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Mealybugs in California Vineyards

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Identification

There are six mealybug species of concern to California vineyard managers. The grape mealybug (*Pseudococcus maritimus*), obscure mealybug (*Pseudococcus viburni*), longtailed mealybug (*Pseudococcus longispinus*), and vine mealybug (*Planococcus ficus*) have already caused economic damage in some California vineyards. The pink hibiscus mealybug (*Maconellicoccus hirsutus*) and citrus mealybug (*Planococcus citri*) have either not been found in California vineyards or are found infrequently.

Geographic Distribution

Each of these mealybug species is currently localized in one or more of the seven main grape-growing regions of California. Vineyard managers should be aware, however, that each species may spread to other regions in the future.

- The grape mealybug is the most widespread and is found throughout the San Joaquin Valley, Central Coast, and North Coast regions.
- The obscure mealybug is found in the Central Coast and occasionally in the North Coast.
- The longtailed mealybug is found in the cooler regions of the Central Coast.
- The vine mealybug is currently found in the Coachella Valley and sections of the Southern and Central San Joaquin Valley. However, its range is expanding, and it was found in a few Central Coast vineyards in 2000 and 2001.
- The pink hibiscus mealybug is found only in the Imperial Valley near the Mexican border but has not yet been found in vineyards.
- The citrus mealybug is rare in vineyards but can be found in the San Joaquin and Coachella Valleys. Growers should be aware that there is potential for any of the mealybug species to move into the South Coast region.

The identification key on page 3 is useful in identifying adult female mealybugs (the males are small, winged, and difficult to find). An important characteristic for distinguishing mealybugs is the presence and length of filaments extruding from the lateral margins and forming a posterior V-shaped tail. These filaments are wax excretions that can break off. Therefore, the approximate sizes shown here are for body length only. For expert identification, samples should be taken to your local County Agricultural Commissioner or University of California Cooperative Extension Farm Advisor's office. To provide an adequate sample, collect 3 to 10 of the



Areas in California with mealybug infestation or potential for infestation (South Coast).

largest mealybugs present and place them in a vial or jar of rubbing alcohol. Label the sample with the collection location and date.

Most of the species found in California vineyards can be discerned by the length of the V-shaped caudal filaments (tail). There are also subtle differences in the biology and behavior of each species. These differences are discussed in the description of each species on pages 5 through 12.

Identification Key

- 1. Wax filaments around body margin well developed?**
Yes. Grape mealybug, obscure mealybug, longtailed mealybug, vine mealybug, citrus mealybug. **Go to 2. No, go to 6.**
- 2. Caudal filaments greater than ¼ of the body length?**
Yes. Grape mealybug, obscure mealybug, longtailed mealybug. These species are *Pseudococcus* mealybugs and can be distinguished by the relative lengths of the tail, the geographic area in which they are found, and differences in population development during the season. **Go to 3. No, go to 5.**
- 3. Caudal filaments between ¼ and ¾ of the body length. Poorly defined mid-dorsal stripe.**
Yes, stop here. Grape mealybug, obscure mealybug. The grape mealybug is found in most grape-growing regions of California. The obscure mealybug is found in the Central and North Coast regions. There are pores called *ostiolae* located near the front and rear margins of both of these mealybugs. When poked with a sharp object, a ball of fluid is excreted from one or more of the pores. In grape mealybug, the fluid tends to be red, and in obscure, it tends to be clear or white. **No, go to 4.**
- 4. Caudal filaments greater than ¾ of the body length. Well-defined, mid-dorsal stripe.**
Yes, stop here. Longtailed mealybug. Occasionally found in cooler regions of the Central Coast.
- 5. Caudal filaments less than ¼ of the body length.**
Yes, stop here. Vine mealybug, citrus mealybug. These two mealybugs are difficult to distinguish. *Submit a sample for expert identification to the local office of the County Agricultural Commissioner or the University of California Cooperative Extension Farm Advisor. No, go to 6.*
- 6. Wax filaments are not well developed around the body margin.**
Yes, stop here. Pink hibiscus mealybug. *Submit a sample for expert identification to the local office of the County Agricultural Commissioner or the University of California Cooperative Extension Farm Advisor.*

Single page version of Key available on page 17.

Damage



Damage to grapevine trunk due to vine mealybug infestation.



Damage to berry cluster infested with vine mealybug.

Mealybugs are phloem feeders that can feed on all parts of the vine: trunk, cordon, canes, leaves, clusters, and occasionally, roots. The numbers of mealybugs found on each plant part varies with mealybug species and time of year. Populations of mealybugs can physically and aesthetically damage grapevines. A loss in vine vigor has been reported for grapevines with large densities of obscure and vine mealybugs. For all of the mealybug species, feeding on the rachises and pedicels in a cluster can result in poor sugar accumulation and color development in the berries. Mealybug feeding activity also provides openings for secondary fungal pathogens such as bunch rots. In addition, the grape, obscure, longtailed, citrus, and vine mealybugs can transmit several types of leafroll virus.

In table grapes, the aesthetic quality of the berries and cluster is paramount to marketability. Cosmetic damage to clusters results from mealybug habitation of and feeding within and above the clusters. As mealybugs feed, they excrete honeydew, which consists of undigested plant sap and sugars. The honeydew covers the berries and clusters and serves as an excellent medium for the growth of sooty mold fungi. The amount of honeydew produced varies with the species of mealybug. Vine mealybug produces large amounts, and when populations are high, the entire vine can be covered by honeydew and sooty mold.

Grape Mealybug



The grape mealybug can be a serious pest throughout the San Joaquin Valley, in some regions of the North Coast, and in the warmer regions of the Central Coast. This mealybug is thought to be native to North America and is found throughout the United States. Grape mealybug is also found on apple, pear, apricot, and pomegranate.

Grape mealybug population densities are dependent on vine vigor and pruning methods. Like



All life stages of the grape mealybug can be present during fruit production.



several other mealybug species, this one prefers more vigorously growing vines. Spur-pruned vines tend to suffer greater damage because the fruit often rests in close proximity to woody parts of the vine where grape mealybugs exist in the largest densities.

Grape mealybugs overwinter under the bark either as eggs in a white, cottony ovisac or as first- or second-instar nymphs. As temperatures warm in spring, the young nymphs move from the old wood

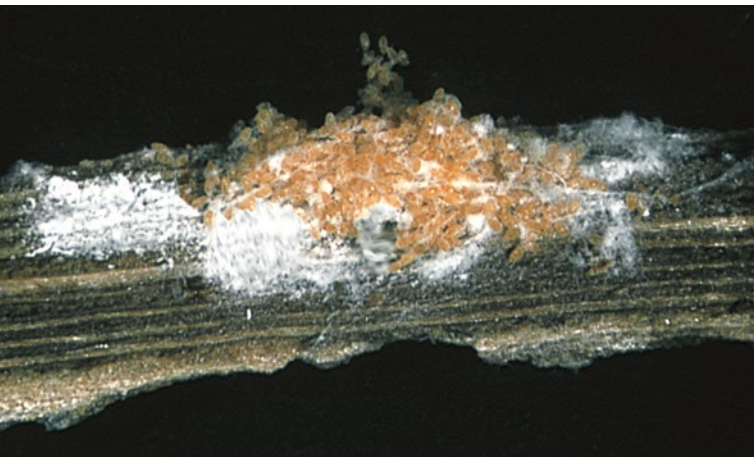
Grape mealybugs move to berry clusters that are in contact with infested old wood.



Grape Mealybug

onto the developing green shoots and leaves to feed and develop. Once these individuals mature in early to mid summer, they return to the old wood to oviposit. Each adult female lays 100 to 300 yellow-to-orange eggs within an ovisac. These eggs hatch in 7 to 14 days, and the crawlers move out to the fruit to feed and develop. This brood develops into adulthood in late summer and early fall. Many of these females return to the old wood to lay the overwintering eggs. However, some adult females that develop in late summer oviposit in the fruit clusters.

Grape mealybug may be tended by ants that feed on the excreted honeydew. The ants can interfere with predators and parasites attempting to attack the mealybugs. This interference reduces the impact of natural enemies on the grape mealybug population.



Eggs of grape mealybug overwinter under bark.



Crawlers of grape mealybug overwinter on spurs and under bark.



Grape mealybug colony with droplets of honeydew nearby.

Obscure Mealybug



Nymphs and adults of the obscure mealybug on grape leaves. The small, reddish nymph on the left is a newly emerged crawler.



An adult obscure mealybug (top) and a newly molted nymph that has not yet developed a waxy coating.


The obscure mealybug is a close relative of the grape mealybug, and it is often difficult to distinguish between the two. The obscure mealybug can be found in the United States, Europe, New Zealand, and Australia; however, its origin is not known. It has a narrower tolerance to temperatures than the grape mealybug and, as a result, is found primarily in the cooler regions of the Central Coast. The obscure mealybug has a larger host range than the grape mealybug and, for this reason, is an important pest on agricultural crops in glasshouses and indoor ornamentals.

In vineyards, the obscure mealybug has two to three generations per year, depending on temperature. In mild climates, there is no diapause, which results in multiple overlapping generations with all life stages present on the vine.

Like the grape mealybug, the obscure mealybug overwinters under the bark of the trunk, spurs, and canes. In spring, this mealybug begins to feed on leaves and continues through veraison. Still, the greatest portion of the population is hidden under bark or in tight grape clusters. At harvest, populations may increase dramatically, perhaps due to an increase in females' reproductive potential. However, the causes of this sudden growth in population are still being researched, and some populations do not seem to experience it at all. With a good food source and mild temperatures, an obscure mealybug female can lay up to 500 eggs in the cottony ovisac.

To find new infestations, look for overwintering nymphs under loose bark on spurs or on young leaves and shoots (in the first 2 to 4 inches [5 to 10 cm] of growth). Near harvest, cut open tight clusters that are close to the trunk and look for mealybugs. Populations of obscure mealybug on the Central Coast are closely associated with the Argentine ant, which tends the mealybug for its honeydew. Therefore, a good search method for obscure mealybug (and other mealybugs) is to look for ants on the vine. The obscure mealybug can also be found on the roots of common vineyard weeds.

Longtailed Mealybug



The longtailed mealybug is found throughout North America and in Africa, Europe, the Middle East, Asia, New Zealand, and Australia. Like the obscure mealybug, it has a relatively narrow temperature tolerance but a wide host range. For this reason, the longtailed mealybug is a far more important pest in glasshouse and indoor plantscapes than in vineyards. In California, infestations in vineyards have been isolated to a small number in the Central Coast region.

The longtailed mealybug has multiple, often overlapping generations. Unlike the other mealybugs, the longtailed mealybug adult deposits active crawlers rather than eggs although a cottony ovisac is still produced to protect the crawlers. This ovisac is made of wax secretions just like the marginal filaments and tails.

Ants tend the longtailed mealybug and protect it from its natural enemies. This protection can result in large increases in the density of longtailed mealybug populations.

This colony of longtailed mealybugs includes nymphs and adult females. Because the longtailed mealybug does not deposit eggs, the small crawlers seen here may have just emerged from nearby females.



Vine Mealybug

The vine mealybug is an economic pest of vineyards in the Mediterranean regions of Europe, Africa, and the Middle East, as well as in South Africa, Pakistan, Argentina, and the south-eastern United States. It is a recent introduction into California, arriving in the Coachella Valley in the early 1990s, then in the southern San Joaquin Valley in the late 1990s, and in a few vineyards in the Central Coast region in 2000 and 2001. In areas outside California, this mealybug has also been reported to attack fig, avocado, mango, and pomegranate. In California, the vine mealybug has been found only on grapevines despite the presence of reported alternate host plants nearby.

All life stages of the vine mealybug can be present year-round on a vine. During winter months, vine mealybug eggs, crawlers, nymphs, and adults are found under bark, within developing buds, and on roots. Most vine mealybugs are found on the lower trunk near the soil line and on roots. As temperatures warm in spring, vine mealybugs increase in numbers and become more visible. This is due to increased reproduction and movement from the trunk to the cordons and aerial parts of the vine. By late spring and summer, vine mealybugs are found on all parts of the vine: under bark, on trunks and cordons, on first- and second-year canes, leaves, clusters, and roots. The



Vine mealybug adults and small crawlers (small, orange nymphs). The crawlers actively disperse from the ovisac in search of food.



Vine mealybug female with ovisac.



Vine Mealybug



Vine mealybugs on roots.



Vine mealybugs on leaves.

above description fits most vine mealybug populations; however, the seasonal abundance of vine mealybug and its distribution on the vine vary with location and vine cultivar.

In the Coachella Valley, the numbers of vine mealybug are largest in mid to late spring and decline dramatically (two- to ten-fold) in midsummer. The numbers of vine mealybug then remain at these low levels through fall and winter.

In the San Joaquin Valley, the increase in numbers begins in late spring with peak densities occurring from the end of June through the middle of August. The densities of vine mealybug then decline (two- to five-fold) and remain at low levels from late fall through mid spring.

Several species of ants can be found in association with the vine mealybug. The ants have been observed transporting vine mealybugs around on the vine, feeding on the honeydew produced, and fending off natural enemies.



Vine mealybugs on a cane.

Citrus Mealybug

The citrus mealybug is thought to be a native of China and can be found in Asia, Europe, the southern and western United States, and Hawaii. In California, the citrus mealybug is considered a pest only in citrus. However, it is periodically found in vineyards in the San Joaquin and Coachella Valleys.

Adult females of this species can lay 300 to 500 eggs in cottony ovisacs that are attached to stems or leaves. Egg hatch occurs in about 1 week, and the light-yellow crawlers begin to move away from the ovisac to feed. These mealybugs can develop from egg to adult in as little as 1 month. Citrus mealybugs can produce from 2 to 5 overlapping generations per year, depending on temperature. They overwinter predominantly in the egg stage, under bark and along stems. It is difficult to differentiate between the citrus and vine mealybugs. Researchers have recently developed mealybug pheromones that will greatly aid in distinguishing between these closely related species.



A colony of citrus mealybugs.



Nymphs of the citrus mealybug.



Pink Hibiscus Mealybug



The pink hibiscus mealybug is a serious pest on many plants in the tropical and subtropical parts of the world. This mealybug is presently established in Africa, Asia, Australia, South America, the Caribbean Islands, the northern Mexicali Valley in Mexico, Hawaii, and the southern Imperial Valley in California. There are a total of 215 host plant species listed for pink hibiscus mealybug, including grape, cotton, avocado, plum, citrus, and lettuce. With this broad host range, pink hibiscus mealybug can spread rapidly once introduced in an area.

Pink hibiscus mealybugs overwinter as eggs on stems, in soil, in cracks and crevices in the stem, and inside crumpled leaves. Freshly laid eggs are orange but turn pink just prior to hatch. The crawlers disperse from the ovisac by way of walking, wind, or ants. The nymphs feed and develop into adults in approximately 30 days. If a mealybug with no caudal filaments (that is, no tail) is found, it could signify a new infestation of the pink hibiscus mealybug. A sample should be submitted immediately to the local County Agricultural Commissioner or the University of California Cooperative Extension Farm Advisor's office.



Pink hibiscus mealybug adults, ovisacs, and crawlers.



submitted immediately to the local County Agricultural Commissioner or the University of California Cooperative Extension Farm Advisor's office.

A colony of pink hibiscus mealybugs on a branch.

Methods of Control

Because different species of mealybug require different methods and timing of treatment, it is important to first identify which species is present at a particular vineyard before considering methods of control.

CHEMICAL CONTROL

Mealybugs found on grapevines are difficult to control chemically because most species spend much of their lives hidden beneath bark, on roots, or on some other protected part of the vine. The timing of insecticide applications is critical in order to coincide with periods of maximum vulnerability for mealybug populations. In addition, ants tending mealybugs must be controlled to ensure maximum effectiveness from the mealybugs' natural enemies. Research is improving pest management programs. To access the most up-to-date recommendations for mealybug and ant control, call your local University of California Cooperative Extension Farm Advisor's office (listed under County Government in your phone book) or visit the University of California Statewide Integrated Pest Management Project website (<http://www.ipm.ucdavis.edu>). On the website, recommendations can be found under **UC Pest Management Guidelines**.

BIOLOGICAL CONTROL

There are many insect parasites that attack mealybugs found in vineyards, but most are specific to only one or two mealybug species. Most life stages of the grape and longtailed mealybugs are parasitized by the tiny wasp *Pseudaphycus angelicus*. However, this parasite prefers second- and third-instar nymphs. Additionally, grape mealybug is parasitized by another tiny wasp, *Acerophagus notativentris*. Parasitism rates in the field range from 10 to 90 percent depending on the season and vineyard management practices. Studies have also shown that if parasites are present and active early in the season, substantial reductions in mealybug densities can occur.



Parasitism by the *Pseudaphycus angelicus* (female shown here) can significantly decrease mealybug populations.

Methods of Control

To improve biological control of the obscure mealybug, two tiny wasps, *Pseudaphycus flavidulus* and *Leptomastix epona*, were imported from Chile in the 1990s. *P. flavidulus* attacks second- and third-instar nymphs whereas *L. epona* attacks large third-instar nymphs and adult mealybugs. Only *P. flavidulus* has been shown to establish in California. It can help reduce densities of obscure mealybug as long as ants are controlled at the same time. Without ant control, most of the mealybug parasites mentioned here are less effective because the ants interfere with adult parasites, often attacking and killing them.

Studies of biological control of the vine mealybug have revealed that a small wasp, *Anagyrus pseudococci*, attacks second- and third-instar nymphs and adult mealybugs. This parasite was introduced throughout California in the 1940s to control the citrus mealybug. Additional studies coordinated by D. Gonzalez at the University of California, Riverside, were conducted, and new strains of *A. pseudococci* and another wasp, *Leptomastidea abnormis*, were introduced into the Coachella Valley in the late 1990s. *L. abnormis*, which prefers to attack first- through third-instar mealybug nymphs, has also been introduced into the San Joaquin Valley over the past few years. These parasites are beginning to establish permanent populations in these regions.

To determine if parasites are active against mealybugs in a vineyard, it is easiest to look for mealybug *mummies*. The mummies are the dead hulls of mealybugs that remain after

the parasites have fed and developed inside. Mummies are typically round or oval in shape and appear to be somewhat bloated.

Also, the *shell* of the mummy is hard, and the white wax is often faded or gone. Occasionally, there are holes in the mummy where adult parasites have emerged. To distinguish between a mummy and a large mealybug, gently prod it. A live mealybug will move, and a mummy will not.



Anagyrus pseudococci female searching for the vine mealybug.



A female of the parasite *Leptomastidea abnormis* oviposits in a vine mealybug.



Exit holes of adult parasites in a grape mealybug mummy.



Cryptolaemus montrouzieri larva (left) and adult (right) feed on mealybugs.

Arthropod predators also attack mealybugs in vineyards. The most common arthropod predators in the vineyard are spiders; however, their effectiveness against mealybugs is not well known. Insect predators include the mealybug destroyer (*Cryptolaemus montrouzieri*), brown lacewing larvae (*Hemerobius* spp.), and minute pirate bugs (*Orius* spp.). Larvae of the mealybug destroyer look very much like mealybugs themselves. However, they are actually a species of lady beetle. The adult beetle is black with a light brown head and is slightly larger than the head of a pin.

CULTURAL CONTROL

Control of mealybugs in vineyards can be enhanced by the incorporation of various cultural practices. Proper sanitation practices are very important in managing the spread of vine and pink hibiscus mealybugs. This is because all life stages of these mealybugs can be transported on farm equipment, trellis materials, harvesting supplies, plant parts (clusters, leaves, small pieces of cane, and so on), and clothing of fieldworkers. To

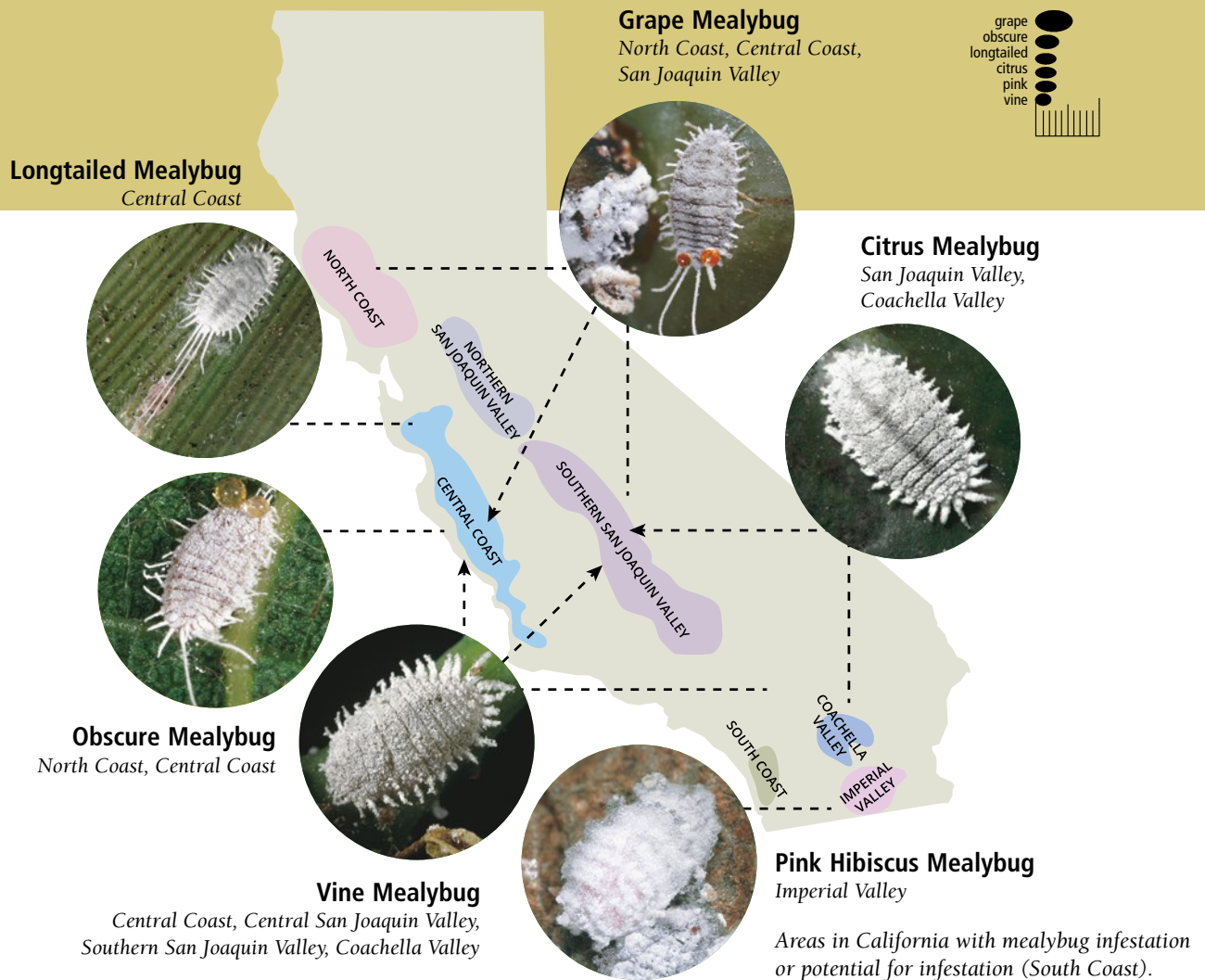
Methods of Control

reduce the spread of these mealybugs, farm equipment and harvesting supplies should be cleaned of all plant parts prior to movement to an uninfested area. In addition, workers should not move from an infested to an uninfested vineyard on the same day.

Using cultural practices to reduce ant populations can also reduce densities of mealybugs by allowing natural enemies greater access. Flood irrigation and soil disturbance can be used to disrupt ant populations. The plowing under of cover crops in the spring also helps reduce ant populations.



Ants feed on the honeydew secreted by mealybugs. They also actively chase away or kill parasites and predators that try to feed on mealybugs.



Geographic Distribution & Identification Key

1. Wax filaments around body margin well developed?

Yes. Grape mealybug, obscure mealybug, longtailed mealybug, vine mealybug, citrus mealybug.
Go to 2. No, go to 6.

2. Caudal filaments greater than $\frac{1}{4}$ of the body length?

Yes. Grape mealybug, obscure mealybug, longtailed mealybug. These species are *Pseudococcus* mealybugs and can be distinguished by the relative lengths of the tail, the geographic area in which they are found, and differences in population development during the season. **Go to 3. No, go to 5.**

3. Caudal filaments between $\frac{1}{4}$ and $\frac{3}{4}$ of the body length. Poorly defined mid-dorsal stripe.

Yes, stop here. Grape mealybug, obscure mealybug. The grape mealybug is found in most grape-growing regions of California. The obscure mealybug is found in the Central and North Coast regions. There are pores called *ostiolae* located near the front and rear margins of both of these mealybugs. When poked with

a sharp object, a ball of fluid is excreted from one or more of the pores. In grape mealybug, the fluid tends to be red, and in obscure, it tends to be clear or white.
No, go to 4.

4. Caudal filaments greater than $\frac{3}{4}$ of the body length. Well-defined, mid-dorsal stripe.

Yes, stop here. Longtailed mealybug. Occasionally found in cooler regions of the Central Coast.

5. Caudal filaments less than $\frac{1}{4}$ of the body length.

Yes, stop here. Vine mealybug, citrus mealybug. These two mealybugs are difficult to distinguish. *Submit a sample for expert identification to the local office of the County Agricultural Commissioner or the University of California Cooperative Extension Farm Advisor.*
No, go to 6.

6. Wax filaments are not well developed around the body margin.

Yes, stop here. Pink hibiscus mealybug. *Submit a sample for expert identification to the local office of the County Agricultural Commissioner or the University of California Cooperative Extension Farm Advisor.*

