PHYTOCORIS, SOFT SCALE, AND MITES

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Phytocoris is a genus of true bugs (Hemiptera: Miridae) that is comprised of more than 400 species worldwide; 160 of these are in western North America. They occur on a wide variety of hosts including pines, oak, almonds, quince and prunes. In 1985, two species of *Phytocoris*, *P. californicus* Knight, and *P. relativus* Knight were documented to damage pistachio by causing epicarp lesion to nuts (Rice et al., 1985).

Treatment for *Phytocoris* with permethrin insecticides (Pounce® and Ambush®) is now common in pistachios grown in the Central Valley of California. Applications are typically applied shortly after fruit set in mid to late April when early evidence of lesion and *Phytocoris* are observed. Separate field trials have been conducted to evaluate pesticide efficacy (Bentley and Mockizuki, 1986; Rice et al., 1986). Both concluded that reductions of *Phytocoris* populations did not produce comparable reductions in epicarp lesion. Their results are supported by recent studies examining the relation between *Phytocoris* and soft scale (Beede et al., 1994; 1995).

DESCRIPTION AND SEASONAL DEVELOPMENT

Phytocoris overwinters in the egg stage on one-year-old fruit wood (Beede et al., 1995). Most eggs are laid in the bark tissue within a tube-like structure capped at the bark surface (Plate 20A). Eggs can also occasionally be found in vegetative or fruit buds. *Phytocoris* has four generations per year (Beede et al., 1995). A fifth generation may occur in hot years. First instar nymphs from the overwintering eggs emerge the first week of March and develop into adults by early April (Figure 20a). Both adults and nymphs are grey in color with long, slender legs and antennae (Plate 20B). Adults are about one-quarter inch in length. When disturbed, they move very quickly to a protected place (Plate 20C). The remaining three generations occur during the growing season with peaks in late April, July and September. These are usually less distinct, presumably because of overlapping from previous generations. Egg laying from the April and July generations occurs principally in the soft rachis tissue of the cluster and less frequently in leaflet petioles and current season shoots (Beede et al., 1995). In November, adult *Phytocoris* migrate to the trunk bark where large numbers of second instar soft scale exist (Beede et al., 1995). They presumably feed on scale before returning to dormant one-year-old wood for egg laying.

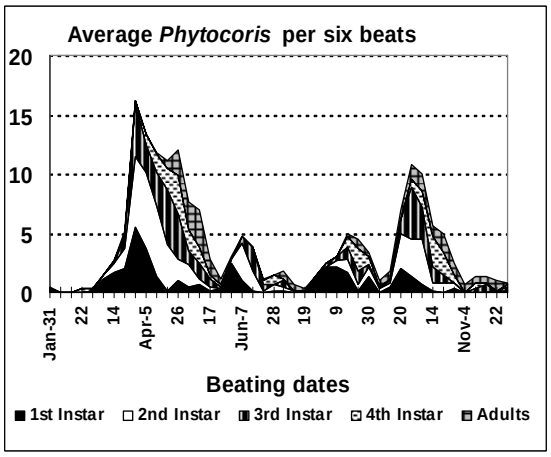

Figure 20a. *Phytocoris relativus* life cycle from March 1 to November 22, 1993, based on weekly beating of female pistachio trees (Kerman cultivar) receiving no insecticide treatments. Averages represent six trees in each of six replications.

During March and April, immature adult soft scale (prior to forming their crust-like covering and laying eggs) are a primary *Phytocoris* food source. Thus, populations of

Phytocoris are often proportional to the density of soft scale (Beede et al., 1995). After adult scale crust, *Phytocoris* then readily feed on scale eggs dislodged from females by wind or by probing beneath them with their needle-like mouthparts. Navel orangeworm eggs are also an important spring food source. *Phytocoris* have not been observed feeding on newly hatched, first instar scale in the spring, but they readily feed on second instar stages migrating from the leaves to woody shoots in the fall (Beede et al., 1995).

Phytocoris feed on both insects and plant material (Rice et al., 1986; 1987). Laboratory feeding studies using field-obtained *Phytocoris* reported that they feed upon southern stinkbug eggs and their newly hatched instars, and on navel organgeworm eggs, which they preferred over frosted and fruit lecanium scale eggs (Rice et al., 1987). *Phytocoris* showed no interest in leaffooted bug eggs, and were documented to cannibalize their weaker members.

In addition to their predatory characteristics, research has demonstrated that the species in California pistachios must feed on plant material for optimal survival (Rice et al., 1986). *Phytocoris* repeatedly probed the ends of pistachio twigs, leaves and fruit stem tissue with their needle-like sucking mouth part which, when not in use, is held against their undersides. Plant tissue probably supplies *Phytocoris* water and carbohydrates; immature scale, various insect eggs and smaller adult insects serve as their protein source. *Phytocoris* consumed an average of 25.6 navel orangeworm eggs daily in petri dish feeding studies where alternative plant food material was provided. When provided only navel orangeworm eggs, daily consumption increased to 40.5 eggs (Rice et al., 1987). *Phytocoris* adults provided eggs and plant material lived 31.5 days compared to only 6.5 days when fed eggs alone. Hence, *Phytocoris* appears to cause epicarp lesion in the process of meeting its dietary requirements. However, they did not appear to cause lesion as readily as two other true bug species, *Neurocolpus longirostris* or *Calocoris norvegicus*. (See Chapter 21)

DAMAGE

Phytocoris is capable of causing epicarp lesion and loss of immature nuts prior to shell hardening (Plates 20D and E). Damage is usually greatest in April from the first generation. Injured nuts occur randomly and vary widely in number. Research in southwestern Kings County indicates that heavy *Phytocoris* levels of five per beat during this period resulted in lesion levels of 15 to 20 percent based on nut number for protected and unprotected clusters (Beede et al., 1995). However, there has been no correlation between the percent lesion and yield of filled nuts for the two years in which data were collected (Beede et al., 1994; 1995). This suggests that factors other than *Phytocoris* levels and nut injury prior to shell hardening affect pistachio productivity.

Studies on percent injury versus percent fruit set suggest that pistachios compensate for the loss of nuts injured prior to shell hardening by setting and filling fruits that would otherwise fall off (Beede et al., 1995; 1996). This compensation capacity appears greater for trees in their “on” bearing year. Artificial removal of up to 80% of the nuts on selected clusters in May had no effect on either the total nut number or the number of filled nuts at harvest compared to control clusters. Compensation decreases at shell hardening when natural nut drop has ended, thus limiting the number of nuts that can be lost without reducing yield. Nut removal in excess of 20% shortly after shell hardening correlated strongly with reduced nut numbers at harvest

MANAGEMENT GUIDELINES

Several insects common to pistachios prey upon *Phytocoris*. They include various spiders, assassin bugs (*Zelus* spp.) and lacewing larvae (green and brown lacewing, *Chrysopa* spp). Spiders have been observed feeding on *Phytocoris* with adults (as well as injurious stink bugs and leaffooted bugs) often found in their webs (Beede et al., 1994; 1995).

Lacewings are observed in greatest numbers after shell hardening and frequently feed on second instar soft scale and *Phytocoris* nymphs.

Spring application of permethrin insecticides adversely impacts these and other beneficial insects for the rest of the season. Included are big eye bugs (*Geocoris* spp.), considered an effective predator of eggs and other small insects, the minute pirate bug (*Orius* spp.), and hymenopterous wasps which parasitize soft scale. *Brochymena* (gray, rough shield stinkbug), considered a beneficial stinkbug since reported as not causing epicarp lesion, is also significantly reduced by permethrin treatment (Beede et al., 1995; Rice et al., 1985; 1985). The economic importance of losing these beneficials early in the season is still not known.

CONTROL

Although very effective pheromones are available for monitoring adults, research has not yet been performed to correlate the trap catches with economic injury. Instead, monitoring for *Phytocoris* is typically performed with a beating tray. Various items have been used for this purpose. White trash can lids 18 to 24 inches will suffice. Although not very durable, styrofoam lids from table grape cartons have also been employed. Most professionals use a wire framed circle about 22 inches in diameter. Two cross braces made from similar sized wire divide the circle into quarters. A six-inch length of one-inch diameter tubing is then welded perpendicular to the frame at the circle's center. This serves as the handle. The wire circle is then covered with white cotton or nylon fabric into which elastic or a drawstring has been sewn around the perimeter for tightening onto the frame.

The beating tray is held at eye level beneath a fruiting limb to enable the user to observe whatever lands on the tray. A hand mallet is used to rapidly strike the tree limb sharply three to four times. The tray is then quickly brought down to a comfortable level for insect counting. Beating is best done at 68 to 72^{o}F to prevent excessive insect flight. Beating is also performed near the orchard perimeters for early detection of migrating insects such as *Lygus*. Approximately 10 beats are conducted for every 40 acres of pistachios. Pest consultants often increase this on smaller acreage when insect counts rise.

There are no data supported treatment thresholds for *Phytocoris*. Pest managers consider trends from week to week and observe nut injury levels. Three *Phytocoris* per 10 beats would be considered low, and seven to 10 might prompt one to consider treatment.

Permethrin insecticides such as Pounce or Ambush significantly reduce *Phytocoris* populations. Applications must be made before nymphs turn into adults in April to prevent additional egg laying and retreatment. This is especially difficult for large growers since ground applicators typically treat about 40 acres per sprayer per day. Research indicates that permethrins reduce epicarp lesion, but marketable nut production may not differ significantly from untreated trees. Guidelines for how much damage can be tolerated at various nut development stages is not yet available. Growers considering not treating *Phytocoris* are therefore advised to experiment with small untreated areas within the orchard and evaluate the impact.

An alternative to treating *Phytocoris* with permethrin in April is the application of carbaryl (Sevin®) and oil during the dormant period. This has been shown to significantly reduce the amount of soft scale as well as *Phytocoris*.

SOFT SCALE

DESCRIPTION AND SEASONAL DEVELOPMENT

Soft scale are a group of insects in the family Coccidae (Homoptera) that use sucking mouthparts to feed on plant juices. Several species can be found infesting pistachios, including European fruit lecanium, Parthenolecanium corni (Bouché), frosted scale, *P. pruinosum* (Coq.) and black scale, *Saissetia oleae* (Olivier). All three species have a wide host range in agricultural and ornamental plants.

Adult female European fruit lecanium and frosted scale are light to dark brown in color and hemispherically shaped (Plates F and G). Their bodies are about one-eighth inch in diameter with shallow wrinkles over the surface. Frosted scale produce a characteristic white wax over their bodies at maturity and are

larger than European fruit lecanium. Male scale occur only rarely. Both scale have only one generation per year.

Soft scales possess a relatively simple biology (Bailey, 1964). Females reproduce parthenogenetically on last year's fruiting wood. The female withers and dies as she lays more than 2000 eggs beneath a crust-like shell in April (Plate 20H). After hatching in mid to late April, the young scale (called crawlers due to their ability to migrate) move from the dead female onto expanding leaf tissue where they settle down in June and feed for the duration of the growing season (Plate 20I). Spring temperatures near 90 °F result in significant crawler mortality and aid in their management (Bailey, 1964).

A product of crawler feeding is honeydew, a sugary substance that serves as a substrate for sooty mold growth on leaves and fruit. Depending upon the time of emergence, settled crawlers will molt once in early July into what is known as second instar scale. Immature scale are shiny, flat and light brown to translucent in color.

In early September, second instar scale migrate back onto the shoots produced that season. Research indicates fruit lecanium scale then migrate in mass to the tree trunks where they remain until late December (Beede et al., 1995). Immature scale remain motile throughout the winter depending upon temperature and weather. Migration back to one-year-old wood occurs in January when they molt into third instar nymphs (Beede et al., 1994). By late February they have grown rapidly and become rubbery. This represents the pre-reproductive stage (Plate 20J). Soon after, they develop their crust-like outer shell (without molting) while the now-mature female lays her eggs. The one generation per year cycle then begins all over again.

Black scale is also a pest of pistachios. It is distinguished from European fruit lecanium by the presence of ridges that form the letter "H" on the back of immature and adult scale. It also has a wide host range and is considered a primary pest of citrus and olives. Black scale produce one generation per year in the Central Valley and two in coastal areas. This soft scale produces honeydew and is commonly found on pistachio fruit during the season. Its life cycle is very similar to that of frosted and European fruit lecanium scales.

DAMAGE

Research suggests heavy (10 to 30 third instar crawlers per inch in early February) densities of soft scale can significantly reduce shoot growth, overall tree vigor, and fruit size (Beede et al., 1995). Soft scale also reduced shell splitting, another stress sensitive physiological event in pistachios. Removal of European fruit lecanium from vigorous, 12-year-old Kerman trees resulted in 50% and 17% longer shoots during the off and on years, respectively (Beede et al., 1995)). Fruit set and kernel filling were not affected, indicating their lesser sensitivity. This data suggests that heavy scale populations could therefore cause economic injury by reducing new fruit wood development and nut quality.

MANAGEMENT GUIDELINES

European fruit lecanium, frosted and black scale are parasitized by several hymenopterous wasps (Bailey, 1964). Depending upon the species and their abundance, parasitic wasps can control soft scale if not disrupted by insecticidal treatments. Parasitized adult scale have a small pin hole on their crust-like cover where the wasps have emerged. An exit hole can also be found on parasitized crawlers. Some parasites only attack specific stages of scale development. Thus, successful biological control often requires that multiple species be present. The identification and distribution of scale parasites on pistachios in different regions is not presently known.

In a study conducted from 1994 to 1995, *Metaphycus luteolus* was the most prevalent parasite of European fruit lecaniumon dormant pistachios grown in western Kings County (Beede et al., 1994; 1995). They attack third instar and immature adult scale beginning in January, increasing until the end of April when young scale emerge from their mothers. Examination of parasitized scale indicated no viable eggs were produced compared to 2500 to 4500 eggs per unparasitized female. *M. luteolus* was not capable of biologically controlling Eurpopean fruit lecanium by itself

because it does not typically attack the crawler stage and its parasitism of immature adults was insufficient.

Small numbers of *Metaphycus bartletti* and *Coccophagous luteolus* have also been identified on pistachios. Although capable of parasitizing second instars, *M. bartletti* typically attack third instar to adult scale. Female *Coccophagous luteolus* are important because they parasitize first instar crawlers. However, the numbers recorded were insufficient for control. Male *C. luteolus* are hyperparasites on *Metaphycus* species. *Metaphycus helvolus*, another effective in-season soft scale parasite, has not yet been found in pistachio.

Parasitic wasps effective against black scale include *Metaphycus helvolus* and *M. bartletti*. *M. californicus* is considered the most effective against frosted scale.

Orchards with high tree vigor, dense canopies and cooler temperatures from low-volume irrigation systems are more predisposed to soft scale outbreaks. Mild winters also favor greater overwintering scale survival. Severe winters with heavy rainfall and wind can cause such dramatic soft scale reductions that treatment is unnecessary. Spring temperatures above 90^{o} F have also been reported to cause significant mortality of newly hatched crawlers.

Several predators present in pistachios feed on soft scale. In addition to *Phytocoris*, lacewing and lady beetle larvae feed voraciously upon the crawler stages. Big-eyed bugs have been observed feeding on eggs. Permethrin applications made against *Phytocoris* in April most likely kill many emerging scale parasites and reduce the predator populations.

CONTROL

Monitoring is performed by visual examination of the one-year-old fruiting wood for scale in early to mid-January. Carefully check randomly selected twelve-inch dormant shoots for live and parasitized scale. Light to moderate populations would be from one to five live scale crawlers per inch in early February. Heavy populations range from 10 to 30 per inch. Tree age, vigor, fruit wood and split nut percentages should be considered when making a treatment decision.

Treatment with one gallon of Sevin XLR plus four to six gallons of Volck® oil from mid-December to mid-February is very effective against soft scale and overwintering *Phytocoris*. Moderate populuations have been successfully controlled with oil alone. For optimal control, frosted scale should be treated before its waxy coating develops. Lecanium scale need to be treated before reaching the "rubber stage" in late February. Depending upon weather conditions and scale pressure, re-treatment may not be necessary for three to five seasons. Oil application also can advance pistachio bud break and nut maturity by 7 to 10 days.

Research indicates that the loss of scale as a preferred food source can result in increased nut feeding by fewer *Phytocoris*. Even so, yield and nut quality was higher than untreated trees (2,3). Eliminating scale from heavily infested trees (10-30 per inch of dormant, one-year-old wood) resulted in significant increases in shoot growth. Nut size was also larger in the "off" year.

MITES

Citrus flat mite, *Brevipalpus lewisi* McGregor (Acarina: Tenuipalpidae) is commonly found feeding on the rachis and hull tissue of pistachio nuts (Plate 20K). Left untreated, they can cause nuts and entire clusters to turn brown and dry up on the tree. Two webspinning (spider) mites, twospotted spider mite, *Tetranychus urticae* Koch, and Pacific spider mite, *T. pacificus* McGregor also occasionally feed on pistachios. However, their presence and damage to foliage in pistachio is minor compared to other California nut crops such as almond and walnut.

DESCIPTION AND SEASONAL DEVELOPMENT

Citrus flat mite

Citrus flat mite is commonly associated with the production of citrus, and was first reported scabbing the rinds of lemons near Porterville (Tulare County) in 1942 (Flaherty, 1992).

Similar injury has been observed on pomegranates resulting in fruit cracking and high cull percentages. It was identified as an injurious pest of pistachios in northwestern Kern County in 1979 by Rice (1980).

Citrus flat mite are very small and can only be seen with the aid of a ten power hand lens. Citrus flat mite is somewhat flat and oblong in shape and is wider closer to its head. It moves very slowly and body color ranges from reddish brown to bright red or pink. Its eggs are very small, oval shaped, and bright red in color (Elmer and Jeppson, 1957).

The citrus flat mite reportedly overwinters as an adult in colonies found in loose bark or bud scales. As temperatures approach about 70° F in the spring, they emerge and begin feeding on fruit and fruit stem areas of their host plants. Populations do not normally reach injurious levels until July or August. High summer temperatures also do not appear to inhibit their feeding. Studies show it has only one generation per season (Weinberger et al., 1984).

Spider mites

Pacific and twospotted spider mites overwinter as mature females under the rough bark at the base of the host tree, on ground cover plants, and in orchard floor trash. Male mites do not overwinter and are less common than female mites. Adult females are 1/50 of an inch (0.5mm) long and are almost devoid of distinguishing marks (food spots) on their dorsum (back) when newly hatched. Soon after feeding begins, twospotted spider mites develop a single dark spot on either side of its dorsum. Pacific mites two large, diffuse spots on the forward area of their dorsum and two smaller ones in the rear. However, the spots are often barely visible or may coalesce to large dark areas, making it difficult to distinguish the two species. Their color varies from slightly amber to greenish. Later in the season they can acquire a reddish color.

When the weather warms in spring, overwintering females become active and begin feeding by rasping surface tissue with their mouthparts to release its cellular contents. They eventually move up into the canopy if natural predators are insufficient. Twospotted spider mite initiates egg laying on the underside of leaves until populations reach higher levels. Pacific spider mite females lay eggs initially on both sides of the leaf. Translucent when first laid, mite eggs become opaque before hatching into immature mites. They molt three times before reaching the adult stage. Provided with favorable temperatures and food supply, spider mites can complete a generation in 7 days. They have an extremely wide host range. (Flaherty, 1992).

DAMAGE

Damage from citrus flat mite to pistachio is similar to that in citrus and pomegranate (Elmer and Jeppson, 1957). Initially, the feeding of low populations causes minor scabbing of the surface tissue of the rachis and nut tissue from their rasping-sucking mouthparts (Rice and Weinberger, 1980). Early damage levels often go unnoticed. As the population rises, the brown discoloration of these tissues becomes readily visible. Left untreated, citrus flat mite continues feeding and causes dried hull tissue and completely dehydrated clusters. This results in reduced harvestability, higher staining, and greater non-split percentages. Citrus flat mite does not damage leaf tissue, thus distinguishing it from webspinning mites. Pacific and twospotted spider mite populations usually reach their most severe levels in summer, especially where predators have been killed by broad spectrum insecticides such as carbamates and pyrethroids. These mites reproduce rapidly in hot, dusty conditions and on water-stressed trees. If temperatures and food supply are favorable, a new generation can occur every 7 days and 8 to 15 generations can be completed in a season. Mites disperse from areas of heavy infestation by wind.

Pacific and twospotted spider mite damage to pistachios initially appears as a loss of green color on infested leaflets (Beede et al., 2000). Continued feeding causes the leaf to develop

small necrotic spots with small amounts of webbing. All life stages of the mites can be found residing and feeding within this webbing. Low mite levels of 3 to 4 per leaflet are sufficient to cause defoliation in pistachio. As in other crops, leaf loss relative to mite levels is enhanced by plant stress from lack of water or salinity. This may be why other orchards have sustained similar mite levels without suffering any leaf loss. Observations by crop consultants suggest spider mites do not seem to favor pistachio as a host since populations do not build up as rapidly as in almond and stone fruits.

MANAGEMENT GUIDELINES

Studies of citrus flat mites have revealed the presence of the predaceous phytoseiid mite, *Metaseiulus mcgregori* (Chant), which is common in several crops throughout California (Schuster and Pritchard, 1963; Weinberger et al., 1984). Its numbers begin increasing in August and reach their highest level at the same time as citrus flat mite, but experience has been that their numbers are insufficient to reduce flat mite populations below economic injurious levels. Mites in the family Tydeidae, which feed on fungi and pollen, are also observed in low numbers in pistachios (Weinberger et al., 1984). It is thought that they serve as an alternative food source for the phytoseiid mites.

Greater incidences of Pacific and twospotted spider mite damage has been reported with increased pyrethroid use for plant bug control. Many cases involve severe defoliation and shriveled crop on infested trees. Predatory mites such as the western predator mite, *Typhlodromus occidentalis*, also are not abundant, even in orchards with low insecticide use. However, the sixspotted thrips, *Scolothrips sexmaculatus*, has been observed as a very effective predator at low populations (Beede et al., 2000). Since webspinning spider mite populations develop very slowly on pistachios, thrips often provide effective biological control and chemical treatment is not justified.

CONTROL

Citrus flat mite is easily controlled with dusting or wettable sulfur applied prior to the development of economically damaging mite densities. Application of 50 pounds of dusting or 15 to 20 pounds of wettable sulfur per acre, has not even in hot weather, resulted in phytotoxicity. Growers report adding wettable sulfur to their April pyrethriod spray for plant bugs and achieving season long control of citrus flat mite. Tests with 415 oil showed that it performed similarly to sulfur (Beede et al., 2001). Trees sprayed with Orchex 692 had adult populations reduced by 72% six days following treatment.; the number of eggs was reduced by 74%. Ten days after treatment, the adult and egg populations were reduced by 88%. After 17 days, only 4% of the initial population remained. Should treatment of spider mites be necessary, treatment with a 415 oil was demonstrated as equally effective in reducing Pacific mite populations as chemical miticides available in 2000 (Beede et al., 2000). None of the oils tested, including a 470 oil similar to Volck (476 oil), showed any phytotoxic symptoms. Since 2000, additional miticides that are effective against spider mites have been registered for pistachios. Consult the UC IPM Pest Management Guidelines for details (http://www.ipm.ucdavis.edu).

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