Large infestations of vine mealybugs can lead to defoliation, berry damage, and rot.

VINE MEALYBUG

Formidable pest spreading through California vineyards

BY Kent Daane, Associate Specialist, University of California Extension, UC Berkeley;
Ed Weber, Napa County Farm Advisor, University of California Cooperative Extension;
Walt Bentley, Entomologist, University of California Statewide IPM Project

Several species of mealybugs are pests of grapevines in many parts of the world. In California, the grape mealybug, long-tailed mealybug, and obscure mealybug have long been present in vineyards, but they are usually minor pests not requiring chemical control. Recently, the invasive vine mealybug (VMB) has emerged as a serious pest in many parts of the state. It brings with it the need for aggressive chemical management.

Distribution and damage

Vine mealybug is found in the Mediterranean regions of Europe and North and South Africa, as well as grapegrowing regions in the Middle East, Argentina and Mexico — and now in California.

In California, vine mealybug was first discovered in 1994 in table grape vineyards in the Coachella Valley (Riverside County), although it probably entered the state a year or two earlier. It spread throughout the Coachella Valley, and in 1998 was found in the southern San Joaquin Valley (Kern County).

Its dispersion into new regions has been dramatic: VMB was found in Fresno County in 1998, Santa Barbara County in 2000, San Luis Obispo County in 2001, and in El Dorado, Madera, Monterey, Napa, Sacramento, Sonoma, and Stanislaus counties in 2002. To date (March 2004), VMB has been found in 17 counties in California (Table I). It is likely that there are more infestations that have yet to be identified or have not been reported.

Circumstantial evidence suggests this rapid dispersion resulted from movement of infested vineyard equipment (mechanical harvesters, bins, tractors, etc.) and through sales of infested nursery stock (from 1998 to 2003). Other possible factors include spread with field crews and natural dispersion (such as birds and wind-blown infested leaves).

Mealybugs are phloem feeders. As they feed, they produce a sugary excretion (honeydew) that supports the growth of sooty mold. Infested clusters become contaminated with honeydew, sooty mold, egg sacs, and lots of mealybugs.

In southern California, severe vine mealybug infestations have also reduced vine growth and resulted in defoliation, bunch rots and even spur and cane death. In addition, like other mealybugs, vine mealybugs can spread grapevine virus diseases, such as leafroll and corky bark.

Several factors make vine mealybug much more damaging and difficult to control than other mealybug species:

- First, the vine mealybug reproduces at a higher rate than other species, enabling small numbers of mealybugs to reach damaging levels in one season. Females can each deposit up to 700 eggs (average is approximately 300).

In San Joaquin Valley, vine mealybug has four to seven generations per year compared with two for the grape mealybug. This greatly increases the population size, and it leads to overlapping generations. The overlap makes chemical control more difficult, since some insecticides are effective only against the nymphal stages.

- Second, vine mealybug excretes much more honeydew than other species. This honeydew can cover leaves, canes, trunks and fruit, making entire clusters and vines a sticky mess. The honeydew often becomes so thick it resembles soft candle wax.

Fruit from heavily infested vines is not suitable for harvest. The stickiness of all the plant parts also facilitates spread of VMB from vineyard to vineyard on equipment and worker clothes.

Cabernet Sauvignon infested with vine mealybug. This degree of honeydew buildup is typical of the damage that occurs in warm areas (San Luis Obispo County, in this case). [Photo by Mark Battany]

Sex-pheromone baited traps are being used to monitor male vine mealybug flight times and densities.

- Third, vine mealybug can feed on all parts of the vine throughout the year. It can be found on leaves, in clusters, under the bark, and even on the roots of grapevines. By hiding under bark or on the roots, VMB is protected from most foliar insecticides, from high summer temperatures, and from parasitoids and other natural enemies.
- Fourth, vine mealybug is not native to California, so it has fewer natural enemies than the grape or longtailed mealybug species. Established populations will require repeated insecticide treatments to keep them at manageable levels.
- Finally, vine mealybug has a wide host range. It can feed on subtropical (grapes, figs, apples, and citrus) and tropical (dates, bananas, avocados, and mangos) crops as well as a number of common weeds, such as malva, burclover, black nightshade, sowthistle, and lambsquarter. However, in California, grapevines appear to be its preferred host throughout the season.

Population cycles

Vine mealybug population cycles and its distribution on vines can vary dramatically, depending on temperatures and vine condition. While it can be found on all parts of the vine at any time of the growing season, there are clear dispersal and abundance patterns that influence the amount of damage and the effectiveness of chemical and biological controls.

For example, in the Coachella Valley, most of the vine mealybug population overwinters on the roots and lower trunk sections. As temperatures warm, populations rapidly increase reaching a peak in April and May. Accompanying the increased density is the pest's movement up the vine, from the roots and lower trunk to the leaves and grape clusters.

Management becomes a race between the table grape harvest (May-June) and the time when mealybugs reach the clusters. With hot summer temperatures after harvest, the population decreases and again is found primarily on the lower trunk and roots. There is another population increase in fall, before the overwintering period.

In San Joaquin Valley, vine mealybugs also overwinter on the roots and lower trunk, and as the temperatures warm in spring and summer, they move up to the leaves and bunches. Unlike in Coachella Valley, populations continue to increase during summer, and they remain on leaves until August.

All stages were found throughout the summer, feeding on leaves and canes in exposed locations, suggesting that San Joaquin Valley temperatures had little effect on vine mealybug densities. A late-season reduction was not accompanied by an increase in summer temperatures, but was associated with increased parasitism levels. Nevertheless, the longer the mealybugs remain on leaves and clusters, the more damage they cause to the crop.

In the Central Coast and North Coast, VMB appears to follow a pattern similar to San Joaquin Valley. However, the populations continue to increase through September and October. The late season increase is most likely due to an absence of parasites in these areas. As in other regions, considerable damage is likely to occur unless insecticides are used. Because most VMB infestations are still discrete in these regions, eradication programs are being attempted in some counties.

Potential for further spread

Until recently, little attention was given to vine mealybug, leading to its rapid spread throughout California. This history shows how easily it can be moved, both within grapegrowing regions and over long distances. With more attention now focused on vine mealybug, its further spread should be slowed, although complete control is not likely to occur.

The sticky nature of the honeydew produced by vine mealybug greatly facilitates its spread. All parts of the vine get very sticky — leaves, canes, berries, clusters, cordons, and trunks. Adult insects, nymphs, and eggs can get stuck to tractors, bins, picking pans, gloves, etc., and can thereby be transported to other locations.

Machine harvesters pose a significant risk because they operate in vineyards when populations are high. They have considerable contact with fruit and foliage, and are frequently moved from vineyard to vineyard. If operated in an infested block and then moved without a thorough cleaning, spread could easily result. Operators need to be made aware of any vine mealybug infestations in blocks they are harvesting, and growers should discuss equipment sanitation practices if using a contract harvesting service.

Movement of infested nursery stock has resulted in numerous infestations throughout California. Some nurseries have recently implemented prevention measures that should greatly reduce the chances of further introductions on plant material. In addition, the California Department of Food and Agriculture (CDFA) has issued a nursery advisory that requires monitoring and/or sanitation protocols for VMB.

Nursery sanitation practices include hot water treatment of cuttings and dormant vines, insecticide applications to green-growing plants, and insecticide applications to nursery mother blocks. CDFA regulations do not require nurseries to take all of these steps, so it is prudent for buyers to discuss vine mealybug control practices with their nursery sources prior to purchasing vines.

Furthermore, while hot water treatments for dormant wood can provide excellent control, insecticide treatments of green-growing plants have not yet been thoroughly tested.

Grape clusters harvested from infested vineyards could also lead to spread of VMB because the stems will likely still contain insects or eggs after passing through a winery crusher/

Table I. Counties with VMB infestations

Alameda	San Joaquin
El Dorado	San Luis Obispo
Fresno	Santa Barbara
Kern	Santa Clara
Madera	Sonoma
Monterey	Stanislaus
Napa	Tulare
Riverside	Yolo
Sacramento	

An adult male vine mealybug (the only stage that has wings), near an adult female which is beginning to deposit a waxy "ovisac" that contains the eggs.

destemmer. If spread directly back into vineyards, new infestations could result.

Composting infested stems (away from any vineyards) should provide adequate control, as long as the composting process follows state regulations and proper temperatures are reached within the compost piles (above 130ºF). Further research is needed to confirm the effects of composting on infested stems.

Monitoring

To prevent damage from vine mealybug, the best way is to keep the pest out of vineyards or to chemically treat populations when an infestation just begins. However, mealybugs are difficult to detect in the early stages because they are often hidden under bark or underground. Visible signs of an infestation include the presence of foraging ants, honeydew or sooty mold on leaves or trunks, bark that appears wet, and white wax protruding from underneath the bark.

Until recently, visual sampling methods were the only way to spot new infestations, and they were far too labor-intensive to be practical. In 2001, a faster, more effective method to monitor VMB was developed, based on a sex pheromone that female VMBs use to attract winged adult males.

This pheromone has now been synthetically produced. In field tests, traps baited with synthetic pheromone were attractive for two months, had an effective range of about 300 feet, and had counts that could be correlated with VMB densities in the vineyard. Using this sex pheromone to attract winged males is a far more efficient method of detecting new infestations than trying to search thousands of vines for hidden females.

Unfortunately, the males are extremely small (less than 1⁄64 of an inch) and difficult to identify without considerable training and experience. Many growers are establishing their own trapping programs and are working with their local agricultural commissioner's office for help in identification of insects in their traps.

Male vine mealybugs are tiny (a bit smaller than adult thrips) and brown-to-black in color. They have a single pair of wings, a small "V" tail, and long antennae. In sticky traps, they quickly lose their coating of white wax and become even more difficult to identify. For this reason, examine traps as soon as suspicious insects are observed. Remember that "close up" photographs make the insects look larger and easier to identify.

Trapping programs

In California, free traps and lures may be available in 2004 from county agricultural commissioners. The preferred trap is the tent-shaped Pherocon® IIID trap (www.trece.com) loaded with a vine mealybug pheromone lure (www.suterra.com). These three-dimensional traps provide better adult male VMB catch and lower "unwanted" insect catch as compared with flat traps.

Traps should be hung at or above the cordon and near the center of the vine. Trellis wires make a good attachment point. Traps can be placed in the canopy to get some protection from wind and equipment, but the open ends should be exposed so that VMB males can easily fly, rather than walk, into the trap. The trap position may have to be changed during the season to avoid interference with vineyard management operations.

Two traps are suggested for each 20- to 40-acre block monitored. Put one trap near the center of the block and the other in a "high traffic" area (near roads or intersections, equipment storage areas, field shops, or packing houses).

There is no reason to place traps deep inside the vine or well within a vineyard block such that crews cannot easily find and monitor them. If more traps are used, they should be placed at least 30 rows apart (about 200 to 300 feet) and at least 10 vines from the edge of each block. Make sure the triangular entrance to the trap is not blocked by leaves. This will reduce the number of males caught.

Traps should be checked every two weeks during the male flight period (see below). Lures should be changed at least every six to eight weeks. Traps need to be changed only when they are old and dirty, or when male VMB are detected (so they can be confirmed microscopically and counted). If no male mealybugs are found and the sticky surface is still functioning, new lures can be placed into old traps.

In heavily infested vineyards, we have found over 2,000 males weekly per trap. Typically, an infested vineyard will have between 20 to 300 males per trap per week. If fewer than 10 VMB males are found weekly in a trap, then the infestation may be in another block. Trapped males may be from neighboring or even distant blocks, as the males can be wind-blown from one-half mile or more away.

In those counties where vine mealybug does not commonly occur, vineyard managers should contact the county agricultural commissioner's office and the UC Cooperative Extension farm advisor to get a positive identification of trapped mealybugs, and to discuss management decisions and compliance agreements as necessary.

Male flight periods

In Coachella Valley, the male flight period extends from about March through August. In San Joaquin Valley, the flight will run from May through October. On the North Coast, males have been trapped from May to November, with the largest numbers occurring late in the season. Females often mate in the fall, so the first male flight in the following spring may be after vine mealybug activity begins.

An adult female vine mealybug just before she begins to produce eggs. Note the short "tail" filaments that help to distinguish the vine mealybug from other vineyard mealybugs.

Chemical controls

A number of insecticides can be used to kill exposed vine mealybug, especially the small nymphal stages. The hidden portion of the population is harder to control. For this reason, vine mealybug is difficult to eradicate once it has become well established in a vineyard. Systemic insecticides (such as Admire®) that reach all parts of the vine have been the most effective. A control program attempting to eradicate vine mealybug should include:

- Delayed dormant application of Lorsban (February or March),
- Spring application of Applaud or Sevin (Sevin may cause mite outbreaks),
- Systemic application of Admire in spring,
- Summer to fall foliar treatments (Applaud, Dimethoate, Imidan, Malathion),
- Post-harvest application of Lorsban.

Be sure to follow all instructions on the manufacturers' labels, and check for restrictions on use and proper safety considerations for your area. For more information on chemical controls, contact your local University of California Cooperative Extension farm advisor or county agricultural commissioner. For University of California guidelines and a list of registered materials, see http://www.ipm.ucdavis.edu/PMG/r302301911.html.

Biological controls

A number of predators and parasitoids have been recorded attacking vine mealybug in California. Many common general predators will feed on all vineyard mealybug species, including vine mealybug.

Vine mealybug is closely related to the citrus mealybug, sharing a number of parasitoid species that are already present in California. Additionally, recent foreign explorations for new parasitoids have added to the parasitoid complex.

Anagyrus pseudococci is the most common parasitoid attacking vine mealybug. It is well established in the San Joaquin Valley. The adult female is about 1/32 of an inch (2 mm) in length, golden brown in color with long antennae that are black at the base and then white to the ends. The male is smaller, dark-colored with hairy antennae.

In the laboratory, *Anagyrus pseudococci* attacked second, third, and adult stage vine mealybugs at rates of 19%, 33%, and 48%, respectively, indicating that it prefers larger mealybugs. Parasitoid development time is about 18 days during the summer.

In field trials, this parasitoid attacked 70% to 95% of the exposed vine mealybugs in August and September in San Joaquin Valley. However, considerable damage to fruit still occurred. Parasitism in Coachella Valley was lower, never exceeding 20% (unless parasitoids were released). The difference in parasitism levels between these two regions is largely attributed to the greater period of mealybug exposure to parasitoids in San Joaquin Valley.

Parasitism rates can be improved by releasing *Anagyrus pseudococci* early in the season. Studies suggest that an early season release of 20,000 parasitoids per acre has increased parasitism and reduced crop damage, although this research is still in progress and may vary greatly among vineyard regions.

Leptomastidea abnormis was recently released in Coachella and San Joaquin valleys. The adult is slender, about 1/32 of an inch (2 mm), and patterned white and black, including the antennae. *Leptomastidea abnormis* is not as common as *Anagyrus pseudococci*, and it currently accounts for less than 10% of the parasitism. In the laboratory, *Leptomastidea abnormis* attacked second, third, and adult stage vine mealybug at rates of 61%, 32%, and 7%, respectively, indicating that it preferred smaller mealybugs.

While predators and parasitoids may help reduce the overall number of vine mealybugs present, they alone will not provide sufficient control to keep populations below damaging levels.

Future prospects

Vine mealybug is a pest that no one wanted. Along with its potential for damaging vines and reducing marketable yields, it brings with it the need for considerable insecticide use. This runs directly counter to the industry's move towards sustainable farming methods and reductions in pesticide use.

Continued vigilance is needed to reduce vine mealybug populations and to limit its further spread, both within vineyards that are currently infested, and from infested vineyards to non-infested ones. Growers should train all workers in mealybug identification and react quickly to any new finds.

Managers of infested blocks should follow all recommended treatment protocols and manage their equipment and workforce to minimize spread.

Wineries need to be aware of the status of vineyards delivering fruit to them, and they must take steps to properly dispose of stems coming from infested blocks. Grapevine nurseries should implement quality assurance measures to prevent further spread on plant materials.

Unfortunately, vine mealybug is a pest that is here to stay in California. However, if everyone takes appropriate steps, its overall impact should be reduced. ■

Additional sources of information:
http://www.vinemealybug.uckac.edu/
http://cenapa.ucdavis.edu/Viticulture/Vine_Mealybug.htm

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PRACTICAL WINERY & VINEYARD
58 Paul Drive, Ste. D, San Rafael, CA 94903 • 415-479-5819