus reduce yields of honey. See fig. 1, p. 4.

Alfalfa Weevil, *Phytonomus variabilis* (Herbst).—The larvae of the alfalfa weevil feed on the tender developing leaf buds of alfalfa and in some places practically ruin a location for the production of honey from this plant wherever they are found in great abundance. The adults do serious damage to alfalfa by their egg punctures in the stems, and beekeepers generally seek new locations whenever it becomes destructive in their territory. See fig. 2, p. 5.

American Foulbrood.—This is the most serious bacterial (*Bacillus larvae*) disease of the brood of bees and is transmitted from colony to colony through the action of robber bees, by the drifting of nurse bees, and by the transfer of diseased combs. It generally causes the death of the colony affected in less than a year. It kills the larva after it has finished feeding, at which time the cell is sealed and the larva is stretched on the bottom of the cell. The dead larva soon loses form and color to become a dark-brown, sticky, and putrid mass and finally a dark-brown scale that adheres tightly to the cell wall with the posterior end against the bottom of the cell. Death sometimes occurs in the pupal stage, in which event the tongue of the pupa often adheres to the top of the cell, a positive, typical characteristic of this disease. The cell cappings soon become discolored and the worker bees cut them open, at first with irregular holes, and later remove the cappings entirely.

As the bees seldom remove the diseased material and as it may be transmitted by honey from the diseased hive, treatment must be drastic. All combs of the diseased colony must be destroyed by fire, melted down into wax, or sterilized by special treatment. Fire is now considered the surest and most economical means in the eradication of this disease. The bees are killed by calcium cyanide and the bees and combs burned by night in a deep pit, after which the remains of the fire are covered with earth and the interior of the hive, bottom board, and inner cover scorched with the flame of a blow torch. Sterilization of brood combs (free of all honey and with every cell uncapped) by fumigation with formalin vapor or by soaking them for 48 hours in a water-formalin

[25] Prepared by J. E. Eckert.

solution is possible but has often resulted in failure with the average beekeeper.

Bee Louse, *Braula caeca* Nitsch.—The bee louse has been reported in several eastern states. It has not been reported as present in California but is likely to be introduced through shipments of queens from infected regions. The adults congregate in numbers on adult bees and especially on queens while the developing stages occur in tunnels made under the cappings of honey.

European Foulbrood.—This disease usually attacks the larva at an earlier stage of its development than American foulbrood and generally while the larva is still curled. The larval remains of this disease are not so ropy or tenacious as in American foulbrood and there is usually but little odor although in severe cases a slight ropiness is manifested and a sour odor is present. This disease is most destructive in early spring and summer and may disappear entirely during a honey flow. It is generally treated by dequeening and requeening by the introduction of ripe queen cells of resistant stock. The period of queenlessness generally gives the bees time to clean up the diseased material, but the colony must be strong in numbers of bees to insure the success of this treatment. Persistent inspection of colonies during the first and second brood cycles in spring, followed by burning the infected colonies, generally gives complete control. Italian stock is generally considered more resistant to this disease than other races. European foulbrood is caused by a bacterium (*Bacillus pluton*).

Mediterranean Flour Moth, *Ephestia kuehniella* Zeller.—This insect lays its eggs in the pollen cells of stored combs and the larvae feed on the pollen but do not destroy the wax. Under some conditions their feeding habits may be beneficial where the beekeeper wishes to clean up pollen-clogged combs. Fumigation, as in the case of wax moths, will destroy them. This moth is also subject to different parasites which tend to keep them under control.

Nosema apis.—*Nosema apis* is a protozoan that destroys the epithelial cells of the mid-gut of the adult bee, causing symptoms that vary in character. It may cause a serious diminution of colony strength in early spring and disappear with warmer weather and the honey flow. It may attack small numbers of bees in different colonies throughout the season but is primarily a spring disease. Young, prolific queens and the destruction of the dead within and outside of the affected colonies usually reduces the damage. Stagnant watering places may be a source of spreading this disease. Proper food and good wintering conditions are preventives.

Paralysis.—This is another disease of adult bees, the cause of which has not been definitely established. The same symptoms as described for typical cases of paralysis are also given for the nosema disease and for poisoning. No definite remedy can be recommended until more is known of the cause.

Sacbrood.—This disease is seldom serious, generally appearing, to a limited extent, in early spring. It kills the larva at about the time of sealing. The body contents of the diseased larva are watery in consistency, and the final scale does not adhere to the cell walls. There is no ropiness. It is often mistaken for European foulbrood. Sacbrood is caused by a filtrable virus.

Sage Worm, *Platyptilia marmarodactyla* Dyar.—This insect does serious damage to the black and purple sages, destroying buds in the "buttons" and is therefore a serious competitor of the honeybee. Beekeepers in the sage region of southern California are all too familiar with the work of this caterpillar, which is referred to as the "sage weevil." Injury is by tunneling through bud after bud in the button until at times practically all have been destroyed. It is not unusual to find two or three individuals to a button. No practical measures can be offered toward control.

Skunks.—In many sections skunks are a serious pest in the apiary. They make nightly visits to a hive, scratch at the entrance and eat the bees brought out by this disturbance. Their depredations reduce colony strength greatly and may result in many lost queens in queen mating yards. Stings of bees have little effect on them. They may be reduced in numbers by trapping, shooting, or poisoning where these activities are allowed by law.

Toads.—Toads eat many bees but their beneficial habit of eating other insects may counteract some of the damage they do in an apiary. Their damage is reduced if conditions are made unfavorable for them to live under the hives.

Wax Moths, *Galleria mellonella* Linn., **the Greater, and** *Achroia grisella* Fabr., **the Lesser.**—These moths are serious pests to stored combs and comb honey. When they attack combs in the hives of colonies, the colonies have generally first been weakened by disease or other causes. Good strains of the Italians, Caucasian, and Carniolan races guard their hives well against these pests. Fumigation of stored combs with sulfur fumes, carbon disulfide, cyanide gas, or paradichlorobenzene, is recommended where the combs are stored under temperature conditions favorable to their development.

Other Enemies.—Among other enemies of bees may be mentioned

mice, rats, various species of birds, numerous spiders, ants, robber flies, and dragon flies. Rats and mice are generally destructive to stored combs and to colonies during the winter period. Certain species of birds are most destructive around queen rearing yards, as are also dragon flies and robber flies which do considerable damage by catching young queens on their mating flights.

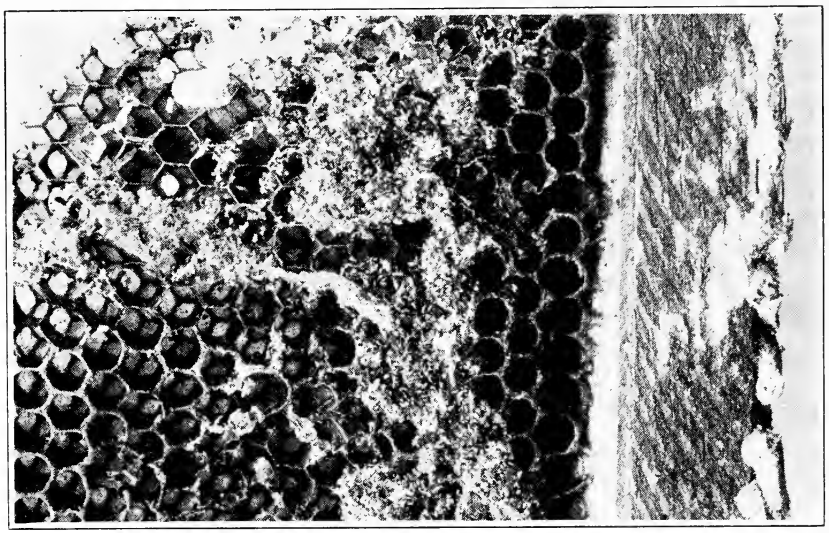


Fig. 104.—Work of the caterpillars of the wax moth in a bee hive. Cocoons may be noted on the edge of the frame at the extreme right.

Spray Poisoning—The subject of spray injury to bees is mentioned here because the effects are sometimes confused with the diseases of brood and adult bees. Great damage is done to bees at times by the application of poisonous sprays and dusts to trees and field crops in bloom. These applications are generally necessary in the control of insect pests, and the honeybee, although of great benefit as a pollinizer, is the unfortunate victim. The beekeeper should keep in touch with the grower so as to be informed as to the time of application of sprays detrimental to his bees and move colonies away from the territory involved. At the same time the grower, who receives the greatest benefit of the activity of bees, can coöperate with the beekeeper by not spraying his trees or other plants when they are in full bloom unless absolutely necessary, by using materials, such as tobacco dust, that are repellent to bees, and by notifying beekeepers of the time of application of sprays whenever possible.

THE CHEMICAL CONTROL OF INSECTS

Although many potential insect pests are kept in check by unfavorable environmental conditions, natural enemies, the development of resistant crops, and other such measures, it happens very often that this "natural control" is ineffective and recourse must be had to "artificial control" through the use of poisonous chemicals. In fact, insecticides may be called man's last line of defense in his conflict with the multitude of insects which constantly devour his food, incapacitate his animals, and destroy his own health and peace of mind. While chemicals have been used in combating insects for many years, it is only within the last three generations that a scientific understanding of what was being done has been gained. A review of the many developments that have taken place would be of great interest, particularly if interpreted from the standpoint of the chemistry of the materials used. At no time in the past has progress in the use and development of insecticides been so rapid as at present. It is not the purpose of this publication, however, either to review the history of insecticides or to describe developments which are very recent, and hence imperfectly understood. Therefore in the following pages discussion will be limited to the insecticides that are well established and of importance in California.

For convenience in discussing the many kinds of insecticides it is necessary to classify them according to some scheme. This can be done on the basis of *method of application,* and most materials fall into one of these classes: sprays, dusts, and fumigants. This is frequently unsatisfactory, however, for the same material may be used in more than one way. For instance, lead arsenate is both a spray material and a dust, while calcium cyanide is a dusting material and hydrocyanic acid gas is a fumigant, though the active ingredient is the same with both materials. A more useful classification is according to the *mode of action,* that is, as stomach poisons, contact poisons, and respiratory poisons. This is of particular importance in connection with the feeding habit of any insect under consideration. Those which bite off and chew their food, for example, the codling moth larva, are usually most easily controlled by stomach poisons, which on the other hand are ineffective against insects that get their food by sucking the juices of plants or the blood of animals.

A third method of classifying insecticides is according to their chemical nature, for example, into inorganic and organic substances, petroleum derivatives, plant products, etc. The last two methods cor-

respond rather closely: for most of the stomach poisons are compounds of metals; contact poisons are mainly oils, soaps, and plant products; and fumigants are very largely limited to rather simple organic compounds. Of course, there are notable exceptions to the broad statement just given. The chemical classification is more valuable now than ever before because of the very active endeavors made in the past few years to isolate and identify the toxic ingredient or ingredients of many preparations long used as insecticides. An instance is afforded by pyrethrum, which has been examined chemically and found to be of value only in proportion to its content of two complex organic compounds, pyrethrin I and II. Similarly, all cyanide preparations are effective only as they liberate hydrogen cyanide. Many other illustrations will be given as the various materials are considered.

Grouped according to mode of action the following materials will be considered:

Stomach poisons: Compounds containing arsenic, lead, fluorine, copper, or mercury; nonvolatile nicotine compounds; and preparations from derris.

Contact poisons: Nicotine compounds, oils (petroleum and plant), soaps, tar distillates, lime-sulfur, formaldehyde, pyrethrum, and derris.

Respiratory poisons: Cyanides, carbon disulfide, carbon tetrachloride, nicotine, paradichlorobenzene, ethylene oxide, ethylene dichloride, naphthalene, sulfur.

Certain other topics of importance, such as compatability of insecticides and the removal of spray residue will also be discussed.

INSECTICIDES CONTAINING ARSENIC

Arsenic Trioxide.—The element arsenic is of use in insect control only in certain of its compounds. Since arsenic has two different combining powers, its compounds fall into two classes which have decidedly different properties. The starting point for the manufacture of the first class, called trivalent or arsenite compounds, is arsenic trioxide, which is the "white arsenic" of commerce. This substance is only sparingly soluble in water, though sufficiently so to prevent its use on plants. Its uses as an insecticide are therefore limited to poison baits for control of grasshoppers, armyworms, cutworms, sowbugs, etc., and to certain other cases where the insecticide is not to be applied to growing plants.

Sodium Arsenite.—Arsenic trioxide may be converted into a very soluble compound, sodium arsenite, by heating with a solution of sodium carbonate (washing soda, sal soda) or sodium hydroxide (lye). Sodium arsenite is extremely poisonous to plants and animals and acts more rapidly than any other common arsenical compound. It is commonly

used in weed killers, poison fly papers, cattle dips for control of ticks, ant syrups, and to some extent in poison baits. It may be purchased as a white powder but various preparations contain different amounts of arsenic. Hence it is often preferable to make it from arsenic trioxide.

FORMULA 1

	Small quantity	Large quantity
Arsenic trioxide	1 ounce	1 pound
Washing soda	2 ounces	2 pounds
Water	½ pint	1 gallon

Put all the ingredients together in an iron or graniteware kettle (do not use aluminum because it will be dissolved) of sufficient size to allow for considerable frothing, and boil 15 to 20 minutes or until the solution is clear. This formula contains a considerable excess of washing soda, which hastens the solution of the arsenic trioxide and does not impair the product.

Poison Bran Mash:

FORMULA 2

	Small quantity	Large quantity
Bran	1 pound	25 pounds
Arsenic trioxide	2 teaspoonfuls	1 pound
Molasses	⅙ pint	2 quarts

A solution of formula 1 (⅓ pint for the small quantity or 1 gallon for the larger), or liquid sodium arsenite weed killer, 8-pound strength[26] (2 teaspoonfuls for the small quantity or 1 pint for the larger) may be used in place of the arsenic trioxide.

If arsenic trioxide is used, mix it dry with the bran and add the molasses after diluting somewhat with water. Mix thoroughly and add enough water to make a dry mash which will broadcast easily. If one of the liquid arsenical solutions is used, it may be mixed with the molasses and bran, and water added as needed. The molasses may be omitted without greatly lessening the effectiveness of the bait. Alfalfa meal, shorts, or rice meal may be substituted for bran in any of these formulas.

Citrus Bran Mash:

FORMULA 3

Bran	25 pounds
Arsenic trioxide	1 pound
Molasses	2 quarts
Lemons (or oranges)	6 fruits
Water (about)	4 gallons

[26] That is, containing 8 pounds sodium arsenite per gallon.

Mix the materials as follows: first stir together thoroughly the arsenic trioxide, molasses, and water. Grind the lemons, including the rinds, in a meat grinder, or chop fine and add. Then slowly pour the combined mixture over the bran and stir thoroughly until an even mixing is secured. Instead of arsenic trioxide, the solution of formula 1 or a liquid sodium arsenite weed killer may be used, the quantities needed being the same as given in the last column of formula 2. The amount of water to use in the preparation of these baits will vary according to the coarseness of the bran, or substitute, used. A barely moist mash is preferable to a wet one because it does not harden under the heat of the sun and remains palatable, while wet mash bakes and becomes unattractive.

Ant Syrup.—Arsenic is also the toxic ingredient of most ant syrups, as in the following one:

FORMULA 4

	Strong for native ants	Weak for Argentine ants	
		Small quantity	Large quantity
Arsenic trioxide	2 ounces	¼ teaspoonful	1 ounce
Concentrated lye	1 ounce	¼ teaspoonful	1 ounce
Sugar	1 pound	1 pound	20 pounds
Water	1 pint	1 pint	3 gallons

Put the arsenic trioxide, lye, and water together in an iron or graniteware kettle (do not use aluminum) and boil until the arsenic trioxide is dissolved. Cool and add the sugar, stirring thoroughly. This formula may be varied by substituting an equal weight of sodium arsenite for the arsenic trioxide and leaving out the lye.

Bureau of Entomology Argentine Ant Syrup.—The Bureau of Entomology of the United States Department of Agriculture recommends another formula for Argentine ant syrup which has the advantages of stability in hot weather, freedom from crystallization and continued attractiveness.

FORMULA 5

Granulated sugar	12 pounds
Water	11 pints
Tartaric acid	¼ ounce
Benzoate of soda	⅓ ounce
Sodium arsenite	¾ ounce
Hot water	½ pint
Honey, strained	2 pounds

Combine granulated sugar, water (11 pints), tartaric acid, and benzoate of soda; boil slowly for 30 minutes; and allow to cool. Dissolve the sodium arsenite in ½ pint of hot water and cool. Add the poison

solution to the syrup and stir well; then add the honey and mix thoroughly.

Caution.—All preparations of arsenic are dangerous, particularly those containing it in soluble form. Children and animal pets occasionally consume ant syrups when these are not kept in proper safety containers.

Antidote for Arsenic.—Call a physician. Empty stomach as completely as possible. An emetic of a tablespoonful of mustard in a cupful of warm water is effective. Then give Epsom salts, milk of magnesia, white of eggs, olive oil, or milk. The best remedy is a mixture of an iron salt (for example, ferric chloride) and milk of magnesia stirred together in solution and taken at once.

Paris Green.—Another compound of trivalent arsenic is paris green which was formerly used in very large amounts in the control of many kinds of chewing insects and is still used on particularly hardy plants. However, its content of water-soluble arsenic is high and variable (1 to 5 per cent or even higher). The decreasing use of paris green is an example of the previously mentioned tendency to use materials of known and strictly controlled properties. It may be substituted for arsenic trioxide or sodium arsenite in poison baits if used at about double the proportions given for the other compounds.

Lead Arsenates.—The second class of arsenical compounds, the pentavalent or arsenate type, includes some of the most important of all insecticides. Two compounds containing lead are extensively used in controlling all kinds of chewing insects. Each has been called by various names: (1) *standard lead arsenate,* also called acid lead arsenate, lead hydrogen arsenate, di-lead arsenate; and (2) *basic lead arsenate,* also called triplumbic lead arsenate, neutral lead arsenate. These two substances differ in the ratios of arsenic to lead. The standard lead arsenate averages approximately 20 per cent arsenic and 60 per cent lead by weight, whereas the basic averages approximately 14 per cent arsenic and 63 per cent lead.

The standard type of lead arsenate contains more arsenic per pound than the basic type, is a stronger poison, and acts more quickly. It is also more susceptible to the action of other chemicals, particularly those of an alkaline nature (such as soaps and lime-sulfur solutions), and is more or less dissolved by them when used in a combination spray. The soluble arsenic so formed may lead to severe burning of tender foliage. In moist climates along the coast, or in continuously damp and cloudy weather elsewhere, considerable arsenic is apt to be rendered soluble and to cause serious foliage injury even when standard lead arsenate is used by itself. Differences in various brands according to whether they

Fig. 105.—Applying arsenate of lead in a liquid spray to a large walnut tree. (After Quayle.)

are "deflocculated" or not will be discussed under the topic "Emulsification and Deposit of Spray Materials," p. 140. The concentration needed in sprays varies with the insect and many other conditions.

FORMULA 6

STANDARD LEAD ARSENATE

Standard lead arsenate powder	2 to 4 pounds
Water	100 gallons

To secure adequate wetting of foliage and fruit a spreader should be used at the amount recommended by the manufacturer.

Basic lead arsenate is a weaker poison and acts more slowly. It is much more stable, not being appreciably decomposed by damp weather or by other insecticides of an alkaline nature. It may be used safely on stone fruits, beans, and other susceptible plants. The proper concentration is subject to various conditions.

FORMULA 7

BASIC LEAD ARSENATE

Basic lead arsenate powder	2½ to 5 pounds
Water	100 gallons

As previously mentioned, a spreader should also be used.

Both standard and basic lead arsenates are also sold as pastes which contain approximately half as much arsenic as the corresponding powders and hence should be used at twice the dosage.

Either kind of lead arsenate is often used in combination with other insecticides for control of more than one pest at once. A combination useful for control of codling moth, thrips, and scab on pears is as follows:

FORMULA 8

COMBINATION LEAD ARSENATE, NICOTINE, AND OIL

Standard lead arsenate	3 pounds
Nicotine sulfate 40 per cent (for example, Black Leaf 40)	¾ pint
Ammonia (20-24 per cent)	½ pint
Commercial oil emulsion (60-70 seconds viscosity and 90 per cent or above unsulfonatable residue) or tank-mix oil of like specifications with 4 ounces blood albumin spreader	1 gallon
Water to make	100 gallons

For a discussion of lead arsenate remaining on fruits or vegetables at harvest see section on "Spray Residue," p. 146.

Calcium Arsenate.—A compound somewhat similar to the lead arsenates is calcium arsenate. The pure material, however, gives rise to far too much soluble arsenic and accordingly all commercial products

contain varying amounts of hydrated lime. The chief uses of calcium arsenate are as dusts and in poison baits. An example of such a dust is that containing equal parts of commercial calcium arsenate and dusting sulfur, which is recommended for control of the alfalfa weevil.

A bait which has proved very satisfactory for the control of root weevils, grasshoppers, sowbugs, and snails is made as follows:

FORMULA 9

CALCIUM ARSENATE BAIT

Bran	5 pounds
Sugar	1 pound
Calcium arsenate	½ pound
Water	1 quart

Thoroughly mix dry the bran, sugar, and calcium arsenate; then add the water, continuing to mix until an even mash is obtained. Broadcast or scatter in small quantities on the ground in the evening, being careful not to get any of the material on vegetables intended for human consumption.

CARBON DISULFIDE

Carbon disulfide is a liquid which evaporates quickly when exposed to the air, forming a heavy and inflammable vapor of great penetrating power. In using the material for the control of insects infesting stored products, for example, granary weevils, it is essential that it be placed near the top of the chamber in a shallow container in order that the heavy vapors as they are given off may thoroughly diffuse through the air contained in the space to be fumigated. The proper amount to use depends upon the type of room being fumigated and ranges from 10 pounds to about 30 pounds to 1,000 cubic feet in ordinary rooms where the walls and floor have not been made especially tight. The best results are obtained by doing this work when the temperature is above 70° Fahrenheit. Since the vapors of carbon disulfide are very inflammable, precaution must be taken to keep all flames and sparks away.

Carbon Disulfide Emulsion.—This is a rather unstable emulsion which is now procurable from manufacturers as needed and is a valuable soil fumigant for the control of certain pests. In the San Francisco Bay region it has proved effective in killing the garden centipede in the soil.[27] Good results have been obtained by diluting the emulsion 1 to 300 of water and applying it to the surface of the soil at the rate of 5 gallons per square yard. See "Soil Disinfection," p. 145.

[27] See: Michelbacher, A. E. Chemical control of the garden centipede, *Scutigerella immaculata*. California Agr. Exp. Sta. Bul. 548:1–19. 1932.

CARBON TETRACHLORIDE

This may be substituted for carbon disulfide in household fumigation by using it in the same manner and slightly increasing the amount used. It is noninflammable and consequently safer than carbon disulfide, while its lower toxicity makes it safer for the operator.

COPPER COMPOUNDS

Compounds of copper are primarily fungicides but they are also of considerable use as repellents against certain insects such as flea beetles and leaf beetles on melons, potatoes, tomatoes, tobacco, etc. The very frequent use of bordeaux mixture in conjunction with many insecticides makes its consideration important here.

Bordeaux Mixture.—As the name indicates this is not a single substance, and fifty years' use has not entirely cleared up the uncertainty as to what compounds are present under all circumstances. The ingredients entering into it are copper sulfate (bluestone), quicklime (or hydrated lime), and water. The objective in preparing any bordeaux mixture is to obtain a very finely divided product that remains in suspension and adheres well. (Emulsifying agents are not usually added, though they often may be beneficial.) The composition is usually expressed in terms of the ratios of bluestone, quicklime, and water, in that order. Thus 4 pounds of bluestone, 5 pounds of quicklime, and 50 gallons of water is known as 4–5–50 mixture. Any other composition may be described similarly.

A satisfactory bordeaux mixture may be made as follows: Slake the lime and dissolve the bluestone in separate barrels. Fill the spray tank half full of water, add the dissolved bluestone, strain in the slaked lime while the agitator is running, add remainder of water, and mix thoroughly. In order to hasten solution of the bluestone, it should be ground as fine as possible and placed in a sack kept near the top of the water in the barrel. Another satisfactory method is to dissolve the bluestone in a small volume of hot water and then dilute with cold water. It must be kept from contact with all metals except copper; for otherwise copper will be thrown out of the compound. Whatever system of preparation is used, it is desirable to have both the bluestone and the lime as much diluted as is convenient before mixing, and the solutions should be cold before they are mixed.

FORMULA 10

5-5-50 BORDEAUX MIXTURE

Bluestone	20 pounds
Quicklime	20 pounds
Water	200 gallons

Hydrated lime may be used but it should be finely ground and preferably should be left to soak in the water for several hours before using. Use one-third more than of quicklime in any particular formula.

Bordeaux Paste:

FORMULA 11

A. Bluestone	12 pounds
Water	8 gallons
B. Quicklime	24 pounds
Water	8 gallons

Dissolve the bluestone and slake the lime separately in the amounts of water specified. Then mix together equal quantities of each ingredient, making up only enough for each day's use and diluting to strength desired. The excess lime is to make the material sufficiently thick to apply as a paint. It is useful as a repellent for tree-boring insects.

Commercial Bordeaux Mixture.—Several preparations of this sort are on the market in the form of a paste or dry powder to be diluted with water. Objection is sometimes made to these preparations that they will not remain in suspension in water as well as the homemade bordeaux mixture, but some of them are probably as good or better than the average mixture prepared on the ranch. The commercial preparations are more expensive, but also more convenient for use, and are of especial value to the small grower.

Copper Carbonate.—For dusting wheat for bunt, use 2 ounces of copper carbonate dust to a bushel. The dust should be intimately mixed to cover each seed thoroughly. The copper carbonate dust should contain 50 per cent of copper in the form of carbonate and hydrate of copper, and should be sufficiently fine to weigh approximately 32 pounds to a cubic foot. The dusted seed may be stored without injury from the dust. Grain so treated is absolutely free from the attacks of the granary and rice weevils, and other insects which attack stored grains.

CYANIDE COMPOUNDS

Hydrogen Cyanide.—The simplest cyanide compound is hydrogen cyanide (HCN), often called hydrocyanic acid gas. This is the most effective fumigant in common use but is so poisonous that only skilled operators should attempt to use it. The material is supplied in steel cylinders under sufficient pressure to liquefy it. Upon releasing the pressure, gas is liberated. For a discussion of the use of liquid hydrogen cyanide for control of scale insects on citrus trees see Bulletin 542.[28]

[28] Quayle, H. J. Biology and control of citrus insects and mites. California Agr. Exp. Sta. Bul. 542:72–79. 1932.

This has largely replaced the pot method in which sodium cyanide was treated with sulfuric acid to liberate hydrogen cyanide.

Calcium Cyanide.—This material in the form of granules or dust, is an increasingly important insecticide. It has the distinctive property that an acid does not need to be added in order to liberate hydrogen cyanide. Moisture from the air is sufficient unless the humidity is low. The granules or dust are used to eradicate household pests, grain insects, and the like, an average dosage for greenhouses being one-half to one ounce per 1,000 cubic feet with overnight exposure. For grain insects 25 pounds per 1,000 bushels is effective. The dust may be used straight or diluted with 50 to 75 per cent of hydrated lime, sulfur, or other carrier. It is used chiefly to control aphids, leafhoppers, bugs, and similar insects. Either the flakes or dust are used as soil fumigants. Its use must be avoided with plants when they are moist because of danger of burning.

ETHYLENE OXIDE, ETHYLENE DICHLORIDE

Ethylene oxide, ethylene dichloride, and similar materials are now commercially available. Particularly when mixed with carbon dioxide, they combine safety with high efficiency as fumigants against household and grain pests. Various commercial products are sold in steel cylinders ready for use.

FLUORINE COMPOUNDS

Fluorine is a constituent of hydrofluoric acid, which is used to etch glass. Several derivatives of this compound have been advocated as insecticides. The simplest, sodium fluoride, is too soluble for use on plants but may be used in poison baits; for example, it may be substituted in formulas 2 and 3. Another material which is finding use is cryolite, which is a complex sodium aluminum fluoride, sometimes called sodium fluoaluminate. This compound is but slightly soluble and can be used against many chewing insects. In damp climates it is apt to cause burning. Both the naturally occurring mineral and a synthetic preparation are on the market.

A formula used for late summer spray against the codling moth on deciduous fruit is:

FORMULA 12

SODIUM ALUMINUM FLUORIDE

Cryolite	3 pounds
Blood albumin spreader	4 ounces
Water	100 gallons

The above formula with the addition of one pint of No. 3 spray oil (see "Tank-Mix Spray for Citrus Trees," p. 123) is used for control of the orange worm. When the material is used as a dust the formula is:

FORMULA 13

SODIUM ALUMINUM FLUORIDE DUST

Cryolite (sodium aluminum fluoride)	25 per cent
Talc (fiber)	70 per cent
Mineral oil, No. 4	5 per cent

Fluosilicates.—Compounds containing silicon as well as fluorine have been extensively studied as insecticides. The two best known of these are sodium fluosilicate and barium fluosilicate. These materials are used chiefly as dusts and are sold mixed with varying amounts of inert fillers, under several trade names.

In moist climates there is danger of burning foliage, especially with the sodium compound. The manufacturers' recommendations as to dosage should be followed carefully.

Concerning the regulation regarding fluorine compounds on fruit and vegetables at harvest see section on "Spray Residue," p. 146.

Fluosilicates are of use in poison baits in the place of arsenic compounds.

FORMULA 14

ARMYWORM AND CUTWORM BAIT

Bran	50 pounds
Molasses	1 quart
Sodium fluosilicate	½ pound
Water sufficient to make a dry mash	

This formula is especially useful against armyworms.

FORMULA 15

FRUIT BAIT

Cull or low-grade raisins	50 pounds
Bran or shorts	50 pounds
Sodium fluosilicate	5 pounds

The raisins are first soaked 12 hours in water and drained. The bran or shorts and sodium fluosilicate are thoroughly mixed dry. All are then mixed together and run through a meat grinder. This is then broadcast over the fields or scattered along the rows or around the bases of the plants.

Dried ground peelings and cores of pears or other fruits might be substituted for raisins. This bait is specially recommended for the control of certain weevils or snout beetles, particularly the strawberry root weevil, the rough strawberry weevil, the black vine weevil, etc.

MERCURY COMPOUNDS

All soluble compounds of mercury are extremely poisonous and are widely used as germicides. Mercuric chloride (corrosive sublimate) is used to some extent in treatment of plant diseases. Its insecticidal use is largely confined to action as a larvicide and repellent for root maggots and similar insects.

Mercuric Chloride:

FORMULA 16

Mercuric chloride	1 ounce
Water	8 gallons

This gives a 1:1,000 solution. Tablets to make this strength when added to 1 pint of water may be obtained at drug stores. Distilled or rain water should be used and the solution must not be kept in a metal container. Contact with any kind of organic matter or absorbent material, for example, clay, results in removal of the mercuric chloride from solution. The solution may be prepared more readily with warm water.

It must be stressed that this substance is extremely poisonous even in very dilute solution. If it is accidentally swallowed, give whites of several eggs at once. Then the stomach should be emptied as completely as possible, and eggs, starch, or flour paste swallowed liberally, until a physician can be called.

NAPHTHALENE

This material has been widely used as a repellent for clothes moths, being sold as the well-known moth balls. Its toxicity to insects is comparatively low but it has a use as a repellent both in the household and the field. A formula recommended for repelling the western flat-headed borer and other insects is:

FORMULA 17

NAPHTHALENE REPELLENT

Fish or whale oil soap	25 pounds
Water	1½ gallons
Flaked naphthalene	12½ pounds
Flour	2 pounds

Dissolve the soap in hot water and stir in the flour. Add flaked naphthalene and heat to 180° Fahrenheit until thoroughly dissolved. Cool and store in sealed containers. For use, thin to consistency of paint and apply to trunks and limbs with brush.

OILS

Nature of Petroleum Oils.—Petroleum is a complex mixture of substances consisting mainly of carbon and hydrogen but with a varying amount of sulfur and nitrogen-containing compounds also present. By

distillation, usually under a vacuum, it is divided into a number of fractions. That fraction which at normal pressure distills between approximately 500° and 750° Fahrenheit is the source of spray oils. It may also be considered as light lubricating oil, for the next fraction coming over at a higher temperature gives the commercial lubricating oils. Since material distilling over such a wide range would vary greatly in its properties it is customary to take the spray-oil fraction in two or more cuts, each covering a narrower temperature interval. These cuts are still composed of a great variety of compounds, some of which are very toxic to plants. It is, therefore, necessary to purify or refine them. This is done either by mixing with cold liquid sulfur dioxide or with hot sulfuric acid. Both processes are often used to obtain very highly refined oils. In order to determine how far the process of refinement has been carried, a test has been devised called the "unsulfonatable residue test." This depends upon the fact that when a petroleum oil is treated with strong hot sulfuric acid under certain specified conditions a reaction goes on until only very nonreactive constituents of the oil are left. For any particular sample of oil this portion not acted upon will be a certain percentage of the volume taken for the test. This percentage is called the "unsulfonatable residue" and represents the portion which is too inert chemically to react with sulfuric acid under the conditions of the test. It has been found that toxicity to plants and insects is less the greater the unsulfonatable residue (U. R.).

The various fractions obtained by this combination of distillation and treatment with sulfuric acid are washed with alkali to remove excess acid. They then are the spray oils of commerce. A number of other tests are used to further identify their properties. The most important is the distillation range. The oil is heated in a long-necked flask under certain definite conditions and the percentage distilling over at 5 to 25 degree intervals of temperature is determined. The data on three well-known brands are given in table 1, to illustrate some of the differences that are found.

TABLE 1

DISTILLATION RANGES OF THREE SPRAY OILS

Oil	500° F	525° F	550° F	575° F	600° F	625° F	650° F	675° F	700° F	725° F	750° F
	Per cent distilled										
A	3	16	35	51	62	74	81	87	90+	....	.....
B	...	....	6	13	22	33	48	62	77	88	90+
C	. .	. ..	....	....	....	4	16	41	72	87	90+

Oil A starts to distill at a rather low temperature but continues over a wide temperature interval, that is, it is a rather wide-cut oil. Oil B is a similar wide-cut oil of an intermediate distillation range, and oil C is a narrow-cut oil of a high distillation range. Since the various cuts can all be blended and low boiling fractions such as kerosene or high boiling fractions such as lubricating oils can be added as desired, it is obvious that a tremendous variety of products is possible. The tendency of late has been to produce as many cuts and as narrow ones as is consistent with economical refinery practice and then to blend only when there is a particular reason for so doing.

Another property used in describing spray oils is the viscosity, which is a measure of the ease of flowing. It is measured in terms of the number of seconds needed for 60 cubic centimeters of an oil to flow through the orifice of a Universal Saybolt viscosimeter when the latter is kept at 100° Fahrenheit. The more viscous the oil the longer the time required to flow out of the viscosimeter, and vice versa. The viscosities of spray oils vary from about forty seconds to considerably over one hundred.

Selection of Oils.—A very important consideration in the use of oils is the fact that plants and trees are much more easily injured when they are growing and in foliage than when they are in dormant condition. This has given rise to the grouping of spray oils into two classes: (1) dormant or winter oils, whose unsulfonatable residue is approximately 65 to 80; and (2) foliage or summer oils, whose unsulfonatable residue is approximately 80 to 100. The viscosities vary widely, with the dormant oils more viscous on the average than the summer oils. In general, the distillation ranges vary in a similar manner. Since the insecticidal value of oils and their harmful action to plants are also proportional to the length of time they remain after spraying, the distillation range affords a useful basis for classifying both summer and winter oils. An important distinction between the requirements for spraying deciduous and citrus trees is that the latter have no true dormant season and accordingly can only be treated with summer oils. The two groups of oils overlap somewhat, for oils of intermediate properties are often necessary for use on deciduous trees at the time of budding. Further specifications will be given in the sections on tank-mix oils for citrus and for deciduous fruit trees.

Oil is used in sprays in four different ways as straight oils, miscible oils, commercial emulsions, and tank mix.

Straight Oils.—The most direct method of applying oil consists in either using a small high-pressure pump to force the oil through a paint-gun-type nozzle or using an air blower with an auxiliary pump which sends the oil at low pressure into the fast-moving stream of air. In either

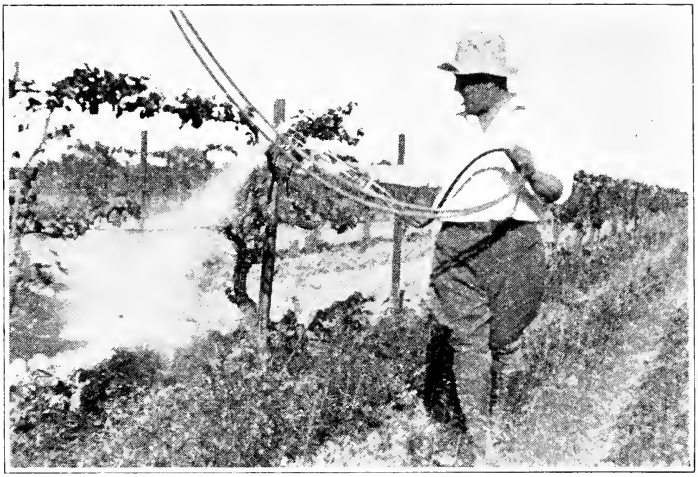


Fig. 106.—Applying a highly refined straight oil by means of a compressed-air equipment to grapevine for the control of the grape leafhopper. This is a new method of insect control. (After Lamiman.)

case the oil is broken up into very small droplets so that it resembles a fog. The term "vapor spraying" is often used to describe this process. A formula found to be efficient against the grape leafhopper[29] is:

Formula 18

Oil-Pyrethrum Vapor Spray

Oil (unsulfonatable residue 90, viscosity 60 sec.)	10 gallons
Refined kerosene	87½ gallons
Extract of pyrethrum (containing 2 grams of pyrethrins per 100 c.c.)[30]	2½ gallons

Use at rate of 2-5 gallons per acre.

The commercial fly sprays are solutions of pyrethrum extracts in kerosene or other volatile petroleum products with other materials added to some of them.

Miscible Oils.—These differ from other kinds of sprays in that the emulsifying agent is soluble in oil and is added to it before any water is used. Most of the homemade emulsions so widely used a few years ago were of this type. They can be made by heating together crude carbolic acid and lye (or caustic potash). This forms crude sodium or potassium cresylate, which is then added to an oil and thoroughly mixed

[29] See: Lamiman, J. F. Control of the grape leafhopper in California. California Agr. Ext. Cir. 72:1–20. 1933.

[30] See section on "Pyrethrum," p. 134, for the meaning of this phrase.

in until a clear solution results. Fish oil may be included with the crude carbolic acid, in which case fish-oil soaps are also formed and the solution in oil is usually not entirely clear. Upon adding water and stirring a very finely divided emulsion results. A recent variation of this process is the use of sulfonated petroleum soaps or similar products instead of the sodium cresylate. They are dissolved in oil at the factory and the resulting product sold either as the clear solution (called soluble oil) or as the concentrated emulsion containing about 15 per cent water.

Miscible oils are more toxic to foliage than other sprays containing the same grade of oil because the emulsifying agents tend to burn plant tissue. For this reason their use is mostly confined to the dormant season.

Miscible oils may occasionally be combined with other insecticides to advantage. When pear thrips appear on prunes, pears, or cherries before the flower buds begin to open the following formula is useful.

FORMULA 19

MISCIBLE OIL-NICOTINE

Miscible oil	5 gallons
Nicotine sulfate 40 per cent (for example, Black Leaf 40)	1 pint
Water to make	200 gallons

Commercial Oil Emulsions.—Stable emulsions containing approximately 85 per cent oil are made by a large number of manufacturers. A wide variety of oils is used but, in general, these preparations fall into the two classes of winter and summer oils previously mentioned. The convenience of using emulsions, particularly for the small user, has made them very popular, and supervision by the State Department of Agriculture has standardized the oils used. Data on the oils used is published by the State Department of Agriculture but the emulsifying agents are secret. Since the type and amount of emulsifying agent largely control the amount of oil that is deposited in spraying, it is not possible to obtain the same results when various oil emulsions are used at the same concentration even though the oils in them are similar. Each manufacturer gives directions for using his preparations. One decided advantage that commercial oil emulsions have is that they require comparatively little agitation since an excess of emulsifying agent is used. The corresponding disadvantage is that some deposit less oil than tank-mix sprays of equal oil content, and somewhat higher concentrations may be advisable for securing equal control of the same insects.

While the manufacturers differ somewhat in dosage recommendations for their products, the following are typical.

Dosage of oil emulsions for use in dormant season:

Insect or mite	Amount of oil emulsion per 100 gallons of spray
San Jose scale	5 gallons
Brown apricot scale	4 gallons
Italian pear scale	7 gallons
Leaf roller eggs	7 gallons
Brown mite eggs	3 gallons

Dosage of oil emulsions for use in foliage season:

Insect or mite	Amount of oil emulsion per 100 gallons of spray	
Red spider	1½-2 gallons	
Aphids, immature thrips	1½-2 gallons	With ¾ pint 40 per cent nicotine sulfate (for example, Black Leaf 40)
Leafhopper nymphs	2 gallons	
Codling moth	1 gallon	

A modification of the commercial oil emulsions has been produced by several manufacturers lately. An emulsifying agent is dissolved in the oil and the solution is marketed without any water being added. This material is something like the miscible oils but differs in that another substance, usually alkaline in nature, must be added to the spray water in order to insure adequate wetting when the spray is applied. If hard water is used, more of this second substance must be added. These so-called soluble oils give a heavier deposit than most commercial emulsions and approach tank-mix oil sprays in this respect.

Tank-Mix Spray for Citrus Trees.[31]—Tank-mix spray depends upon the production of a finely divided emulsion of oil in water in the spray tank at the time of use. It is the result of an investigation made by the University of California Citrus Experiment Station with the object of aiding in the standardizing of oil sprays and simplifying spraying for pest control. The principal advantage is that it provides the citrus grower with a standard type of spray of known composition at a low cost. It was approved for general use by the Experiment Station at the beginning of the spray season in 1931 and has since become a leading type of spray.

The oil, just as it is produced at the refinery, and a spreader known as *powdered blood albumin spreader,* are added separately to the spray tank, and a uniform mixture is produced and maintained by effective agitation.

Specifications of Oil.—As a result of experimentation during a period of years, it has been determined that five grades of oil are needed to meet the various conditions of citrus pest control. The grades have been

[31] The section on tank-mixture spray for citrus trees was prepared by Ralph H. Smith, Entomologist in the Citrus Experiment Station.

designated by number, grade 1 being the lightest and grade 5 the heaviest. Through the coöperation of the oil companies that produce spray oils on the Pacific Coast, the various grades have been standardized as to specifications, so that the grower who orders tank-mix grade 2 spray oil, for example, and finds this designation printed on the barrel, may be assured of obtaining the particular oil specified by the Experiment Station.

Grade 1 is a rather narrow-cut oil and falls strictly in the light class. It has a wide margin of safety, as regards volatility, and therefore is particularly useful for off-season spraying for red spider and scale insects. It is the preferred grade to use in the interior districts where red spider is not a problem and where impaired blooming and coloring of fruit are important factors of consideration in spraying navel oranges. The dosage recommended for citricola and black scales is 1½ to 1⅔ per cent. For average conditions of infestation, 1½ per cent is adequate. For winter and spring treatment of red spider a thorough application, using 1½ per cent, has given satisfactory results.

Grade 2 falls in the light-medium class. Experiments indicate that it meets the needs for black scale and red spider control in the districts intermediate between coastal and interior. It provides a relatively safe oil for navel oranges in those districts where impaired coloring, rind breakdown, and development of decay have been factors of consideration in the use of oil sprays. Dosage recommended is 1½ per cent.

Grade 3 also falls in the light-medium class. It has been used extensively in the coastal districts in spraying oranges for red, purple, and black scales, and red spider. On the whole, the results have been very satisfactory, although the control has not been as high as obtained with grade 4. The dosage recommended is 1½ to 1⅔ per cent.

Grade 4 corresponds to the oils contained in the leading brands of medium emulsions which have been used extensively in spraying oranges in the coastal districts. It will give a higher degree of control of scale insects, particularly red scale, and a more effective hold-over control of red spider than will grade 3. It is the heaviest oil that should be used on orange trees. The dosage recommended is 1½ per cent.

Grade 5 is used only in spraying lemon trees in the coastal districts for red scale. The dosage may be gauged within limits by the degree of infestation and the degree of control desired, bearing in mind that 1⅔ per cent of this oil in tank-mixture spray is equal to 2 per cent of the heavy commercial emulsions, which have been widely used for control of this insect. The prevailing dosage has been 1⅔ to 2 per cent.

Spreader.—The spreader or emulsifier consists of 1 part powdered

blood albumin and 3 parts fuller's earth. This mixture, known as *powdered blood albumin spreader,* is used at the rate of 4 ounces to 100 gallons of spray. The use of the spreader at this rate gives a spray that is about average in oil-depositing quality, efficiency, and safety. This means that when the proper grade of oil is used at 1½ or 1⅔ per cent, and the degree of thoroughness of the spray application is average, and the physical condition of the tree is normal, effective control may be obtained without especial risk of excessive fruit-drop, leaf-drop, or other unfavorable effects.

Sprayer Equipment.—In order that the use of tank-mixture spray will be adequately safe, spray tanks are required to have sufficient agitation to produce a uniform mixture within approximately ½ minute after starting the motor. Most of the sprayers in the citrus districts are equipped to meet this requirement. It necessitates an agitator speed of approximately 200 r.p.m. and the use of large-sized agitators.

Directions.—No particular directions need be followed in placing the oil and spreader in the spray tank; but the preferable procedure is to add the oil when starting to fill, and then sift in the spreader. *The agitator should be kept running continuously from the time the oil is added until the spray is applied.* This requirement eliminates the possibility of the use of imperfect mixtures, and also the possibility of splashing the oil out while hauling the sprayer from the filling station to the point of spraying in the grove.

When to Spray.—The favorable period for using oil spray on orange trees is from about July 15 or 20, to about September 15. August is definitely the preferred month. It is generally believed that early spraying may accentuate the "June drop" of green fruit, which normally occurs during June and July. Beginning with about the first of September, there is a gradual increase in the risk of encountering such unfavorable reactions as delayed coloring, impaired blooming, and, in the navel area of Los Angeles County particularly, accentuated rind breakdown, which is associated with rainy weather in winter and spring. In the coastal districts, and perhaps in all districts, there is evidence that orange trees undergo a sort of subnormal physical condition in the fall—October usually being the critical month—when the trees may react unfavorably, and more or less erratically, to pest-control treatments. With oil spraying there may occur pronounced or even excessive leaf-drop and fruit-drop in occasional groves. While rather early spraying is preferred from the standpoint of tree and fruit reaction, late summer spraying may be desirable where red spider is a problem of particular importance.

The combination spray of miscible oil and lime-sulfur is used in the late fall and early winter, November and December particularly.

Winter Tank-Mix Spray for Deciduous Fruit Trees.[32]—In the destruction of San Jose scale, brown apricot scale, Italian pear scale, greedy scale, oyster-shell scale, brown mite eggs, and leafroller eggs, and as a general winter clean-up spray for deciduous fruits the tank-mixture method has proved most efficient and economical. Not only is there a large saving in the cost of materials but also a saving in time in operation

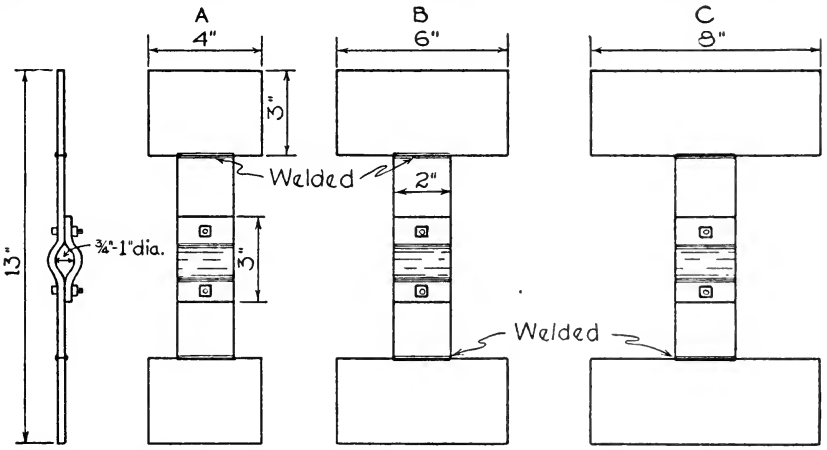


Fig. 107.—Specially constructed flat paddles for attachment in spray tanks for the proper applications of tank-mix oils. (After Borden.)

and less runoff when the spray is applied to dormant trees. It may be combined with lime-sulfur, bordeaux mixture, or caustic soda if desired.

Oil.—For dormant spraying the type of oil recommended is one of from 100 to 120 seconds (Saybolt at 100° Fahrenheit) and 70 per cent or above in unsulfonatable residue. Such an oil may be obtained from oil companies at considerably less cost than emulsions containing the same grade of oil.

Pending further experiments, the emulsifying agent used in southern California on citrus—blood albumin spreader—is recommended for deciduous-fruit sprays. It is not affected by the hardness of the water as are the caseinate spreaders and gives a very uniform oil deposit. It is available in glassine-lined bags in 8-ounce and 12-ounce packages, enough for 200 and 300-gallon tanks.

Spray Equipment.—Conditions in the deciduous-fruit districts are somewhat different from those in the citrus districts in that in northern California much of the spraying equipment is powered with motors from 2 to 6 hp. and is grower-owned and operated.

[32] This section and the following one, on summer tank-mix spray, were prepared by A. D. Borden, Assistant Entomologist in the Experiment Station.

The high-speed agitation recommended for citrus spraying cannot readily be obtained with these low-powered outfits while still maintaining sufficient pressure. In order to obtain adequate agitation without a high speed on the agitator shaft, a different type of agitator blade was found to be necessary. This new device is known as a 2-bladed flat square-end agitator and is made of $\frac{3}{16}$-inch steel plate of the following dimensions for a 200 gallon tank:

Length over all	13 inches
Shank	2 inches wide
Tips (at right angle to shank)	3 inches × 4 inches
Groove to fit	1 inch shaft
Binding plate with $2\frac{3}{8}$ inch bolts	2 inches × 6 inches

The tips are best welded to ends of shank. Four of these agitators in a 200-gallon tank at a speed of 95–100 r.p.m. or above will give a uniform mixture. The energy consumed is less than 0.2 hp. In a 300-gallon tank four agitators with 3 × 8 inch tips to the blades should be sufficient at 95–100 r.p.m.

Directions.—No definite directions for mixing are necessary when adequate agitation is available. Usually the agitator is started and the spreader is added when the water is up to the agitator rod, then the oil is added and the tank is filled with water. The motor is kept running until the tank is emptied.

Dosage.—The following dosage rates are recommended for insects usually controlled in the dormant season:

Insect or mite	Amount of oil per 100 gals. of spray
San Jose scale	3 gallons
Brown apricot scale	2 gallons
Italian pear scale	4 gallons
Leaf roller eggs	4 gallons
Brown mite eggs	2 gallons

Summer or Foliage Tank-Mix Spray for Deciduous Fruits.—In the control of aphids, red spider, immature thrips, immature mealybugs, leafhopper nymphs, and as an ovicide for codling moth, the tank-mix method is applicable. It may be combined with nicotine if desired.

Oil.—The oils used on foliage are more highly refined products and may range from 50 to 70 seconds (Saybolt, at 100° Fahrenheit) in viscosity with an unsulfonatable residue of 90 per cent or above. They are classed as light or light-medium oils and are obtainable from most refineries. On Yellow Newtown and Smith Cider apples only the light type of oil (viscosity 55 seconds) should be used.

Spreader.—The same blood albumin spreader is used in the summer sprays as in the winter sprays, and at the same dosage rate of 4 ounces per 100 gallons of dilute spray.

Dosage.—The following dosage rates are recommended:

Insect or mite	Amount of oil per 100 gallons of spray
Red spider	¾ to 1 gallon
Aphids, immature thrips, leafhopper nymphs, and codling moth	¾ to 1 gallon, with ¾ pint nicotine sulfate

Combinations of Oil with Other Insecticides.—Oils enter into the formulas for many combination sprays. In general, tank-mix oils and commercial emulsions may be used interchangeably in these sprays. The following formulas indicate some of the useful combinations:

FORMULA 20

OIL AND LIME-SULFUR

Commercial oil emulsion (100-120 seconds viscosity and 70 per cent unsulfonatable residue)	5 gallons
(Or tank-mix oil of similar specifications with 4 ounces blood albumin spreader)	4 gallons
Commercial lime-sulfur solution[33]	3 gallons
Water to make	100 gallons

This mixture is particularly useful for winter control of mealybugs on deciduous trees and vines.

FORMULA 21

OIL, NICOTINE, AND AMMONIA

Commercial oil emulsion (100-120 seconds viscosity and 70 per cent unsulfonatable residue) or tank-mix oil of like specifications with 4 ounces blood albumin spreader	1½ gallons
Nicotine sulfate 40 per cent (for example, Black Leaf 40)	¾ pint
Ammonia (20-24 per cent solution)	½ pint
Water to make	100 gallons

This is used for the control of adult pear thrips, aphids, and scales on trees in bud or before the leaves appear.

A similar formula, except that the oil should have a viscosity of 60–70 seconds and an unsulfonatable residue of 90 per cent or over is useful for summer control, for example, of young thrips infesting prune, pear, cherry, etc., in the spring time.

[33] If homemade lime-sulfur solution is used the amount necessary may be calculated from the Baumé reading by use of table 2, page 138.

A fungicide is included in the following formula:

FORMULA 22

OIL, NICOTINE, AND LIME-SULFUR

Commercial oil emulsion (60-70 seconds viscosity and 90 per cent unsulfonatable residue) or tank-mix of like specifications with 4 ounces blood albumin spreader	1 gallon
Nicotine sulfate 40 per cent (for example, Black Leaf 40)	¾ pint
Lime-sulfur solution	5 gallons
Water to make	100 gallons

Bordeaux mixture 5-5-50 may be substituted for the lime-sulfur by using 10 pounds of quicklime and 10 pounds of bluestone in the above formula.

A general winter clean-up spray for moss which also controls San Jose scale is the following combination:

FORMULA 23

OIL AND CAUSTIC SODA

Commercial oil emulsion (100-120 seconds viscosity and 70 per cent unsulfonatable residue	5 gallons
(Or tank-mix oil of like specifications with 4 ounces of blood albumin spreader)	4 gallons
Caustic soda[34] (lye)	1-3 pounds
Water to make	100 gallons

Oil Emulsions and Miscible Oils as Carriers.—Because of their penetration, oil emulsions and miscible oils are often of value in carrying other materials, like nicotine. They should be used sparingly, about 2 gallons to 200 gallons of diluted spraying materials. When so diluted they have little value except as spreaders.

PARADICHLOROBENZENE OR PDB

The use of paradichlorobenzene as a soil fumigant to control soil-infesting insects has created a large interest in California.

The material in question is a white crystalline substance which is insoluble in water and evaporates slowly at a temperature of 55° to 75° Fahrenheit and more rapidly at higher temperatures. The vapor is more than five times heavier than air and more than twice as heavy as carbon disulfide vapor. It possesses a weak ether-like vapor which is practically nonpoisonous and noncombustible.

Paradichlorobenzene is such a long name that it seems advisable to abbreviate it by using "PDB" for short. Various trade names such as

[34] The smaller amount of caustic soda is satisfactory in the interior valleys and the larger amount is only required where moss growth is very vigorous as in the coastal regions.

"Paracide," "Crystal Glass," etc., have already appeared, and many others will soon follow.

In applying the material two considerations are important: soil moisture and temperature. Because gases do not readily circulate in a thoroughly wet soil, applying paradichlorobenzene is useless unless the soil is not more than ordinarily moist; in California the soil is usually in proper condition during the summer and fall except just after irrigations. In such cases a week or two after the application of water would be preferable. For the best results the soil temperature should range from 75° to 85° Fahrenheit, for under such conditions the paradichlorobenzene volatilizes more rapidly and the insects are more active, requiring a greater air supply, and are consequently more readily killed by the vapor.

In California the period from the first of May until November may be roughly designated as the proper time to make the applications, provided the soil temperature is over 55° Fahrenheit and the soil moisture is not excessive.

From ¾ to 1 ounce of paradichlorobenzene is sufficient to treat an average-sized tree. First, level the surface of the soil around the base of the tree; then sprinkle the material around the tree in a continuous band or circle 2 inches wide with the inner margin 2–4 inches from the bark of the tree. Cover the material with soil around the base of the tree to a depth of 2–4 inches and pack well with several strokes of the shovel.

Under eastern conditions, where the use of this insecticide has been extensive, it has been applied chiefly to peach trees on peach rootstocks. The eastern investigators caution against using it on trees under six years of age, although younger trees are reported to have been treated with no injurious results in many instances.

In California apricot trees on myrobalan rootstock and infested with the Pacific peach tree borer have been treated with good results in killing the borers without injury to the trees. Even nursery stock on myrobalan and peach roots treated in the early summer showed no ill effects, but such work should receive more attention before general recommendations can be made.

California conditions are so different from those in the southern and eastern states that it is to be expected that many unusual problems in the handling of the material will be encountered here and that its uses may be very greatly enlarged.

Paradichlorobenzene is being recommended by some insecticide dealers for all wood-boring insects, particularly for the western flat-headed borer. This insect and the other wood borers which work above ground

cannot be satisfactorily reached by the fumes of the fumigant and *cannot be controlled by it!*

Although paradichlorobenzene has been extensively used over a period of many years in California there is still much to be learned regarding it and a great deal of experimental work remains to be done. The action of the vapor on the roots of the plants is so slow that the after-effects may not be noticed for several years, and trees treated in the preliminary tests of 1921 are still under observation. While a single treatment may produce no ill effect we are not now able to determine what results may develop from successive treatments over a period of years. Therefore, the growers should take all precautionary measures possible and at least observe the following:

1. Avoid using excessive dosages.
2. Do not place the crystals in contact with the bark of the trunks, stems, or the roots of the plants.
3. Do not apply the material immediately before or after irrigation and do not wet the surface of the soil until two or three weeks after applications of the crystals, or until the crystals have volatilized.
4. In treating nursery stock and young trees remove the residue after three weeks.
5. Do not apply paradichlorobenzene during the winter and early spring. Late summer and fall are the best times for such applications.
6. Only one application a year is advisable. Several treatments in one season may be fatal to the plants.
7. Paradichlorobenzene is recommended in the orchard and garden only for insects which attack the plants at or below the surface of the soil and cannot be used for borers which infest the trunks and limbs above the ground.

PLANT PRODUCTS

A significant feature of recent investigations of insecticides has been the chemical studies on many plant products. These have sought to discover and study the toxic factor or factors included in the earlier insecticidal preparations from plants, in order that materials of high purity and known composition may be made available.

Derris.—Extracts from the root of derris, a tropical plant, have long been used as fish poisons. Rotenone is the principal constituent; preparations of this substance are made by several concerns. Its toxicity seems to vary greatly with different kinds of insects. Since it is nontoxic to humans it has been recommended for use on vegetables. Various preparations differ greatly in strength so the manufacturer's directions should be followed.

Tobacco.—Tobacco dusts and infusions were used many years ago both as fumigants and as contact poisons. Substantial progress, however, was not made until the toxic constituent, nicotine, was isolated in commercial quantities. Certain facts must be kept in mind in order to use nicotine preparations to the best advantage. By itself, nicotine is a fairly volatile and very toxic liquid. It reacts with a great variety of substances to form nonvolatile compounds, which are also relatively nontoxic as long as they remain undecomposed. Free nicotine is liberated from any of its compounds by the addition of an alkaline substance such as lye, soap, washing soda, lime, bordeaux mixture, lime-sulfur, and to a less extent even by limestone. For insecticidal use it is marketed chiefly as a 40 per cent solution of nicotine in the form of its compound with sulfuric acid, that is, as nicotine sulfate. Unless otherwise stated, the directions and formulas of this circular are given in terms of actual nicotine.

Nicotine Sprays.—These are very widely used against soft-bodied insects such as aphids. An alkaline substance, sometimes called an activator, is added. A common formula is:

FORMULA 24

NICOTINE AND SOAP

Nicotine sulfate solution, 40 per cent (for example, Black Leaf 40)	1 pint
Whale oil soap	4 to 5 pounds
Water	100 to 150 gallons

Liquid whale oil soap, 1 to 1½ gallons, may be substituted for the solid

For small quantities use 1 teaspoonful of nicotine solution and 2 tablespoonfuls of soap to 1 gallon of water. This formula contains a large excess of soap, which also has insecticidal value.

For plants sensitive to soap, such as potatoes and tomatoes, formula 24 may be altered to 1 to 1½ pounds of soap or ¼ pint of ammonia (20–24 per cent solution).

The formula recommended for use against the first-brood nymphal stage of the grape leafhopper (see p. 58) is:

FORMULA 25

NICOTINE AND CASEIN

Nicotine sulfate solution, 40 per cent (for example, Black Leaf 40)	1 pint
Calcium caseinate spreader	½ pound
Water	100 gallons

Nicotine has received much attention of late as a substitute for lead arsenate in the late sprays for control of the codling moth. Here it func-

tions chiefly as a stomach poison and an attempt is made to reduce its volatility and hence cause it to remain on the fruit and foliage as long as possible. The addition of tannic acid favors this. A typical formula is:

FORMULA 26

NICOTINE AND TANNIC ACID AND OIL

Nicotine alkaloid, 50 per cent	1 pint
Tannic acid (liquid, 50 per cent, from galls)	3 pints
Commercial oil emulsion (70 seconds viscosity and 90 per cent or over unsulfonatable residue) or tank-mix oil of same specifications	1 gallon
Water to make	100 gallons

For combinations of nicotine with various insecticides see formulas under other headings.

Nicotine Dusts.—The old-fashioned tobacco dusts were unsatisfactory because they contained variable amounts of nicotine. To overcome this defect Ralph E. Smith mixed commercial nicotine solutions with various finely divided solids and thus prepared dusts of known strength. The nature of the solid or carrier is very important, for it determines the ease with which nicotine will be liberated at any given temperature. Alkaline carriers, such as lime, cause more rapid evolution than neutral carriers, such as silica. Much work has already been done on the problem of regulating the rate at which nicotine is liberated. With some insects a high concentration maintained for a very short period is most effective; this calls for "fast" dusts. In other cases a moderate concentration for a longer time is better and "slow" dusts are best. An example of a very "fast" dust is that used to control the nymphal stages of the grape leafhopper. This contains an activator, that is, a very alkaline substance which liberates the nicotine with great rapidity. The composition of nicotine dusts may be given in terms either of actual nicotine or in terms of the nicotine preparation used. The former method is used in this circular.

FORMULA 27

ACTIVATED NICOTINE DUST

Nicotine sulfate solution, 40 per cent (for example, Black Leaf 40)	10 pounds (1 gallon)
Hydrated lime	80 pounds
Sodium carbonate (soda ash, an activator)	10 pounds

This should be made in a barrel mixer in which the lime is placed and the nicotine added gradually. After turning for 5 minutes add the sodium carbonate and turn for 5 minutes more. The mixture should then be put

into air-tight cans. It loses nicotine so readily that it cannot be kept more than a few hours even in tight cans. Sulfur to the extent of 30 per cent may be substituted for an equal weight of hydrated lime in the previous formula, but since mixing is difficult a proprietary nicosulfur dust is usually preferable. Other mixtures containing less-reactive carriers can be stored in tight cans without appreciable loss of nicotine.

Recently, machines for mixing and applying the materials at the same time have been devised. These give increased efficiency and economy in some large-scale operations.[35] A wide variety of nicotine dusts are made commercially, differing in concentration of nicotine and in carrier. They should be used according to the manufacturer's recommendation.

The strengths commonly used are 0.8[36] per cent nicotine dust for walnut aphid and cherry or pear slug, 1.25 or 1.50 per cent for most of the aphids and thrips, and a 4 per cent dust for the more resistant aphids (such as the pea aphid) and grape leafhopper. Nearly all of the hairy caterpillars, such as the tent caterpillars, webworms, and thistle butterfly larvae, as well as the velvety cabbage worms, to which the nicotine dust adheres readily, are easily killed with a 4 per cent dust if applied while the caterpillars are young. Smooth caterpillars, like cutworms, on the other hand, do not readily succumb to any ordinary treatment with the material. Insects which are protected with a waxy or cottony material, such as the woolly apple aphid, the mealy plum louse, and mealybugs, are not susceptible to nicotine dust at all unless completely smothered in it. Those which have a wet or slimy covering, like the cherry or pear slug, or have glandular hairs, like the walnut aphid, are easily killed with very weak nicotine preparations.

A number of combination dusts containing nicotine are produced commercially. Arsenate of lead and sulfur are mixed with nicotine dust at the time of manufacture and give convenient combinations for treating different types of insects or insects and fungus diseases at one application.

In using all dusts containing nicotine it should be borne in mind that a high temperature favors the evolution of nicotine. The best results are obtained only when the temperature is over 70° Fahrenheit. Very poor control results from dusting in cold weather.

Pyrethrum.—For many years the powdered flowers of the pyrethrum plant have been sold for use against fleas, bedbugs, etc., and mixed with

[35] See: Smith, Ralph E., and Joseph P. Martin. A self-mixing dusting machine for applying dry insecticides and fungicides. California Agr. Exp. Sta. Bul. 357:495–506. 1923. This bulletin is out of print but may be consulted in many city and county libraries in California.

[36] In terms of actual nicotine. If nicotine sulfate solution containing 40 per cent nicotine (as in Black Leaf 40) is used, multiply these percentage figures by 2½.

water it has been used against such insects as cankerworms. Within the last few years extracts of the flowers have appeared under various trade names. At first these were not standardized except that a certain weight of dried flowers was used to make a gallon of prepared spray. Since different methods of extraction varied in efficiency the products were far from uniform. It was then discovered that the principal insecticidal constituents are two complex organic compounds which have been called "pyrethrins." The latest practice is to produce pyrethrum concentrates having a guaranteed pyrethrin content. This material is frequently used with oil. A typical formula for use against grape leafhopper (p. 57) is:

FORMULA 28

PYRETHRUM AND OIL

Pyrethrum extract	1 quart[37]
Summer-grade commercial oil emulsion or tank-mix oil with 4 ounces of blood albumin spreader	4 gallons
Water to make	200 gallons

SOAPS

When animal or plant fats and oils are treated with hot alkali, soaps are formed. These soaps consist of the fatty acids from the fats and oils combined with the sodium or potassium hydroxide of the alkali. Similarly, resin soaps may be formed. By first treating certain petroleum products with strong sulfuric acid under specified conditions and then adding alkali, a number of compounds called sulfonated petroleum soaps are prepared. These various soaps all have valuable properties as emulsifying agents and wetting agents which will be discussed in a later section. By themselves, soaps are sometimes used against soft-bodied insects at the rate of 4 to 10 pounds per 100 gallons of water. Their greatest use, however, is with other insecticides, such as nicotine or nicotine-oil sprays. Largely on account of lower cost, fish or whale-oil soaps have been used more than other kinds, but powdered soaps are very convenient and even laundry soap is effective.

SULFUR

Sulfur is used in four forms: (1) as a dust, (2) as a suspension, (3) as a solution of lime-sulfur, and (4) as dry lime-sulfur. The dust and the suspension have comparatively little value against most insects but are of great value against fungi and against mites.

Dusting Sulfur.—This is mostly produced by one of two methods, (*a*) precipitation by cooling sulfur vapor, and (*b*) grinding. Precipitated sulfur usually has less tendency to cake. This can be prevented with any

[37] Since commercial extracts differ in strength the manufacturer's directions should be followed with each preparation.

type of sulfur by adding a small percentage of dehydrated lime, kaolin, or other inert powder.

The essential feature of any good dusting sulfur is extreme fineness. Recognition of this by manufacturers has led to the use of such names as "superfine," "cloud." "microscopic," "smoke," "colloidal," "fog," and

Fig. 108.—Applying dry sulfur and hydrated lime to citrus trees for the control of red spiders. (After Quayle.)

similar terms. Practically all brands are now fine enough so that only a very small percentage fails to pass through a 300-mesh screen. Such materials usually adhere well and find extensive use against red spiders and other mites. Combination treatments including sulfur for control of mildew are also widely used.

Sulfur Paste or Wettable Sulfur.—These are suspensions of finely divided sulfur in water. Either precipitated or ground sulfur may be used. An emulsifying agent is needed to make the suspension stable enough for use. Soap, calcium caseinate, glue, flour, or any of a wide variety of commercial preparations may be used. If the emulsifying agent is intimately mixed with the sulfur, the resulting powder is readily wet by water, from which fact the term "wettable sulfur" was derived. When a small percentage only of water is added a thick paste is produced which may be diluted further as needed.

Homemade wettable sulfur may be prepared by the following formula:

FORMULA 29

HOMEMADE WETTABLE SULFUR

Calcium caseinate	½ pound
Water	½ gallon
Sulfur (dusting grade)	5 pounds
Water to make	100 gallons

Make a smooth paste of the calcium caseinate and ½ gallon of water, mix with the sulfur, and add enough water to make 100 gallons. The same formula may be used with ¾ ounce of glue dissolved in 1½ gallons of hot water instead of the calcium caseinate paste.

Lime-Sulfur Solution.—This is a reactive solution containing several compounds of lime and sulfur. Those of chief insecticidal value are the polysulfides, which consist of one atom of calcium combined with three to five atoms of sulfur. Such compounds readily take up oxygen and decompose, depositing extremely finely divided sulfur. Lime-sulfur solution is alkaline and decidedly caustic to most foliage. Its principal use is as a dormant spray for the control of certain fungus diseases, scale insects, red spider, and a variety of other resistant pests of deciduous trees.

Commercial lime-sulfur solution is usually 32° or 33° Baumé. The Baumé scale is a method of expressing the density of liquids. It is being replaced by the use of specific gravity. A 33° Baumé preparation has a specific gravity of 1.295, which means that 1 cubic centimeter weighs 1.295 grams or 1 gallon weighs 10.8 pounds. Such material needs only to be diluted for use. See table 2, p. 138.

Lime-sulfur solution may be made at home as follows:

FORMULA 30

HOMEMADE LIME-SULFUR SOLUTION

Quicklime	50 pounds
Sulfur (sublimed or powdered)	100 pounds
Water to make	50 gallons

Heat about one-third of the total volume of water required. When the water is hot add all of the lime, and then immediately all the sulfur, which should previously have been made into a thick paste with water. After the lime is slaked another third of the water should be added, preferably hot. The mixture should then be cooked until a clear orange-colored solution is obtained (usually 45 to 60 minutes), when the remainder of the water should be added, either hot or cold, as is most con-

venient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the beginning, but stirring is necessary during the subsequent cooking. After the wash has been prepared it must be allowed to settle and then strained through a fine sieve as it is being run into the spray tank. The resultant product is a concentrated solution of lime-sulfur, usually Baumé 27° to 28°, which should be diluted about six times

TABLE 2

DILUTION TABLE FOR CONCENTRATED LIME-SULFUR SOLUTION*

Degrees Baumé	Specific gravity	Number gallons concentrated lime-sulfur to make 50 gallons spray solution		
		Summer or foliage strength	Winter or dormant strength	
			San Jose scale	Blister mite†
36	1.330	1¼	5½	4¾
35	1.318	1¼	5¾	5
34	1.306	1½	6	5
33	1.295	1½	6¼	5¼
32	1.283	1½	6½	5½
31	1.272	1½	6¾	5¾
30	1.261	1¾	7	6
29	1.250	1¾	7¼	6¼
28	1.239	1¾	7½	6½
27	1.229	2	8	6¾
26	1.218	2	8½	7¼
25	1.208	2	8¾	7½
24	1.198	2¼	9¼	8
23	1.188	2¼	9¾	8¼
22	1.179	2¼	10¼	8¾
21	1.169	2½	11	9¼
20	1.160	2½	11½	9¾

* From: Diegler, E. H., and A. M. Daniels. Lime-sulphur concentrate. U. S. Dept. Agr. Farmer's Bul. **1285**:11. 1922.

† See also "Pear Leaf Blister Mite," p. 72.

with water for a winter spray. By means of a hydrometer for liquids heavier than water, a simple table, and an easy computation, the solution may be made to any desired concentration. This is particularly important where the material is to be used on plants in foliage which may be easily injured if the spray is too concentrated. Table 2 gives the dilutions for lime-sulfur solutions of different initial concentrations.

Dilutions of the commercial 32–33° Baumé product are often given as the ratio of volume of lime-sulfur concentrate to final volume of spray. Thus if 10 gallons are diluted to 100 gallons the resulting solution is a 1:10 lime-sulfur spray.

This method for expressing dilution is usually limited to the use of commercial lime-sulfur of standardized strength.

Lime-sulfur solution is sometimes combined with other materials, as in formula 20 (p. 128), but it is not compatible with several insecticides (see "Compatibility," p. 140).

Dry Lime-Sulfur.—By evaporation of lime-sulfur concentrate, usually under a vacuum or in presence of an inert gas, a dry powder is obtained. This product is not identical chemically with lime-sulfur in solution and the addition of water does not exactly reproduce the original material. If allowed to soak for several hours, or better, at an elevated temperature, the resulting liquid more nearly resembles liquid lime-sulfur. Increased efficiency is secured by removing the insoluble residue or sludge. On account of this complicated behavior, dry lime-sulfur is seldom used, liquid lime-sulfur or oil being preferred.

TAR DISTILLATES

The destructive distillation of coal gives rise to a great variety of products, of which one fraction is known as "coal tar oil." From this several proprietary "tar-distillate washes" or "fruit tree carbolineums" are obtained. These differ considerably in composition, but all contain carbolic acid, naphthalene, and other complex organic compounds. Many of these are toxic to plants, so use of the coal tar preparations is at present limited to the dormant season. They are particularly effective against overwintering eggs.

WHITEWASH

Use has long been made of certain dormant sprays designed to deposit such a thick coating on tree trunks as to prevent hatching of eggs or emergence from eggs or pupal cases. The best material because of its efficiency and cheapness is a suspension of freshly slaked lime. The simplest formula is:

FORMULA 31

WHITEWASH

Water	2 gallons
Quicklime	10 pounds

Add more water after slaking to bring the wash to the desired consistency.

A more durable whitewash for tree trunks, barns, and fences is as follows:

FORMULA 32

WHITEWASH, SALT, AND SULFUR

Quicklime	5 pounds
Salt	½ pound
Sulfur	¼ pound

Slake the lime slowly with about 5 pints water and add the salt and sulfur while it is boiling. Add enough water to make a good wash. This is good for whitewashing the bodies of trees in the fall.

A formula advocated by the United States Department of Agriculture is:

FORMULA 33

GOVERNMENT WHITEWASH

Quicklime	40 pounds
Salt	15 pounds
Rice flour	3 pounds
Spanish whiting	½ pound
Glue	1 pound
Water	5 gallons

MISCELLANEOUS TOPICS RELATING TO INSECT CONTROL

Bands.—See "Banding Trees" under "Codling Moth," p. 12.

Compatibility.—Combination sprays or dusts fall into two classes. In the first class, two or more insecticides are used against the same insect with the idea that those which escape one ingredient will be killed by the other. An example is the use of nicotine-oil sprays against various kinds of aphids. The second class of combination sprays includes those intended for use against two or more pests of different types. An example is the use of bordeaux mixture with basic lead arsenate for simultaneous control of peach twig borer and brown rot of peaches.

In both classes the question arises as to what materials may be used together. This is much more than merely a matter of whether a reaction occurs between the materials used. Two types of incompatibility may be distinguished, (1) a harmful substance is formed or liberated with consequent injury to plants; and (2) a useful ingredient is removed and the effectiveness lessened. The difference in reaction of plants in dormant and in foliage conditions must be recalled, for mixtures extremely toxic during the summer may be entirely satisfactory during the winter. A practical factor which lessens the number of compatible mixtures is the necessity that the correct times for application of each of the components must coincide at least fairly closely.

Bearing the above points in mind table 3 has been constructed in which the two types of incompatibility are shown separately and reasons are given so far as they are definitely known.

Emulsification and Deposit of Spray Materials.—Three principal stages may be distinguished in the application of sprays which are used with water: (1) The insecticide, for example, lead arsenate or spray oil, and the water are separate. (2) An intimate mixture of finely divided

TABLE 3

INCOMPATABILITY CHART

Material	Combined with (or followed by)	Result	
		Toxic substance formed	Efficiency decreased
1. Standard lead arsenate	*a*. With oil emulsions (soap)	Forms lead soaps and liberates soluble arsenic; also breaks oil emulsion.	.....
	b. With soaps	Forms lead soaps and liberates soluble arsenic	.....
	c. With lime-sulfur	Forms lead sulfide; liberates soluble arsenic and decomposes lime-sulfur	.....
2. Calcium arsenate	With sodium fluosilicate barium fluosilicate or sodium aluminum fluoride	Forms calcium fluoride and liberates soluble arsenic, unless excess lime is present	.....
3. Bordeaux mixture or copper carbonate	*a*. Followed by any cyanide preparation	Forms complex cyanides toxic to foliage	.....
	b. With oil emulsions (soap)	Forms copper soaps and breaks oil emulsion	Forms insoluble copper soaps and reduces efficiency as a fungicide.
	c. With soaps	.....	
4. Hydrogen cyanide gas or calcium cyanide	Preceded by bordeaux mixture or copper carbonate	See 3*a*	.....
	With nicotine preparations	.....	Cyanide requires acidic condition; nicotine requires basic condition
5. *a*. Sodium fluosilicate	With calcium arsenate	See 2	.....
	With soaps	Decomposes fluorine compounds and liberates soluble fluoride	.....
	With lime	Small amount of lime gives rise to soluble fluoride	Large amount of lime forms insoluble calcium fluoride and reduces efficiency
5. *b*. Barium fluosilicate	With calcium arsenate	See 2	.....
	With nicotine sulfate	Forms barium sulfate and liberates soluble fluoride	.....
	With soaps	Forms insoluble barium soaps and liberates soluble fluorides	.....
	With lime	See 5*a*	.....
5. *c*. Sodium aluminum fluoride	With calcium arsenate	See 2	.....
	With soaps	Decomposes fluoride compounds and liberates soluble fluoride	.....
	With lime	See 5*a*	.....

TABLE 3—(*Concluded*)

Material	Combined with (or followed by)	Result	
		Toxic substance formed	Efficiency decreased
6. Oil emulsions (soap)*	*a*. With standard lead arsenate	See 1	.....
	b. With bordeaux mixture or copper carbonate	See 3*b*	See 3*b*
	c. With lime-sulfur	Forms calcium soaps, breaking oil emulsion	Forms calcium soaps and decomposes lime-sulfur
7. Pyrethrum	With soaps	.....	Long contact destroys pyrethrins
8. Nicotine (sulfate)	*a*. With hydrogen cyanide gas or calcium cyanide	.....	See 4*b*
	b. With barium fluosilicate	See 5*b*	
9. Soaps	*a*. With standard lead arsenate	See 1*b*	.....
	b. With bordeaux mixture or copper carbonate	.....	See 3*c*
	c. With lime-sulfur		Forms calcium soaps and decomposes lime-sulfur
10. Sulfur	Followed by oil sprays	With rising temperature may lead to foliage and fruit injury	.....
11. Lime-sulfur	*a*. With standard lead arsenate	See 1*c*	.....
	b. With oil emulsions	See 6*c*	.....
	c. With soaps	.....	See 9*c*

* This refers to oil sprays emulsified with soap.

solid or liquid with the water is formed. (3) After spraying, most of the water and some of the insecticide have run off leaving the remainder on the plant or insect. Two critical points should be noticed, namely, that between 1 and 2, involving the formation of a suspension or emulsion; and that between 2 and 3, having to do with the amount and mode of deposit of the toxic material.

If a liquid and an insoluble, finely ground solid or two immiscible

liquids are put together with sufficiently violent agitation, one material will become uniformly distributed within the other, forming a suspension in the first case and an emulsion in the latter case. Such preparations, however, are unstable, and separation occurs soon after the agitation ceases. In order that a uniform mixture may be maintained, a third material, possessing certain peculiar properties, must be present. Such materials are called emulsifying agents. They collect, or are absorbed, at the surface of the solid particles or liquid droplets and prevent them from coming together. Preparations containing an emulsifying agent or emulsifier are said to be stabilized, though it does not follow that they will remain uniform indefinitely. Several other terms are used in referring to this lack of complete stability. When a finely divided solid material clumps, it is said to "flocculate" and substances used to prevent this are often called "deflocculators." Thus some commercial brands of lead arsenate are "deflocculated," that is, a material is added to the dry powder which will make it easier to keep in suspension in water. Similarly when an emulsified liquid, for example, oil, separates from an emulsion, the latter is said to "crack," or "break." If the oil does not completely separate but merely rises with the emulsifying agent to form a very concentrated emulsion it is said to "cream." This is very easy to put back into the original state, but a broken emulsion is often very difficult to restore. The terms "tight" and "loose" are used to designate varying degrees of stability of either emulsions or suspensions.

The substances capable of acting as emulsifying agents are extremely numerous. Among those of principal interest with sprays are the soaps (from fatty acids, resins, or petroleum), cresylates, proteins (casein, albumin, gelatine, glue), hydrolyzed starch, flour paste, saponins, and bordeaux mixture.

In the application of sprays to solid surfaces a number of important points need to be considered. If a mechanical mixture of lead arsenate and water is sprayed upon foliage, it will be observed that the mixture draws back from the surface, forms large drops, and rolls off, with the result that an uneven deposit of insecticide is left there. In other words, proper wetting does not occur. To bring this about a wetting agent or spreader must be included. Such a substance will collect at the surface of the leaves and enable the water to really wet this surface. By also increasing the viscosity of the spray liquid it enables a thicker layer to remain upon the foliage after spraying has ceased. The purposes served by the wetting agents and emulsifying agents are obviously entirely different, but the conditions are similar and in general the same materials act in both capacities. Thus the emulsifying agents listed above are also good wetting agents or spreaders.

It is not true that the presence of a wetting and emulsifying agent ensures the deposit of more insecticide. This is particularly the case with oils, for the coating of emulsifying agent around the oil droplets and wetting agent on the foliage prevent intimate contact of oil with leaf and may actually decrease the deposit. This is in agreement with the observation that a loose oil emulsion is more toxic than a very tight emulsion. Experiments have also shown that a mechanically maintained emulsion of oil and water without any emulsifier or wetting agent present is most efficient in control of scale insects from the standpoint of concentration of oil needed. But it is lowest in safety, for each time a region is passed over additional oil is deposited with the result that in making sure that all parts of a tree are reached, excessive amounts of oil are left on some parts. By including an emulsifier and wetting agent this continuous "build-up" is avoided and safety insured. With either oils or other materials an even "film" coating is much easier to obtain when a wetting agent is used.

Since many leaf surfaces are waxy, mineral oils, which readily wet such a surface, are often used as wetting agents with bordeaux mixture, lead arsenate, and other such sprays. Fish oils are sometimes used for the same purpose. Since oils, particularly if of high boiling point, stay on the surface a long time and hold the solid insecticide, they are called "stickers." The term "fixator" is also used sometimes in describing materials that increase the tendency of spray materials to adhere.

Hard and Saline Waters.—Water containing considerable quantities of calcium or magnesium compounds in solution is called "hard" water. If these elements are lacking but soluble compounds of sodium or potassium are present, it is called "saline." The principal compounds present in hard water are calcium and magnesium sulfates, chlorides, and bicarbonates; and those in saline waters are sodium and potassium sulfates, chlorides, carbonates, and bicarbonates. Combined hard and saline water occasionally occurs also. All such types of water give rise to difficulties with certain spray solutions.

Owing to the formation of insoluble lead compounds and the release of soluble arsenic, burning often results from the use of standard lead arsenate in such waters. Basic lead arsenate may usually be substituted. Sodium fluosilicate and sodium aluminum fluoride (cryolite) in hard waters give rise to soluble fluoride with consequent danger to plants. Nicotine sprays, activated with soap (for example, formula 24), are lessened in efficiency in hard water because the soap is removed as insoluble calcium or magnesium soaps, which are not alkaline enough to liberate nicotine. Similarly soap solutions alone are rendered useless and there

is danger of plugging up the spray nozzle. Oil emulsions stabilized with soap become unstable in hard or very saline waters and may break.

Hard water may be softened by the use of washing soda, lye, or soap, or by passage through a commercial water-softening chamber. If washing soda or lye is used, the amount necessary must be ascertained by analysis of the water, for an excess will be as bad as the original water. No practical treatment for saline waters is known.

Much effort has been expended to find emulsifiers and spreading agents which are not affected by the quality of the spray water. Oil emulsions containing blood albumin or petroleum soaps are relatively unaffected. Insecticides made up with an excess of lime, as are bordeaux mixture, many commercial fluorine preparations, and lime-sulfur, may be used with almost any water. Lastly it should be mentioned that the use of dusts instead of sprays avoids the difficulty.

Heat as an Insecticide and Disinfectant.—A temperature of 130° Fahrenheit, as far as records go, if prolonged for several hours, will kill all forms of insect life. This temperature can readily be obtained in well-built buildings which are connected with a steam plant. The first expense of installing radiators is considerably more than fumigation with chemicals, but after-treatments are very much cheaper and without danger to the operators or to the contents of the building.

Higher temperatures of 145° to 180° Fahrenheit have been reported as successful in a much shorter period of time than the first figure mentioned. As the desired degree of heat, however, must be obtained throughout the entire mass which is being treated, it is not sufficient to heat the room alone to 145° Fahrenheit or more.

Hot water is also a useful agent for destroying many fungi and other injurious organisms. See "Nematode," p. 96, "Bulb Mite," p. 29, and "Soil Disinfection."

Soil Disinfection.—For the prevention of soil inhabiting insects, nematodes, and centipedes, treatment may be practical in cases such as seedbeds, greenhouse soil, or where limited amounts of material are to be dealt with. Plants at first are slightly retarded, but soon grow with increased vigor in properly disinfected soils.

Steam Cooking.—This is generally considered the most effective method of soil treatment for the above purposes and various devices have been employed for doing the work. A system of 1½-inch pipes may be laid 18 inches apart and 1 foot below the surface. These pipes should be perforated on their lower sides with ¼-inch holes at intervals of 6 inches and should be supplied with steam at a pressure of 80 to 150 pounds. The soil should be covered with blankets before the steam is admitted, and potatoes buried in different places in the soil. After treat-

ment for an hour, the potatoes may be examined; if they are cooked, the treatment may be considered effective. The soil may be used in place or may be removed to clean benches or beds, using care not to contaminate it again. Benches, frames, etc., should be drenched with boiling water or formaldehyde solution before use. See below.

The inverted-pan method consists in admitting steam below an inverted galvanized iron pan, furnished with handles for moving, which is pressed down to confine the steam. A size 6 feet wide, 8 feet long, and 6 inches deep has been recommended.

Injurious insects, fungi, nematodes, and weed seed are destroyed by steam cooking and it has been reported in some cases that the cost has not been greater than that of weeding untreated soil.

Surface Firing.—Brush is frequently piled on seedbeds prepared for sowing and burned. Seed is sown as soon as possible with a minimum stirring of the surface. The effect in this case is very superficial.

Formaldehyde Treatment.—Formaldehyde may be used on seedbeds prepared to sow. The soil may be soaked with a solution of 1 pound of formalin in 6 gallons of water. The soil should be kept covered for a day and allowed to stand for a week before sowing.

Hot-Water Treatment.—Considerable benefit may be derived from drenching the soil with boiling water. Empty pots, flats, pots with soil, and implements may be immersed in boiling water for 5 minutes.

Spray Residue.—On plant products intended for human or animal consumption, the amount of certain insecticides remaining at harvest time is important. Laws have been passed and enforced regarding several of these materials on food for human use. Definite limits are set for arsenic, lead, and fluorine. This has been done for several years for arsenic, but was a new step two years ago for the other two elements. These limits or "tolerances" are 0.01 grain of arsenic as arsenious oxide per pound, 0.014 grain of lead per pound (0.019 grain per pound during 1934) and 0.01 grain of fluorine per pound. Two courses are open to avoid condemnation of produce on account of residue. It may be washed or otherwise cleaned before selling or the use of these insecticides may be avoided for as long an interval before harvesting as possible. The latter is by far the cheaper method and should be done whenever possible. Thus in control of codling moth, it is recommended in most states that lead arsenate be used only for the early spray applications. The use of nicotine-oil sprays in codling moth control has largely risen from this situation.

Even the avoidance of lead-arsenate spray for several weeks before harvest does not ensure a low enough residue on fruit in districts where heavy early applications are needed, and wiping or washing is therefore

necessary. For large quantities of fruit the use of commercial machines is the only way that is practical. A washing fluid containing 1 per cent commercial hydrochloric acid is perhaps most widely used. At 70° Fahrenheit this will bring fruit below the tolerances unless excessive wax has formed or oil sprays have held much lead arsenate on the fruit. In the latter case higher temperatures or an alkaline wash are necessary. Most alkaline washes, however, remove arsenic efficiently but leave much of the lead, and they impair the keeping quality of fruit.

Tanglefoot.—Several commercial tanglefoot products are available for use either directly on tree trunks or on paper or burlap strips which can then be fastened around the trunks. In general they are more satisfactory than homemade banding material. A great number of formulas have been proposed for making such adhesive materials, mostly based on the use of resin and an oil. One of the simplest is three parts resin and one part cottonseed oil, heated together to the boiling point and applied either hot or cold.

INDEX