MONITORING, DAMAGE, NATURAL ENEMIES AND CONTROL OF AVOCADO LACE BUG, PSEUDACYSTA PERSEA (HEMIPTERA: TINGIDAE)

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Abstract. Trends in seasonal abundance, natural enemies, damage and control of the avocado lacebug (ALB) Pseudacysta persea (Heideman) (Hemiptera: Tingidae) were investigated in Dade County, Florida. Avocado lacebug population densities increased during the dry season (November - February), and declined during spring and summer. The cultivars 'Wal- din', 'Booth 8' and 'Loretta' had the highest natural infestation levels. The most susceptible cultivar appears to be "Booth 8" with damage levels of 20-28% to the leaf area. Leaf photosynthesis was reduced by 50% when the leaves sustained 40% damage. Cultivars (Simmonds) with 100% of their leaves infested exhibited an early leaf drop and a total reduction of fruit set. By contrast the West Indies × Guatemala hybrid was scarcely affected by the pest. Four major biological control agents were observed. Two egg parasitoids, Oligosta sp., and an unidentified mymarid wasp, the green lace wing Chrysoperla rufilabris, and a predacious mirid, Hyalidodes vitripennis. Several pesticides, M-pede (soap), citrus oil, Mycotrol (Beauveria bassiana) were applied to an avocado orchard with an average of 15-28 ALB/leaf. Seven days after spray application, ALB densities were significantly reduced by Mycotrol, and by M-Pede compared with the untreated control. Mycotrol (3 gts/100 gal) significantly reduced ALB densities for 29 days compared to the untreated control.

Introduction and Review of Literature

The avocado lace bug (ALB), Pseudacysta persea was described in 1908 as Acyta persea from Florida specimens and considered a minor pest of avocado. However, persistent population outbreaks of P. persea observed since the mid 1990s in Florida and the Caribbean region, reveal that made P. persea has become one of the most important pests of avocado (Medina-Gaud et al., 1991, Abud Antun, 1991). Pseudacysta persea is found in Florida and Georgia in the United States, Bermuda, Dominican Republic, Puerto Rico and Mexico (Mead and Peña 1991). The common hosts for this pest besides avocado are red bay, Persea borbonia (L.) and camphor, Cinnamomum camphora (L.). The life cycle of Pseudacysta persae was reported by Abud-Antun (1991) to require 22 days from egg stage to adult. The most complete description of adults and late instar nymphs was elaborated by Heidemann (1908).

Pseudacysta persea confines its attack to the lower surface of the foliage, causing chlorosis, necrosis and a severe defoliation of avocado, and probably reduced yields. This bug usually lives in colonies, depositing eggs upright in irregular rows in clusters on the lower leaf surface. This insect opens an avenue of penetration for the leaf anthracnose fungus, Colletotrichum gloeosporioides (Mead and Peña 1991). Since the avocado lacebug was previously not considered an important pest, it is suggested that in recent times suitable natural enemies were decimated by application of pesticides or by some other type of environmental desequilibrium. The objectives of this study were (1) to monitor populations of the avocado lace bug and attempt to discover its endemic biological control agents, (2) to test efficacy of such resident biocontrol agents, and (3) to evaluate the effect of feeding on photosynthesis and (4) observe if there is a relationship between cultivars and avocado lace bug populations.

Materials and Methods

Seasonality and monitoring

The study was conducted from January 1995 through May 1997 in four avocado orchards approximately 6 km N of Homestead in Dade County, Florida. Ten trees were selected randomly and each tree inspected bimonthly from 1995 through 1997. On each sampling date one twig with an average of 9-12 leaves was cut from each tree, placed in a plastic bag, transported to the laboratory, and examined with a dissecting microscope. The numbers of P. perseae eggs, nymphs and adults and the percentages of leaf area damaged were recorded. The means of counts were calculated on each sampling date.

Natural enemies

Survey. Leaves from the orchards mentioned above that contained eggs, nymphs and adults of P. perseae were observed and the presence of entomophagous insects recorded. Leaves were held individually for parasitoid emergence in 1-liter paper cartons. These cartons were held in the laboratory at 22 ± 3°C, and 75-80% RH for 1 month. Parasitoids that emerged were removed from containers, counted and identified by J. Pinto (University of California, at Riverside) or by the authors. Seasonal trends of the parasitoids and predators were assessed using the numbers of parasitoids emerging or the number of predators collected from infested leaves.

Effectiveness of Chrysopa rufilabris as predator of avocado lace bug. In tests where avocado lace bug were offered as prey, 50 nymphs of the P. perseae were placed daily, for 12 days, on leaves that contained 1 C. rufilabris larva. Based on the feeding capacity of C. rufilabris, the number of P. perseae nymphs provided daily per arena were increased to 100 from day 13 to day 20 after initiation of the experiment. The prey and predator were confined in 20.5 cm in diameter petri dishes. The experiment was performed in the laboratory at a temperature of 23 ± 3°C and RH of 75-80%. To determine natural mortality, the same numbers of P. perseae were introduced into arenas without the predator. Each treatment was replicated 10 times.
Effectiveness of Hyaliodes vitripennis as predator of avocado lace bug. One hundred *P. perseae* nymphs were offered daily as prey to 1 *H. vitripennis* adult held in similar predator-prey arenas as described above. The number of *P. perseae* killed or pierced by the predator were recorded during four consecutive days.

**Damage**

The second objective of our research was to identify the damaging levels of avocado lace bug in different avocado varieties. Avocado cultivars belong to one of three races based on their evolutionary center of origin. The majority of avocado cultivars grown commercially in Florida are West Indian, Guatemalan and Guatemalan × West Indian hybrids (Crane 1992, Schaffer 1995). The cultivars, Booth 8, Loretta, and Waldin were evaluated. Each cultivar was grown in 2 gallon containers. There were 10 single-plant replicates per treatment. Trees were infested by placing adults and nymphs of *P. perseae* on five tagged leaves and by recording the number of *P. perseae* eggs, nymphs and adults on the tagged leaves during 6 weeks. Percent leaf damage was determined visually. At the end of the experiment the leaf was detached and the undamaged leaf area and damaged leaf area measured using a video image analysis system (Bioscan Optimas version 4.0, Bioscan Incorporated, Edmonds, WA) following a procedure developed by Schaffer et al. (1997).

**Effect of leaf damage on photosynthesis**

An experiment to test the effect of percent leaf damage and net photosynthesis was conducted in February 1996. Ten trees of the cultivar Booth eight were selected and five leaves from each tree sampled. Each leaf was divided into different areas, distal, central and proximal area. Net photosynthesis was determined with a LCA-3 portable gas exchange system with a PLC-3B leaf cuvette (Analytical Development Corporation, Hoddesdon, Herts., England) as described by Larson et al. (1991). After photosynthetic determinations, the total area of each leaf was measured with a LiCor LI-3000 leaf area meter (LiCor, Inc., Lincoln, Nebraska) and the amount of leaf area damaged determined by multiplying the total leaf area by the fraction of the leaf area that was damaged.

**Effect of Lacebug on Avocado Yield**

Avocado lacebug populations, damage caused by the insect and effect of the insects on yield (number of fruits per tree) were studied following the same methods used for the population survey in 5 different avocado cultivars, ‘Simmonds’, ‘Choquette’, “Unknown”, ‘Pollock’ and a West Indies × Guatemalan hybrid. Before harvest, the number of fruit per tree were counted and their number related to the amount of *P. perseae* damage.

**Microbial and Chemical control of avocado lace bug**

The effect of a strain of *Beauveria bassiana* (BbHa) on *P. perseae* populations was evaluated under laboratory and orchard conditions.

**Laboratory Tests.** *P. perseae* infested avocado leaves were sprayed with a *Beauveria bassiana* (BbHa) spore suspension (4.83 × 10^7 CFU). Leaves were allowed to dry for 10 min and placed individually in 500 ml plastic containers. A similar number of leaves were left untreated. Subsequently, each container was covered with cheesecloth to allow proper ventila-

**Results and Discussion**

**Seasonality and Monitoring**

Approximately 20,000 leaves were inspected between January 1995 and May 1997 to determine the presence of *P. perseae* adult and immature stages. *P. perseae* density and the percent of damaged leaf area increased from October through March and declined sharply from April through August (Fig. 1). The most likely reasons were: (1) increases in avocado lacebug population density are related to development of the avocado canopy after the bloom period, and (2) the applications of pyrethroids against phytophagous mirids and thrips (i.e., *Daghbertus sp.* and *Frankliniella kelliae*), reduced predators and parasitoids of *P. perseae*. Injured leaves offer portals of entry for *Colletotrichum gloeosporioides*. The latter causes increases in leaf necrosis and premature defoliation. *P. perseae* populations reached their highest peak (12-15 ALB/leaf) in January and March 1995 and declined between April to May (0-1 ALB/leaf). *P. perseae* began a steady build up from...
July through March (3-6 ALB/leaf) (Fig. 1). Avocado lacebug populations can survive in fallen leaves, and they begin to re-colonize the tree as soon as the new leaves appear.

Natural Enemies

Four major biological control agents were collected in Homestead, FL and were identified as two egg parasitoids, Oligosita sp (Hymenoptera: Trichogrammatidae) and a unidentified mymarid (Hymenoptera: Mymaridae) species, the predators, green lace wing, Chrysoperla rufilabris (Neuroptera: Chrysopidae) and a predacious mirid, possibly, Hyalodes vitripennis (Hemiptera: Miridae). The egg parasitoid Oligosita was the most frequent during the first major peak in the P. perseae population, whereas the green lacewing, C. rufilabris was quite common in the avocado orchards between August and December, when populations of the ALB are low (Fig. 2).

Effectiveness of Chrysopa rufilabris as predator of avocado lace bug. C. rufilabris attacked nymphs of P. perseae. Only 13% of the initial nymph population was eaten during the first day of the study. Feeding increased progressively in the next five days. Thirteen days after P. perseae exposure to the predator,

consumption increased to 54% and reached 73% at 20 days. In the absence of the predator, mortality was 6-7% and reached 13% at the end of the experiment (Fig. 3). Our laboratory studies showed that green lace bug larvae cause a cumulative mortality of 75% of the avocado lacebug population (n = 50) during a 20-day exposure period. C. rufilabris prefers feeding on P. perseae nymphs over eggs and adults.

The predacious mirid, Hyalodes vitripennis feeds on lacebug (n = 100) eggs and nymphs causing 30-50% reduction of P. perseae immature forms during a 4-day observation period (Fig. 4). These preliminary findings, allow us to hypothesize that the inadvertent and indiscriminate reductions of parasitoids and predators by applications of pyrethroids may have caused imbalances of the populations of the lacebugs and have allowed them to attain outbreak levels.

Damage

During a greenhouse trial, the cultivars, Waldin, Booth 8 and Loretta had damage levels fluctuating between 20 and 28% of necrosis in the leaf surface. The most susceptible cultivar appeared to be 'Booth 8' (Table 1). Defoliation occurred when an average 36.90 P. perseae per leaf were recorded for 5 weeks after infestation. P. perseae levels re-

Table 1. Mean avocado lace bug density and damage in three avocado cultivars, 5 weeks after infestation.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>1 week after infestation</th>
<th>5 weeks after infestation</th>
<th>5 weeks after infestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Booth 8</td>
<td>36.90 ± 33.29</td>
<td>76.69 ± 347.24</td>
<td>14.00 ± 333.62</td>
</tr>
<tr>
<td>Waldin</td>
<td>4.92 ± 35.88</td>
<td>11.34 ± 311.64</td>
<td>2.14 ± 33.63</td>
</tr>
<tr>
<td>Loretta</td>
<td>12.92 ± 315.25</td>
<td>30.17 ± 350.91</td>
<td>2.23 ± 335.47</td>
</tr>
</tbody>
</table>
Effect of leaf damage on photosynthesis

In a different experiment, the photosynthetic activity of lacebug damaged foliage was compared with leaves without lacebug damage. Photosynthetic activity was reduced by about 50% when leaves sustained 40% or more damage (Fig. 5).

Effect of Lacebug on Avocado Yield

The cultivar ‘Simmonds’ sustained a total leaf drop early in the spring of 1996, that was preceded by 100% leaf infestation and severe necrosis and yellowing. The cultivar ‘Choquette’ had a late spring leaf drop, moderate leaf damage and less than 100% infestation. The “Unknown” variety remained lower for the ‘Waldin’ cultivar. P. perseae densities increased up to 30 P. perseae per leaf in the ‘Loretta’ cultivar, however, the percent damage per leaf was similar to that obtained for ‘Waldin’.

Microbial control of avocado lace bug

Data from the laboratory experiment are summarized in Table 2. Eleven days after treatment, adult lacebug mortality was 90% on B. bassiana treated leaves compared with 1.3% in the untreated leaves. Nymphal mortality on treated leaves was 72% compared to 2% for the untreated control. Mortality observed in the field trial was lower than that observed in the laboratory test. Nevertheless, the mortality levels observed in B. bassiana treated trees was significantly higher than that observed in the untreated plots (Table 3). Indeed a single application of B. bassiana was considered effective against P. perseae. P. perseae densities were low during the 1997 experiment. Applications of Mycortrol, M-Pede and FC-435 oil appeared to increase P. perseae mortality during 8 days following their application. The Mycortrol treated leaves appeared to maintain

Table 2. Mean survival of avocado lace bug adults and nymphs after treatment with Beauveria bassiana under laboratory conditions.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Adults per leaf</th>
<th>Nymphs per leaf</th>
<th>Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alive</td>
<td>Dead</td>
<td>Infected Alive</td>
</tr>
<tr>
<td>Untreated</td>
<td>4.55a</td>
<td>0.058b</td>
<td>0.60b</td>
</tr>
<tr>
<td>Treated</td>
<td>0.30b</td>
<td>0.44a</td>
<td>2.97a</td>
</tr>
</tbody>
</table>

Means followed by the same letter within the same column were not statistically different (P < 0.05).

was characterized by little leaf damage and minimum leaf drop during spring. The ‘Pollock’ and the WI x Guatemalan cultivars sustained no damage, and the avocado lace bug population remained very low. The largest number of fruit was collected from the West Indies x Guatemalan hybrid (81.00 ± 9.33) followed by ‘Choquette’ (53.5 ± 8.41), ‘Pollock’ (50.70 ± 5.00) and ‘Unknown’ (23.80 ± 4.47). No fruits were harvested (0.00 ± 0.00) from the ‘Simmonds’ cultivar (Fig. 6). These results suggest that different cultivars greatly in susceptibility to attack by the avocado lacebug.

Table 3. Mean survival of avocado lace bug adults and nymphs of under field conditions.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Adults per leaf</th>
<th>Nymphs per leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alive</td>
<td>Dead</td>
</tr>
<tr>
<td>Untreated</td>
<td>4.41a</td>
<td>0.40a</td>
</tr>
<tr>
<td>Treated</td>
<td>0.87b</td>
<td>0.30a</td>
</tr>
</tbody>
</table>

Means followed by the same letter within the same column were not statistically different (P < 0.05).

Table 4. Mortality of avocado lace bug adults and nymphs under field conditions.

<table>
<thead>
<tr>
<th>Treatment Dose/</th>
<th>Mean Dead Lace Bug individuals per leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1DBT</td>
</tr>
<tr>
<td>Untreated</td>
<td>0.02b</td>
</tr>
<tr>
<td>Mycortrol 2 qts</td>
<td>0.12ab</td>
</tr>
<tr>
<td>Mycortrol 3 qts</td>
<td>0.25a</td>
</tr>
<tr>
<td>Impede 250 oz</td>
<td>2.35a</td>
</tr>
<tr>
<td>FC-435 oil 1 gal</td>
<td>0.05ab</td>
</tr>
</tbody>
</table>

Means within columns followed by the same letter were not significantly different (P < 0.05).

DBT = Days before treatment
DAT = Days after treatment

a higher mortality than other insecticide treatments during 
15 to 30 day post treatment period (Table 4).

Because of increasing concerns about the excessive use of 
pesticides, non pesticidal methods and environmentally 
friendly methods for controlling *P. perseae*, such as those dis-
covered or tested in this study, should be given priority to be 
adapted or used by the Florida avocado industry.

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