Entomology

David Held
Section Editor and Moderator

T.P. Hoagland and P. B. Schultz
Virginia Polytechnic Institute and State University, Virginia Beach, VA 23455-3363
TPHOAG@aol.com

Index Words: Asian ambrosia beetle, *Xylosandrus crassiusculus*, IPM, ethanol

Significance to Industry: Nurseries are vulnerable to serious economic losses from Asian ambrosia beetle and may experience losses to highly marketable trees including *Acer rubrum* and *Cercis* sp. Trees shipped to retailers that subsequently died become a customer retention issue, as well as a financial matter. One nursery lost 200 *Prunus* valued at $15,000 in 2004. Nurseries that used Lindgren funnel traps to identify the flight period and optimize insecticide applications did not sustain significant losses to their inventory.

Nature of Work: The Asian ambrosia beetle (AAB), *Xylosandrus crassiusculus* (Motschulsky), was introduced into the southeastern United States in 1974 and was discovered in Virginia in 1995. Since that time, it has become a serious pest of landscapes, nurseries, and forests. The pest attacks apparently healthy trees (2) and has a broad host range; thus, there is potential for severe economic loss to the nursery industry.

Over 130 species of host trees have been identified, including maple, *Prunus*, and magnolia. Mated female AAB bore into host trees and excavate extensive galleries, and simultaneously inoculate hosts with fungal spores, including a pathogenic blue-stain fungus which can cause tree death. All life stages occur within the tree. Spring trap collections are excellent indicators of pest populations and timing for control. Our objective was to determine seasonal flight activity through trapping of AAB in order to recommend strategies that minimize losses and relate those practices to potential economic impact to the nursery industry. Ethanol-baited lures placed in Lindgren funnel traps (PheroTech, Delta, BC) were deployed, with three traps per site. The traps were hung from a shepherd’s hook, approximately 1.3 m above ground level. Each location had at least one trap located at the edge of woodlands and one in open nursery production area. Trap contents were collected every week from March 3 through September 30.

Results and Discussion: Trap collections were minimal from March 7 through April 2. Beginning the week of April 9, AAB trappings increased 10 fold to a peak the week of April 22 (X = 224, SE = 58). Following the April 22 peak AAB numbers declined rapidly. Both the flight peak and overall flight period fell within range of earlier observations in 1997-2001 (3). Our data (Figure 1), confirm that peak activity occurs in mid-late April. Trap collections on the edge of adjacent wooded areas were greater than from those located in open areas at both
Trapping adults to minimize the risk from AAB is a key component of successful pest management of commercial nursery hardwood tree production. Ethanol lures in a variety of trap configurations have been successful, including the Lindgren trap used in this study. Ethanol is typically produced by stressed or aging trees and is a reliable attractant for a variety of bark and ambrosia beetle species. An effective management plan should include adult flight monitoring, early recognition of an infestation ("toothpick" projections of frass and sawdust), destruction of infested trees, and leaving a small number of infested trees as a potential trap crop for a period of up to 50 days (to reduce attacks on nearby healthy trees) followed by their destruction (1). Some nurseries are deploying ethanol-baited traps to detect initial flight. Upon detection of AAB flight, a registered insecticide with a spreader-sticker is applied to the tree trunks. This strategy greatly reduces damage from AAB migrations into nursery stock. Future research could exploit this attraction to ethanol by adult bark and ambrosia beetles to develop strategies that would eliminate AAB as a pest of nursery tree production.

**Literature Cited:**


**Figure 1.** *Xylosandrus crassiusculus* collected from 3 traps each at 2 Virginia nurseries, 2005.
Evaluation of Neonicotinoid Insecticides for Control of the Strawberry Rootworm

Charles Hesselein\textsuperscript{1} and David Boyd\textsuperscript{2}
\textsuperscript{1}PO Box 8276, Mobile, AL, 36689
\textsuperscript{2}PO Box 287, Poplarville, MS, 39470
chessele@aces.edu

Index Words: \textit{Paria fragariae}, insecticides, pest control, beetle, chrysomelidae

Significance to Industry: The Strawberry Rootworm, \textit{Paria fragariae} Wilcox, is a small (1/8 inch long) chrysomelid beetle that feeds on the foliage of several ornamental species and has become a serious pest in container azalea production. The biology, pest status and control of the adult strawberry rootworm has been recently reviewed (1, 2). Strawberry rootworm larvae in the media of small containers can be controlled with Orthene and Talstar (3). In the current study, we evaluated neonicotinoid insecticides, applied as drenches, for their ability to kill strawberry rootworm adult beetles as they walk and feed on foliage. Preliminary results of this study are presented in this paper.

Nature of Work: On May 17, 2006, one-gallon containerized ‘Pink Pearl’ azaleas were drenched with one of the following treatments (all treatments are expressed as ounces or fluid ounces per 100 gallons): untreated control, Safari 20 SG 12 oz, Safari 24 oz, Celero 5.6 oz, Celero 11 oz, Flagship 0.2 oz, Marathon II 21.8 fl oz, Discus 120.3 fl oz, Discus 167.7 fl oz, Talstar N 10 fl oz, Talstar N 40 fl oz. Each plant was treated with 4.2 fluid ounces of treatment solution. Plants were treated and left on site at Tom Dodd Nursery in Semmes, AL. Plants were irrigated within an hour of being treated. The experimental design was a completely randomized design with four replications per treatment. An experimental unit consisted of a single one-gallon potted azalea. Efficacy was evaluated by removing one multi-stemmed branch from each experimental unit, placing the stem in a plastic bag with a moist paper towel, transporting the stems in a cooler to the Mobile Ornamental Horticulture Research Center for evaluation. Excised stems were immersed in a water-filled, capped, #53 Aquapick tube (Syndicate Sales, Inc., Kokomo, IN) inserted in a hole in the bottom of an 8 fl oz capped sample cup (arena) with one stem per arena. On the same day, three strawberry rootworm beetles were placed in each arena and allowed to feed on the foliage. Arenas were suspended on a wire covered bench in the laboratory for the duration of the experiment. Stems were removed from plants at the nursery 8 and 28 days after treatment (DAT). For samples collected 8 DAT, only data collected six days after the beetles were exposed to treated foliage will be discussed. For samples collected 28 DAT, only data collected eight days after the beetles were exposed to treated foliage will be discussed. Data collected consisted of a foliar damage rating based on the 1-12 rating system (4) where 1= no damage, 2= 0-3%, 3 = 3-6%, 4= 6-12%, 5 = 12-25%, 6 = 25-50%, 7 = 50-75%, 8 = 75-88%, 9 = 88-94%, 10 = 94-97%, 11 = 97-100% and 12 = 100% of the foliage in the arena was damaged. In addition, the number of dead beetles per arena was analyzed for the 8 DAT data and the percentage of beetles found dead in each arena was analyzed for the 28 DAT data. All data were analyzed using ANOVA ($P \leq 0.05$) and means were separated using Fisher’s Protected LSD ($\alpha = 0.05$).
Results and Discussion: Stems taken from plants 8 DAT that were treated with the products Discus (both rates), Marathon, Celero, and the high rate (24 oz) of Safari had lower damage ratings than the untreated control after 6 days of exposure to beetles. However, only Celero (5.6 oz) and Safari (24 oz) treated plants had more dead beetles than the control (Figure 1). Stems taken from plants at 28 DAT that were treated with Marathon, Discus (both rates), and the high rate (11.3 oz.) of Celero had the lowest damage ratings. At that time, stems from plants treated with Celero (5.6 oz) and Safari (24 oz) had lower ratings than controls stems, but higher, and probably commercially unacceptable, ratings than stems from the Marathon or Celero (11.3 oz) treatments (Figure 2). It appears the effective treatments (damage ratings ≤ 4) stop beetle feeding before killing beetles. This experiment has also shown that Marathon, Discus (both high and low rates) and Celero (11.3 oz) treatments had the longest residual activity (28 d).

Drench treatments are expensive and may only be justified when evaluating their longevity and efficacy compared to currently recommended sprays. We will continue evaluating the treatments in this experiment until there are no longer any effective treatments. We are currently evaluating treatments at 56 DAT. We will also plan on evaluating neonicotinoid insecticides as foliar sprays and as drenches for controlling larvae in the potting media.

Literature Cited:
Figure 1. Data collected 8 DAT and six days after exposed to insecticide treated foliage. Means for both damage number of dead beetles and damage rating were separated using Fisher’s Protected LSD (α=0.05). Treatments represented by columns topped by the same letter are not different for number of dead beetles or damage rating. Damage rating is based on the following: 1 = no damage, 2 = 0-3%, 3 = 3-6%, 4 = 6-12%, 5 = 12-25%, 6 = 25-50%, 7 = 50-75%, 8 = 75-88%, 9 = 88-94%, 10 = 94-97%, 11 = 97-100%, and 12 = 100% of the
**Figure 2.** Data collected 28 DAT and eight days after exposed to insecticide treated foliage. Means for both damage number of dead beetles and damage rating were separated using Fisher’s Protected LSD ($\alpha = 0.05$). Treatments represented by columns topped by the same letter are not different for number of dead beetles or damage rating. Damage rating is based on the following: 1 = no damage, 2 = 0-3%, 3 = 3-6%, 4 = 6-12%, 5 = 12-25%, 6 = 25-50%, 7 = 50-75%, 8 = 75-88%, 9 = 88-94%, 10 = 94-97%, 11 = 97-100%, and 12 = 100% of the foliage in the arena was damaged by strawberry rootworm feeding.
Impact of Insecticide Residue on Silverleaf Whiteflies

Scott W. Ludwig¹ and Cindy McKenzie²
¹Texas Cooperative Extension, P.O. Box 38, Overton, TX 75684
²U. S. Horticultural Research Laboratory, 2001 South Rock Road, Fort Pierce, FL 34945
swludwig@ag.tamu.edu

Index Words: silverleaf whiteflies, Bemisia tabaci, poinsettia, insecticides

Significance to Industry: In 2005, the Q-biotype of Bemisia tabaci was identified in the United States. This find and increased problems with management of the silverleaf whitefly (B-biotype of Bemisia tabaci) have resulted in a national effort to develop a comprehensive management plan for whiteflies on ornamental crops. The objective of the following study was to evaluate the activity of insecticide residue against silverleaf whitefly to aid in the development of a whitefly resistance management program. This initial study indicated that Judo, Avid, Sanmite, Enstar II, Endeavor, and Distance provide poor residual control of adult whiteflies. However, Judo, Avid, and Distance provided excellent control of immature whiteflies and eggs that resulted from adult whitefly exposed to plants 16 days after application.

Nature of Work: In 2005, the Q-biotype of Bemisia tabaci was identified in the United States. This population was found to have reduced susceptibility to many of the insecticides used by ornamental producers. This find and increased problems with management of the silverleaf whitefly (B-biotype of Bemisia tabaci) have resulted in a national effort to develop a comprehensive management plan for whiteflies on ornamental crops. The objective of the following study is to evaluate the activity of insecticide residue against silverleaf whiteflies to aid in the development of a whitefly resistance management program.

In this study we evaluated pesticide residue at three time intervals after a single foliar application to poinsettia (Freedom Red) plants. The following treatments were evaluated at labeled rates: Judo (spiromesifen), Avid 0.15EC (abamectin), Sanmite 75WP (Pyridaben), Enstar II (S-kinoprene), Endeavor 50WG (pymetrozine), Distance IGR (pyriproxyfen), and an untreated control (see Table 1 for rates). Clip cages were placed onto leaves at 7 hrs, 8 days, and 14 days after the application. These leaves were fully expanded when the plants were treated. Ten adult whiteflies of mixed sex and age were then placed into each cage. After 48 hours, the number of eggs and dead whiteflies were recorded. Eggs were allowed to hatch, nymphs develop, and adults emerge. The number of emerged adults was then recorded.

Data were transformed using an arcsine transformation prior to analysis. Data were analyzed with ANOVA and means separation was accomplished by using the least significant difference test (LSD) at the $P<0.05$ level. All data are presented as original means.
Results and Discussion: No insecticide provided greater than 70% direct adult mortality (Table 1). Distance provided 100% control of the resulting generation on all sample dates (Table 2). Judo provided greater than 80% control of the resulting generation on all sample dates. Avid provided greater than 90% control for the first two sample periods. The other insecticides have varying levels of residue activity.

These results indicate that none of the products evaluated will provide effective control of adults once the insecticides have dried. However, Distance, Judo and Avid provided excellent immature whitefly control during the period evaluated. Sanmite managed to kill over 60% of the nymphs during the periods evaluated. This trial will be repeated and additional trials are planned to evaluate the residue activity of other insecticides used to manage whiteflies. These results will enable grower and extension personnel to better understand the residual activity of insecticides. This will in turn result in better insecticide rotation programs for the management of whiteflies.

Acknowledgement: We would like to thank the USDA-ARS Floriculture and Nursery Research Initiative (agreement numbers 58-6204-5-0033) and USDA-ARS project number 6618-22000-030-12 for providing financial support. We would also like to thank Paul Ecke Ranch for supplying the poinsettias used in the study.

Table 1. Percent (±SEM) adult mortality after 48 hours of exposure to insecticide residue.

<table>
<thead>
<tr>
<th>Rate / 100 gal</th>
<th>7-55 hours</th>
<th>8-10 day</th>
<th>14-16 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judo 4 fl oz</td>
<td>31.0±5.1 bc</td>
<td>11.4±3.5</td>
<td>6.8±3.4</td>
</tr>
<tr>
<td>Avid 0.15EC 8 fl oz</td>
<td>68.6±12.2 a</td>
<td>14.6±3.7</td>
<td>5.5±5.5</td>
</tr>
<tr>
<td>Sanmite 75WP 6 oz</td>
<td>31.6±10.9 bc</td>
<td>25.8±5.1</td>
<td>7.9±5.0</td>
</tr>
<tr>
<td>Enstar II 10 fl oz</td>
<td>55.5±10.2 ab</td>
<td>9.1±3.5</td>
<td>9.1±3.9</td>
</tr>
<tr>
<td>Endeavor 50WG 5 oz</td>
<td>10.6±6.3 c</td>
<td>7.9±4.2</td>
<td>15.0±6.1</td>
</tr>
<tr>
<td>Distance IGR 8 fl oz</td>
<td>21.3±5.2 c</td>
<td>10.9±2.7</td>
<td>1.4±1.4</td>
</tr>
<tr>
<td>Untreated Control</td>
<td>9.1±6.5 c</td>
<td>5.5±5.5</td>
<td>7.9±5.6</td>
</tr>
</tbody>
</table>

Means within a column followed by different letters are significantly different (P<0.05, LSD). Statistical analysis not conducted on second two columns due to low adult mortality rates.
Table 2. Percent (±SEM) of eggs that failed to produce adults after exposure to insecticide residue.

<table>
<thead>
<tr>
<th>Cage Placement</th>
<th>Rate / 100 gal</th>
<th>7-55 hours</th>
<th>8-10 day</th>
<th>14-16 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judo</td>
<td>4 fl oz</td>
<td>99.1±0.6 a</td>
<td>94.0±3.0 b</td>
<td>82.6±6.8 b</td>
</tr>
<tr>
<td>Avid 0.15EC</td>
<td>8 fl oz</td>
<td>100 a</td>
<td>95.5±1.5 ab</td>
<td>55.4±12.3 bc</td>
</tr>
<tr>
<td>Sanmite 75WP</td>
<td>6 oz</td>
<td>73.4±4.2 b</td>
<td>60.8±9.5 c</td>
<td>73.0±8.7 b</td>
</tr>
<tr>
<td>Enstar II</td>
<td>10 fl oz</td>
<td>81.6±5.1 b</td>
<td>36.5±8.3 d</td>
<td>31.1±11.6 cd</td>
</tr>
<tr>
<td>Endeavor 50WG</td>
<td>5 oz</td>
<td>24.3±8.9 c</td>
<td>49.5±6.4 cd</td>
<td>26.6±8.1 d</td>
</tr>
<tr>
<td>Distance IGR</td>
<td>8 fl oz</td>
<td>100 a</td>
<td>100 a</td>
<td>100 a</td>
</tr>
<tr>
<td>Check (water spray)</td>
<td></td>
<td>35.9±12.2 c</td>
<td>28.7±6.6 d</td>
<td>9.6±4.5 d</td>
</tr>
</tbody>
</table>

Means within a column followed by different letters are significantly different (P<0.05, LSD).
Cultural Practices for Removal of Wax Scales and Sooty Mold from Ornamentals

David W. Held, Corey Wheeler and Wayne McLaurin
Mississippi State University Coastal Research and Extension Center,
1815 Popps Ferry Road, Biloxi, MS 39532
david.held@msstate.edu

Index Words: Ceroplastes, water washing, pest management

Significance to the Industry: Scale insects, including wax scales (Ceroplastes spp.) are among the most difficult to control pests in nursery production. Although they rarely kill their host, a scale infestation can reduce growth and make plants less vigorous. In addition, dead scales and sooty mold that persist after the scale is eliminated can prevent the sale of otherwise healthy plants. For this reason, we evaluated removal of wax scales and sooty mold using a commercial pressure washer and varying pressure. We also evaluated the usefulness of insecticidal soap and oil soap for removal of sooty mold. This research demonstrates the usefulness of high pressure washing for ornamentals in production or the landscape that are infested with wax scales. Although pressure washing was ineffective at reducing the incidence of sooty mold, additional experiments suggest a 1% solution of oil soap applied to foliage may help loosen and remove sooty mold.

Nature of Work: Scale insects, including wax scales (Ceroplastes spp.) are among the most difficult to control pests in nursery production. Although they rarely kill their host, a scale infestation can reduce growth and make plants less vigorous. Insecticide applications that target crawlers (2) or the use of systemic insecticides (1, 4) seem to be the most effective chemical control strategies. Despite this, the presence of dead scales and sooty mold coated foliage often persist and can prevent the sale of otherwise uninfested plants.

Use of water to dislodge insects is common practice by organic gardeners to control ornamental and vegetables pests such as aphids without the use of insecticides. This practice has also been researched for removal of insect pests from fruit in production and in post-harvest (5). Evaluation of this technique for ornamentals has been limited (4). A grower in south Mississippi was using a washing technique to remove living or dead wax scale from plants before being sent to market. This tactic removed 71 and 69% of scales from stems and leaves, respectively (Held, unpublished data). The purpose of this project was to evaluate pressure washing to dislodge wax scales and sooty mold from foliage and foliar application of soap products for removal of sooty mold.

We conducted an experiment on a hedge of holly surrounding the parking lot of the convention center in Hattiesburg, MS. This hedge is infested with Florida wax scale and sooty mold covers most of the older foliage. We used a commercial, gas-powered pressure washer (Ex-Cell model ZR 2700) with an added pressure gauge on the wand to confirm the operating pressure. The 15° tip used was used for all washing experiments when it was determined that a 0° tip (pinpoint stream) would cause severe plant damage.
Ten shoots, about 13–28 cm (5–11 inches) long with an average of 18 leaves per shoot, were flagged on either side of the hedge. On each shoot, leaves with wax scales and sooty mold were randomly selected for evaluation. The percent sooty mold coverage and number of scales on the upper and lower leaf were counted before treatment. Then, a portion of the hedge that included that shoot was pressure washed for 10 sec. then the number of remaining scales and percent sooty mold coverage were re-evaluated. The operating pressure was initially set at 2000 kPa (290 PSI) and increased in 2000 kPa increments to a maximum of 14000 kPa (2030 PSI).

Additional experiments were conducted to evaluate Murphy’s oil soap (Colgate-Palmolive, New York, NY) and Safer’s insecticidal soap for removal of sooty mold and potential phytotoxicity on selected ornamentals. Murphy’s oil soap was chosen based on conversations with Master Gardeners and review of extension service literature that claim use of soap solutions can remove sooty mold from infested plants (3). Solutions (1, 5, 10, 25, 50, and 75% by volume in water) of Murphy’s oil soap were prepared in separate 900 ml plastic handheld spray bottles. Insecticidal soap product was included because it has labeled rates which are safe for use on many ornamentals. The insecticidal soap was mixed at the labeled rate in a separate plastic spray bottle.

The first experiment was conducted in a stand of mixed variety crape myrtles growing on the MS State Research Farm in McNeil, MS. All plants were field grown and received <2 inches of rainfall and no overhead irrigation during the experiment. Plants were approximately 1.5 m tall and densely coated with sooty mold as a result of previous infestation of crape myrtle aphids. On each plant, eight shoots selected at random and flagged with a code indicating the treatment to be applied. Shoots were sprayed with each treatment to runoff. Shoots were all 100% covered with sooty mold at the beginning of the experiment. After treatment, the percent sooty mold coverage was evaluated at 1 and 2 weeks after treatment.

The second experiment was conducted to assess the phytotoxicity of the two lowest rates of Murphy’s oil soap on eight species of ornamentals: Pittosporum tobira ‘Wheeler’s Dwarf’; Magnolia grandiflora ‘Little Gem’; Loropetaleum chinense var. rubrum ‘Ruby’; Zamia pumila; Podocarpus macrophyllus; Osmanthus fragrans; Ilex × ‘Nellie R. Stevens’; and Rhaphiolepis umbellata ‘Olivia’. This experiment was conducted on 24 March when loropetalum, Indian hawthorn, and osmanthus were in flower. Two shoots were flagged on a minimum of three plants of each species and treated with either the 1 or 5% solution of Murphy’s oil soap or just water as previously described. At 4 days after treatment (DAT), the shoots were examined for possible phytotoxicity including yellowing or leaf or flower drop.

Results and Discussion: Pressure washing removed ≤20% of the sooty mold from any single leaf. Sooty mold was removed at pressures ranging from 580–1450 PSI. However, pressure washing was able to remove >80% of the observed scales (range 33–100%) across all pressures evaluated. Damage, loss of individual leaves or the entire shoot, was not observed until pressure was ≥1740 PSI. Higher pressures may not be necessary because wax scales were
easily removed at lower pressures (Figure 1). Timing of the pressure wash may also be critical in reducing a wax scale infestation. For example, if wax scales are removed before the first crawler hatch then that would prevent new scales from re-infesting the plant or infesting new plants in the landscape or nursery. This technique may also be adapted to remove other soft scales, mealybugs, or aphids. High pressure washing has been shown effective at reducing the incidence of mealybugs and caterpillars on apples after harvest (5).

Murphy’s oil soap significantly reduced the coverage of sooty mold on crapemyrtle leaves at 7 and 14 days after treatment ($F = 5.3$ and $3.1; P = 0.005$ and 0.04; df = 4, 19, respectively). Murphy’s oil soap concentrations <25% were only considered in the analysis because these were the only concentrations where partial or complete defoliation was not observed (Figure 2). At 25, 50, or 75% concentrations of Murphy’s oil soap, 3, 5, and 6 of the six sprayed shoots (respectively) were defoliated as a result of treatment. Only the lowest rate of Murphy’s oil soap significantly reduced the amount of sooty mold below 50% in 2 wks. Performance on an oil soap to remove sooty mold from ornamentals as well as associated phytotoxicity may be for plants grown under overhead irrigation. Murphy’s oil soap or other soap products recommended by extension publications (3) are not labeled for use on plants. However, the insecticidal soap product which has been tested for phytotoxicity was not effective at removing sooty mold. Application of Murphy’s oil soap solution (1%) effective for removal of sooty mold was not phytotoxicity to eight species of ornamentals.

The results of these studies provide growers some hope that plants severely infested with wax scales may be salvageable and marketable. Also, this provides opportunities for researchers to explore new applications of high pressure washing for other pests of ornamentals.

Literature Cited:
6. Whiting, D. C., L. E. Hoy, J. H. Maindonald, P. G. Connolly, and R. M. McDonald. 1998. High-pressure washing treatments to remove obscure mealybug (Homoptera: Pseudococcidae) and lightbrown apple moth (Lepidoptera: Tortricidae) from harvested apples. J. Econ. Entomol. 91: 1458–1463.
**Figure 1.** Removal of wax scales from holly foliage on ten flagged shoots at increasing water pressures.

![Graph showing the removal of wax scales at different water pressures.](image)

**Figure 2.** Reduction in the coverage of sooty mold on treated crapemyrtle leaves that were treated with solutions of Murphy’s oil soap in water.

![Graph showing the reduction of sooty mold coverage.](image)
Are Two Predators Better than One? 
Effects of Combining a Predatory Mite 
and a Predatory Bug for Control of Western 
Flower Thrips on Greenhouse Roses

Andrew Chow, Amanda Chau and Kevin M. Heinz
Department of Entomology, Texas A&M University,
College Station, TX 77843-2475
achow@tamu.edu

Index Words: biological control, inundative releases, Amblyseius degenerans, Frankliniella occidentalis, Orius insidiosus, cut roses

Significance to Industry: Intensive insecticide use for western flower thrips (WFT), Frankliniella occidentalis (Pergande), is often necessary to meet consumer demands for floricultural crops. Despite widespread insecticide use, WFT are still difficult pests to control because they can escape contact insecticides by hiding within plant parts, and, in part, due to widespread resistance. As an alternative to chemical control, we evaluated the predatory bug, Orius insidiosus (Say), alone and together with the predatory mite, Amblyseius degenerans Berlese, for suppressing WFT on roses. In greenhouse studies simulating commercial production of cut roses, we found that plants protected by releases of predators had fewer WFT than unprotected plants. However, the abundance of WFT did not differ between plants protected by predatory bugs alone and plants protected by both predatory bugs and predatory mites. In laboratory studies, we found that predation of A. degenerans by O. insidiosus may detract from suppression of WFT within rose flowers. Given the high costs of A. degenerans in the US, we do not recommend releases of both predator species for thrips control on cut roses.

Nature of Work: The WFT is a serious widespread pest of cut roses and other ornamental crops worldwide (5). Chemical control has been the preferred tactic for thrips management in greenhouses. However, even chemical control of WFT is difficult because this pest has developed resistance to many insecticides and also tends to hide within flowers, buds, and apical meristems (3). Intensive pesticide use for WFT may pose hazards to water quality or worker health and disrupt effective biological control programs for other pests such as aphids, spider mites and whitefly (1). An alternative to insecticides is the use of natural enemies for biological thrips control.

Both predatory bugs and predatory mites are commercially available in the US for control of WFT. Orius insidiosus can suppress high W+ I densities but have limited ability to attack thrips within confined plant parts. Amblyseius degenerans, can reach more confined habitats than O. insidiosus but kill primarily first-instar larvae of thrips. Simultaneous use of both agents may provide both effective and cost efficient control of WFT through complimentary predation. Our objective was to determine whether suppression of WFT on greenhouse cut roses by inundative releases of predatory bugs could be enhanced by concurrent
releases of predatory mites. *Orius* species readily prey on WFT but may also attack beneficial species (6). To evaluate whether predation of *A. degenerans* by *O. insidiosus* may detract from control of WFT, we also conducted laboratory studies to investigate prey preference of *O. insidiosus*.

For our greenhouse study, we established our roses from bare-root rose stock (*Rosa hybrida* L. cv. ‘Tropicana’ grafted onto ‘Dr. Huey’ rootstock) individually planted in 14-L, plastic nursery-containers with soilless mix, pine bark, and sand (3:1:1 ratio). Plants were cultivated as a cut flower crop following conventional guidelines (4) in greenhouses for nine months before being used for our study. We compared control of WFT under conditions simulating greenhouse production in Texas by exposing roses to only WFT, WFT and predatory bugs, or WFT with both predatory bugs and predatory mites. The number of replications was three per treatment and the three treatments were equally distributed within a randomized block design, using position within the greenhouse as the blocking factor. All natural enemies were obtained from Koppert Biological Systems Inc. (Romulus, Michigan).

Each replicate consisted of eight potted plants spaced 5cm apart and arranged in a 4 × 2 grid on a greenhouse bench enclosed by a PVC frame (305cm long x 152cm wide x 122cm high) sheathed with thrips-proof screen. To simulate a thrips infestation, we released five adult females of WFT near each plant over seven consecutive weeks (total = 560 thrips over 14 releases per replicate). Beginning 2 wks after the first thrips release, one adult female and one adult male predatory bug were released near each plant in all replicates assigned only predatory bugs during the third, fifth, and sixth week of the study (total = 48 bugs over three releases per replicate). In addition, 10 adult mites were released onto each plant with *O. insidiosus* in replicates assigned both predatory bugs and predatory mites (total = 240 mites over three releases per replicate).

The experiment was conducted in a greenhouse from November 2005 to January 2006. We counted all the fully opened flowers in each replicate once a week for eight consecutive weeks. Starting the same week that predators were released (week 3), we harvested two thirds of the shoots with flowers that opened recently (before pollen release). Flowers were cut from the harvested shoots and placed in individual plastic containers. The vegetative part of each harvested shoot was placed in a separate plastic container. Using a standard protocol (2), we extracted WFT from the flowers and counted all WFT stages. Flowers were harvested during the third to eighth weeks of the crop. We transformed flower and WFT counts to their square root values and analyzed weekly counts with one-way repeated-measures ANOVA using treatment as the main effect.

We also evaluated preference by *O. insidiosus* for both WFT and *A. degenerans* by evaluating predation when both prey were available in equal numbers. A single female predatory bug was placed in a mesh-screened Petri dish cage (15.5 cm diameter x 4.0 cm height) for 24 h. Each cage contained a single rose stem with an open flower and 10 adult mites and 10 adult WFT. Twenty-one replicates were completed and we used the Wilcoxon paired-sample test to compare numbers of each prey type killed by predatory bugs.
Results and Discussion: In our greenhouse study, we found significant differences between WFT counts from flowers harvested from plants exposed to only WFT (unprotected) or both WFT and predators (protected) (one-way repeated measures ANOVA: $F_{2,6} = 5.326; P = 0.047$) (Figure 1). Unprotected plants always had the most WFT, but thrips counts on protected plants did not vary significantly with the number of predatory species released. Thrips counts were similar for all treatments from the third to fourth week but were around 25-45% greater for unprotected plants than protected plants from the fifth to the eighth week. Numbers of open flowers were similar for all treatments (one-way repeated measures ANOVA: $F_{2,6} = 0.183; P = 0.624$) and started at 4.56 ± 0.24 (n = 9; ± SE) in the first week, increased to 9.67 ± 0.78 (n = 9; ± SE) by the third week, and gradually declined to 4.44 ± 0.63 (n = 9; ± SE) by the eighth week.

In our predation trials, predatory bugs always killed more of the most abundant prey type, but show preference for *Amblyseius degenerans*. Predatory bugs killed more than twice as many mites as adult WFT when provided with both prey types in equal numbers (Figure 2). From these experiments, we concluded that predation of *A. degenerans* by *O. insidiosus* could affect suppression of WFT on cut roses. *Amblyseius degenerans* is quite expensive, with US clientele paying up to $80 US for an order with around 1000 mites. Given our results, we would not recommend the concurrent use of *A. degenerans* with *O. insidiosus* for control of WFT on cut roses.

Funding for this work was provided in part by the USDA-ARS Floriculture and Nursery Research Initiative and the Texas Department of Agriculture – Texas Israeli Exchange and U.S./Israel Binational Agricultural Research and Development Program. We also thank Ran-Pro Farms, Inc. for donating the bare-root roses used for these studies.

Literature Cited:
Figure 1. Weekly counts of adult *Frankliniella occidentalis* (WFT) (mean + SE) in cut roses exposed to ‘no predators’ or *Orius insidiosus* or both *O. insidiosus* and *Amblyseius degenerans*, n = 3 per treatment, 8 plants per replicate. Releases of WFT began on the first week and finished in the seventh week. Releases of predators began on the third week and finished in the sixth week. WFT were counted once every week during the third to eighth weeks of the crop.

![Graph showing weekly counts of adult Frankliniella occidentalis (WFT) in cut roses exposed to different treatments.](image)

Week

Number of thrips per flower

Figure 2. Mean numbers of prey killed by a single *Orius insidiosus* female (n = 21) at different ratios of adult *Frankliniella occidentalis* (WFT) and adult *Amblyseius degenerans* (Mites) on flowering rose stems. Bars indicate ± SE. Different letter(s) above bars representing each prey ratio indicate significant differences (P < 0.05) determined by Wilcoxon paired-sample test.

![Graph showing mean numbers of prey killed by a single Orius insidiosus female at different ratios of WFT and Mites.](image)

Ratio WFT : Mites
Reducing Fertilization for Greenhouse Cut Roses: Implications for Thrips and Spider Mite Management

Amanda Chau and Kevin M. Heinz
Department of Entomology, Texas A&M University,
College Station, TX 77843-2475
achau@tamu.edu

Index Words: fertilizer, Rosa hybrida, Frankliniella occidentalis, Tetranychus urticae, abundance, distribution

Significance to Industry: Manipulating fertilization influences not only crop yield but also pest populations. Reduction of fertilization could be a useful tactic in an integrated pest management program if pest populations could be reduced with little loss in crop yield and productivity. Our study examined the influence of fertilization on the abundance and distribution of western flower thrips (WFT) [Frankliniella occidentalis (Pergande)] and twospotted spider mite (TSSM) [Tetranychus urticae Koch] on cut roses [Rosa hybrida L. cv. Tropicana]. We found no significant fertilization effects on the WFT abundance and within-shoot distribution. We also found no significant fertilization effects on the abundance and within-shoot distribution of adults or immature TSSM, but more TSSM eggs were found on plants fertilized above the recommended level than on plants fertilized below the recommended level. By lowering fertilization to 75 ppm N, 50% of the recommended level (150 ppm N), we were able to reduce TSSM eggs by 26.8% with no loss in either crop productivity or quality.

Nature of Work: Lowering fertilization has been demonstrated to be a useful management tactic for WFT on potted mums (2). A previous study has shown that fecundity of TSSM increases with greater nitrogen fertilization (6). If fertilization could be manipulated to slow pest population growth while maintaining crop productivity, this tactic may be used with other management practices to control WFT and TSSM, two of the most important pests of cut roses. Fertilization could be lowered to 90 ppm N, below the recommended range (150 to 250 ppm N) for commercial cut rose production (5), without adversely affecting rose yield (1). A recent study showed that fertilization could be further reduced to 75 ppm N without affecting rose yield (3). It is essential to understand the influence of fertilization not only on plant productivity but also on pest populations when developing crop management practices that seek to reduce inputs and minimize runoff for ornamental production.

In our study, we tested four fertilization levels: 50, 75, 100, and 125% of the recommended rate (150 ppm N). A water-soluble, complete, and commercially available fertilizer (Peters Excel 15-5-15 Cal-Mag, Scotts Company, Marysville, OH) was used to maximize the applicability of research results for practical crop management practices. Reverse-osmosis-filtered tap water (RO water) was used to make the fertilizer solutions and water the plants. Using the same cultivation practices described in another study (3), we grew our roses as a cut flower crop in the greenhouse. Twenty rose plants were used for the experiment and each plant was a replicate. Plants were placed on two greenhouse benches. We used
a randomized design with three replicates per treatment per bench and two replicates per treatment on the remaining bench, totalling 5 replicates per treatment.

To simulate a thrips infestation, five adult females and 1 adult male of WFT were released near the base of each plant. We harvested flowering shoots when the flowers had fully opened, starting about two and half weeks after thrips inoculation. Flowers were removed from the harvested shoots and placed in individual plastic containers. The vegetative part of each harvested shoot was placed in a separate plastic container. Using the same method described in an earlier study (4), we extracted WFT from the flowers and counted all WFT stages. Most of the plants were heavily infested with naturally-occurring TSSM. We determined the within-shoot distribution of TSSM by examining the petals from each flower and individual leaves of each flowering shoot under a dissecting microscope and counting all TSSM stages.

To control for the possible effect of TSSM populations on WFT populations, we repeated the experiment after treating all plants with a miticide, Acequinocyl (Shuttle® 15 SC, Arvesta, San Francisco, CA, USA), at the recommended rate of 0.50 ml/l. The plants were monitored for TSSM infestation throughout the experiment to determine if additional insecticide applications were needed. Number of flowering shoots produced, proportion of thrips-infested flowering shoots, and number of thrips per infested shoots were analyzed using repeated measures one-way ANOVA with fertilization level as the main factor. Within-shoot distribution of WFT was analyzed using the Scheirer-Ray-Hare two-way ANOVA of ranks test with fertilization level and plant part as the main effects. Number of adults, immature stages, and eggs of TSSM per infested shoots were first square-root transformed and analyzed using two-way ANOVA with fertilization level and location as the main factors.

Results and Discussion: We found no significant fertilization effect on the proportion of thrips-infested flowering shoots per plant and the number of WFT per infested shoot on rose plants. The percentage of flowering shoots infested with thrips was higher (52%) for the 1st harvest than the 2nd harvest (37%). On average, 3.4 thrips were found on each infested flowering shoot. More adult and immature WFT were found in the flowers than on the vegetative part of the flowering shoot regardless of fertilization level (Figure 1). No significant interactions were found between plant part and fertilization level suggesting the apparent preference of WFT for the flowers was not influenced by fertilization level. This finding was similar to our earlier study on chrysanthemum (4). Although most plants were infested with both TSSM and WFT during the first flush of growth and flowering, the presence of TSSM did not seem to influence WFT abundance and distribution.

A naturally-occurring population of TSSM was found on rose plants during the first harvest. Percentage of plants infested with TSSM ranged from 73% (plants fertilized with 50% of the recommended level) to 100% (plants fertilized with 75%). All stages of TSSM were found on the vegetative part of the flowering shoot but none in the flowers. There were no significant fertilization effects on the numbers of adults and immatures of TSSM per infested shoot except the number
of eggs per infested shoot. The number of eggs per infested shoot increased with fertilization (Figure 2). Lowering fertilization to 50% of the recommended level reduced TSSM eggs by 26.8% with no loss in either crop productivity or quality. It may be feasible to lower fertilization below 50% of the recommended level for cut roses to further reduce both WFT and TSSM populations on this crop.

Acknowledgement: We thank the USDA-ARS Floriculture and Nursery Research Initiative and the Texas Department of Agriculture- Texas-Israeli Exchange and U.S./Israel Binational Agricultural Research and Development Program for providing financial support and Ran-Pro Farms, Inc. for donating bare-root rose plants.

Literature Cited:
Figure 1. Mean number of adult or immature western flower thrips (WFT) (+ SE) in the flower or on the vegetative parts of infested flowering shoots for two harvests (n = 20). More adult and immature WFT were found in the flowers than on the vegetative part of the flowering shoot regardless of fertilization level.

![Mean number of WFT per infested shoot](chart1)

Rose harvest

Figure 2. Mean number of twospotted spider mite (TSSM) eggs per infested flowering shoot (+ SE) on rose plants fertilized with 50, 75, 100, or 125% of the recommended fertilization level (150 ppm N). Different letter(s) above the bars indicate significant differences among fertilization treatments at P ≤ 0.05 (n = 5).

![Number of TSSM eggs per infested shoot](chart2)
Morphological Differences between Two Gall-inducing Species, *Gynaikothrips uzeli* and *Gynaikothrips ficorum*

Corey Wheeler¹, David Held¹ and David Boyd²

¹Mississippi State University Coastal Research and Extension Center, 1815 Popps Ferry Rd, Biloxi, MS 39532
²USDA ARS Southern Horticulture Laboratory, P.O. Box 287, Poplarville, MS 39470
cnw69@msstate.edu

Index Words: Cuban Laurel Thrips, *Gynaikothrips uzeli*, *Gynaikothrips ficorum*, Morphology

Significance to the Industry: Ficus are one of the most widely produced foliage plants for commercial interiorscapes and consumer markets. Foliage plants represent 12.4% of all ornamental nursery production operations in the U.S. (6). Thrips (*Gynaikothrips uzeli* and *Gynaikothrips ficorum*) are major pests of Ficus and can induce leaf galls on the newly developing foliage of its host that conceal and protect larvae as they develop. Misidentification of *G. uzeli* as *G. ficorum* (Cuban laurel thrips) may have facilitated the spread of this new exotic species. These two species are similar and can only be separated by the relative length of setae on the pronotum (4, 5). Anecdotally they can be separated by host association with *G. uzeli* being noted as inducing galls on *F. benjamina*. We compared setal hair measurements on thrips from seven locations in six states [CA, FL, HI, LA, MS (2), and TX]. Two samples from *F. microcarpa* were identified as *G. ficorum*, and five from *F. benjamina* as *G. uzeli* reiterating the close host association. Furthermore, our preliminary data suggests that *G. uzeli* is incapable of inducing galls on *F. microcarpa*. Host association is a useful tool for field detecting galls induced by *G. uzeli*, whereas setal hair measurements will confirm the identity of the thrips present.

Nature of Work: *Ficus benjamina* is the only plant on which *G. uzeli* has been reported to successfully reproduce although it has been collected from inside of leaf galls on *Ficus microcarpa* var. *retusa* (Chinese banyan) formed by Cuban laurel thrips (5). Both species are morphologically similar and were considered one species until they were separated based on the length of the pronotal posteroangular setae (5). On *G. ficorum*, these setae are never more than 0.5 times as long as the epimerals and usually no longer than the discal setae (Figure 1). On *G. uzeli*, they are at least 0.7 times as long as the epimeral setae (rarely less than 0.5), and always longer than the discal setae (5). This morphological distinction and host associations is widely accepted for separation of these two species but has yet been empirically tested for specimens collected outside of its native range.

Thrips were collected from galls on *F. benjamina* from plants across the continental U.S. (Riverside, CA; S. Padre Island, TX; Lucedale, MS; Poplarville, MS; New Orleans, LA; and Ft. Lauderdale, FL) and Oahu, HI. Each thrips was cleared by piercing the ventral side of the abdomen with a No. 0 insect pin and
placing it in ~100 µl 5.0% NaOH overnight. Specimens were then dehydrated in a series of ethanol (50, 60, 70, 80, 95, and 100%) and stored in absolute ethanol until slide mounted. Cleared, dehydrated specimens were placed dorsal side up on a clean microscope slide. One drop of euparol was placed on the specimen and the thrips was positioned with an insect pin. A cover slip was placed on the top and held in position with a paper clip. Slide-mounted specimens were cured at 35° C on a slide warmer (Fisher Scientific, Hampton, NH) overnight and allowed to cool to room temperature before removing the paper clip. Thrips were viewed with a compound microscope (Olympus BX51, Olympus America Inc., Center Valley, PA) and images of the setal hairs were taken with a digital camera (Micropublisher 3.3, Q Imaging, Burnaby, BC, Canada) mounted on the microscope. Setal hairs were measured in micrometers using the measuring tool of Image Pro-Express software (Media Cybernetics, Silver Spring, MD). The ratio of epimeral setae and posteroangular setae were then compared for at least two males and seven females of each population.

Results and Discussion: Of the seven locations sampled, thrips from California and Florida were found to have pronotal posteroangular setae less than 0.5 times as long as the epimeral setae (Figure 2). This indicates these populations are G. ficorum not G. uzeli (5). The other populations all had pronotal posteroangular setae more than 0.5 times as long as the epimeral setae indicating they are all G. uzeli. Gynaikothrips ficorum was found only on F. microcarpa whereas G. uzeli was found only on F. benjamina. Furthermore, preliminary data suggests that G. uzeli is incapable of inducing galls on F. benjamina.

This information presented here is useful for plant inspectors, other entomologist, and growers in areas where Ficus are produced. If galls are noted on Ficus benjamina, one should not assume they are just Cuban laurel thrips. Host association can be a useful tool for detecting galls in the field. Residents of these galls can then be reliably identified using setal hair measurements.

Literature Cited:
Figure 1. Dorsal view of adult Gynaikothrips uzeli. Line drawings indicate morphological differences of the pronotal setae between Gynaikothrips ficorum and G. uzeli. (pps = pronotal posteroangular seta, es = epimeral seta).

Figure 2. Ratio of pronotal poseroangular vs. epimeral setae. Host plants for thrips are indicated above the bars.
A Novel Pheromone Lure Monitors Dogwood Borer Seasonal Flight Activity and Relative Abundance in EUS Urban Landscapes, Apple Orchards and Woodlands

J. Christopher Bergh¹, William E. Klingeman², Tracy C. Leskey³, James F. Walgenbach⁴, David P. Kain⁵ and Aijun Zhang⁶

¹VPI (Winchester, VA) ²Plant Sciences Department, University of Tennessee, Knoxville, TN 37996-4561 ³USDA-ARS (Kearneysville, WV), ⁴NCSU (Fletcher, NC), ⁵Cornell Univ. (Geneva, NY), ⁶USDA-ARS (Beltsville, MD) wklingem@utk.edu

Index Words: callus tissue, graft union, integrated pest management, monitoring, Synanthedon scitula

Significance to Industry: Commercial dogwood borer (DWB) lures used to monitor this economically important ornamental plant pest vary in effectiveness. Lures typically provide a synthetic sexual pheromone as an attractant, yet all appear to be suboptimal due to an incomplete blend of components or a behavioral antagonist often present as contaminants. To address this, a trinary DWB sex pheromone blend has recently been identified. Rubber septa lures loaded with the novel trinary pheromone blend attract large numbers of S. scitula to lures and impart greater species-specificity thus providing a highly sensitive and reliable DWB monitoring tool for orchard, nursery and landscape managers. Evidence of season-long trapping, along a latitudinal transect extending from New York to Tennessee, supports evidence of bivoltine DWB populations. DWB populations were far lower than expected in woodland habitats despite the extensive host range reported for this pest moth. Significant risks of plant loss are predicted if new apple plantings and landscape development occurs in close proximity to established apple orchard blocks that support high DWB populations.

Nature of Work: Dogwood borer (Synanthedon scitula Harris, DWB) is reported to have the broadest host range of clearwing moth species but in eastern North America, has emerged primarily as a pest of deciduous ornamental plants and in commercial apple orchards (1, 3, 5, 6). Since the 1980’s, DWB have been particularly problematic on apple trees grafted onto dwarfing rootstocks. Among grafted apple varieties, those joined with dwarfing rootstocks produce clusters of adventitious root initials (burr knots) on rootstocks below the graft union. Infestation of young apple orchards begins when female DWB deposit eggs on burr knots. Newly hatched larvae burrow into this tissue, where they feed and develop. While commercial DWB sexual pheromone lures used to monitor this pest vary in effectiveness (2, 4), all are suboptimal due to an incomplete blend of components and a behavioral antagonist is often present as a contaminant (2, 4, 5). A trinary DWB sex pheromone blend has recently been identified that increases attraction of S. scitula to lures with greater species-specificity thus providing a highly sensitive and reliable monitoring tool (4, 7).
Seasonal flight activity and relative abundance of DWB were compared in three habitat types in a latitudinal transect extending from New York to Tennessee. From spring through fall 2005, Delta-style pheromone traps (Great Lakes IPM, Vestaburg, MI) were baited with red rubber septa containing a 1 mg loading of the trinary blend of DWB sex pheromone and deployed in apple orchards, managed urban landscapes and native woodlands in New York, West Virginia, Virginia, North Carolina and Tennessee. Two traps were deployed at each of two sites per habitat in all states except New York, where two traps were deployed at one site per habitat. Apple orchards were under commercial production except for one abandoned block in Tennessee. Urban sites included three university campuses, a golf course, a municipal park, a cemetery, a residential subdivision and a National Conservation Training Center campus. Woodland sites included a nature preserve and a nature park, several unmanaged woodlots and an arboretum. DWB male captures were recorded approximately weekly and all trap bottoms were either cleaned of moths or replaced each week. Lures remain effective for an entire season and were not replaced during the study.

**Results and Discussion:** Total DWB captures in apple orchards vastly exceeded those in urban habitats, which were greater than in woodland sites (Table 1). Considerable variability was apparent among states and, in Tennessee, between orchards. Urban sites yielded more DWB than woodland sites. Populations of DWB in woodland habitats were surprisingly small, considering presumed native host availability. The difference in DWB population density between apple orchards versus other habitats is likely due, in part, to effects of monoculture.

Despite large differences in the total number of moths captured among habitats, there was close agreement among habitats within each state in the onset of flight activity. DWB were captured at apple orchard and urban sites in New York, from 10 June until 30 September, while male DWB moths were captured in Tennessee from 13 May through 28 October (data not shown). Trap captures at many apple sites from states other than Tennessee showed numerous peaks during season-long DWB flight activity. Yet, data from apple orchard and urban sites from all states consistently demonstrated a first peak in flight activity in June or early July & a second in late August through early September.

Although developmental duration of DWB larvae on any of its plant hosts has not been quantified under controlled conditions, most authors have considered it univoltine.

Yet, preliminary trials by T.C. Leskey in 2005 have examined the developmental duration of DWB on apple burr knots yielding evidence that strongly supports DWB development in apple burr knots that is at least bivoltine, & probably multivoltine, depending upon latitude. In turn, this may partially explain high populations of DWB in apple orchards and some peaks in trap capture that occur during the flight period.

It appears that while woodland habitats support DWB populations, they do not pose a significant risk to new apple orchards or to ornamental host plants installed into managed urban landscapes. A much more significant risk would
occur to new apple plantings and development of parcels in close proximity to older orchard blocks supporting high DWB populations.

**Acknowledgement:** We thank our grower and landscape manager cooperators for allowing us access to their properties and research support from USDA-CSREES' Southern Region IPM Program.

**Literature Cited:**


**Table 1.** Summary of 2005 trap catch in each EUS region of male dogwood borer moths (*S. scitula*) and comparative efficacy between habitat types.

<table>
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<th>Apple Orchard</th>
<th>Urban</th>
<th>Woodland</th>
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Apple Orchard vs. Urban: 16X
Apple Orchard vs. Woodland: 219X
Urban vs. Woodland: 14X
Evaluation of USDA-APHIS-PPQ Bifenthrin Band Treatment Protocols for Management of Hybrid Imported Fire Ant in Tennessee Field Nursery Stock

Jason B. Oliver¹, Shannon James², Sam Ochieng¹, Nadeer N. Youssef¹, Karen Vail¹, Mark A. Halcomb⁴, Tahir Rashid³, James P. Parkman³, Walker G. Haun⁵ and Anne-Marie Callcott²
¹Tennessee State University, Institute of Agricultural and Environmental Research, Otis L. Floyd Nursery Research Center, McMinnville, TN 37110
²USDA-APHIS Soil Inhabiting Pests Section, Gulfport, MS
³University of Tennessee, Department of Entomology and Plant Pathology, Knoxville, TN
⁴University of Tennessee, Extension, McMinnville, TN
⁵Tennessee Department of Agricultural, Plant Certification, Nashville, TN
joliver@tnstate.edu

Index Words: Band Treatment, Bifenthrin, Hybrid, Field Nursery, Solenopsis

Significance to Industry: Current treatments to manage imported fire ants in balled and burlapped field nursery stock are expensive and impractical. The USDA-APHIS-PPQ has been developing pyrethroid band (plus fire ant bait) protocols for fire ant quarantine treatment of field nursery stock in Mississippi (MS). During 2005, the most promising band treatments from MS studies (i.e., bifenthrin [Talstar Nursery F and Talstar EZ G]) were evaluated in Tennessee (TN) to determine treatment effectiveness in a region with different temperatures, soil type, and fire ants (i.e., hybrid imported fire ant in TN versus red imported fire ant in MS). Bifenthrin granular and liquid treatments effectively eliminated all fire ant colonies in spray bands from 2 to 7 months post-treatment in TN. Test results suggest growers may be able to apply a bifenthrin band treatment to field nursery stock in early September and then harvest and ship plants from late October through May. If approved, the bifenthrin band treatment will provide significant cost savings to the nursery industry in fire ant infested areas over existing quarantine methods.

Nature of Work: Imported fire ants (Solenopsis spp.) (IFA) now infest over 325 million acres in North America and are continuing to expand their range. A major issue for the U.S. nursery industry is the Federal IFA Quarantine, which requires insecticide treatment of all nursery stock moved from quarantined to non-quarantined regions (6). Currently, only three treatments are approved for field nursery stock: 1) a pre-harvest broadcast bait (e.g., Amdro Pro, Award, Distance, or Extinguish) followed 3-5 days later with granular chlorpyrifos (e.g., Dursban 2.32 Granular or Dursban 2.5 Granular), 2) a post-harvest root ball dip in chlorpyrifos (e.g., Dursban 4E, Chlorpyrifos Pro2 Insecticide, or Chlorpyrifos Pro4 Insecticide), or 3) a post-harvest twice daily for three consecutive days drench in chlorpyrifos (e.g., same formulations as dip) (6). Other insecticide products may exist that have not been named and the mentioning of products does not imply an endorsement. The broadcast bait plus granular chlorpyrifos treatment method is the most feasible application method, but is cost prohibitive due to the chlorpyrifos formulation labeled for commercial nurseries (bait +
granular is about $266/acre based on recent vendor price quotes) and requires a 30-day post-treatment delay before shipping can begin. The post-harvest dip or drench methods are impractical and labor intensive when treating large numbers of root balls. In addition, drench or dip treatments are potentially damaging to the environment because large volumes of chlorpyrifos are used. A major issue is all field nursery quarantine methods require the use of chlorpyrifos. Growers do not have the option to use other insecticides that may be safer for workers. The EPA has increasingly targeted chlorpyrifos and no longer permits usage in residential or landscape settings where children may be exposed (5). Although chlorpyrifos agricultural uses remain, the lost homeowner markets may reduce manufacturing and re-registration incentives for companies. For example, Dursban TNP labeled for nurseries was recently dropped. If chlorpyrifos availability is lost for any reason, there will be no alternative methods existing to certify field nursery plants against IFA. In southern states, the livelihood of field nursery growers would be lost, due to inability to ship to long standing markets in the northeast.

The USDA-APHIS-PPQ Soil Inhabiting Pests Section, Gulfport, MS (SIPS) has been evaluating a number of promising pyrethroids (e.g., bifenthrin, deltamethrin, lambda-cyhalothrin), a phenylpyrazole (e.g., fipronil), and chlorpyrifos band sprays in combination with low cost baits as alternatives to the current field nursery quarantine treatments. Band treatments have many advantages over current quarantine treatments, including ability to apply by standard tractor sprayers, less labor intensive, and lower treatment costs. Treatment cost will vary depending on plant / row spacing and harvested root ball size. Treatment bands will most likely require a minimum of 1.5 ft past the largest sized root ball (Shannon James, SIPS, personal communication). Therefore, a 24-inch balled and burlapped (B&B) plant would require a 5 ft treatment band (12 inches on each side of trunk + 1.5 ft buffer). The cost to band treat a field nursery planted at a typical 7 by 6 ft spacing without roadways and with plants harvested as 24 inch B&B ranges around $20 to $53 / acre (plus additional $17 / acre for broadcast bait) using bifenthrin 7.9F (e.g., Bifenthrin Pro Multi-Insecticide, Cross Check GC F, Menace GC F, Talstar Nursery F, Up-Star SC, Wisdom F), deltamethrin 5SC (e.g., DeltaGard T&O 5SC), lambda-cyhalothrin 9.7GC (e.g., Scimitar GC), or chlorpyrifos 4E (e.g., Dursban 4E) based on recent vendor price quotes. Other insecticide products may exist that have not been named and the mentioning of products does not imply an endorsement. The current broadcast granular chlorpyrifos plus bait protocol is about $196 to $229 more per acre than the band methods. Another advantage for band treatments is they can be applied in September before tree harvesting begins. The objective of this study was to evaluate SIPS bifenthrin (Talstar Nursery Flowable and Talstar EZ Granular) band treatment protocols at a TN location for the potential to eliminate IFA from nurseries.

Treatments developed by SIPS in southern MS require additional support data from other regions to support adoption into the Federal Fire Ant Quarantine. TN was selected because it is at the northern limit of the U.S. IFA infestation. In addition, IFA at MS test sites were red IFA (*Solenopsis invicta* Buren), whereas IFA populations in TN and the northern sections of MS, AL, and GA are black IFA (*Solenopsis richteri* Forel) or the hybrid of the red and black IFA (1, 2, 4, Oliver et al., unpubl. data). The study was performed along a highway right-of-
way in Sequatchie and Hamilton Co. with the permission of the TN Department of Transportation (TDOT). No pesticides were applied to the sites by TDOT. Experimental plots consisted of 520 ft long strips at nine separate locations scattered along a 5-mile stretch of the highway. Each plot had a centerline marked by stretching a string and applying spray paint along the string. Plots had a minimum of five active IFA mounds within 2 ft of either side of the centerline. Plots received one of three treatments replicated three times: 1) control (no treatment), 2) Amdro (hydramethylnon) bait plus 6 ft wide band of Talstar Nursery Flowable, or 3) Amdro bait plus an 8 ft wide band of Talstar EZ Granular. Amdro was applied on 22 Sept. 2005 using a Herd® Sure-Feed Broadcaster (Herd Seeder Company, Inc., Logansport, IN) mounted on a Mule All-Terrain vehicle and calibrated to deliver a rate of 1.5 lbs product / acre. The Herd spreader treated a swath width about 20 ft wide with the inner 16 ft receiving the most bait. The bait was applied down the center plot line in a single pass. Prior to bait application, a small quantity of bait and a potato chip was placed near an IFA mound to confirm that IFA were actively foraging and that the bait was still fresh. The Talstar treatments were subsequently applied 29-30 Sept. 2005. The granular Talstar was applied using a 6504T18 Gandy spreader (Wikco.com Inc., Casa Grande, AZ) pulled by a Sears Craftsman riding lawn mower. The granular spreader was calibrated to deliver 0.4 lb active ingredient / acre, and the treatment was applied to an 8 ft wide band centered on the middle plot line. The Talstar Nursery F treatment was applied at 0.2 lb active ingredient / acre. The Flowable treatment was applied to the first plot using a Mule All-Terrain vehicle having a spray boom with four 8006 brass tips spaced 18 inches apart and 18 inches above the treatment surface and a pump operating at 32 psi with nozzles calibrated to deliver a solution volume of 80 gallons per acre. However, during treatment of the first spray plot, the Mule All-Terrain vehicle did not maintain consistent drive speed in the field. Therefore, the remaining two Talstar Nursery F plots were treated with a John Deere 770 tractor using a 3-point hitch mounted 50 gallon tank and a Hydro® Model 6500C Roller Pump. Talstar Nursery F was applied by tractor at the same 0.2 lb ai / acre rate, but the application differed in using a spray boom with four 8008 brass tips operated at 26 psi with a solution delivery rate of 99 gallons per acre. Talstar Nursery F was applied by making a single 6 ft wide band centered on the middle plot line. Active IFA colonies were counted within 2 ft of each side of the band centerline before chemical treatments and at 1, 2, 4, 6, and 8 weeks post treatment. After 8 weeks, plots were rated monthly through 32 weeks. Mound activity was determined by lightly disturbing the mound with a small wire. Mounds were considered active if any IFA appeared after disturbance. Rainfall was monitored from Sept. to the end of Nov. by rain gauge, but a Spectrum WatchDog model 450 data logger was installed on 1 Jan. 2006 to track rainfall and soil temperature.

**Results and Discussion:** IFA were absent from the treated bands in the TN study from 2 to 7 months post-treatment (Table 1). However, a single IFA colony was found in one flowable and one granular bifenthrin plot at 8 months post-treatment. A September bifenthrin band may be able to certify nursery stock against IFA for most of the fall to spring harvest / shipping period.

Results of the TN study were similar to SIPS studies in MS with the exception that treatments required 6 weeks longer to eliminate all IFA colonies from the
bifenthrin bands (Table 1). Samples removed from several IFA colonies at the TN site and processed by gas chromatography confirmed the ants were hybrid IFA. Hybrids have exhibited more insecticide tolerance in laboratory studies than red and black IFA (3). In this study, hybrids may also have been more tolerant to bifenthrin than red IFA colonies in MS studies. Weather may have played a role in the differences observed between TN and MS studies. Rainfall was moderate at the TN site with totals of 1.5, 0.9, 4.2, 5.1, 2.1, 2.9, 5.4, and 2.5 inches in Sep., Oct., Nov., Jan., Feb., Mar., Apr., and May, respectively (Dec. and June missing). Average soil temperatures during winter and spring months were mild (Fig. 1). Soil types at the TN study sites consisted of Allen Loam, Lily Loam, Lonewood Silt Loam, or Cumberland Silty Clay Loam, which likely had higher clay and silt contents than the sandy coastal plain soils of the SIPS MS studies.

Due to discrepancies between TN and MS studies, at least one additional year of bifenthrin band test data will be needed from TN before SIPS can recommend the treatment for inclusion into the Federal IFA Quarantine. The final determination of post-treatment certification length will be made by USDA-APHIS. Overall, the use of bifenthrin band treatments appears very promising for IFA quarantine treatment of field nursery stock.

**Acknowledgements:** We thank Joshua Basham, Crystal Lemings, Heath Overby, Brian Brown, Caleb West, and Jason Basham for their assistance with experiments. Jim Moyseenko (visiting USDA-ARS technician) also assisted with evaluations on two dates. We acknowledge the USDA-CSREES Pest Management Alternatives Program Award Number 2003-34381-13660 for providing funding that made the research possible.

**Literature Cited:**

Table 1. Fire ant mount counts in band treatment plots (22 September 2005 to 12 June 2006).

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<th>4</th>
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<th>12</th>
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</tbody>
</table>

*Active mound is at the beginning of the plot and probably did not receive a full treatment dose. The problem has occurred before in SIPS trials, and therefore, the mound has been excluded from consideration. On week 32, the mound at the beginning of the plot was dormant. However, a new mound was found at the center of the plot on week 32, and therefore, was considered a new infestation in the plot.
Figure 1. Average daily soil temperature at band test site during winter / spring.
Biology and Distribution of *Pryeria sinica* (Lepidoptera: Zygaenidae) in Virginia and Maryland

Peter B. Schultz, Eric R. Day, Adria Bordas and Richard Bean
Virginia Tech, Dept. of Ent., Hampton Roads AREC, Virginia Beach, VA 23455
Virginia Tech, Dept. of Entomology,
Insect Identification Lab., Blacksburg, VA 24061,
Virginia Cooperative Extension, Fairfax County, Fairfax VA, Maryland
Department of Agriculture, Annapolis, MD
schultzp@vt.edu

**Index Words:** Euonymus, Celastrus, *Pryeria sinica*

**Significance to Industry:** *Pryeria sinica* is a newly discovered foliar feeding insect that feeds on Celastrus and Euonymus. Producers and landscape contractors need to be aware of this new pest introduction, and monitor susceptible hosts, particularly in areas near the current infestation.

**Nature of Work:** Euonymus leaf notcher, *Pryeria sinica* (Lepidoptera: Zygaenidae) is a Palaearctic species that occurs in China, Korea, Japan, and Taiwan. In Asia, it occurs on plants in the genus Celastrus and Euonymus. In the spring of both 2001 and 2002 larvae were noted feeding on *Euonymus japonicus* by a homeowner in Fairfax Virginia. In May 2002 these unknown larvae were collected and submitted to the Fairfax office of the Virginia Cooperative Extension and forwarded to the Insect Identification Laboratory at Virginia Tech. Since the larvae pupated immediately and preserved larvae did not match any reference material, the pupae were held until November 2002 when the adults emerged. Adults were submitted to the Systematic Entomology Laboratory in December 2003 and were determined by John W. Brown in May 7, 2003 as *Pryeria sinica* Moore, a new North American record. Larvae were subsequently found in Maryland on May 28, 2003. In 2002 and 2003, *P. sinica* was found at several sites in two delimited areas of Maryland and Virginia. Collection sites in Virginia are located in the County and City of Fairfax, in northern Virginia, approximately 21 miles west from the center of Washington D.C. The Maryland collection sites are from the County of Anne Arundel near the town of Glen Burnie, approximately 52 miles northeast from the center of Washington D.C. In Virginia and Maryland, *P. sinica* has only been observed on *Euonymus japonicus* and *Euonymus kiautschovicus* 'Manhattan'.

**Results and Discussion:** *Pryeria sinica* is univoltine in Virginia and Maryland. Egg hatch was observed on March 17, 2004, March 18, 2005, and March 13, 2006 at 26-66 DD (50 °F base). Larvae are gregarious in late March and early April, initially feeding as leaf skeletonizers then later as leaf notchers on new leaves. When disturbed the larvae drop from a silk thread and if handled exude an unidentified sticky material. The larvae begin to disperse on the host plants in late April and early May. Pupation occurs at 430-470DD, or approximately mid-May. Prior to pupation most larvae leave the host and pupate on nearby surfaces including brick walls, decks, and outdoor furniture. A small number of pupae will be found on the trunks of the host plant and wrapped in leaf folds.
Adults are present in late October and early November although they have been collected in early December. Adults are diurnal and most commonly seen flying at midday. They have a weak fluttering flight pattern. After mating egg clusters of 100-200 eggs are laid on the tips of twigs and undersides of leaves on the host plants. Egg clusters have a fine covering of setae from the female abdomen. They overwinter in the egg stage.

**Literature Cited:**


Landscape Mulches: Do They Encourage Formosan Subterranean Termite Colonies?

Jian-Zhong Sun and Margaret E. Lockwood
Coastal Research & Extension Center, Mississippi State University,
711 West North St., Poplarville, MS 39470, US
js841@ra.msstate.edu

Index Words: Coptotermes formosanus, landscape, mulch, wood

Significance to Industry: Use of tree-based mulches in urban and rural settings in the United States may inadvertently contribute to the spread of the Formosan subterranean termite, Coptotermes formosanus. We investigated the nutritional ecology of incipient colonies of C. formosanus teeding on seven weathered and non-weathered landscape mulches: pine bark, pine straw, bald cypress, cedar, water oak, eucalyptus, and melaleuca. In a forced feeding test, pine straw, eucalyptus, and bald cypress, were ideal nutritional food resources for breeding pairs of C. formosanus when either weathered or non-weathered. Colony fitness values were significantly different between the weathering treatment groups and among the different types of mulches. This suggests that mulch application and its management could significantly impact the establishment of new colonies of C. formosanus. The resistant natures of melaleuca and cedar mulch could be potentially used as an alternative barrier in termite IPM program to reduce the risk of termite infestations.

Nature of work: In the U.S., the number of areas infested with the Formosan subterranean termite (FST), Coptotermes formosanus, is increasing. Organic tree-based mulches, such as pine straw, pine bark, and other ground wood products have long been suspected of contributing to the spread of C. formosanus (6, 14). Recently emerging public concerns over the spread of termites via mulch products produced from termite infested debris trees from Hurricane Katrina has raised and become a controversial issue. Termite swarms (alates) are a common phenomenon in the spring producing thousands of winged termites. Alates are weak flyers and can only fly a couple of miles. Successful establishment of an incipient colony is known to be dependent upon available food and moisture around a structure. However, mulches, especially tree-based organic mulches, may provide C. formosanus with all the necessities for survival, specifically food, moisture, and shelter (9, 14). We investigated the nutritional ecology of incipient colonies of C. formosanus feeding on various types of tree-based landscape mulches to determine which, if any, of these mulches encouraged successful colony establishment.

Seven different mulches, pine straw pine bark, bald cypress, cedar wood, water oak, eucalyptus wood, and melaleuca wood, were divided into two groups, weathered and non-weathered. Weathered mulches were placed outdoors in full sun for a minimum of three months. All mulches were ground to 2 mm using a Wiley Mill. Test arenas were fashioned out of Petri dishes, 9 × 50 mm diameter, which were loaded with 2 grams of mulch-dust moistened with 2 ml sterile distilled water.
Alates of *C. formosanus* were collected in Pearl River County, Mississippi using light traps during May 2005. Alates were transported to the lab and placed inside 11.3L storage boxes with wet paper towels until they lost their wings (dealates). As the dealates paired, each pair was placed inside a 12.4 ml snap-cap plastic vial with a piece of wet paper towel (4 × 4 cm) for food. They were monitored daily for mortality and oviposition. Only ovipositing pairs were selected for this experiment. Prior to being placed inside a test arena, dealates were removed from their eggs to allow all of the pairs to have the same start time for oviposition. There were 60 incipient colonies prepared for each type of mulch both in weathered and non-weathered groups, which were kept in total darkness at 26-27°C, 95 ± 5% RH for the duration of the study. For the first three months, each dish was visually inspected every 15 d to count eggs and offspring, and to record mortality. After that, the pairs were monitored monthly.

**Results and Discussion:** When compared between mulch types and the weather treatments, differences in numbers of eggs laid were significant (both effects, \( P < 0.01 \)). The greatest mean number of eggs observed was 24.53 ± 0.76 in the weathered pine straw. No visible eggs were laid by pairs fed non-weathered melaleuca, and very few eggs (mean < 0.4) were observed in the weathered melaleuca within the first two months.

Three out of the seven types of mulches tested, pine straw, eucalyptus, and bald cypress, could be utilized by the dealates of *C. formosanus* to establish their incipient colonies successfully (Table 1). Colonies fed on pine straw, either weathered or non-weathered, had the greatest number of the progeny than the rest of the mulch types (\( P = 0.048 \)). This indicates that pine straw has the best nutritional constituents for *C. formosanus* in terms of colony growth. This is consistent with similar studies with termite foragers of *Reticulitermes flavipes* (11). Pine needles, especially young needles, contain higher proportions of N and other mineral elements than the stembark, stemwood, and branches(13). Termites prefer the N-rich foods, which enable protein synthesis and hence colony growth (10). Pine straw possess more than 1% of nitrogen (% of dry wt) which is 4-5 times of the other wood tissues (8).

Colony founders fed on weathered mulches had a significantly greater survival (\( P < 0.01 \)) than those fed non-weathered mulches (Table1). However, variations in survival rate over time (Figure 2) among different types of mulches, either weathered or non-weathered, were significantly different (\( P < 0.01 \)). Incipient colonies fed on either weathered or non-weathered pine bark mulch experienced a substantial declination in survival after 180 d (Figure 2), indicating a nutritional deficiency or unknown allelochemicals acting as the chronic toxicants (1). Pine bark contains 35-40 % cellulose (by dry wt) and about half as much nitrogen as pine straw (13), but some antitermitic compounds, such as resins, wax, Klason lignin, tannins, as well as aromatic constituents could potentially be toxic to *C. formosanus* (1, 15, 16). Although commercial pine bark mulch could be consumed by foragers of *R. flavipes*, it is not considered a favorite food (6, 11). Differences in survival between foragers and incipient colonies might be due to the termite’s susceptibility to certain nutritional constituents or allelochemicals in pine bark.
None of the nuptial pairs fed on melaleuca or cedar mulches could successfully initiate a new colony. Termites fed melaleuca demonstrated a significantly greater acute toxicity than those fed cedar mulch (Figure 2). Although colonies fed on the weathered mulch had survived longer, the colonies eventually died, which suggests that some antitermitic chemicals could persist despite weathering. Carter and Huffman (3) reported that no survival of *C. formosanus* or *R. flavipes* foragers after 8 weeks of feeding on melaleuca sawdust or on a pad treated with melaleuca extract. Similarly, other researchers have observed reduced feeding and accompanied higher mortality of *C. formosanus* and *R. flavipes* foragers when fed on different cedar wood species or melaleuca wood (1, 2, 11).

This research demonstrated that tree-based mulches vary as a food source and habitat for the swarmers of *C. formosanus* to establish incipient colonies. Swarming, in subterranean termite life cycle, is the major means for colonies to spread. Colony survival and success mainly rely on the food quality, the availability of moisture, and other related environmental factors (7, 12). Tree-based mulches are a unique food source for termites because decomposition through weathering and some microorganisms will generally enhance the food quality for termites (11, 14). Also, weathering might reduce toxins in the mulches allowing dealates access to nutrition-rich fungal sporophores (15). The effects on colony survival due to toxic volatiles associated with specific tree-based mulch could be significantly reduced after weathering (14). Obviously, the stage of decomposition is an important factor in determining the ability of an incipient colony to succeed. Weathering the mulches significantly improved the food quality in developing incipient colonies with higher survival rate, larger population of progeny, and better colony fitness.

Melaleuca and cedar mulches could be selected as natural barriers and as an additional tools in termite control. The most important finding of this work is the positive indication that the proper management of mulch could significantly affect the success of incipient termite colonies in urban landscapes.

**Acknowledgement:** We acknowledge Ted A. Roland, Russell Drury, Christopher Werle, and Nathan Cottrell of the USDA ARS (Poplarville, MS) for collecting alates. We are also grateful for financial support from USDA ARS SRRC for this study.

**Literature Cited:**


Table 1. Effects of mulches and the weathering treatment on the progeny, survival, and fitness of incipient *C. formosanus* colonies at 210 days§.

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<thead>
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<th>Treatment</th>
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<th>Colony fitness*</th>
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</tr>
<tr>
<td>Non-weathered</td>
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<td>17.04 ± 0.47 b</td>
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<td>Bald Cypress</td>
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** Progeny calculated as total number of eggs, workers, and soldiers in a colony. # Survival rates calculated as colonies alive divided by total colonies in a type of mulch.

* Fitness calculated as the product of progeny times survival rate.

§ Data analyzed using Proc Mixed of SAS. Means in each column followed by the same letter within treatment group were not significantly different (P = 0.05, Tukey HSD). Mulch effect was nested under weather factor. For progeny, survival, and fitness for weathered mulches: F = 3.12, 6.99, and 4.67; df = 1, 312, 1, 28, 1, 28; and P = 0.048, 0.013, and 0.039, respectively. The main effects of mulch type for progeny, survival, and fitness: F = 68, 42.7, and 20.5; df = 12, 312, 12, 28, 12, 28; and P < 0.01, respectively.
Figure 1. Mean number of eggs produced by *C. formosanus* fed on seven mulches for 210 days after establishment. Letters in parentheses represent the mean number of eggs compared in each group of the mulch treatments. Those followed by the same letter did not differ significantly (*P* = 0.05, Tukey HSD).
**Figure 2.** Cumulative percentage survival of *C. formosanus* incipient colonies fed on 7 tree-based mulches of weathered and non-weathered groups for 210 D after colony establishment (* the letters in the parentheses after each mulch name in the charts represent the mean survival rate comparisons in each group of the mulch treatments of which followed by the same letter did not differ significantly at $\alpha = 0.05$, Tukey HSD).
Aphid Susceptibility of Rose Cultivars Under Low Maintenance Culture

James A. Reinert, W.A. Mackay, S.W. George, C. McKenney, R.I. Cabrera, J.J. Sloan and P.F. Colbaugh
Texas A&M University Research & Extension Center, 17360 Coit Road, Dallas, TX 75252-6599
j-reinert@tamu.edu


Significance to the Industry: By producing and providing rose (*Rosa* spp.) cultivars that are less susceptible to aphids or any of the other rose pests, the nursery and landscape industries will provide the end user/home owner with cultivars that require less pesticides to maintain healthy, pest free plants with good flowering potential. Benefits of the selection process are also given to the grower who can gain production efficiency and reduced operational overhead by growing pest free rose cultivars. When growers produce a rose cultivar with pest resistance, they can directly reduce or eliminate monitoring during production or in the landscape. An added benefit is the reducing pesticide usage which could potentially contaminate surface/groundwater. This study has characterized the susceptibility or resistance of 116 commercial rose cultivars. More importantly, we have identified several cultivars that do not have significant aphid populations and damage when these roses are cultured under low maintenance as in this study.

Nature of Work: Several species of insects, mites and disease organisms can severely limit growth and flowering potential of roses (4, 5). Aphids, one of the most important insect pests, cause discolored (yellow or brown) leaves; curled or malformed leaves and petals; wilted appearance of plant or plant parts; and shiny, sticky (honeydew) which can promote sooty mold on the leaves (4, 5). New and rapidly growing bud and shoot tissue are preferred by aphids which promotes their rapid population increases. Low to moderate numbers of aphids per terminal usually cause little damage to plants. In this study, the rose aphid (*Macrosiphum rosae* (L.)) and the cotton or melon aphid (*Aphis gossypii* Glover) were the most prevalent species, but several other species damage roses depending on local prevalence and the region where they are grown.

For this study, rose cultivars growing on their own roots were obtained from several commercial nurseries and established in 1998 in field plots at the Texas A&M University Research & Extension Center at Dallas, TX. The plants were spaced 1.53 m (5 ft.) apart with the rows 3.05 m (10 ft.) apart. Plants were arranged in four replications in a randomized complete block design with 116 rose cultivars. Soil in the plots was Austin silty clay (calcareous in nature with a pH of ~7.8) and no amendments were added during preparation. Rose plants were planted, watered as needed (through a drip irrigation system) during the first two years but otherwise grown with no inputs of fertilizer or pesticides. During the third year after establishment, the entire test area was mulched with chipped wood obtained from a local tree pruning company.
Data collection on growth and adaptability of roses under low maintenance culture began in spring 2000 and continued through 2002. Aphid infestations were assayed in 2001 (9–12 April) when all plants flushed tender growth. Infested terminals and buds were first visually evaluated for aphid infestations and then aphid sampling was biased by censusing up to nine newly developed terminals or flower buds with the highest aphid populations. Mean number of aphids per terminal per plant and the highest aphid count per terminal per plant were analyzed by analysis of variance (ANOVA) and treatments were separated by Fisher’s LSD multiple comparison procedures ($P = 0.05$).

**Results and Discussion:** Twenty-five cultivars were infested with ≤1 aphids per terminal/bud per plant (Table 1). Cultivars, ‘Kronprincess Viktoria’, ‘Gold Glow’, and ‘Baronne Prevost’ were free of aphids during this study. Fifteen cultivars had ≤1 aphid per terminal/bud on average, and 25 cultivars had a mean of ≤1 aphid on the three highest infested terminals per plant. Among these 25 cultivars there also exists resistance to one or more of the common rose diseases, Black Spot (*Diplocarpon rosae*), Alternaria Petal Blight (*Alternaria alternate*) and Powdery Mildew (*Sphaerotheca pannosa*) (1, 2, 3). Alternately, resistance to aphids does not equate to disease resistance. Cultivar ‘Baronne Prevost’, for example, is susceptible to Black Spot disease whereas ‘Kronprincessin Viktoria’ is susceptible to Powdery Mildew. Cultivar ‘Gold Glow’ is susceptible to both Alternaria Petal Blight disease and Black Spot disease (1, 2, 3).

The most susceptible cultivar was ‘Chrysler Imperial’. Four cultivars, ‘Chrysler Imperial’ > ‘Midas’ > ‘Tournament of Roses’ > ‘Pascali’, each had mean populations of >10 aphids per terminal (Table 1). These four cultivars along with ‘Iceberg’ each had >20 aphids per terminal/bud. Additionally, aphid populations showed no correlation with rose types.

These results suggest cultivars which are less susceptible or resistance to aphid infestations when grown under low cultural maintenance. These cultivars were being maintained under very low management inputs including no added nutrition, no insecticides or fungicides and minimal irrigation during the first two years of establishment. Under a higher management level, these results will most likely change considerably.

**Acknowledgements:** We thank Joe McCoy and Dennis Hays for technical assistance.

**Literature Cited:**


Table 1. Aphid populations on rose terminals/buds as an indication of susceptibility/ resistance (9 -12 April 2001).

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<td>Puerto Rico</td>
<td>Tea</td>
<td>0.25 lm</td>
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</tr>
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<td>Found</td>
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</tr>
<tr>
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<td>Bourbon</td>
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<td>Gold Glow 4</td>
<td>Hybrid Tea</td>
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<tr>
<td>Baronne Prevost</td>
<td>Hybrid Perpetual</td>
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A Methodology for Evaluating Ornamental Butterfly Nectar Plants

Anthony Camerino and Thomas Emmel
McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History University of Florida, Gainesville, FL 32611
camerino@ufl.edu

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Significance to Industry: Gardening for wildlife, especially butterflies, is a growing niche market in retail garden centers throughout the US. Plants sold in such retail outlets are often marketed as butterfly or wildlife “friendly.” Most published references about butterfly gardening are based on the field observations of nature and gardening enthusiasts. More authoritative references are made available by research ecologists, entomologists, and horticulturalists. To date, few studies have been conducted that directly evaluate the usefulness of various cultivated plants in attracting wildlife (1, 2, 3, 4, 5). In addition, the authors of this study were not able to locate any published studies that could verify landscape plantings of ornamental crops were directly beneficial to butterfly populations. The present authors sought to develop a standardized methodology by which ornamental plants marketed as butterfly nectar plants could be evaluated to determine their relative potential usefulness in supplying adult butterflies with nectar. This bioassay study does not attempt to determine which plants/cultivars butterflies prefer, but rather the plant specie’s or cultivar’s potential to provide energy and nutrients to adult butterflies as measured by the life span of the adult butterfly.

Nature of Work: The purpose of this study is to develop a biological assay by which to determine the relative value of four Pentas lanceolata cultivars (species, ‘Nova,’ ‘Monarch White,’ and ‘New Look’ red) as nectar source plants for the Gulf Fritillary (Agraulis vanillae). Common thought among butterfly gardeners is that the true species (red) is superior in attracting butterflies and providing nectar, while the dwarf cultivars are the least effective. By determining the effect on the lifespan of A. vanillae based on the number of flower clusters and plant cultivar, the authors sought to determine the relative value of a specific cultivar and flower cluster. The unit of “flower cluster” was selected for this study not only for ease but also for transferability to other plant species and sizes. Ultimately, based on counting the number of flower heads and plant types present, one would be able to determine the relative nectar value of a plant species or cultivar.

Eight flight cages (4 x 4 x 4 ft) split into two groups of four were used for the study. The cages were constructed of 2 x 2 inch pressure-treated pine and the sides were made of fiberglass window screening. The bottom of each cage was suspended at five feet off the ground to permit sufficient air movement through the cage for butterfly flight. Each cage grouping was used to evaluate a specific P. lanceolata cultivar. Within each group of four cages, varying numbers of P. lanceolata plants with flowers were used to stock a flight cage. The first cage
held four plants and only a single flower cluster, the second cage held four plants and two flower clusters (on different plants), the third cage held four plants and four flower clusters (all on different plants), and the final cage had four plants and no flower clusters. Non-flowering plants were added to the cages not only to make the various treatments as uniform as possible, but also to provide refuge for the butterfly. It has been our experience that *A. vanillae* performs and adapts better to confinement if refugia is added. The plant groupings were randomly assigned to a cage. The plants selected for the experiment had only one flower cluster; if other flower clusters were present then they were removed as well as developing flower buds. The plants selected for each replication had a flower cluster that was as close as possible to 99% fully expanded. The plants were watered just before placement in a flight cage. Watering continued every other day until completion of the replication. The plants were irrigated by hand until water ran through the bottom of the pot.

*Agraulis vanillae* was chosen for the study because the butterfly is adaptable to confined areas, is native to Florida, has a relatively short life span (5-21 days), and is readily available for purchase from butterfly farms. The butterfly’s moderate size and proboscis length permit the butterfly to be used on a wide range of potential nectar plants. Chrysalides were purchased from a local butterfly farm (Greathouse Butterfly Farm, Melrose, Florida) in groups of about 30. Once four butterflies emerged within the same 12-hour period, one butterfly was placed into each of the four cages of a group. The sex of the butterfly was kept consistent within a particular replication (i.e., all males or all females). Each butterfly was monitored for five minutes twice a day. A record was kept as to when the butterfly was introduced and how long the butterfly was able to live on the provided nectar. Once all butterflies died, the procedure was repeated with a different *P. lanceolata* cultivar.

**Results and Discussion:** During the summer of 2005, production related problems reduced the ability of suppliers to provide enough *A. vanillae* for this study. In addition, eclosion was much more variable than predicted. Eclosion occurred in as short a time as one day and as long as two weeks after the pupae arrived. As a result, in future studies 50 chrysalides will be budgeted to ensure at least four butterflies eclose on the same day within 12 hours of each other. As expected, the sex ratio at emergence was about 1:1 in this study.

The number of flower heads provided to the butterflies from which to feed was changed as the study evolved to ensure separation of data and uniformity of the plants used in the experiment. Originally the butterflies were to be provided with one, two, three, or four flower heads. Early trials indicated that there was not a significant difference in the lifespan of the butterfly under this scheme (especially between the three and four flower head treatments). In addition, since it was not always possible to observe the butterflies feeding, there was no way to know that short lifespan was due to lack of nectar rather than lack of feeding. As a result, the three flower head treatment was replace with a no flower treatment. The no flower treatment would provide a base line from which to compare the other treatments.
Overall, this study proved to be a good pilot study from which future nectar plant evaluations could be conducted. While trends can be seen in the data from this study (Table 1), the number of replications was too low to derive any significant results. The authors look forward to repeating this study in Spring 2006.

**Literature Cited:**


**Table 1.** Life span of adult *Agraulis vanillae* (Nymphalidae) on various *P. lanceolata* (rounded to the nearest half day).

<table>
<thead>
<tr>
<th>Number of Flower Heads</th>
<th>Average Lifespan of <em>A. vanillae</em> on true species (red)</th>
<th>Average Lifespan of <em>A. vanillae</em> on ‘New Look’ (red)</th>
<th>Average Lifespan of <em>A. vanillae</em> on ‘Nova’ (pink)</th>
<th>Average Lifespan of <em>A. vanillae</em> on ‘Monarch White’ (white)</th>
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