Lepidopterous Insects

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GENERAL CHARACTERISTICS

Biology

Complete metamorphosis is a characteristic of lepidopterous insects. They have four distinct stages of development: egg, larva, pupa and adult. Larvae, known as caterpillars, have chewing mouthparts and molt several times during growth. Larvae have three pairs of true legs on the front body segments and two to five pairs of false legs (prolegs) on the rear segments. Mature larvae usually seek a protected site in which to pupate. During pupation, the insect changes from a larva to an adult moth or butterfly. Adult females attract males for mating by producing sex pheromones. Males find the females by following the plume of pheromone. After they mate, the females produce eggs.

Damage

It is in the larval stage that lepidopterous insects do their damage. Larvae use their chewing mandibles to consume leaf or fruit tissue. Foliar damage reduces the photosynthetic area of the plant and thus reduces the production of carbohydrates for plant health and fruit production. Defoliation can also result in indirect damage from sunburn. Fruit feeding causes direct injury to the crop. Much less fruit feeding than foliar feeding can be tolerated. This means that the damage threshold for fruit feeders is much lower than for leaf feeders.

Management

Effective management of lepidopterous pests relies on knowledge of their biology. An understanding of their overwintering habits and the timing of infestation is critical in determining the best management approach. Some species are vulnerable to winter sanitation. Their overwintering sites can be removed or destroyed, thus reducing the population emerging in the spring. Growers can exploit the moths' mating communication by using synthetic pheromones in traps to monitor each generation's adult flight. Where applicable, this helps growers time sprays accurately for best control. Researchers are looking into ways to use synthetic pheromones to disrupt moth mating and reproduction by interfering with the males' ability to find the females.

Lepidopterous larvae are susceptible to the stomach poisons cryolite and Bacillus thuringiensis Berliner (B.t.). These materials are not disruptive to the natural control organisms in the vineyard and do not cause secondary pest outbreaks. They should be the first choices when chemical control is necessary.

The following is a brief discussion of the major pestiferous species in raisin grapes. For more detailed information refer to Grape Pest Management (see References at the end of this chapter).

WESTERN GRAPELEAF SKELETONIZER

Life Cycle

The western grapeleaf skeletonizer (WGLS), Harri-sina brillians Barnes & McDunnough, overwinters as a pupa within a small, oval, purse-shaped cocoon under the vine bark or in the leaf litter at the base of a vine. Overwintering pupae complete their development in early spring and the dark, metallic blue-black moths (Plate 24.1) begin to appear in early to mid-April. The overwintered female moths lay their eggs in clusters on the undersides of basal leaves on the vine. Clusters contain from a half-dozen to over 300 eggs, which are evenly spaced (Plate 24.2). The eggs hatch in about 8 to 10 days in the spring and more quickly in later generations. Newly hatched larvae are creamy white with black head capsules and feed in regular ranks on the undersurface of the leaves (Plate 24.3). This behavior continues through the middle of the fourth stage, after
which the larvae disperse for individual feeding. By the third stage, the larvae begin to show a characteristic color banding around the body, which becomes deeper blue, black, and yellow at maturity (Plate 24.4). There are usually three generations per year in the central San Joaquin Valley. Moths emerge in early April, mid- to late June, and late August.

**Damage**

Skeletonizer larvae feed on the foliage, reducing the photosynthetic ability of the plant. Fewer carbohydrates are produced and consequently yield and sugar levels are reduced. Heavy defoliation also results in sunburn of the berries and loss of grade. Under heavy populations, larvae may also feed directly on the berries. Field workers are reluctant to enter vineyards with high populations of skeletonizers because the mature larvae have urticating hairs that cause itching on contact.

**Monitoring**

The moths are day fliers seen most often in the mornings and are easily seen when populations are significant. Once you have observed the moths in the spring, examine the undersides of the basal leaves of the vine at regular intervals for the presence of egg clusters. You can time treatments for soon after the eggs begin to hatch. Pay particular attention to end vines and border rows: these tend to have the first and heaviest infestations.

**Control**

**Biological.** A number of parasitoids prey upon WGLS. Among the complex, a tachinid fly, *Ametadoria misella* (Wulp), and a braconid wasp, *Apanteles harrisinae* Muesbeck, are the most effective. In other parts of the state these parasitoids have been effective at reducing WGLS populations to low levels, but in the raisin grape-producing region neither has been effective enough to bring about economic control. A granulosis virus pathogen of WGLS has been released in some areas and appears to be spreading throughout the grape-growing region. The parasites may be important in helping spread the virus. Egg clusters of virus-infected skeletonizers contain fewer eggs than uninfected clusters and the eggs are laid haphazardly rather than in the regular spacing usually seen. Infected larvae also tend to feed in a random pattern instead of in rows. Where the virus is present, skeletonizer populations seem to have been maintained at low levels. The reasons for the low populations are not altogether known, however, and populations may resurge.

**Chemical.** Two insecticides, cryolite and *Bacillus thuringiensis* Berliner (B.t.), are the most commonly used materials for WGLS control. Spring applications aimed at the first generation of larvae often give season-long control. Both pesticides are nondisruptive to natural enemies and will not provoke a spider mite outbreak. Cryolite is more effective than B.t. sprays against mature larvae. Other effective materials such as methomyl and carbaryl may be used later in the season but can lead to explosive mite flare-ups.

**OMNIVOROUS LEAFROLLER**

**Life Cycle**

Omnivorous leafroller (OLR), *Platynota stultana* Walshingham, overwinters primarily as mature larvae in mummified fruit left in the vineyard. The larvae do not hibernate and will feed during warmer weather. The larvae complete development in late January and begin to pupate. Adults usually begin to emerge from these pupae around the end of February, but they have been known to begin emergence as early as mid-February after warm winters. Adults are bell-shaped moths about ¼ to ½ inch (6 to 12 mm) long, the females usually being larger (Plate 24.5). The wings are a dark, rusty brown near the body and light tan at the outer ends. Mouthparts extend from the front of the head in a snoutlike protrusion. Adults mate and lay eggs on smooth bark and leaves as well as on berries later in the season. The eggs are laid in clusters and overlap like fish scales (Plate 24.6). The newly hatched larva is creamy white with a light brown head capsule. A mid-stage larva has a dark brown to black head capsule. Mature larvae take on a greenish tinge and the head capsule is brown (Plate 24.7). The mature larvae also have two rows of whitish, oval spots (*pinaculae*) running down the back. Hatching larvae begin feeding in the developing shoot terminals. Later they will tie leaves together and feed within the shelter or begin feeding on the cluster stems and flowers. At fruit set, larvae continue to feed on the developing berries. Injury to the berries at this time will scar over and will not result in a significant reduction in crop size or quality. Larvae mature in mid- to late May, pupate near their feeding sites, and emerge as adults in early to mid-June. There usually are four generations per year in the San Joaquin Valley. Larvae produced by fourth-generation adults become the overwintering generation. Occasionally there is a partial fifth flight of OLR.

OLR has a wide range of hosts, including alfalfa, tree fruit, and many species of weeds. Vineyards near alfalfa or weedy fields are especially vulnerable to OLR.
Damage

OLR causes damage by feeding on the developing berries, stems, and rachises. Early damage usually is not significant, but damage after the berries soften opens the berries to bacteria and fungi, resulting in bunch rot.

Monitoring

An effective synthetic pheromone for monitoring OLR flights is commercially available. Pheromone traps should be placed in vineyards by mid-February. Pheromone traps are not useful for determining population levels. Traps may get high numbers of moths, particularly if near other hosts, without significant corresponding damage to the vineyard. A phenology or degree-day model has been developed which, with the traps, can forecast when future generations will occur. The model uses 48°F as the lower developmental threshold and 87°F as the upper limit. A total of 1,260 degree-days accumulates between generations.

You must use larval counts to estimate damage potential. To monitor larvae, examine grape clusters within the vine. Examine a minimum of 200 clusters a week throughout the season to determine the percentage of clusters infested. Early in the season and under low population conditions, a minimum of 500 clusters may be needed to get an accurate population estimate. Do not rely on one or two cluster counts early in the season as a basis for estimating damage.

Control

Cultural. An essential element in managing OLR populations is the removal of decaying and mummified grape bunches from underneath the vines and their destruction by flailing or disking. You can accomplish this with a French plow or mechanically sweep the berms clean. This must be done in the winter before the larvae can pupate or adults emerge in February. Resident vegetation or other cover crops, while valuable for other cultural purposes, may aggravate OLR problems by serving as alternate hosts. OLR may then move into the vines when the cover crop dries up.

Biological. A complex of parasitoids attack OLR, including braconid wasps that parasitize the larvae and Trichogramma wasps that parasitize the eggs. Parasitoids usually do not adequately control OLR in the vineyard. Trichogramma releases have been attempted, but no economic control has been documented. Other generalist predators such as spiders and lacewing larvae also feed on OLR eggs and larvae, but the impact of such feeding is unknown.

Chemical. The same two insecticides used against WGLS are effective against OLR, but B.t. usually is not as effective as cryolite. Bloom is the preferred timing for sprays because the limited foliage and open clusters allow for better coverage. This treatment often gives adequate season-long control in raisins where other OLR hosts are not nearby. Later in the season populations are more difficult to control because the greater leaf canopy and larger berries make it harder to get adequate insecticide coverage inside the clusters. B.t. or cryolite dust applications can be effective in these situations because dusts penetrate more thoroughly into the foliage and bunches.

The use of degree-days to time treatments is under evaluation. Current data suggests that 900 degree-days after the start of a flight (determined by pheromone monitoring traps) is the optimum timing for a single treatment. In the first flight, this timing corresponds well with bloom, validating that method of timing in most years. However, extraordinarily cold or warm weather preceding this event may result in a bloom time that does not coincide with the degree-day timing because the plant and the insect do not respond to temperatures at the same rate. Timing based on the biology of the insect rather than the plant should result in better control. This method should also improve treatment effectiveness in later generations when there is no corresponding indicator on the plant. If treatments for later generations are necessary, consider multiple treatments bracketing the degree-day timing if you are using a short-residual insecticide like B.t. Contact your local Farm Advisor for further information.

GRAPe LEAFFOLDER

Life Cycle

Grape leaffolder (GLF) moths, Desmia funeratis Hubner, begin to emerge from the overwintering pupae in late March to mid-May in the San Joaquin Valley. The moths are metallic brownish black, with two white spots on the front wings (Plate 24.8). When resting, the moths’ spread wings are about 1 inch (25 mm) wide. They lay their eggs singly or in clusters of a few to a dozen or more eggs, usually on the underside of leaves near a main vein, but sometimes on the upper surface. The eggs overlap in the clusters something like OLR eggs. Newly hatched larvae are about 1/16 inch (1.6 mm) long and creamy white. The third instar develops a dark spot on each side of the second segment behind the head. Fourth and fifth instars develop one and two additional dark spots near the tail end (Plate 24.9). These spots help to distinguish GLF from...
omnivorous leafroller. Three generations of GLF occur in the San Joaquin Valley, with the second and third flights respectively beginning in early to mid-June and early August. Larvae produced by third-generation adults mature to the pupal stage and then overwinter in cocoons of silk and leaf fragments, mostly in the leaf debris under the vines.

**Damage**

Grape leaffolder populations tend to be sporadic over time and locations. Several years with very low populations and no significant damage can be followed by an increase to highly damaging populations. These high populations will usually decline to insignificant levels for several more years. Likewise, there are “hot spots” scattered throughout the San Joaquin Valley where GLF tends to be a more consistent problem and where damage is more severe.

Damage is caused by larvae feeding on the leaves and making leaf rolls, thus reducing the photosynthetic capacity of the plant. Since defoliation is common toward the top of the vine, fruit are also sunburned. Small larvae feed between touching leaves where they are somewhat protected from predators. As they reach the fourth and fifth larval stages, they make leaf rolls by pulling over the edge of the leaf and tying with silk. They then feed on the edge of the leaf within the roll.

First-brood populations very rarely cause significant damage, but in years with high populations second-brood larvae can sometimes cause up to 50 percent defoliation, and third-brood larvae can completely defoliate vines if left uncontrolled.

**Monitoring**

No commercial sex pheromone is available for monitoring adult flights. If populations are high enough to cause significant damage, however, there will be enough of the distinctive adults flying during the daytime to be noticeable. Growers and pest control advisors can use malt syrup or terpinyl acetate bait traps to follow the moth flights, but since there is no validated phenology model available to interpret the flights, trapping is of little use.

After you observe the presence of adults, examine leaves for the presence of eggs and young larvae feeding in leaf folds or where leaves overlap. Pay attention to the larval growth stage and time your treatments when most are third instars. This is before much leaf rolling takes place, so better coverage is possible. First-generation larvae are usually controlled by bloom sprays applied for grape leaf skeletonizer and omnivorous leafroller. Grape leaffolder populations can increase sever-

al-fold within the season, however, so later generations may also need to be controlled. If needed, second- and third-brood treatments usually should be applied in early July and late August, respectively.

**Control**

**Biological.** Several wasp and fly parasites attack GLF, but the most effective appears to be a small Braconid wasp, *Bracon cushmani* (Muesbeck), the larvae of which feed externally on GLF larvae. From 1 to 20 parasite larvae may be observed feeding on the GLF within the leaf rolls. After they mature, they pupate within small, yellow, oval cocoons next to the remains of the GLF larva. Parasitism by *B. cushmani* usually ranges around 30 to 40 percent but may be much higher, especially in the second and third GLF broods. They often prevent GLF populations from increasing to damaging levels. Pull open leaf rolls and look for the feeding larvae and pupae or the shriveled remains of the caterpillar to estimate the percentage of parasitism (Plate 24.10).

**Chemical.** *Bacillus thuringiensis* formulations, cryolite, and carbaryl are effective materials for GLF control. B.t. and cryolite are stomach poisons and must be ingested to be effective. Therefore, timing and coverage are critical for adequate control. B.t. dusts are effective during later generations when the canopy is extensive and the overlapped broods mean that many larvae are already located in rolls at the same time as immature larvae are feeding on leaf surfaces. Carbaryl may be needed late in the season under high population pressure, but it can lead to heavy outbreaks of spider mites in some localities.

**Raisin Moth**

Raisin moth, *Cadra figulillela* Gregson, has always been considered a pest of stored raisins, either infesting raisins on the trays in the field or in storage. Recently, however, there have been reports of damage to fresh grapes in the field. The damage appears to be similar to that of omnivorous leafroller.

**Life Cycle**

Raisin moths overwinter as late-stage larvae in cocoons in the top layer of soil or under the bark of trees and vines. They complete maturation and pupate in early spring and begin to emerge as small, pale tan-gray moths in late March and early April (Plate 24.11). The
moths search for drying fruit but will lay eggs on mum-
mified fruit if nothing else is available. Mulberries are
often infested by this first brood and may be a “bridge”
host carrying the population until later hosts are avail-
able. Later generations will infest fallen fresh shipping
fruit and figs. Grapes are infested when they begin to
soften, especially when rot or premature raisins are
present. Grapes drying on the trays are then attacked.

Eggs are white, oval, and less than $\frac{1}{25}$ inch (1 mm)
long. They are laid singly or in small groups on the
fruit surface. Hatching larvae are small, creamy white,
indistinct caterpillars that grow to about $\frac{1}{2}$ inch (12
mm) long at maturity. Mature larvae have four rows of
purple spots with light brown lines running through
them down the back (Plate 24.12). There are usually
three generations per year, occasionally with a partial
fourth.

**Damage**

Larvae feed on the drying raisins, causing a reduction
in quality. They also leave considerable contamination
in the form of webbing and frass. In addition, there are
reports of feeding on fresh fruit within the bunches
hanging on the vines, predisposing them to rot. The
extent of this type of damage is unknown at present.

**Monitoring**

An artificial sex pheromone lure is commercially avail-
able for monitoring raisin moth flights in packing
plants and storage yards. Pheromone monitoring has
not been evaluated for field populations, however. It is
not known whether trap catches would have any rela-
tionship to the severity of raisin moth infestation.

You can evaluate raisin moth infestation within
bunches on the vines at the same time as you moni-
tor for omnivorous leafroller. Feeding damage is very
similar for the two, and you must observe the larva
itself to distinguish which species is causing damage.
No thresholds have been established for raisin moth
damage to bunches on the vine or on the tray.

**Control**

*Cultural.* Raisin moth is another one of many “garbage
insects” that inhabit mummified or spoiling fruit in
and around the vineyard. A principal means of reduc-
ing the population is to clean up and destroy leftover
bunches in the vineyard and other fruit from surround-
ing areas. This must be done early in the fall before
larvae leave the material for their overwintering sites
under bark and in the soil. Raisins drying in the field
should be biscuit-rolled as soon as possible to prevent
moths from laying eggs on the fruit.

*Biological.* Several parasites and some diseases attack
raisin moth. The most important parasite is *Bracon
hebetor* Say, which is active on warm days in the win-
ter when it stings and paralyzes larvae under bark. It
begins to lay eggs on the paralyzed larvae as tempera-
tures warm in the spring. Several generations are pro-
duced in a season. It also effectively parasitizes raisin
moth larvae in stored raisins. Several diseases may be
important in controlling raisin moth in storage, where
larval populations may reach levels high enough for an
epizootic outbreak of the disease to occur.

*Chemical.* Raisin moths are controlled to some extent
by late-season sprays applied for omnivorous leafroller
control. Since they do not infest bunches until after
berry softening (veraison), bloom sprays have little
effect against raisin moth. No treatment thresholds
have been established for field treatments. Raisins that
have been infested on the trays should be fumigated
immediately after boxing to prevent further damage
while in storage.

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