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Avocado Lace Bug in California

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Avocado lace bug, *Pseudacysta perseae* (Heidemann) (Hemiptera: Tingidae), is a new avocado pest in California and populations were first detected on backyard avocado trees in the Chula Vista and National City areas south of the City of San Diego in September 2004. Following detection and initial survey work, California Department of Food and Agriculture officials indicated that eradication was unfeasible for the following three reasons: (1) The 250 mile^2 area that was infested was too large to treat effectively with insecticides. (2) There were no efficient monitoring systems (e.g., pheromone traps) to detect very low-density populations enabling rapid determination of the success of pesticide applications within an eradication program. (3) There were few good data on the efficacy of pesticides that might be used to eradicate avocado lace bug populations. Very little was known about the biology and ecology of avocado lace bug despite it being a well known pest of cultivated avocados. This situation (i.e., a paucity of information) is similar to that experienced when the persea mite and avocado thrips successfully invaded California in 1990 and 1996, respectively. The remainder of this article outlines what is known about avocado lace bug, preliminary research results, and provides an outline of the development of management strategies for this pest.

Avocado lace bug was described in 1908 from specimens collected from avocados in Florida over the period 1897-1907. Avocado lace bug is known from Florida, Texas, and Georgia (U.S.), Bermuda, Jamaica, Puerto Rico, the Dominican Republic, St. Lucia, St. Thomas, St. John, St Croix, (all in the Caribbean), the east coast of Mexico (states of Veracruz and Yucatan), and French Guyana in South America. Avocado lace bug is a true bug with sucking mouth parts, and the common name “lace bug”, is derived from the highly reticulate “lace-like-patterning” of the thorax and wings of adults. There are around 1,820 species of lace bug and 154 species are found in North America. Whereas many species of lace bugs in the U.S. are native and cause little economic damage, some are important ornamental pests attacking azaleas and rhododendrons.

In all areas where avocado lace bug occurs it is considered a pest of avocados that can be of economic importance.

Life Cycle and Phenology

Adult avocado lace bugs are small winged insects about 2 mm in length (slightly longer than 1/16 inch) with black bodies, yellow legs and antennae, and are visible to the naked eye. The insects live in colonies on the lower surfaces of leaves, often with adults, eggs and nymphs together (Fig. 1). Eggs are laid in an irregular pattern, sometimes in loose rows or clumps on the lower leaf surface. Eggs are often covered with irregular globules of a black, sticky tar-like substance excreted by adults. These sticky exudates may protect eggs from attack by natural enemies, pathogens, or reduce desiccation risk. The eggs hatch into wingless young called nymphs, which go through gradual metamorphosis shedding their exoskeleton several times as they grow in size, finally developing wings and becoming flying adults. The nymphs are dark red-brown to black and covered with spines. Nymphs feed for approximately two to three weeks before maturing into winged adults, which lay eggs, restarting the life cycle (Fig. 2). In Florida, avocado lace bug outbreaks typically occur from October through March and decline sharply over April through August. These observed population trends in Florida are thought to be strongly influenced by the development of the leaf canopy following bloom. It is too early to predict with certainty the times of the year when lace bug populations will peak and subside in California, the number of generations this pest will have, or how far north from San Diego this pest may be able to extend its range. However, preliminary data from San Diego collected over a 10 month period (July 2005 to April 2006) suggests that lace bug populations may begin to increase around April, peak in late October and then steadily decline to low densities in March before beginning to increase again.

Feeding Damage

Lace bugs restrict their feeding to the undersides of leaves, inserting their needle-like mouthparts into leaf tissue cells to extract cell contents. Feeding initially causes small white or yellow spots on the surface of leaves as individual cells dry out (Fig. 3). It is suspected that feeding damage can provide entrance for pathogenic fungi, in particular *Colletotrichum* spp., which are leaf anthracnose fungi. As lace bug colonies grow, brown necrotic (dead) areas develop where there has been heavy feeding damage. These necrotic areas look like tip-burn caused by salt damage, but in this case, the necrotic areas are islands of dead tissue in the interior of the leaf surrounded by living tissue (Fig. 3). Heavy feeding can cause striking leaf discoloration and early leaf drop (Fig. 4). Other signs of lace bugs are dark, varnish-like excrement and shed white nymphal skins on the undersides of leaves. Avocado lace bug nymphs and adults do not feed on fruit, but will likely have a detrimental effect on yield resulting from the loss of photosynthetic capacity in damaged leaves. In recent years, avocado lace bugs have become an economic problem in Florida and the Dominican Republic, with occasional severe infestations causing defoliation and reduced yields.

Host Plants

Avocado lace bugs have only been reported feeding on avocado (*Persea americana*), red bay (*Persea borbonia*), and camphor (*Cinnamomum camphora*), all members of the Lauraceae family. Experimental evidence from Florida indicates that avocado varieties vary in their susceptibility to feeding damage. West Indian x Guatemalan avocado hybrids appear to be particularly resistant to attack in Florida. Observations in the Dominican Republic indicate that Hass avocados (a Mexican-Guatemalan hybrid) can be severely damaged by lace bug outbreaks. In California, field observations in San Diego suggest that the Bacon variety is preferred over the Hass variety.

Controlling Avocado Lace Bug

Because avocado lace bug is a quarantine pest, work on the insect is being conducted at the San Diego County Insectary in Chula Vista, inside the current area of infestation. Substantial renovation of this facility has been necessary and has included the installation of new swamp coolers and associated electrical apparatus to operate the swamp coolers for the greenhouses, new lights, temperature and humidity monitoring devices, replacement of rusted metal framing that was compromising the integrity of rearing greenhouses, purchase of potted avocado plants for colonies, and transformation of an old storage room into an insect rearing room with a new swamp cooler and thermostat to maintain uniform temperatures inside the room for bioassays and biological studies. Most of this renovation work and associated materials was paid for by the California Department of Food and Agriculture. Research on control efforts for avocado lace bug at this facility are focusing on biological and chemical control.

Biological Control. Bological control agents reported from Florida include two egg parasitoids including *Oligosita sp.* (a trichogrammatid wasp) and an unidentified mymarid wasp. Egg parasitoids lay their eggs inside the egg of the lace bug. The parasitoid larva that hatches from an egg feeds on the internal contents of the lace bug egg, killing it. Preliminary surveys in Florida by Dr. Jorge Peña at the University of Florida indicate that egg parasitism rates are probably low at < 5%. Green lacewings and other generalist predators (e.g., predatory mirids) are also thought to be important natural enemies in Florida because populations of these predators increase in response to growing pest populations. Lacewing larvae have also been observed attacking avocado lace bugs in Texas (Fig. 5). However, mortality rates imposed by predators are difficult to quantify and their overall impact is unknown. A predatory thrips, *Franklinothrips vespiformis*, has been observed in high numbers feeding on avocado lace bugs on Hass avocados in the Dominican Republic. The natural enemies attacking avocado lace bug in California include green lacewings and predatory thrips but no parasitoids have been reared from eggs in limited surveys to date. In a trial reported in 1998, Mycotrol, an insect-killing fungus, (*Beauveria bassiana*), was trialed by Dr. Peña, and Mycotrol provided some control of avocado lace bug. However, conditions are much more humid in Florida than California, and historically insect-killing fungi have not been effective at controlling pest insects in arid environments. Preliminary work in the laboratory has indicated that predatory *Franklinothrips* will attack small nymphs, inflicting around 60% mortality. Medium and large nymphs and adults are immune to

attack because they are larger than the predator. Green lacewing larvae are more aggressive and can kill more and larger avocado lace bug nymphs than *Franklinothrips*. Small arena trials with green lacewing larvae indicated that mortality of nymphs can range over 60-96% for small and medium sized nymphs and 71% of adults can be killed. These results require verification in more realistic field settings and experiments will be conducted on small potted plants to quantify attack rates by foraging predators on avocado lace bug nymphs and adults.

Foreign Exploration for Avocado Lace Bug Natural Enemies: In March 2006, we surveyed parts of the Caribbean and Mexico for avocado lace bug and associated egg parasitoids. Lace bugs and egg masses were collected in Jamaica, Puerto Rico, St. Thomas, and St. John. Avocado lace bugs were easy to find in these Caribbean countries, damage was high and every avocado tree (backyards and semi-commercial orchards) that was located was infested. Avocado lace bug was not observed in Barbados, Trinidad, or Tobago verifying records that this insect is absent in these countries in the eastern Caribbean. However, French Guyana in northeastern South America which is close to the eastern Caribbean has avocado lace bug populations which were first observed in 2003. This disjunct Caribbean distribution, recent arrival in some countries (e.g., avocado lace bug was first detected in U.S. Virgin Islands [i.e., St. Croix, St. Thomas, and St. John] in 1992), high pest populations, considerable levels of damage, and no parasitoids associated with eggs suggests that this pest may not be native to the Caribbean but is an invasive species that is spreading throughout this region on avocado trees (for example, a home owner in St. John had received avocados for back yard planting from Puerto Rico.) The situation in Mexico appears to be substantially different to that observed in the Caribbean. Infested avocados were not as common, avocado lace bug colonies were typically of smaller size on infested leaves, and fewer colonies were found on infested trees. Despite these promising observations, shipments of hundreds of avocado lace bug eggs to the University of California Riverside Insectary and Quarantine facility failed to produce a single egg parasitoid. Either eggs were collected at the wrong time of the year and shipped back to California, or natural enemies other than egg parasitoids are responsible for avocado lace bug control in Mexico. Further work in Mexico is planned and multiple trips over the course of several years may be necessary to find avocado lace bug egg parasitoids. Multiple trips may be especially important if there is only a narrow window for finding natural enemies and collecting efforts are to coincide with harvestable populations.

Chemical Control. Researchers at the University of Florida have shown that citrus oil, and M-Pede (an insecticidal soap) provided short-term lace bug control. Pesticides used for sucking insect control may be effective for avocado lace bug control and research at UC Riverside is underway to identify the best insecticides for lace bug control. Results of small tree trials or weathered residue tests have indicated that carbaryl, imidicloprid, cyfluthrin, carbaryl, fenpropathrin, and malathion provide good control of avocado lace bug nymphs. Spinosad, abamectin and mineral oil were much less effective and are not being considered as part of a list of potential control materials. Work is ongoing to determine most effective products and application rates, and these data may be very important for guiding highly localized eradication efforts should avocado lace bug be detected in commercial orchards outside of the currently infested residential areas in San Diego County.

Genotyping and DNA Analyses

Microsatellite markers are being used to determine if there is a correlation between these markers and the geographic origin of avocado lace bug populations in Florida, Texas, the Caribbean, Mexico, and possibly, northeastern South America. In addition to microsatellite markers, ribosomal and mitochondrial DNA sequences are being used to determine if avocado lace bugs, as they are currently known, are either a single species or a cryptic multiple species complex that is difficult or impossible to separate using morphological characters. It is important for us to know if we are dealing with a single species of avocado lace bug for a number of reasons: 1) It will allow us to match egg parasitoids, should we find promising candidates, with the correct pest species, and 2) if we try to use the microsatellites on two different species our analyses will be confounded.

The sequence and microsatellite marker data from source populations collected during foreign exploration efforts can be compared with those of the California population and estimates of the likelihood of the California population originating from a particular source population can be determined. The mitochondrial gene, COI, from one population of avocado lace bug from Florida (20 individuals) and California (7 individuals) have been sequenced. These sequences differ consistently by a single base pair. This tentatively indicates that the CA population is not derived from the sampled Florida population, however, the sample size is much too small to state this with high confidence at this time and additional analyses will be conducted. In addition, the D2 region of the ribosomal complex has been sequenced and indicates that the California and Florida populations are identical. The D2 region is considered a good indicator for species status because it is generally a highly conserved section of DNA. If two populations differ in this D2 region, they often belong to different species, and if they are the same, the chance that the two populations belong to the same species is substantial. Therefore, we may tentatively state that avocado lace bug specimens analyzed from the sampled Florida populations and the California populations are likely the same species. Research on this subject is ongoing and foreign exploration efforts, along with specimens sent to UC Riverside by overseas cooperators, have resulted in a large specimen data bank that is being evaluated with these molecular tools.

The Current Management Strategy

At the time this article was written (June 2006), avocado lace bug populations are restricted to backyard plants in southern areas of San Diego County. There have been no reports of infested commercial orchards. Following an emergency meeting with UCR scientists, the CDFA, representatives of the San Diego County Agricultural Commissioner's office, UC Cooperative Extension Farm Advisors, and California Avocado Commission representatives, several simultaneous management strategies were implemented. (A) There are to be restrictions placed on the movement of host plant materials out of infested areas in San Diego County, in particular, movement of live avocado and camphor trees that might harbor avocado lace bugs and assist in rapid large distance spread. (B) Adoption of a Voluntary Code of Compliance by commercial

growers will be requested to prevent the movement of avocado foliage in packing bins to areas outside of the currently infested zone. (C) Insecticide screening trials and evaluation of natural enemy releases are to commence in San Diego County. (D) The area of origin of avocado lace bug is to be determined using genetic analyses and natural enemies are to be searched for in the exact area of origin of the avocado lace bug. (E) Immediate identification and cataloguing of natural enemies, especially egg parasitoids, that attack avocado lace bug in San Diego County will be initiated and the population phenology of the pest is to be followed closely in this area to determine its seasonal population pattern.

Acknowledgments

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Further Reading

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More information on avocado lace bug can be found on the web at:
http://creatures.ifas.ufl.edu/fruit/avocado_lace_bug.htm
http://growers.avocado.org/growers/pdf/AvoResearchWinter05.pdf

Figure 1. *Avocado lace bug colony on the underside of a leaf with winged adults, globular black eggs, and reddish-brown nymphs at various stages of development (Photo: Guy Witney).*

Figure 2. *Adult avocado lace bugs laying eggs on the underside of an avocado leaf to initiate a new colony adjacent to damage caused by previous feeding (brown leaf area on the left of the photograph). Adult avocado lace bugs seldom fly from the surface of the leaf even when disturbed (Photo: Guy Witney).*

Figure 3. *Feeding by avocado lace bug initially causes stippling and bleaching of the leaf because the insect removes the contents of individual leaf cells. Feeding damage is visible from the upper leaf surface. Eventually this damage results in islands of completely dead (necrotic) leaf tissue (Photo: Guy Witney).*

Figure 4. *Heavy feeding by avocado lace bug will eventually cause striking discoloration of the entire tree and heavy leaf drop (defoliation) (Photo: Guy Witney).*

Figure 5. *Avocado lace bug adult being attacked by a lace wing larva in a Texan avocado orchard (Photo: Matt Ciomperlik).*