Progress Made on Control of the European Grapevine Moth: Present Status and Next Steps

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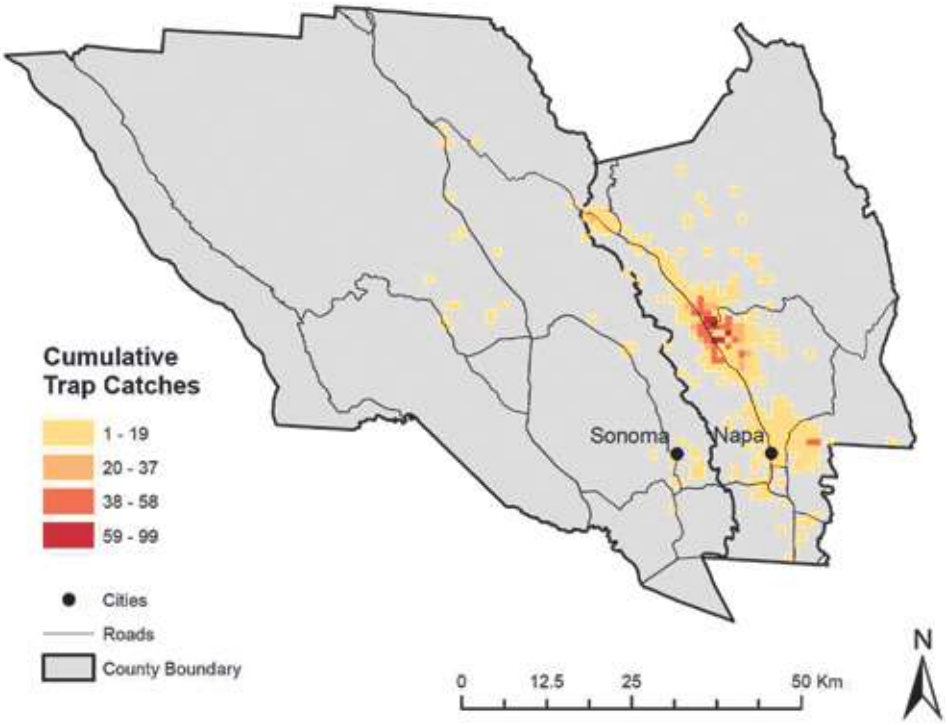
In recent years California vineyards have been threatened by a wide range of arthropods and pathogens. Among the most prominent new threats, but also one that is emerging as an eradication success story, is the European grapevine moth (EGVM), *Lobesia botrana* (Fig. 1).

Lobesia botrana is a tortricid moth that is likely native to Mediterranean Europe. However it has invaded several other regions, causing economic damage throughout Europe, and in parts of Asia, the Middle East, and North Africa. More recently, EGVM has invaded parts of South America and California. Grapevines are a favored host for EGVM. Although it has been reported on other plants, most appear to be used opportunistically only when EGVM populations are very large.

Lobesia botrana has multiple generations a year, with three documented in California. Successive generations of larvae target later developmental stages of grapes. The first feeds on flower clusters, the second on green berries, and the third inside mature fruit. Webbing within the clusters may be apparent, along with excrement and shriveled berries (Fig. 1). Feeding also encourages fungal infections and rots in the clusters, which are at least as problematic as the direct damage caused by EGVM feeding.

Figure 1. Adult European grapevine moth (*Lobesia botrana*; EGVM) and larval feeding damage (inset). Images by Jack Kelly Clark courtesy of UC IPM.

Figure 2. Geographic distribution of cumulative Lobesia botrana (EGVM) detections (km-2) in Napa and Sonoma Counties between 2010 and 2015.



The situation in California

Lobesia botrana was first documented in California in Napa County in October of 2009. In response, in 2010 an extensive monitoring program was established that included deployment of traps throughout vineyards statewide at

varying densities up to 1 trap per 25 acres. This program in 2010 included more than 60 thousand traps, with more than 10,000 alone in Napa and Sonoma Counties.

In California, EGVM damage has been exclusively associated with grapevines. Although this insect is a relatively poor flier, it can disperse significant distances passively as a contaminant on fruit and equipment. In 2010 EGVM was detected throughout much of Napa (Fig. 2), and, in the first years of the infestation, in more limited numbers in other areas including Sonoma, Mendocino, Solano, Fresno, San Joaquin, Santa Clara, Santa Cruz, Merced, Nevada and Monterey Counties.

In light of the dramatic number of EGVM detections in 2010 (Fig. 3A), UC Cooperative Extension personnel in conjunction with county agricultural officials, the California Department of Food and Agriculture, and the United States Department of Agriculture initiated an eradication program based on the recommendations of a Technical Working Group that consisted of international subject-area experts, UC and USDA scientists, and a representative of the wine grape industry. Coupled with continued widespread monitoring for EGVM, quarantines were established around confirmed detections (i.e. more than 2 moth finds or any immature finds), which regulated the movement of plant material and required proper handling of green waste and sanitation of equipment. The program also included active control of EGVM in both residential areas and commercial vineyards surrounding sites where moths were detected. In residential areas, treatments typically consisted of application of a Bt product, voluntary fruit stripping, and limited mating disruption. In commercial vineyards, management included treating the first and second generations with conventional or organic insecticides and extensive use of mating disruption.

Components of successful EGVM control

The EGVM eradication program developed in conjunction with the Technical Working Group involved coordinating multiple regulatory and control measures. In commercial vineyard settings the key elements included the following:

1. Monitoring. Statewide monitoring for EGVM was used to guide regulatory decisions with respect to delimiting quarantines and treatment areas. Moreover, within-season monitoring was used to refine insecticide applications, whose efficacy against EGVM depend on timing.

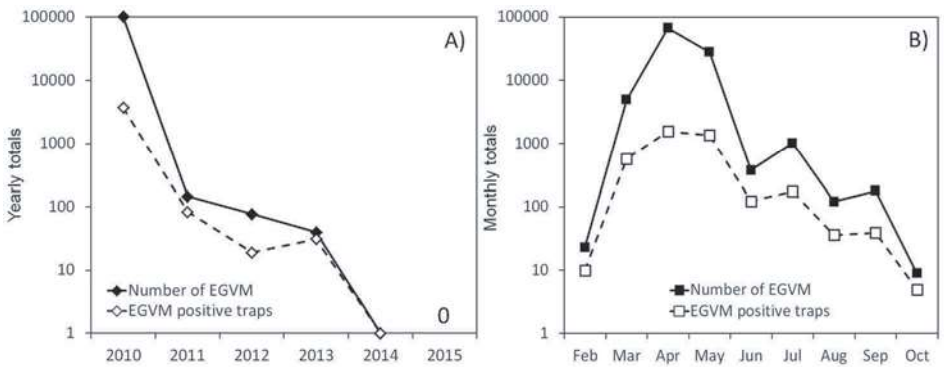
Lobesia botrana was monitored with delta traps embedded with a synthetic version of the female-produced sex pheromone that are attractive to male moths. To adequately capture the first flight, traps were deployed starting at bud break, at densities of one per 25 acres. Seasonal patterns in the monitoring show that peak catch began in April, with additional smaller peaks in July and September (Fig. 3B). In 2010, while EGVM densities were high, UCCE personnel also directly monitored for eggs and larvae on flower clusters and berries to facilitate more precise timing of insecticide applications.

This extensive monitoring was critical for delimiting the area over which EGVM was already well established by the time the program began. In addition, it is plausible that such monitoring helped to identify the location of other, more recent, introductions before EGVM became widespread there, improving the chance for a successful outcome at those locations.

2. Insecticides. A range of insecticides are available for EGVM control on grapevines. These include several conventional foliar insecticides (e.g., insect growth regulators, diamides), as well as microbial products (i.e. Bt) and other organic insecticides (e.g., spinosyns).

Chemical control targeted young EGVM larvae for the first two generations. By the third generation, bunch closure can limit the effectiveness of insecticides. Timing of the applications for the first generation was based on monitoring of the insect and plant development, with the optimal being just prior to bloom. This timing usually provided effective control via a single conventional application, or a few applications of organics made at approximately weekly intervals. Timing of applications for the second generation was based on a degree-day model. Initially the amount of area treated around an EGVM detection varied, but starting in

Figure 3. Overall A) yearly and B) seasonal trends in *Lobesia botrana* (EGVM) catch in California.



2011 it was standardized to a 500 m radius around detections based on the relatively short distances usually travelled by this insect.

A concerted effort was made to recommend products effective against EGVM that minimize non-target effects, as well as organic treatment options. These considerations, plus extensive outreach to the grape-growing community, were intended to maximize grower participation in the program - which pesticide use reports suggest was successful.

3. Mating disruption. In addition to their use in traps, pheromones play an important role in EGVM control via mating disruption. Such programs seek to reduce reproductive rates by inundating the local environment with enough female pheromone that males have trouble locating a mate. Mating disruption is most effective when females are relatively uncommon (i.e. low population densities) and when the program includes deployment over significant contiguous areas for a sustained period.

In California's EGVM program, dispensers were deployed at a density of 200 per acre, placed throughout the block and in advance of the first male moth flight (i.e. just before budbreak). However, because the same pheromone is used in monitoring traps, there is potential for the use of mating disruption to undermine trapping efficacy. Therefore, mating disruption was only deployed in areas where EGVM was documented – not areas being monitoring to determine whether EGVM was present.

The use of mating disruption in addition to insecticides was recommended because multiple, layered control measures often increase the chance of success compared to individual tactics. Indeed, the EGVM program in California may well be a case study for the effective implementation of mating disruption as part of a larger eradication program.

Present outlook and next steps

In 2010 a total of more than 100,000 male EGVM were caught on nearly 4,000 positive traps, mostly in Napa County (Fig. 3A). However, after a season of management, trap catch declined dramatically to 146 male moths in 2011. By 2012 EGVM appeared to be restricted to Napa County, and in 2014 there was a single male moth caught in Sonoma County.

As a result of these declines in trap catches, quarantines were lifted in most regions and mating disruption efforts were reduced. As of October no EGVM have been caught in 2015 (Fig. 3A). In 2015 insecticide applications made have been supplementary treatments at sites where EGVM had been trapped in 2013.

The temporal trends in EGVM dynamics are promising in that they suggest the initial invasion has been effectively controlled, if not eradicated. This apparent success is attributable to a range of factors. Central among them is having the support of not only grape growers and the general public, but also scientists, extension personnel, regulators, and others to address this pressing problem. With funding from multiple sources, the program was able to leverage scientific knowledge into developing sound recommendations, which were communicated to growers and the general public via extensive outreach efforts. Such efficient transfer of knowledge and widespread cooperation is critical to mitigating the threats posed by invasive species.

Despite the success in controlling EGVM in California over the last six years, continued vigilance is needed. Because of worldwide trade and ongoing infestations in other regions there are plausible pathways for reintroduction of EGVM into California. Thus, planning is underway to develop a post-eradication response plan in the region that will include continued monitoring across the state to facilitate a rapid, robust response to EGVM should the need arise.

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