Entomology

Charles P. (Chazz) Hesselein
Section Editor and Moderator

A Multiple Species Approach to Binomial Scouting of Greenhouse Ornamentals

Karol A. Burns, Kevin M. Heinz, and Bastiaan M. Drees
Texas A&M University, Dept. of Entomology,
College Station, TX 77845-2475

Index Words: Presence-Absence Sampling, Poinsettia, Chrysanthemum, Insect Population Density

Nature of Work: Monitoring for arthropod pests is the foundation of any integrated pest management (IPM) strategy. The crop damaging form of most arthropod pests of greenhouse ornamentals are the non-flying immature stages, thus making sampling of plant parts a necessary requisite to an effective IPM program. Counting minute arthropods on plant parts is difficult and tedious. As an alternative, sampling methods based on the presence or absence of a pest on a plant (binomial sampling) have been developed. Binomial sampling plans simply equate the proportion of infested plants or plant parts to absolute pest densities. The foundation for binomial sampling is based on an equation known as Taylor's Power Law (1),$s^2 = a\bar{\chi}^{b}$. Taylor's coefficients (*a* and *b*) are generally believed to be arthropod species and host plant specific (2,3,4,5). Coefficients are obtained from the regression of the logarithm of the variance (*a*) within a sample against the logarithm of the mean (*b*) of the sample, and are used to calculate the precision of density estimates obtained from given sample sizes.

Production greenhouses and nurseries commonly contain a multitude of plant species and cultivars, each infested with its own pest complex. Development of individual sampling plans for individual pests on individual crops are impractical and too costly to implement. What is desperately needed is a simple, affordable, method for monitoring the entire pest complex across an array of host plants. To accomplish this task, we set out to determine whether a common set of Taylor's coefficients could be applied to the complex of arthropod pests commonly found on two important potted crops, chrysanthemum and poinsettia.

A comprehensive search for Taylor's coefficients found in published literature provided data for linear regressions which indicated that the distribution of greenhouse pests in ornamental crops is described by common Taylor's coefficients. Field trials were conducted in 1998 to generate an independent set of Taylor's coefficients for comparison with the coefficients derived from the literature. In the field trials, weekly samples at 4 commercial nurseries producing either potted chrysanthemum (*Chrysanthemum morifolium Ramat*) or poinsettia (*Euphorbia pulcherrima* Willd.) and located in geographically different areas of Texas consisted of quantitative arthropod samples from 100 whole-plant inspections of three minutes duration. Sample plants were chosen using a stratified random method in which one greenhouse bay (approximately 30' x 96') of a gutter-connected range was divided into quadrats with 25 plants per quadrat selected for sampling. Scouted insects included: aphid adults and nymphs (*Myzus persicae, Aphis gossypii*); two-spotted spider mites adults and nymphs (*Tetranychus urticae*); mines containing live larvae of serpentine leafminers (*Liriomyza trifolii, L. huidobrensis*); and whitefly nymphs and pupae (*Trialeurodes vaporariorum, Bemisia tabaci*).

Results and Discussion: A search of the published literature yielded Taylor's Power Law coefficients for the greenhouse-grown potted crops listed in Table 1. Analysis of variance for Taylor's coefficients obtained from literature data showed no significant differences from the coefficients generated from field trials ($F = 0.89$; $df = 1, 3$; $P = 0.36$). Regression lines for field data for each pest species at each greenhouse crop/ location were plotted on the same *x*- and *y-axis* to illustrate their high degree of similarity (Figure 1). Mean separations indicated that Taylor's coefficients are common for some pest species but not for all. Thus, simplified binomial sampling plans utilizing a reduced number of infestation-density relationships is possible. Two important components of a binomial sampling regime are the sample size required for maintaining statistical validity, and the optimal inspection period per sample, i.e. how long must the sample be inspected before an absence of insect pests is accurately determined? These are issues currently being addressed in our research and results will be available in future papers.

Significance to Industry: This analysis examines the statistical properties of binomial sampling for multiple crops and insect species using common Taylor's coefficients as a foundation for evaluating the precision of pest density estimates. Future examinations will focus on the economic feasibility and statistical validity of binomial sampling for a range of fixed sample sizes. Results will then be compared to sequential (optimal size) sampling methods that are based on individual grower's economic (aesthetic) threshold levels. A determination will be made whether greenhouse scouting is statistically accurate under these constraints, or if, without relaxing the low or "zero" pest infestation and damage tolerance required by many growers, the statistical validity of scouting at low pest population densities is even possible.

Literature Cited:

1. Taylor, L. R. 1961. Aggregation, variance and the mean. Nature 189: 732-735.

2. Raworth, D. A. 1986. Sampling statistics and a sampling scheme for the twospotted spider mite, Tetranychus urticae (Acari: Tetranychidae), on strawberries. Can. Entomol. 118: 807-814.

3. Shipp, J. L., & N. Zariffa. 1991. Spatial patterns of and sampling methods for western flower thrips (Thysanoptera: Thripidae) on greenhouse sweet pepper. Can. Entomol. 123: 989-1000.

4. So, P-M. 1991. Distribution patterns of and sampling plans for Tetranychus urticae Koch (Acarina: Tetranychidae) on roses. Res. Popul. Ecol. 33: 229-243.

5. Jones, V. P. 1990. Developing sampling plans for spider mites (Acari: Tetranychidae): those who don't remember the past may have to repeat it. J. Econ. Entomol. 83: 1656-1664.

6. Liu, T. X., R. D. Oetting, & G. D. Buntin. 1993. Distribution of Trialeurodes vaporariorum and Bemisia tabaci (Homoptera: Aleyrodidae) on some greenhouse-grown ornamental plants. J. Entomol. Sci. 28(1): 102-112.

7. Rumei, X., C. Chuo & J. C. van Lenteren. 1993. The parasite-host relationship between Encarsia formosa Gahan (Hym., Aphelinidae) and Trialeurodes vaporariorum (Westwood) (Hom., Aleyrodidae). J. Appl. Entomol. 116(2): 199-211.

8. Guldemond, J. A. 1993. Preliminary results on density and incidence counts of aphids in cut chrysanthemums in the greenhouse. Bulletin-OILB-SROP. 16(8): 92-97.

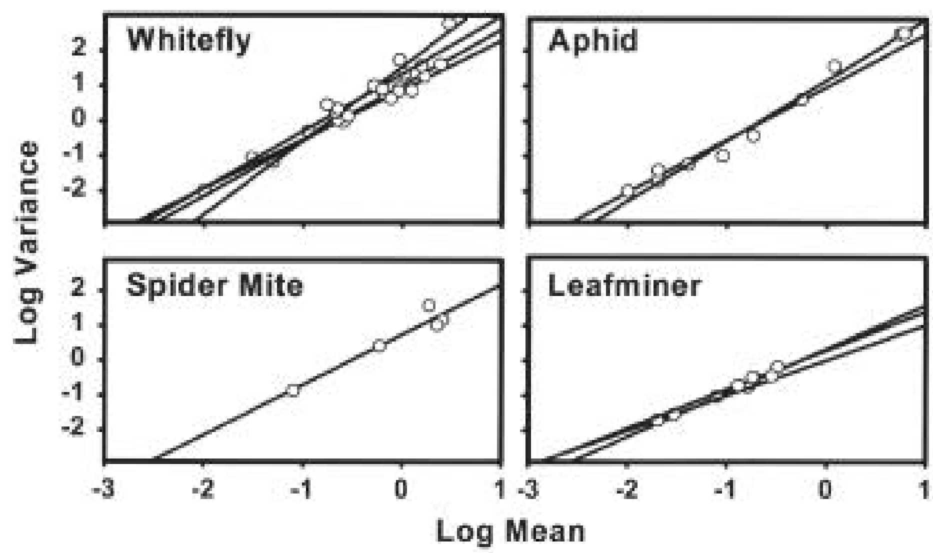
9. Jones, V. P. & M. P. Parrella. 1986. Development of sampling strategies for larvae of Liriomyza trifolii (Diptera: Agromyzidae) in chrysanthemums. Environ. Entomol. 15: 258-273.

Table 1. Taylor's Power Law Coefficients Obtained from Published Literature

Authors	Species	Envir.	Crop	α	β	r^2	*n*	Stage(s)
Spider mites:								
Jones (unpublished)[b]	T. urticae	n/a	Carnation	2.71	1.54	0.91	21	active
Jones (unpublished)[b]	T. urticae	n/a	Tuberose	2.79	1.50	0.75	19	active
Jones (unpublished)[b]	T. urticae	n/a	Rose	2.59	1.56	0.97	21	active
So (4)	T. urticae	GH	Rose	1.22	1.63	0.98	115	active
Whiteflies:								
Liu et al. (6)	B. tabaci	GH	Poinsettia	0.83	2.03	0.91	10	nymph
Liu et al. (6)	B. tabaci	GH	Poinsettia	0.58	2.15	0.92	n/a	nymph
Liu et al. (6)	B. tabaci	GH	Poinsettia	0.62	1.79	0.89	n/a	nymph
Rumei et al. (7)[c]	T. vaporariorum	GH	Tomato	0.31	1.76	0.97	n/a	adults
Aphids:								
Guldemond (8)	M. persicae	GH	Chrysanthemum	0.77	1.13	0.88	various	n/a
Guldemond (8)	A. gossypii	GH	Chrysanthemum	1.08	1.43	0.98	various	n/a
Leafminers:								
Jones & Parrella (9)	L. trifolii	GH	Chrysanthemum	0.75	1.19	0.92	149	larvae
Jones & Parrella (9)	L. trifolii	GH	Chrysanthemum	0.78	1.15	0.93	n/a	empty mines

n/a = not reported by author
b = reported in Jones (5)
c = from Noldus et al. (1986)

Figure 1. Commonality of Taylor's Power Law Coefficients for the Key-Pest Complex Infesting Chrysanthemum (Aphids, Spider mites, Leafminers) and Poinsettia (Whiteflies) From 1998 Field Trials at 4 Geographic Locations.



Circles represent n = 100 whole-plant inspections on one sample date.
Lines represent the regression of a single production crop at one grower location.
Although there were 4 cooperating growers, not every crop was infested with every insect species and thus, not every graph has 4 lines.

Efficacy of Media Drenches Against Western Flower Thrips

Scott W. Ludwig and Ronald D. Oetting
Department of Entomolgy, University of Georgia, Griffin, GA 30223

Index Words: Western Flower Thrips, Insecticides, Ornamentals

Nature of Work: Western flower thrips, *Frankliniella occidentalis* (Pergande), is a worldwide pest of greenhouse ornamental production. The Georgia ornamental industry lost over $13 million to thrips damage and control costs in 1996 (1). Western flower thrips feed by puncturing flowers, stems, or leaves. This damage results in the foliage having a silvery to brown appearance, while flowers may become spotted, deformed, or fail to open. Adults are capable of vectoring tomato spotted wilt virus or impatiens necrotic spot virus if they feed on infected plants as an immature. Not all of the immature thrips instars feed on plant material. The first two instars feed on the plant, which makes them susceptible to foliar insecticide sprays. The last two instars are non-feeding and drop to the potting media. These non-feeding instars are difficult to control since they are not affected by conventional foliar insecticide sprays. Media drenches are one method of insecticide application which target thrips pupae. The objective of this experiment was to evaluate insect growth regulators (insecticides which target immature stages), when used as media drenches, to reduce adult thrips emergence from the media.

Three rooted cuttings of chrysanthemum ‘Charm’ were planted in each 6 inch pots containing Pro-Gro Professional Growing Media® 300. Plants were watered daily with 200 ppm N using 20-10-20 Peter’s Peat-lite Special®. The test was conducted in a randomized complete block design with five replicates and three pots per experimental unit. Plants were exposed to thrips early during their vegetative growth to ensure large populations at flowering. Treatments began at bud break. A 3 fl oz drench was applied to each pot at the initiation of the experiment and again on day six. The treatments investigated were:

Trade Name	Common Name	Company	Application Rate
Precision®	fenoxycarb	Novartis Crop Protection, Inc.	0.04 oz/gal
Adept®	diflubenzuron	Uniroya	0.01 oz/gal
Distance®	pyriproxyfen	Valent	11.5 fl oz /gal
Enstar® II	kinoprene	Sandoz Agro	0.07 fl oz /gal
Azatin® XL	azadiractin	Olympic Horticutural Products	0.16 fl oz/gal
Control			

After the first application, one 7 oz plastic cup was inverted onto the media in one pot from each experimental unit. The cups had a Tanglefoot® (sticky substance to capture insects) coated inside bottom and black sides. Every six days the cups were removed and a new cup placed onto a subsequent pot within the experimental unit. The number of adult thrips collected were recorded to determine emergence rates. To determine differences in emergence rates between treatments, data were analyzed using the GLM procedure and means were separated with a LSD test ($P \leq 0.05$).

Results and Discussion: Overall, insect growth regulator media drenches resulted in lower thrips emergence from the potting media than the control (fig. 1). Precision®, Adept®, and Distance® provided the greatest reduction in thrips emergence. Enstar® II was effective days 6-12, 18-24, and 30-36 (fig. 1a) in the first trial and days 6-24 in the second trial (fig. 1b). Azatin® provided little control in the first trial, while in the second trial significantly lower emergence rates occurred during five of the six sampling periods.

Significance to Industry: This experiment indicates that media treatments for thrips management can become a vital component in greenhouse pest management programs. Media applications, with insect growth regulators such as with Precision,® Adept,® or Distance,® made simultaneously with foliar sprays or natural enemy releases would result in all non-egg instars being exposed to a control. The results from this experiment warrant further research into the use of media drenches as a component in integrated pest management programs for thrips control.

Literature Cited:

1. Hudson, W. G., S. K. Braman, R. D. Oetting, and B. L Sparks. 1997. Ornamental, Lawn and Turf Insects. pp. 21-23. In Summary of losses from insect damage and costs of control in Georgia in Georgia 1996. Eds. Riley, D.G., G. K. Douce, and R. M. McPherson. University of Georgia Special Publications #91.

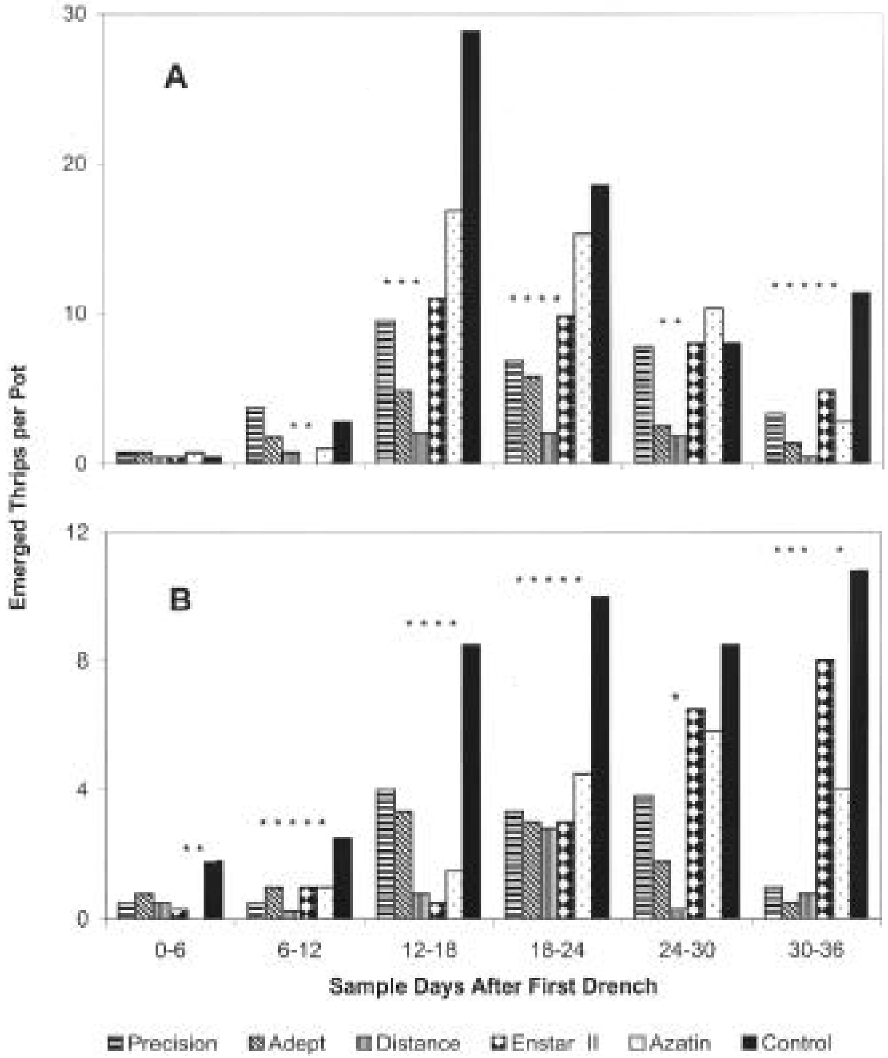


Figure 1. Mean number of emerged western flower thrips per pot in the first (A) and second (B) trials. Within each sampling period means followed by * are significantly different than the control, LSD, P<0.05.

FeedingResponse of Azalea Lace Bug to Epicuticular Waxes from Leaves of Piedmont Azalea and Florida Flame Azalea

Mary B. Clark, Joyce G. Latimer, S. Kristine Braman, and Carol D. Robacker
Department of Horticulture, Georgia Staion, Griffin, GA 30223

Index Word: Azalea Lace Bug, Piedmont Azalea, Florida Flame Azalea, Resistance, Susceptibility

Nature of Work: The azalea lace bug [*Stephanitis pyrioides* (Scott)], a native of Asia, has become a serious pest of azaleas in the United States (2). Adults and nymphs feed on the underside of the leaves, piercing the leaf and feeding on the sap, causing chlorotic blotching on the upper surface (2). Resistance of deciduous azaleas to the azalea lace bug is extremely variable (1). The Piedmont azalea [*Rhododendron canescens* (Michx.) Sweet] is considered the most resistant species, while the Florida flame azalea (*Rododendron austrinum* Rehyd.) is considered more susceptible (1). Research has provided evidence that components of the plant cuticle may play an important role in mediating the degree of resistance of azaleas (5). A preliminary study was conducted to assess the role of epicuticular (surface) wax from the Piedmont or Florida flame azalea in plant resistance or susceptibility to the azalea lace bug.

Six plants of each species were grown in one-gallon (3.785L) pots in a shaded greenhouse and fertilized weekly with 200 ppm nitrogen of Peter's 20-10-20 (Scott's, Marysville, OH). Three mature leaves from each plant were selected and allowed to dry at room temperature in glass beakers. The dried samples from each species were then immersed in 30 ml of chloroform for 45 to 60 seconds to extract the epicuticular waxes. The chloroform extracts were taken to dryness, and the samples were dissolved in a solution of ethanol : water (2:1 v:v). Another three mature leaves per plant of each species were then selected, and two 0.6" (1.5 cm) diameter circles were drawn on the upper side of each leaf evenly across the midvein. The circles constituted treatment arenas, and were visible on the lower side when backlit following the procedures of Tallamy et al., 1997 (4). On the lower surface of the Florida flame azalea leaves, two drops of the solution containing wax from Piedmont azalea were placed on either side of the midvein in one arena, while two drops of the solvent alone were placed in the second arena. The same procedure was used on the leaves of the Piedmont azalea, applying waxes from Florida flame azalea and solvent alone in the same manner.

Each petiole was wrapped in a sterile cotton ball moistened with deionized water, and each leaf was placed in a separate vial with three adult female azalea lace bugs, and the vials were stopped with plastic corks. The lace bugs were allowed to feed for 48 hours, and lace bug survival and frass (excrement) deposits were counted three times over the 48 hour period (about every 16 hours). Differences between azalea lace bug frass spots in the extract and solvent arenas on each leaf were determined by a general linear model in SAS (3).

Results and Discussion: On the suspectible Florida flame azalea leaves treated with wax from the resistant Piedmont azalea, the differences between the means of frass counts in the wax and solvent arenas were not significantly different (Table 1). However, the means for the frass counts in the arenas containing Piedmont azalea wax were consistently lower than the means for arenas containing solvent alone. On the leaves of Piedmont azalea treated with wax from Florida flame azalea, the first and third frass counts had statistically significant differences, while the second count did not. On each count, the means in the arenas containing Florida flame azalea wax were consistently higher than the arenas containing solvent alone. These findings suggest that the azalea lace bugs fed more in the arenas containing the wax of the susceptible Florida flame azalea regardless of which leaf was used to present the wax. This indicates a possible stimulatory effect of Florida flame azalea wax, and a deterrent effect of Piedmont azalea wax on azalea lace bug feeding.

Significance to Industry: Once epicuticular wax compounds contributing to azalea lace bug susceptibility and/ or resistance in deciduous azaleas are identified, breeding of insect resistant plants may become possible. This could reduce the use of pesticides, thereby lowering nursery and landscape costs as well as the potential for soil and water pollution.

Literature Cited:

1. Braman, S. K. and A. F. Pendley. 1992. Evidence for resistance of deciduous azaleas to azalea lace. J. Environ. Hort. 10(1):40-43

2. Buntin, G. D., S. K. Braman, D. A. Gilbertz and D.V. Philips. 1996. Chlorosis, photosynthesis and transpiration of azalea leaves after azalea lace bug (Heteroptera: Tingidae) feeding injury. J. Econ. Entomol. 89:990-995.

3. SAS Institute. 1990. SAS User’s Guide: Statistics (6^{th} edition). SAS

4. Tallamy, D. W., J. Stull, M. P. Dhresman, P. M. Goski, and C. E. Mason. 1997. Cucurbitacins as feeding and oviposition deterrents to insects. Environ. Entomol. 26(3):678-683.

5. Wang, Y., S. K. Braman, C. D. Robacker, J. G. Latimer, and K.E. Espelie. 1999. Composition and variability of epicuticular lipids of azaleas and their relationship to azalea lace bug resistance. J. Amer. Soc. Hort. Sci. 124(3):239-244.

Table 1. Means of frass spots counted in solvent and wax arenas on Florida flame azalea and Piedmont azalea, and the respective *P*-values associated with the differences.

		--Frass Means--		
Species	Observation	Solvent	Extract[z]	*P*-value[y]
Florida flame	Time 1	3.11 a	1.89 a	0.14
	Time 2	4.17 a	2.72 a	0.17
	Time 3	4.94 a	3.50 a	0.13
Piedmont	Time 1	0.22 b	1.11 a	0.02
	Time 2	0.72 a	1.61 a	0.06
	Time 3	0.89 b	2.00 a	0.01

[z] Extract treatment arenas contained the surface extracts of the reciprocal azalea species to the one being tested.

[y] *P*-values of analysis of variance between the solvent and wax treatment arenas at each observation time using SAS software (2). Means within a row followed by the same letter are not significantly different, $P < 0.05$.

Functional Response of the Azalea Plant *Bug, Rhinocapsus vanduzeei,* a Predator of the Azalea Lace Bug, *Stephanitis pynoides*

Colin D. Stewart, S. Kristine Braman, and Andrew F. Pendley
University of Georgia Dept. of Entomology, Griffin, GA 30223-1797

Index Words: *Rhododendron canescens, Rhododendron austrinum,* Azalea Lace Bug, *Stephanitis pyrioides, Rhinocapsus vanduzeei,* Azalea Plant Bug, Predation

Nature of Work: The azalea plant bug (APB), *Rhinocapsus vanduzeei,* has one generation per year with egg hatch in synchrony with azalea bloom. It is a generalist predator that has been observed feeding on the azalea lace bug *(Stephanitis pyrioides),* whitefly, leafhoppers, aphids, small flies, a number of species of thrips (1) fall armyworm eggs and larvae, twospotted spider mites, azalea leafminer pupae, and each other (Stewart, unpublished data). The APB also feeds on azalea pollen (4) which allows it to survive when prey is scarce. This predator has been observed on Flame, Piedmont, Alabama, wild swamp, and Korean azaleas *(R. austrinum, R. calendulaceum, R. alabamense, R. viscosum, R. yedoense* var. poukhenense, respectively) as well as the Ghent hybrids of the name azalea. Its recorded range is from Ontario and Maine to Florida and as far west as Missouri (4). The functional response, first discussed by Solomon (3), describes the relationship between prey density and the number of prey consumed. Holling (2) described three possible responses in which the number of prey consumed rises linearly, in a curve, or sigmoidally, for a Type I, Type II, and Type lil response, respectively. The Type II response is characteristic of most arthropod predators. At lower prey concentrations, most of the time is spent searching for prey, while at the highest prey densities most of the predator's time is spent "handling" (i.e. subduing and eating) the prey. The goal of this study was to determine the functional response of the APB when challenged with a range of fourth and fifth instar azalea lace bug densities.

Immature azalea plant bugs were collected from native azaleas *(Rhododendron canescens, R. austrinum)* at Callaway Gardens (Pine Mountain, GA) on April 9, 13, and 20, 1999 by beating the foliage over a 15.7" x 9.4" enamel pan. APB's were placed in individual 1.4" x 0.39" petri plates containing one fall armyworm *(Spodoptera frugiperda)* egg mass, a leaf, and piece of damp paper towel. The dishes were placed in a 70°F Percival growth chamber set to a 14:10 light: dark cycle. The insects were checked every 24 hours to determine if they had molted. Food (fall armyworm eggs, aphids, thrips, or fourth and fifth instar azalea lace bugs) was added as needed. Newly molted fourth or fifth instar APBs (as determined by the length of the wing pads) were starved for 24 hours by placing them in individual 1.4" x 0.39" petri dishes containing a moist paper towel.

The test area consisted of a terminal Hinodegiri azalea *(Rhododendron obtusum* 'Hinodegiri') branch with four to seven leaves. New growth was removed. The cut terminal was inserted through a 3/8" diam x 0.39" long section of tygon tubing and then sealed using parafilm. It was inserted through a 3/8" hole in the plastic bottom of the cage so that the stem was in contact with the 60 ml of water contained in a 120 ml plastic cup. One, 3, 5, 10, 15, 2O, 25 and 30 fifth instar azalea lace bug nymphs were placed on the top of the foliage. A fifth instar APB was placed on the bottom portion of the stem and observed to move upward. A 2" diem by 4.33" long plastic tube, open on one end with a mesh screen on the other end, was placed over the stem and sealed to the cage bottom. Controls were run without the predator present. After 24 hours the predator was removed from the cage and the number of live prey was determined. The experiment was duplicated using fourth instar azalea lace bug nymphs.

Results and Discussion: In both sets of trials, one of the ninety azalea lace bugs died in the absence of the predator for a control mortality of 1. 1%. Despite the fact that it is similar in size to its prey, the APB is capable of consuming between 5.5 and 7.25 fourth instars, and between 4.35 and 5.00 fifth instar azalea lace bugs in a 24 hour period at high prey concentrations (Tables 1 and 2). A curve fit through each of the data sets indicate that the fifth instar azalea plant bug shows a Type II functional response (Figs. 1, 2) which is common among arthropod predators.

Significance to Industry: The results indicate that the azalea plant bug is a valuable predator of the azalea lace bug and should be conserved whenever possible. The number of azalea plant bugs should be factored into decision-making guidelines when considering treatment for the azalea lace bug. When these predators, which are often mistaken for pests are present, a higher treatment threshold may be indicated.

Literature Cited:

1. Braman, S. K., and R. J. Beshear. 1994. Seasonality of plant bugs (Heteroptera: Miridae) and phytophagous thrips (Thysanoptera: Thripidae) as influenced by host plant phenology of native azaleas (Ericales: Ericaceae). Environ. Entomol. 23(3): 712-718.

2. Holling, C. S. 1959. Some characteristics of simple types of predation and parasitism. Can. Entomol. **91**: 385-398.

3. Solomon, M. E. 1949. The natural control of animal populations. J. Anim. Ecol. **18**: 1-35.

4. Wheeler,A.G.,Jr.andJ.L.Herring. 1979. Apotentialinsect pest of azaleas. Am. Rhodo. Soc. Quart. Bull. **33**: 12-14.

Table 1: APB vs Fourth Instar Azalea Lace Bugs

Initial Prey Per Cage	Mean Number Dead Prey	N
1	0.53 ± 0.034	15
3	1.60 ± 0.061	15
5	3.13 ± 0.087	15
10	4.40 ± 0.174	15
15	7.25 ± 0.214	16
20	5.50 ± 0.321	10
30	6.00 ± 0.330	3

Table 2: APB vs Fifth Instar Azalea Lace Bugs

Initial Prey Per Cage	Mean Number Dead Prey	N
1	0.33 ± 0.033	15
3	0.93 ± 0.061	15
5	1.40 ± 0.081	15
10	2.13 ± 0.142	15
15	3.73 ± 0.175	15
20	3.53 ± 0.118	15
25	5.00 ± 0.184	16
30	4.35 ± 0.092	23

Figure 1: Relationship Between Fourth Instar Azalea Lace Bug Density and the Number Consumed

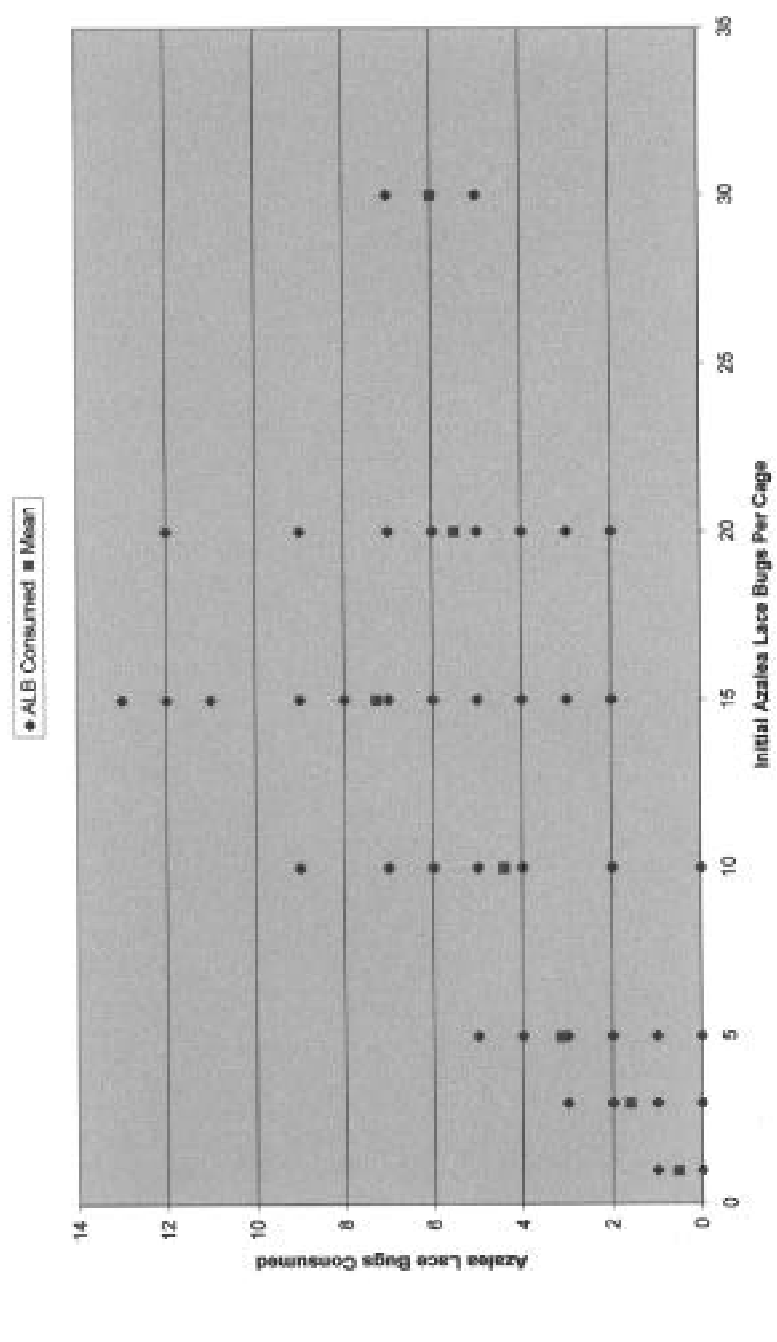
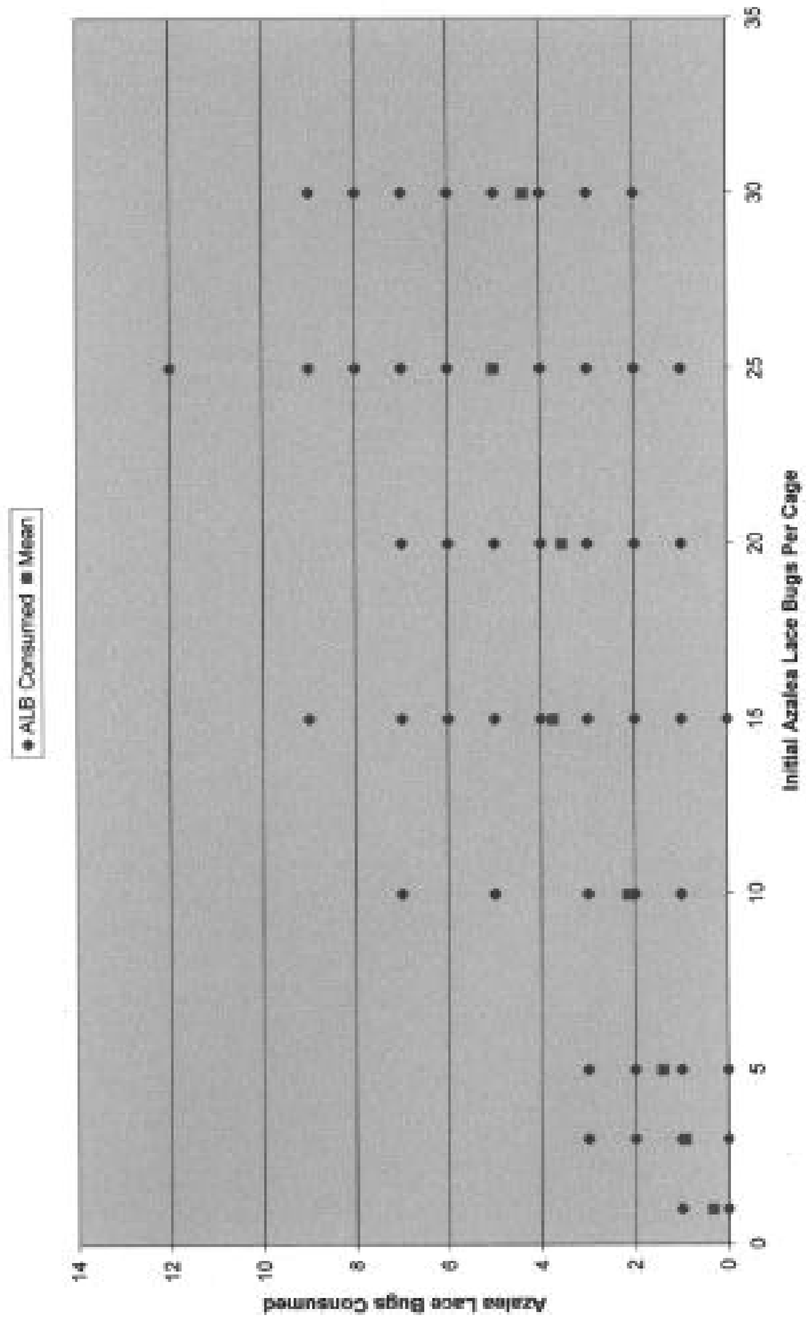


Figure 2: Relationship Between Fifth Instar Azalea Lace Bug Density and the Number Consumed



Chemical Control of Differential Grasshoppers, (Melanoplus differentialis) on Urban Landscape Plants

James A. Reinert, Steven J. Maranz, Wayne Mackay, Steve George, James Read and M. C. Engelke
Texas A&M University Research & Extension Center
17360 Coit Road, Dallas, TX 75252-6599
972-231-5362 j-reinert@tamu.edu

Index Words: Grasshopper Control, Urban Landscape

Nature of Work: Several species of grasshoppers can invade the urban landscape and retail/wholesale nurseries during hot dry summers to consume the foliage of many landscape plants and turfgrass. Based upon limited surveys during the summer and fall of 1998 and summer of 1999, the differential grasshopper, *Melanoplus differentialis* (Thomas), is the most frequently encountered species in damaging numbers. One grasshopper feeding on a small plant can defoliate it and several adults can devastate a landscape in a short time. The extremely hot and dry summer of 1998 created ideal conditions for extensive outbreaks across many southern states. Populations the following year (1999) were also extremely high and devastating. As pastures and field crops were either harvested or desiccated from drought, the grasshoppers readily migrated into plant nurseries and the urban landscape in search of food. As a result, extensive damage was common on many of the landscape plants and grasshopper control strategies for the urban landscape were needed. The purpose of these experiments was to determine which insecticides could be used to control grasshoppers on landscape plants, and to determine if any of the treatments would provide residual control.

Two experiments were conducted to evaluate insecticides for differential grasshopper control. Chemicals and rates evaluated are given in Tables 1 and 2. For each experiment, plants of ‘Disco Rose Red’ hibiscus, *Hibiscus moscheutos*, 12-16 in. high and growing in 6 in. pots were sprayed till runoff with the respective chemicals. Two plants were treated with each insecticide in each experimental unit to insure adequate treated foliage would be available for several residue tests. Plants were maintained in full sun to allow maximum photo-degradation. For each treatment, leaves were clipped at either 1-, 5- or 11-days after treatment and taken to the laboratory. Two to three treated leaves were caged with one adult grasshopper in each 3.54 in. (9 cm) diam. x 0.79 in. (2 cm) deep plastic growth chamber and observed every 24 hr for up to five days. Each feeding chamber was first provided with two water saturated 2.95 in. (7.5 cm) filter paper discs, to maintain leaf turgidity. For both experiments, five reps. each with four adults on each residue test date were evaluated. Mortality ratings were made at 24-, 48- and 72-hr after grasshoppers were caged with the respective plant material. For these studies, field populations of adult differential grasshoppers were collected on stands of Johnsongrass, *Sorghum halepense*, growing in the railroad- or highway-rights-of-way. Adults were individually collected with a sweep net and stored in cooled ice chests for transport to the laboratory. Healthy grasshoppers were used the next day to establish these tests. Replicates were blocked by grasshopper sex.

Data were adjusted to the untreated check by Abbott's formula (1) and subjected to analysis by a General Linear Model Procedure; treatment means were separated by Waller-Duncan k-ratio (k=100) t test (P = 0.05) (4). Data were transformed by arcsine of the percent mortality data; untransformed means are presented.

Results and Discussion: Treatments with two synthetic pyrethroids: Talstar (bifenthrin) and Scimitar (lambda-cyhalothrin) each provided greater than 83% control within 24 hr and 100% control of the grasshoppers within 72 hr exposure to the hibiscus leaves that had been treated a day earlier (Table 2). Treatments with Diazinon or Diazinon + Avid (abamectin) also provided 78-83% control within 72 hr following exposure to the 1-day-old treated leaves (Table 1). Orthene TTO (acephate) provided limited initial control (33-39%) (Tables 1-2). The other treatments did not provide control.

To determine residual control, leaves that had been treated 5 and 11 days earlier were also harvested and grasshoppers were caged with them. Scimitar provided 84% control within 72 hr on 5-day-old treated leaves (Table 2). Both Talstar and Orthene TTO (53 and 46-50%, respectively) also provided residual control (Table 1-2). None of the treatments provided any residual control when grasshoppers were exposed to 11-day-old treated leaves (Table 2). No phytotoxicity to hibiscus was observed due to any of the treatments.

A higher level of control may be achieved with these treatments if they are applied directly to the feeding grasshoppers or if the grasshoppers are immediately exposed to the treated foliage. Additionally, a higher level of control would be expected if the treatments were applied to the immature stages of the insect. The primary purpose of these experiments, however, was to evaluate the effect of these toxicants on grasshoppers migrating onto the treated plants. It is likely that only a limited percentage of the grasshopper population would actually be sprayed at the time of treatment. In experiments by other researchers, lambda-cyhalothrin and bifenthrin as well as several other synthetic pyrethroids: cypermethrin (Ammo); esfenvalerate (Asana) and permethrin (Ambush) provided excellent control of related grasshopper species in pastures (2,3).

Significance to Industry: Grasshoppers can severely defoliate nursery plants and are devastating to urban landscape plantings when they migrate from adjacent areas. These experiments show that Scimitar and Talstar (both synthetic pyrethroid insecticides) as well as Diazinon can each provide good control of grasshoppers, even if they migrate onto the treated foliage a day after treatments are applied. The level of control may be higher if the grasshoppers are directly contacted with the spray treatments. Scimitar, Talstar and Orthene also provided at least 5-day residual control for grasshoppers. Each of the materials exhibiting control in these studies is labeled for commercial and homeowner use.

Literature Cited:

1. Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol. 18: 265-267.

2. McLeod, P. 1998. Evaluation of insecticides for control of redlegged grasshopper in a pasture adjacent to mustard greens, 1997. Arthropod Management Tests. 23: 351.

3. McLeod, P. 1999. Evaluation of insecticides for control of redlegged grasshopper in a pasture adjacent to mustard greens, 1998. Arthropod Management Tests. 24: 377.

4. SAS Institute. 1987. SAS User's Guide: Statistics, Version 6 ed. SAS Institute, Cary, NC.

Table 1. Percentage control of differential grasshoppers (Melanoplus differentialis) with selected insecticides, applied on 10 September 1998 (5 reps).

Treatment [a]	Rate: oz of product per 100 gal	% Grasshopper Mortality: Exposed 1 DAT [b] 24hr	48hr	72hr	Exposed 5 DAT [b] 24hr	48hr	72hr
Diazinon + Avid	54.5 + 4.0	40 a [cd]	53 a	83 a	–	–	–
Diazinon AG600	54.4	20 b	58 a	78 a	0 b	0 b	0 b
Orthene TTO 75WP	10.67	5 bc	21 b	33 b	25 a	35 a	50 a
293,343 + E. Benzoate	2.1 + 3.0	0 c	0 c	22 bc	–	–	–
293,343 25WG	4.3	0 c	5 bc	17 bcd	–	–	–
Relay 50 WG	2.5	5 bc	5 bc	5 cd	–	–	–
Avid 0.15 EC	4.0	5 bc	5 bc	5 cd	–	–	–
E. Benzoate 5 SG	3.0	0 c	0 bc	0 cd	–	–	–
Relay + Avid	2.5 + 4.0	0 c	0 c	0 cd	–	–	–
Relay + E. Benzoate	2.5 + 3.0	0 c	0 c	0 d	–	–	–
293,343 + Avid	2.1 + 4.0	0 c	0 bc	0 cd	–	–	–
Untreated Check	0	0 c	0 bc	0 cd	0 b	0 b	10 b

[a] Silwet, an organosilicon wetting agent was added to all treatments at a rate of 13 oz/100 gal of water.

[b] Leaves were harvested from plants with the respective treatments at 1 and 5 days after treatment and caged with four individual grasshopper adults. Mortality of the grasshoppers was assayed at 24, 48 and 72 hr following exposure to the treated leaves.

[c] Analysis was made on arc sine transformation of the percent mortality data.

[d] Means in a column not followed by the same letter are significantly different by Waller-Duncan k-ratio t-test

(k = 100) (P = 0.05).

Table 2. Percentage control of differential grasshoppers (*Melanoplus differentialis*) with selected insecticides, applied on 24 September 1998 (5 reps).

Treatment [a]	Rate oz of product per 100 gal	% Grasshopper Mortality								
		Exposed 1 DAT [b]			Exposed 5 DAT [b]			Exposed 11 DAT [b]		
		24hr	48hr	72hr	24hr	48hr	72hr	24hr	48hr	72hr
Talstar 0.66F	10	94.4 a [cd]	94.4 ab	100 a	40.0 ab	45.5 b	52.6 b	0 [ns]	0 [ns]	0 [ns]
Scimitar 9.52WP	10	83.3 a	100 a	100 a	55.0 a	68.4 a	84.2 a	0	0	0
Talstar 0.66F	5	50.0 b	83.3 b	88.9 b	15.0 bc	15.0 c	26.3 cd	–	–	–
Orthene TTO 75%S	10.67	33.3 bc	38.9 c	38.9 c	40.0 ab	45.5 b	45.5 bc	0	0	0
DeltaGard 50SC	20	16.7 cd	16.7 cd	16.7 d	5.0 c	10.5 c	26.3 cd	–	–	–
DeltaGard 50SC	5	0 d	0 d	0 d	0 c	10.5 c	26.3 cd	–	–	–
Sevin 4SL	32	0 d	0 d	0 d	0 c	0 c	5.3 d	–	–	–
Merit 75WP	0.5	0 d	0 d	0 d	0 c	0 c	5.3 d	–	–	–
Untreated Check	0	0 d	0 d	0 d	0 c	0 c	0 d	–	–	–

[a] Silwet, an organosilicon wetting agent was added to all treatments at a rate of 13 oz/100 gal of water.

[b] Leaves were harvested from plants with the respective treatments at 1, 5, and 11 days after treatment and caged with individual grasshopper adults. Mortality of the grasshoppers was assayed at 24, 48 and 72 hr following exposure to the treated leaves.

[c] Analysis was made on arc sine transformation of the percent mortality data.

[d] Means in a column not followed by the same letter are significantly different by Waller-Duncan k-ratio t-test (k = 100) (P = 0.05).

Impact of Differential Grasshoppers, *Melanoplus differentialis*, on Urban Landscape Plants

James A. Reinert, Wayne Mackay,
Steve George, James Read, M. C. Engelke & S. J. Maranz
Texas A&M University Research & Extension Center
17360 Coit Road, Dallas, TX 75252-6599
972-231-5362 j-reinert@tamu.edu

Index Words: Grasshopper, urban Landscape

Nature of Work: The differential grasshopper, *Melanoplus differentialis* (Thomas), along with several other species of grasshoppers will invade the urban/suburban landscape and retail/wholesale nurseries during hot dry summers to consume the foliage of turfgrass and many landscape plants. Based upon limited surveys during the summer and fall of 1998 and early summer of 1999, the differential grasshopper is the most frequently encountered species in damaging numbers. A single grasshopper feeding on a small plant can defoliate it and a migration of adults can devastate an entire landscape in a short period. The extremely hot and dry summer of 1998 created ideal conditions for extensive outbreaks across many southern states. Populations the following year (1999) were also extremely high and quite devastating. As pastures and field crops were either harvested or desiccated from the drought, grasshoppers readily migrated into plant nurseries and the urban landscape in search of food. As a result, extensive damage was common on many landscape plant species and grasshopper control strategies for the urban landscape were needed.

Several studies have been conducted to determine the feeding preference of selected species of grasshoppers on various grasses and field crops (1, 3, 4, 5, 8) but only limited documentation is presented on their damage to landscape plants (2). The purpose of this experiment was to determine which landscape plants serve as preferred hosts for the differential grasshopper, and whether any of the commonly used landscape plants exhibit resistance to this pest.

A representative collection of landscape plants found either growing in the landscape or in the container nursery at the Texas A&M University Research & Extension Center at Dallas, TX, was selected for this study. Johnsongrass was also included as a standard host plant, since the grasshoppers were collected from it in the wild and it is a common feed source. Plants evaluated are listed in Table 1.

For each plant in each replicate, leaves or terminal shoots were clipped from the plant and taken to the laboratory. Adequate plant material (leaves or shoots) to support one adult grasshopper for at least three days was caged with each individual in 3.54 in. (9 cm) diam. x 0.79 in. (2 cm) deep plastic growth chambers. Chambers were observed daily for feeding activity and mortality. Each feeding chamber was provided with two water saturated filter paper discs, 2.76 in. (7 cm) in diameter, to maintain plant turgidity. The feeding study consisted of one grasshopper per feeding chamber, with three chambers per experimental unit and eight replications.

After 3 days of exposure, each grasshopper was moved to a new feeding chamber and several parameters of feeding or resistance were assayed: 1) the amount of feeding was ranked on a scale of 1-5, 1 = little or no feeding, and 5 = near complete consumption of the plant material; 2) fecal pellets were counted; 3) fecal pellets were oven dried and weighed; and 4) mortality was recorded. Grasshoppers were fed for a total of 14 days with fresh plant material supplied every 2-3 days. After 14 days of feeding, fecal pellet counts and dried weights were totaled.

For this study, field populations of adult differential grasshoppers were collected on stands of Johnsongrass growing in the railroad- or highway-rights-of-way. Adults were individually collected with a sweep net and stored in cooled ice chests for transport to the laboratory. Grasshoppers were held with no food and only water for 72 hr to allow them to eliminate any waste from plants on which they had been feeding. Healthy grass-hoppers were then used to establish this test. Replicates were blocked by sex.

Data were subjected to analysis by a General Linear Model Procedure and treatment means were separated by Waller-Duncan k-ratio (k=100) t test (P = 0.05) (7).

Results and Discussion: The feeding response by the differential grasshopper to the various plant species is presented in Fig. 1-5. Fig. 1 shows that in the first 3 days, the least visual feeding damage occurred on ‘Flare’ perennial hibiscus, ‘VIP’ petunia, Chinese trumpet vine, ‘John Fanick’ perennial phlox and ‘Gold Star’ esperanza. Conversely, the highest amount of feeding per adult grasshopper occurred on ‘Hullaba-loo’ blue plumbago, ‘Blue Princess’ perennial verbena, red canna, ‘Pumila’ dwarf pampas grass and Johnsongrass in descending amount of feeding. When the number and dry weight of fecal pellets (Fig. 2-3) per grasshopper for the 3 day feeding period were examined, ‘Marguerite’ ornamental sweet potato, bougainvillea and lantana could also be grouped among the plants fed-upon the least (nonpreferred). Based

upon these two parameters, canna and perennial verbena were the preferred hosts with the highest number of fecal pellets (perennial verbena) or the highest weight of fecal pellets (canna).
After 14 days of feeding, the same plants continued to exhibit the least feeding (resistance) based upon the number and dry weight of fecal pellets per grasshopper per day of feeding. Also, canna, perennial verbena, plumbago and pampas grass continued to be among the preferred hosts. However, 'Hardy Red' oleander emerged as the most preferred host with nearly eight fecal pellets (weighing 15 mg) produced per grasshopper per day. Grasshopper mortality was also very low on oleander. Conversely, grasshopper feeding on the resistant plants produced fewer than four pellets and less than 6 mg of pellet weight per day of feeding.

The strong feeding preference by the grasshoppers on oleander was unexpected. Oleander is extremely toxic to man and animals due to the presence of glucosides in both fresh and dry foliage (6). Due to this toxicity, Nerium also has few insect pests that includes two species of caterpillars, an aphid, and two species of scale insects.

Additional studies are planned to determine the feeding preference of grasshoppers on the landscape plants most commonly utilized in the South.

Significance to Industry: Grasshoppers can severely defoliate nursery plants and are devastating to urban landscape plantings when they migrate from adjacent areas. Knowing the feeding preference of this group of pests can help a nurseryman or landscape manager to determine which plants to monitor in his/her pest management program. Additionally, this information can serve as a guide for plant selection in areas with a higher potential for grasshopper outbreaks and invasion of the landscape.

Literature Cited:

1. Brunson, A. M and R. H. Painter. 1938. Differential feeding of grasshoppers on corn and sorghums. J. Am. Soc. Agron. 30: 334-346.

2. Feaver, M. N. 1985. Grasshopper (Orthoptera: Acididae) damage to pine seedlings at night in a seed orchard. Fla. Entomol. 68(4): 694-696.

3. Fielding, D. J. and M. A. Brusven. 1992. Food and habitat preference of *Melanoplus sanguinipes* and *Aulocara elliotti* (Orthoptera: Acrididae) on disturbed rangeland in southern Idaho. J. Econ. Entomol. 85(3): 783-788.

4. Harvey, T. L. and C. A. Thompson. 1993. Differences in leaf feeding on corn hybrids by the differential grasshopper, *Melanoplus differentialis* (Thomas). J. Agric. Entomol. 10(1): 31-34.

5. Hinks, C. F., O. Olfert, N. D. Westcott, E. M. Coxworth and W. Craig. 1990. Preference and performance in grasshopper, *Melanoplus sanguinipes* (Orthoptera: Acrididae), feeding on kochia, oats, and wheat: implication for population dynamics. J. Econ. Entomol. 83(4): 1338-1343.

6. Muenscher, W. C. 1948. Poisonous plants of the United States. Macmillian Co. New York.

7. SAS Institute. 1987. SAS User's Guide: Statistics, Version 6 ed. SAS Institute, Cary, NC.

8. Yang, Y. and A. Joern. 1994. Compensatory feeding in response to variable food quality by *Melanoplus differentialis*. Physiol. Entomol. 19(1): 75-82.

Table 1. Landscape plants evaluated in feeding study for host resistance to the differential grasshopper, August 1998.

Plants/Cultivar	Species
Bougainvillea	*Bougainvillea*
Chinese Trumpet Vine	*Campsis grandiflora*
Red Canna	*Canna x generalis*
'Pumila' Dwarf Pampas Grass	*Cortaderia selloana*
'Flare' Perennial Hibiscus	*Hibiscus hybrid*
'Marguerite' Ornamental Sweet Potato	*Ipomoea batatas*
Crape Myrtle	*Lagerstroemia indica*
Lantana	*Lantana horrida*
'Hardy Red' Oleander	*Nerium oleander*
'VIP' Petunia	*Petunia violacea*
'John Fanick' Choice Perennial Phlox	*Phlox paniculata*
'Hullabaloo' Blue Plumbago	*Plumbago auriculata*
'Pinkie' Rose	*Rosa sp.*
'Gold Star' Esperanza	*Tecoma stans*
'Blue Princess' Perennial Verbena	*Verbena x hybrida*

Fig. 1. Feeding by Differential Grasshopper on Selected Landscape Plants (First 3 Days)

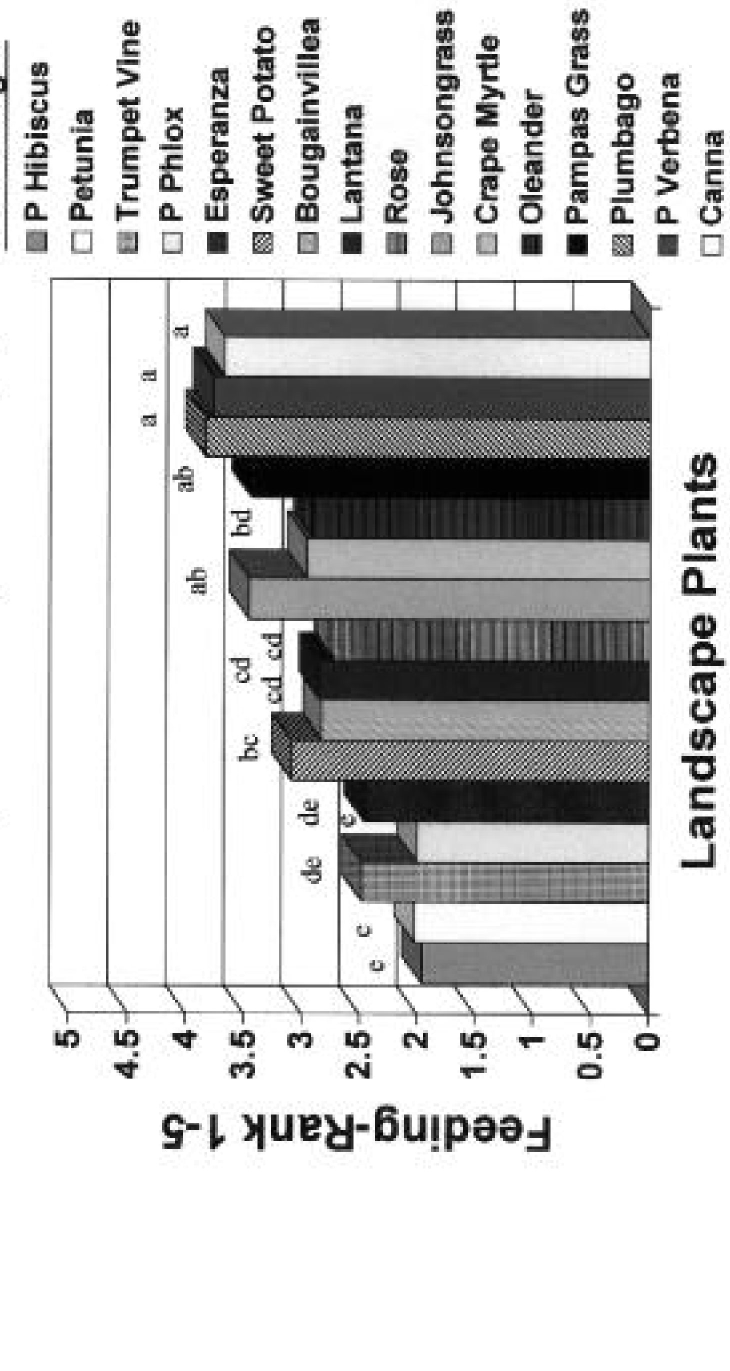


Fig. 2. Feeding by Differential Grasshopper on Selected Landscape Plants (Fecal Pellets/First 3 Days)

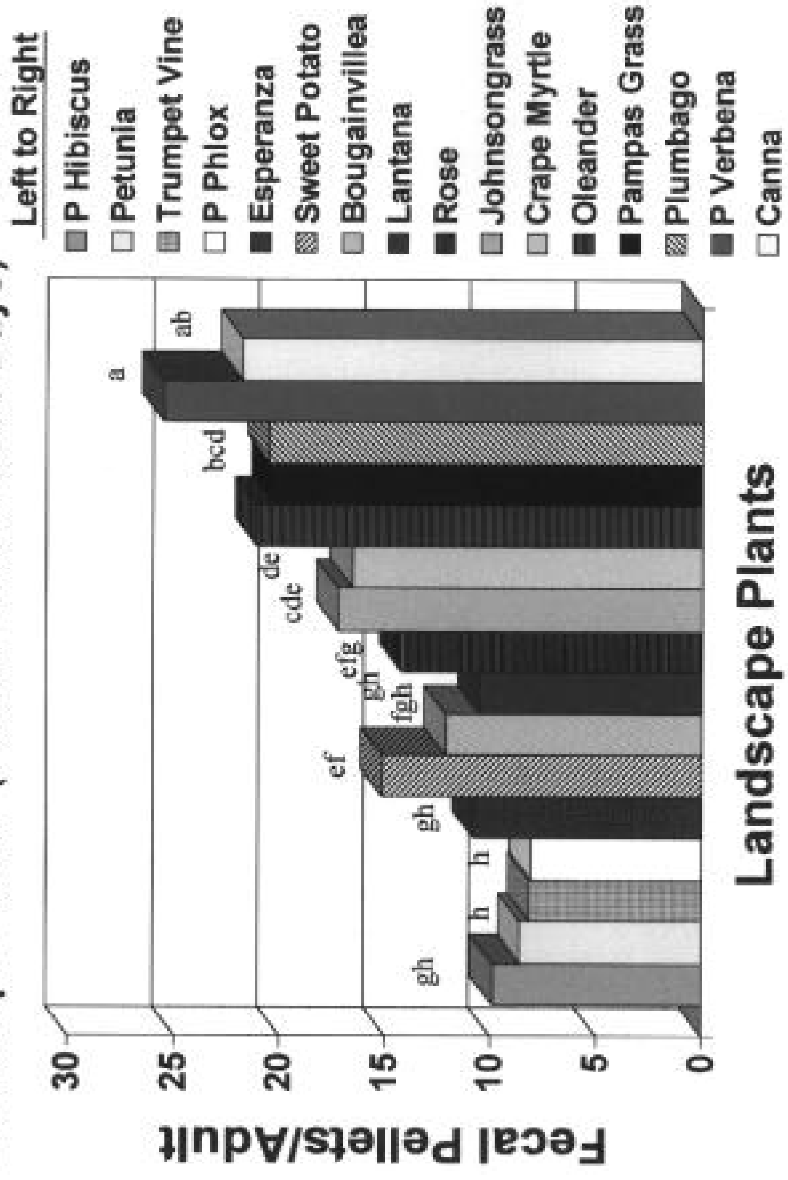


Fig. 3. Feeding by Differential Grasshopper on Selected Landscape Plants (Fecal Pellet Wt / First 3 Days)

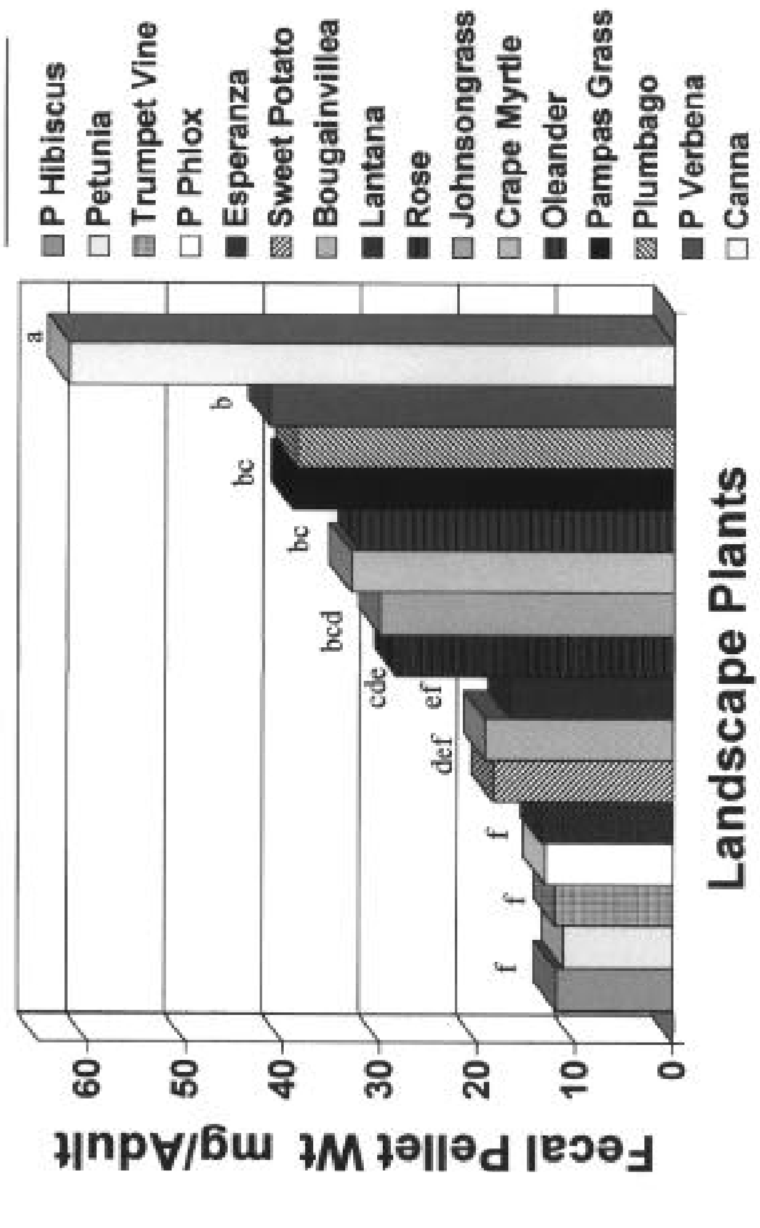


Fig. 4. Feeding by Differential Grasshopper on Selected Landscape Plants (Fecal Pellets/Day for 14 Days)

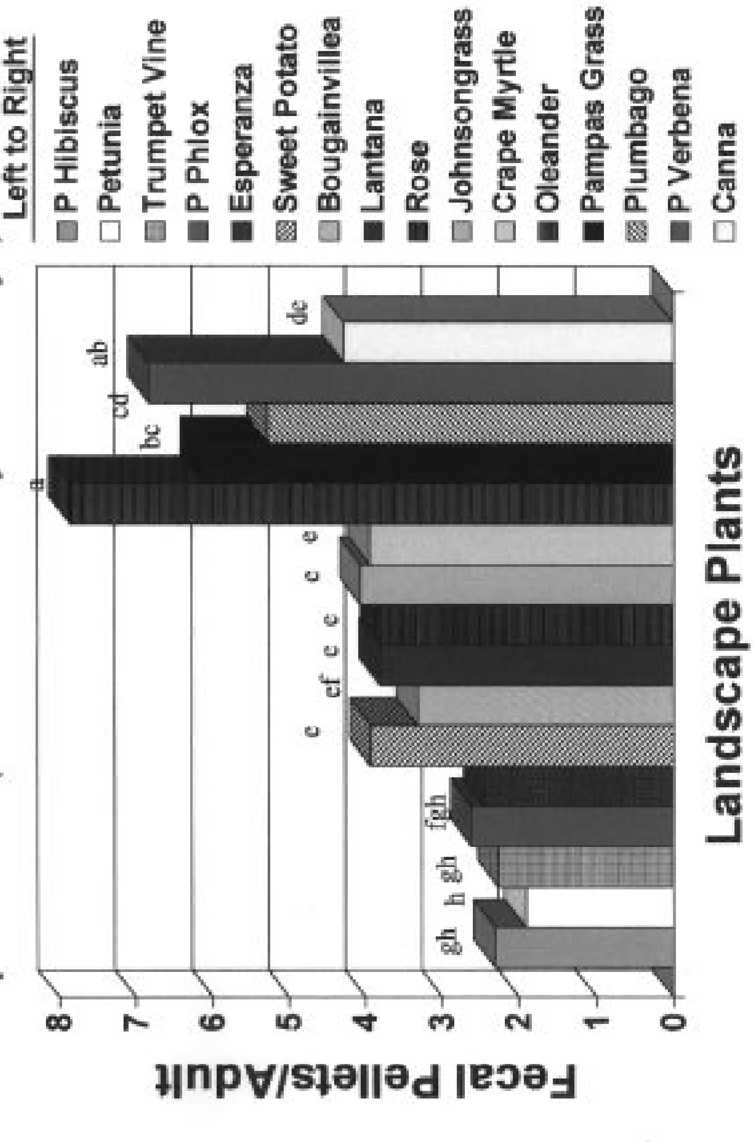
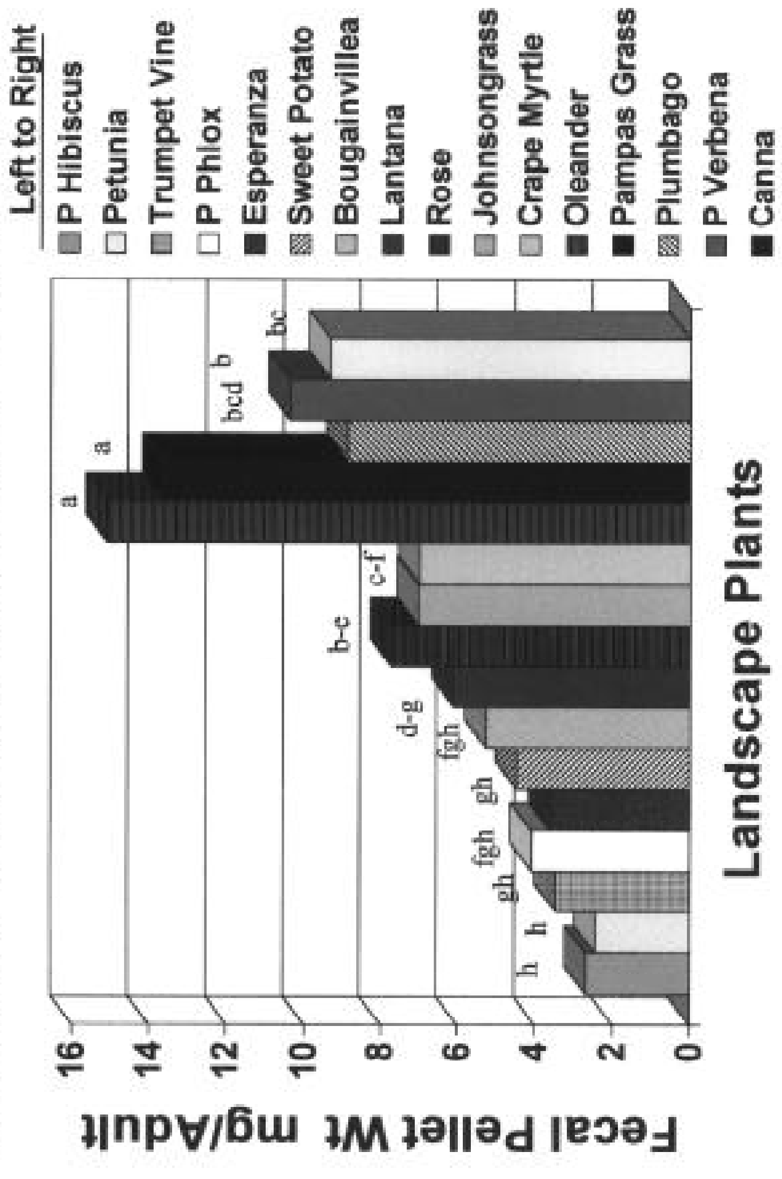


Fig. 5. Feeding by Differential Grasshopper on Selected Landscape Plants (Fecal Pellet Wt/Day for 14 Days)



Opportunities for Western Flower Thrips Biological Control in Potted Chrysanthemums

Kevin M. Heinz[1], Judy M. Mason, & Paul Ode
Department of Entomology; Texas A&M University;
College Station, TX 77843-2475
Tel[1]. 409-862-3408. Email[1]: KMHeinz@tamu.edu

Index Words: Western Flower Thrips, *Frankliniella occidentalis*, Biological Control, Entomopathogenic Nematode, *Thripinema nicklewoodi*, Predatory Mite, *Neoseiulus cucumeris*, Potted Chrysanthemum,

Nature of Work: Western flower thrips (WFT), *Frankliniella occidentalis* (Pergande), is a severe pest of most greenhouse and some nursery crops. Use of insecticides against this highly resistant pest and the absence of economical, commercially available, and effective natural enemies prevent biological thrips control. Dependence on chemical control of this pest also hinders the adoption of successful biological control methods for management of other arthropod pests. Entomopathogenic nematodes, which are generally easy to rear and may be applied using conventional spray technologies, exhibit great potential for thrips biological control. The allantonematid nematode, *Thripinema nicklewoodi* Siddiqi, parasitizes female thrips residing within the foliar terminals and flower buds where they are safe from attack from arthropod natural enemies. This nematode sterilizes thrips without killing them and nematode populations are probably self-sustaining. Can this species be used for biological control of WFT infesting greenhouse floricultural crops? A robust answer to this question requires a thorough understanding of the interactions among *T. nicklewoodi* and its thrips host, the environmental constraints placed upon the infectivity of thrips by this nematode, and statistically valid evaluations of capability to elicit thrips biological control under various greenhouse conditions. While *T. nicklewoodi* may provide prolonged levels of suppression, additional biological control agents may have to be released simultaneously during early stages of outbreaks due to time lags associated with sterilization of the WFT host by the nematode.

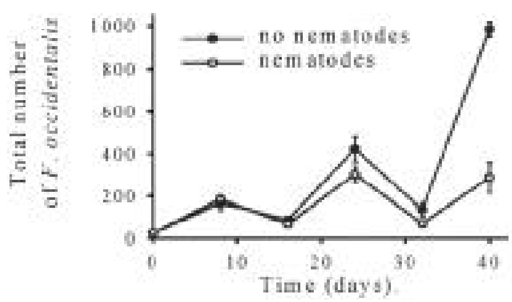
Several species of predatory mites have been investigated for biological control of WFT in Europe on greenhouse cucumbers and sweet peppers. These mites show promise, but this research is poorly applicable to flower crops because near zero damage tolerances on flowers and species-specific plant features strongly affect population growth rates of WFT and predator efficacy. Research is needed to develop effective biological control solutions for WFT on flower crops. Mite species useful on vegetables may not be the species most effective on flower crops. We are currently investigating mites that differ in life histories along a live prey/pollen diet spectrum. For example, *Galendromus occidentalis* must feed on live prey to persist; it cannot survive on pollen alone. By contrast *Neoseiulus cucumeris* prefers WFT to pollen but offering pollen as a diet supplement may enhance their performance as a biological control agent and may allow them to persist in the absence of live prey. We are investigating if predatory mite life histories interact with pollen applications and affect population regulation over realistic cropping periods. This will provide experimental data that will improve our understanding of how to best use predatory mites as thrips control agents in greenhouses.

Thripinema nicklewoodi **Biology Studies.** Only female WFT larvae are infected by *T. nicklewoodi*, with larval WFT as the primary host stage infected by the adult female nematode. Infection of WFT pupae and adults does also occur. The number of parasitic females infecting a thrips host varies; the highest number we have observed developing in the abdomen of WFT is eleven. Following infection, the oviparous female nematodes release their eggs into the WFT. Upon hatching, the vermiform juveniles feed within the thrips' abdominal cavity, with finally the mature male and female nematodes exiting the host via the anus in the frass. *Thripinema* fertilization and infection of new hosts probably occurs within plant structures that provide the high humidity necessary for nematode movement. Sharga (1932) suggested that Thripinema fertilization may occur within the host prior to emergence based on the observation that no males were observed emerging from the host. However, it is generally thought to occur outside of the host (Nickle & Wood, 1964; Siddiqi, 1986). The preferred feeding site of WFT, within the confined habitat of flowers and meristematic tissues, is an ideal habitat for such nematode activities.

In order to determine the site of transmission of *T. nicklewoodi* we conducted a preliminary study to examine on which plant structure infection of WFT does indeed occur. Cut chrysanthemum flowers, with leaves and stems attached, were infested with both adult female WFT infected with *T. nicklewoodi* and uninfected larvae. All thrips were removed after four days and status of nematode infection assessed. Nematode-infected larval WFT were recovered only from the flowers, with those that had fed on the leaves not infected. Additionally, flowers and leaves were washed with tap water to check for the presence of nematodes. Approximately 88% of the nematodes recovered were found on flowers. The results from this study tend to confirm that infection of WFT by *T. nicklewoodi* does occur primarily within the protected environment of the flower. However, we have also shown that, in the absence of flowers, transmission does occur on the leaves.

Population Suppression of WFT by *T. nicklewoodi*. *Thripinema nicklewoodi* is a potentially promising biological control agent of WFT, with features that suggest that it may be better than current means of control. Nematode-infected WFT can enter feeding sites, areas impenetrable with current control options. In other words, nematodes are vectored live into traditionally inaccessible areas of ornamental plants. Indeed, we have already shown that it is in these exact sites where transmission of *T. nicklewoodi* occurs (see above). Such vectoring of the nematode should effect long-term WFT suppression. Can long-term suppression be achieved? Results from a preliminary study that we have conducted suggest that long-term suppression of WFT by *T. nicklewoodi* can be attained. We established populations of nematode infected and uninfected WFT by releasing nematode infected or uninfected WFT (controls) in cages containing kidney bean leaves as a food source, with transmission of *T. nicklewoodi* then allowed to proceed naturally. Numbers of WFT life stages were then recorded every eight days for a total of three WFT generations. In Figure 1, the midpoints of each of the three WFT generations for both infected and uninfected are on days 8, 24 and 40.

Figure 1. The effect of *T. nicklewoodi* on *F. occidentalis* populations



No difference in WFT numbers between the two populations is observed on day 8. By day 24, a small difference in WFT numbers are observed, with the numbers being slightly lower in the nematode infected population. However, by the middle of the third generation (day 40), there is an approximate 3.5 fold reduction in WFT numbers in the nematode infected WFT population. This reduction in WFT numbers in the nematode infected population is even more striking as the initial percentage parasitism in the nematode infected WFT was only 10%, and the host material was not the most ideal environment for nematode infection as per the preceding comments.

WFT Population Regulation with *Neoseiulus cucumeris*. A 2-by-2 factorial experiment, with or without augmented apple pollen and with or without releases of *N. cucumeris* as treatments, was overlaid onto a WFT infestation occurring on a commercial potted chrysanthemum range. A completely randomized design was used with 4 replicated plots per treatment. Insectary-reared predatory mites were released once on the first day of the trial and pollen, at a rate of 8 kg/ha was broadcast over the tops of pots weekly using a pollen puffer gun. WFT densities were significantly lower in plots receiving releases of *N. cucumeris* than in the no-release plots, but there were no significant differences in WFT densities associated with pollen treatments. WFT densities were persistently low throughout the trial. Thus, the need for alternate prey (pollen) may only be necessary when predators must bridge cycles of depressed prey levels to combat periodic WFT resurgences.

Significance to the Industry. The preliminary results presented here suggest the potential of using *T. nicklewoodi* for suppression of WFT. We have shown that transmission of *T. nicklewoodi* occurs within flowers, the very feeding sites of immature WFT. In addition, the nematode-infected WFT vector the nematodes into these sites, areas currently impenetrable with sprays or arthropod natural enemies. Using a natural infection process, we have also demonstrated the potential suppression of WFT by *T. nicklewoodi*. These results suggest that use of *T. nicklewoodi* would be for long-term WFT suppression, and not for immediate reduction in population numbers. However, with development of *T. nicklewoodi* as a spray application or in combination with predatory mite releases, it may be possible that a more immediate reduction in WFT numbers can be attained. Release of *N. cucumeris* was successful in suppressing WFT populations in potted chrysanthemums. Augmentation of pollen as an alternate prey source does not appear to increase levels of population suppression when WFT populations are persistent.

Acknowledgements. The American Floral Endowment, the Texas Higher Education Coordinating Board, and Yoder Bros., Inc. provided funding for this work.

Literature Cited:

1. Nickle, W.R. & G.W. Wood. 1964. Howardula aptini (Sharga 1932) parasite in blueberry thrips in New Brunswick. Can. J. Zool. 42: 843-846.

2. Sharga, U.S. 1932. A new nematode, Tylenchus aptini n.sp. parasite of Thysanoptera (Insecta): Aptinothrips rufus (Gmelin). Parasitol. 24:

3. Siddiqi, M.F. 1986. Tylenchida, Parasites of Plants and Insects. CAB Commonwealth Institute of Parasitology. London, UK. 645 pp.

IR-4 Research for Pest Control in Nursery Crops – 1998

J. Ray Frank
Rutgers/State University of New Jersey
New Market, Maryland 21774

Index Words: Pesticides, Biopesticides, Label, Registration

Nature of Work: Research trials carried out by the IR-4 Ornamental Program include pesticide evaluations for nursery, greenhouse, forestry, Christmas tree, tissue culture, commercial landscape and interior plantscapes. Most 1998 trials evaluated phytotoxicity but some efficacy trials were also conducted. 27 fungicides, 32 herbicides, 21 insecticides, 2 nematicides and 6 plant growth regulators were evaluated in 1998.

The 1998 research was conducted by 21 state, federal, and private researchers. 466 funded trials were conducted at 19 sites in 15 states. IR-4 protocols insure uniform and accurate data required for national label registration.

Results and Discussion: The following 12 fungicides were evaluated:

Bordeaux mixture (13.3%)
Captan (50W)
Chlorothalonil (Daconil Ultrex) (82.5%)
Etridazole (Ethazole) (Terrazole 35WP, Truban 5G)
Flutolanil (Prostar 50WP)
Fosetyl-Al (Chipco Aliette WDG 80)
Mefenoxam + Mancozeb (Pace)
Oxytetracycline (Mycoshield)
Streptomycin (Agri-Mycin 17)
Tebuconazole (Lynx 45)
Thiophanate-Methyl (Clearys 3336 4.5F, 50WP)
Triforine (Triforine EC)

The following 18 herbicides were evaluated:

Atrazine (Attrex 4L)	Napropamide (Devrinol 5G, 50DF)
Clethodim (Envoy)	Oryzalin (Surflan AS)
2, 4-D Amine (Weedar 64)	Oxadiazon (Chipco Ronstar G, 50WP)
2, 4-D Lvester (Weedone LV4)	Oxyfluorfen + Oryzalin (Rout 2G)
Dicamba (Vanquish)	Oxyfluorfen + Pendimethalin (OHII)
Dithiopyr (Dimension 1EC)	Pendimethalin (Pendulum 60WDG)

Fluazifop-P-Butyl (Fusilade II)	Pendimethalin G(Ornamental Weed Grass Control)
Halosulfuron (Permit)	Prodiamine (Barricade 65WG, Factor 65)
Isoxaben (Gallery 75DF)	Trifluralin (Gowan Trifluralin 10G)

The following 15 insecticides were evaluated:

Acephate (Orthene Turf, Tree & Ornamental Spray)
Carbofuran (Furadan 4F)
Chlorpyrifos (Dursban lawn + ornamental insecticide)
Clofentrazine (Ovation SC)
Diazinon (Diazinon 4E)
Diazinon (Micro) (Knox Out 2FM)
Diflubenzuron (Dimilin 4L, 25W)
Dimethoate (Cygon 400)
Fipronil (Chipco Choice 1G)
Formetanate Hydrochloride (Carzol SP)
Permethrin (Astro 36.8%)
Pirimicarb (Pirimor 50DF)
Pyridaben (Sanmite)
Tefluthrin (Fireban 1.5G)
Trichlorfon (Dylox 80)

The following two nematicides were evaluated:

Abamectin (Avermectin) (Avid – 0.15 EC)
Diazinon (Micro) (Knox Out 2FM)

The following tplant growth regulators (PGRs) were evaluated:
Flurprimidol (Cutless TI)Paclobutrazol (Profile 2SC)

1998 IR-4 research led to 495 new ornamental label registrations for products that can be used by the ornamental horticulture industry. (Table 1)

Significance to Industry: Since its inception, the IR-4 Ornamental Research Program has developed data for over 5,400 label registrations for the ornamental horticultrure industry.

For additional Information:

1. IR-4. 1998. IR-4 Project Statement: October 1, 1998 to September 30, 2003. Cook College, Rutgers The State University of New Jersey, New Brunswick, NJ. 46pp.

2. IR-4. 1998. IR-4 Annual Report. Cook College, Rutgers The State University of New Jersey, New Brunswick, NJ. 29pp.

3. IR-4. 1999. “Commercially Grown Floral, Forestry, Nursery and Turf Crops”. IR-4 Minor Use Report Card – 1999 Update. 16pp.

Table 1. 1998 Pesticide Registrations supported by IR-4 data.

Acephate (Ortene Turf, Tree and Ornamental Spray)
- Aster
- Balsam (Impatiens)
- Birch
- Chrysanthemum

Ancymidol (A-Rest)
- Angelonia
- Coleus
- Coral Plant (Russelia)
- Coral Porterweed (Stachytarpheta)
- Egyptian-Star Cluster (Pentas)
- Mexican Petunia (Ruellia)
- Sweet-Potato Vine (Ipomoea)
- Yellow Shrimp Plant (Pachystachys)

Bendiocarb (Turcam 2.5G, Dycarb 76WP)
- Holly

Bentazon (Basagran T/O)
- Crabapple (non-bearing)
- Holly
- Marigold
- Oak
- Petunia
- Yew

Carbofuran (Furadan 4F)
- Azalea
- Rhododendron
- Yew

Chlorothalonil (Daconil 2787)
- African Violet
- Ageratum
- Fir (Abies)
- Fuschia
- Gloxinia
- Larkspur
- Nasturtium
- Periwinkle
- Persian Violet
- Pinks
- Primrose
- Snapdragon
- Vervain (Verbena)

Chlorothalonil (Exotherm)
- Poinsettia

Clethodim (Envoy)
- Ageratum
- Snapdragon

Slopyraolid (Stinger)
- Arborvitae
- Azalea
- Bridal-Wreath (Spirea)
- Christmas Trees
- Crabapple (non-bearing)
- Douglas Fir
- Fir (Abies)
- Juniper
- Maple
- Oak
- Pine
- Mugo Pine
- Rhododendron
- Norway Spruce
- White Spruce
- Yew

Copper Hydroxide (Kocide)
- Elm
- Flag (Iris)
- Honey Locust
- Honeysuckle
- Nephthytis (Syngonium)
- Rose-of-Sharon
- Snapdragon
- Umbrella Tree (Schefflera)

Cyfluthrin (Decathlon)
- Balsam (Impatiens)
- Calendula
- Carnation
- Chrysanthemum
- Geranium
- Poinsettia
- Primrose

Cyromazine (Citation)
- Calendula

Diazinon (E)
- Wax Vine (Hoya)

Diazinon (Micro)
- Ageratum
- Gazania
- Japanese Spurge
- Scarlet Sage
- Velvet Plant

Dithiopyr (Dimension EC)
- Arrowwood (Viburnum)
- Tree Fern (Asparagus)
- Geranium
- Hawthorn
- Honey Locust
- Juniper
- Lilac
- Sugar Maple
- Red Oak
- Yew

Diuron (4L)
- Ash (Fraxinus)

Etridazole (E) (Ethazole, Truban)
- Scarlet Sage

Etridazole (G) (Ethazole, Truban)
- Marigold
- Petunia
- Shrub Verbena (Lantana)

Flutolanil (Prostar)
- Azalea
- Balsam (Impatiens)
- Begonia

Fostyl-Al (Chipco Aliette WDG)
- Arrowwood (Viburnum)

Gliocladium Virens (Soil Gard)
- Balsam (Impatiens)
- Begonia
- Cockscomb
- Marigold
- Petunia
- Scarlet Sage
- Snapdragon
- Zinnia

Isofenphos (Offanol)
- Christmas Tree
- Japanese Holly

Isoxaben (Gallery)
- Arrowwood (Viburnum)
- River Birch
- Blue Fescue
- Ch. Pennistum
- False Spirea
- Heath
- Heather
- Blue Holly
- Japanese Flowering Cherry
- Southern Magnolia
- Red Bud
- Wax Myrtle (Myrica)

Isoxaben + Trifluralin (Snapshot)
  Pygmy Date Palm

Mancozeb (Dithane)
  Frangipani (Plumeria)
  Gloxinia
  Hackberry

Mefenoxam (Subdue Maxx)
  Bleeding Heart
  Snapdragon
  Stonecrop

Metolachlor (Pennant)
  Snapdragon

Metolachlor + Simazine (Derby)
  Birch

Oryzalin (Surflan)
  Arrowwood (Viburnum)
  White Ash
  Bell Flower (Campanula)
  River Birch
  Japanese Dogwood
  Redbud

Oxadiazon (Chipco Ronstar 50 WP)
  Baby's Breath
  Bald Cypress
  Blanket Flower
  Blazing Star
  Cheddar Pink (Dianthus)
  Cleyera
  Dahlia
  Daylily
  Golden-Rain-Tree
  Hardy Ice Plant
  Hardy Mum
  Lance Coreopsis
  Leopards Bane
  Plantain Lily
  Linden
  Statice (Limonium)
  Sweet William
  Tickseed (Coreopsis)
  Wild Sweet William (Phlox)
  Wisteria
  Wooly Thyme (Thymus)

Oxadiazon (Chipco Ronstar 5G)
  Dahlia
  Lambs-ears
  Mock Orange
  Peony
  Sweet William

Oxyfluorfen (Goal T/O)
  Crabapple (non-bearing)
  Crape Myrtle
  Flowering Dogwood
  Japanese Flowering Cherry
  White Spruce

Oxyfluorfen + Oryzalin (Rout)
  Honeysuckle

Oxythioquinox (Morestan)
  Japanese Spurge

Pendimethalin (Pendulum 60 WDG)
- Avens (Geum)
- River Birch
- Blazing-Star
- Crabapple (non-bearing)
- Leyland Cypress
- Flowering Dogwood
- French Hydrangea
- American Holly
- Blue Holly
- Fosters Holly
- Honey Locust
- Japanese Dogwood
- Japanese Flowering Cherry
- Lagerstroemia Fauriei
- Lagerstroemia Indica X Fauriei
- Saucer Magnolia
- Southern Magnolia
- Star Magnolia
- Amur Maple
- Red Maple
- Sugar Maple
- Trident Maple
- Bradford Pear
- Rose-of-Sharon
- Sweet Gum
- Tulip Tree
- Wax Myrtle (Myrica)
- Weeping Willow
- Western Mugwort

Pendimethalin (G)(Ornamental Weed Grass Control)
- Chrysanthemum
- Foxglove
- Lobelia
- Paperbark Maple
- Scarlet Sage
- Yarrow

Permethrin (Astro)
- Ash
- Azalea
- Beech
- Birch
- Black Locust
- Cherry (non-bearing)
- Cottonwood
- Elm
- Eucalyptus
- Flowering Dogwood
- Freesia
- Hawthorn
- Hickory
- Honey Locust
- Hop Hornbeam
- Lilac
- Maple
- Mountain Ash
- Oak
- Peach (non-bearing)
- Loblolly Pine
- Pitch Pine
- Virginia Pine
- White Pine
- Poinsettia
- Rhododendron
- Willow

Prodiamine (Barricade 65 WDG)
- Andromeda (Pieris)
- Arrowwood
- Aucuba
- Barberry
- Begonia
- Bellflower
- Blue Spire (Perovskia)
- Boltonia
- Boxwood
- Bridal Wreath (Spirea)
- Butterfly Bush
- Carpobrotus
- Chinese Pistachio
- Cleyera
- Crabapple (non-bearing)
- Crap Myrtle
- Cypress
- Daffodil
- Daylily
- Douglas Fir
- Evening Primrose
- False Cypress
- False Dragonhead (Physotegia)
- Japanese Flowering Cherry
- Flowering Dogwood
- French Hydrangea
- Gardenia
- Geranium
- Hardy Ice Plant
- Hardy Bamboo
- Hemlock
- Holly
- American Holly
- Japanese Holly
- Honeysuckle
- Hop Bush (Dodonaea)
- Japanese Pittosporum
- Juniper
- Larkspur
- Lily
- Plantain Lily
- Lilyturf (Liriope)
- Creeping Lilyturf (L. spicata)
- Giant Lilyturf (L. muscari)

Prodiamine (Barricade 65 WDG)(Con't.)
- Lobelia
- Saucer Magnolia
- Southern Magnolia
- Star Magnolia
- Maple
- Oak
- Oleander
- Pampas Grass
- Bradford Pear
- Peony
- Periwinkle (Vinca)
- Photinia
- Pine
- Potinillia
- Privet
- Purple Loose Strife
- Purpleleaf Wintercreeper
- Rose-of-Sharon
- Shrub Verbena
- Southern Yew
- Spruce
- Star Jasmine
- Stonecrop (Sedum)
- Trailing Lantana
- Yarrow

Prodiamine (Barricade 2G)
- Arborvitae
- Arrowwood
- Azalea
- Blue Spire (Perovskia)
- Boltonia
- Boxwood
- Cleyera
- Cotoneaster
- Crape Myrtle
- False Dragonhead (Physotegia)
- Firethorn
- Forsythia
- Gardenia
- Geranium
- Holly
- Japanese Pittosporum
- Juniper
- Lobelia
- Photinia
- Pine
- Privet
- Purple Loosestrife
- Purpleleaf Wintercreeper
- Rhododendron
- Rodgersia
- Southern Yew
- Weigela
- Yarrow

Pronamide (Kerb)
- Maple
- Oak

Pyridaben (Sanmite)
- Holly
- Juniper
- Rose
- Winged Euonymus

Sethoxydim (Vantage)
- English Ivy

Simazine (Princep)
- Flowering Dogwood
- Holly
- American Holly
- Blue Holly
- Fosters Holly
- Honey Locust
- Japanese Dogwood

Sunspray Ultra Fine Spray Oil
- Ageratum

Thiophanate Methyl (Clearys 3336)
- Ageratum
- Baby's Breath
- Begonia
- Blanket Flower
- Bougainvillea
- Carnation
- Chrysanthemum
- Coleus
- Coneflower
- Crossandra
- Fuchsia
- Gazania
- Geranium
- Globe Amaranth
- Hibiscus
- Impatiens
- Larkspur
- Marigold
- Moss Rose
- Nicotiana
- Ornamental Cabbage
- Ornamental Kale
- Petunia
- Phlox
- Austrian Pine
- Pinks (Dianthus)
- Pocketbook Flower (Calceolaria)
- Primrose
- Rose Periwinkle (Catharanthus)
- Scarlet Sage
- Shasta Daisy
- Snapdragon

Thiophanate Methyl (Clearys 3336) (Con't.)
- Statice
- Stock
- Tickseed
- Transvaal Daisy
- Vervain (Verbena)
- Violet

Trifluralin (Gowan 10G)
- Blue Fescue (F. Cinerea)
- Blue Fescue (F. Ovina Glauca)
- Cheddar Pink
- Rose
- Speedwell (Veronica)
- Stonecrop

Vinclozolin (Ornalin)
- Hydrangea

Insecticide Evaluation for Control of the Asian Ambrosia Beetle, *Xylosandrus crassiusculus*, In Vitro

Frank A. Hale[1]; Jason Oliver[2]
and Catharine Mannion[2]
[1]The University of Tennessee Agricultural Extension Service
5201 Marchant Dr.
Nashville, TN 37211-5112
[2]TSU Nursery Crop Research Station
Cadillac Lane
McMinnville, TN 37110

Index words: Insecticide Evaluation, Asian Ambrosia Beetle, *Xylosandrus crassiusculus*, (Motchulsky) Orthene, Dursban, Tame, Ambush, Mavrik, Talstar, Warrior T

Nature of Work: Insecticides were evaluated in vitro for efficacy and behavior effects for the Asian ambrosia beetle (AAB), *Xylosandrus crassiusculus* (Motchulsky).

Previous field studies (1,2) have tentatively indicated the efficacy of some of the common insecticides for control of AAB. To our knowledge this study is the only in vitro data for this important pest. The beetles used in the test were reared in cut sections of a branch of an infested eastern redbud, *Cercis canadensis* 'Forest Pansy' from Nashville, TN on April 30, 1999. The wood sections were placed in a screened container until adult emergence. AAB adults began to emerge in mid May and were stored in a closed container to increase humidity and prevent desiccation of the beetles prior to the test. On May 28, units of 8 *AAB* were held in empty 100 x 15 mm polystyrene petri dishes. Dishes were modified by cutting a circular 13mm hole in the top center. Insect screen was attached with sillicon glue to cover the hole. A Whatman filter paper (90mm, Qualitative 1) was placed in the bottom of each dish.

A water check (distilled water) versus the following commercial insecticide formulations were tested: Tame 2.4 EC (fenpropathrin [10.67 fl oz/100 gal]), Talstar 7.9% F (bifenthrin [4oz/10 gal]), Warrior T 1CS (lambda-cyhalothrin [4.4 fl oz/100 gal]), Mavrik Aquaflow 22.3% F (fluvalinate [10 fl oz/100 gal]), Orthene TTO 75% SP (acephate [21.3 oz/100 gal]), Dursban 4EC (chlorpyrifos [2 gal/100 gal]), and Ambush 2EC (permethrin [12.8 fl oz/100 gal]). Warrior T 1CS is not labeled for use on ornamentals but was used at the same active ingredient label rate as Scimitar 0.88 CS which is labeled for use on ornamentals in the landscape.

Each treatment consisted of 1 ml dilute insecticide applied to a filter paper in the modified petri dish. Each treatment was replicated 4 times. The filter papers were allowed to air dry for 60 minutes. The units of eight beetles were transferred to each treated petri dish and the top and bottom of the petri dishes were secured with Parafilm “M” Laboratory Film. The dishes were kept between 24° and 26°C (75° and 79°F). The beetles were observed for the next 76 hr.

Results and Discussion: The activity of the test beetles varied depending on the treatment. The distribution of the beetles in the water check, Mavrik, Orthene, and Tame was mostly clumped. The distribution of the beetles in Warrior was less clumped and that in Dursban and Ambush was mostly dispersed. Some of the beetles in 4 of the 5 pyrethroid insecticide treatments exhibited short flights. This occurred 1.3 hr after exposure for Ambush, 2.2 hr and 2.5 hr for Talstar, 18.2 hr for Marvrik and 24.3 hr for Tame. The beetles in Talstar chewed holes in the filter paper 5.5 hr after treatment and the beetles in the Warrior treatment chewed holes 32.2 hr after treatment.

The results of the study are shown in Table 1. The fastest rate of kill was achieved in the Dursban treatment which had 100 percent mortality 5.5 hr after treatment. Dursban was significantly different from all other treatments and the water check at 5.5 hr and 20.2 hr after treatment. Talstar and Ambush had 100 percent mortality after 52.3 hr and were not significantly different from Dursban. This in vitro test gives an indication of toxicity of these insecticides to this beetle. It does not indicate whether these treatments would protect plants from AAB attack. The use of the higher label rates of Dursban as a preventative treatment to trees needs to be evaluated. Talstar and Ambush, although not as fast acting, may have some repellency affects that also aid in protecting sprayed trees. This also merits further investigation.

Significance to the Industry: Dursban, Talstar and Ambush are three labeled insecticides that have shown significant toxicity to the Asian ambrosia beetle in vitro. The 2 gal/100 gal Dursban 4E rate is only labeled for applying on tree bark to the main trunk of trees. Read and follow label directions before using any pesticide. These insecticides need to be field tested before grower recommendations are made.

Table 1. Asian Ambrosia Beetle Control In Vitro

	Mean Percent Mortality		
Treatments	5.5 hr	20.2 hr	52.3 hr
Mavrik	0.0 b*	0.0 c	25.0 bc
Orthene	3.1 b	3.1 bc	56.3 b
Talstar	6.3 b	15.6 b	100.0 a
Tame	0.0 b	3.1 bc	9.4 c
Warrior	3.1 b	3.1 bc	21.9 bc
Dursban	100.0 a	100.0 a	100.0 a
Ambush	0.0 b	6.3 bc	100.0 a
Water check	0.0 b	3.1 bc	3.1 c

*Means within each column having the same letter are not significantly different (ANOVA; Tukey's Test; P<0.05)

Literature Cited:

1. Mizell, R., S.K. Braman, B. Sparks, & W.Hudson. 1994. Outbreak of the Asian ambrosia beetle, Xylosandrus crassiusculus (Motschulsky), is cause for concern. Proc. SNA Res. Conf. 39: 191-193

2. Mizell, III, R.F., A. Bolques & P. Crampton. 1998. Evaluation of insecticides to control the Asian ambrosia beetle, Xylosandrus crassiusculus. Proc. SNA Res. Conf. 43: 162-165

Control of Tea Scale (*Fiorinia theae*) on 'Pink Snow' Camellia (*Camellia sasanqua* 'Pink Snow') Using Root Absorbing Systemic Insecticides

Charles P. Hesselein[1], Joseph R. Chamberlin[2] and Michael L. Williams[3]
[1]Ornamental Horticulture Substation, Mobile, AL 36689-0276; [2]Valent USA Corporation, 2386 Clower St., Suite E-100B, Snellville, GA 30078-6134; [3]Department of Entomology, Auburn University, AL, 36849

Index Words: Tea Scale, *Fiorinia theae*, acephate, Orthene, Imidacloprid, Marathon, Systemic Insecticide

Nature of Work: Tea scale (*Fiorinia theae*) is probably the most common and damaging pest of camellias and dwarf burford hollies as well as a pest of many other ornamental and fruiting crops. Controlling tea scale can be particularly problematic because of the difficulty in contacting them with insecticide sprays. Factors which make spray contact difficult include tea scale's habit of heavily colonizing the undersides of older foliage, the cottony, waxy coating exuded by the male insects, the armored cover over the female's body which protects both her and her eggs, and nursery cultural practices which promote thick, difficult to penetrate plant canopies. In addition, this insect's non-synchronous, year-round life cycle makes targeting the vulnerable crawler stage with insecticide sprays problematic. Media applied, root absorbing systemic insecticides may be one way of overcoming the obstacles to insect/ insecticide contact. The objective of our test was to evaluate four media applied systemic insecticides (Table 1): four rates of Pinpoint 15G, Orthene TTO (OTTO) 75 SP (applied as a drench), Marathon 1G and Marathon 60 WP (applied as a drench).

'Pink Snow' camellias potted in a pine bark based medium in trade gallon containers were utilized for this study. The tea scale infested plants were obtained from a local nursery and were well established in their containers. To determine insecticide efficacy, leaves were haphazardly picked from test plants and 50 adult female scale insects were probed with an insect mounting pin to determine if they were alive or dead. Scale insects that did not exude liquid body contents when probed were assumed dead. Insects viewed under a 14x binocular dissecting microscope while being probed. The test was a randomized complete block design with six single plant replications of eight treatments. Observations were made prior to treatment (Pre), 7, 14, 21, 28, 40 and 95 DAT. Data were analyzed using ANOVA (PROC GLM, SAS). Data were analyzed as the percentage dead scale per 50 probed insects (y/50) and were transformed using an arcsine transformation prior to analysis. Transformed means were separated using Duncan's Multiple Range Test ($\alpha \leq 0.05$) (Table 1). Plants were treated on October 9, 1998 and the last data were collected on January 12, 1999 (95 DAT). To minimize insecticide loss through leaching, all treatments were applied or watered in with four ounces of water and plants were not irrigated for 24 hours following treatment. Plants were maintained under shade and irrigated as needed by overhead impact sprinklers throughout the course of the study.

Results and Discussion: No differences among treatments were detected until 14 DAT (Table 1). The most effective treatments, from 14 DAT through the conclusion of the trial, were Pinpoint 15G at 1/2 and 3/4 teaspoon (2 and 3 g respectively) per pot and OTTO 75 SP (0.4 g) treatments. The percentage dead adult female scale insects during the trial for the untreated control ranged from 20 to 29 percent while the percentage dead adult female scale insects in the most effective treatments ranged from 79 percent at 14 DAT to 98 percent at 95 DAT. The 1/4 teaspoon (1 g) per pot Pinpoint 15G treatment also demonstrated some efficacy but was not as effective as the 1/2 and 3/4 teaspoon per pot Pinpoint 15G and OTTO 75 SP treatments. Marathon 1G (5 g), Marathon 60 WP (0.09 g) and 1/8 teaspoon (0.5 g) per pot Pinpoint 15G proved ineffective for controlling tea scale. No phytotoxicity was observed during the trial.

Significance to Industry: Nursery producers have a difficult time controlling tea scale with conventional high volume insecticide sprays. This test demonstrates that even the low label rate of Pinpoint 15G (one half teaspoon) provides greater than 90 percent control of this insect.

Table 1. Mean percentage dead tea scale per treatment/date

Treatment	Rate	PRE[z]	7 DAT[y]	14 DAT	21 DAT	28 DAT	40 DAT	95 DAT
Untreated check		20 a[x]	21 a	24 c	27 c	24 d	25 c	29 c
Pinpoint 15G	$^1/_8$ t/pot	21 a	27 a	34 bc	39 c	35 cd	37 c	28 c
Pinpoint 15G	$^1/_4$ t/pot	20 a	24 a	40 b	72 b	75 b	69 b	70 b
Pinpoint 15G	$^1/_2$ t/pot	20 a	28 a	69 a	90 a	96 a	94 a	97 a
Pinpoint 15G	$^3/_4$ t/pot	21 a	31 a	79 a	88 a	94 a	96 a	98 a
Orthene TTO 75 SP	0.014 oz /pot	20 a	34 a	76 a	91 a	94 a	95 a	93 a
Marathon 1G	1 $^1/_4$ t/pot	21 a	28 a	22 c	30 c	41 c	36 c	39 c
Marathon 60 WP	0.003 oz/pot	19 a	23 a	20 c	29 c	34 cd	34 c	33 c

[z] Pre= pretreatment sample date

[y]DAT= days after treatment (October 9, 1998)

[x]Means separated using Duncan's Multiple Range Test. Means with the same letter are not significantly different ($\alpha \leq 0.05$). Means transformed using an arcsine transformation prior to analysis. Non-transformed data presented.

Thrips Damage to Potted Anthurium Cultivars in Interior Environments

Jianjun Chen, Richard J. Henny, Lance S. Osborne,
Russell D. Caldwell and Cynthia A. Robinson
University of Florida, IFAS
Central Florida Research and Education Center
2807 Binion Road, Apopka, FL 32703

Index Words: Anthurium, Thrips

Nature of Work: Potted *Anthurium* has become an important flowering foliage plant because of its long-lasting, colorful flowers and deep green, shiny, arrow-shaped leaves. *Anthurium* can grow and flower under low light conditions; thus it is becoming more widely used for interior plantscaping (Griffith, 1998).

Thrips have been one of the most troublesome problems in *Anthurium* production (Griffith, 1998; Henny et al. 1991). Thrips damage under interior-growing conditions on *Anthurium* has not been reported. Thrips feed on flowers, buds and leaves by piercing plant cells with a single mandible and extracting the cellular contents with the strawlike stylets, resulting in distorted leaves and deformed flowers (Gill and Sanderson, 1998; Henny et al. 1991). Our recent evaluation of the interior performance of *Anthurium* found severe damage on flowers and leaves caused by banded greenhouse thrips, *Hercinothrips femoralis* (O. M. Reuter). Banded greenhouse thrips is a widely distributed pest throughout the world and can attack many crops. Typical symptoms on *Anthurium* are numerous small brown and irregularly sized spots on young leaves and new flowers. The damaged leaves and flowers are usually smaller than the healthy ones, eventually causing complete loss of the plant's aesthetic value. Thrips control during *Anthurium* production has been mainly through chemical means, such as applications of Orthene (acephate), Avid (abamectin) and other chemicals. The use of these chemicals indoors, however, remains questionable because of potential hazardous effects to human beings. The objectives of this study were to evaluate the most popular *Anthurium* cultivars' response to thrips and provide growers and interior plantscapers with cultivars exhibiting a potential for thrips resistance.

Finished *Anthurium*, cultivars 'Mary Jean', 'Lollipop', 'Pink Frost' and 'Sherry Lynn' grown in 8" pots, and cultivars 'Bubble Gum', 'Cotton Candy', 'Nicolien' and 'Red Hot' in 6" pots were obtained from growers and acclimatized in a shade house under a light level of 1,000 foot candles (190 $\mu mol \cdot m^{-2} \cdot s^{-1}$) for three weeks. The plants were then placed into interior rooms under light levels of 25, 50 and 100 foot candles (4, 8, and 16 $\mu mol \cdot m^{-2} \cdot s^{-1}$ respectively), temperatures of 75 to 80 °F and humidity of 60%. The experiment was a complete randomized design with three replications. Three plants of each cultivar remained in the shade house as controls. The thrips population was naturally occurring, i. e., no thrips were released into the experiment. Two months after being placed in the interior rooms, thrips damage to the eight *Anthurium* cultivars was scored according to the following ratings and criteria: (1) no damage; (2) very little feeding on the lower epidermis of the leaf, plants were salable; (3) noticeable feeding damage with leaf distortion, barley salable, (4) significant distortion and/or necrotic feeding damage, not salable; and (5) severe damage, not salable.

Results and Discussion: Results indicated significant cultivar differences in thrips damage (Table 1). 'Sherry Lynn' was markedly damaged; 'Pink Frost' and 'Mary Jean' were moderately damaged; 'Red Hot', 'Cotton Candy' and 'Lollipop' were only slightly damaged. No damage was noted on 'Nicolien' and 'Bubble Gum', regardless of interior light levels. 'Mary Jean' was less damaged under the light level of 100 foot candles than under 25 and 50 foot candles. There was no observed thrips damage on any of the control plants, suggesting that light intensity may be an important factor that can trigger thrips infestations. In addition, the thrips showed no flower color preferences in this study.

Significance to Industry: Since interior plantscapes require more environmentally sound practices for pest control, the identified resistant cultivars should have potential for being used in pesticide free interior environments. Although further confirmation is needed, this study did reveal cultivar differences in response to banded greenhouse thrips damage.

Literature Cited:

1. Griffith, L. P. 1998. Tropical Foliage Plants: A Grower's Guide. Ball Publishing. Batavia, IL

2. Gill, S., and J. Sanderson. 1998. Ball Identification Guide to Greenhouse Pests and Beneficial. Ball Publishing. Batavia, IL

3. Henny, R. J., A. R. Chase and L. S. Osborne. 1991. Anthurium Production Guide. CFREC-Apopka Research Note RH-91-3.

Table 1. Mean ratings of *Anthurium* cultivars damaged by banded greenhouse thrips, *Hercinothrips femoralis* (O. M. Reuter), grown indoors under three light levels[z].

	Interior light level (foot candles)		
Cultivar	25*	50**	100**
Bubble Gum	1.0 b	1.0 b	1.0 c.
Cotton Candy	1.7 ab	1.7 b	1.7 bc
Lollipop	1.7 ab	1.7 b	2.3 bc
Mary Jean	3.0 a	3.0 a	1.7 b
Nicolien	1.0 b	1.0 b	1.0 c
Pink Frost	3.0 a	3.0 a	3.0 ab
Red Hot	2.0 ab	1.7 b	2.7 abc
Sherry Lynn	3.0 a	3.7 a	4.0 a

[z]Thrips damage ratings: (1) no damage; (2) very little feeding on the lower
epidermis of the leaf, plants were salable; (3) noticeable feeding damage with leaf distortion, barley salable, (4) significant distortion and/or necrotic feeding damage, not salable; and (5) severe damage, not salable.

* For the column, means followed by the same letter do not differ according to Duncan's New Multiple Range Test (p=≤ 0.05).

** For the columns, means followed by the same letter do not differ according to Duncan's New Multiple Range Test (p=≤ 0.01).

Potential Role of Wildflowers in Pest Management

S. Kristine Braman, Department of Entomology, University of Georgia, Georgia Station, Griffin, GA 30223-1797

Index Words: Biological Control, Landscape, Predators, Parasites, Fall Armyworms, Turf, Wildflowers

Nature of Work: In urban landscape pest management there are few examples of classical biological control successes. However, conservation and augmentation of naturally occurring beneficial arthropods (1,2) is a promising strategy for biologically-based pest management in outdoor urban environments. This research seeks to determine whether the addition of wildflower plantings will enhance the occurrence, abundance, and impact of beneficial arthropods in adjacent turfgrass areas. Plots were installed at the Georgia Station Research and Education Garden in Griffin, GA in March 1998. Plots each contained 133.9 yd^2 (111.6 m^2) turf area surrounded on three sides by a 3.3 yd (3 m) wide border of either 'Border Patrol' pest control wildflower mix or Smith wildflower mix or bare cultivated soil. All borders were mulched at planting with straw. Turfgrass interiors in each plot were equally divided between 'Emerald' zoysia grass (less susceptible to fall armyworm) and 'Tifway' bermuda grass (more susceptible to fall armyworm). Three replications of each treatment were installed with a minimum of 33.6 yd (30.5 m) between plots. Arthropod activity in each turf type and in each border type was measured using vacuum and pitfall samples. At the Georgia Station turf was artificially inoculated with fall armyworm eggs and neonate larvae during July and August. Fate of eggs following a 2-hour exposure period was determined. Neonate larvae (100 per plot) were released into the center of each plot. Number of larvae recovered 24 h later using a Vortix vacuum sampler were compared among border types.

Results and Discussion: Relative abundance of beneficial arthropods varied among ground cover types as illustrated in Table 1 and Figure 1 for collections on July 28. Ant, formicidae were among the more numerous predators; their abundance varied by date and among cover types (Figure 2). When 900 fall armyworm eggs were exposed in turf for 24 hours, < 1% were recovered. When 900 fall armyworm eggs were exposed for a 2 h period, survival ranged from 33.7 to 74.9% depending on turfgrass border (Figure 3). Lowest survival was observed in turfgrass plots surrounded by Smith Mix. When 100 neonate larvae were released per plot, the number recovered 24 hours later varied depending on plot border type (Figure 4). Lowest survival was observed in plots surrounded by Border Patrol Mix.

Significance to the Industry: A potential for wildflower mixes that are commonly available to attract beneficial arthropods to home and commercial landscapes and recreational turf was demonstrated during 1998. Wildflower plantings can enhance natural pest control in the landscape by serving as refugia and nectar and pollen sources for generalist and specialist predators and parasites.

Literature Cited:

1. Braman, S.K. and A. F. Pendley. 1993. Relative and seasonal abundance of beneficial arthropods in centipedegrass as influenced by management practices. J. Econ. Entomol. 86: 494-504.

2. Braman, S.K. and A.F. Pendley. 1993. Activity patterns of Carabidae and Staphylinidae in centipedegrass in Georgia. J. Entomol. Sci. 28: 299-307.

Table 1. Relative abundance of beneficial arthropods in various cover types (7-28-98)

	Smith Mix	Border Patrol	Mulch	Bermuda/ SM	Bermuda/ BP	Bermuda/ Mulch	Zoysia/ SM	Zoysia/ BP	Zoysia/ Mulch
Parasitic Wasps	10.7 a	5.3 b	0.7 c	1.0 c	0.7 c	1.3 c	0 c	2.0 c	0.3 c
Ants	7.3 bc	16.7 a	0 d	6.3 bcd	6.7 bcd	2.7 bcd	2.3 bcd	8.3 b	1.3 cd
Stilt bugs	0 a	4.3 a	0 a	0 a	0.7 a	0 a	0 a	0.3 a	0 a
Big-eyed bugs	2.7 a	0.3 b	0 b	2.7 a	1.3 ab	1.7 ab	0.3 b	0 b	0.3 b
Spiders	4.0 a	4.3 a	1.3 a	9.3 a	3.7 a	6.7 a	5.0 a	3.0 a	10.7 a

Fig. 1. Beneficial arthropod activity in turfgrass and wildflowers (7-28-98)

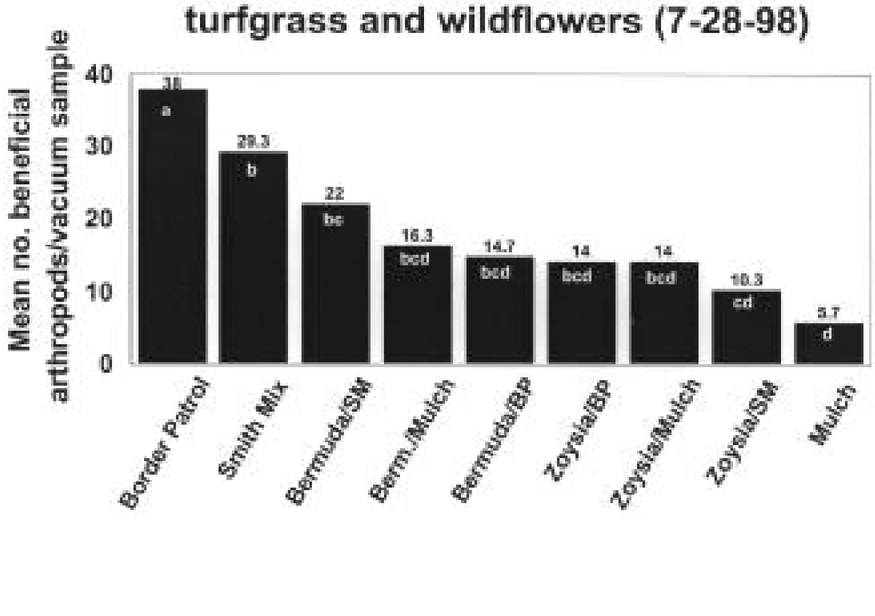


Fig. 2. Ant activity in different cover types

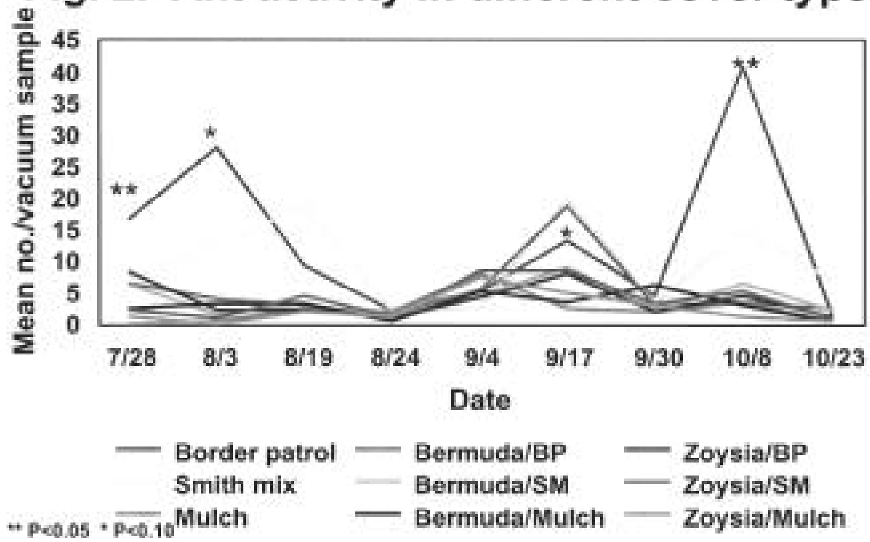


Fig. 3. Fate of fall armyworm eggs following a 2-hour exposure in turfgrass (7-28-98).

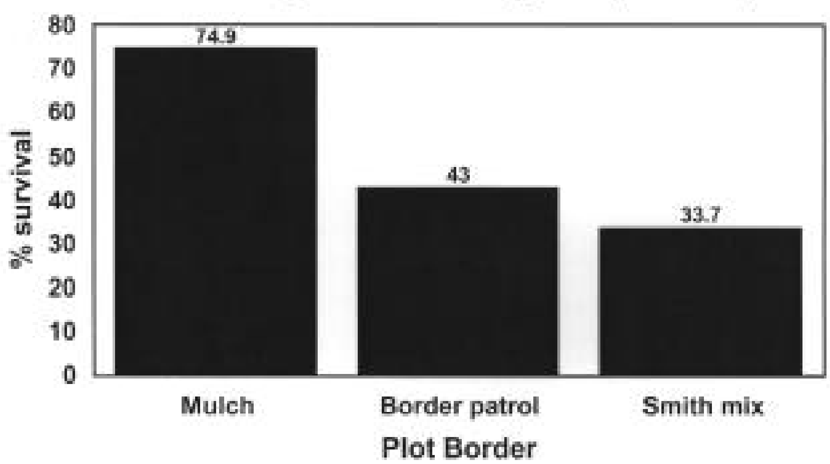
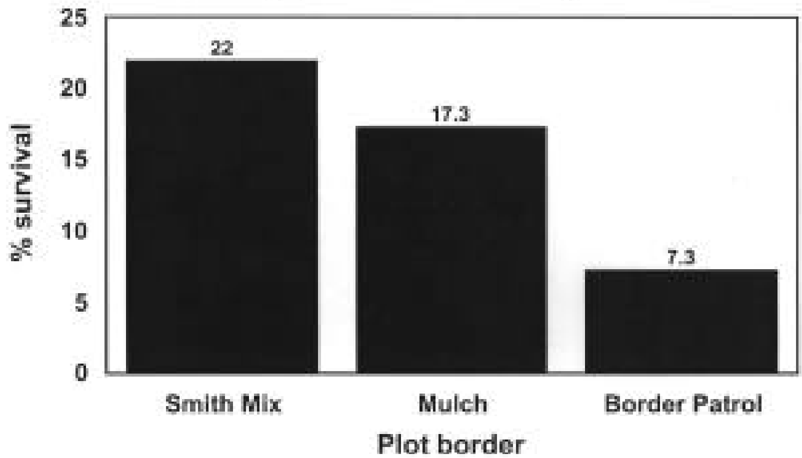


Fig. 4. Fate of fall armyworm larvae in turfgrass with differing borders.



Insect Resistance Evaluations among 58 Ornamental Crabapples

W. E. Klingeman, W. T. Witte, and P. C. Flanagan
University of Tennessee, Department of Ornamental Horticulture and Landscape Design, P.O. Box 1071, Knoxville, TN 37901-1071

Index Words: Crabapples, *Malus* spp., Pest Resistance, Eastern Tent Caterpillar, Tortricidae

Nature of Work: Ornamental crabapples (*Malus* spp.) are small to medium sized trees, representing over 300 species and cultivars, that are widely planted in the landscape (1). Many crabapples are susceptible to disease and insect pests resulting in challenges for both nursery production and management in the landscape. Studies conducted in several plant growth zones, have investigated crabapple varietal susceptibility to diseases (8,9), Japanese beetles (2,3,4,5,7), and lepidopteran pests (6). In 1992, a collection of 58 crabapple cultivars donated by the J. Frank Schmidt & Son Nursery Co. were planted in 5 replications, three trees of each cultivar per replication, at the Tobacco Experiment Station, Greeneville, TN (USDA zone 6b). On April 20 and May 4, 1999, cultivars were evaluated for resistance to the eastern tent caterpillar, [*Malacosoma americanum* (Fabr.)] and an unidentified tortricid leaf-rolling caterpillar (Lepidoptera:Tortricidae). On April 20, independent observers made counts of the number of *M. americanum* tents per tree. On May 4, when eastern tent caterpillars were observed leaving the trees to pupate, defoliation was independently ranked, where (1.0) represented uninjured trees, (2.0) represented 1-25% defoliation of the entire plant canopy, (3.0) represented 26-50% defoliation, (4.0) represented 51-75% defoliation, and (5.0) represented 76-100% defoliation. Also, on May 4, the number of injured terminal tips, attributed to an unidentified tortricid leaf roller, were counted among five randomly selected 15 cm sections of new growth per tree. Data presented in Figure 1 and 2 represent cultivar means for values that were averaged among the three trees in each replicate.

Results and Discussion: Although injury caused by the tortricid caterpillar was minor and would not warrant chemical control in the landscape, limited consistencies in crabapple cultivar preferences were apparent among the two lepidopteran pests. No correlation was apparent for the feeding injury of either pest with crabapple leaf color (Figure 1 and 2). ‘Red Baron’, ‘Winter Gold’, and ‘White Angel’ had high levels of tent caterpillar defoliation (Fig. 1) and more terminal stem tip injury caused by the tortricid leaf roller (Fig 2). Both pests caused little injury to

'Sargent', 'Coral Burst', and 'Brandywine' crabapples. In contrast, a Michigan study found no eastern tent caterpillar infestations among 'Red Baron' crabapples but moderate infestations in 'Brandywine' trees (6). Selection of crabapples for landscape use and production in the Southeast should be based, in part, on eastern tent caterpillar injury as well as feeding preferences of the Japanese beetle (*Popillia japonica* Newman). Injury among the crabapples at the Tobacco Expedriment Station, which could be attributed to Japanese beetle feeding, had not been assessed in time for submission with this report. However, researchers have identified linalool, a volatile compound, as a key component in determining plant attractiveness to Japanese beetles (3). In a separate study, plant resistance was positively correlated with the phenolic agent phloridzin, which may act independently to limit beetle feeding (2). Those studies found 'Radiant', 'Red Splendor', 'Dolgo', 'Royalty', and Baskatong' to be susceptible cultivars, while *M. baccata* 'Jackii', 'Harvest Gold', 'Jewelberry', 'David', *M. floribunda*, and 'Brandywine' were resistant to Japanese beetles (2,3). Observations of Japanese beetle preferences among crabapple cultivars at the Tobacco Experiment Station will be undertaken this summer.

Significance to Industry: Successful ornamental nurseries are faced with the challenges of producing abundant, high quality nursery stock and are continually searching for new plant materials. Growers are often limited in the numbers of cultivars that they can produce by space or sales constraints. Cultivars of ornamental plants resistant to diseases and insect pests are in increasing demand by landscape architects and landscape management professionals. Nursery growers benefit by producing pest resistant cultivars that require less chemical input and reduced labor investments to control pests.

Literature Cited:

1. Guthery, D.E. and E. R. Hasselkus. 1992. Jewels of the landscape. Am. Nurseryman 175:28-35, 38-41.

2. Fulcher, A. F., T. G. Ranney, J. D. Burton, J. F. Walgenbach, and D. A. Danehower. 1998. Role of foliar phenolics in host plant resistance of *Malus* taxa to adult Japanes beetles. HortScience 33(5): 862-865.

3. Loughrin, J. H., D. A. Potter, T. R. Hamilton-Kemp, and M. E. Byers. 1996. Volatile compounds from crabapple (*Malus* spp.) cultivars differing in susceptibility to the Japanese beetle (*Popillia japonica* Newman)

4. Potter, D. A., P. G. Spicer, D. Held, and R. E. McNiel. 1998. Relative susceptivility of cultivars of flowering crabapples, lindens, and roses to defoliation by Japanese beetles. J. Environ. Hort. 16(2): 105-110.

5. Ranney, T. G. and J. F. Walgenbach. 1992. Feeding preference of Japanese beetles for taxa of birch, chery, and crabapple. J. Environ. Hort. 10(3): 177-180.

6. Smitley, D. R. and N. C. Peterson. 1993. Evaluation of selected crabapple cultivars for insect resistance. J. Environ. Hort. 11(4): 171-175.

7. Spicer, P. G., D. A. Potter, and R. E. McNiel. 1995. Resistance of flowering crabapple cultivars to defoliation by the Japanese beetle (Coleoptera: Scarabaeidae). J. Econ. Entomol. 88(4): 979-985.

8. Tilt, K. M., A. Hagan, J. D. Williams, A. K. Akridge, and W. T. Witte. 1997. Evaluation of crabapple cultivars in zone 8. Proc. SNA Res. Conf. 42: 523-526.

9. Windham, M. T., A. S. Windham, and W. T. Witte. 1997. Fireblight and frogeye leafspot resistance in crabapple cultivars. Proc. SNA Res. Conf. 42:232-233.

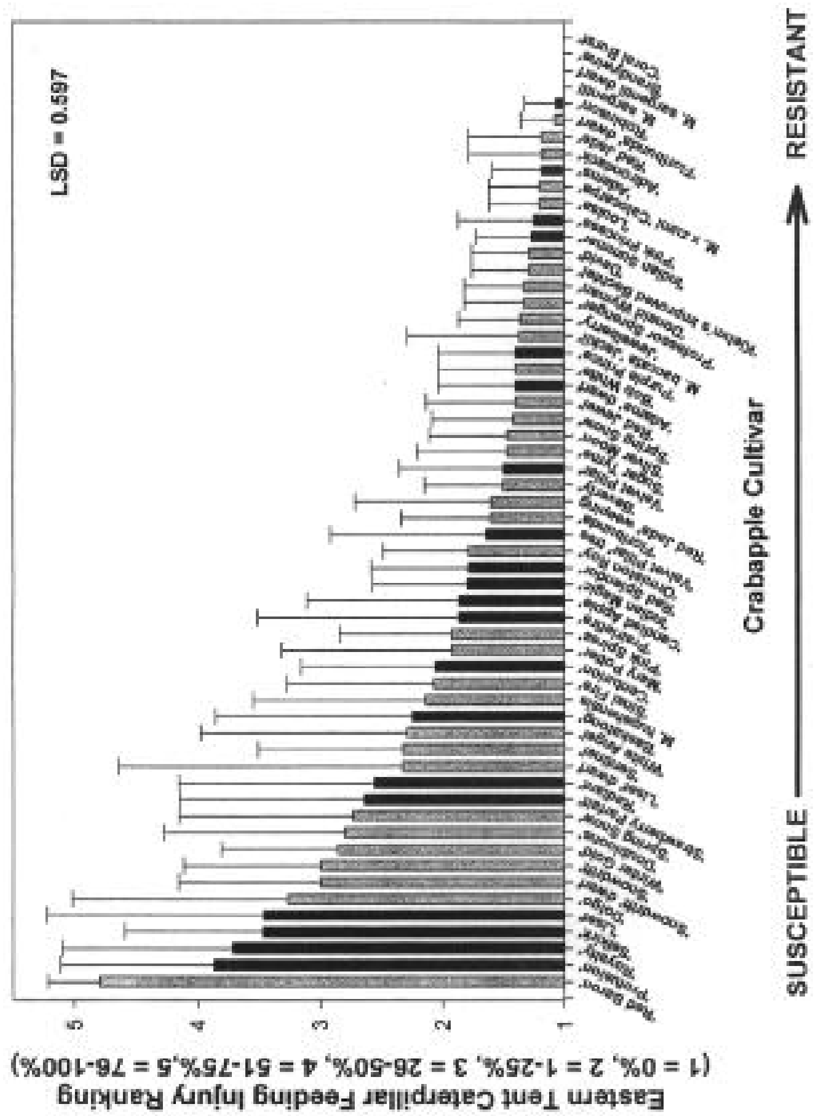


Figure 1. Eastern tent caterpillar [*Malacosoma americanum* (Fabr.)] injury rankings of crabapple cultivars on May 4, 1999 at the Tobacco Experiment Station in Greeneville, TN. Dark bars represent dark purple-and light purple/green-leaved cultivars and light bars represent green-leaved cultivars.

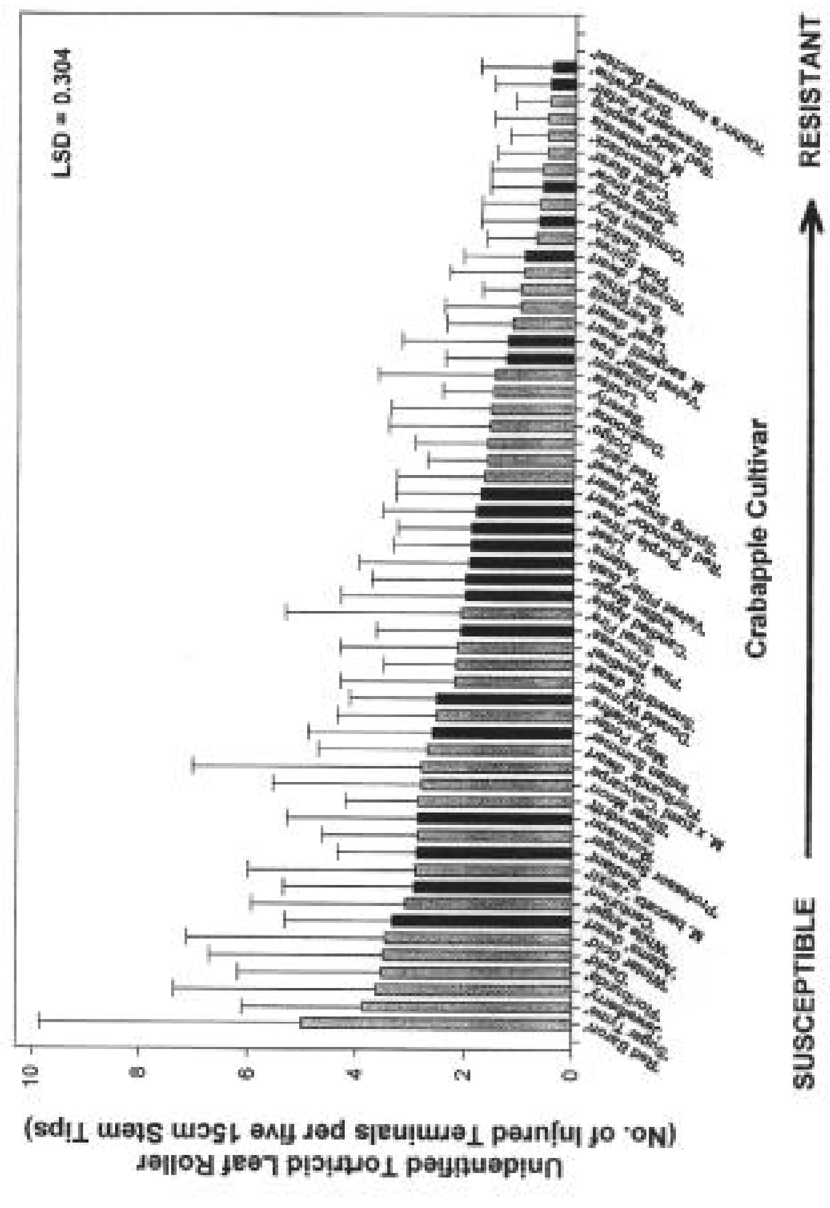


Figure 2. Crabapple terminals injured by an unidentified tortricid leaf roller (Lepidoptera: Tortricidae) observed on May 4, 1999 at the Tobacco Experiment Station in Greeneville, TN. Dark bars represent dark purple-and light purple/green-leaved cultivars and light bars represent green-leaved cultivars.

Trapping Asian Ambrosia Beetles in Virginia

P.B. Schultz and C.S. Whitaker
Virginia Tech Hampton Roads AREC, Virginia Beach, VA 23455

Index Words: Asian Ambrosia Beetle, Insect Monitoring, Pest Management

Nature of the work: The Asian ambrosia beetle, *Xylosandrus crassiusculus* (Motshulsky), has become a pest of a wide variety of nursery and landscape trees. Introduced into the U.S. in 1972, it attacks apparently healthy trees and inoculates them with a fungus used to feed its larvae. As the insect digs galleries in the wood, the sawdust and frass are extruded from the entrance hole in the form of brittle "toothpicks." These structures are often the first indication that a tree is under attack. Heavily infested trees usually die.

In order to devise a plan of control, the flight times of the insect must be known. We also wanted to determine if the damage we observed in nursery stock was the result of one species alone or several species infesting the trees sequentially. In this study we deployed traps in early spring at three nurseries where the presence of *X. crassiusculus* was observed or suspected. The nurseries are surrounded by woods, which provide overwintering sites for the beetles. Metal funnel traps designed for Japanese beetle monitoring, were modified with a lure of 70% denatured ethanol in a container with a dental wick and a vial with antifreeze as a killing agent and preservative. The traps were set out in blocks of Kwansan cherry trees, a known host, checked weekly March/April to October/November, 1996-1998, and the collected insects were tabulated.

Results and Discussion: The results of the study are shown in Figures 1-3. Site 3 was removed from the third year of the study due to the low number of ambrosia beetles recovered. Sites 1 and 2 remained active sources of ambrosia beetles, with collections at Site 1 generally higher than Site 2.

The first peak of flight activity occurred before traps were set out in April, 1996. A second peak of activity occurred in late summer and early fall. In 1997, the traps were set out in April as the first emergence peak was in progress, and a second peak was also observed. In 1998, the first peak was captured in late March. Large numbers of smaller, unidentified, borers were also recovered from the traps. Specimens of these unidentified borers are presently being identified. The timing of the appearance of these beetles in the traps and the quantities collected were similar to the ambrosia beetle. These beetles have also been recovered from infested trees next to the traps. It is unclear whether these beetles are part of an ambrosia beetle complex, or merely attracted to the traps and stressed trees.

Significance to Industry: As Asian ambrosia beetles attack apparently healthy trees, merely keeping the nursery stock in good condition is not sufficient protection against crop loss. Trees that are attacked are usually killed. Prophylactic sprays with insecticides have produced mixed results. Knowing when the insects are active will determine the most effective timing for any sprays used. Current recommendations include leaving infested trees in place for 30 days. Fewer individual trees will be more heavily attacked, with fewer trees killed.

Literature Cited:

1. Mizell, R.F., III, A. Bolques, and P. Crampton. 1998. Evaluation of insecticides to control Asian Ambrosia Beetle, Xylosandrus crassiusculus. Proc. Sou. Nur. Assoc. Res. Conf. 43:162-165.

2 Ree, B., J. Robinson, R. Mizell, III, W. Hudson, B. Sparks, F. Hale, and C. Mannion. 1998. Biology and integrated pest management of the Asian ambrosia beetle. Proj. Summ. Rpt. Hort. Res. Inst. 22p.

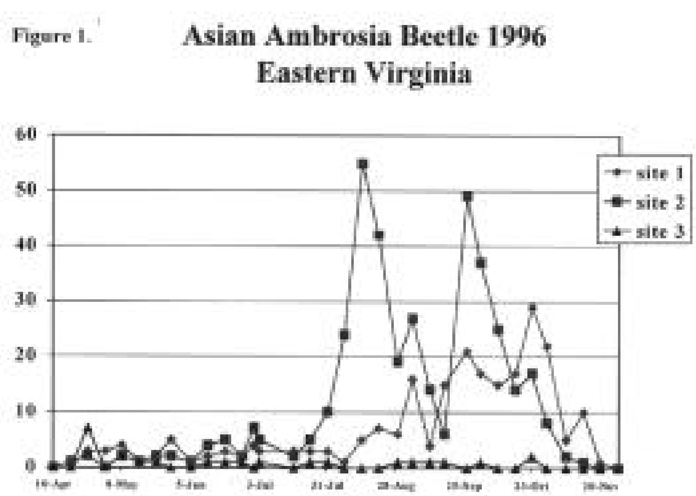


Figure 1.- Emergence trapping of Asian ambrosia beetle, 1996.

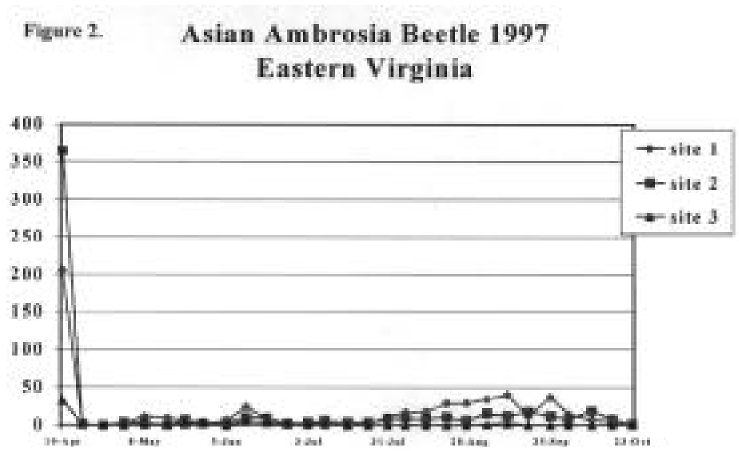


Figure 2.- Emergence trapping of Asian ambrosia beetle, 1997.

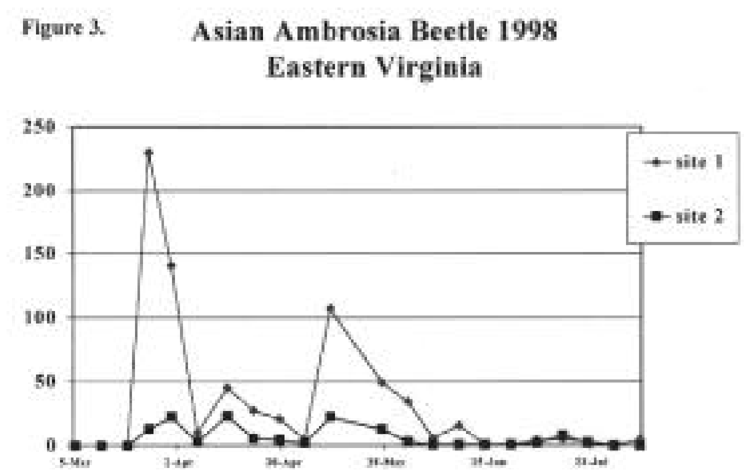


Figure 3.- Emergence trapping of Asian ambrosia beetle, 1998

Management of Asian Ambrosia Beetle, *Xylosandrus crassiusculus*, in Nurseries

Will Hudson[1] and Russ Mizell[2]
Department of Entomology, University of Georgia, Tifton, Ga[1] and University of Florida, AREC, Monticello, FL[2]

IndexWords: Asian Ambrosia Beetle, Nursery IPM, *Xylosandrus crassiusculus*

Nature of Work: A management program for Asian Ambrosia Beetle was developed and implemented in nurseries in Georgia and Florida based on trapping data and insecticide screening trials from the last 4 years.

The Asian Ambrosia Beetle (AAB) has become a serious pest for nurseries across the south in recent years (1). These beetles have proven difficult to control with the barrier sprays typically used in the industry for prevention of damage from other types of borers such as clearwing moths and long-horned beetles. While nurseries throughout the region have suffered losses each season, the number of locations experiencing severe problems has varied greatly from year to year. Trapping data from locations in north Florida and Georgia have provided some information about seasonal occurrence of adult females, but no clear pattern emerged that would allow prediction of the location or severity of outbreaks.

Pesticide screening trials (2) shed some light on relative efficacy of the insecticides available to nurserymen for control of borers. In general, synthetic pyrethroid insecticides were more effective than chlorpyrifos or lindane, the materials most commonly used for borer control in nursery stock. Apparently, the sprays growers had been using were essentially useless for AAB control.

The management recommendation that emerged from the several years of trapping and screening included trapping adult females in late winter to determine when the flight began in a particular location(2) and spraying with synthetic pyrethroid insecticides at 10-14 day intervals once the beetles were active in an area. Because nursery plant losses to the AAB are limited to the time when the plants are breaking dormancy and flushing out in the spring, we also recommended that growers spray at this time and discontinue spraying particular plants once they were completely leafed out. An additional suggestion was that trees showing signs of AAB attack (small holes with frass/sawdust “toothpicks”, wilting, running sap from entry holes) be moved to the edge of the block. These attacked trees serve as a “trap crop” to attract arriving beetles and reduce the overall number of plants attacked.

In 1999, two nurseries in Georgia and one in north Florida had traps operated by UF or UGA personnel to monitor beetle flight. Another nursery in south Georgia installed and operated traps of their own but cooperated closely with the others. Once beetles were detected, insecticide sprays were initiated and continued through the spring green-up period as long as beetles were active. Trees that were attacked were flagged and inspected, sometimes destructively, to determine the age and status of the infestation and progress of beetle reproduction.

Results and Discussion: The value of trapping was immediately demonstrated. The first flights, which had occurred in early to mid-March in the previous four years, began the week of Feb. 17 Cold weather returned a few days later, and virtually no beetles were trapped until mid-March when spraying was resumed. Beetle flights were sporadic for the rest of the spring.

While the program of trapping and using pyrethroid sprays did not prevent attack from AAB, it did limit losses from the beetles. Inspection of individual plants with signs if AAB attack revealed a striking difference between those sprayed with pyrethroids and those that were unsprayed or treated with chlorpyrifos or lindane. There was a very low incidence of successful attack in pyrethroid-treated plants; generally, less than 25% (often less than 10%) of the tunnels had beetles or fungus colonization of the tunnel walls. Because the most detrimental effects of AAB attack come from introduction of pathogenic fungi into the vascular system, growers were encouraged to monitor attacked plants for the wilting that indicates fungal infection. Most pyrethroid-treated plants recovered and will, apparently, heal completely with no detectable damage in the long run. This is in sharp contrast to the situation in untreated or traditionally treated plants. Few attacks on that group were unsuccessful, and inspection of the tunnels showed the beetles and fungi were reproducing actively.

Significance to the Industry: Although there are still many important questions to be answered about AAB, this program provides an AAB management strategy for growers while research is ongoing. Better understanding of which cues the beetles use to select hosts would allow even more refinement of treatment scheduling. Predicting which nurseries will experience problems in a given year would allow growers to spray only when necessary, saving money and reducing the amount of pesticides introduced into the environment. Timing treatments to coincide with beetle activity should result in fewer and more effective treatments. Monitoring for adult females in late winter is key to this management strategy. Both Kovach traps (3) (Fig. 1) and a commercially available windowpane trap from Theysohn are effective for trapping AAB.

Literature Cited:

1. Mizell, R. S. Braman, B. Sparks, and W. Hudson. 1994. Outbreak of the Asian ambrosia beetle, Xylosandrus crassiusculus (Motschulsky), is cause for concern. Proc. SNA. 39:191-193.

2. Mizell, Russell F., A. Bolques, and P. Crampton. 1998. Evaluation of insecticides to control the Asian ambrosia beetle, Xylosandrus crassiusculus. Proc. SNA. 43:162-165.

3. Kovach, J. 1986. Life cycle, seasonal distribution and tree responses to scolytid beetles in South Carolina peach orchards. Ph.D. Dissertation, Clemson Univ. 78 pp.

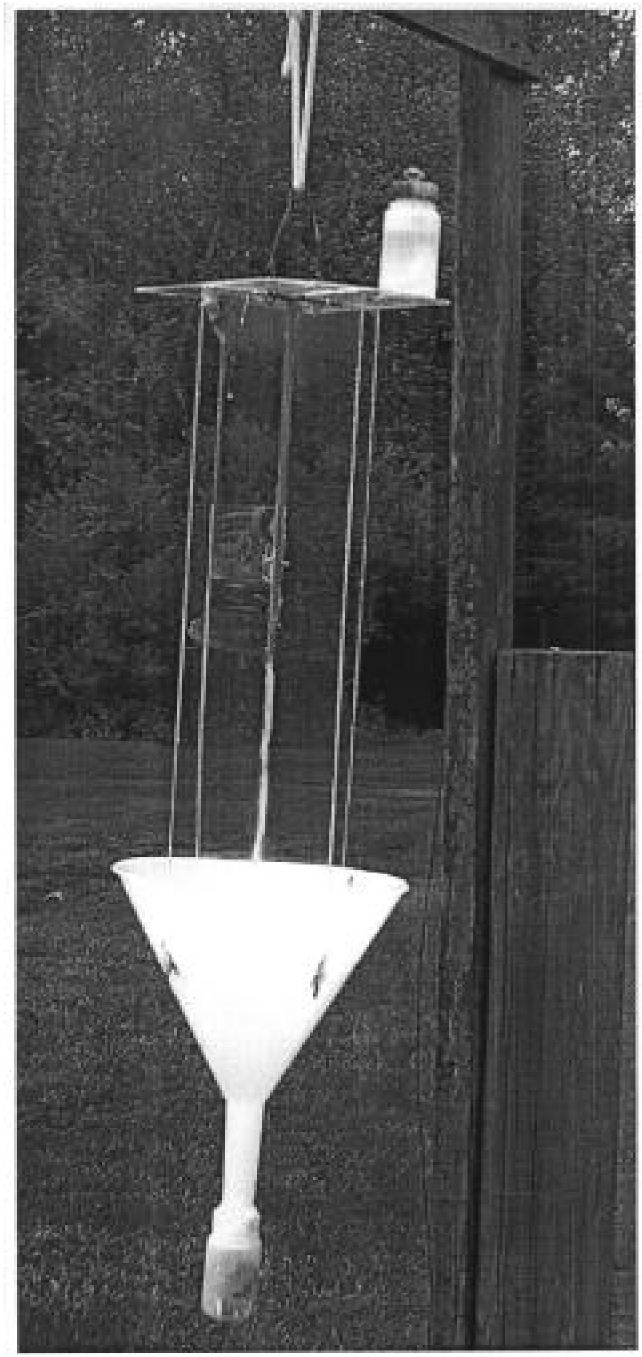


Fig 1. Kovach trap baited with ethanol wick bottle.

Kentucky Nursery Inspection: Regulation through Education

Joseph T. Collins and Carl W. Harper
University of Kentucky, Dept. of Entomology,
Lexington, KY 40546-0091

Index Words: Nursery Inspection, Kentucky, Regulation

Nature of Work: Kentucky's Nursery Inspection Program differs from most other states in the United States in that it is operated out of the University of Kentucky rather than the State Department of Agriculture. The Kentucky Revised Statutes (KRS) Chapter 249 – Trees, Plants, Weeds and Pests states, "The chair of the Department of Entomology of the Agricultural Experiment Station at the University of Kentucky shall be the state entomologist" (1). For this reason and because Kentucky's Cooperative Extension Service is also a part of the University of Kentucky's College of Agriculture, we have chosen to conduct our nursery regulation using what we term, "an Extension style." This style allows us to work with growers both as advisors and as regulators. As a result of this system our growers have a different mindset about regulation. This unique situation allows us to utilize university resources to teach the nursery industry about plant pests, diseases, quarantines, etc.

We have implemented several methods to educate Kentucky's nursery industry. Beginning in 1997, we developed "Inspector Findings in Kentucky", a monthly newsletter issued during the months of April through September. The newsletter consists of short articles relating to various plant pests and diseases, which are contributed by Extension specialists in Entomology, Horticulture and Plant Pathology. Color pictures of key insect pests seen during nursery inspections or pests that should be monitored in the upcoming month are featured. Insects and diseases that historically have been a problem in the upcoming month are listed on the front page.

Initially, we only sent the newsletter to licensed nurseries. In 1999, we expanded the newsletter distribution to include the Class A Dealers (landscapers and garden centers). Today, approximately 500 newsletters are distributed each month.

In the fall of 1997 we began to utilize the Internet by developing a web site (www.uky.edu/Agriculture/NurseryInspection) for our nursery inspection program. Our web site includes: the "Inspector Findings in Kentucky" newsletter (both current and past issues), information about gypsy moth and the annual gypsy moth detection survey, a listing of certified nurseries and nursery dealers, information on the history of the Kentucky nursery law and a link to a copy of the Kentucky nursery law, application forms for the Kentucky nursery/dealer license (both printable and on-line versions) and links to various other nursery-related web sites. Linked sites include: Asian long-horned beetle, state departments of agriculture, U.S. Department of Agriculture, National Plant Board, Kentucky Nursery and Landscape Association, American Nursery and Landscape Association, and Southern Nursery Association. Future plans for our web site include pictures of insects and diseases common to Kentucky nurseries and links to licensed nurseries or dealers in Kentucky that have their own web site.

Results and Discussion: Many in the nursery industry have stated that they like our style of inspections. They feel that the nursery inspection program is a resource they can utilize to help solve their pest management problems.

Our newsletter has received a great deal of positive feedback. Growers have stated they enjoy the color pictures of pests encountered during nursery inspections and the list of pests to monitor in the coming month. It gives them a direction for their pest management programs. They also like the articles because the information is directly applicable to current and/or future problems.

Utilization of the web site is continuing to grow as more growers are connecting to the Internet. Kentucky Extension horticulture agents and interested parties from outside our state have also found our web site useful. Our regularly updated list of certified nurseries and dealers has proven to be a big help to officials in other states.

Significance to Industry: It is our hope that by educating the nursery industry, we can prevent or reduce many nursery pest problems. We also hope our education program will help to slow or prevent the establishment of devastating exotic pests such as the gypsy moth and the Asian long-horned beetle in Kentucky.

It is often said “an ounce of prevention is worth a pound of cure”. The goal of the Kentucky Nursery Inspection Program is to be that “ounce of prevention”.

Literature Cited:

1. Kentucky Revised Statutes. 1996. Trees, Plants, Weeds and Pests. Kentucky General Assembly, Frankfort, KY. Chapter 249.

The Interaction Between Two Soil Insecticides (Imidacloprid and Halofenozide) and *Tiphia vernalis*, a Parasitoid of Japanese Beetle

Catharine Mannion and Michael Klein
TSU Nursery Crop Research Station, McMinnville, TN 37110

Index Words: *Popillia japonica*, Japanese Beetle, Imidacloprid, Nalofenozide, *Tiphia*

Nature of Work: Japanese beetle (*Popillia japonica* Newman) was accidentally introduced into the U.S. early this century, and very quickly became a significant pest due to the favorable climate, abundance of host plants, and lack of natural enemies (1). Japanese beetle adults feed on the foliage, fruit, and flowers of more than 300 plant species and the immature stages (grubs) feed on the roots of a wide variety of plants, including most grasses, ornamental plants, and vegetables (1, 2). The potential spread of Japanese beetles is a great concern to many states because this pest can be artificially spread through several avenues. Movement of nursery stock and its soil infested with the Japanese beetle grubs has been a contributing factor in the spread of Japanese beetles to uninfested areas. Although the federal quarantine for nursery stock was terminated, individual states maintain quarantines or certification requirements in order to reduce the risk of Japanese beetle introductions. To reduce the chance of Japanese beetle grub exportation, soil insecticide treatments have been recommended for nursery stock prior to shipping.

The effect of some of the suggested insecticide treatments on natural enemies of Japanese beetle is not known. Previous studies have shown that broad-spectrum insecticides applied to turfgrass can reduce the abundance and diversity of beneficial invertebrates and predators (3). The Spring *Tiphia, Tiphia vernalis* (Hymenoptera: Tiphiidae) is a parasitic wasp that searches for white grubs in the soil environment (4). The immature wasp develops externally on the grub ultimately consuming and killing it. *Tiphia vernalis* has recently been found in Ohio, North Carolina, Indiana and Tennessee. The Spring *Tiphia* searches for grubs in the late spring, a period that may coincide with applications of insecticides that target early instars of the Japanese beetle. Marathon (imidacloprid) which is registered for use in commercial nurseries and Mach2 (halofenozide) which is a turf insecticide, are two examples of insecticides that target early instars Japanese beetle.

The objectives of these tests were to determine if exposure to either Marathon or Mach2 would affect the ability of *T. vernalis* adults to parasitize Japanese beetle grubs or the ability of the parasite larvae to develop on grubs exposed to treated soil. The laboratory experiments were conducted in two phases. In the first phase, adult *Tiphia* were exposed to insecticide-treated soil prior to parasitism and in the second phase, the grubs were exposed to insecticide-treated soil prior to being parasitized. Marathon 60WP was applied at 0.4 lb ai/A (3g product per 2 kg soil) and Mach2 2F was applied at 2 lb ai/A (16µl product per 2 kg soil). *Tiphia* were field collected and held in cages with a food source (sugar water) in the laboratory until use. Japanese beetle grubs were field collected and stored in containers of soil in the laboratory until use.

In the first phase, one adult *Tiphia* was placed in each test container (8 oz. plastic cup) filled with either soil treated with Marathon, soil treated with Mach2, or untreated soil. There were 30 replications per treatment. Four days after exposure, each *Tiphia* was removed and placed into a second test container with untreated soil and two third instar Japanese beetles. The *Tiphia* were removed from all containers two days later, and the grubs were examined for parasites four days after the *Tiphia* were removed. Additional observations at three and five weeks after the adult *Tiphia* were removed determined the percentage of *Tiphia* that successfully developed into pupae (cocoons). In the second phase, Japanese beetle grubs were exposed to insecticide-treated or untreated soil for four days as noted above. After the four-day exposure, the grubs were removed from the treated soil and placed in containers with clean soil. Two grubs were placed in each container with 30 containers (replications) per treatment (Marathon, Mach2 and untreated). One adult *Tiphia* was placed in each container for two days. Subsequent steps were the same as described in phase 1. Both phases of the test were repeated in a second test.

Results and Discussion: Overall, exposing Japanese beetle grubs or adult *Tiphia* to either Marathon or Mach2 for four days did not have a negative impact on parasitism (Tables 1 and 2). The only significant difference among treatments was in the second test in which there was greater parasitism of grubs by *Tiphia* exposed to Mach2 compared with parasitism of grubs by *Tiphia* exposed to untreated soil (Table 1). However, successful development of the *Tiphia* did not differ among treatments in subsequent evaluations. Initial parasitism of grubs exposed to Tiphia treated with either Marathon or Mach2 ranged from 23.3 to 50.0%. Successful development of *Tiphia* to the cocoon stage ranged from 5.0 to 20%. Initial parasitism of grubs exposed to either Marathon or Mach2 ranged from 49.2 to 56.7%. Successful development of *Tiphia* to the cocoon stage ranged from 8.0 to 27.1%. Initial parasitism of the untreated grubs and Tiphia ranged from 21.7 to 54.2% with successful development to the cocoon stage ranging from 5.0 to 22.0%.

These preliminary results demonstrate that exposing third instar Japanese beetle grubs or *Tiphia* adults to either Marathon or Mach2 did not have a negative impact on parasitism or development of *Tiphia* to the cocoon stage. More tests are necessary to determine the effect of insecticide exposure for longer periods of time as well as the effect on Tiphia after entering the cocoon stage.

Significance to Industry: Japanese beetle is a major pest, which requires integrated management to reduce its damage potential and the risk of spreading the beetle to non-infested areas. The use of soil insecticides is a necessary component of managing this pest. Using low impact insecticides will help conserve the natural enemies that play a role in reducing pest populations. These preliminary results demonstrate that both Marathon and Mach2 can be used without affecting the level of parasitism by *Tiphia vernalis*.

We would like to acknowledge and thank Jim Moyseenko, USDA-ARS, and Jason Oliver, Tennessee State University, for their help on this project.

Literature Cited:

1. Fleming, W. E. 1972. Biology of the Japanese beetle. U.S. Dep. Agric. Res. Serv. Tech. Bull. 1449.

2. Tashiro, H. 1987. Turfgrass Insects of the United States and Canada. 389p. Cornell University Press, Ithaca and London.

3. Terry, L. A., D. A. Potter, and P. G. Spicer. 1993. Insecticides affect predatory arthropods and predation on Japanese beetle (Coleoptera: Scarabaeidae) eggs and fall armyworm (Lepidoptera: Noctuidae) pupae in turfgrass. J. Econ. Entomol. 86(3): 871-878.

4. King, J. L. and L. B. Parker. 1950. The spring Tiphia, an imported enemy of the Japanese beetle. USDA, Bur. Entomol. Plant Quar. E-799. 8p.

Table 1. Parasitism of Third Instar Japanese Beetle by *Tiphia vernalis* and Development of *T. vernalis* after Exposing the parasites to Insecticides for Four Days.

Test	Treatment	Mean Percent Parasitism	Parasite Survival at 3 Weeks (%)	Parasite Survival at 5 Weeks (%)
Test 1	Marathon 60WP	23.3 a	15.0 a	6.6 a
	Mach2 2F	40.0 a	26.7 a	20.0 a
	Untreated	39.7 a	34.5 a	19.0 a
Test 2	Marathon 60WP	35.0 ab	15.0 a	5.0 a
	Mach2 2F	50.0 a	26.7 a	10.0 a
	Untreated	21.7 b	11.7 a	5.0 a

Table 2. Parasitism of Third Instar Japanese Beetle by Tiphia vernalis and Development of T. vernalis after Exposing the Third Instars to Insecticides for Four Days.

Test	Treatment	Mean Percent Parasitism	Parasite Survival at 3 Weeks (%)	Parasite Survival at 5 Weeks (%)
Test 1	Marathon 60WP	53.3 a	26.7 a	8.3 a
	Mach2 2F	53.3 a	28.3 a	25.0 a
	Untreated	52.5 a	32.2 a	22.0 a
Test 2	Marathon 60WP	49.2 a	35.6 a	27.1 a
	Mach2 2F	56.7 a	36.7 a	25.0 a
	Untreated	54.2 a	33.8 a	18.6 a

Insect Visitors to Flowers of Flowering Dogwood, *Cornus florida* L., in Eastern Tennessee: Potential Pollinators

Adriean J. Mayor, Jerome F. Grant, Mark T. Windham, Robert N. Trigiano
University of Tennessee, Entomology & Plant Pathology, Ornamental Horticulture & Landscape Design

Index Words: Flowering Dogwood, *Cornus florida* L., Flower Visiting Insects, Anthracnose Resistance

Nature of Work: Flowering dogwood, *Cornus florida* L., is an outstanding small spring blooming tree and is economically important to nursery producers, as well as environmentally important as a food source for many wildlife species. Unfortunately, dogwoods, especially in the natural environment, have been impacted recently by dogwood anthracnose, a fungal disease caused by *Discula destructiva* Redlin. Populations of dogwoods have declined in the northeastern United States, as well as in the Appalachian Mountain region. Research is underway at The University of Tennessee to develop anthracnose-resistant varieties of dogwood. Because only a few resistant trees are available for breeding programs, researchers need to develop new methodologies to enhance fruit set for breeding purposes. Insect pollinators may improve fruit set and seed production; however, the duration of the flowering period in flowering dogwood is short, lasting for only about 3 weeks, in eastern Tennessee. The presence of effective pollinators during this period may be an important factor for successful fruit set. Honey bees are not attracted to the flowers in large numbers (personal observations), presumably because the rewards (pollen and nectar) are too small. Natural fruit set is also low (1), with a seasonal range of 2.5% to 6.1%. Little scientific attention has been paid to insect visitors, primarily solitary bees, of flowering dogwood; this study was initiated to identify the insects (potential pollinators) attracted to the flowers of flowering dogwood in eastern Tennessee. Insects were sampled at the following four sites (sampling dates are listed in parentheses):

A Knox Co., Knoxville, Sequoyah Hills (13 April, 19 April, and 22 April,1999)
B Knox Co., Knoxville, Island Home (21 April 1999 - 11AM-12PM and 3-4PM)
C Knox Co., Knoxville, Univ. of Tenn. Agricultural Campus (15 April, 19 April 1999)

D Anderson Co., Oak Ridge, Univ. of Tenn. Arboretum (20 April, 22 April 1999)

Sampling was conducted from 13 April to 22 April 1999, as weather permitted. Each site was visited at least twice, with a minimum of four mature trees sampled per visit. An effort was made to visit the sites at different times of day; however, at most sites, insects were not active on the flowers until late morning, so most collecting took place in the afternoon. Collecting lasted from 1-2 hours, and insects were collected into individual vials, frozen, and pinned and labeled at a later date. Bees were identified using published keys (2, 3). All insect specimens were sorted to morphospecies; however, some (primarily 'other hymenoptera' and diptera) were identified only to family or genus. The identification of most insect species was verified during a visit to the Florida State Collection of Arthropods, Gainesville, FL (FSCA). Voucher specimens for this study are deposited in the insect collection of the Department of Entomology and Plant Pathology at the University of Tennessee, Knoxville, TN, and in the FSCA.

Results and Discussion: During the sampling period, 70 species of insects, representing 352 specimens in 5 orders and 35 families were collected from the flowers of dogwood. The orders are: Hymenoptera (11 families, 35 species, 257 specimens), Coleoptera (10 families, 15 species, 47 specimens), Diptera (12 families, 18 species, 45 specimens), Neuroptera (1 family, 1 species, 2 specimens), and Lepidoptera (1 family, 1 species, 1 specimen). Compared with other taxa, bees were found in greatest abundance and diversity at all sites, with 244 specimens representing 6 families and 27 species collected. Earlier studies (4) suggest that short-tongued bees play an important role in pollination of *C. florida*. This conclusion is supported by the current study, which found short-tongued bees to be the most diverse and prolific visitors to dogwood flowers. The short-tongued bees represent 3 families, 24 species, and 229 specimens, and were common at all collecting sites, with 8 species (*Andrena confederata* Viereck, *A. crataegi* Robertson, *A. illini* Bouseman & LaBerge, *A. imitatrix* Cresson, *A. miserabilis* Cresson, *Dialictus admirandus* Sandhouse, *D. imitatus* (Smith), and *D. zephyrus* (Smith)) collected from at least three sites. Only 15 specimens, representing 3 families and 3 species of long-tongued bees, such as the honey bee, *Apis mellifera* L., were collected from dogwood flowers. These bees were not attracted to the flowers in sufficient numbers to be effective pollinators. In fact, only six honey bees from two sites were collected. Other long-tongued bees collected included *Nomada bishoppi* Cockerell (4 specimens from 2 sites), a parasite of other solitary bees which does not forage for pollen, and *Osmia lignaria* Say (5 specimens) collected at the Island Home site. Many of the coleoptera and diptera collected feed on pollen or nectar and may play a secondary role in pollination; however, none was found in sufficient numbers to be considered effective pollinators. Following is a list of the insects we found associated with the flowers of flowering dogwood. Wherever possible, the sex of the specimens collected is listed, with the collection sites and number of specimens collected in parentheses separated by a colon.

HYMENOPTERA (35 species, 257 specimens):

Short-tongued bees (24 species, 229 specimens). **Colletidae** (5 Specimens). *Colletes inaequalis* Say &(B: 1), *C. thoracicus* Smith ♂(C: 1), *Hylaeus modestus* Say ♂(C: 2), *H. cressoni* (Cockerell)♂(D: 1). **Andrenidae** (99 specimens). *Andrena confederata* Viereck ♂(A: 9, B: 3, D: 4), *A. crataegi* Robertson ♂(A: 6, B: 1, C: 1), *A. cressonii* Robertson ♀ (B: 1, C: 1), *A. illini* Bouseman & LaBerge ♂ ♀(A: 13, B: 12, C: 4), *A. imitatrix* Cresson♂♀(A: 5, B: 3, C: 1), *A. miserabilis* Cresson♂♀(A: 8, B: 1, C: 5, D: 1), *A. nasonii* Robertson ♂ ♀(B: 6, C: 6), *A. personata* Robertson ♂♀(B: 1, D: 4), *A. viburnella* Graenicher ♀(A: 2), *A. vicina* Smith ♀(C: 1). **Halictidae** ♀(125 specimens). *Augochlorella aurata* (Smith) (D: 2), *A. striata* Provencher (D: 2), *Dialictus admirandus* Sandhouse (A: 2, B: 1, C: 1, D: 8), *D. illinoensis* (Robertson) (A: 7), *D. imitatus* (Smith) (B: 4, C: 10, D: 65), *D. versatus* (Robertson) (D: 14), *D. zephyrus* (Smith) (A: 1, B: 2, C: 2, D: 1), *Halictus confusus* Smith (D: 1), *Lasioglossum fuscipenne* (Smith) (C: 1), *L. zonulum* (Smith) (B: 1).

Long-tongued bees (3 species, 15 specimens). **Megachilidae**. *Osmia lignaria* Say (B: 5). **Anthophoridae**. *Nomada bishoppi* Cockerell ♀(A: 1, B: 3). **Apidae**. *Apis mellifera* L.♀(A: 2, C: 4). ***Other Hymenoptera*** (8 species, 13 specimens). **Tenthredinidae**. Species 1 (A: 1), Species 2 (C: 1). **Braconidae**. Species 1 (B: 1). **Ichneumonidae**. Species 1 (C: 1), Species 2 (C: 1), Species 3 (B: 1). **Tiphiidae**. *Tiphia vernalis* Rohwer (D: 6). **Formicidae**. Species 1 (C: 1).

COLEOPTERA (15 species, 47 specimens): **Elateridae**. *Limonius auripilis* Say (D: 1). **Cantharidae** (2 specimens). *Cantharis bilineatus* Say (D: 1), *Silis percomis* (Say)♂(D: 1). **Dermestidae** (6 specimens). *Anthrenus verbasci* (L.) (A: 3, B: 2, C: 1). **Melyridae** (7 specimens). *Anthocomus bipunctatus* (Harrer) ♀(B: 1), *Attalus scincetus* (Say) ♀(B: 1, D: 5). **Coccinellidae**. *Hyperaspis binotatus* (Say) (A: 1). **Byturidae**. *Byturus unicolor* Say (D: 3). **Oedomeridae**. *Asclera ruficollis* (Say) (D: 1). **Anthicidae**. *Pedilus terminalis* (Say) ♂(D: 2). *Cerambycidae* (21 specimens). *Grammoptera haematites* Newman (A: 2, B: 1, D: 11), *Molorchus bimaculatus* Say (B: 2, D: 5). **Chrysomelidae** (3 specimens). *Borowiecius ademptus* (Sharp) (B: 1), *Mantura chrysanthemi floridana*

Crotch (D: 1), *Tymnes metasternalis* Crotch (D: 1).
DIPTERA (18 species, 45 specimens): **Tipulidae**. Species 1 (D: 1). **Sciaridae** (11 specimens). Species 1 (A: 6, B: 2, C: 3). **Chironomidae** (2 specimens). Species 1 (B: 1), Species 2 (A: 1). **Bombyliidae**. *Bombylius major* L. (D: 1). **Empididae**. Phamphamyzia species 1 (C: 1). **Syrphidae** (4 specimens). *Epistrophe (Epistrophella) emarginata* (Say) (D: 1), *Eristalis arbustorum* (L.) (A: 1), *Eumerus strigatus* (Fallen) (B: 1), *Toxomerus geminatus* (Say) (B: 1). **Lauxaniidae** (4 specimens). *Poecilolycia* species 1 (A: 1, D: 2), Species 2 (D: 1). **Drosophilidae**. *Chymomyza* species 1 (A: 1). **Scathophagidae**. *Scathophaga* species 1 (C: 1). **Anthomyiidae** (15 specimens). Species 1 (A: 2, B: 1, C: 10, D: 2). **Muscidae**. Species 1 (A: 1, B: 1). **Calliphoridae** (2 specimens). *Phaenicia sericata* (Meigen) (B: 1), *Pollenia rudis* (F.) (A: 1).

NEUROPTERA (1 species, 2 specimens): **Hemerobiidae**. *Hemerobius* species 1 (B: 2).

LEPIDOPTERA (1 species, 1 specimen): **Lycaenidae**. *Calycopis cecrops* (F.) (A: 1).

The pollen of *C. florida* has a distinctive triangular appearance in polar view (5). Our next study will analyze the pollen found on the insects collected, and determine whether dogwood pollen is present or absent. Pollen loads will be analyzed using pollen slide preparations and scanning electron micrographs.

Significance to Industry: Our study suggests that short-tongued bees may be important to pollination and thus fruit set of flowering dogwood. Onset and duration of flowering of the newly developed varieties of flowering dogwood may be important considerations with respect to the availability of insect pollinators. The presence of short-tongued bees while flowers are receptive is probably essential to the successful pollination and fruit set of flowering dogwood.

Literature Cited:

1 Malueg, K. R. 1998. The Reproductive Biology of Cornus florida L. (Cornaceae). Dissertation. The University of Tennessee, Knoxville. 148pp.

2 Mitchell, T. B. 1960. Bees of the Eastern United States. Volume I. North Carolina Agricultural Experiment Station Technical Bulletin No. 141, 538pp.

3 Mitchell, T. B. 1962. Bees of the Eastern United States. Volume II.

North Carolina Agricultural Experiment Station Technical Bulletin No. 152, 557pp.

4 Robertson, C. 1928. Flowers and Insects. Lists of Visitors of Four Hundred and Fifty-Three Flowers. The Science Printing Press Company, Lancaster, PA. 221pp.

5. Jones, G. D., V. M. Bryant, Jr., M. H. Lieux, S. D. Jones, and P. D. Lingren. 1995. Pollen of the Southeastern United States: With Emphasis on Melissopalynology and Entomopalynology. AASP Contributions Series No. 30, 76pp. + 104 photographic plates.

Integrated Pest Management Demonstrations in Manatee County, Florida

Frank Melton and Sylvia Shives
University of Florida, Manatee County Extension Service

Index Words: IPM, Scales, Mites, Biocontrol, Extension Service

Nature of Work: The Integrated Pest Management (IPM) Demonstrations are an attempt to find the most effective way to implement IPM in a wholesale nursery. We use a basic approach to plant production by testing irrigation water and media for pH, electrical conductivity, alkalinity, and various salts that affect plant growth. Growing media are also tested for aeration. Nurserymen are encouraged to adjust their fertilizer and media to fit their irrigation water. A decision should be made in the beginning of an IPM program to test water and media regularly and send samples of problems to labs. This reduces the delay in diagnosing problems and assures application of the correct chemical, especially for diseases. We also observe the nursery for good drainage and sanitation practices. Poor potting methods also are a contributing factor to poor plant health. All of the above can cause problems with plants, for which some people want to apply pesticides. We try to avoid the confusion by being sure that proper environmental and physiological conditions exist.

The cornerstone of an IPM program is scouting or monitoring plants for insects, diseases, and other problems. We count the percentage of leaves in a sample that have pests present. Five leaves are counted on each of twenty plants for every 1,000 square feet as described by Shives and Cashion. We also scout for seasonal variations in populations by counting numbers of pests on one half of three leaves on five plants. We have such warm temperatures at various times in the winter that we do not find a definite time in winter when there are no insects.

Growers are advised that some pesticides are safer to use with beneficials than others. Dr. Mizell has a North Florida REC Research Report and The Central Florida REC has a web page, http://www.ifas.ufl.edu/~apkweb/entomol/b853a4.htm with some of the more common pesticides that are relatively safe on beneficials.

It is important for growers to work with the scout and extension agent to follow any recommendations in a timely manner (within a day or two), because a higher pest population changes the recommendation that would be given. Also, the timing of pesticide recommendations needs to be done with the scout in mind. The scout needs to know what has been

sprayed for their safety and to comply with the WPS laws.
Our main emphasis the last two years has been scale control. We had been successful with mite control, but scale infestations cause nurserymen to apply more toxic pesticides.

Results and Discussion: We have five nurseries cooperating with us on this program. One cooperating nurseryman had a problem with Florida red scale *Chrysomphalus ficus* (Ashmead) on Kentia palms, *Howea forsteriana* (Becc). He sprayed Cygon (dimethoate) once in the fall of 1997. He was using predator mites for two-spotted spider mite nearby, and did not want to kill the predators every time he sprayed. Enstar II (S-kinoprene) is the only chemical for scale that has been tested as relatively safe on beneficial insects and mites. Enstar II was applied about a month after Cygon, and then five times after that. The adult population had increased by the end of March. *Aphytis holoxanthus* (De Bach) is a wasp that lays its eggs in the Florida red scale, and the young develop inside the scale as they eat the live part of the scale under the armor. This parasite has been used on Florida red scale on citrus, so we obtained a few on a Dracaena marginata that had red scale and set it among the Kentia palms about April 15, 1998. Within a week, some twice stabbed lady beetles appeared from the surrounding area. It seemed that the wasps were killing the scale and the lady beetles were cleaning them off the leaves. The population has been kept low since that time with no pesticide applications.

Another nursery used minute pirate bugs, *Orius insidiosus* (Say), on thrips, *Frankliniela sp.*, on marigolds, *Tagetes sp.* Thrips were a problem on twenty-five percent of the marigolds when Minute pirate bugs were released April 14, 1998. Within three weeks, thrips were a problem on less than five percent of the marigolds, and stayed at that level or less for ten weeks.

Another grower had Florida wax scale, *Ceroplastes floridensis* (Comstock) on Indian hawthorn, *Raphiolepis indica* (Lindl). We tried three biocontrols on a total of 400 plants: 1) *Metaphycus helvolus* (Compere), a tiny black and yellow wasp parasite at the rate of five per plant; 2) *Lindorus lophanthae* (Blaisdell), a tiny black coccinelid beetle predator at the rate of three per plant; and, 3) *Cryptolaemus montrouzieri* (Mulsant), the mealybug destroyer, at the rate of five per plant. *Metaphycus* provided the best control by reducing the Florida wax scale by 40% in about 8 days. The reduction was then slower, but *Metaphycus* spread to the other release areas, because exit holes were found in scale in all plots.

Another grower had magnolia scale, *Pseudaulacaspis cockerelli*

(Cooley), on pygmy date palm, *Phoenix roebellinii* (O'Brien). We released *Aphytis melinus* (DeBach) at a rate of 8 per plant on 600 plants, and the population was reduced from 11% to 3% in 10 days. The population remained low compared to the control for about 2 months, and then went to zero.

Significance to Industry: The pest management program, which includes proper basic horticultural practices, scouting, coordination between grower, scout and extension agent, use of pesticides that are less toxic to beneficial organisms, and the release of beneficials, has saved four growers about $5,000 per year on these crops. The nurserymen have saved about $20,000 per year on their whole nursery.

Literature Cited:

1. Cashion, G.J. and Shives, S.A., 1995. The role of the professional scout in ornamental IPM. Proc. Fla. State Hort. Soc 108: 1995.

2. Johnson, F., Koehler, P. and Short, D., 1998. Florida insect management guide, volume 1: Ornamentals and turf, livestock, forest and shade trees, fruits and nut crops, household, poultry, stored products 1998: 1.3.5

3. Mizell, R.F. III, 1997. Pesticides registered for the nursery and landscape and their impact on beneficials and nontarget organisms. Monticello-NFREC Research Report BB97-1.

4. Southern Nurserymen's Association 1997. Best management practices guide for producing container-grown plants 1997:44-46.

Assessment of Biological Control of Japanese Beetle in Eastern Tennessee: Is it Working?

Daniel Otto and Jerome F. Grant
Entomology and Plant Pathology, University of Tennessee,
Knoxville, TN 37901

Index Words: Japanese Beetle, *Popillia japonica*, Biological Control, Pest Management

Nature of Work: Since its accidental introduction into the United States, the Japanese beetle, *Popillia japonica* Newman, has moved across the country at an alarming rate (1). First recorded in 1916 near Riverton, New Jersey, the Japanese beetle is now established in 22 states east of the Mississippi river and isolated infestations have been reported in states west of the Mississippi (2). With no natural biological controls, the grubs are capable of annual monetary losses of $234 million in North America, with adults capable of causing an equal amount of damage (3) by feeding upon the leaves, fruit, and soft tissues of a wide variety of agriculturally and ornamentally important plants (4). Several biological controls, such as parasitic insects, milky spore, and entomopathogenic nematodes, have been introduced to combat the Japanese beetle in Tennessee with varying amounts of success. Are these natural controls present in eastern Tennessee? Have these natural controls been effective in controlling Japanese beetle populations in eastern Tennessee? This research was initiated in April 1999 to address these questions. The specific objectives of this research are to: 1) monitor population levels of Japanese beetle adults and grubs in eastern Tennessee, 2) assess incidence and seasonality of natural control agents of Japanese beetle in eastern Tennessee, and 3) determine parasitism and infection levels of Japanese beetles by natural controls (parasitoids and pathogens).

Sampling for Japanese beetles and natural enemies was conducted in two plots in each of five counties (Campbell, Greene, Johnson, Knox, and Monroe Co.) in eastern Tennessee. One plot in each county had previously been inoculated with milky spore within the last 25 years and the second plot had not been inoculated with milky spore. Plots (30ft x 30ft) were divided into nine 10ft x 10ft subplots. During each biweekly sampling period, beginning in April 1999, one soil sample (1ft x 1ft) was chosen randomly from each subplot, and soil was removed to a depth of 8in. Each soil sample was examined for Japanese beetle grubs and pupae, and miscellaneous coleopterans. All coleopterans were collected, taken to the laboratory, catalogued, and identified. Grubs were placed in small containers and monitored to determine the incidence of infection or parasitism. Three Japanese beetle traps, containing pheromone and floral lure, were positioned around each plot, monitored weekly, and emptied as needed. Adults were counted to obtain population estimates and also examined for tachinid eggs.

Sampling for parasitoids of Japanese beetles also was initiated in April 1999. Soil samples were examined for parasitoid larvae and pupae (such as *Tiphia* spp.) and any parasitoids found were taken to the laboratory, identified, and catalogued. Adult trapping of *Tiphia* spp. began in late April 1999 and will continue until August. Foliage of trees around each plot were sprayed with a 10% sugar water solution and monitored for the presence of adult *Tiphia*. Any *Tiphia* captured were taken to the laboratory, catalogued, and mailed to experts for verification. Additional soil samples will be taken from each plot and bioassayed to determine the presence of entomopathogenic nematodes and milky spore. Nematodes will be extracted from soil samples by use of distillation and centrifuge or will be extracted from grubs by a similar procedure. Nematodes will be examined under a microscope and identified. Milky spore will be detected from soil samples by the use of PCR (Polymerase Chain Reaction) technique. A primer for the 16S sequence will be developed and then used to identify milky spore from soil samples. In addition, grubs collected through soil samples are being examined and monitored for the presence of milky spore and entomopathogenic fungi/ disease-causing organisms.

Results and Discussion: Density of Japanese beetle grubs, averaged across all sampling dates, ranged from <1 to 3.0 grubs/1ft2. The greatest number of Japanese beetle grubs and adults were collected from Knox County, with as many as 7 grubs/1ft2 collected over several sampling dates. Ironically, the Knox County plot producing the most grubs (ÿ = 3 grubs/1ft2 sample plot) had been inoculated with milky spore in the early 1980s; however, no milky spore had been detected in grubs in 1999. Adult Japanese beetle populations have been roughly equal across counties, with >10,000 adult Japanese beetles collected/ trap/week in each county since mid-June. Adult eclosion began in early May for three counties, with two counties experiencing adult eclosion several weeks later in the season, possibly due to weather. Few natural enemies have been identified in the limited number of samples collected thus far. *Tiphia vernalis* Rohwer, a parasitic wasp of Japanese beetle grubs, has been tentatively identified from one plot in Campbell County and found independently in a separate study in the University of Tennessee Arboretum in Anderson Co. The fungus *Metarhizium anisopliae* (Metsch.) Sorokin was recovered from a Japanese beetle grub collected in Campbell County on July 9 and the fungus *Paecilomyces lilacinus* Bainier was recovered from an unidentified grub in Greene County on July 21. To date, no nematodes or milky spore have been recovered from any of the processed soil samples and/or insects collected from any of the counties. This research will be conducted through October 1999 and repeated next year.

Thus far, few natural enemies of the Japanese beetle have been recovered in eastern Tennessee. However, many more soil samples and insects still need to be processed to fully evaluate the status of potential natural enemies. At the conclusion of this 2-year study, we hope to have a better understanding of the incidence and effectiveness of natural biological control agents of the Japanese beetle in eastern Tennessee.

Significance to industry: The spread of Japanese beetles through natural dispersion and artificial means is of great concern. Japanese beetles are well established in eastern and middle Tennessee and the front is entering western Tennessee. The presence of Japanese beetles in these areas limit shipment of plant products to uninfested areas due to quarantine. Limitations in shipments translate to losses in revenue. Thus, any means of natural control to reduce populations of Japanese beetles would benefit nursery producers as well as the general public. The use of one or a combination of natural biological controls may play an important role in management of the Japanese beetle, leading to less reliance on pesticides while providing long-term reduction of the pest population.

Literature Cited:

1. Flesinger, W. E. 1970. The Japanese beetle in the United States. Agric. Handbook No. 36.

2. U.S.D.A. 1997. Managing the Japanese beetle: A homeowner’s handbook. U.S.D.A. Program Aid No.1599.

3. Garland, J. A, F. Meloche, E. J. Dobesburger, and R. S. Dickhout. 1992. Special project on Japanese beetle. Plant Res. Centre, Ottawa, Res. Contrib. No. 1425.

4. Hawley, I. M. and F. W. Metzger. 1940. The feeding habits of the adult Japanese beetle. U.S.D.A. Circ. No. 547.