Entomology and Nematology

Karla Addesso

Section Editor

Evaluation of Pyrethroids and New Strategies to Deter Ambrosia Beetle Attacks in Nurseries

Zenaida Viloria[1], Ric Bessin[2], Win Dunwell[3], Ginny Travis[3], Christopher Ranger[4], and Raul T. Villanueva[1]

[1]Department of Entomology. University of Kentucky, Research and Education Center-Princeton, KY

[2]Department of Entomology. University of Kentucky, Lexington, KY

[3]Department of Horticulture. University of Kentucky, Research and Education Center-Princeton, KY

[4]USDA ARS, Application Technology Research Unit. Wooster, OH

wdunwell@uky.edu

Index words Nursery crops, ethanol, apple bolts, flooding

Significance to Industry In nursery farms, invasive ambrosia beetles (AB) cause irreparable damage to high value ornamentals and recently were found infesting apple saplings in Kentucky. Preventive trunk sprays of pyrethroids, every two weeks, is a common practice recommended for nursery crops. This practice is labor intensive and expensive. There are several registered pyrethroids for use in nurseries, however their effectiveness to manage AB is unknown. A selection of an effective class of pyrethroid is necessary for control of AB as well as the incorporation of other management tactics. Commercial pyrethroid treated netting has been recently implemented in apple orchards to control the invasive brown marmorated stink bug (2). Here we investigated its protective effect against AB.

Nature of Work The granulate ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky) and black stem borer, *X. germanus* (Blandford) attack more than 200 tree species. Attacks of AB is conditioned by a plants' physiological (i.e. health) status rather than related to host susceptibility *per se*; healthy plants are not likely to be attacked whereas weak but living plants that emit stress-related volatiles (i.e. mainly ethanol), prompt attack (5). Stressed plant identification is often a difficult task. Thus, preventive pyrethroid trunk sprays are the main management practice to control ambrosia beetles before they enter the sapwood (1, 6). Ambrosia beetle attack was induced following a modified pot-in-pot protocol described by Ranger et al. (4,5).

Pyrethroid-treated netting Ambrosia beetle attack was induced following a modified pot-in-pot protocol described by Ranger et al. (4,5). Trees planted in 7 gallon-pots containing pine bark as substrate were set in a 15-gallon pot that had been lined with a black plastic bag filled up until 3/4 with water. Bags were tightened to the stem base to reduce evaporation. Plants were under flood stress during April-June period.

This experiment was completed in two nurseries, located in Graves and Calloway counties, and the UK's REC at Princeton. Liners (1.82-2.4 m tall, 3-4 cm diam.) of eastern red bud (*Cercis canadensis*) (Calloway Co.), redbud, apple (*Malus domestica* 'Granny Smith') and maple (*Acer rubrum* 'October Glory') (Graves Co.) and red bud and apple (Caldwell Co.) were chosen. Five treatments were set to evaluate a deltamethrin impregnated polyester net (Dead on Contact© (AgBio Inc., Westminister CO)) as a barrier against AB: individually wrapped tree, multiple wrapped trees, tree without protection set next to wood edge, or net separated from woods and trees set among nursery stock (Figure 2). Experiments were set up at two sites next to the woods in each location.

Pyrethroids and vinegars AB attack was induced in Fuji apple bolts (30 cm long, 3-4 cm diameter) with 2-4 mL 95% ethanol was aliquoted in a hole drilled at the core. The hole was sealed with paraffin film; then bolt ends were immersed in melted paraffin (Figure 5).

Apple logs were subjected to five treatments: Hole + Ethanol, Hole + No Ethanol, No Hole + No Ethanol, Hole + Ethanol + Hardwood Vinegar, Hole + Ethanol + Croton Vinegar, Hole + Ethanol + Mustang® Maxx, Hole + Ethanol + Baythroid ® XL. Treated logs were hung at the edge of a wooden lot. Each treatment was applied to nine bolts.

Results and Discussion The treatment with apple logs injected with ethanol was a successful strategy to attract granulate ambrosia beetles and black stem borers. The numbers of attacks per bolt were similar in apple bolts treated with either vinegar solutions or Baythroid. These chemicals did not show any protection when they were compared with the number of attacks in Hole+Ethanol control treatment (Table 1). On the contrary, logs treated with Mustang® Maxx were not attacked by ambrosia beetles during the two weeks they were exposed to the first beetle emergence in the spring. Two species emerged from the apple logs after eight weeks in laboratory conditions; granulated ambrosia beetle (GAB) and black stem borer (BSB), the former being the most abundant. The number of emerged GAB per attack hole was over three times higher in hardwood vinegar treatment than beetle emergence from Hole+Ethanol control and Baythroid®, and 2.5 times higher that emergence from croton vinegar. Some ambrosia beetle holes looked empty or with low boring activity in logs treated with croton vinegar at the moment they were brought to the laboratory. A few BSB emerged from galleries, which coincides with the low population found in this area in the last three years.

Mustang® Maxx deterred ambrosia beetle attacks for two weeks in apple logs, whereas Baythroid treated apple logs were attacked by ambrosia beetles. These findings showed that not all pyrethroid insecticides work effectively for the management of ambrosia beetles. The efficacy of other registered pyrethroids for the management of ambrosia beetles needs to be evaluated. These will be conducted in 2019.
The efficacy of the deltamethrin treated net was evaluated in induced flood-stressed trees. Plant stress symptoms in late April (two weeks after the beginning of the

experiment) were: late leaf out and growth reduction. By early May, when the GAB reached the first population peak after overwintering, the plants had been grown in water excess for two weeks. It has been previously reported that ambrosia beetle attack was induced four days after flooding conditions were provided (5). In this study, the only attack induced was in eastern red buds in Calloway Co. (Figure 3). In the rest of sites (Caldwell and Graves Counties) there were no attacks on any plant (Table 2) out of 40 plants in each site. In Calloway, only 5 plants were attacked out of 40 plants, the number of attacks were too low to determine the net effectivity (Table 3). It is worth noting that the three selected sites had previously reported severe ambrosia beetle attack, furthermore in Graves Co. there was an attack in container-grown trees with root bound and symptoms of vascular diseases in stems and roots. Plastic bags with water was tightened to the stems, this might have affected ethanol release from flooded roots. Overall, plants showed severe die back in late June; leaf drop and size reduction and reduced growth. Although the deltamethrin impregnated netting results were inconclusive, the treated net has been successfully proven against other pests (3). In this study, ambrosia attacks were very low, out of 40 trees in each of the 3 location only 5 trees were attacked in Calloway Co. The test will be conducted again in 2019.

Acknowledgements
Funds to conduct this study was provided by the Specialty Crop Block Grants of the Kentucky Department of Agriculture. We thank the Nursery farmers and Apple growers of Kentucky for allowing us to monitor ambrosia beetles in their properties. We extend our gratitude to Yaziri Gonzalez, Rocio Davila, Izabela Gomes, Alex Teutsch, and Kaleb Tamez for helping us to set up this study.

Literature Cited

1. Frank, S.D. and C.S. Sadof. 2011. Reducing insecticide volume and nontarget effects of Ambrosia beetle management in nurseries. J. Econ. Entomol. 104(6): 1960-1968. DOI: http://dx.doi.org/10.1603/EC11124
2. Kuhar, T. P., B. D. Short, G. Krawczyk and T. C. Leskey. 2017. Deltamethrin-incorporated nets as an integrated pest management tool for the invasive *Halyomorpha halys* (Hemiptera: Pentatomidae). J. Econ. Entomol. 110: 543–545
3. Marianelli, L., F. Paoli, G. Sabbatini Peverieri, C. Benvenuti, G. P. Barzanti, G. Bosio, D. Venanzio, E. Giacometto, and P. F. Roversiy. 2018. Long-Lasting Insecticide-Treated Nets: A new integrated pest management approach for *Popillia japonica* (Coleoptera: Scarabaeidae) Integr Environ Assess Manag 9999:1–7.
4. Ranger, C.M., M.E. Reding, P.B. Schultz and J.B. Oliver. 2013. Influence of flood-stress on ambrosia beetle host-selection and implications for their management in a changing climate. Agric.For. Entomol. 15:56-64.
5. Ranger, C.M., P.B. Schultz, M.E. Reding, S.D. Frank and D. E. Palmquist. 2016. Flood stress as a technique to assess preventive insecticide and fungicide treatments for protecting trees against ambrosia beetles. Insects 7(3):40. https://doi.org/10.3390/insects7030040

6. Ranger, C. M. and M.E. Reding, 2017. Residue age and attack pressure influence efficacy of insecticide treatments against ambrosia beetles (Coleoptera: Curculionidae). J. Econ. Entomol. 111(1): 269–276. https://doi.org/10.1093/jee/tox327

Figure 1. Hanged apple bolt (30x3.5 cm length x diam.) on edge of forest. Bolt ends were sealed with parafilm after 95% ethanol was pour into a drilled hole.

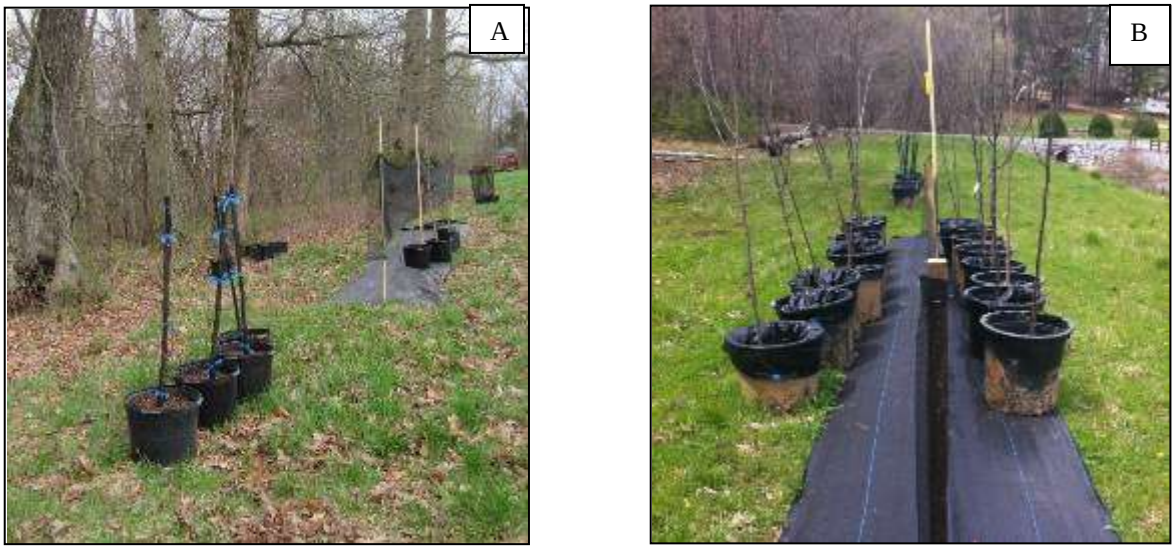

Figure 2. Pyrethroid treated netting evaluation to protect apple, maple and eastern redbud liners from AB attack in Caldwell (A), and Graves (B).

Figure 3. Eastern redbud (*Cercis canadensis*) attacked by Ambrosia beetles at lower stem in not fully wrapped trees with pyrethroid treated netting and without net in Calloway Co., KY.

Table 1. Mean number of attack holes per Fuji apple bolt and emerged *X. crassiusculus* and *X. germanus* per treatment after eight weeks in laboratory conditions.

Treatments	Attacks	Emerged Beetles/Attack hole	
	Mean ± SE	GAB	BSB
Hole + Ethanol	3.78 ± 0.89	14.81	1
Hole + No Ethanol	0.00 ± 0.00	0	0
No Hole + No Ethanol	0.00 ± 0.00	0	0
Hole + Ethanol + Hardwood Vinegar	2.63 ± 1.34	50.95	0
Hole + Ethanol + Croton Vinegar	4.88 ± 0.95	20.29	1
Hole + Ethanol + Mustang® Maxx	0.00 ± 0.00	0	0
Hole + Ethanol + Baythroid ® XL	2.63 ± 1.73	14.07	1

Table 2. Numbers of trees attacked by ambrosia beetles in three locations to test the effectiveness of a deltamethrin treated net in KY. All trees were flood stressed.

Treatment	Graves Co.	Caldwell Co.	Calloway Co.
Individually wrapped tree	0	0	2
Multiple wrapped trees	0	0	1
Wood Edge	0	0	1
Net-separated plant from woods	0	0	1
Nursery stock	0	0	0

Table 3. *Xylosandrus crassiusculus* attack on flood stressed eastern redbud (*Cercis canadensis*) liners in Calloway Co., KY and AB emergence in laboratory conditions.

Treatment	No. of attacked Plants	Entrances/Attacked plant	Emerged beetles
Individually wrapped tree	2	3	1
Multiple wrapped trees	1	9	16
Wood Edge	1	3	0
Net-separated plant from woods	1	2	25
Nursery stock	0	0	0

Amblyseius swirskii as a tool for pest management in nursery production

Karla M. Addesso, Paul A. O'Neal and Lisa Alexander

Tennessee State University, Agricultural and Environmental Sciences
Otis L. Floyd Nursery Research Center, McMinnville, TN 37110

kaddesso@tnstate.edu

Index words predator, biological control, spider mite, thrips, broad mite

Significance to Industry

Adoption of biological control tools in woody ornamental nursery production has lagged behind other agriculture fields. The diversity within woody ornamental nurseries nursery results in an array of potential pest problems, depending on the time of year or plant species in question. The predatory mite *Amblyseius swirskii* Athias-Henriot (Arachnida: Mesostigmata: Phytoseiidae), sold commercially as "swirski mite," is a generalist predatory mite that has recently been adopted as a control tool for a wide range of mite and insect pests including thrips (Thripidae), whiteflies (Aleyrodidae), eriophyid mites (Eriophyidae), broad mite (*Polyphagotarsonemus latus* (Banks)) and spider mites (Tetranychidae). Most of the work conducted to date in nursery production utilizing predatory mites has been performed by biological control companies consulting with private nursery owners to address specific pests. Published research in the use of predatory mites in ornamental pest management has been largely limited to key species in greenhouse production (1, 2) and a few trials in container and field crops (3-5).

Nature of Work The goal of these experiments was to explore swirski mite as a potential management tool for woody ornamental propagation. Two greenhouse experiments were conducted and a third was conducted in outdoor propagation beds.

Greenhouse Establishment. Swirskii mites (Evergreen Growers Supply, LLC, Clackamas, OR) were applied to flowering dogwood seedlings (*Cornus florida* L.) across four 15-pot flats (4 in square pots) at a recommended rate of 5 mites/ft^2 in cages (1) alone, (2) with a pollen supplement (Nutrimite, Biobest Group NV, Westerlo, Belgium) (3) or with a flowering ‘Explosive Embers’ ornamental pepper plant as a refuge. Two additional treatments with (4) one banker pepper plant containing 125 mites and (5) an untreated control were also evaluated. Recovery of predators and prey counts were monitored weekly for three weeks by randomly sampling 8 leaves per cage (n = 6).

Hydrangea Cultivars. Four cultivars with different trichome densities were treated with swirski mite at a rate of 5 mites/ ft^2 to evaluate establishment on plants with different levels of pubescence. The treatments were *Hydrangea quercifolia* Bartram 'Ruby Slippers', *H. macrophylla* (Thunb.) Ser. 'Decatur Blue' and one 3n (*H. macrophylla* 'Zaunkoenig' x 'Princess Juliana') and one 2n (*H. macrophylla* 'Trophy' x 'Zaunkoenig')

breeding line. Variability in trichome density is known to affect establishment of swirski mite in vegetable crops and such variability is common between species and cultivars of ornamental plants. Recovery of predators and prey counts were monitored on individual 15-pot flats (4-in square pots) weekly for five weeks by randomly sampling 4 leaves per flat (n = 4).

Propagation Beds. Swirski mites were applied at 2.3 mites/ft^3 in Mid-May to 300 ft of stock 'Sun Valley' red maple two weeks before propagation. Cuttings were held under mist for 8 wk. After plastic was removed, two additional treatments were introduced into beds propagated from untreated stock plants - an application of 5 mites/ft^2 with and without pollen supplement. Each treatment and an untreated control plot (4 × 4 ft) were evaluated bi-weekly from late July - Sept to assess recovery of predators and prey counts by randomly harvesting 16 leaves across the treatment plot (n = 4).

Results and Discussion

Greenhouse Establishment. Recovery of predators in all experiments was difficult as swirski mite has the ability to move quickly when disturbed. Initial establishment of predators was possible in all caged treatments so long as prey or supplemental pollen was provided (Fig. 1). One challenge in the greenhouse trials was excluding predators from untreated plants. Despite the use of screened cages, some swirski mites were found in untreated controls by 14 DAT. At 21 DAT, predators were recovered from cages containing either a banker or refuge plant, suggesting that a continuous supply of pollen provided by the flowering pepper plants was necessary to maintain the population once prey were depleted.

Hydrangea Cultivars. The species with the most pubescence (*H. quercifolia* 'Ruby Slippers') had the most swirski recovered and was the only plant treatment to have swirski mites recovered after 5 weeks (Fig. 2). Also after 5 weeks, no broad mites were recovered from 'Ruby Slippers' samples. The other three treatments were plants bred from *H. macrophylla*, and all had substantially fewer trichomes than 'Ruby Slippers'. Despite the presence of ample prey, swirski failed to establish on the *H. macrophylla* treatments which had fewer oviposition sites and refugia suitable to maintaining the predator populations. These results suggest that in order to use these predators on plants with glabrous foliage, multiple applications will likely be required to control target pests. Alternatively, artificial oviposition sites may facilitate the establishment of swirski mites in such settings.

Propagation Beds. Predatory mites were recovered from rooted cuttings taken from treated stock plants that were held under mist for 8 weeks, suggesting that the treatment of stock plants may be an efficient methods for distributing predatory mites into propagation beds. Post-misting, predators in all treatments appeared to decline over the six-week sampling period, while prey available increased (Fig. 3). The post-misting treatments, however, were too variable to provide much information on swirski efficacy in controlling red maple pests. We identified three main challenges when working with swirski in propagation beds. The first was variable establishment of rooted

cuttings during the trial. This caused discontinuous canopies across the propagation beds, a condition which has been reported to decrease predator efficiency in other studies. Second, due to the farm setup of the propagation beds it was not possible to guarantee swirski were excluded from untreated controls. Swirski are capable of dispersing to untreated areas as demonstrated in our cage study above and previous work using this predator in container yards (5). Finally, it was sometimes difficult to discern swirski mites recovered from the beds from other similar looking mites. In future studies, genetic markers will be used to confirm that recovered predators are in fact swirski and not native predators present in the field.

Acknowledgements
Funds for this work were provided by Southern SARE On-Farm Grant (OS17-101) and USDA Evans-Allen Program (1007887).

Literature Cited

1. van Driesche, R.G. and S. Lyon. 2003. Commercial adoption of biological control-based IPM for whiteflies in poinsettia. Florida Entomol. 86:481-483.
2. Casey, C., J. Newman, K. Robb, S. Tjosvold, J. MacDonald, and M.P. Parella. 2007. IPM program successful in California greenhouse cut roses. California Agr. 61(2):71-78.
3. Pratt, P.D. and B.A. Croft. 2000. Screening of predatory mites as potential control agents of pest mites in landscape plant nurseries of the Pacific Northwest. J. Environ. Hort. 18:218-223.
4. Pratt, P.D., R. Rosetta, and B.A. Croft. 2002. Plant-related factors influence the effectiveness of *Neoseiulus fallacis* (Acari: Phytoseiidae), a biological control agent of spider mites on landscape ornamental plants. J. Econ. Entomol. 95:1135-1141.
5. Addesso, K.M. A. Witcher, D. Fare, and P. A. O'Neal. 2018. Swirski Mite Controlled-release Sachets as a Pest Management Tool in Container Tree Production. Hort Tech. 28:391-398.

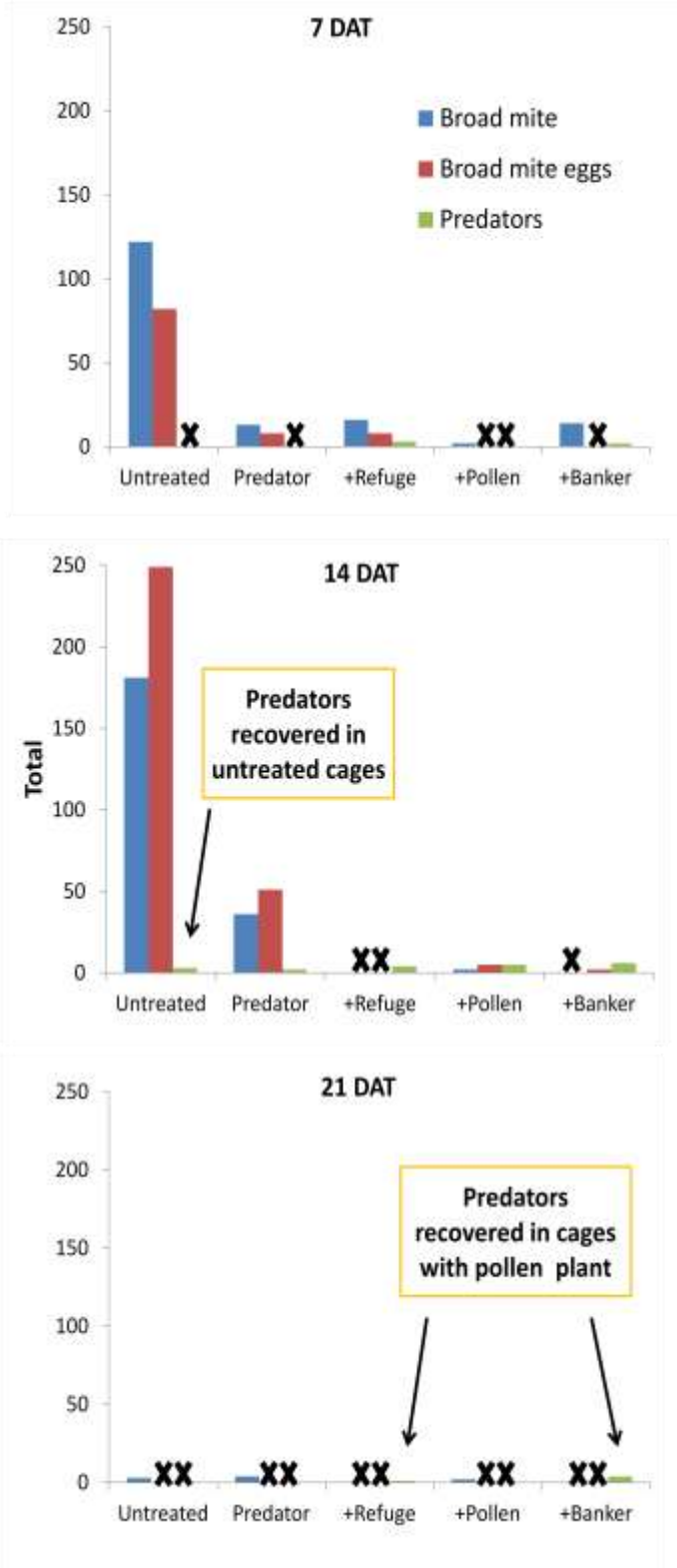

Figure 1. Establishment of swirski mites on flats of dogwood seedlings in greenhouse cages over a three-week period.

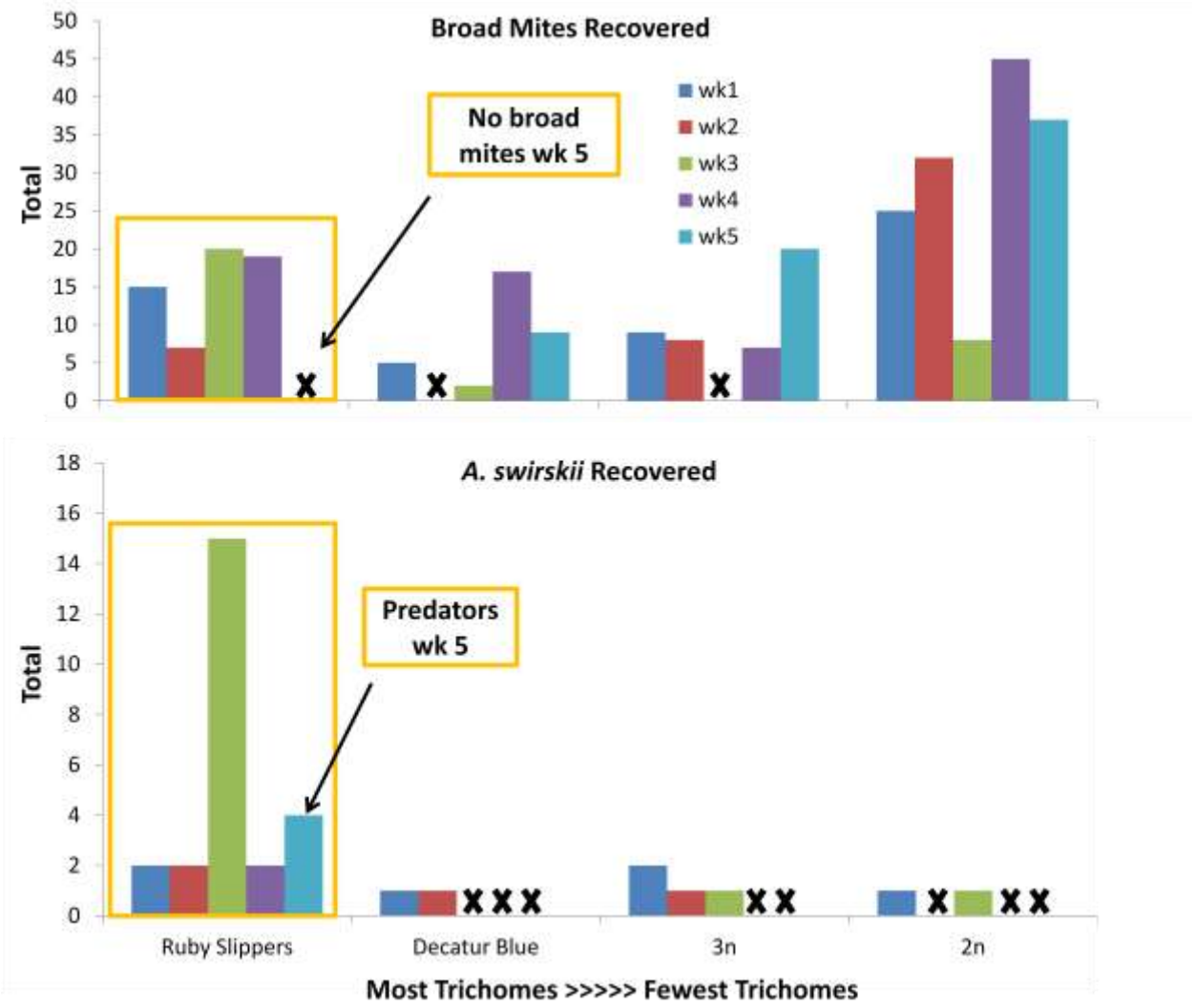

Figure 2. Recovery of swirski and broad mites on greenhouse propagated hydrangea cultivars over five weeks.

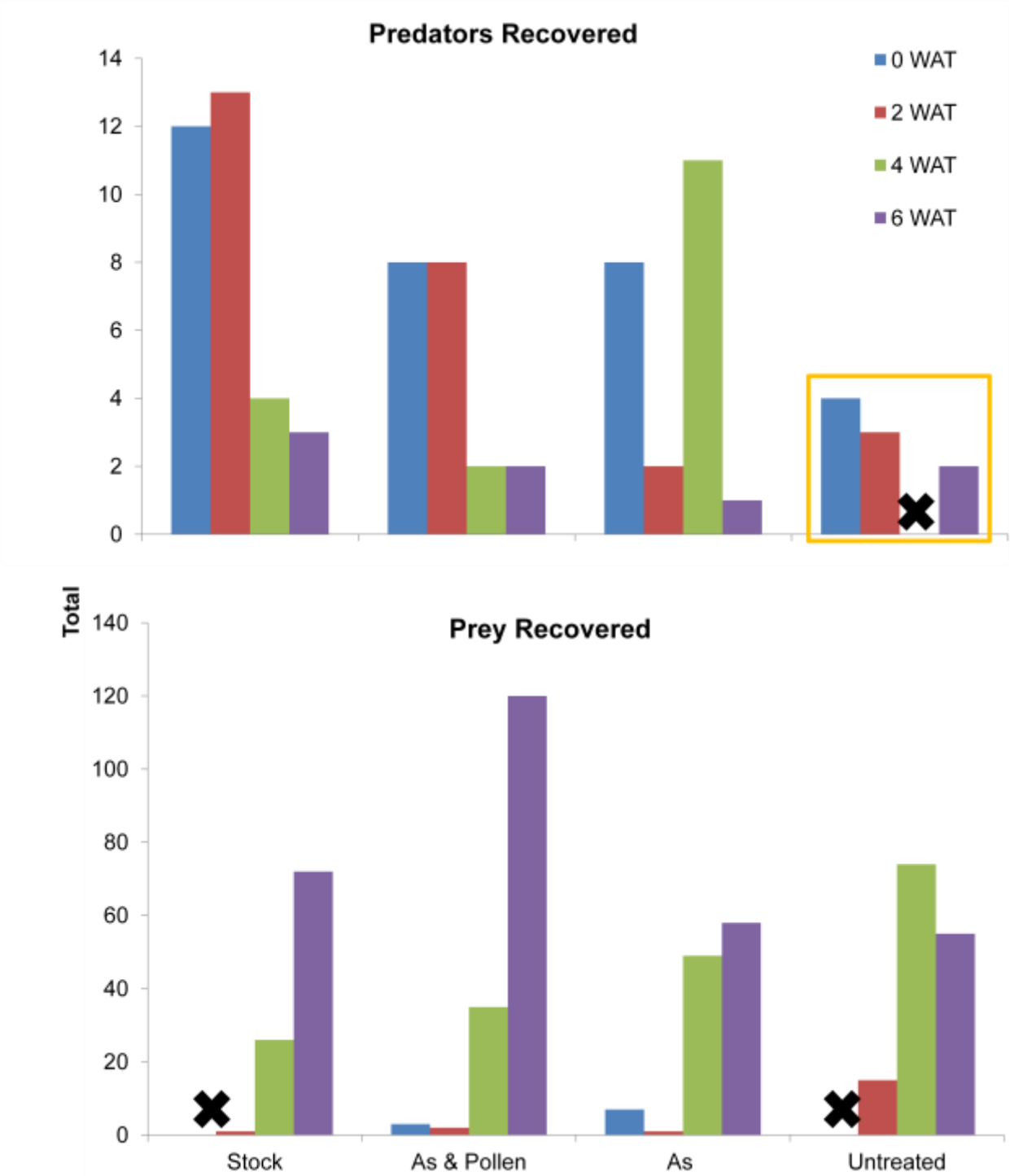

Figure 3. Total predators and prey recovered in 'Sun Valley' red maple propagation beds after a single application of swirskii. Swirskii were applied to stock plants (Stock), with (As & pollen) and without pollen (As) and Untreated beds were also evaluated as controls.

Time of day affects performance of spinosad for Chilli thrips (*Scirtothrips dorsalis* Hood)

David Held, Jeremy Pickens, and Kyle Owsley

Auburn Alabama University, Entomology & Plant Pathology Dept.
301 Funchess Hall, Auburn, AL 36849

dwh0004@auburn.edu

Index Words *Scirtothrips dorsalis*, *Ternstroemia gymnanthera*, pest management, spinosyn

Significance to the Industry Chilli thrips (*Scirtothrips dorsalis* Hood, Thysanoptera: Thripidae) is an introduced thrips that feeds on >100 host plants. This pest invaded Alabama in the last 5 years has quickly become the number one insect pest in ornamental production along the Alabama Gulf Coast. Chilli thrips have less flight activity in the morning and evening than at midday. In this study, we determine if these daily activity patterns can be exploited to enhance chemical control. Blocks of cleyera infested with chilli thrips were divided for application with spinosad in the morning, at midday, and early evening, or not treated. Thrips were sampled before treatment then again at 5 d after treatment. Non-treated plants had a 50% reduction in thrips from pre- to post counts, which was not different from plants treated at midday or in the evening. However, plants treated in the early morning had 83% fewer thrips in the post-treatment sample which was a significant reduction relative to control plants. These results suggest that time of day can influence the effectiveness of spinosad and perhaps other insecticides applied for control of chilli thrips.

Nature of Work Chilli thrips (*Scirtothrips dorsalis* Hood) is an introduce thrips that feeds on >100 host plants including common ornamental plants like roses, Indian hawthorn, and cleyera (6, 8, 9). Chilli thrips are multivoltine with perhaps 10 or more generations per year in AL (5). The biology of Chilli thrips and Western flower thrips are similar; eggs are embedded into plant tissue with the saw-like ovipositor of the female. The eggs hatch in less than a week, then larvae develop through two feeding stages, followed by two non-feeding pupal stages that often occur off the plant in leaf litter or soil. Most (77%) Chilli thrips overwinter in leaf litter and soil as pupae or adults (10), but some can remain active in overwintering structures (12). During the growing season, Chilli thrips will remain on host plants overnight or from dusk until about 10 am, or >300 accumulated degree hours (3). Between 10 am and 4 pm most thrips are actively moving as reported from consistent captures on sticky cards or yellow traps (3, 7, 9, 11). This is also the time corresponding with the greatest daily oviposition (eggs per female) for this thrips (11).

We conducted an experiment in July 2018, using 3 gallon (trade) plastic potted cleyera (*Ternstroemia gymnanthera*) plants potted in a pine bark mix. Plants for this study were

located in two container blocks in an uncovered gutter-connected cold frame. Blocks were arranged in a north to south orientation. Plants in these two blocks had an initial growth index of 21 (n = 10) and were all showing damage from chilli thrips at the beginning of the trial. Each experimental unit consisted of 100 pots (10 plant × 10 plant area) with a buffer strip, 2 plant × 10 plant wide, between each experimental unit. Experimental units were randomly assigned to each treatment and marked along the aisle with a tag indicating treatment and replicate. Treatments in this experiment were the timing when the insecticide was applied. The insecticide Entrust® SC Naturalyte® (22.5% spinosad; Dow® AgroSciences), a common active ingredient used by growers in Alabama to control chilli thrips, was a used at 1.5 ml per gallon water. Three treatments representing application times of 9:00 AM, 2:00 PM, and 4:30 PM were used. A non-treated control block was used for comparison. Each timing treatment and control were replicated with 10 experimental units each.

On 18 July 2018, plants were sampled to determine the initial population. From each experimental unit, five plants were randomly selected and three terminals (about 2.5 cm long) were picked from each plant (15 terminals total) and placed immediately into a 50 ml labeled vial with ethanol. Samples were then brought to the lab and thrips were filtered from the ethanol using Whatman #8 ruled filter paper with a grid (1). The numbers of thrips on the paper were then counted by adult or immature life stages under a stereomicroscope. On 19 July 2018, Entrust® SC Naturalyte® was applied using a backpack sprayer to the designated experimental units at the assigned time. Winds were negligible and no rain fell during the application. Five days after the application (24 Jul 2018), each experimental unit was sampled again to determine treatment efficacy using the same sampling procedure previously described. The percent reduction in thrips relative to the pre-treatment counts for each timing treatment and control was calculated then submitted to arcsin transformation before being analyzed. Means were compared using LSD ($P < 0.05$). All means presented are actual means.

Results and Discussion In the pre-treatment sample, most (89%) of the thrips collected were immatures. There was an average of 100.23 ± 5.7 adults and 12.05 ± 1.1 immature thrips per the sample of 15 terminals from 5 plants (Fig. 1). There was no difference in the numbers of adults, thrips or combined life stages before treatments were applied ($P \geq 0.79$). All post-treatment samples, including non-treated controls had fewer thrips than pre-treatment samples. Reductions in the control block could be due to the maturing of thrips into the pupal stage or movement of thrips between plants. Development of the plant-feeding immatures stages ranged from 3.25-6 d (4) and plants were sampled at 5 d after treatment. Thrips in post-treatment samples were also mostly (95%) immatures. Given the fast development time of the immature stages, these immatures present in the post-treatment samples were likely eggs and not the same individuals present at the time of the application. Relative to pre-treatment samples, the percent reduction was significantly different between treatments ($P = 0.036$). Among the timing treatments, the morning treatment (83% fewer thrips) was the only timing that had a greater reduction relative to pre-treatment (Fig. 2).

These results suggest that applications of spinosad made in the morning should have greater impact on reducing chili thrips than those applied in evening or midday. Dale and Borden (2) suggested the knockdown (similar to the percent reduction used in this test) is most evident at 1 d after application, declining at 7 and 14 days to levels similar to control plants. The 5 d between treatment and post-treatment sampling could have impacted the conclusions from this experiment. Based on Figure 2, we could speculate that the evening timing of treatment with spinosad may also have been significant if we sampled at 1 d. After 5 d, the evening treatment was not significantly different from both the non-treated control and the morning timing. This would make sense because both timings would target a population of thrips that are less mobile (3, 7, 9, 11) and more likely to have longer residency on treated plants. Readers should use caution when trying to apply these results to insecticides with different routes of exposure. Spinosad has activity by contact and ingestion. Insecticides that have contact activity may produce similar results, but insecticides that rely on the thrips behavior such as feeding deterrent may not.

Literature Cited

1. Aristizábal, L.F., G.M. Mascarin, R. Cherry, B. Chaves-Cordoba, and S.P. Arthurs. 2016. A rapid sampling plan for *Scirtothrips dorsalis* (Thysanoptera:Thripidae) on container shrub rose (*Rosa* ‘Radrazz’). J. Econ. Entomol. 109:2543-2550.
2. Dale, A.G. and M.A. Borden. 2018. Evaluation of reduced-risk insecgicide to control chilli thrips (Thysanoptera:Thripidae) and conserve natural enemies on ornamental plants. Fl. Entomol. 101:237-243.
3. Derksen, A.I., C.M. Mannion, D.R. Seal, L.S. Osborne, and C.G. Martin. 2016. Direction and timing of dispersal of *Scirtothrips dorsalis* (Thysanoptera:Thripidae), on select ornamental host plant species in south Florida. Florida Entomol. 99:710-717.
4. Duraimurugan, P. and A. Jagadish. 2011. Preliminary studies on the biology of *Scirtothrips dorsalis* (Thysanoptera:Thripidae) as a pest of rose in India. Arch. Phytopathol. Plant Prot. 44: 37-45.
5. Holtz T. 2006. NPAG Report: *Scirtothrips dorsalis* Hood. New Pest Advisory Group, Center for Plant Health Science and Technology, United States Department of Agriculture, Animal and Plant Health Inspection Service, Raleigh, North Carolina.
6. Kumar, V., G. Kakkar, C.L. McKenzie, D.R. Seal, and L.S. Osborne. 2013. An overview of Chilli thrips, *Scirtothrips dorsalis* (Thysanoptera:Thripidae) biology, distribution, and management. InTech http://dx.doi.org/10.5772/55045
7. Kumar, V., G. Kakkar, D.R. Seal, C.L. McKenzie, J. Colee, and L.S. Osborne. 2014. Temporal and spatial distribution of an invasive thrips species *Scirtothrips dorsalis* (Thysanoptera:Thripidae). Crop Protect. 55:80-90.

8. Mannion, C.M., A.I. Derksen, D.R. Seal, L.S. Osborne and C.G. Martin. 2013. Effects of rose cultivars and fertilization rates on populations of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) in southern Florida. Florida Entomol. 96: 403-411.
9. Mannion, C.M., A.I. Derksen, D.R. Seal, L.S. Osborne and C.G. Martin. 2014. Population dynamics of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) and other thrips species in two ornamental host plant species in southern Florida. Environ. Entomol. 43: 849-858.
10. Okada, T. and I. Kudo. 1982. Overwintering sites and stages of *Scritothrips dorsalis* Hood (Thysanopera: Thripidae) in tea fields. Jap. J. Appl. Entomol. Zool. 26:177-182.
11. Seal, D.R., W. Klassen, and V. Kumar. 2010. Biological parameters of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) on selectred hosts. Environ. Entomol. 39:1389-1398.
12. Van Hoogmoed, A. 2015. Inspection report week of December 9, 2015. AL. Dept. Agric. Industries.

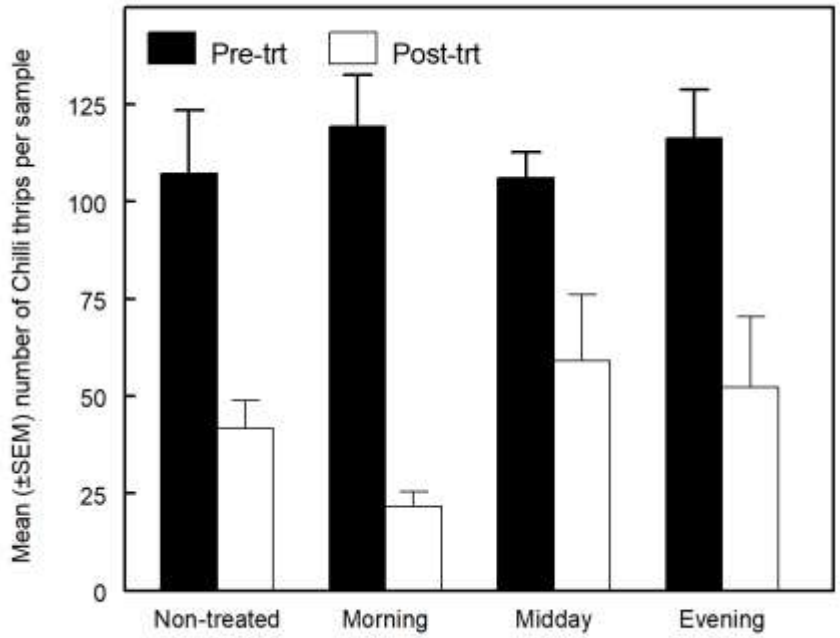

Figure 1. Numbers of thrips on three terminals of cleyera in pre- and post-treatment samples from 5 plants in each block.

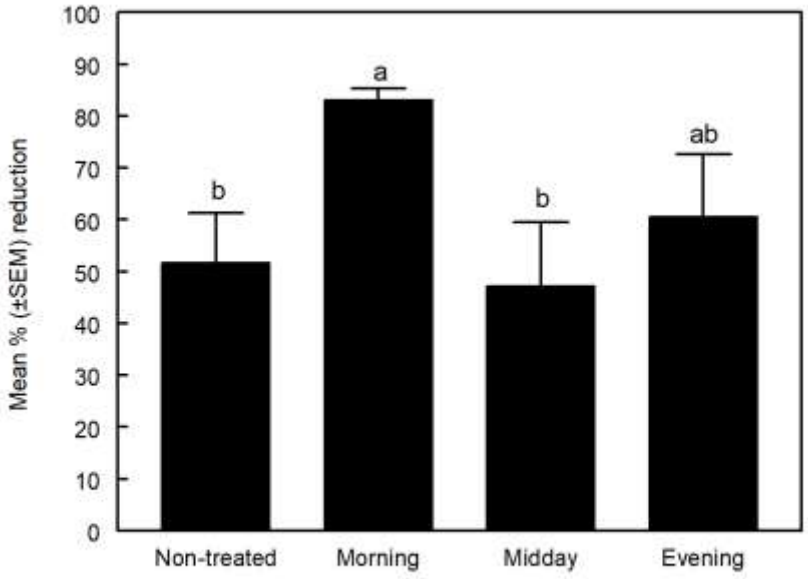

Figure 2. Percent reduction of adult and immature Chilli thrips from pre- to post-treatment samples when spinosad was applied at different times of the day to infested cleyera.

Active Predators of Crapemyrtle Bark Scale

Victoria Hicks, Kyle Gilder, Kevin M. Heinz

Department of Entomology Texas A&M University
College Station, TX 77843-2475

kyle.gilder@tamu.edu

Index of Words *Acanthococcus lagerstroemiae, Eriococcus, Lagerstroemia* spp.

Significance to Industry The data shows that predatory insects present on crapemytle were active predators of crapemyrtle bark scale. They can be recognized as a potential method of *A. lagerstroemiae* scale population regulation. *H. axyridis* and *C. cacti*, in particular, displayed considerable appetite for *A. lagerstroemiae*. Efforts should be made to conserve the natural enemy populations.

Nature of Work Crapemyrtles (*Lagerstroemi*a spp.) are flowering trees and bushes native to Southeast Asia and Australia. They have been cultivated in the Southeastern U.S. for over 175 years, and are commonly used in landscapes due to their long-lasting summer bloom, diverse plant forms and function, and adaptability to a wide range of macro and micro environments. Breeding efforts have resulted in 133 commercially available cultivars as of December 2011, which has increased their popularity in the landscape (1). In 2004, the crapemyrtle bark scale [*Acanthococcus* (=Eriococcus) *lagerstroemiae* (Kuwana)] was first detected on trees in Richardson, Texas (4) and has since spread across the southern U.S. (2). The aesthetic damage caused by the growth of black sooty mold on the sugary excrement from this insect and the overall stress placed on trees from heavy infestations led to the recognition of this pest as one of the top nine pests to the ornamentals industry (3). While a large number of possible insect predators have been associated with crapemyrtle bark scale (4), the purpose of this research was to identify which common ones actually consume *A. lagerstroemiae*.

Predation characteristics were obtained from preliminary studies not described here. Predators associated with *Lagerstroemi*a spp. in College Station, Texas were collected by hand and placed into centrifuge tubes with a screened hole in the cap. The predators were placed in plastic petri dishes, 100mm diameter by 15mm height, with a water moistened piece of paper towel that was 50.8 mm^2 squared. Next, the petri dishes were placed in an incubator for 24 hours, at 25°C and a 12L:12D light cycle. During this predator starvation period, *A. lagerstroemiae* samples were collected from crapemyrtles in College Station, Texas. The scale samples of *A. lagerstroemiae* were fed to the predators after the 24-hour starvation period had elapsed. Each predator was provided a branch with 10 undamaged adult females and a varying number of male pupae and other life stages. The number of first instar scales, second instar up to adult, and male pupae were recorded, but not standardized. For every ten adult female scales placed in a petri dish there were also on average 3.83 first instar scales, 32.25 second instar

scales up to but not including adults, and 9.03 male pupae. Over the course of the experiment 1,030 adult female scales were collected and placed in petri dishes to feed predators. 394 first instars were collected with a standard error of 0.54 per petri dish. Second instar up to but not including adults had a total of 3322 with a standard error of 3.23 per petri dish. Lastly, 930 male pupae were collected with a standard error of 0.88 per petri dish.

All damaged male pupae and adult females were removed from the branches with forceps, thereby leaving only live, undamaged scales for the study. Predators and scales were returned to the incubators for a period of 48 hours. After 48 hours, the petri dishes were removed from the incubators, the predators were removed from the petri dishes, and the number of present and/or damaged scales was recorded.

Results and Discussion The following number of individual predators were evaluated during this two month-long study: 30 *Chilocorus cacti* adults (L.) (Fig 3*),* 30 *Harmonia axyridis* (Pallas*)* adults and 25 *Harmonia axyridis* larvae (Fig 1 and 2). Also collected and shown together in Figure 4 are 3 *Hyperaspis lateralis* (Mulsant)*,* 1 *Exochomus marginpennis (*LeConte)*,* 7 *Coccinella septempunctata* (L.)*, 1 Axion plagiatum* (Olivier), and 4 *Olla v-nigrum* (Mulsant)*,* as well as 2 assassin bugs, *Zelus renardii* (Kolenati*).* 6 *H. axyridis* larvae died and/or went into pupation before their trial ended but many were still active predators as shown in Figures 1 and 2. The ones that remained still displayed an appetite for adult females and second instar up to adult. Some scale eggs hatched while in the petri dish during the feeding cycle. It is undetermined if individuals tested active with this life stage or not due to high eclosion. This is with the exception of *C. cacti* which consumed all life stages as shown in Figure 3. Every lady beetle tested was shown to consume adult female *A. lagerstroemiae*. Figure 4, “other species,” indicates that while the assorted predators shown were not collected in high numbers a considerable number of predator species present in the environment will consumer *A. lagerstroemiae.*

Literature Cited

1. Chappell, M. R., S.K. Braman, J. Williams-Woodward, and G. Knox (2012). Optimizing plant health and pest management of Lagerstroemia spp. in commercial production and landscape situations in the southeastern United States: a review. Journal of Environmental Horticulture, 30(3), 161-172.
2. EDDMapS. 2018. Developed by The University of Georgia - Center for Invasive Species and Ecosystem Health. Accessed October 23, 2018, https://www.eddmaps.org/cmbs/distribution.cfm
3. Miller, C. 2015.Top 9 Pest Reports in the Past Two Years. http://www.greenhousegrower.com/retailing/top-9-pest-reports-in-the-past-two-years/5/

4. Wang, Z., Y. Chen, and M. Gu, (2016). Crapemyrtle Bark Scale: A New Threat for Crapemyrtles, a Popular Landscape Plant in the U.S. Insects, 7(4): 78. doi: 10.3390/insects7040078

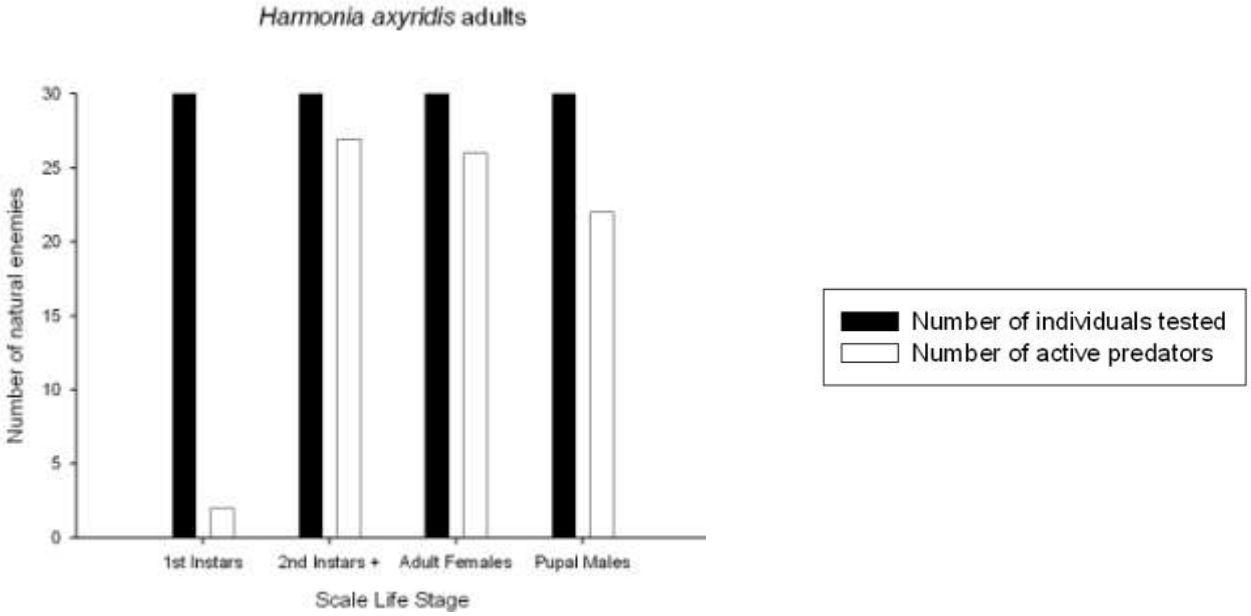

Figure 1: For Harmonia axyridis adults, high levels of active predation were displayed for the second instar up to adult category, adult females, and pupal males.

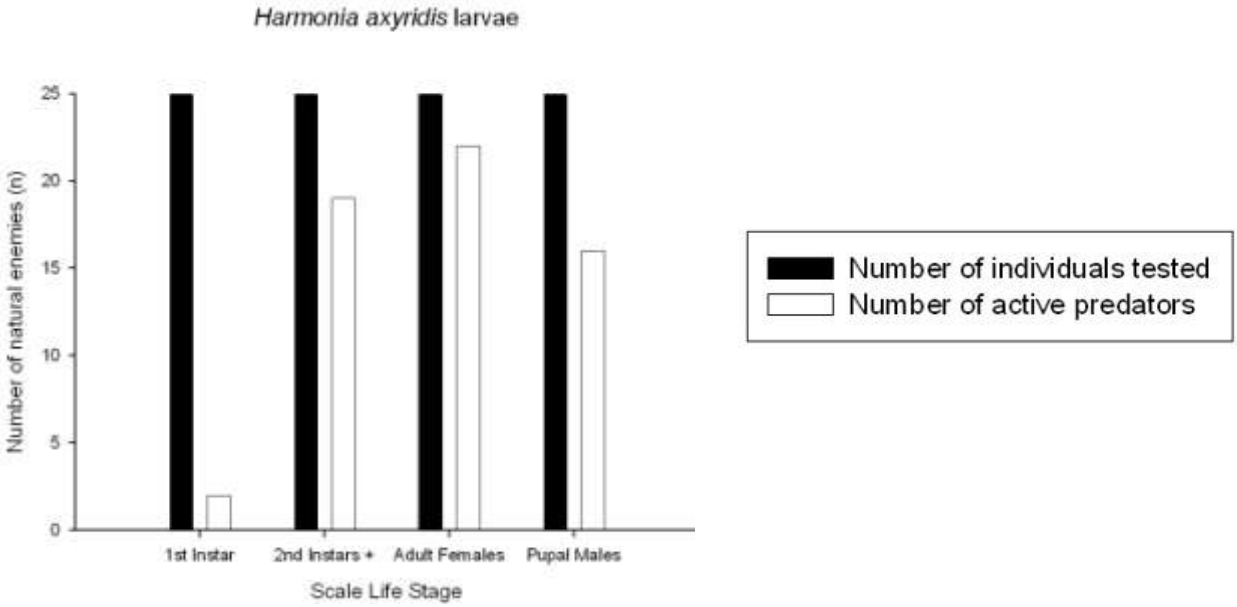

Figure 2: For Harmonia axyridis larvae, high levels of active predation were displayed.

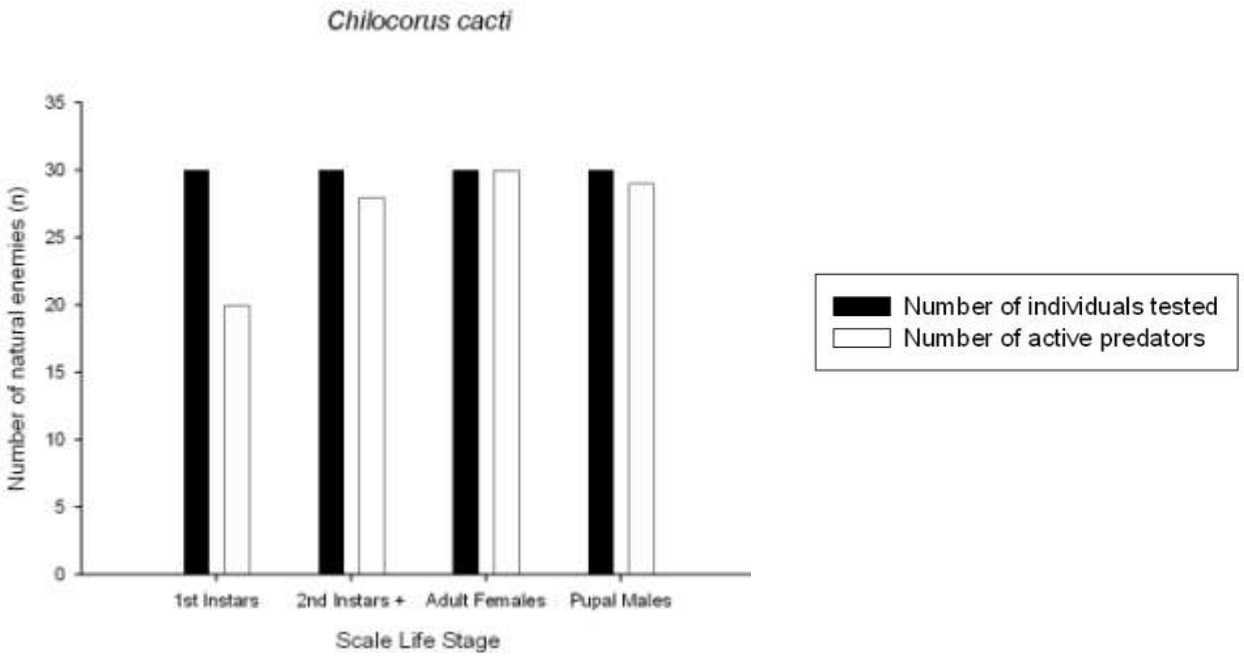

Figure 3: For C. cacti adults, high levels of active predation for every life stage of scales given.

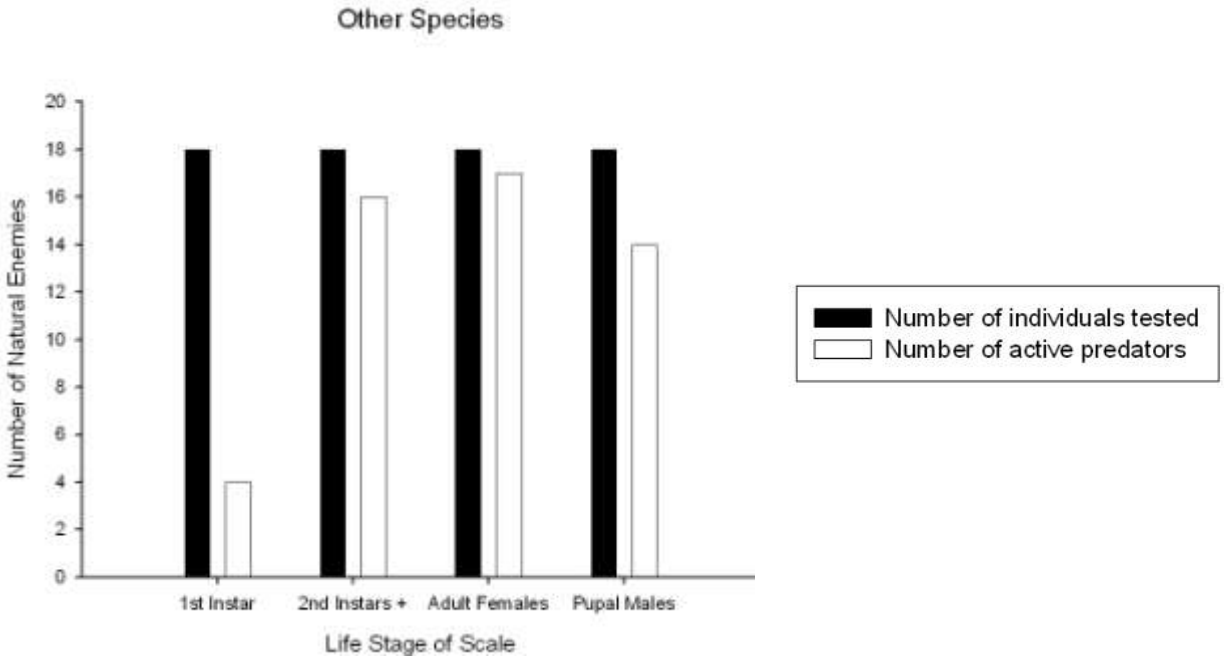

Figure 4: Many species in this group showed interest in 2nd instar up to adult, adult females, and pupal males.

Phenology and control of false oleander scale (*Pseudaulacaspis cockerelli*) on *Aucuba japonica*

Kendra M. H. Carson and David Held

Auburn Alabama University, Entomology & Plant Pathology Dept.
301 Funchess Hall, Auburn, AL 36849

Kmh0100@auburn.edu and dwh0004@auburn.edu

Index Words *Pseudaulacaspis cockerelli*, *Aucuba japonica*, pest management, life cyle

Significance to the Industry False oleander scale (*Pseudaulacaspis cockerelli* (Cooley), Hemiptera: Diaspididae) is a common pest of broadleaf evergreen plants and palms. All life stages can be present year round (3) and there are no published studies on crawler hatch period. In this study, we evaluated control of false oleander scale using various insecticides applied as foliar treatments in April, and recorded the seasonal occurrence of life stages and gravid females on *Aucuba japonica*. Insecticides provided control of this scale species but none, including systemics, were effective beyond 4 months after treatment. Less than half of the females at any sample contain eggs or crawlers and crawler hatch is not synchronous. Populations on leaves had two peaks, mid to late July and in early November. The phenology and control work suggests that maybe one treatment in early July may provide control of both population peaks.

Nature of Work False oleander scale was first described in California collected from quarantined palms from China, and became common in the southeastern U.S. in the late 1960's (3,4,7,8). Female and male false oleander scale feed on leaves of broadleaf ornamental plants causing chlorosis and making plants less vigorous (7). False oleander scale has multiple life stages present on *A. japonica* year round. Females spread out exhibiting a preference for the upper surface of leaves, whereas males aggregate on the lower surface. Eggs and nymphs (crawlers) appear to have an asynchronized crawler hatch period. Adults feed directly on plant cells and xylem tissues, producing no sugary honeydew or sooty mold (5). Control of the different life stages can be difficult due their abundant populations and hatch timing. Previous studies, mostly from Florida, have evaluated applications of insect growth regulators, systemic and contact insecticides applied on ornamental plants (1, 6, 7). In these studies, reductions in scale populations are noted for 4-8 weeks after treatment with certain insecticides, but populations are often not different from non-treated controls thereafter. Applications are typically made in Jan, Feb, or Apr, but generally there is no accompanying data on population dynamics or occurrence of crawlers. Building on these previous studies, we investigated control of false oleander scale while concurrently monitoring populations and occurrence of females with offspring (gravid).

We conducted an experiment, April to November 2018, using 3 gallon (trade) plastic potted plants (*Aucuba japonica*) infested with false oleander scale obtained from a local

nursery. These plants, about 2 years old, were never treated with insecticides before being used in this study. Plants were transported to Auburn University campus, Auburn, AL and held on an overhead-irrigated container pad under 50% shade. Plants were fertilized (Osmocote 15-9-12, 55g per pot) on 29 Mar and again on 15 Jul. Plants were infected with *Phytophthora* root rot and were treated with a granular fungicide (Subdue GR, 38g per pot) on 9 Jul and 2 Aug. This resulted in stem and leaf loss on some plants. They were watered routinely with overhead sprinklers, twice a day in the early morning and late afternoon. During the summer, at peak heat, plants were watered more frequently.

Within a week of the first treatment, plants were sampled to determine the initial population and these data were also used to assign plants into blocks (replicates) with similar infestation levels. We surveyed populations on a 10 leaf sample from each plant using two methods; the number of leaves infested, and the number of live false oleander scales per leaf, including all life stages. These methods were done initially (time 0) and at each subsequent evaluation. In addition, a sample of 25 female scales (gravid vs. nongravid) on a minimum of 5 leaves were evaluated from each plant. Post-treatment, populations were sampled on day 7, 14, 28, then again at 4 and 6 months after the initial applications. Plants were randomly assigned to one of 12 foliar applications or non-treated control (Table 1, 2, 3). The first application was made on 27 Apr, with a second application at the same rate 2 wk later. Treatments were sprayed during appropriate conditions to avoid spray drift using a backpack sprayer.

In addition to monitoring the effects of foliar insecticides on populations of false oleander scale, we monitored life stages and population dynamics on a set of 14 potted, and non-treated *A. japonica*, using the same three sampling methods. Samples were taken bimonthly, except for Sept and Oct when sampling was done once each month.

Results and Discussion Before treatment, populations ranged from 25.6-44 false oleander scales of all life stages per leaf, with most plants having scales on 7 of the 10 leaves sampled (Table 2, 3). Across all post-treatment samples, there were no significant reductions in the populations (all life stages) relative to the non-treated controls from any insecticide (Table 3). However, differences between treatments were detected for the percentage of live females and number of infested leaves. Ventigra plus UltraPure oil (low rate) had significantly fewer live females than non-treated control plants on day 7. Ventigra plus UltraPure oil (high rate) also had significantly fewer live females than non-treated control plants on day 28. The two rates of Ventigra plus UltraPure oil were never significantly different from one another. Similarly, this was the only treatment that contained UltraPure oil. It is possible that the effects observed on live females may then be due to the oil alone and not the Ventigra product. There were no differences with 14 d after treatment in numbers of infested leaves, but there were significant differences at 28 d and 4 months after treatment. At 28 d, treatments IKI-3106, Azaguard (high rate), Ventigra, Tri-Star and Distance had significantly fewer number of infested leaves than the non-treated control. After 4 months, only Talus and Distance had significantly fewer infested leaves than the non-treated control (Table 2).

All treated plants had similar numbers of infested leaves as non-treated control plants at 6 months after treatment.

False oleander scale populations on non-treated Aucuba plants (Fig. 1) suggest that no more than 62% of females on leaves (gravid and nongravid) are alive at any time. Also during the 8 months that were sampled, a maximum of only 45% of living females (in Aug) ever had eggs (gravid). A majority of females are not gravid during most of the year. In mid-Apr to early May, there is a decline in female survival that ends with about 32% of females alive. The proportion of living females increases back to 62% by early Jul but declines to around 50% where it remains until Nov. From the beginning to the end of Nov, the number of living females per plant declines to only about 30% by the end of the month. Female scale insects that are dead, but that remain attached to host plants is common occurrence for armored scales. From spring into early summer, there are 15-44 scales (all life stages) per leaf. Between 6-20 Jul, scale densities quickly increase to a peak average of 185 per leaf, only to decline and increase again to an average of 127 per leaf by early Nov. These rapid increases and decreases in scales per leaf are due to crawlers hatching. The rapid decline is due to dispersal to other plants or mortality.

The timing of insecticide applications in this study and others likely explains why certain products do not seem to provide adequate long-term reductions in false oleander scale populations. Applications in spring are targeting a population already in decline. If scales were actively feeding we would expect a more rapid decline in the population following treatment. Since this study and others do not record short-term population reductions (7 or 14 d), except when horticultural oils are used, it may indicate that older individuals are not feeding readily and therefore not exposed to translaminar or systemic insecticides. Our sampling of non-treated populations suggests that a late Jun or early Jul application window may be more effective than spring applications. That window would target an increasing population, where growth may indicate more feeding and greater susceptibility to ingestion of insecticides. If populations need to be treated in the spring for aesthetic reasons, perhaps an oil or other contact-active product could be used for a short-term reduction in the population. Future studies should compare this summer application window to a spring application timing for possible season-long management of this scale insect. While this study was conducted on a non-flowering host, precautions on insecticides labels should be followed when applying insecticides to flowering hosts like magnolias and palms, especially when pollinators are present.

Literature Cited

1. Buss, E. A. 2004. False oleander scale control, 2003. Arthrop. Manage. Test Rep. 29: G40.
2. Cooley, R. A. 1897. New species of *Chionaspis*. Canad. Ent. 29: 278-282.
3. Dekle, G. W. 1976. Florida armored scale insects, in Arthropods of Florida and neighboring land areas. FL. Dept. Agric. Consumer Serv., Div. Plant Ind. 3: 1-345.

4. Hamon, A. B., and T.R. Fasulo. 2000. False oleander scale, *Pseudaulacaspis cockerelli* (Cooley) (Insecta: Hemiptera: Coccoidea: Diaspididae). EENY-149, one of a series of the Department of Entomology and Nematology, UF/IFAS Extension. 1-2.
5. Held, D. W. 2017. Controlling scale insects and mealybugs. ANR-2423, Alabama Cooperative Extension System. 1-8.
6. Leibee, G. L., and K. E. Savage. 1994. Insecticidal control of magnolia white scale (false oleander scale) (Homoptera: Diaspididae) on magnolia. Proc. Fla. State Hort. Soc. 107: 226-228.
7. Reinert, J. A. 1974. Management of the false oleander scale, *Pseudalacaspis cockerelli* (Cooley). Proc. Fla. State Hort. Soc. 87: 518-520.
8. Tippins, H. H. 1968. Observations on *Phenacaspis cockerelli (*Cooley) (Homoptera: Diaspididae), a pest of ornamental plants in Georgia. J. Georgia Entomol. Soc. 3: 13-15.

Table 1. The mean (± SE) percent of live female false oleander scale evaluated out of 25 scale on a minimum of 5 Aucuba before treatment and following two applications of 12 different foliar treatments.

Treatment	Rate (oz. prod. /100 gal)	Mean (±SE) percent of live female FOS per sample after the following number of applications					
		Before treatment[a]	Day(7)[a]	Day14)[a]	Day(28)[a]	Month(4)[a]	Month(6)[ah]
UTC	NA	74±5.0[m]d	34±5.5*bcd	45±5.4ab	49±9.2ab	57±9.7abc	49±8.6abc
AzaGuard	16	76±6.5[m]cd	34±7.2*bcd	43±5.0ab	49±10.6ab	47±10.4abc	51±4.6ab
AzaGuard	32	82±2.7[m]abcd	31±3.2*cde	44±11.6ab	31±10.3abc	58±8.0abc	49±8.9abc
IKI-3106 50SL + NIS at appropriate rate	22	78±4.1[m]bcd	26±5.6*cde	42±6.1ab	30±9.7abc	60±5.5ab	51±7.8ab
IKI-3106 50SL + NIS at appropriate rate	28	84±4.2[m]abcd	30±3.7cde	32±5.2b	22±9.9*bc	48±10.1abc	50±4.1ab
IKI-3326 SL	12	90±3.0[m]ab	37±5.9*bc	42±8.5ab	46±10.6ab	47±5.9abc	38±4.8abc
IKI-3326 SL	16.5	77±5.7[m]cd	56±8.9a	58±3.5a	57±8.7a	64±8.3a	55±8.2*a
Ventigra + UltraPure Oil	7	92±3.4[m]a	19±4.6de	23±4.1b	14±5.5*c	32±21.2bc	43±9.6c
Ventigra + UltraPure Oil	4.8	76±5.8cd	16±2.2*e	28±8.6b	27±10.8bc	57±9.8abc	61±6.7a
Altus	14 (or 10.5)	80±1.3[m]abcd	38±8.0bc	40±8.8ab	36±11.1*abc	56±9.6abc	42±7.2abc
Talus 70DF	14	79±7.6[m]abcd	32±3.6*bcde	41±5.9ab	48±7.6ab	35±11.0bc	59±8.4abc
Tri-Star 8.5SL	16.5	85±3.9[m]abcd	38±9.0*bc	40±9.2ab	42±12.2abc	50±6.8abc	57±4.8a
Distance	12	88±7.0[m]abc	49±5.3ab	35±9.4b	42±9.2abc	31±12.6*c	38±5.3bc
Statistics		F=1.56 P=0.137	F=3.05 P=0.003	F=1.26 P=0.270	F=1.55 P=0.138	F=1.13 P=0.362	F=1.06 P=0.414

m=maximum average number of scale recorded for that treatment
*=greatest reduction of populations relative to the before treatment sample
a Means in this column followed by the same letter were not significantly different at P = 0.05 (LSD)
b Means in this column followed by the same letter were not significantly different at P = 0.1 (LSD)
h Means in this column the homogenous group format cant' be used because of the pattern of significant differences

Table 2. The mean (± SE) number of leaves infested with live false oleander scale evaluated out of 10 leaves on a minimum of 5 Aucuba before treatment and following two applications of 12 different foliar treatments.

Treatment	Rate (oz. prod. /100 gal)	Mean (±SE) number of leaves infested with live FOS per sample after the following number of applications					
		Before treatment[a]	Day(7)[a]	Day(14)[a]	Day(28)[a]	Month(4)[a]	Month(6)[a]
UTC	NA	7.0±0.71a	5.4±0.24a	3.8±0.86*ab	6.0±0.55a	8.4±0.24abc	8.4±1.1[m]ab
AzaGuard	16	7.0±0.84a	5.0±0.55a	4.2±0.58ab	4.2±0.49*abcde	9.4±0.40a	9.6±0.40[m]a
AzaGuard	32	7.2±0.73a	5.6±0.51a	3.8±0.97ab	3.4±0.51*bcde	7.6±1.03abcd	8.6±0.93[m]ab
IKI-3106 50SL + NIS at appropriate rate	22	7.0±0.45a	4.4±0.68a	2.8±0.73b	2.6±0.93*cde	8.2±0.92abc	8.8±0.37[m]ab
IKI-3106 50SL + NIS at appropriate rate	28	7.0±0.55a	4.2±1.2a	4±0.63ab	3.6±0.75*bcde	9±0.63abc	9.0±0.45[m]ab
IKI-3326 SL	12	7.0±0.71a	4.6±0.87*a	4.8±0.86ab	4.8±0.73abc	9±0.32[m]abc	8±1.0ab
IKI-3326 SL	16.5	7.2±0.74a	5.2±1.02a	4.2±1.4*ab	5±1.05ab	9.2±0.49ab	9.4±0.24[m]ab
Ventigra + UltraPure Oil	7	6.8±0.66a	5.2±0.73a	4.0±1.1ab	2±0.71*e	6.0±2.1cde	9.3±0.67[m]ab
Ventigra + UltraPure Oil	4.8	7.2±0.58a	5±0.55a	2.6±0.68b	2.4±1.2*de	7.4±1.1abcd	8.6±0.40[m]ab
Altus	14 (or 10.5)	7.0±0.71a	5.6±0.93a	5.4±0.51a	4.6±0.40*abcd	6.6±0.81cd	9.6±0.24[m]a
Talus 70DF	14	7.2±0.86a	4.6±1.3a	5.4±0.68a	3.8±1.1*abcde	5.4±1.4de	7.8±0.85[m]b
Tri-Star 8.5SL	16.5	7.0±0.45a	5.6±0.75a	4±0.71ab	2.6±0.68*cde	6.8±0.37bcd	8.8±0.37[m]ab
Distance	12	6.6±0.68a	6±0.55a	4.3±0.85ab	3.6±0.68*bcde	3.6±1.2e	9.0±0.41[m]ab
Statistics		F=0.63 P=0.804	F=0.46 P=0.927	F= 1.01 P= 0.458	F=2.10 P=0.035	F=3.67 P=0.0007	F=0.80 P=0.650

m=maximum average number of scale recorded for that treatment
*=greatest reduction of populations relative to the before treatment sample
a Means in this column followed by the same letter were not significantly different at P = 0.05 (LSD)
b Means in this column followed by the same letter were not significantly different at P = 0.1 (LSD)

Table 3. The mean (± SE) number of live false oleander scale (all life stages) per leaf evaluated out of 10 leaves on a minimum of 5 Aucuba before treatment and following two applications of 12 different foliar treatments.

Treatment	Rate (oz. prod. /100 gal)	Mean (±SE) number of live FOS (all life stages) per leaf per sample after the following number of applications					
		Before treatment[a]	Day(7)[a]	Day(14)[a]	Day(28)[a]	Month(4)[a]	Month(6)[a]
UTC	NA	25.6±3.2*a	36.4±14.4abc	31.8±14.8ab	33.6±18.2ab	61±17.99ab	133.6±80.5[m]ab
AzaGuard	16	26±3.6*a	29.8±5.9abc	29.0±6.2ab	30.6±9.97ab	109.4±25.4ab	133.4±23.1[m]ab
AzaGuard	32	27.6±3.7a	27.2±5.5abc	19.8±8.7b	13.8±5.4*ab	61.6±24.7ab	92.2±15.9[m]ab
IKI-3106 50SL + NIS at appropriate rate	22	44.0±15.1a	11.8±3.5bc	8.8±2.96b	8.6±3.2*b	82±51.3ab	114.4±34.1[m]ab
IKI-3106 50SL + NIS at appropriate rate	28	42.2±8.5a	47.8±17.7a	39.2±17.4ab	26.0±12.4*ab	149.8±37.95[m]ab	103.8±19.6ab
IKI-3326 SL	12	36.8±14.7a	46.2±11.4ab	62.8±22.4a	27.8±10.4*ab	122.8±45.9[m]ab	120.6±45.0ab
IKI-3326 SL	16.5	30.4±4.8a	37.4±16.99abc	19.2±6.6*b	21±7.3ab	102.0±37.6ab	155.6±62.9[m]a
Ventigra + UltraPure Oil	7	26.8±4.7a	25.6±7.7abc	15±4.2b	5.6±3.5*b	177.0±161.0[m]a	117.7±27.4ab
Ventigra + UltraPure Oil	4.8	42.2±10.1a	9.8±2.4*c	12.4±4.4b	12.6±6.8ab	63.0±22.7ab	78.0±31.9[m]ab
Altus	14 (or 10.5)	33±14.2*a	36.8±15.7abc	44.4±23.3ab	45.2±29.4a	53.8±14.4ab	128.2±37.7[m]ab
Talus 70DF	14	31.4±8.2a	23±7.2abc	21.2±5.98b	17.0±6.7*ab	74.4±35.1[m]ab	40.0±16.2b
Tri-Star 8.5SL	16.5	35.4±07.5a	36.6±19.7abc	24±8.8ab	12.4±6.2*ab	33.6±12.8b	59.0±14.5[m]ab
Distance	12	33.8±4.5a	47.2±11.7a	56.3±24.4ab	27.4±4.97*ab	75.8±38.6ab	93.8±21.9[m]ab
Statistics		F=0.57 P=0.856	F=1.01 P=0.451	F=1.41 P=0.196	F=0.88 P=0.571	F=0.81 P=0.638	F=0.68 P=0.763

m=maximum average number of scale recorded for that treatment
*=greatest reduction of populations relative to the before treatment sample
a Means in this column followed by the same letter were not significantly different at P = 0.05 (LSD)
b Means in this column followed by the same letter were not significantly different at P = 0.1 (LSD)

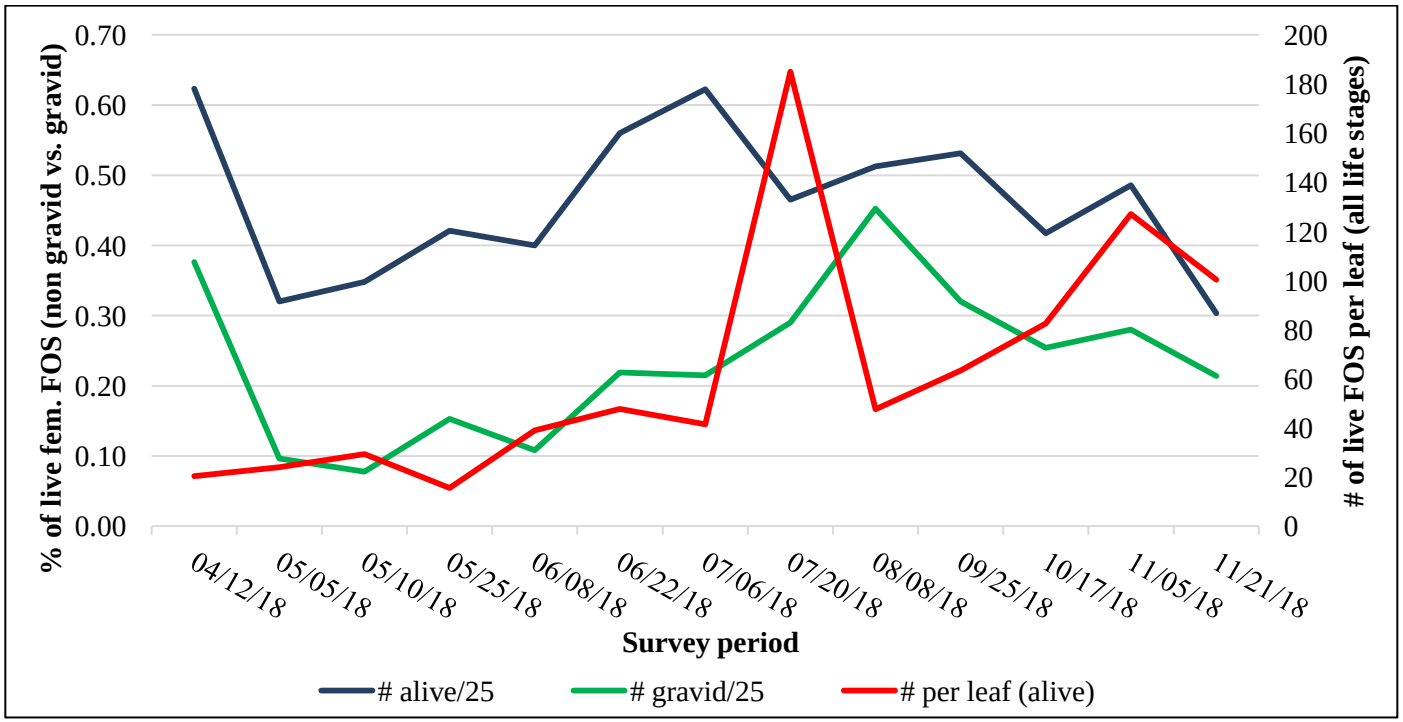

Figure 1. The mean number of live *FOS* (all life stages) per leaf evaluated out of 10 leaves on a minimum of 5 untreated Aucuba and the mean percent of live female *FOS* evaluated out of 25 on a minimum of 5 untreated Aucuba. Leaves were steadily infested throughout this time period.