Mealybugs in Vineyards: Identifying, Monitoring and Managing

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Mealybugs have become increasingly important pests in California vineyards. These tiny, plant sap sucking insects can be quite elusive; often growers do not realize they have a problem until harvest, when "suddenly" mealybugs appear in clusters. PCAs working in vineyards should become familiar with the tools helpful in finding mealybugs early in the season, the tricks to identifying which species are present, and the rationale for appropriate management at the right time.

General Mealybug Biology

Most mealybugs lay yellow or orange eggs in a white fluffy ovisac under bark on the trunk, cordon and spurs. The tiny, yellow-orange first instar nymphs, called crawlers, hatch and move out from under the bark to the spurs and leaves, molting several times and usually returning to under the bark before reaching the adult stage. The long-tailed and the Gill's mealybug lay live crawlers directly without an egg stage. Mealybugs produce white waxy secretions that cover their bodies in various amounts depending on the species, usually producing more wax as they grow through their nymphal instars to adults. This wax also serves as a barrier to pesticides and predators which is why the crawler stage is the most vulnerable stage to pesticide sprays, *if* the crawlers are on a part of the vine that sprays can reach with good coverage. Only the male mealybugs have wings but they are so tiny they are never seen, except for the vine mealybug for which a pheromone trap is available. The male vine mealybug can be seen on the trap with a hand lens.

Mealybugs feed on plant phloem producing honeydew, and they have a mutualistic relationship with ants; ants will feed on mealybug honeydew and in return the mealybugs are protected by ants from natural enemies. When probed or attacked by predators, mealybugs produce ostiolar fluid from their rear abdomen which is thought to be a defense mechanism.

Mealybugs stress vines by feeding on phloem and can affect sugar and color accumulation in berries; their white waxy bodies, honeydew and associated sooty mold is unsightly. Researchers are gaining a better understanding of the role of mealybugs in transmitting plant viruses; we now know that many mealybug species can transmit strains of leafroll virus, a potentially serious disease impairing the ripening of grapes.

While the presence of vine mealybug necessitates treatment, vineyards with other mealybug species may only need treatment one in a few years when populations build to intolerable levels. Factors that may influence the need to treat include harvesting date, those varieties harvested later will have more time to build mealybug populations, and pruning style, styles that leave a lot of clusters in close contact to wood will have greater mealybug densities in those clusters.

Fig.1: Vine mealybug, Planococcus ficus, adult female and egg mass on bark. Photo: Jack Kelly Clark, courtesy UC Statewide IPM Program.

Key Mealybug Species

Key features used in identification are: presence and length of the body margin and caudal tail filaments; the amount of wax present; and the color of the ostiolar defense fluid.

There are four relatively common species of mealybugs found in grapes in California: vine (*Planococcus ficus*) (Figure 1), grape (*Pseudococcus maritimus*) (Figure 2), obscure (*Pseudococcus viburni*), longtailed (*Pseudococcus longispinus*) and a fifth species is a rare newcomer, Gill's mealybug (*Ferrisia gilli*) (Figure 3). Your geographic location will help determine which mealybugs are likely to be present: grape and obscure mealybug are found in North Coast and San Joaquin Valley vineyards; obscure and longtailed mealybugs are found in the Central Coast; longtailed mealybug is found in the Coachella Valley; vine mealybug is found in nearly every grape growing region except for the upper Sierra foothills; grape mealybug is in the Sierra foothills, and Gill's mealybug has only been found, to date, in the Sierra foothills.

Fig.2: Grape mealybug, Pseudococcus maritimus, adult and immatures. Photo: Jack Kelly Clark, UC Statewide IPM Program.

Fig.3: Adult female Gill's mealybug, Ferrisia gilli. Photo: D. Haviland

The Newcomer: Gill's Mealybug

Gill's mealybug adults are relatively large (2-5 mm) and easy to spot due to their large amounts of long, filamentous wax. The interruption of the waxy coating gives this mealybug the appearance of two stripes, and for a time it was confused with the striped mealybug. Gill's mealybug is a bit of a mystery; it was first found on pistachio in the Valley in the 1990s, and then in 2004 in a foothill vineyard; we are not sure why Gill's mealybug has moved to grapes. Gill's may eventually be found in other grape growing regions of California and PCAs should be on the lookout for it.

Resources for Mealybug Identification

University of California Cooperative Extension (UCCE) Farm Advisors, UCCE Specialists and UC IPM have published a number of excellent resources to assist with mealybug identification and management. The article authored by Lucia Varela, Rhonda Smith, Mark Battany and Walt Bentley appropriately entitled *"Which mealybug is it, why should you care?"* (Practical Winery and Vineyard January/February 2006) is a favorite. The article is online at the Sonoma County UCCE Viticulture website, *http://cesonoma.ucdavis.edu/viticulture717/* under Mealybugs, along with other useful mealybug articles and photos. Table 1 from that article is included here, amended with information on Gill's mealybug (see Table 1).

The UC IPM website has good photos and information on all of the mealybug species *http://www.ipm.ucdavis.edu*, including monitoring and control guidelines. The UC ANR publications *"Mealybugs in California Vineyards"* (Pub. 21612), and *"Vine Mealybug: What You Should Know"* (Pub. 8152) are leaflet sized and provide large color photos. These and other ANR publications are available for sale at county UCCE offices or through the online catalog *http://anrcatalog.ucdavis.edu*. UC Berkeley specialist Kent Daane and UC IPM entomologist Walt Bentley have a mealybug website at *http://vinemealybug.uckac.edu/*. The October-December 2008 issue of ANR's California Agriculture magazine, online at *http://calag.ucop.edu/*, is wholly devoted to sustainable viticulture and includes an in-depth article on mealybugs and their natural enemies.

Parasitoids-Mealybug Natural Enemies

The most important natural enemies of mealybugs are the tiny wasps (parasitoids) that attack them. These parasi-

toids are effective at searching under bark and in cracks and crevices to find the mealybugs-places where pesticides can not reach. The parasitoid stings the mealybug and deposits its eggs into the mealybug-the eggs develop into wasp larvae that eventually emerge from the mealybug as adults, killing the mealybug. Parasitized mealybugs are referred to as "mummies" and PCAs should be able to distinguish between live mealybugs and mummies to gauge the level of biological control in a vineyard. The live wasps are almost never seen but mummies can be quite commonly found under the bark, they are golden in color and they do not move when prodded.

Monitoring (AKA Mealybug Hunting)

I like to refer to mealybug monitoring as mealybug "hunting," since it is like trying to find a needle in a haystack. It is a challenge to enter a vineyard knowing it has mealybugs but not knowing exactly where, which vines, which block. Mealybugs move around the vine during the season; different species are in different locations, at different stages, at different times of the year. Thus, the importance of identifying which species(s) is present.

Essential mealybug monitoring tools include: 1.) hand lens (+ eyeglasses if you need them) to identify the mealybugs; 2.) screwdriver or chisel to chip away bark on the trunk and spurs; 3.) gel caps (available at nutrition and natural food stores) for collection, these fit easily in your pocket and the mealybugs can be transferred to alcohol when you get back to the truck; 4.) flagging to mark vines with active populations so you can return to those vines to monitor; and 5.) the vine mealybug pheromone trap and lures if you are monitoring for vine mealybug.

Mealybugs have a clumped distribution- they are often found in patches, especially when at low densities or when first infesting a vineyard block. The more clumped the distribution of an insect, the larger the sample number needed to accurately monitor, but there are some tricks to help save time. The presence of honeydew and/or ants is a big tip off to a mealybug infestation, however, by the time there is noticeable honeydew production it may be late to treat.

A screwdriver or small chisel is a valuable tool for scraping vine bark and looking for mealybug evidence- the remnants of what I call "mealybug fluff" or the waxy filamentous secretions of mealybugs (although it does not really appear waxy at all but rather fluffy) left by the mealybugs and their production of ovisacs (Figures 4 and 5). Scraping bark can be done in the winter when one can move fairly quickly from vine to vine in a suspect block until mealybug evidence, and then the mealybugs, are found. Removing the bark will not harm the vine and in fact can assist with treatments for mealybugs. Locating vines that have active mealybug populations allows you to return to those same vines to check for the stage and location of the mealybugs to time treatments for when crawlers are present and in a vine location vulnerable to sprays.

In spring, old spurs and pruning scars should be

Fig.4: A screwdriver or a chisel can be used to scrape bark to locate mealybug ovisacs and other mealybug "evidence." Photo: Robin Cleveland

Fig.5: The author, UCCE Farm Advisor Lynn Wunderlich, uses her hand lens to identify mealybugs under the bark. Photo: R. Cleveland.

Table 1: Distinguishing Characteristics Of Grape, Obscure, Vine And *Gill's Mealybugs.

Mealybugs				
	Grape ***Pseudococcus maritimus***	**Obscure** ***Pseudococcus viburni***	**Vine** ***Planococcus ficus***	****Gill's** ***Ferrisia gilli***
Body shape	Rectangular	Rectangular	Oval	Rectangular
Filaments surrounding body	Thin, non-uniform	Thin, non-uniform	Thick, uniform	Thin, non-uniform long filaments cover adult
Filaments posterior end	Thin, long	Thin, long	Thick, short	Thick, medium
Defensive fluid	Reddish, orange	Clear	Clear	Reddish
Diapause (dormant period)	Yes	No	No	Yes
Generations	2	2 to 3	4 to 7	2-3
Synchronized generations?	Yes	No	No	Yes
Stages overlap throughout year?	No	Yes	Yes	No
Overwinters under the bark primarily in:	Upper trunk, cordons, spurs	Trunk, cordons, spurs	Graft union, pruning wounds on trunk, base of spurs. (roots in light soils)	Lower trunk
In summer lays eggs	Under bark on old wood, bunches	Under bark on old wood, bunches	Under bark on old wood, bunches, throughout the canopy, above the fruit zone	No eggs. Lays live crawlers in filamentous "sac" under bark on trunk and spurs, bunches.
Honeydew production	Moderate	Moderate to high	High	Moderate to high late in season.

*Amended from the article *"Which mealybug is it, why should you care?"* by Lucia G. Varela, Rhonda J. Smith, Mark Battany and Walt Bentley, University of California Cooperative Extension, in Practical Winery & Vineyard, January/February 2006.
**Gill's information based on Sierra foothill monitoring data (Wunderlich, Cooper, Daane unpublished).

scraped to look for mealybugs as they will be moving from the trunk up towards the new emerging shoots. During the season mealybugs will return to bark under the spurs, under the cordon and will move to those bunches in close contact with bark so those are the best places to search. The canopy is probably the most difficult place to find mealybugs and therefore really the worst place to look unless infestations are so large they are out of control; vine mealybug is more likely to be found on leaves than other mealybugs, and since it has overlapping multiple generations it's numbers can build rapidly. Prior to verasion is a critical time to monitor for mealybugs, due to the closing of clusters as the berries fill out. Treatments need to be applied prior to cluster closing, since once mealybugs enter the cluster they are nearly impossible to treat and mealybugs can reproduce within the cluster leading to heavy infestations by harvest.

UC IPM guidelines for monitoring grape mealybug recommend monitoring one spur per twenty vines in different locations in the vineyard. Treatments may be warranted if 20% or more of the spurs have mealybugs in wine grapes and, in table grapes, if 4% or more of the spurs have mealybugs. Vine mealybug thresholds are based on male trap catches-consult the UC IPM guidelines online for details.

Crews can be extremely helpful in locating mealybug hotspots if trained on what to look for. Workers moving from vine to vine during shoot thinning, leafing and at harvest can flag vines with suspect infestations (bird tape can work in a pinch). Good record keeping and mapping

of mealybug infestations is essential and will assist PCAs in year to year follow-up.

If vine mealybug is the species of concern, pheromone traps should be employed beginning in spring and checked every 2 weeks. The pheromone is highly effective and males can be trapped from as far away as ¼ mile. The UC IPM guidelines online has information on how to use the traps as well as monitoring guidelines and sample record keeping sheets for mealybugs throughout the year.

Mealybug Imposters

Mealybugs are tiny, so a good hand lens will help you distinguish mealybugs from imposters, such as the predator lady beetle larva, mealybug destroyer (*Cryptolaemus montrouzieri*), and other beetle species that mimic mealybugs with a waxy covering (Figure 6). These beetle larvae are larger than mealybugs, have longer waxy filaments, and when flipped upside down it is easy to distinguish their body parts, head and longer legs.

A PCA brought in a leaf sample that had white wooly fluff on it and wanted to know if it was mealybugs. The sample was caused by a plant hopper that lays its eggs in the petiole, small shoots and leaves and covers the egg incision with a tuft of white wooly material (the adult hopper was not present and neither were any mealybugs).

Those using the vine mealybug trap need to have access to a good dissecting scope or hand lens and be trained in order to identify the tiny (less than 1 mm) males on the trap. Grass mealybug males are commonly found on the traps and look very similar to vine mealybug, but they have longer antennae, no caudal hairs and a very pointed last abdominal segment. The UCCE Sonoma website has an excellent male vine mealybug identification sheet with pictures of both the vine and grass mealybugs.

Treatment

When growers first encounter mealybugs in their vineyards the knee jerk reaction is to "just get rid of them," but the very nature of mealybug biology, the fact that some individual mealybugs are nearly always under bark and inaccessible to sprays, makes this a near impossible task. A more reasonable goal is to use treatments to suppress populations enough to prevent mealybugs from entering clusters, rather than chase eradication. A chemical program that considers conserving natural enemies will provide the best and most cost-effective long-term management solution.

Effective chemical management of mealybugs requires knowing when mealybugs are accessible to sprays (out from under bark), understanding the chemistry of the chosen material, and using large spray volume to get adequate coverage. Growers used to spraying less than 100 gal/ac. for a mildew treatment will need to recalibrate their sprayers in order to apply the recommended minimum of 150 gal/ac for most materials. This is especially true of the reduced-risk materials such as insect growth regulators that require contact with the mealybugs to be effective. As with any pesticide information, the label is the law so please read labels carefully and follow all directions.

Fig.6: Larva of a predatory beetle that feeds on Gill's mealybugs. Photo: David Haviland

The organophosphate chlorpyrifos has a section 24(c) special local needs registration until June 30, 2009 but it has come under intense scrutiny due to water quality concerns-it is extremely toxic to fish and is being closely monitored in water sampling conducted to meet the State Water Resource Board's Conditional Ag. Waiver. PCAs need to be mindful of incoming rains and the potential for site runoff when recommending chlorpyrifos. In addition, chlorpyrifos can disrupt natural enemy populations and so should be reserved to knock down particularly severe mealybug populations. Chlorpyrifos can only be used post harvest until budbreak and PCAs recommending chlorpyrifos post harvest should consider neighboring blocks that may not yet be harvested and the potential for drift onto adjacent fruit. It's a good idea to readjust nozzles for the chlorpyrifos application, targeting the trunk and cordon rather than canopy, if leaf fall has occurred. Larger droplets can be produced by using lower pressures and by nozzles specifically made for this purpose (such as venturi nozzles) to help reduce the potential for drift.

Buprofezin is an insect growth regulator that inhibits chitin synthesis; chitin is a key component of the insect cuticle (skin). Thus buprofezin is only effective on mealybug nymphs that are going through the molting process, and especially on the crawler stage which has less wax than other nymphs and is generally more susceptible to sprays. Due to it's mode of action, it can take a few days for this material to kill nymphs, but feeding should cease prior to death. An advantage to using buprofezin is its short REI, relative low mammalian toxicity, and its softness on natural enemies. Checking to see if the formulation is a dry flowable which requires good agitation to properly mix it; and a surfactant that spreads the material on plant surfaces, rather than a sticker which can coat a.i. particles, is recommended.

Acetamiprid is a neonicotinoid that can be effective on all stages of mealybugs, including adults. Again, good coverage is essential since kill is by contact and ingestion. There has not been a lot of published work on the effect of acetamiprid, or any of the other pesticides, on natural enemies in grapes; but in tree crops acetamiprid has been shown to have toxicity to some species of natural enemies. Acetamiprid is in the same chemical class as imidacloprid and dinotefuran (4A), so these materials should be considered the same for resistance management purposes and should be rotated with another class if multiple mealybug treatments are needed.

Imidacloprid and dinotefuran are available in systemic formulations that can be applied through the drip irrigation system as specified on the labels. Special care to follow regulations and label directions to avoid flow back into the water supply source needs to be taken when applying these materials through the drip. The ANR publication *Chemigation in Tree and Vine Microirrigation Systems* (Pub. # 21599) can be helpful when considering this system. Uptake is essential for this application and soils should be pre-wetted. Binding to soil organic matter and clay particles can impair good uptake and make treatments less effective.

Spirotetramat is a new material now registered for use on grapes for mealybug control. It is classified in Group 23 as a lipid biosynthesis inhibitor. Several UC researchers are looking at this material and should have experimental results published soon. The label warns of damage to berries and clusters when spirotetramat is mixed with some adjuvants and applied after the initiation of bloom.

The vine mealybug pheromone used in mating disruption and applied in dispensers is currently being studied by UC researchers Kent Daane and Monica Cooper and has recently become commercially available. Implementation of such IPM friendly techniques such as mating disruption, used for years in tree fruit, is certain to be the wave of the future in vineyard pest management. Although mealybugs are surely here to stay as vineyard pests, there is also a growing body of knowledge and experience in understanding how to successfully manage them.