Figure 1. Grape berry moth (*Lobesia botrana*). Todd M. Gilligan and Marc E. Epstein, TortAI Tortricids of Agricultural Importance, USDA APHIS ITP. Courtesy of Bugwood.org.

Best practice eradication

Learnings from European grapevine moth eradication efforts in Napa, California.

While in the US on a study tour in September, Vinehealth Australia Technical Manager Suzanne McLoughlin met with Monica Cooper and Lucia Varela, University of California Cooperative Extension Farm Advisors, to discuss efforts in controlling, containing and ultimately eradicating *Lobesia botrana* (European grapevine moth). This article provides insight into the collaborative approach taken to eradicating this exotic pest, which earnt program leaders a federal Administrator's Award in September 2012. What can we in Australia learn from this?

Native to Mediterranean Europe, the European grapevine moth (*Lobesia botrana*) (Figure 1) is a serious pest of grapes. It has invaded Europe, west Asia, North Africa and East Africa, Middle East and eastern Russia. It was detected for the first time in Chile in April 2008, in California in September 2009 and in Argentina in April 2010 (Ioriatti et al. 2012 and Varela et al., 2013).

Grape is the preferred host and larvae feed on flowers, and on or inside both green and softening berries (Smith et al, 2010) (Figure 2).

In the United States, the first detections were in the Napa county, California, where this invasive pest and associated fungal rot caused significant crop damage in 2009. Crop loss of US$150,000 was reported in the vineyard in which L. botrana was first detected.

How did the wine industry respond? With a coordinated, award winning eradication program.

Setting the plan of attack

Getting the right people around the table

Within 2 months of detection, the United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA APHIS) agency put in place a Technical Working Group (TWG) of subject-matter experts, comprising federal, state and county government personnel, researchers, extension staff and a representative of the winegrape industry. The group was tasked with providing urgent scientific recommendations to regulatory program managers in California.

International scientists were also identified and engaged from Italy, Spain, Chile, France and Germany, and invited to be part of this group. These specialists were imperative to share knowledge; particularly the Chilean who had dealt with an incursion a year prior. The

Chilean management program was in fact replicated in the first instance for the Californian situation.

Setting the eradication strategy

The TWG set an eradication strategy as follows:

1. Identify the geographic range of *Lobesia botrana* in California;
2. Develop and implement detection and management programs;
3. Regulate the movement of plant material and equipment to minimise the threat of dispersal;
4. Incorporate research-based information developed by subject-matter experts into policy decisions; and
5. Promote a wide-reaching educational program for grapegrowers, the public and local officials.

The activities of this strategy drastically reduced insect populations and limited the distribution in Californian vineyards such that previously affected areas were removed from quarantine. Within six years, *L. botrana* was eradicated.

CONSIDERATIONS FOR AUSTRALIA:

- Do we have local and international specialists listed for our high priority plant pests whom we can call on as needed?

Gauging the enormity of the problem

Monitoring

Monitoring of male moth flights was undertaken both outside and inside the quarantine zones using pheromone-baited sticky traps. Traps were distributed by government staff on a standard 10 traps per km² grid system for planted vineyard inside a quarantine area and at three to six traps per km² outside a quarantine area.

In urban environments, traps were placed on potential host species at a density of two traps per km². These traps gave the TWG a guide as to hotspot areas where additional surveillance could be deployed at a higher density. It also offered a guide to initiation and peak of flights, to help time insecticide applications for larval emergence. Monitoring for larvae and egg masses was also undertaken by government staff. Effectiveness of the eradication strategy can be seen by the large decrease in male moth numbers trapped over the life of the incursion in Napa County (Table 1).

Table 1. Number of *L. botrana* male moths trapped in Napa County and traps deployed at peak trapping (modified from Varela et al., 2015 and Eberling, 2015).

Year	Males moths trapped	Traps deployed
2010	100,831	3,882
2011	113	4,930
2012	77	4,706
2013	40	11,621
2014	0	11,656
2015	0	11,627
2016	0	unidentified

Identifying host plant species

Pheromone traps and treatments were deployed in all potential host species of *L. botrana*, including blackberry, elderberry, olive, wild rose, wild and domestic grapes, wild and domestic plums, peach, nectarine, blueberry and gooseberry (a host list of 40 species, but true hosts were few and grape was identified as the favoured host).

Olives were found to be a minor host of *L. botrana*, but only to the first generation, as flowers were the preferred feed source.

The TWG identified that *L. botrana* did not venture into commercial crops other than grapes in California. Eradication probably wouldn't have been possible if this wasn't the case.

Quarantine

Setting up quarantine zones

In the first year of the eradication strategy in 2010, a conservative approach was taken to setting up quarantine zones, also known as 'regulation' zones. These were established in an 8km radius of a detection, where a detection was defined as either:

1. Two or more adult moths trapped within 5km of each other during the same life cycle ; or
2. Immature stages proved to be *L. botrana* by DNA analysis.

Regulating movement

In June 2010, a federal order indicated plant host species as well as plant parts, products, farming and processing equipment, and green waste residues could not be transported interstate from a European grapevine moth quarantine area, except under specific conditions. State quarantine enforced restrictions parallel to those in the federal order, for intrastate movement of items within or from quarantine areas. Businesses were required to sign compliance agreements that mandated specific activities prior to and during harvest, transport, processing and waste handling (Cooper et al., 2014).

Continual research into the biology of the insect determined that it was in fact a weak flier, flying less than 50m in distance. With this additional knowledge, the 8km quarantine zone was reduced to 5km by 2013, and the treated area reduced to 500m from the point of detection occurring in the current year and previous two years.

Qualifying for deregulation from quarantine status

The TWG recommended that all portions of an entire contiguous regulated area should be deregulated at the same time, and specified a range of conditions underpinning qualification for deregulation:

1. No moths captured during five consecutive generations;
2. Insecticide treatments to continue to target the first and second generations;
3. Mating disruption may not be used during the final two generations within the area under regulation; and
4. During these final two generations, trap density must increase to 39 traps per km² in all vineyards within 500m of previous detections.

Based on the above criteria, four counties were removed from regulation at the beginning of 2012. By the end of 2012, another three counties were fully deregulated and two counties partially deregulated, leaving Napa county and parts of Sonoma and Solano counties remaining under regulation in 2013.

The remainder of the Solano county and most of the Sonoma county, as well as southern Napa County were deregulated in 2014, leaving the remainder of the Napa Country and a small portion of northern Sonoma County – 115,500 hectares in total – regulated during 2015.

No moth was detected in 2015 or in the first two flights of 2016. As a result, *L. botrana* was declared eradicated from California in August 2016.

Management of winery waste

While it is still unclear as to how *L. botrana* entered the state of California, winegrape movement was deemed the movement vector responsible for spreading the pest within the state. In addition, spread also occurred by machinery moving between vineyards.

One research project focussed on investigating potential pest spread through the movement and treatment of winery waste. Results showed that winery waste was not a large contributing factor to spread, as *L. botrana* was killed during the (whole bunch) pressing stage when pressed to 28 psi. However, accidental spills of grape matter were found to be a potential mechanism for spread in the winery, so cleaning disassembled winery machinery with hot water was found to be critical.

During the quarantine period, a mandated practice was that all stalks

and stems were required to be properly composted inside the quarantine zone, to ensure specified temperatures were reached to kill the insect. In practice this meant composting at commercial facilities.

CONSIDERATIONS FOR AUSTRALIA:

- Do we know where our urban vines are?
- Do we have comprehensive host species lists for all high priority exotic plant pests?
- Do we have digital land use maps showing the location of these species?
- What are our guidelines for continued monitoring after an eradication is declared?
- Do we have a gauge on the amount of composting of grape marc, stalks and stems that is conducted away from commercial facilities that could pose a pest and disease risk?

Action in the field

The eradication strategy involved the use of three tools – insecticides, pheromone-based mating disruptors and host removal, which varied in combination based on land use and occurrence of potential host species. In the urban environment, fruit removal from backyard grapevines in spring or early summer was the preferred approach.

Identifying insecticides and timing of applications

In the first year, two large insecticide research trials were undertaken. Every registered insecticide for use on grapes was evaluated for effectiveness to kill *L. botrana* eggs and larvae. This was important research given both conventional and organic management systems needed to be provided for.

These research trials determined insecticide options to be used in conjunction with mating disruptors for non-organic growers – Intrepid (chlorfenapyr) and Altacor (chlorantraniliprole), for use in alternation for each moth flight. For organic growers, *Bacillus thuringiensis* (Bt) and Entrust Naturalyte (spinosad) were identified. The latter was not used by growers, however, due to cost. A limited product list allowed fewer negotiations with chemical companies to ensure sufficient product was available for the eradication effort. In addition, fewer product choices meant that varying efficacy did not affect the eradication effort.

Timing of insecticide applications played a very important part in leading to the eradication of *L. botrana*. Local research using temperature modelling, predicted three generations per year in the Napa Valley, which was then validated through ground observations (Gutierrez et al., 2012).

A subgroup of the TWG met every week to revise the spray schedule for growers, based on degree days, to model the lifecycle development of the insect. Insecticide applications were timed to coincide with the most vulnerable stages of the pest.

Once preferred products were identified, discussions with manufacturers occurred in attempt to gain registration for use in affected crops in the required counties. Some chemical companies did not chose to take out registrations for their products for this cause.

Mating disruption

The use of mating disruptors in the form of ISOMATE pheromone dispensers applied over large, contiguous areas, in conjunction with well-timed insecticides, were found to be very successful in controlling *L. botrana*. Significant research was undertaken by the TWG to evaluate the efficacy and longevity of four pheromone lures before a suitable lure was chosen, approved and registered for use.

Mating disruption works by using many ISOMATE dispensers to saturate the air with synthetic female sex pheromones which confuses the male moths and renders them unable to locate females. This suppresses mating and therefore crop damage. Although mating disruption does not completely inhibit *L. botrana* mating, delayed mating reduces populations because older females produce fewer eggs than younger females (Torres-Vila et al., 2002).

CONSIDERATIONS FOR AUSTRALIA:

- How quickly can we obtain chemical registrations in an emergency scenario?

Communicating the eradication strategy

Program leaders provided transparent, consistent, timely and coordinated communication to parties directly and indirectly affected by the eradication effort (Cooper et al., 2014), which became a hallmark of the program. Communication included:

- A toll free number, established for reporting possible *L. botrana* finds.
- A range of education materials such as brochures, posters, weekly newsletters, a training video, postcards, door-hangers, magnets, billboards, signs, radio announcements, social media and websites.
- Community meetings.
- Field days.
- Focussed communication with core groups such as growers, hobby (non-commercial) winemakers and grape carriers.

CONSIDERATIONS FOR AUSTRALIA:

- Do we have contact lists of non-commercial winemakers and a plan for reaching them in an incursion?
- Do we have a list of concerned lobby groups that require consultation in the event of an incursion?
- Do we have a list of grower liaison staff and wine industry consultants who could be key to information dissemination in times of an incursion?
- Do we have a public relations plan that includes consistent messaging for public-facing industry personnel?

Funding

While grapegrowers did not contribute extra levies to the *L. botrana* eradication strategy, they were responsible for paying for and applying the required insecticides. Application of mating disruptors was not adopted as effectively as the insecticides, with only approximately 50% of growers applying them in the first full year of the strategy in 2010. The following year, a grant was obtained which paid for the pheromone dispensers, which growers then applied.

A state-wide spend of at least US$105 million has been reported for the *L. botrana* eradication activity. USDA contributed US$46.5 million, Napa County spent US$9.8 million and the wine industry, US$49 million, with activity including trapping, insecticide application and quarantine compliance (Eberling, 2015).

Given the value of the grape industry at more than US$4 billion in California alone (European Grapevine Moth Post-Eradication Response Working Group, 2016), the high cost of the eradication program for *L. botrana* at more than US$100 million was justified, along with maintaining a robust and sensitive early detection trapping program for the insect.

Major lessons learned

- When faced with an incursion, the first thing to assess is whether it's even possible to eradicate, based on money, time, resources available and pest host range. The ease and success of an eradication effort is far more likely for an insect with a limited host range.

- All participants in an eradication effort need to be on board.
- Having extension staff as part of the TWG playing an impartial role between the regulators, researchers and growers was important to ensure the needs of all parties were met when devising the eradication strategy.
- Permitting researchers to undertake research concurrently with rolling out the eradication strategy hastened learnings and practical solutions.
- Ensuring research funding bodies were at the table from the start meant research priorities were identified and appropriately funded.
- Availability of a continual funding source at the required level for the life of the eradication strategy allowed the strategy to be fully implemented, contributing greatly to the result.
- Communication to industry personnel must continue post eradication, to ensure recognition of the pest, so that any new outbreaks are rapidly identified.
- A single, unified message to industry and community is vital to ensure no confusion of message.
- Effective control measures must be available for use.
- Stakeholder networks must assist in communicating messages. This will be the fastest way to reach everyone.
- Transparency and honesty is key – distrust takes a long time to repair.
- Don't make assumptions.
- Learn from previous eradication efforts around the world.

Note: This is an edited version of a case study. The full version is available on the Vinehealth Australia website, visit http://www.vinehealth.com.au/news-events/case-studies/.

Figure 2. European Grapevine Moth (*Lobesia botrana*) mature larva out of its nest on a cluster of damaged Merlot grape berries. Photo by Jack K. Clark.

References

1. Cooper, M., Varela, L., Smith, R., Whitmer, D., Simmons, G, Lucchi, A., Broadway, R and Steinhauer, R. (2014). Growers, scientists and regulators collaborate on European grapvine moth program. California Agriculture. October-December. http://californiaagriculture.ucanr.edu

2. Eberling, B. (2015). European Grapevine Moth nearing eradication – from the Napa Valley Register. CDFA Planting Seeds Blog http://plantingseedsblog.cdfa.ca.gov/wordpress/?p=9276

3. European Grapevine Moth Post-Eradication Response Working Group (2016). European Grapevine Moth Post-Eradication Response Guidelines. Report.

4. Gutierrez, A.P., Ponit, L., Cooper, M.L. et al. (2012). Prospective analysis of the invasive potential of the European grapevine moth *Lobesia botrana* (Den. & Schiff.) in California. Agr Forest Entomol 14:225-238.

5. Ioriatti, C., Lucchi, A. and Varela, L. G. (2012). Grape berry moths in western European vineyards and their recent movement into the New World. In: Bostanian, N.J., Vincent, C, Isaacs, R. (eds). Arthropod Management in Vineyards: Pests, Approaches, and Future Directions. Springer Science + Business Media B.V. p339-359.

6. Smith, R. J., Varela, L. G., Cooper, M, L., Bentley, W. J. and Bettiga, L. J. (2010). European Grapevine Moth (*Lobesia botrana*) brochure. University of California Agriculture and Natural Resources.

7. Varela, L. G., Cooper, M. L. and Smith, R.J. (2013). Can European grapevine moth, Loesia botrana (Lepidoptera: Tortricidae) be eradicated from California? In: Calonnec, A., Duso, C., Gessier, C. et al. (eds). IOBC/WPRS Bulletin 85: 92-102.

8. Varela, L. G., Cooper, M. L., Lucchi, A. (2015.) Update on *Lobesia botrana* Program in California. https://www.iobc-wprs.org/pub/2015_WG_Viticulture_Vienna/20151022_09_IOBC_Vienna_Entomology_Varela.pdf