# Identification of Tortricid Moths in California Vineyards

*Lucia G. Varela, Monica L. Cooper, Larry J. Bettiga, and Rhonda J. Smith. University of California Cooperative Extension*

Since the 1960s two North American leafroller species have been pests of California grapevines: orange tortrix (OT), *Argyrotaenia franciscana*, and omnivorous leafroller (OLR), *Platynota stultana*. More recently, males of a leafroller native to Australia, light brown apple moth (LBAM), *Epiphyas postvittana*, have been trapped in some coastal vineyards. Thus far, there are no official reports of LBAM larvae feeding on grapes in California vineyards. These three moth species belong to the family Tortricidae, sub-family Tortricinae. As a group, they are commonly called leafrollers due to the larval behavior of forming nests by rolling leaves. For the remainder of this article, we will use the term leafroller to refer to these three species.

In September 2009, a new tortricid moth, European grapevine moth (EGVM), *Lobesia botrana*, was reported from the Napa Valley (CAPCA July 2010). Native to Europe, this moth belongs to the sub-family Olethreutinae; the larvae are berry feeders that burrow into the berry and also feed on the flower cluster. Unlike the leafrollers, EGVM larvae do not feed on or roll leaves.

Because they all belong to the same family, the larval stage of these four species appears similar and can be confused. There are a few morphological characters that distinguish them. In addition, an understanding of their life cycles is critical to predicting when different stages will be present in the field. Behaviors such as host range, larval feeding site, egg-laying pattern, continuous versus discrete generation development, and overwintering behavior are useful for distinguishing EGVM from the leafrollers.

## Hosts and Geographic Distribution

All three leafrollers are polyphagous (feeding on many host plants). OT was given its common name because it was first observed as a pest of oranges. Its larva feeds on numerous weeds, cover crops and vegetation inside and adjacent to the vineyard. It is distributed throughout coastal areas and interior valleys of the coastal ranges but is best adapted to cooler coastal regions. OT seldom reaches pest status because it is controlled by a complex of predators and parasitoids. Negative impacts on the natural enemy complex such as disruptive pesticide applications can result in economic damage from OT. Additionally, vegetation adjacent to the vineyard may affect the species complex of tortricid moths and their parasitoids, resulting in inferior natural controls in areas of the state where alternate hosts are absent.

Leafroller forming nest at shoot tip
Photo: Jack Kelly Clark, courtesy UC Statewide IPM Program

As the name "omnivorous" implies, an OLR larva feeds and develops on many host plants including weeds, crops, ornamental and native vegetation inside and adjacent to the vineyard. It is found in hotter, inland valleys and is considered a pest in San Joaquin and Sacramento Valley vineyards. It is also found in warm coastal valleys. However, the authors have readily collected OLR larvae from Carneros, a cool region in Napa and Sonoma counties, and throughout the Napa Valley.

Light brown apple moth, in its native range, is a major pest of pome and berry fruit and a minor pest of grape, citrus, stone and kiwi fruit. It has a broad host range including fruit crops, ornamental plants, native trees and broadleaf weeds. In California it has been found in costal counties from San Diego to Sonoma with isolated finds in northern Central Valley. The highest populations are in the San Francisco Bay Area and the Santa Cruz/Monterey Bay region in urban areas and surrounding native vegetation. The optimal conditions for LBAM development are mild to cool summers with high humidity.

In contrast, the EGVM larva feeds primarily on grapes and a limited number of plants. In Europe, the larva has been reported feeding on nearly 30 host plants. However, many of these plant species host only one generation. So far in California, EGVM has only been found on cultivated grapes and in infinitesimal numbers in olive flowers next to infested vineyards. It has not been reported from olive fruit.

High numbers of moths and larvae have been found in the Napa Valley; low numbers of moths have been caught in the counties of Fresno, Mendocino, Merced, San Joaquin, Solano and Sonoma and one moth was caught in Monterey County.

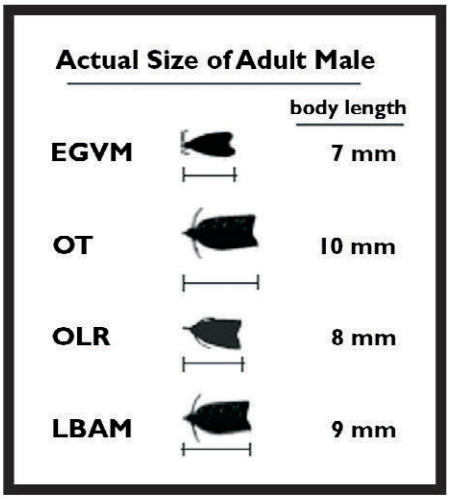
## Identification

Adults of each species are very distinct and readily identifiable. However, adults tend to hide during the day and are seldom seen. Males caught in pheromone traps are the most common way to encounter adults. Pheromone lures are specific for each species and all are commercially available. The authors have not observed trap cross contamination among these four species, but other species of moths may be caught in the traps.

At approximately ¼ inch in length, EGVM adult males are the smallest of these 4 moths. The tan-cream forewings are mottled with brown and black markings and bluish-gray bands, the widest of which is in the center of the wings.

Following in size is the bell-shaped OLR, readily distinguishable by its protruding snout-like mouthparts. The dark rust-brown forewing is tan at the tip, with a V-shaped dark marking in the middle.

OT and LBAM males are approximately 0.4 inch in length. The forewings of OT males are tan to orange-brown and marked with a dark V-shape in the middle and crescent-shapes on the outer edges. There is considerable variation in the color pattern of the LBAM male forewing. Some specimens have two-tone forewings with a light brown basal half (closest to the head) and a reddish-brown distal half. Other specimens are light brown with a slightly darker oblique marking. The basal quarter of the LBAM male forewing has an expanded outer edge that folds up and over that portion of the wing as a flap called the costal fold.



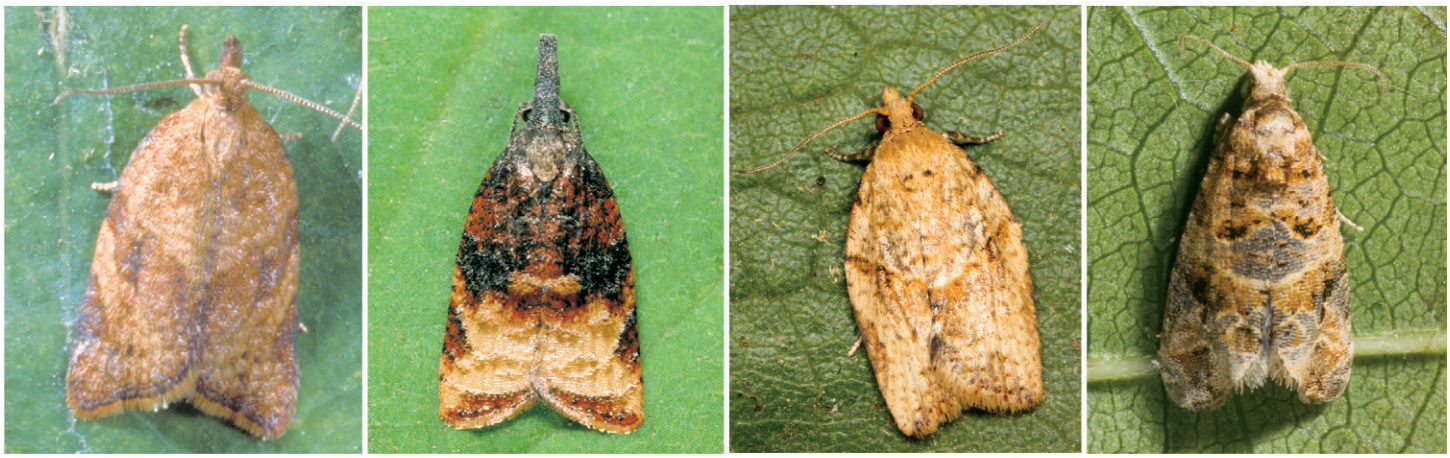

## Eggs

All three leafroller species lay imbricate (overlapping) egg masses on smooth surfaces such as the upper surface of leaves, canes, or berries. Eggs are flat, oval and an egg mass may contain few to hundreds of eggs. OT eggs are cream colored, OLR eggs are green, and freshly-laid LBAM eggs are translucent green, turning light yellow as the larvae develop. In contrast EGVM females lay eggs singly on portions of the flower cluster or on berries. The eggs are elliptical, flat and visible to the naked eye. A freshly laid EGVM egg is white, turning yellow as the larva develops, until the black head of the larva becomes visible through the egg shell when the larva is ready to hatch.

## Larvae

OT and LBAM larvae are morphologically very similar and must be sent to a specialist for identification or reared to adult to distinguish them. When fully grown, OT and

Four species of adult males, L-R: Orange Torrix (OT), Omnivorous Leafroller (OLR), Light Brown Apple Moth (LBAM), and European Grapevine Moth (EGVM). (Photos: Jack Kelly Clark, courtesy UC Statewide IPM Program)



LBAM larvae are the longest of the 4 species discussed here— approximately 0.6 to 0.7 inches. The head remains tan throughout the five larval stages. The pro-thoracic shield (segment behind the head) is tan or the color of the body with no dark markings. The body is cream in younger stages and straw-colored or medium green on mature stages. The thoracic legs are the same color as the head, but a lighter shade.

Fully mature OLR larvae are generally 0.5 to 0.6 inch long. Earlier stages have brownish-black heads and shields. Mature stages have light-to-dark brown heads and shields; the shield may have a darker border on the side and rear outer edge (closest to the body). The body color is cream in younger stages and cream to brownish-green in mature stages. Mature larvae have whitish, slightly convex and oval tubercles (pinaculae) at the base of the body hairs on the upper side of the abdominal segments. Morphologically similar larvae either lack or have rounded pinaculae.

When fully grown, EGVM larvae are the smallest of these species, reaching about 0.5 inches in length. Upon emergence the larva is creamy white with a black head. In later stages the head and shield are yellowish brown; the shield has a darker border on the side and rear edge (closest to the body). In early stages the body is tan to yellow-brown; in the last stage it is dark green to shades of dark pink and maroon and white pinaculae are visible. The thoracic legs are dark brown to black.

### Pupae

The pupae of all 4 species turn from green to brown as they mature. The easiest way to separate the leafroller species is to rear them. The pupa of the leafroller species can be distinguished from that of EGVM by the cremaster (the prolongation of the last segment). In the leafrollers it is longer than broad; in EGVM it is broader than long. In all species the female is slightly larger than the male. OT and LBAM pupae are 0.6 to 0.4 inches long; OLR are 0.5 to 0.4 inches; and EGVM are 0.4 to 0.2 inches. Leafrollers pupate at or close to the feeding site. Before pupating the mature larva weaves a loose silken cocoon.

During the spring and summer generations, EGVM also pupates at or close to the feeding site. However, in the fall, the fully mature larvae leave the cluster, migrate under the bark to the cordon or trunk, spin a dense cocoon, and overwinter as pupae.

### Seasonal Development

#### Overwinter

The life cycles of OT, OLR, and LBAM are very similar; thus we will describe a generic leafroller life cycle. In the vineyard, they overwinter as various larval stages on the vines in mummified clusters or on ground vegetation.

Therefore, removal and destruction of cluster mummies at pruning and mowing of weeds and cover crops before budbreak are important sanitation practices for leafroller control. Since leafrollers do not hibernate (diapause), larvae can be found feeding on warm days in winter. Due to the absence of diapause, all developmental stages can be found during the year making it difficult to separate the generations. Pheromone traps used to monitor male flights indicate that OT, LBAM and OLR have three generations a year in coastal areas; OLR has 4 generations and sometimes a partial fifth in warmer inland valleys.

EGVM overwinters as a diapausing pupa under the bark on the trunks, cordons and arms and in cracks in the soil and wooden stakes. As the nights lengthen in the fall, mature larvae begin pupating in September, such that by mid-to-late October the majority of the population is in the overwintering pupal stage. Thus, sanitation practices entail the removal of the bark to remove pupae, and may only be practical if the vines are heavily infested. Diapause is terminated in early February and the pupae enter post-diapause development. Due to diapause, the generations are discrete: 3 generations in Northern California and 4 with possibly a partial 5th in the south Central Valley.

## Spring

Leafroller moths emerge in late winter and early spring. In the spring, females lay egg masses on the upper surface of leaves. Larvae disperse upon emergence with high mortality due to predation and difficulties of establishing a nest. During rapid shoot growth, first generation larvae feed individually inside nests formed by tender leaves tied together at shoot tips. This leaf-tying is a typical spring symptom of leafroller damage, and can be easily spotted by field scouts. When the larva completes its development, it pupates in its nest.

EGVM adults begin to emerge before budbreak. Females lay eggs singly on or near the developing flower cluster from two-inches shoot growth through cluster expansion. Prior to bloom and through fruit set, first generation larvae web flower parts together to form a nest. They feed on pre-bloom flowers (sometimes being concealed inside), cluster parts and on newly set berries. During bloom, the presence of EGVM larvae may be indicated by clumps of dehisced calyptra, joined by larval webbing. Pupae form inside webbed cocoons in the flower cluster, in a folded lobe of a leaf blade or under the bark.

EGVM forming nest during bloom
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## Summer

Second generation leafroller larvae may enter the cluster as early as bloom. They form tubes of webbing along the cluster stem, feeding externally on developing berries. Third or later generation larvae feed along the cluster stem and damage berries from veraison through fall. From one to few larvae may be found per cluster.

Eggs of the second EGVM generation are laid individually on developing green berries. Larvae tie several berries

Four species of larvae (Left to right): OT, OLR, LBAM, EGVM
Photos: Jack Kelly Clark, courtesy UC Statewide IPM Program

together with webbing and feed on the surface when the berries are hard. They penetrate mid-size berries where two berries touch. With time, the area surrounding the pin-size hole where they enter the fruit will turn purple. A larva can fully excavate the berry leaving the seeds and somewhat intact berry skin full of excrement and loosely attached to the pedicel. Around veraison, eggs of the third generation are laid on single berries. Shortly after hatching, larvae penetrate the berries and feed internally on ripening fruit. Larvae can be found inside one or more berries per cluster. When the berries are too juicy they leave the berries, form webbing along the cluster stem and feed externally on ripe fruit.

Summer generations of leafroller or EGVM larvae populations can increase the occurrence of bunch rots by creating wounds that allow fungal organisms to colonize the damaged berries.

## Biological Control

Both OT and OLR are native to North America and as such they have an important complex of natural enemies, including parasites and predators. While scouting for tortricid larvae in clusters, you may encounter some of these parasitoids, especially in the pupal stage, thus we will describe the most abundant species. Two species of braconid parasitoids attack young larval stages. Apanteles aristoteliae parasitizes second instar larvae of OT. The female braconid wasp lays an egg inside the leafroller larva, and the parasitoid larva consumes its host from inside. The mature parasitoid larva exits the dead leafroller larva. It pupates inside a white silken cocoon spun inside the dead leafroller's nest, next to the carcass of the leafroller larva.

Adult broconid parisitoid (top left) emerging from white cocoon (center right). Dead, shriveled larva is to right of cocoon. Photo: Jack Kelly Clark, courtesy UC Statewide IPM Program

The adult wasp emerges from this cocoon in about a week. Because of the silken webbing, at first glance the parasitoid cocoons can be confused with leafroller nests. However close inspection reveals the leafroller carcass in the vicinity of the parasitoid cocoon. A second braconid species parasitizes OT and OLR larva, and its life cycle is similar to that described for A. aristoteliae. The Ichneumonid wasp Enytus eureka is a larval parasitoid of OT that has also been found parasitizing LBAM. It forms a brown oval cocoon. The Ichneumonid wasp Exochus sp. is a larval parasitoid whose cycle is slightly different than the others in that it emerges from the leafroller pupa rather than the larva. Exochus sp. has been reared from OT, OLR and EGVM.