Chapter 6
Strawberry Pests and Their Management

Fruit- or Flower-Feeding Pests

Tarnished Plant Bug (*Lygus lineolaris*; order Hemiptera, family Miridae)

Damage: Slightly to severely uneven berry growth and deformed berries with hollow seeds can result from tarnished plant bug feeding on flower buds and seeds in developing fruit. Ripening berries that remain small, with a concentration of seeds at the tip, are called button berries, cat-faced berries, or nubbins. Injured berries can be woody and unmarketable. Later-maturing cultivars are more seriously affected by this pest than early cultivars.

Appearance: Adult tarnished plant bugs are about 1/4-inch long, coppery brown with yellow and dark brown markings, and somewhat shiny in appearance (Figure 6-1). A yellow-tipped triangular plate is present in the middle of their backs. The immature stages, or nymphs, are smaller and green (Figure 6-2). Nymphs are plain green when young but marked with black spots when older. Both nymphs and adults have needle-like mouth parts used for sucking plant juices.

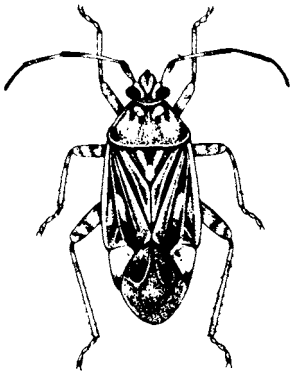

Figure 6-1. Tarnished plant bug adult.

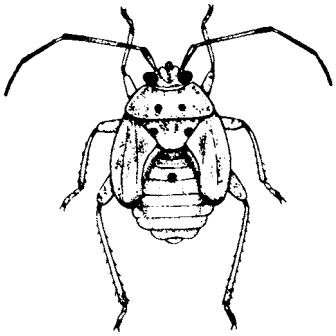

Figure 6-2. Tarnished plant bug nymph.

Life Cycle and Habits: Adults overwinter in vegetation or stubble that provides protection from extreme cold. In the spring, they are attracted to flower buds (Figure 6-3) and shoot tips of many plants, including strawberry, peach, and apple. They lay eggs in the plant tissues of many agricultural crops and weeds. Eggs hatch in about one week, and the nymph stages last about three weeks. Tarnished plant bugs suck sap from developing seeds during and after bloom, or from the receptacle of developing fruit. Their feeding kills surrounding cells and leads to distorted seedy berries. Several generations of this insect develop each year, and adults and nymphs are present on many different plants from April or May until a heavy frost in the fall.

Figure 6-3. Tarnished plant bug on flower.

Cultural Control: Strawberry cultivars that are least susceptible to plant bug injury are Honeoye, Sparkle, Canoga, Catskill, and Veestar, according to studies in New England. Plants that produce more flowers and fruit, on a per area basis, tend to suffer less fruit damage than less productive plants. Cultivars that flower earlier tend to have less severe damage than later-flowering cultivars.

Controlling weeds in and around strawberry fields reduces overwintering sites and removes sources of early-season flowers that attract adult tarnished plant bugs to fields. However, weeds in and near strawberry fields should not be mowed or pulled when strawberry buds are swelling and flowers are beginning to open, because tarnished plant bugs will move from weed hosts to strawberries at a time when the crop is especially vulnerable to damage. If mowing must be done during this period, it is better to mow after applying insecticide than to mow before applying insecticide. Weeds preferred by the tarnished plant bug include dandelion, chickweed, goldenrod, curly dock, pigweed, lambsquarters, ragweed, and shepherds purse.

Mechanical Control: Row covers put on in the fall to exclude plant bugs in the spring have been shown in New England to reduce, but not eliminate, plant bug injury.

Biological Control: Several natural enemies of tarnished plant bug have been studied but details on how best to use them in strawberries are not yet available. A braconid wasp, *Peristenus digoneutis,* attacks the nymphs. A mymarid wasp, *Anaphes iole,* attacks the eggs.

Monitoring and Thresholds: Guidelines for monitoring tarnished plant bug infestations and determining whether to use an insecticide vary depending on whether adults or nymphs commonly cause damage in a particular region.

Where migratory adults appear to cause more damage than subsequent nymphs, as happens during most seasons in Illinois, producers are advised to monitor the bug population by sweep net sampling as buds begin to form. Control is suggested if the population is found to be above the threshold of two tarnished plant bug adults per 10 sweeps.

Where damage tends to be caused by nymphs that are present when buds are forming, particularly for later cultivars or day-neutral cultivars, shake sampling is more useful than sweep net sampling. Sampling should be done at least once, preferably twice, per week. At each of five sites per field, shake six flower clusters over a white pan or paper to dislodge the nymphs and then count them. Calculate the average number per flower cluster. If counts exceed 0.25 nymph per flower cluster before 10% bloom, or if counts exceed 0.5 nymph per flower cluster during mid- to late-bloom, or more than 10% of the flower clusters are infested (regardless of count), then application of an insecticide is warranted.

White sticky traps are commercially available for monitoring tarnished plant bug adults, but recent evaluations of these traps in Iowa has shown them to be unreliable for detecting plant bug infestations in strawberries.

Control by Insecticides: Control of tarnished plant bugs may be justified if the field has suffered substantial damage from tarnished plant bugs in previous years or where the threshold (as described earlier) is exceeded. Insecticide should be applied soon after blossom buds first become visible and again if reinfestation occurs just before bloom. To protect bees and other insect pollinators, do not spray insecticide during bloom. Chemical control can be difficult because the adult bugs are very mobile and can recolonize the field quickly.

Flower Thrips or Eastern Flower Thrips

(Frankliniella tritici; order Thysanoptera, family Thripidae)

Damage: Strawberry fruits can be dull or bronzed, small, and seedy as a result of the flower thrips feeding during bloom and fruit set (Figure 6-4). Thrips may also cause blemished seeds on achenes and uneven maturity of fruit. Berries can be marketable if thrips damage is light but unmarketable when damage is severe. In California, a related species called the western flower thrips causes golden brown discoloration of fruit that renders berries unmarketable when populations of thrips are large.

Figure 6-4. Thrips damage on strawberries.

Figure 6-5. Flower thrips.

Thrips damage to strawberries was rare until 1994, when problems were reported throughout the Midwestern and eastern United States. The strawberry crop failed to develop normally in 1994; berries failed to enlarge or ripen and remained golden brown and leathery. Some plantings had yield reductions of up to 90%. Scattered infestations have been observed in most years since 1994.

In Illinois, this problem was greatest in the central portion of the state and less severe in the far south and the north. Whether or not the flower thrips caused these dramatic strawberry losses cannot be proved, but many observations now suggest that thrips were to blame. The thrips injury in 1994 probably resulted from an earlier-than-normal immigration of thrips that coincided with strawberry bloom and fruit set in a large portion of the Midwest.

Growers who did not traditionally apply an insecticide for control of tarnished plant bug or meadow spittlebug experienced greater losses due to thrips during outbreaks.

Appearance: The flower thrips, which is sometimes called the eastern flower thrips, is a tiny, slender, cigar-shaped insect (Figure 6-5). Nymphs and adults have the same general shape. Nymphs are wingless, whitish yellow when small, and yellow when fully grown. Adults are yellowish brown, 1/16-inch long, and have narrow wings that are fringed with hairs. While resting, the wings are folded lengthwise over the back.

Life Cycle and Habits: The flower thrips is not known to overwinter outdoors in the upper Midwest, but overwintering in greenhouses probably occurs. Populations of flower thrips develop each year as a result of long-distance migrations from southern states on high-level winds associated with weather fronts. Migration of thrips probably occurs simultaneously with migration of the potato leafhopper.

Adult flower thrips are attracted to flowers of many different plants. Adults and nymphs feed using rasping-sucking mouthparts to obtain sap. On strawberry fruit, they begin feeding on seeds soon after the buds open. They feed on the tissue between the seeds as the fruit expands. Bronzing results from surface cells being killed.

Thrips are often overlooked because they are tiny and prefer to feed in protected sites, such as under the calyx (cap) and in grooves around seeds, rather than exposed sites. When the population is large, they run out of space in protected sites and thus may be found anywhere on the fruit. They actively run when disturbed.

The adults lay eggs in plant tissue. There are two active nymph stages and two inactive pupal-like nymph stages. The life cycle can be completed in several weeks; there can be many generations per year.

Monitoring and Thresholds: To determine whether or not thrips control is warranted, strawberry growers should begin sampling for thrips by examining early flower clusters on early cultivars and continue sampling all cultivars as they begin to bloom. Tap flowers onto a white or very dark plate or saucer and look for the slender yellow thrips. As an alternative, flower blossoms can be placed into a zipper-type reclosable plastic

bag and shaken to dislodge thrips and allow counting.

Although the relationship between eastern flower thrips density and strawberry damage is not well understood, control is probably warranted if populations exceed two to 10 thrips per blossom. Once berries are 1/4 inch in diameter, 50 randomly selected fruits should be picked and examined; control is suggested if an average of 0.5 or more thrips per fruit are detected.

Control by Insecticides: If insecticides are to be used for thrips control, applications must be timed to avoid killing pollinators. Insecticide should be applied prebloom or before 10% of the plants have open blossoms. This timing may coincide with control measures for tarnished plant bug.

Strawberry Bud Weevil or Strawberry Clipper

(Anthonomus signatus; order Coleoptera, family Curculionidae)

Damage: Nearly mature blossom buds are injured by adult clippers that puncture buds with their snouts, girdle the flower buds, then clip the stem below the buds (Figure 6-6). Clipped buds hang down or fall to the ground. Injured buds that survive to flowering may have small holes in the petals.

Many cultivars can compensate for this injury, especially if it occurs early and if only secondary or tertiary flower buds are affected. Examples of cultivars with high compensation are Seneca and Jewel. Examples of cultivars with low compensation are Honeoye and Earliglow.

Appearance: The strawberry clipper adult is a dark, reddish-brown weevil about 1/10-inch long; its head is prolonged to form a slender, curved snout about one-third as long as the body (Figure 6-7). The larva is white and 1/16-inch long.

Life Cycle and Habits: Adult clippers overwinter in fence rows and woodlots near strawberry plantings. Once temperatures reach 60°F, the adults move to strawberry fields where flower buds are emerging from the crown. A small portion of a population may remain in the strawberry field over the winter. Strawberry flowering coincides with the time that clippers move out of their

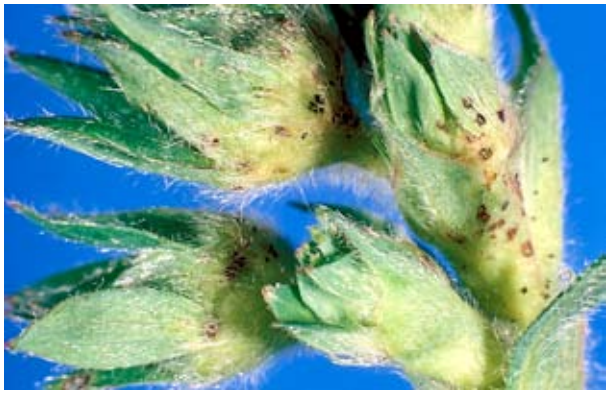

Figure 6-6. Strawberry clipper damage.

Figure 6-7. Strawberry clipper adult.

overwintering sites, so strawberries are ideal host plants for this insect. Redbud trees are another early host.

Adult clippers first feed on immature pollen by puncturing nearly mature blossom buds with their snouts. Each female then deposits a single egg inside the bud and girdles the bud, which prevents it from opening and exposing the developing larva. The female then clips the stem. Eggs hatch in about one week. Larvae feed within the damaged bud for three to four weeks; a new generation of adults emerges in late June and July. These weevils feed on the pollen of various flowers for a short time, but seek shelter in midsummer in preparation for overwintering. There is one generation per year.

Cultural Control: Because the strawberry clipper does not disperse over long distances, locating strawberry plantings away from woodlots and hedgerows that harbor this insect through the winter can reduce the number of adults that move into strawberries in the spring. Because early cultivars are usually damaged more than later ones, planting two or three rows of an early

cultivar as a trap crop around the perimeter of each field has been suggested as a way to reduce overall damage or to concentrate the adults for control by use of an insecticide only in the trap crop.

Monitoring: Early detection of clipper activity is important. Watch for clipper adults and damage when flower buds start coming out of the crown and when temperatures approach 65°F. Check one meter (3 feet) of row at each of five sites per field. Sampling should be most intensive along field edges near woods or hedgerows or where weeds are heavy. Get down on hands and knees and look closely for clipped buds of unopened flowers and look for adult weevils in unexpanded flower clusters. Keep separate counts for primary buds vs. secondary or tertiary buds; one strawberry truss produces 15 buds: one primary bud that opens first, then two secondary buds, then four tertiary buds, then eight quaternary buds.

Thresholds: Treat with insecticide if there are three or more clipped primary buds per meter of row, or 30 or more clipped secondary or tertiary buds per meter of row. The reason that this much injury is allowed is that many cultuvars can compensate for injury.

Control by Insecticides: If control is necessary, insecticide should be applied as soon as the threshold is exceeded; this can occur before most flowers have begun to open. When damage is observed only in rows along a field border, then insecticide application can be limited to border rows.

Strawberry Sap Beetle

(Stelidota geminata; order Coleoptera, family Nitidulidae)

Damage: Deep cavities or tunnels in ripe berries are chewed by strawberry sap beetle adults (Figure 6-8). This injury also can lead to infection of berries by rot organisms. Because over-ripe fruit is especially attractive to sap beetles, damage is often greatest in pick-your-own operations where pickers leave large numbers of ripe and over-ripe berries in the field.

Appearance: Adult strawberry sap beetles are about 1/8-inch long, oval shaped, flat, and mottled brown in color (Figure 6-9). Larvae are white with a brown head and up to 1/10-inch long.

Figure 6-8. Strawberry sap beetle damage.

Figure 6-9. Strawberry sap beetle adult.

Life Cycle and Habits: Strawberry sap beetle adults fly into strawberry plantings from wooded areas at about the time berries begin to ripen. They chew on berries, often in groups of several beetles per berry. They may be hard to see because they drop to the ground when disturbed.

Females deposit eggs on the injured fruit. Eggs hatch in two to three days. Although larvae feed in berries for about one week, they usually are unnoticed because the fruit has already begun to decompose as a result of damage caused by adults.

A parasitic wasp contributes to suppression of this pest by laying eggs in the adult beetles; parasitized beetles lay fewer eggs than healthy beetles.

Cultural Control: Strawberry sap beetles are best controlled by timely and complete picking of harvestable berries and the removal of over-ripe and damaged berries.

Mechanical Control: Trap buckets of over-ripe fruit can be placed outside field borders as the crop begins to ripen, to intercept immigrating beetles and reduce pest numbers in the crop.

Control by Insecticides: Because sap beetle populations usually do not build up until the picking cycle is underway, the use of insecticides is limited by frequent harvests. The required preharvest interval specified on the insecticide label must be obeyed.

Slugs

[Deroceras (Agriolimax) species (family Limacidae) and *Arion* species (family Arionidae); Phylum Mollusca, Class Gastropoda]

Damage: Slugs damage fruit by chewing deep ragged holes into the surface of berries, especially under the cap (Figure 6-10). Slugs leave slime trails on the fruit or leaf surfaces as they move around.

Appearance: Soft-bodied and slimy, slugs are worm-like molluscs that range in size from 1.5 to 7 inches long. They may be dark gray, black, yellow-gray, or brown and may be covered with spots.

Life Cycle and Habits: Slugs that damage strawberries in the spring and early summer hatched from eggs deposited in the soil in strawberry plantings the previous fall. Conditions that favor egg-laying in the fall include the continuous presence of straw mulches. Slugs survive best and damage fruit the most in fields with rows close together and thick mulch, and when overcast and rainy weather creates continuously moist conditions in strawberry beds. Slugs feed mainly at night.

Figure 6-10. Slug and its damage on strawberry.

Cultural Control: Planting at lower densities, removal of straw mulch after harvest, summer renovation, and delaying fall mulching as long as is practical are effective steps in reducing slug populations. Removal of trash and debris around the field helps to eliminate slug breeding grounds.

Mechanical Control: Traps made of wet boards or burlap bags may be set out in the evening. Remove and destroy trapped slugs the following morning. Shallow dishes of beer can be used as a bait under the traps. Although trapping can remove many slugs, it usually does not remove enough to result in significantly less injury to fruit.

Control by Insecticides: Slug baits that contain metaldehyde or iron phosphate may be used in strawberries only if the baits are applied to the soil or mulch surface and do not contact plants. Baits are most likely to work when used at the full labeled rate and when they are applied before ripe berries are present. If metaldehyde baits are used, care must be taken to keep dogs out of the treated area.

Root- or Crown-Feeding Pests

Strawberry Root Weevil and Black Vine Weevil

(Otiorhynchus ovatus and *Otiorhynchus sulcatus;* order Coleoptera, family Curculionidae)

Damage: Infested plants have leaves that turn red and berries that are undersized. Plants are weakened, stunted, or killed by the larvae of root weevils, which are grubs that feed on strawberry roots and crowns. Root systems weakened by weevils are then more susceptible to winter injury and diseases. Infestations are generally in patches in the field. A pocket of damage in one corner of a field can expand and cause heavy losses the following year. Damage is worse when plants are under stress such as during drought periods (Figure 6-11). Although the adult weevils chew notches from the edges of leaves, their feeding usually causes no economic losses.

Appearance: Adult strawberry root weevils are black or dark brown beetles that are about 1/5-inch long (Figure 6-12). They have a prominent blunt snout and elbowed antennae on the snout. Their backs are marked by many rows of small pits. Larvae are thick-bodied, white, legless grubs with brown heads; they are usually found in a curved position (Figure 6-12). Grubs reach about 1/4 inch in length.

Another species of weevil similar to the strawberry root weevil is the black vine weevil *(Otiorhynchus sulcatus)*. A third species is the rough strawberry weevil *(Otiorhynchus rugo-sostriatus)*. These species are similar in appearance to the strawberry root weevil except that they are larger — 1/4 inch for rough strawberry weevil and 1/3 inch for black vine weevil. They are also similar to the strawberry root weevil in damage and life cycle.

Figure 6-11. Root weevil damage.

Figure 6-12. Root weevil life stages: egg, larva, pupa, adult.

Life Cycle and Habits: Root weevils overwinter as full-grown grubs, pupae, or adults in soil, or as adults in plant debris or other protective habitat. Most damage is caused in the spring by grubs after they resume feeding. Overwintered adults become active in strawberries in May.

Grubs complete development in the spring and emerge as new adults in May or June. The adults feed on leaves at night and hide in crowns or under mulch during the day. After feeding for as short as 10 to 14 days (strawberry root weevil) to as long as 30 to 60 days (black vine weevil), the adult weevils begin laying eggs in soil near strawberry plants. Each female deposits 150 to 200 eggs, and eggs hatch in about 10 days. After eggs hatch in late summer or early fall, larvae burrow through the soil to feed on roots until they mature or until cold temperatures suspend their activity.

The adult root weevils cannot fly, but they can walk from one field to another. Where food is available, they walk only short distances, but if they are searching for a new food source, they can travel longer distances such as several hundred feet. Mass migration of weevils can occur from an infested field as it is being disked.

Mechanical and Cultural Controls: Infested old plantings should be disked under soon after harvest, to destroy grubs before new beds are planted. To reduce mass migration of weevils during disking, one or two rows of plants should be left at the edge of the old field to serve as a trap crop. The trap crop should be turned under at the end of the season. New plantings should be isolated from existing fields and wooded overwintering sites by a distance of several hundred feet.

Monitoring: Plants should be examined in the spring if patches of poor vigor are noticed. Lift up a section of row with a spade and examine the roots within a 6-inch layer of soil. If grubs are found, control measures should be taken after harvest, when the adults emerge. In mid- and late summer, look every one to two weeks for notch-like feeding damage on leaves.

Biological Control by Beneficial Nematodes: This new pest management option is untested in the Midwest but has been under development in New Jersey and Oregon. Nematodes can be purchased from commercial suppliers and applied to soil in mid-May, by means of a sprayer or irrigation. The two species of nematodes that are best for root weevil control are *Heterorhabditis bacteriophora* and *Heterorhabditis marelatus.*

Control by Insecticides: Sprays that target the adult weevils are not usually very effective but

can be helpful if applied at night at the time of peak feeding, which is usually in July. In some states, a systemic insecticide (carbofuran) is permitted after harvest for control of root weevil larvae under a Special Local Needs (SLN) label, also called a 24(c) label. Check in the annual *Small Fruit Spray Guide* or check with your state's Department of Agriculture to find out if your state has such a SLN label. Soil fumigation can be used to kill overwintering larvae.

White Grubs

(*Phyllophaga* species; order Coleoptera, family Scarabaeidae)

Damage: White grub larvae feed on crop roots. Root injury weakens the plant and also provides an entry site for root diseases like black root rot. Risk of white grub infestation is highest in new plantings established on newly plowed sod or other grasses. As adults, the beetles feed on leaves in late summer, which results in skeletonized leaves.

Appearance: Adults are called May beetles or June beetles (Figure 6-13). They range in length from 1/2 to 1 inch and vary in color from tan to dark brown and are shiny. C-shaped larvae are whitish gray with brown heads and three pairs of legs; they are 1/2- to 1-1/2-inches long (Figure 6-14). White grub species in the genus *Phyllophaga* are known as perennial white grubs or true white grubs. Other beetle species that have similar grubs are Japanese beetle *(Popilla japonica)*, rose chafer *(Macrodactylus subspinous)*, and green June beetle *(Cotinis nitida)*.

Life Cycle and Habits: Females deposit eggs in soil during late spring or early summer; they especially prefer grass sod near wooded areas for egg-laying. Eggs hatch in two to three weeks. Newly hatched larvae feed on crop roots throughout the summer, then burrow deep in the soil to overwinter. The following year they again migrate to the root zone to feed. These larger larvae cause much greater damage than they did the year before. After overwintering again well below the soil surface, white grubs pupate early in the following summer, and adults emerge from pupal cells the next spring, three years after the cycle began. Adult beetles hide in soil during the day and fly to trees to feed at night.

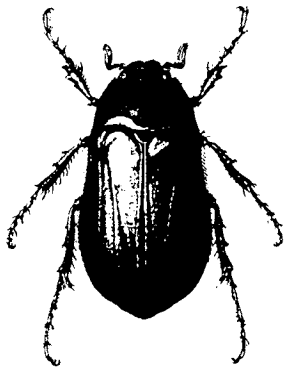

Figure 6-13. White grub adult.

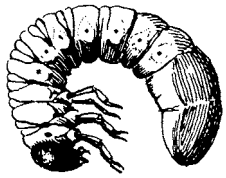

Figure 6-14. White grub larva.

Cultural Control: Do not put new strawberry plantings on newly turned ground that was used for sod, pasture, or grass set-aside the previous year. On such sites, plow the field and let it lie fallow or in a rotational cover crop such as sudan grass or buckwheat, or a salable crop such as pumpkins or squash, for at least one season prior to planting with strawberries. Avoid setting a strawberry field next to large grassy fields that could be a source of these beetles and their larvae.

Control by Microbial Insecticides: This method currently is not effective in northern soils and thus is not recommended for Midwestern fruit growers but is included here because growers sometimes ask about it. Milky spore is a bacterial disease that kills white grubs; it is commercially available as a product that is incorporated into the ground. Several formulations are on the market. Once this kind of bacteria is established in the soil, grub control is perennial and effective. There has been difficulty in getting the bacteria established in northern soils; milky spore cannot be considered a reliable control measure in the Midwest until this problem is overcome.

Control by Conventional Insecticides: An insecticide labeled for grub control can be banded over the row to reduce the amount and cost of insecticide treatment.

Strawberry Crown Borer

(Tyloderma fragariae; order Coleoptera, family Curculionidae)

Damage: Strawberry plants are weakened, stunted, or killed as one or more larvae bore downward in the crown. Field borders or the portions of fields nearest older, infested plantings are often most heavily damaged. Infestations spread slowly. Leaves of infested plants might turn red. The adult beetles chew many small round holes in leaves in the fall, but this defoliation rarely is economically damaging.

Appearance: Adult crown borers are reddish-brown weevils about 1/6-inch long. They have a short thick snout. Their backs are marked with punctures and three pairs of dark irregular spots. The larva is a yellowish white, legless grub, about 1/5-inch long when fully grown (Figure 6-15).

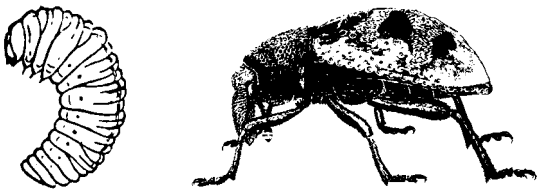

Figure 6-15. Strawberry crown borer larva (left) and adult (right).

Life Cycle and Habits: Adults overwinter in plant debris in strawberry fields or in surrounding areas.

They become active in the spring at about the same time that strawberries begin to bloom. They feed in crowns, opening holes into which they lay eggs that hatch in about one week. Egg laying continues through mid-June.

Eggs hatch into grubs that feed for several weeks in strawberry crowns before pupating in late summer and emerging as adults in the fall. Adults are unable to fly; they feed on strawberry foliage and then seek shelter in plant debris to pass the winter.

Cultural Control: Isolating new fields from existing infestations greatly reduces the likelihood that this insect will cause significant losses, because adult strawberry crown borers cannot fly. Commercial growers should purchase plants that are free of crown borer and establish new fields at least 300 yards from existing fields. To prevent crown borer survival and migration, infested fields should be destroyed and tilled soon after the final picking.

Control by Insecticides: Although chemical control is rarely advised, some insecticides applied to control other insects may kill crown borers as well. Prebloom sprays intended to limit damage by tarnished plant bug can kill some crown borer adults, but peak adult activity occurs slightly later. Egg-laying adults are especially active during bloom, a time period when insecticides should not be applied.

Insecticide applied between bloom and harvest for the control of leafroller or sap beetle may also kill crown borer adults if they are still active on foliage, but killing adults at this time is unlikely to significantly reduce crown damage. Post-harvest sprays may be used to reduce the population of newly emerged adults in late summer before they overwinter, but this practice is seldom warranted.

Foliage- or Stem-Feeding Pests

Meadow Spittlebug

(Philaenus spumarius; order Hemiptera, family Cercopidae)

Damage: Spittlebugs pierce the plant and suck on sap, which can result in reduced plant vigor, stunting, and decreased yield. Early-season feeding can result in stunted, off-color plants; this damage can appear much like that caused by cyclamen mite. Spittlebugs are also a nuisance pest because they are not liked by pickers at pick-your-own operations because of the unsightly foam on plants when picking.

Appearance: Hidden beneath masses of frothy spittle on stems or leaves (Figure 6-16) are the immature spittlebugs, which are soft-bodied, elongated bugs. Young nymphs (Figure 6-17) are 1/8-inch long and yellow; older nymphs are 1/4-inch long and green. The adults, which are called froghoppers, are brown or gray and 1/4-inch long.

Life Cycle and Habits: The meadow spittlebug overwinters as egg masses in the stubble of strawberries and other hosts, such as small grains or alfalfa. Eggs hatch at about the time that the

Figure 6-16. Meadow spittlebug.

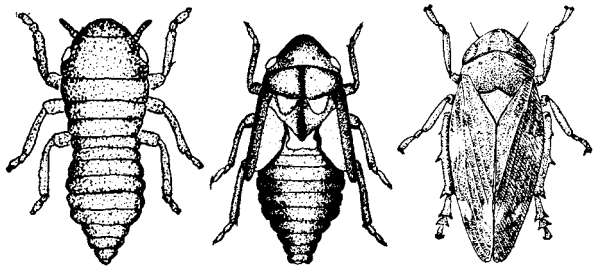

Figure 6-17. Meadow spittlebug – young nymph, older nymph, and adult (left to right).

earliest strawberry flowers appear. Once nymphs begin feeding, they begin to produce spittle.

Spittlebugs feed first at the base of plants, then move up on stems and blossom clusters before and during bloom. They pierce the plant and suck on plant sap. The nymph stages last for five to eight weeks. Once they reach adulthood, they leave the spittle mass. Female adults lay eggs in September. There is only one generation per year.

Cultural Control: Spittlebugs are most abundant in weedy fields, so weed control can contribute to spittlebug management. Often heavy rains or irrigation can wash froth from plants.

Monitoring: Plants should be scouted weekly starting at 10% bloom. Randomly inspect five one-foot-square areas per field. Look for white frothy spittle masses while spreading apart leaves to inspect crowns, leaf bases, leaf stems, flower stems.

Threshold: Complaints most often occur when there is one or more spittle mass per square foot of canopy. Treatment is suggested when there are two or more spittle masses per square foot of canopy.

Control by Insecticides: Insecticide applications early in the season, such as those targeting the tarnished plant bug, are usually adequate for keeping spittlebugs in check.

Potato Leafhopper

(Empoasca fabae; order Hemiptera, family Cicadellidae)

Damage: Leaves turn yellow at the edges and between the veins, and become curled and distorted (Figure 6-18) due to leafhopper adults and nymphs feeding on the underside of leaves. Damage is most noticeable in new strawberry plantings. Feeding activity is most serious during the late spring and early summer.

Appearance: Potato leafhoppers (Figure 6-19) are 1/8-inch long, green, bullet-shaped insects that take flight quickly if disturbed. The nymphs are light green, 1/16 inch long, and do not fly. Nymphs are easily identified by their habit of moving sideways when disturbed.

Life Cycle and Habits: The potato leafhopper does not overwinter in Ohio but must fly in from the southern states each spring. Migratory adults can infest alfalfa, potato, and snap beans in addition to strawberry.

Monitoring: Scouting is especially important in new strawberry plantings. Scout by brushing the leaves with the hand and looking for small adult leafhoppers flying off. Examine the underside of injured leaves to see if nymphs are present.

Control by Insecticides: Insecticides should be applied only when large populations of nymphs

Figure 6-18. Potato leafhopper damage.

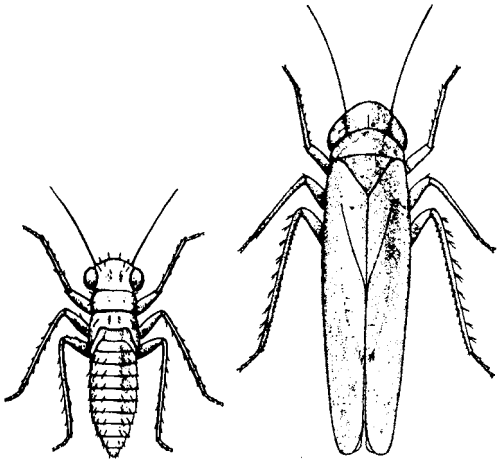

Figure 6-19. Potato leafhopper nymph (left) and adult (right).

are noted on the leaves or symptoms become apparent. No threshold has been determined.

Strawberry Rootworm

(Paria fragariae; order Coleoptera, family Chrysomelidae)

Damage: Strawberry leaves attacked by strawberry rootworm beetles are riddled with small holes (Figure 6-20). Some leaf damage occurs in May, but most occurs in August. Heavy infestations can reduce plant growth or kill plants. Although larvae of the strawberry rootworm feed on the roots of strawberry, leaf-feeding by adult beetles is more damaging to strawberry production.

Appearance: Adult strawberry rootworms are brown to black, shiny, oval-shaped beetles with four blotches on the shell-like wing covers (Figure 6-21). They are 1/8-inch long. The immatures (Figure 6-22) are grubs that are 1/8-inch long, creamy white, with three pairs of legs.

Life Cycle and Habits: Adult strawberry rootworms overwinter in mulch and soil crevices and become active in May and June. Adults feed primarily at night and hide in soil or mulch during the day. They chew small holes in leaves, and females lay eggs on older leaves near the soil surface. Larvae burrow into the ground to feed on strawberry roots from late spring to early summer. New adults begin emerging in mid-summer, and these beetles feed on strawberry foliage through early fall.

Figure 6-20. Strawberry rootworm damage.

Figure 6-21. Strawberry rootworm adult.

Figure 6-22. Strawberry rootworm larva.

Monitoring: Scouting for the presence of adult beetles is best done after dark using a flashlight to examine plants. No threshold has been established for this insect, but a population of 10 to 20 beetles per square foot is considered high.

Control by Insecticides: As with all the root-feeding insects, control of the root-feeding stage is very difficult. Therefore, control measures for strawberry rootworm should be directed toward the adult stage. If feeding injury is observed in

May or June, an insecticide spray at this time will reduce the number of egg-laying females and, therefore, the number of grubs feeding during the summer. When the next generation of adults emerges in July or August, control measures may be needed again. Post-harvest foliar sprays of registered insecticides applied according to label directions provide control of adult strawberry rootworms.

Two-Spotted Spider Mite

(Tetranychus urticae; order Acari, family Tetranychidae)

Damage: Mottling, speckling, or bronzing of foliage is caused by spider mites feeding on plant sap by rasping and sucking on leaf surfaces, which destroys leaf chlorophyll (Figure 6-23). Severely damaged leaves die and drop, which can lead to reduced plant vigor and yield reduction. The undersides of infested leaves can be covered with a fine webbing. Two-spotted spider mites are common pests in Midwestern crops, but infestations in most strawberry fields do not reach densities high enough to require control by pesticides.

Appearance: Adult two-spotted spider mites are 1/50-inch long and barely visible to the naked eye. They are yellowish-white with two large dark spots (Figure 6-24). They have eight legs. Immature forms are usually dark in color.

Life Cycle and Habits: Mated adult females overwinter in the cover of vegetation in fields and along roadsides and hedgerows. They begin feeding and laying eggs when temperatures rise in the spring, and many generations develop each season. Adults and immatures feed on the underside of leaves.

Although wingless, the adults are highly mobile, as they disperse by ballooning in the wind on fine silken threads that they secrete while feeding. Warm, dry weather favors spider mite outbreaks, and problems occur most often in new fields where spider mites are carried in by winds before predatory mites have reached the field or in older plantings where insecticides have eliminated predators.

Cultural Control: Annual renovation of strawberry beds reduces the potential for mite outbreaks in the following season, because the destruction of leaf tissue by renovation removes the mites' food and habitat.

Figure 6-23. Spotted spider mite damage.

Figure 6-24. Spider mite adults and eggs.

Biological Control: There is a natural predator called *Neoseiulus (Amblyseius) fallacis* that feeds on the two-spotted spider mite. This predator is also a mite that is equally as small as two-spotted mites but is flatter and lacks the two spots on its back; it is teardrop shaped, shiny, and yellowish white.

The predatory mites move around on the leaf much more rapidly than the two-spotted mite. It is important to encourage natural enemies of spider mites by reducing the use of pesticides that harm them.

Several companies commercially produce predatory mites, including *N. fallacis.* These predators can be released in strawberry plantings

and may provide some control of spider mites, but more research is needed to determine appropriate release rates and timing.

Monitoring and Thresholds: Early detection of mites is critical for successful management. Mite colonies are usually localized in hot-spots in the field rather than being evenly distributed throughout the field. Look over the whole field and choose the first samples in any spots where bronzing is seen on leaves. Collect and examine 60 strawberry leaflets per field. Examine the underside of the leaves for the presence or absence of mites. A magnifier can help. Record the information on a field map so that hot spots can be identified and treated.

The use of a miticide for control of spider mites is justified if 25% of the leaflets (15 out of 60) are infested by one or more mites. This threshold corresponds to an average infestation of five mites per leaflet during random sampling.

When sampling a field, presence of predatory mites, as well as two-spotted spider mites, should be noted. Where predatory mites such as *N. fallacis* are present, miticide applications usually are unnecessary. A ratio of one predatory mite per 10 two-spotted mites is an approximate target for adequate biological control.

Control by Insecticides: Several miticides and combination miticide/insecticides are currently registered for use on strawberries. Most miticides do not kill eggs, so if eggs and motile mites are both present at the time of application, then a second application may be needed five to seven days later to kill motile mites that emerge from eggs. Thorough coverage of the canopy is needed for the miticide to be effective.

Cyclamen Mite

(Phytonemus pallidus; order Acari, family Tarsonemidae)

Distorted, crinkled leaves can result from the cyclamen mite feeding on young, unfolding leaves in the crowns of plants. Infested leaves can look purplish or yellow. Distorted blossoms and small seedy fruits can result from the cyclamen mite feeding on blossoms. This mite is most common as a pest of greenhouse plants, but it can cause serious losses where infested strawberry plants are transplanted in new fields. It is important to buy nursery stock from a reputable source to avoid bringing in mite-infested plants. Infestations are generally localized within a field. The cyclamen mite is tiny (Figure 6-25); it is only 1/100-inch long and is not visible without the aid of a magnifying glass. The cyclamen mite varies in color from orange-pink to white or green.

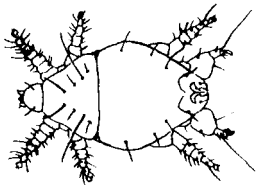

Figure 6-25. Cyclamen mite adult.

Control of cyclamen mites is best accomplished by planting only transplants that are mite-free, as determined by careful examination as soon as plants arrive from the nursery. This pest is difficult to control by pesticides once it becomes established. If a field infestation is discovered, use a registered pesticide in a high volume of water, one to two days before bloom and again 10 to 14 days later. Pesticides are not effective at controlling cyclamen mite if application is delayed until mid-summer.

Strawberry Leafroller

(Ancylis comptana fragariae; order Lepidoptera, family Tortricidae)

Damage: Strawberry leaflets infested by leafroller are folded and tied together with silken threads. Only the epidermis of each leaf is fed upon, but entire leaflets usually turn brown. Damage by first-generation larvae occurs in late May and June. Damage by second-generation larvae occurs in late July and August.

Other leafroller species that can cause similar damage in strawberries are the variegated leafroller *(Platynota flavedana)*, the oblique-banded leafroller *(Choristoneura rosaceana)*, and the blueberry leafroller *(Sparganothis sulfureana)*.

Appearance: Strawberry leafroller larvae change from pale green when young to grayish brown when fully grown (Figure 6-26). Larvae are approximately 1/2-inch long when fully grown. The adult stage of strawberry leafroller is a reddish brown moth, with distinctive yellow markings

on the forewings (Figure 6-27). The wingspan is approximately 1/2-inch.

Figure 6-26. Strawberry leafroller larva.

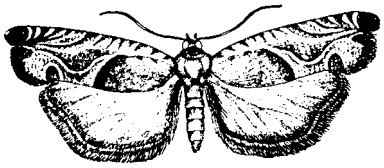

Figure 6-27. Strawberry leafroller moth.

Life Cycle and Habits: Strawberry leafrollers overwinter as fully grown larvae or pupae in folded leaves or leaf litter. Adult moths emerge in April and May and deposit translucent eggs, usually on the lower surface of strawberry leaves. Eggs hatch in one to two weeks. As larvae feed on leaves, they secrete silken threads to fold and tie leaves around them. They pupate for about one week inside the folded leaves.

The strawberry leaf-roller undergoes two or three generations each year. Moths of the summer generations are often present from July through September. Infestations may develop in spring and early summer, but they may also build up after harvest. Natural enemies of strawberry leafroller include two parasitoid wasp species that often kill a high percentage of larvae, especially during summer generations.

Threshold: Low levels of leafroller infestation do not warrant control because they do not cause reductions in plant vigor or yield during the current or subsequent season. The definition of low-level infestation has not been determined, but 10 to 20% of strawberry leaflets, especially after harvest, is a reasonable estimate.

Mechanical Control: If an infestation is detected at an early stage, rolled leaves can be removed and destroyed.

Control with Insecticides: Where control is necessary, several registered insecticides are effective. Products that contain *Bacillus thuringiensis (Bt)* can provide effective control if spray coverage is good and applications are made when many larvae are young and have not yet webbed leaves together fully. For *Bt* products to work, sprays must reach the leaf surfaces where larvae are feeding.

Strawberry Aphid

(Chaetosiphon fragaefolii; order Hemiptera, family Aphididae)

Aphids cause damage primarily by transmitting viruses from infected to non-infected plants. When present in great numbers, aphid feeding can result in stunted, malformed plants. Aphids occur on new shoots, undersides of leaves, and on buds while they are still in crowns. There are several species of aphids that infest strawberries; all are small (1/16-inch long), soft-bodied insects. Both wingless and winged forms of aphids can be found. Viruses are best managed by using virus-tolerant cultivars, planting certified virus-free plants, and eliminating wild strawberries from the area.

Strawberry Whitefly

(Trialeurodes packardi; order Hemiptera, family Aleyrodidae)

Strawberry plants infested with whiteflies may show a large number of tiny white adults (Figure 6-28) that move actively when plants are shaken, or they may show a large number of immobile scale-like immatures on the underside of leaves. Both immatures and adults suck on plant sap. They produce honeydew, a sticky substance that drips onto plants and serves as a substrate for growth of black sooty mold. They overwinter as eggs on the underside of leaves.

Figure 6-28. Whiteflies.

Summary of Strawberry Insect Pest Management Procedures

I. Cultural controls when establishing a new planting.
   A. Site selection:
      1. Do not plant after sod or grasses to avoid problems with white grubs.
      2. Avoid planting near woods or fence rows to avoid problems with clipper weevils.
      3. Do not plant near old plantings if root weevils or crown borers were present.
   B. Cultivar selection: Avoid cultivars highly susceptible to tarnished plant bug injury.
   C. Source of nursery stock: Get plants that are free of cyclamen mite.
   D. Plant density and row spacing: Wide plant spacing will contribute to slug management.

II. Cultural controls while maintaining a planting.
   A. Weed control: Contributes to tarnished plant bug and spittlebug management.
   B. Harvest: Prompt removal of all ripe and cull berries helps sap beetle management.
   C. Mulch: Remove mulch after harvest and delay mulching in fall to discourage slugs.
   D. Renovation: Helps with slug and mite management.
   E. Sanitation: Remove debris that may shelter pests, in and around fields.

III. Mechanical control options.
   A. Bait buckets prior to and during harvest for sap beetles.
   B. Traps for slugs.
   C. Row covers to exclude tarnished plant bug.

IV. Scouting for pests.
   A. Pre-bloom (once per week)
      1. Strawberry clipper: Examine plants for clipped buds.
      2. Two-spotted spider mite and predatory mites: Examine leaflets.
      3. Tarnished plant bug, adults: Sweep-net sampling.
   B. During bloom (once per week)
      1. Flower thrips: Shake flowers in plastic bag.
      2. Tarnished plant bug, nymphs: Shake flowers over dish.
      3. Spittlebug: Examine plant stems.
   C. Post-harvest (once every two weeks)
      1. Two-spotted spider mite and predatory mites: Examine leaflets.
      2. Strawberry rootworm beetles: Examine leaflets.
      3. Miscellaneous pests: Leafrollers, leafhoppers, whiteflies, aphids, root weevils.