Timing of Insecticide Treatments for European Grapevine Moth

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European grapevine moth, *Lobesia botrana*, has three generations a year in California with a possible partial fourth in warm regions. With the goal of eradicating this pest, insecticide applications should target both the first and second generations, which is when larvae are most exposed. Third generation larvae quickly penetrate the berries after emerging from eggs, therefore, insecticides targeting the third generation are not advised. To prevent development of resistance by the larvae, it is critical to rotate with different classes of insecticides.

Timing for the First Generation

The best time to control the first generation is when the highest proportion of the larvae are about to emerge from eggs. This can be ascertained by following the male moth flight with pheromone traps and monitoring egg development. Begin monitoring for eggs about peak flight. Target treatments when the head of the larvae is visible in 20% of the eggs. When eggs are too few to monitor, treat shortly after peak flight.

In 2010 the flight of the adults emerging from the overwintering pupae (first flight) lasted 14 weeks in Oakville, Napa County. The first moth was caught on February 17, before bud-break. However males were not caught consistently in traps until a month later, beginning on March 17. From the latter date the number of moths caught increased steadily for four weeks peaking on April 19 and taking about 6 more weeks for the flight to end. If we disregard the early moth catches, the period during which male moths were consistently caught in traps was 10 weeks (see Figure 1).

Females begin to emerge about a week after the start of the male flight. For mating to take place the evening temperatures have to exceed 59º F. Eggs are laid in the evening when temperatures are between 57 and 93º F (optimum 70 - 77 º F). In the spring expect to see consistent egg-laying about 10 to 14 days after consistent trap catches. Peak egg-laying is approximately at peak flight.

As soon as females began emerging, we searched for eggs in grapevines and other possible hosts. No eggs were found before bud break on grapevines or on other plants searched. Eggs were first found on or near flower clusters at the end of March when the flower cluster was about 1 inch long. The literature states that egg development during cool springtime temperatures takes between 7 to 11 days. 2010 had an exceptionally cool spring with extended periods of rain. We did not observe larvae emergence until early May. The time between the first observed egg and the first observed hatched egg was over one month. Thus, it is critical to mark eggs and monitor their development. Egg color is pearly white when first laid, yellow as the embryo is developing, and when the black head of the larvae is observed, the egg is called the "black cap" stage.

Egg of *Lobesia botrana*: The black head of the larva is visible through the egg shell, indicating that the larva is ready to hatch. Photo: Monica Cooper, UCCE Napa County

The majority of the insecticides currently on the market for conventional and organic production kill the larvae. There are a few **conventional** insecticides that are primarily larvicidal yet have some ovicidal activity. These

ovicidal/larvicidal insecticides are most effective if applied from before egg deposition through presence of first larval stage. However, experience has shown that this timing may be premature under some conditions.

Given that the first flight and egg laying period is very extended, if the application for this generation is done before egg laying or too early in the egg laying period a second application may be needed to cover the prolonged egg hatch. Furthermore at this time the flower cluster is rapidly expanding, decreasing the surface covered by an insecticide.

To avoid having to make two applications for the first generation, it is critical to time the application of a conventional ovicidal/larvicidal when the majority of the larvae are about to emerge which is when 20% of the eggs are in the black cap stage. For this generation, it is better to err on the side of being a little late (many black caps and a few larvae emerging) than too early (only white and yellow eggs). Since the target is primarily young larvae and the ovicidal/larvicidal insecticides have at least a three-week residue there is a grace period of about two weeks to make the application. This would span a period from about 5% black cap to 10% emerged larvae and should facilitate combining the insecticide with a powdery mildew treatment.

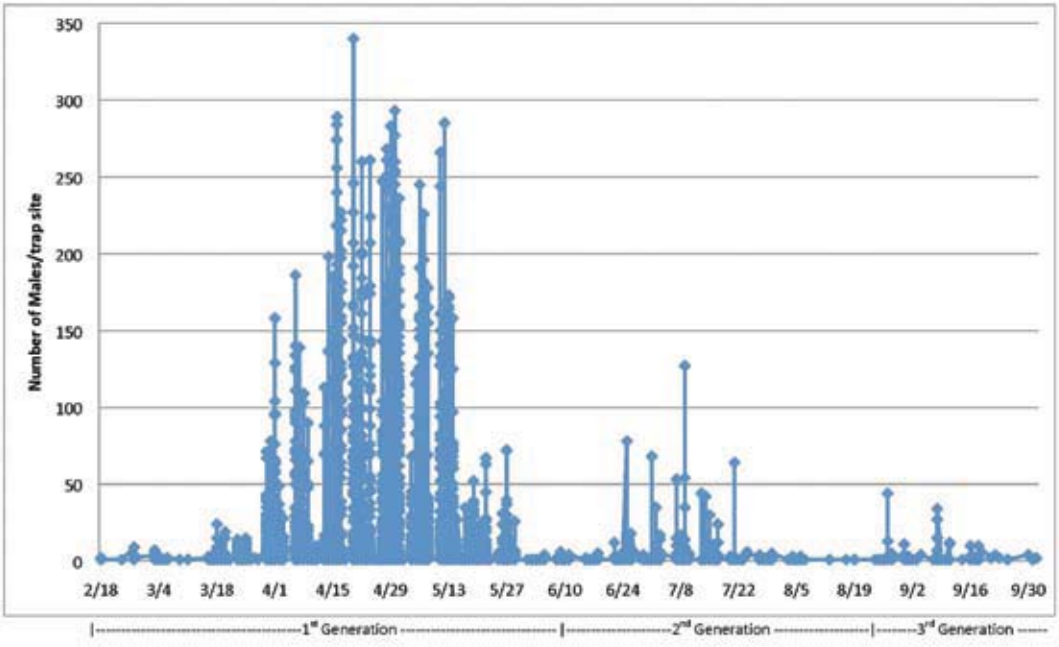
Insecticides registered for **organic** production are larvicidal and should be targeted for egg hatch. Due to the short residue of organic materials, two or more applications are warranted starting at egg hatch and continuing weekly for as long as larvae are detected. Presence of the empty egg shells (flat and iridescent) signals egg hatch.

Adult European grapevine moth. Photo: Jack Kelly Clark, courtesy UC Statewide IPM Program

To evaluate the effectiveness of the sprays, especially if an organic material was used, monitor flower clusters for larval nests 4 to 7 days after an application. Look for flowers and abscised flower caps webbed together with silk forming a clump. Inspect for evidence of a larva inside the webbing, feeding damage on pre-bloom flowers and excrement that appears as saw dust.

Good coverage is easily obtained during the first generation when the canopies are small making this a very effective time to treat.

Figure 1.- European grapevine male moths caught in traps in California in 2010. (USDA, APHIS, PPQ - European Grapevine Moth Program)



Timing for the Second Generation

The time to make the second application depends on whether the insecticide has some ovicidal properties or if it is strictly larvicidal. If it has ovicidal properties the applications can start a few days after the first male for the second flight is caught in a trap. For larvicidal insecticides (conventional or organic) the applications can start 10 to 14 days after

catching the first moth of the second generation.

In 2010 in Oakville, no moths were caught during a period of two weeks at the end of May and the beginning of June. This made the first and second flights very distinct and made it easy to determine the beginning of the second flight.

The flower cluster is more nutritious than the berries for the development of the larva. Thus, the larvae of the first generation develop relatively fast and larval stages synchronize as temperatures increase in the spring. The second flight is substantially shorter than the first, lasting approximately four weeks; two weeks to reach peak flight and two more weeks to end. This makes timing for control of the second generation easier to predict. As with the first generation, the majority of the eggs are laid about peak flight.

The development of second-generation larvae in 2010 took longer than what the predictive models estimated. In Oakville we observed an overlap between the end of the larval development of the second generation and the beginning of the third generation.

Young larva comes out of its nest to feed on grape flower cluster.
Photo: ©2010 AgStockUSA / Jack K. Clark

Empty, hatched egg shell of European grapevine moth.
Photo: Jack Kelly Clark, courtesy UC Statewide IPM Program

Insecticide applications targeting the second generation occur when the cluster is still open, ensuring good coverage and making this treatment as effective as the one(s) for the first generation.

Third Generation

If treatments are timed appropriately for the first and second generations, treatment of the third generation should not be necessary. Treatments during the third generation are limited in their efficacy due to the overlap in generations, the difficulty in penetrating a closed cluster and the brief period between egg hatch and the larvae entering a berry.

Predictive models

Several researchers in Europe have developed degree-day models based on the accumulation of heat units per day to predict the occurrence of the different life stages through the season. In 2010 we studied the accuracy of several of these models by comparing the prediction to the stages observed in the field. Some models were accurate at predicting the first and early second generation but none accurately predicted the third generation. These models need to be validated for California conditions to obtain accurate predictions. Validation of a degree-day model is typically done over a period of three years.

For more information, see: *http://ucanr.org/NapaEGVM* and *http://ucanr.org/egvm&leafrollers*