Entomology

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Isolation of Bacteria from Imported Fire Ants

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Significance to the Industry: Imported fire ants have been a serious problem since their accidental introduction from South America into the southeastern United States. Since 1950, their successful invasion has allowed imported fire ants to spread and infest over more than 320 million acres in 13 states including Tennessee, Oklahoma, New Mexico, and California. In Tennessee, the ants continue to spread northwards as evident by the gradual annual movement of the quarantine line. In Tennessee and surrounding states, three types of imported fire ant predominate: the red imported fire ants *(Solenopsis invicta)* Buren, the black imported fire ant *(Solenopsis richteri)* Forel, and their hybrid *(S. richteri x S. invicta).* These ants cause serious health, economic and environmental problems in the communities they invade leading to loss of millions of dollars in the urban and agricultural areas. Damage to property, lawns and ornamentals, crops, interference with electrical cables and watering equipment as well *as* endangerment of pets and domestic animals and wildlife by fire ants have an enormous economic impact (2). Biological Pest Control is based on highly specific, naturally occurring insect diseases caused by natural pests such as bacteria, protozoa, viruses and fungi (1). These agents are very effective against their target insects but are nontoxic to humans, pets, wildlife and beneficial insects. Biological pesticides also break down quickly in the environment and are less likely to produce pest resistance than chemical pesticides. Given the numerous environmental hazards and economic impacts of the use of chemical insecticides, our research avenue exploring the potential for biological control of fire ants may be invaluable. Here, we report isolation, characterization and identification of bacteria from fire ants. Our long term goal is to isolate and characterize bacterial strains that could be manipulated genetically and physiologically for use in biological fire ant control.

Nature of Work: Live fire ants were collected from five ant mounds in a field in Lantern, Winchester in the Franklin County, TN and were nested in the insectary at TSU Nursery Center in McMinnville. The insects in the nest were fed on diluted honey. Dead ants which had been isolated or were in the process of being isolated by the other ants were collected and stored in 70 % ethanol. The fire ants were all hybrids, an observation that was unexpected since red and black fire ants have been rare in the area of collection. About 50 ants were washed and crushed in nutrient broth using sterile forceps and ant extracts were prepared for bacterial isolation. About 50 µL extract per plate was spread on Brain Heart infusion Agar (BHIA), Sabouraud Dextrose Yeast Agar (SDYA) and Nutrient Yeast Agar (NYA) and incubated at 28° C. Morphologically distinct single colonies were purified and characterized using cultural, morphological, physiological and biochemical features including gram stain, catalase test, KOH test, oxidase test and antibiotic susceptibility testing.

Results and Discussion: Bacteria from hybrid fire ants *(S. invicta* x *S.richteri)* were examined and 37 different bacteria were isolated from extracts of crushed ants cultured on Brain Heart infusion Agar (BHIA), Sabouraud Dextrose Yeast Agar (SDYA) and Nutrient Yeast Agar (NYA) with most of the bacteria coming from BHIA. The relatively small to large colonies displayed different colors ranging from pink, cream, to orange. Some were slimy and others were gummy with firm consistency. Others were broad with yeast-like characteristics. Table 1 summarizes the features of the isolates.

Cultural, morphological, physiological and biochemical characteristics revealed a diversity of colony colors including, pink (2%), cream (22%) and three shades (light, moderate and deep) of yellow (51%) and orange (22%). Same colony color does not necessarily mean they are the same. Further analysis is needed to confirm their identity. Colonies were soft (28%), mucoid (28%) or firm (42%). Most of them appeared within 48 hours of incubation. Colony sizes were 40% tiny (<1mm), 40% small (1-2mm) and 20% large (>2mm). The majority was gram positive (72%) and catalase positive (97%). About half of the isolates (52%) tested negative with KOH. It was expected that results from gram reaction would be about the same for KOH test. This is because most gram-negatives are KOH positive. KOH test is important in view of the pitfalls in gram staining technique where there is the tendency of some gram-positive bacteria to decolorize more rapidly than others often resulting in these bacteria being classified incorrectly as gram negative. Only a few (25%) were oxidase positive. Twenty-five of the isolates were tested for susceptibility to 10 antibiotics. Between 88% and 92% of these were susceptible to 6 of the antibiotics. Susceptibility to colistin and kanamycin were 41% and 38% respectively. All 25 isolates were susceptible to tetracycline and about 92% were resistant to nalidixic acid (Table 2). More work on biochemical/physiological characteristics as well as molecular work involving sequence analysis of 16S rRNA genes is needed to correctly identify and characterize these isolates to the species level. This will provide a way of assessing their potential to be used for biological control of fire ants.

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Table 1. Morphological, physiological and biochemical characteristics of bacteria isolated from hybrid fire ants (*S. invicta* x S. *richteri*).

Isolate numbers	Mound	Isolate ID number	Status	Colony consistcy texture	Colony color	Colony margin	Colony shape/size	Shape of bacteria	Gram stain	Catalas	KOH te	Oxidase test
01	2A	2		Firm	Yellow	smooth	Elevated/s	coccus		+	-	-
02	2A	8		Firm	[-yellow	smooth	Elevated/s	coccus	+	+	-	-
03	2A	12		Mucoid	D.yellow	smooth	Elevated/tin	coccus	+	+	+	-
04	2A	13		Firm	D.yellow	smooth	Elevated/tin	very short rod	+	+	-	-
05	2A	15		Firm	D.yellow	smooth	Elevated/s	very short rod	+	+	-	-
06	2A	I6		Soft	Cream	smooth	Elevated/tin	coccus	+	+	-	-
07	2A	17		Mucoid	D.orange	smooth	Elevated/tin	very short rod	+	+	-	-
08	2A	22		Soft	Cream	smooth	Flat/large	short rod	+	+	+	-
09	2A	24		Mucoid	D.yellow	smooth	Flat/small	coccus	+	+	+	-
10	2A	26		Soft	Cream	Irregular	Flat/tiny	short rod	-	+	-	-
11	2A	28		Soft	Cream	Smooth	Flat/small	medium rod	+	+	-	-
12	2A	30		Soft	L.yellow	Irregular	Flat/tiny	Short rod	+	+	+	+
13	3A	1		Soft	Yellow	Smooth	Flat/large	Long rod	-	+	-	_
14	4A	3	w	Soft	Orange	smooth	Elevated/s	Rod	+	+	-	-
15	4A	4	w	Firm	D.orange	smooth	Elevated/s	Rod	+	+	-	-
16	4A	5		Firm	D.orange	smooth	Elevated/s	Short rod	+	+	-	-
I7	6A	1		Firm	Lorange	smooth	Elevated/tin	Very short rod	+	+	-	-
18	6A	4		Soft	Cream	smooth	Flat/large	Short rod	-	+	+	+
19	6A	5		Mucoid	Pink	smooth	Elevated/tin	Short rod	-	+	-	-
20	6A	6		Mucoid	D.yellow	smooth	Elevated/tin	Short rod	+	-	+	+
	6A	7		Mucoid	Yellow	smooth	Elevated/tin	Very short	-	+	+	-
22	6A	10		Firm	D.orange	smooth	Elevated/s	Very short rod		+	+	+
23	6A	13		Firm	Yellow	smooth	Elevated/s	Very short rod	+	4-	+	-
24	6B	1		Firm	Yellow	smooth	Elevated/tin	Very short rod	+	+	-	-
25	6B	3		Soft	Cream	Irregular	Flat/large	Short rod	+		+	-
26	6B	4		ND	ND	ND	ND	ND	ND	ND	ND	ND
27	6C	I		Mucoid	D.yellow	smooth	Elevated/s	rod	+	+	+	+
28	6C	2		Firm	D.orange	smooth	Elevate/sm	Very short rod	-	+	+	+
29	6C	3		Mucoid	Cream	smooth	Elevated/lar	rod	+	+	-	-
30	6C	4		Mucoid	Lyellow	smooth	Elevated/s	short rod		+	4-	+
31	6C	5		Firm	D.yellow	smooth	Elevated/tin	Short rod	+	+	-	-
32	6C	12		Mucoid	Cream	smooth	Elevated/lar	Long rod	+	4-	-	
33	6C	14		Firm	Yellow	smooth	Elevated/tin	Very short rod	-	+		-
34	6C	15		Mucoid	D.orange	smooth	Elevated/s	Short rod		+	+	-
35	6C	16		ND	ND	ND	ND	Long rod	+	+	+	+
36	6C	17		Mucoid	D.yellow	smooth	Elevated/s	short rod	-	+	+	-
37	6C	18		Firm	L.yellow	smooth	Elevated/tin	Short rod	+	+	-	-

ND- Not determined; L-light; D-deep

Table 2. Antibiotic resistance profile of bacterial isolates.

Isolate number	Mound	Isolate ID	Status	Rifampicin (5µg)	Erythromycin (30µg)	Vancomycin (30µg)	Amoxycillin (30µg)	Neomycin (5µg)	Tetracycl in (30µg)	Chloramphenicol (30µg)	Coliistin (10µg)	Kanamycin (50µg)	Nalidixic (50µg)
01	2A	2		S	S	S	S	R	S	S	S	ND	R
05	2A	15		S	S	S	S	S	S	S	ND	R	R
06	2A	I6		S	S	S	S	S	S	S	S	S	R
10	2A	26		S	S	S	S	S	S	S	R	S	S
13	3A	I		S	S	S	S	S	S	S	S	S	R
14	4A	3	weak	S	S	S	S	S	S	S	R	S	R
15	4A	4	weak	S	S	S	S	S	S	S	R	R	R
17	6A	I		S	S	S	S	S	S	S	S	S	R
18	6A	4		R	R	R	R	R	S	R	S	R	R
20	6A	6		S	S	S	S	S	S	S	R	S	R
21	6A	7		S	S	S	S	S	S	S	R	R	R
22	6A	10		S	S	S	S	S	S	S	R	R	R
24	6B	1		S	S	S	S	S	S	S	S	S	R
27	6C	1		S	S	S	S	S	S	S	S	R	R
28	6C	2		S	S	S	S	S	S	S	R	S	R
29	6C	3		S	S	S	S	S	S	S	S	S	R
30	6C	4		R	R	R	R	R	S	R	S	R	R
31	6C	5		S	S	S	S	S	S	R	R	R	R
32	6C	12		S	S	S	S	S	S	S	S	S	R
33	6C	14		S	S	R	S	S	S	S	S	R	R
34	6C	I5		S	S	S	S	S	S	S	R	S	R
36	6C	17		S	S	S	S	S	S	S	R	S	R
37	6C	18		S	S	S	S	S	S	S	S	R	R
EccKR	mutant	N3		S	S	R	S	R	S	S	S	R	R
EccNR	mutant	N3		S	R	R	S	S	S	R	S	S	R
% Resistant				8	8	12	8	12	0	12	41	38	92

Fertilization Reduction for Greenhouse Roses: Effect on Crop Productivity and Twospotted Spider Mite Abundance

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Index Words: *Tetranychus urticae*, *Rosa hybrida*, Fertilizer, Floriculture, IPM

Significance to Industry: Fertilizers are essential for producing floriculture crops of high aesthetic quality; however, over fertilization of ornamental crops can contribute to higher pest control costs because high nutrient levels in plant tissue cause pest insects or mites to rapidly grow and multiply, thus causing more crop damage and requiring more control effort. We studied the response of the twospotted spider mite, *Tetranychus urticae* Koch, to different fertilization levels for cut roses and determined fertilization effects on spider mite abundance and crop productivity. Fertilization reduction could be used as a pest management tactic if it reduces spider mite populations with little loss in rose yield and quality. A study was conducted on roses fertilized with 33%, 50%, and 100% of the commercially recommended level (150 ppm N). We found that counts of spider mites and spider mite eggs on flower shoots were, on average, twice as high on roses fertilized with 100% versus 33% or 50% of the recommended level. Cut rose yield was not compromised on plants fertilized with 50% of the recommended level. We argue that fertilization reduction could be an effective and easily implemented tactic for management of spider mites on roses.

Nature of Work: Roses are widely produced in the US as nursery crops, potted flowering plants, or cut flowers. The twospotted spider mite (TSSM), *Tetranychus urticae* Koch, is a serious pest of roses and many floricultural crops (1). Chemical control is the preferred tactic for pest mites on greenhouse or field-grown roses, but widespread use of miticides has resulted in TSSM resistance to many products (2, 3). Frequent miticide applications also increase production costs, phytotoxic damage to plants, water contamination, and worker health risks. Alternative approaches for TSSM control which address resistance, environmental, and worker health issues are essential to the continued success of US rose growers.

Reduction of fertilization could be a useful management tactic for TSSM on roses if fertilization regimes can be adjusted to lower spider mite numbers without detrimental effects on crop yield or quality. As a pest management tactic, manipulation of plant fertilization is attractive because it is relatively simple to integrate into commercial production and compatible with biological control and other integrated pest management (IPM) practices. In an earlier study, we compared control of TSSM with a predatory mite, *Phytoseiulus persimilis* Athias-Henriot; or a miticide, Floramite®

(bifenazate), on cut roses (*Rosa hybrida* cv. 'Tropicana') grown under two fertilizer regimes: 10% and 100% of the recommended level of 150 ppm N (4). Roses fertilized with 10% of the recommended rate and treated with predatory mites or miticide had, on average, 60–70% fewer spider mites and 70–80% fewer spider mite eggs than plants fertilized with 100% of the recommended level and treated with similar control methods. However, roses fertilized at the recommended level produced on average 2.5 times as many harvestable cut flowers as roses fertilized at the lower level. Our findings prompted us to ask if less drastic reductions in fertilizer could benefit TSSM management without detrimentally affecting crop yield or quality.

For this study, we compared the size of TSSM populations on cut roses grown under fertilizer regimes representing 33%, 50% or 100% of the commercially recommended level (150 ppm N, Peters Excel 15-5-15 Cal-Mag). To maintain the same ratio of macro- and micro- nutrients for all our fertilizer regimes, we varied only the strength of the fertilizer with RO water. Our trial was conducted during March to May of 2007 in research glasshouses on the Texas A&M University, College Station campus. Individual bare-root plants (*R. hybrida* cv. 'Tropicana' on 'Dr. Huey' rootstock) were grown in 14-liter plastic nursery containers with soilless potting mix, pine bark mulch, and sand (3:1:1 by volume). The plants were cultivated as a cut flower crop following conventional practices (5). For six weeks prior to our experiment, we fertilized one set of plants with the 33 % level, a second set with the 50% level, and a third set with the 100% level. At the end of the six weeks, all plants were pruned to initiate a synchronous crop of cut roses. We assigned six plants to each of 12 greenhouse benches (total plants = 72) and used a randomized design with two replicates per fertilization treatment on each bench.

Four weeks after pruning (week 4), we released an adult female TSSM onto each of four flower shoots belonging to one of the two plants assigned to each fertilization treatment on each bench (12 plants per fertilizer level). None of the infested shoots were in physical contact with other stems. Every 7 d, weeks 5-8, we harvested one of the four infested shoots on each plant. For each harvested shoot, we counted all stages of TSSM and measured total leaf area infested by TSSM. To separate the effects of fertilization level and TSSM feeding on rose yield and quality, we used the 36 rose plants (12 per fertilization level) not infested with TSSM. To prevent infestation of these clean plants, we applied a miticide, Shuttle® 15 SC (Acequinocyl) and visually monitored these plants for TSSM. At the end of week 8, we recorded the total numbers of flower shoots and blind shoots produced by each clean plant. The effects of fertilization level on weekly counts of TSSM on harvested shoots and infested leaf area were analyzed with repeated-measures ANOVA. Shoot counts were analyzed by one-way ANOVA.

Results and Discussion: Increasing fertilization level enhanced the growth of TSSM populations on roses. Both the numbers of TSSM (one-way repeated-measures ANOVA: $F = 73.76$; df = 3, 99; $P < 0.001$) and TSSM eggs (one-way repeated-measures ANOVA: $F = 99.22$; df = 3, 99; $P < 0.001$) increased quickly during the four weeks after infestation, but were significantly higher on roses fertilized with the recommended level than the two lower levels (Figs. 1 and 2). Interestingly, dispersal of spider mites on infested flower shoots did not vary with fertilization level. On a per-shoot basis, the leaf area infested by TSSM increased during the four weeks after infestation (one-way repeated-measures ANOVA: $F = 120.8$; df = 3, 99; $P < 0.001$), but was statistically similar among fertilization levels (one-way repeated-measures ANOVA: F ranged from 0.01 to 1.6; df = 2, 33; all P values were > 0.05). Leaf area infested by TSSM increased from 12.8 ± 1.2 cm^2 (mean ± SE; $n = 36$) per shoot on week 5 to 298.4 ± 22.4 cm^2 (mean ± SE; $n = 36$) per shoot by week 8.

We found a significant fertilization effect on the number of flower shoots produced by clean roses. Total number of shoots was not significantly different among fertilization treatments (one-way ANOVA: $F = 0.5$; df = 2, 33; $P = 0.6$), but numbers of flowering shoots and blind shoots differed with fertilization level (one-way ANOVA: $F_{2, 33} = 5.8$; df = 2, 33; $P < 0.01$; $F = 3.5$; df = 2, 33; $P = 0.04$, respectively) (Fig. 3). Plants fertilized with 50% or 100% of the recommended level produced, on average, 34% more flower shoots and 31% fewer blind shoots than plants fertilized with 33% of the recommended level (Fig. 3).

Our findings show that lowering fertilization to 50% of the recommended level not only had minimal adverse effects on rose yield but also significantly reduced the potential severity of TSSM infestations. Growers would benefit from having to apply fewer miticide applications if TSSM numbers on floriculture crops could be substantially reduced by lowering fertilization. Reduction in both fertilizer and miticide use should directly reduce grower costs.

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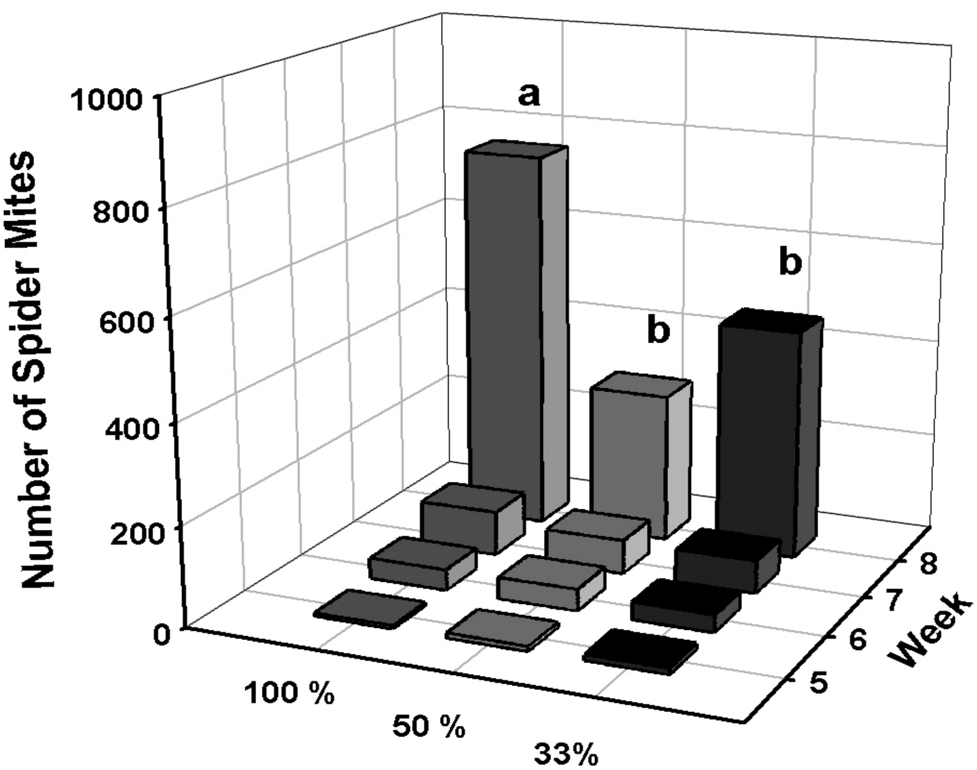

Figure 1. Numbers of two-spotted spider mites (± SE; *n* = 12) on individual rose stems infested with a single female spider mite during the fourth week of the crop. Rose plants were fertilized with 33% (black bar), 50% (light gray bar), or 100% (dark gray bar) of the recommended level (150 ppm N). Different letters above the bars indicate significant differences ($P \leq 0.05$) determined by the Bonferroni multiple comparison test.

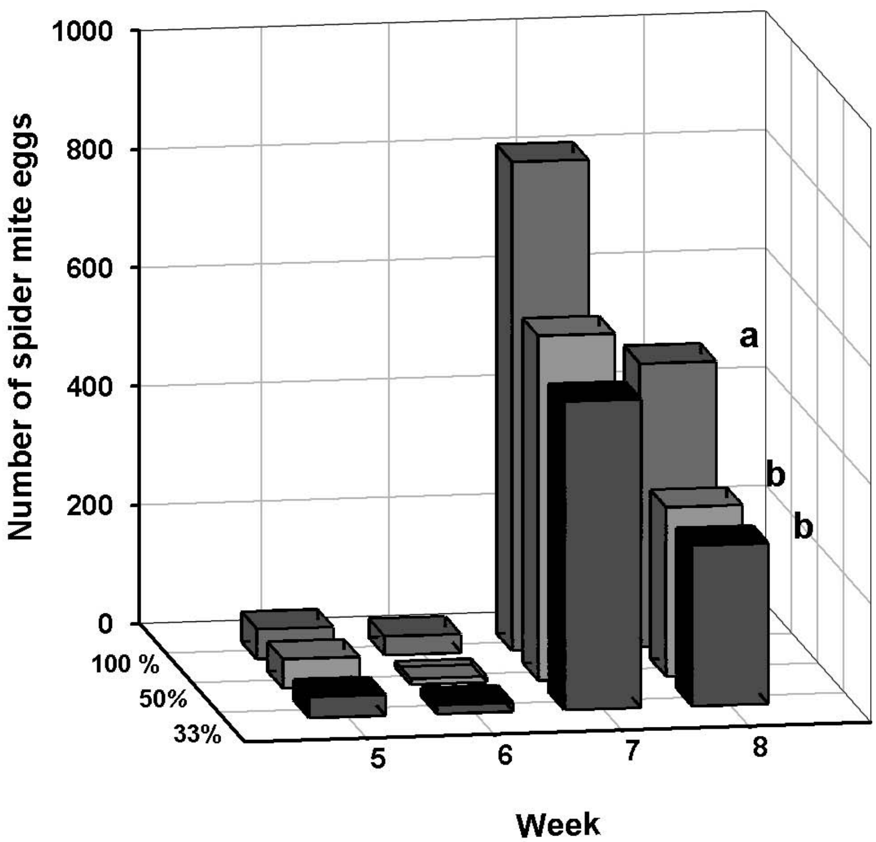

Figure 2. Numbers of two-spotted spider mite eggs (± SE; *n* = 12) on individual rose stems infested with a single female spider mite during the fourth week of the crop. Rose plants were fertilized with 33% (black bar), 50% (light gray bar), or 100% (dark gray bar) of the recommended level (150 ppm N). Different letters above the bars indicate significant differences ($P \leq 0.05$) determined by the Bonferroni multiple comparison test.

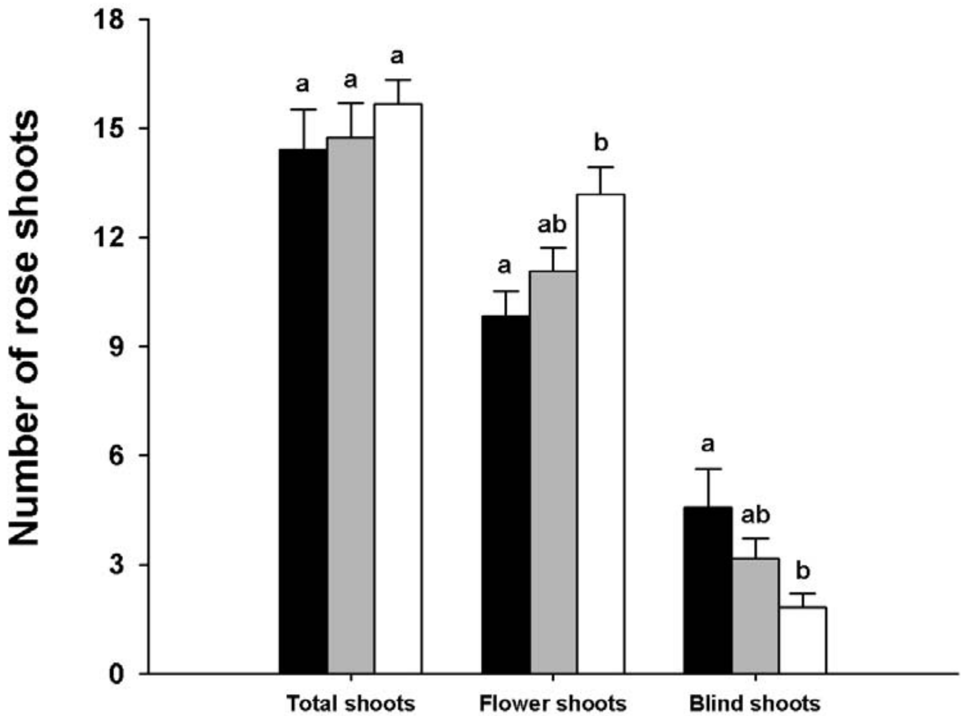

Figure 3. Total shoots, flower shoots, and blind shoots (± SE; n = 12) produced by roses fertilized with 33% (black bar), 50% (light gray bar), or 100% (white bar) of the recommended level (150 ppm N). For each type of shoot, different letters above the bars indicate significant differences ($P \leq 0.05$) determined by the Bonferroni multiple comparison test.

Combining an Insect Growth Regulator and a Novel *Beauveria bassiana* Product for Management of Thrips on Potted Roses

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Index Words: *Frankliniella occidentalis*, *Beauveria bassiana*, Reduced Risk Product, Biopesticide, Floriculture, Integrated Pest Management

Significance to Industry: Western flower thrips (WFT), *Frankliniella occidentalis* (Pergande), is becoming increasingly difficult to control on floriculture crops with conventional insecticides due to the widespread development of insecticide resistance in field populations of this pest. Alternation of conventional insecticides with biopesticides and reduced-risk products could extend the efficacy of conventional insecticides against WFT and also reduce negative effects on the environment and worker health. We evaluated the efficacy of both a novel *Beauveria bassiana* product, BioExpert® SC, and an insect growth regulator, Pedestal®, for control of WFT on container crops of 'Belinda's Dream' and 'Knock Out'™ roses at two commercial nurseries in Texas. We found that single applications of BioExpert® SC or Pedestal® at the recommended rate, alone or in combination, significantly reduced WFT counts on plants within one week of treatment, but product efficacy differed between the two rose cultivars. Our findings show that BioExpert® SC or Pedestal® could be used in management programs for WFT to reduce insecticide resistance, environmental, and worker health risks associated with conventional insecticides.

Nature of Work: Texas is one of the top 5 states for commercial floriculture production and the high value of its floriculture crops results in greater insecticide inputs per acre than any other form of agriculture in this state (1). Despite the extensive use of insecticides by Texas growers, western flower thrips, *Frankliniella occidentalis* (Pergande), remains a difficult pest to control on roses and other floriculture crops. Roses are a dominant factor in the production of color for U.S. consumers and more than half of the nation's rose bushes are packaged and shipped from northeast Texas (2). Thrips can badly damage container rose plants in the spring during the peak sales and shipping period for Texas growers, who must apply costly preventative treatments and/or remove damaged flowers, buds and foliage to ensure crop sales. If WFT populations in Texas become resistant to conventional insecticides, economic lost for rose growers would increase dramatically and be catastrophic for the industry. Development of insecticide resistance by WFT is documented for 22 compounds from five different classes of conventional insecticides (3, 4). As a result, alternative products and application strategies are desperately needed to augment integrated pest management (IPM) programs for WFT.

Biopesticides and reduced-risk products could be used in resistance management programs for WFT and other pest insects. *Beauveria bassiana* (Bals.) Vuill. (Ascomycota: *Hypocreales*) is an entomopathogenic fungus and certain strains are marketed as biopesticides (5). Upon contact, the fungal spores attach to the insect cuticle, grow into the insect body and kill the insect via depletion of nutrients and release of toxins. In comparison, insect growth regulators (IGRs) are reduced-risk insecticides that disrupt the hormone ratio within juvenile insects to prevent them from molting and becoming an adult. Combined use of both *B. bassiana* and IGRs can enhance their efficacy against WFT because the IGRs inhibit molting which prevents shedding of infectious spores (Carlos Bográn, personal communication). For this study, we evaluated the efficacy of a novel *Beauveria bassiana* product, BioExpert® SC (Live Systems Technology S.A., Bogota, Colombia), and an IGR, Pedestal® (Novaluron, Chemtura Corporation, Middlebury, CT), for control of WFT on 'Belinda's Dream' and 'Knock Out'™ roses grown as container plants for landscape applications. We selected BioExpert® SC because it uses a new strain of *B. bassiana* (DSM 12256) that is reported by its developer to have greater efficacy against thrips than the strains used by other *B. bassiana* products currently available in the US.

During June 2009, we conducted field trials at two different commercial nurseries. The first trial was conducted at 'The Antique Rose Emporium' (Independence, TX) with a crop of 'Belinda's Dream' roses individually planted in 2-gallon, plastic pots. The crop was arranged in four blocks and each block consisted of 110 rows with six plants per row (total plants = 2640). We divided each block into six plots and each plot consisted of 18 rows (total plots = 24; 108 plants per plot). Individual plots were treated with one of six control methods: no application, water application, BioExpert® SC 'Carrier Only'(25.6 fl. ozs / 100 gals), BioExpert® SC (25.6 fl. ozs / 100 gals), Pedestal® (7.0 fl. ozs / 100 gals), BioExpert® SC (25.6 fl. ozs / 100 gals) combined with Pedestal® (7.0 fl. ozs / 100 gals). Each of the six treatments were randomly assigned to only one of the six plots within each of the four blocks (total replicates per treatment = 4). With the exception of the absolute control (no application), equal volumes of solution were applied to each plot with a backpack sprayer (Jet Pack Model 475, Solo®**,** Newport News, VA).

The second trial was conducted at 'Creekside Nursery' (Hempstead, TX) with a crop of 'Knock Out'™ roses individually planted in 1-gallon, plastic pots. We used the same experimental design except that each of the four blocks consisted of 98 rows (total plants = 2304) and each of the six plots consisted of 16 rows (total plots = 24; 96 plants per plot). We treated the 'Belinda's Dream' crop on June 4 and the 'Knock Out'™ crop on June 5, 2009. Approximately one hour before the solutions were applied (Week 0) and once every seven days for three consecutive weeks (Weeks 1-3), we harvested a open flower from three different 'Belinda's Dream' plants (flowers per treatment = 12; total flowers = 72) or four different 'Knock Out' ™ plants (flowers per treatment = 16; total flowers = 96) in each plot and counted all the live WFT extracted from these flowers. Plants from the end three rows of each plot were not sampled and served as a 'buffer' between treatment replicates. We used ANOVA, with control method as the main effect, to compare weekly counts of WFT. Dunnett's pairwise multiple comparison t-test was used to compare weekly counts of WFT for each control method against the untreated plants (plants that received no applications). If more than one control method was found to be statistically different from the untreated plants, we used the Bonferroni multiple comparison test to determine significant differences between pairs of mean values.

Results and Discussion: During the first week after treatments, 'Belinda's Dream' roses treated with applications of BioExpert® SC and Pedestal®, alone or in combination, had, on average, 60-70 % fewer WFT than untreated plants (Table 1). However, thrips counts on 'Belinda's Dream' roses treated with either BioExpert® SC or Pedestal® were not statistically different from plants treated with both products. In comparison, only 'Knock Out'™ roses treated with both BioExpert® SC and Pedestal® had significantly fewer WFT than untreated plants (Table 2). Numbers of thrips recovered from 'Belinda's Dream' or 'Knock Out' roses treated with the BioExpert® SC 'Carrier Only' or the water applications were similar to those from untreated plants. Thrips counts for treated and untreated plants were not statistically different at the start of the trials or during the second and third weeks of the trials (Tables 1 & 2). Interestingly, thrips counts were, on average, up to ten times higher on 'Belinda's Dream' than 'Knock Out'™ roses treated with the same control methods. 'Belinda's Dream' roses may attract and support larger populations of WFT because their flowers (48 to 89 petals) are much larger than those of 'Knock Out'™ roses (5 to 12 petals).

In 2008, US floriculture receipts exceeded $4 billion dollars; 42% of these from growers in the Southern US (6). Novel or alternative management approaches that address resistance, environmental and human health concerns associated with chemical control of WFT and other persistent insect pests are essential to the continued success of this industry. If proven effective, biopesticides and reduced risk products such as BioExpert® SC and Pedestal® are likely to be adopted by ornamental growers who are running out of options to ensure insecticide resistance avoidance. Adoption of these alternative products into IPM programs for thrips should provide growers with an expanded suite of insect pest management practices that are economical, effective, and safe for the environment, workers, and consumers. Our findings show that BioExpert® SC or Pedestal® are effective for control of WFT on roses, but combining both products did not substantially improve control.

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Table 1. Mean numbers of thrips (±1 SEM; n = 4) counted in flowers from Belinda's Dream roses before (Week 0), or one week (Week 1), two weeks (Week 2), and three weeks (Week 3) after plants were treated with one of six different control methods.

Treatment	Week 0	Week 1	Week 2	Week 3
No application 'Control'	124.0 ± 25.2[a]	82.8 ± 18.6[a]	108.3 ± 9.8[a]	124.0 ± 25.2[a]
Water	126.8 ± 22.2[a]	78.5 ± 7.6[a]	70.8 ± 8.5[a]	139.8 ± 30.1[a]
Pedestal®	130.3 ± 18.2[a]	32.8 ± 4.0[*b]	69.0 ± 22.4[a]	123.0 ± 30.5[a]
BioExpert SC® 'Carrier Only'	171.3 ± 4.0[a]	76.0 ± 8.8[a]	87.5 ± 7.4[a]	147.3 ± 20.9[a]
BioExpert SC®	127.5 ± 25.6[a]	33.5 ± 9.0[*b]	81.8 ± 22.6[a]	141.0 ± 23.7[a]
BioExpert SC® & Pedestal®	139.3 ± 8.1[a]	22.0 ± 8.1[*b]	86.3 ± 21.5[a]	174.3 ± 33.8[a]

[1] Asterisks within each column indicate significant differences (P < 0.01) from the 'Control' (plants receiving no application) as determined by Dunnett's pairwise multiple comparison *t* test.

[2]Different letter(s) within each column indicate significant differences among control methods ($P < 0.01$) as determined by the Bonferroni multiple comparison test.

Table 2. Mean numbers of thrips (±1 SEM; n = 4) counted in flowers from 'Knock Out'™ roses before (Week 0), or one week (Week 1), two weeks (Week 2), and three weeks (Week 3) after plants were treated with one of six different control methods.

Treatment	Week 0	Week 1	Week 2	Week 3
No application 'Control'	63.0 ± 28.8[a]	52.3 ± 12.0[a]	11.3 ± 2.4[a]	12.5 ± 4.7[a]
Water	60.0 ± 6.4[a]	38.0 ± 5.8[a]	8.5 ± 2.8[a]	12.0 ± 1.1[a]
Pedestal®	51.3 ± 8.4[a]	26.5 ± 6.3[a]	11.3 ± 4.2[a]	18.3 ± 1.7[a]
BioExpert SC® 'Carrier Only'	57.8 ± 15.9[a]	55.5 ± 7.6[a]	12.0 ± 2.6[a]	13.3 ± 2.0[a]
BioExpert SC®	55.8 ± 14.6[a]	26.0 ± 6.2[a]	6.8 ± 1.7[a]	10.5 ± 3.7[a]
BioExpert SC® & Pedestal®	46.8 ± 2.8[a]	20.5 ± 7.0[*a]	6.8 ± 1.2[a]	10.8 ± 2.2[a]

[1] Asterisks within each column indicate significant differences (*P* < 0.05) from the 'Control' (plants receiving no application) as determined by Dunnett's pairwise multiple comparison *t* test.

[2]Similar letter(s) within each column indicate no significant differences among control methods (*P* > 0.05) as determined by the Bonferroni multiple comparison test.

Technique to reduce the volume of insecticide applied for Granulate Ambrosia Beetle

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Index words: Granulate Ambrosia Beetle, targeted insecticide application, insecticide drift, coverage, permethrin

Significance to industry: Granulate Ambrosia Beetle (GAB), *Xylosandrus crassiusculus*, is one of the most damaging insect pests to nursery crops in the Southeast. Growers of deciduous trees spend a lot of time and money each spring making insecticide applications to prevent damage from this beetle. Most growers make these applications with air-blast sprayers which produce a fine spray of insecticide. This allows many trees to be treated in a short amount of time. However, only a small amount of the insecticide that is sprayed lands on tree trunks where it is needed. The rest billows through nursery rows covering tree canopies, the ground, and may leave the target area as drift. Thus, more insecticide is released into the environment than is needed to effectively control GAB. In cooperation with local growers we developed a spray wand with two opposing nozzles. Using a backpack spray rig, tree trunks can be sprayed quickly. Though pesticides are not applied as fast as with an air-blast sprayer, our method reduces by 85% the insecticide volumes used compared with air-blast applications.

Nature of work: Targeted insecticide applications are a foundation of Integrated Pest Management. Treating only the plants or plant parts that need insecticide reduces the impact of insecticides on non-target organisms and reduces the volume of insecticide released into the environment. Indiscriminate application of broad spectrum insecticides can also promote secondary pest outbreaks, pest resurgence, and insecticide resistance. In order to reduce the volume of insecticide used, growers need alternative application methods that are effective and economical.

Granulate Ambrosia Beetle is one of the most damaging insect pests of nursery trees. Adult female GAB bore into the heartwood of young trees to form a gallery and lay eggs. Trees typically die from boring damage, ambrosia fungus carried by the adult beetles, or secondary infection. To reduce damage from this pest, growers need to apply pyrethroid insecticide to tree trunks every two weeks. This kills or repels beetles when they land on the trunk to prevent boring. This spray program begins in early spring and continues for approximately 12 weeks when GAB activity subsides. Applications are typically made with an air-blast sprayer the releases a fine insecticide spray at a great velocity. Air-blast sprayers are drawn by a tractor which allows many trees to be treated in a short amount of time. However, only a small amount of the insecticide that is sprayed lands on tree trunks where it is needed. The rest billows through nursery rows covering tree canopies, the ground, and may leave the target area as drift. Thus, more insecticide is released into the environment than is need to effectively control GAB.

A grower in Johnston County, NC developed a spray wand with two opposing nozzles eight inches apart. Using this wand and a backpack sprayer all sides of a tree can be sprayed in a single pass down the trunk. The grower developed this to spray trees that grow around his pond to avoid contaminating water with an air-blast sprayer. In this research our objective was to compare the application time, volume of insecticide released and coverage achieved by the dual nozzle wand, and air-blast sprayer.

This research was conducted at a pot-in-pot nursery in Johnston County, North Carolina. Plots of red maple trees were assigned to one of three treatments: single wand (n=3), dual wand (n=3, or air-blast (n=4). Each plot had between around 150 trees which were counted each visit. On March 19 and April 16, 2009 the nursery was visited to make permethrin applications. Before applications were made 9 spray cards were hung in each plot to measure coverage. On three randomly selected trees a spray card was tied to the trunk below the first branches (~4 ft.), and in the canopy (~7 ft.). Two cards were also hung on stakes between trees to measure the insecticide that does not land on tree trunks. The last card was hung on a stake 6 feet outside of the plot to measure insecticide drift leaving the target area.

Wand applications were made using a CO2 charged backpack sprayer set at 30 psi to release 12.5 gallons per acre. Applications with the dual nozzle wand were made by making a single pass down each trunk which covered all side of the trunk. Air-blast applications were made by the grower using a Tifone air-blast sprayer. Applications were made from two sides of each plot. After each plot the amount of insecticide left in the backpack or air-blast tank was recorded.

Spray cards were collected and scanned to produce jpeg images. The percent of the card that was covered was measured using ImageJ software. Time, volume, and coverage data were log(x+1) as needed to meet assumptions of normality and homogeneous variance and analyzed using t tests SAS (version 9.1).

Results and Discussion: It took about 7 times as long to apply permethrin the trees in each plot using the double wand and backpack sprayer than with the air-blast sprayer in March (t = 4.34; df = 5; P = 0.007) and in April (t = 6.78; df = 5; P = 0.001) (Figure 1). When corrected for the number of trees per plot wand applications took 6 seconds per tree which is 10 times longer than air-blast applications in March (t = 4.43; df = 5; P = 0.007) and April (t = 4.49; df = 5; P = 0.007) (Figure 1).

The volume of insecticide applied in each plot averaged 5.9 quarts using the double wand. This is approximately 85% less than the 47 quarts applied to each plot using the air-blast sprayer in March (t = 4.49; df = 5; P = 0.007) and April (t = 6.78; df = 5; P = 0.001) (Figure 2). When corrected for the number of trees per plot wand applications took applied 5.5 times more insecticide per tree which than air-blast applications in March (t = 2.67; df = 5; P = 0.045) and April (t = 7.58; df = 5; P < 0.001) (Figure 2).

Coverage of tree trunks was not significantly different between application methods in March (t = 0.87; df = 5; P = 0.423) or April (t = 0.96; df = 5; P = 0.373) indicating the efficacy of both methods should be similar (Figure 3). Air-blast coverage of the canopy was greater in March (t = 3.07; df = 5; P = 0.028) but not April (t = 0.71; df = 5; P = 0.373) indicating that air-blast applications place insecticide where it is not essential to prevent GAB damage (Figure 3). By measuring coverage between rows we determined that air-blast applications placed significantly more insecticide on unintended surfaces in March (t = 4.59; df = 5; P = 0.006) and April (t = 6.22; df = 5; P = 0.002). In addition, during air-blast applications more insecticide landed on cards 6 feet outside of the plots as drift in March (t = 19.07; df = 5; P < 0.001) and April (t = 2.89; df = 5; P = 0.034) (Figure 3).

To protect trees from GAB insecticide has to be applied to tree trunks where GAB boring occurs. Our results indicate that coverage of tree trunks is not different between wand and air-blast applications. Thus, efficacy of each method should be similar.

Applying permethrin directly to tree trunks using a dual wand had several potential advantages for pest management and the environment. First, 85% less insecticide applied was per plot of maples using the double wand versus the air-blast application. We found that the approximately 41 quarts of extra insecticide per plot coated the canopy of the tree, landed in empty spaces between trees, and left the plot as insecticide drift. Applying broad spectrum insecticides to tree canopies has been shown to promote secondary pest outbreaks or pest resurgence due to depletion of natural enemies (1). Thus, growers may face greater pest problems later in the year due to air-blast applications in early spring. In addition, air-blast sprayers apply insecticide based on area rather than the number of plants present in a plot. Thus, as stock is shipped or moved out of an area insecticide volume can be reduced when applied with a wand but not when applied with an air-blast sprayer.

Although, most growers are careful to prevent insecticide drift from landing in areas outside the nursery, a large amount of insecticide is landing on non-target areas within the nursery that could be toxic to workers, other organisms, or ground and surface water (2). In fact the large majority of insecticide solution dispensed does not land on tree trunks and thus performs no service to the grower. Time is the major advantage of using an air-blast sprayer. Plots can be sprayed much faster and growers assume that wasted insecticide is less costly than labor. This may well be the case with permethrin which is relatively inexpensive. However, this does not account for potential loss of valuable ecosystem services provided by natural enemies (3).

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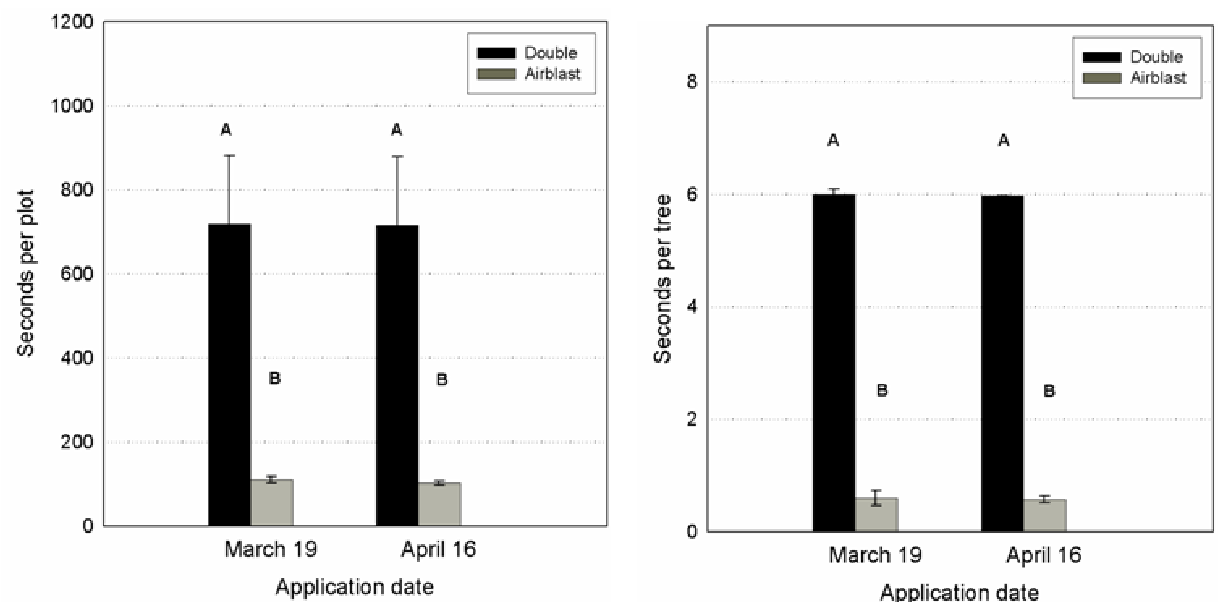

Figure 1. Number of seconds required to spray plots of maple trees with a double-nozzle wand and backpack or a Tifone air-blast sprayer.

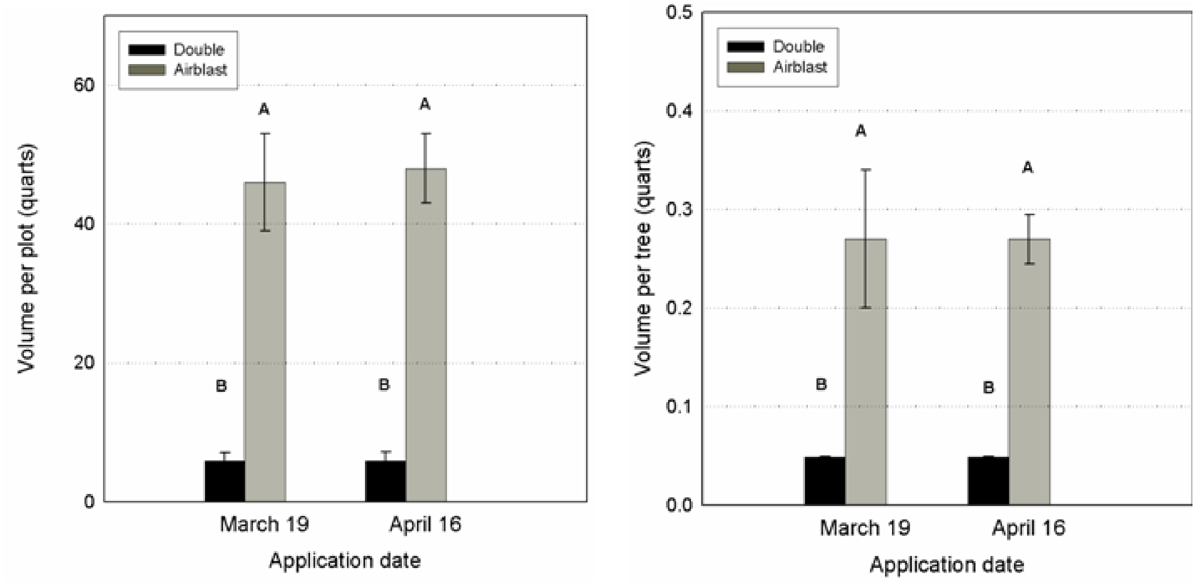

Figure 2. Volume of permethrin solution released during application to plots of maple trees with a double-nozzle wand and backpack or a Tifone air-blast sprayer.

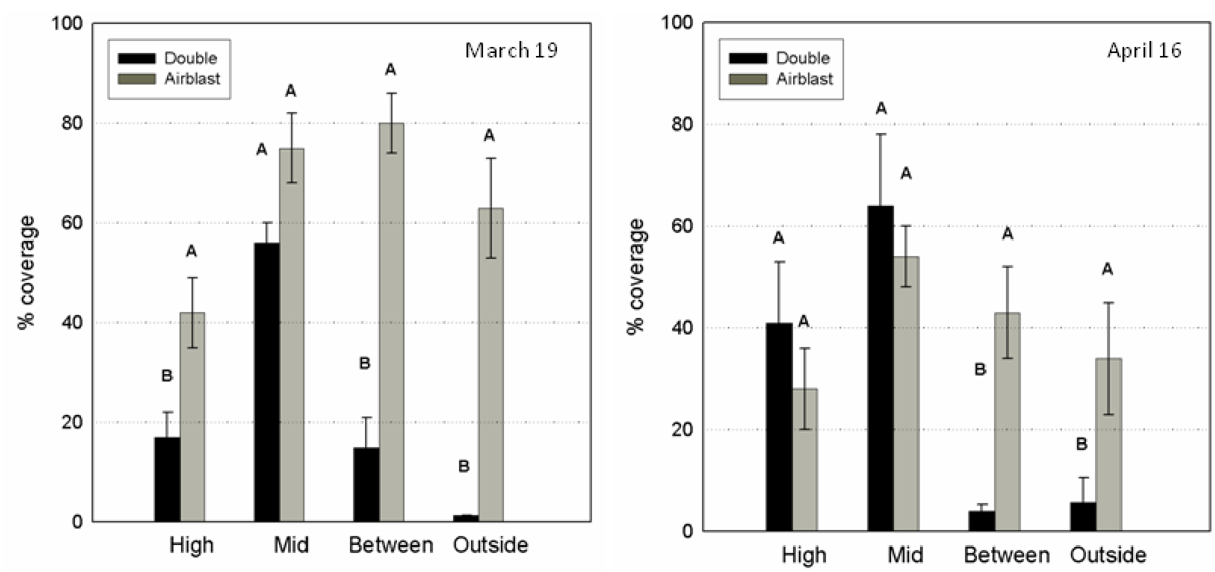

Figure 3. Coverage of water sensitive spray cards with permethrin solution applied with a double-nozzle wand and backpack or a Tifone air-blast sprayer when hung in the canopy (high), on the trunk (mid), between rows (between), and 6 feet outside (outside) plots of maples.

An IPM approach to gall-making insects and mites

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Index Words: Eriophyid mites, gall wasps, gall midges, bulletgall wasp, gouty oak gall, horned oak gall, Oriental chestnut gall wasp

Significance to Industry: Most types of plant galls found in the nursery and landscape are caused by eriophyid mites (gall mites) and insects such as cynipids (gall wasps), cecidomyiids (gall midges), aphids, adelgids, phylloxera and others. The leaf galls are predominantly an aesthetic problem and not a detriment to normal plant growth and development, although there are exceptions. Some types of cynipids (gall wasps) such as the rough bulletgall wasp produce twig galls that can reduce the growth rate of susceptible trees (1). The Oriental chestnut gall wasp, *Dryocosmus kuriphilus*, is an exotic (non-native) gall wasp that can cause annual die-back of new twig and leaf growth of Chinese, European, and American chestnut which can stunt the tree (2). The gall wasp species responsible for the gouty oak gall and the horned oak gall can cause severe branch die-back that might take over a year to fully manifest. These and other twig galls are especially apparent in the fall and winter when no leaves are on the tree to hide their unsightly appearance.

Since feeding or egg deposition by the insects or mites initiates gall formation, any form of chemical control needs to be applied prior to when the gall insects and mites are expected to become active. While prevention of leaf gall formation is difficult but possible using chemical control, an effective preventative control of twig gall formation is not known. For these reasons, a comprehensive integrated pest management (IPM) approach is needed to try to determine how to better manage these galls.

Nature of Work: Many of the gall-making insects and mites produce leaf galls that are primarily aesthetic in nature. Increased education might persuade some consumers to accept leaf galls on plants in their landscapes and refrain from using chemical control. Aesthetic damage from leaf galls is potentially more of a problem in the commercial nursery, especially if the plants are to be sold with their foliage. While chemical control options are available, control is difficult because the activity of the pest is often not known. Thus, proper timing of the application or the need for multiple applications is often unknown.

Chemical pest control is used extensively throughout the nursery industry because it is generally cost-effective. It is indeed the exception when there is not at least one effective chemical control option for a particular pest. The effectiveness of chemical control has in many instances been a detriment to an IPM approach to pest control. The lack of an effective chemical control to prevent formation of some of the more damaging twig galls has increased the interest in an IPM approach to gall insects and mites.

Host plant resistance is an area of interest in need of further study. There is a broad range of resistance of bur oak to the rough bulletgall wasp with some trees being essentially gall-free while adjacent ones are heavily galled (1). Trees that appear resistant can be selected for propagation and eventual testing for resistance. Gall resistant trees with other superior horticultural characteristics could potentially be patented and sold at a premium.

Conservation of natural enemies is another area in need of investigation. Often, the natural enemies of a pest are more susceptible to insecticide than the pest. It is important to know the life cycles of the natural enemies that are the most important regulators of the pest. Insecticide applications can then be best made at times when the susceptible stages of the natural enemies are not exposed to the insecticide. Another common control tactic is to prune out infested limbs. This is only practical on small trees with only a few infested twigs. One concern with this practice is that the removal of the gall has the potential to remove parasitoids of the pest (1). Thus, it is important that the life cycles of the natural enemies be understood so that they are not removed during pruning. This makes the timing of any pruning extremely important. One of the best ways to control exotic gall-making insects is to introduce natural enemies of the exotic pest from its native land. The Oriental chestnut gall wasp which first appeared in the United States in 1974 has been controlled in the South by an introduced parasitoid wasp (3).

Results and Discussion: The difficulty in preventing the formation of plant galls with traditional chemical control has opened up the opportunity to take an IPM approach. While control of leaf galls that are primarily aesthetic in nature is discouraged in the landscape, control is probably warranted in the commercial nursery. IPM tactics that show much promise include conservation of natural enemies, the introduction of natural enemies for exotic pests, and host plant resistance. A better understanding of the relationship between the gall insect or mite and its natural enemy complex will be important in any IPM approach.

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Spray and Pray: Canna Leafroller Insecticide Evaluation

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Index words: *Geshna cannalis*, caterpillar, insect pest, leaf feeding

Significance to industry: The lesser canna leafroller, *Geshna cannalis* (Quaintance) (Lepidoptera: Pyralidae), is one of the most damaging insect pests in both nursery canna production and landscape situations. The caterpillar attaches silken threads to unfurled leaves and feeds within the developing leaf whorl. Damaged plants have a tattered, unthrifty appearance and may have a reduction in blooms.

Nature of Work: *Canna* x *generalis* 'Phaison', planted into 1-gallon containers, were treated 6/13, 6/18, 6/25, and 7/2 and evaluated by determining the percentage shoots damaged by the lesser canna leafroller on 6/18 (data not shown, no significant differences among treatments), 6/24, 7/1 and 7/8. On 7/8 shoots were also evaluated for percentage shoots severely damaged by the lesser canna leafroller, *Calpodes ethlius* (Stoll). Treatments included the insecticides (rates are in oz or fl oz/100 gal): metaflumizone (6, 8, 12, and 16 fl oz), Orthene 97 (12 oz). TriStar 30 (5.3 oz) and QRD400 (130 fl oz). Plants were thoroughly sprayed with all plant surfaces sprayed including directing spray down the unfurled leaf whorls. The experimental design was a completely randomized design with six replications of each treatment. An experimental unit consisted of a one-gallon container-grown canna.

Results and Discussion: Orthene 97 was the most effective treatment with a range of 0 to 6% damage and 0% severe damage (Tables 1 and 2). TriStar 30 and metaflumizone treatments were moderately effective with from 8-35% damage; however, for severe damage the 8-16 fl oz metaflumizone treatments had less than 10% foliar injury (0-8%). Damage to the untreated control ranged from 53 to 77% and 47% severe damage. QRD400 had the greatest damage of any insecticide treatment with 56-94% damage and 94% severe damage. On 7/8 shoots were cut off, dried and weighed. There were no differences among treatments based on dried shoot weight (*data not presented*).

Based on presented data, Orthene would be the recommended treatment for controlling lesser canna leafroller larvae. However, if some plant damage can be tolerated the 8-16 fl oz metaflumizone and TriStar 30 treatments could be use as stand alone or as part of an insecticide rotation. The manufacturer of metaflumizone, BASF, has decided not to pursue the registration of this insecticide in the ornamental marketplace at this time.

Table 1. Percentage damage caused by the lesser canna leafroller.

	6/24		7/1		7/8	
Water-treated	53	ab*	77	ab	65	ab
metaflumizone 16 fl oz	25	abc	65	abc	35	bcd
metaflumizone 12 fl oz	31	abc	50	cb	28	cd
metaflumizone 8 fl oz	21	bc	45	c	42	bc
metaflumizone 6 fl oz	48	ab	59	abc	22	cd
Orthene 97	0	c	6	d	6	d
TriStar 30	8	c	36	c	21	cd
QRD400 (plant extract)	56	a	82	a	94	a

*Means separated using Fisher's Protected LSD, α=0.05, *P*≤0.05. Means followed by the same letter are not different.

Table 2. Percentage severe damage caused by the lesser canna leafroller.

	7/8	
Water-treated	47	b*
metaflumizone 16 fl oz	3	c
metaflumizone 12 fl oz	8	c
metaflumizone 8 fl oz	0	c
metaflumizone 6 fl oz	22	bc
Orthene 97	0	c
TriStar 30	17	c
QRD400 (plant extract)	94	a

*Means separated using Fisher's Protected LSD, α=0.05, *P*≤0.05. Means followed by the same letter are not different.

Testing a novel insecticide, Kontos, for efficacy against Florida Wax Scale

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Index words: *Ceroplastes floridensis*, spirotetramat, holly, *Ilex*, insect pest

Significance to Industry: Florida wax scale, *Ceroplastes floridensis* Comstock, is one of the most common insect pests of Chinese holly, especially in the landscape, but is also found on *Cleyera*, citrus, laurel, *Ficus*, oleander, and crepe myrtle in both landscape and production nursery settings. While infestations of these insects generally don't kill plants, the honeydew they excrete and subsequent growth of sooty mold on that honeydew make infested plants very unsightly and unmarketable.

Nature of Work: The experimental design for this experiment was a randomized complete block design with five replications of each treatment. An experimental unit consisted of a single, Florida wax scale-infested, 1-gallon containerized dwarf 'Burford' holly plant (*Ilex cornuta '*Burfordii Nana'). Blocking and data collection were based on the number of scale insects counted on the upper sides of the leaves of at least three terminal shoots per container. At the start of the experiment, there were a minimum of 30 scale insects located on these terminal shoots in each plot. Terminal shoots used to evaluated treatment efficacy were delineated with a cable tie. Scale insects were in the "star" or second-instar stage when treated. Treatments were as follows:

Treatment	Amount	Application Method
Untreated	--	--
Kontos	0.007 fl oz/ pot	Drench
Kontos	0.014 fl oz/pot	Drench
Merit 2F	0.007 fl oz/pot	Drench
Kontos+Adjuvant	1.7 fl oz/100 gal	Foliar Spray
Kontos+Adjuvant	3.4 fl oz/100 gal	Foliar Spray
Merit 2F+Adjuvant	1.7 fl oz/100 gal	Foliar Spray
Preference (Adjuvant)	32 fl oz/100 gal	Foliar Spray

A total volume of 240 ml of insecticide solution was applied to the surface of the potting substrate of each container in drench treatments. Plants were sprayed using a R&D CO2 sprayer set at 50 psi using a TX-18 conejet spray tip. An average of 162 ml of spray solution was applied to each plant.

Pre-treatment data were collected 5/29/08 and plants were treated on 5/30/08. Efficacy data were collected on 6/9/08, 6/16/08, 6/30/08, 7/30/08, 8/26/08, and 9/8/08; 10, 17, 31, 61, 88, and 101 DAT respectively. Scaled counted on 9/8/08, 101 DAT, were offspring produced by scale that survived the 5/30/08 treatment (second generation). Second generation scale crawlers were prevented from moving from plant to plant by placing containerized plants on top of a cut piece of PVC pipe placed within a 10" water-filled plastic pot saucer.

Data were analyzed using SAS, Proc GLM. Means were separated using Fisher's Protected LSD, α=0.05, $P \leq 0.05$.

Results and Discussion: From 10 days after treatment (DAT) through 88 DAT, all of the treatments except the Merit drench had significantly fewer scale than the untreated control (Table 1). By 17 DAT through the end of the experiment the Merit drench treatment had fewer scale than the untreated control (Table 1 and Figure 1). By the time the first generation scale had matured to adult insects, 61 and 88 DAT significant natural death had occurred and all treatments, including the adjuvant only treatment, had significantly fewer scale than the control and were indistinguishable from one another.

For the second generation scale, the drench treatments and Merit spray had the lowest number of scale, significantly lower than the untreated control (Figure 1). However, none of the treatments suppressed scale populations enough to warrant not treating the second generation scale.

One of the "functioning agents" of the surfactant used was "sodium salts of soya fatty acids" or soya soaps. It is likely that, at least in part, the insecticidal activity of the surfactant was due to the soya soap component. There appeared to be no additional benefit to adding Kontos to the adjuvant for increased scale kill. Kontos used as a drench and Merit (imidacloprid) applied both as a drench and a spray worked well to control first generation scale and decreased the number of second generation scale.

As one would expect, the drench treatments seemed to kill more scale on the interior of the plant than the spray treatments which may be largely responsible for the lower numbers of scale counted on these treatments in the second generation (CPH, personal observation).

Table 1. Mean number of Florida wax scale counted on each experimental unit: First Generation

	Pre		10 DAT		17 DAT		31 DAT		61 DAT		88 DAT	
Untreated	31.6	a*	22.8	a	20.6	a	11.8	a	5	a	5.2	a
KONTOS 0.007 fl oz/ pot- Drench	31.6	a	10	d	6	cd	3.2	bcd	0.8	b	0.6	b
KONTOS 0.014 fl oz/pot- Drench	31.8	a	16.4	c	5	d	1.4	d	0	b	0	b
MERIT 2F 0.007 fl oz/pot- Drench	31.4	a	22.6	ab	14.8	b	6	b	1.2	b	0.2	b
KONTOS 1.7 fl oz spray	31.4	a	9.2	d	7.8	cd	5	bc	1.8	b	1.6	b
KONTOS 3.4 fl oz spray	31.8	a	12.4	cd	6.4	cd	3.6	bcd	0.8	b	1.2	b
MERIT 2F 1.7 fl oz spray	32	a	7.2	d	2.4	d	2.4	cd	1	b	1	b
PREFERENCE 32 fl oz spray	31.4	a	17	bc	11.2	bc	4.8	bc	2	b	1.8	b

*Means were separated using Fisher's Protected LSD, α=0.05, $P \leq 0.05$. Means followed by the same letter within a column are not significantly different.

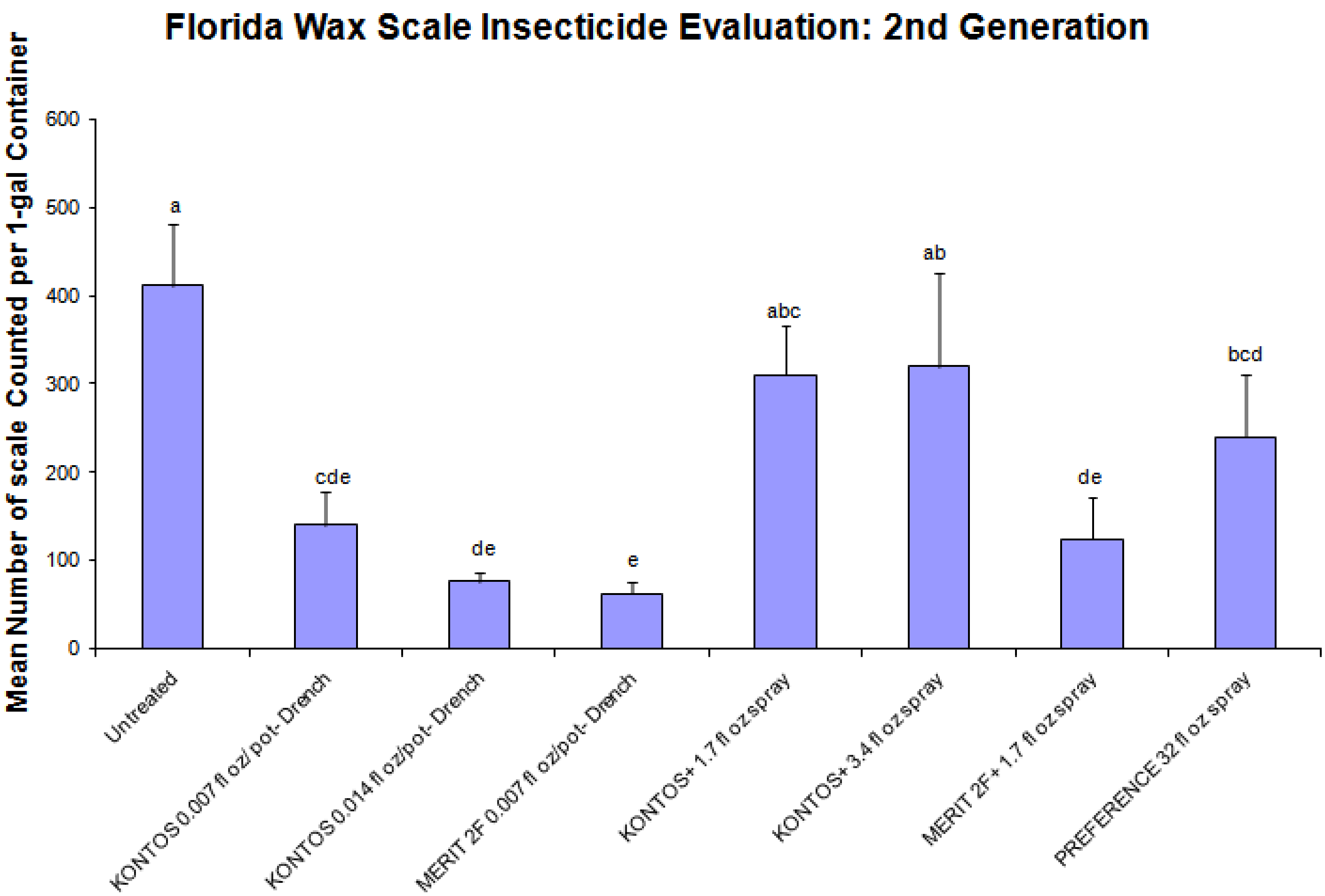

Figure 1. Columns represent the mean number of scale per experimental unit per treatment. "T" lines topping columns represent the standard error of the mean. Means were separated using Fisher's Protected LSD, α=0.05, *P* ≤0.05. Means followed by the same are not significantly different.

2009 Survey of strawberry rootworm in MS: Assessment of yellow sticky-traps for monitoring strawberry rootworm in nurseries.

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Index Words: *Paria fragrariae*, pest monitoring, evergreen azalaeas.

Significance to industry: The strawberry rootworm, *Paria fragrariae* Wilcox (Coleoptera: Chrysomelidae), has become a major pest of evergreen azaleas in the Gulf Coast Region. Pesticide applications are having limited effect and damage continues to occur on carry-over plants not sold due to the current economic slowdown. To date, SRW have not been reported to be a pest in the landscape, but this area needs to be addressed. Adequate means for monitoring this insect pest would save ornamental producers time and money by providing more effective ways to detect the pest and reduce pesticide applications with more effectively timed insecticide sprays. If efforts are not continued to decrease populations of SRW in ornamental nurseries in the Southeast, this pest has the potential to severely impact the evergreen azalea industry in the gulf states region.

Nature of Work: Members of the strawberry rootworm (SRW) species complex are emergent pests of evergreen azaleas in the Southeast. Larvae feed in soil on roots, but cause no noticeable damage. Adults feed at night on foliage and damage plants.
The strawberry rootworm species complex consists of two sub-species, *Paria fragariae fragariae* and *Paria fragariae kirkii* (1). Both species have been found to damage evergreen azaleas in production nurseries in the Southeast (2). Gaps in knowledge on the abundance, distribution, and life history of these insects are needed to develop more effective controls. Previous sampling methods for these insects involved manual techniques attempting to dislodge adults from infested plants (2) or using powerful vacuums to collect adults from foliage.

In this study, we evaluated both yellow sticky traps and tent traps for monitoring of SRW adults at 11 nurseries in MS. We surveyed azalea-growing nurseries in MS for overall abundance and distribution of SRW in evergreen azaleas and to correlate these numbers with SRW beetle adundance on unbaited sticky traps. Azalea growing nurseries were identified using the 2007 Quick Reference guide to ornamental nurseries and sod producers (4). A total of 25 nurseries were initially screened for presence of SRW damage. Eleven nurseries were selected for SRW monitoring with sticky cards for rootworm abundance. All of these nurseries had SRW damage present and grew SRW-susceptible cultivars. A list of cultivars commonly found with SRW damage is presented in Table 1. Yellow sticky cards were attached singly to irrigation risers directly adjacent to the damaged plants approxiamtely 3 feet (0.914 m) above the ground. Traps were placed in nurseries in the last week of March and sampled every 30 days though November 7, 2009. Trap collection data were compiled to correlate SRW damage with trap catch. Yellow sticky and tent traps were both used intitally, but the use of tent traps was discontinued after the traps were found to be completely inneffective.

Results and Discussion: Initial surveys found SRW damage in 50% of nurseries sampled. Monthly sampling of these nurseries showed damage persisted throughout the year and in most cases the damage worsened. All nurseries that had SRW damage were conducting routine sprays and still had damage, although nurseries with more extensive spray programs (more than 3 applications per growing season) did have less accumulation of damage over our sampling period. Future sampling will include closer observations of spatial orientation of the damage and how the adult beetles disperse annually. Overhead maps of nurseries will be utilized next year to create a grid-quadrant system for repeated sampling of affected areas. Yellow sticky trap counts were very low (5% trap catch effeciency), with only 28 SRW adults collected over the entire sampling period. Insects on the yellow sticky traps were damaged extensively by overhead irrigation, and many traps were molded as well.

Tent traps were completely ineffective for sampling for SRW in nurseries (0% catch effeciency), although the tent traps were not effective for SRW, the enclosed design did offer some degree of protection for the insects stuck to the trap. The USDA-ARS is currently collaborating with researchers at the Otis L. Floyd Nursery Research Center in McMinnville, TN to isolate sex and aggregation pheromones. These pheromones combined with the tent traps may provide a more useful tool for monitoring nurseries for this damaging insect pest and will be evaluated once they are available. Currently, manual sampling is still the best method for monitoring for SRW in production nurseries. Using a beat net and knocking foliage with a blunt object (1/2" (12.7 mm) PVC pipe with T-connector on the end works well) will dislodge adults tucked away in the foliage. Sampling leaf litter by tipping the pot and giving 3-4 hard strikes with a blunt object is also effective and will yield adult SRW if they are present. Future monitoring efforts will incorporate baited pheromone traps for monitoring SRW in nurseries and will still necessitate manual sampling to determine presence of SRW in the field.

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Table 1. Azalea cultivars with frequent damage from strawberry rootworm larval feeding.

Cultivar	**Series**	**Growth habit***	**Flowers**
Watchet	Robin Hill	Dwarf	Early-Late**
Renee Michelle	Girard	Compact	Late Spring
Conversation Piece	Robin Hill	Mounding	Late Spring
Fashion	Glenn Dale	Erect/branched	Mid Spring
Pink Ruffles	Rutherford	Compact	Late Spring
Sir Robert	Robin Hill	Dwarf	Late Spring
Hershey Red	Kurume	Compact	Mid Spring
Osasuki	Satsuki	Dwarf	Mid Spring
Aikoku	Satsuki	Dwarf	Late Spring
Congo	Robin Hill	Dwarf	Mid Spring
Gillie	Robin Hill	Compact	Late Spring
Autumn Rouge	Encore Autumn	Medium	Early-Late**
Autumn Embers	Encore Autumn	Medium	Early-Late**
Autumn Angel	Encore Autumn	Medium	Early-Late**
Autumn Debutante	Encore Autumn	Medium	Early-Late**
Midnight Flare	Harris	Compact	Mid Spring
Coral Bell	Kurume	Compact	Mid Spring

** Growth Habit information obtained from Azaleas, by Galle (3).*
*** Re-blooming cultivars*

Evaluation of insecticides for flatheaded borer management in field-grown red and sugar maples

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Index words: Buprestidae, *Chrysobothris femorata*, *Acer rubrum*, *Acer saccharum*

Significance to Industry: Flatheaded borers can cause major damage to woody ornamentals due to larval feeding on vascular tissues, either killing the tree or rendering it unsuitable for sale. Maples are popular landscape trees that are commonly attacked by flatheaded borers both in the nursery and landscape. This study determined that a single drench of a systemic neonicotinoid insecticide (i.e., Allectus SC, Discus, Merit FXT, Arena 50WDG, or Safari 20SG) protected about 90 to 95% of the crop from flatheaded borers during a 4-year period, while other insecticide treatments generally protected about 80% of the crop. About one-third to two-thirds of the non-treated trees were lost to flatheaded borers during the 4-year period. Imidacloprid applied as a drench to the lower trunk and soil, or as a root dip, was the most effective treatment. New flatheaded borer attacks continued to accumulate during each year of the four-year study in non-effective treatments; however, the rate of new attacks declined as the amount of time increased from transplanting. Soil inserted imidacloprid tablets were not initially as effective as imidacloprid drenches, but provided complete borer prevention during the third and fourth evaluation years, indicating borer control from tablets improved with time. Trunk diameter growth was also enhanced by Discus and Safari applications (7), indicating another benefit.

Nature of Work: Flatheaded borers are the larval stage of beetles in the metallic wood-boring beetle family (Coleoptera: Buprestidae). The common name is derived from the enlarged first segment of the thorax, which gives the larva the appearance of an enlarged and flattened head. The larvae primarily tunnel beneath the bark in the cambium area and into the wood (xylem) to pupate (3). Larval damage can be confused with other types of common trunk injury (e.g., freeze damage, mechanical, cankers), and therefore, it is likely flatheaded borer damage is frequently misdiagnosed. Adult flatheaded borers deposit eggs on the trunks of trees during the spring, and subsequent larval damage is often unapparent until the following fall, which is another challenge to growers attempting to manage this pest. The flatheaded appletree borer (FAB) (*Chrysobothris femorata* [Olivier]) is a problem species in nursery crops (1, 3, 9) throughout the United States, attacking up to 30 tree species (2). Prophylactic trunk sprays with contact insecticides like chlorpyrifos (e.g., Dursban), bifenthrin (e.g., Talstar or Onyx Pro), or permethrin (e.g., Perm-Up 3.2EC) are commonly used to prevent FAB attacks. A May and June application of chlorpyrifos or a February to mid-April application of imidacloprid is the current extension recommendation for FAB control in Tennessee (5). Recent damage surveys in the middle Tennessee indicate flatheaded borers are not being adequately managed in some nursery crops like dogwood and maple, where crop losses near 25 to 40% are common (Oliver and Fare, unpublished data). Oliver et al. (6, 7, 8) reported borer and leafhopper control with several neonicotinoid insecticides on field grown red maples. Therefore, the purpose of this study was to evaluate systemic and contact insecticides for prevention of flatheaded borer damage in maples.

Insecticides were applied to newly transplanted red maple (*Acer rubrum* L.) or sugar maple (*Acer saccharum* Marshall) cultivars at a commercial nursery in 2005 or 2006 to evaluate effectiveness against flatheaded borers (Table 1). Systemic insecticides (Borer-Stop EcoTab, Allectus SC, Discus, experimental imidacloprid gel, Merit FXT, Arena 50WDG, Flagship 25WG, or Safari 20SG) were applied only one-time during the study in either March, April, May, or June (Table 1). Discus rates were based on the trunk diameter (DBH [diameter at breast height]) as specified on the insecticide label; however, we used trunk diameter measurements at 15.2 cm (6 in) above the soil line where nursery trees are normally measured. The majority of trees in this study had trunk diameters ~ 2.5 cm (1 in). Other systemic insecticide rates were based on manufacturer trial rates. The Arena 50WDG rate was selected to be one-third less than the active ingredient rate of Discus. Contact insecticides (Dursban 2E or 4E; Onyx Pro Insecticide) were applied either one time during the first year or twice during the first and second year. Two applications per year of contact insecticides are recommended by extension (5). Contact insecticides are frequently used in grower spray programs, and our damage surveys indicate flatheaded borer damage is not being consistently managed. In this study, contact insecticides were applied at 2X (Dursban) or 2.5X (Onyx) the labeled rate. One Dursban treatment was sprayed only on the southwest side of the trunk because flatheaded borers prefer to oviposit on the sunny side of the tree (1), trunk damage is most common where the bark is exposed to sunlight (4), and in nursery surveys, the highest damage incidence is located on the southwest side of the tree (Oliver and Fare, unpublished data). Trees were then monitored for new flatheaded borer damage in the fall and spring for a 4-year period. A sub-sample of damaged trees was removed during the study to rear flatheaded borer adults for identification.

Results and Discussion: The only flatheaded borers reared from maple trees in this study were FAB. Maples sustained high levels of flatheaded borer attack when not treated with insecticides (Table 1). With the exception of one test with Franksred (2.3% damage), all non-treated control plants in the maple tests had flatheaded borer damage ranging from one-third to two-thirds of the crop by the end of four years with a combined total damage of 35.4%. These levels of crop damage are not likely to be economically acceptable to most growers and indicate a substantial loss in potential crop income. Flatheaded borer damage occurred during all evaluation years, but the first and second years following transplanting had the highest attack rates in the non-treated control and Dursban treatments followed by an almost curve-linear decrease in attacks by the third and fourth years (Fig. 1). In contrast, most imidacloprid treatments were protected during the first and second years, but began to have a slight damage increase during the third and fourth years (Fig. 1). The least effective insecticide treatments were Borer-Stop EcoTab acephate tablets and Dursban trunk sprays. The six-tablet rate of Borer-Stop EcoTab caused severe phytotoxicity, visually expressed as leaf scorch, which may also explain why this treatment had the highest percentage of flatheaded borer attacks in the study. A single application of Onyx Insecticide Pro was more effective than two applications of Dursban and was equivalent to some of the systemic insecticides like Arena and Safari. However, Onyx was applied at a non-labeled 2.5X rate and was only about 90% effective, which would limit practicality to growers. All of the systemic insecticides provided greater protection than Dursban, Borer-Stop EcoTab, or the untreated. Flagship was the least effective systemic insecticide, but also had the lowest rate in the study, which may have been a factor in the reduced control. Safari was 100% effective during the first year, but its effectiveness declined in subsequent years (data not shown). A single Merit FXT (now marketed as CoreTect) tablet or the experimental imidacloprid gel was generally not effective. However, two Merit FXT tablets provided reasonable control during the first and second year and provided 100% control during the third and fourth years (data not shown). The improved control observed with Merit tablets in years three and four might suggest a slower release of active ingredient with these formulations compared to other formulations like drench treatments. Discus applied as a drench or root dip was very effective. The highest Discus drench rate (44 ml [1.5 fl oz]) provided 100% borer control during the four-year test period. At the 22 ml (0.75 fl oz) rate, Discus applied in March was slightly more effective than the May application, indicating a potential advantage for early-season applications that allow more time for imidacloprid to translocate into the tree. Flatheaded borer damage increased from 0 to 6.3% as imidacloprid rate decreased from 1.38 to 0.30 grams (0.04 to 0.01 oz) for drench treatments like Discus and Allectus (Table 1). Overall, Discus drenches and root dips, other systemic insecticides, and contact insecticides protected about 95%, 90%, and 80% of the crop, respectively. In this test, a one-time application provided up to four years of flatheaded borer protection, which is a major advantage compared to repeated applications and higher labor costs for trunk sprays with contact insecticides. Systemic insecticides have a higher initial cost, but the effective long-term control of leafhoppers (6, 7) and borers coupled with lower labor costs may allow these products to be a valuable part of pest management programs.

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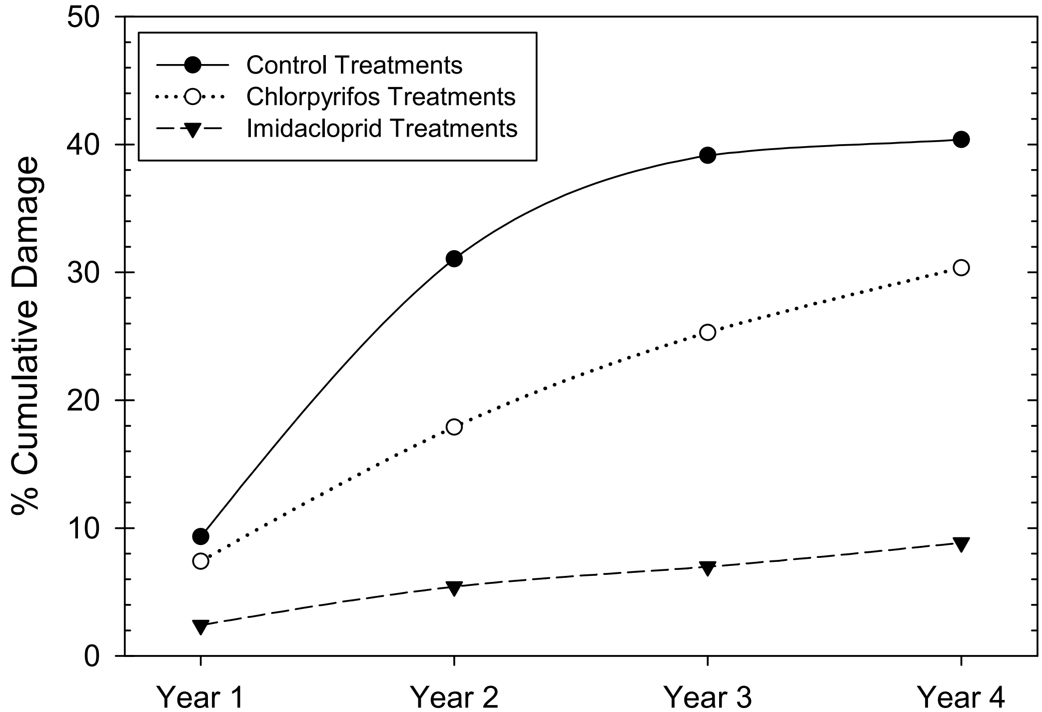

Fig. 1. Percentage cumulative flatheaded borer damage for each consecutive year following treatment for all non-treated control, chlorpyrifos, and imidacloprid treatments. Data are pooled damage totals for tests initiated in 2005 or 2006 (red and sugar maple cultivars). Note: Dursban treatments were not applied after year 1 for tests initiated in 2005 and after year 2 for tests initiated in 2006.

Table 1. Summary of the percentage of field-grown red and sugar maple cultivars with flatheaded borer damage in the fourth year after insecticide treatment.

							% Flatheaed Borer Damage[T]							All Tests	
Treatment[Z]	Primary Active Ingredient[Y]	Treatment Method[X]	Total Applications in 4-Year Period[W]	Treatment Month[V]	Product / Tree[U]	Active Ingredient / Tree	Autumn Flame (n = 48)	Franksred (n = 44)	Fairview Flame (n = 16)	Franksred (n = 39)	October Glory (n = 27)	Bow Hall (n = 10)	Flax Mill Majesty (n = 21)	n	%
Untreated	None	----	----	----	----	----	39.6	2.3	37.5	41.0	32.1	66.7	42.9	205	32.2
Borer-Stop EcoTab	Acephate	Soil insertion	1	June	2 tablets	2.00 g	35.4	9.1	----	----	----	----	----	92	22.8
Borer-Stop EcoTab	Acephate	Soil insertion	1	April	6 tablets	6.00 g	----	----	75.0	28.2	18.5	50.0	33.3	113	35.4
Allectus SC	Imidacloprid	Drench	1	May	5.6 ml	0.30 g	8.3	0.0	0.0	7.7	3.6	11.1	19.0	205	6.3
Discus	Imidacloprid	Drench	1	March	22 ml	0.69 g	----	----	0.0	0.0	0.0	0.0	14.3	113	2.7
Discus	Imidacloprid	Drench	1	May	22 ml	0.69 g	6.4	4.5	6.3	5.1	0.0	0.0	14.3	205	5.4
Discus	Imidacloprid	Drench	1	May	44 ml	1.38 g	0.0	0.0	----	----	----	----	----	92	0.0
Discus + Terrasorb	Imidacloprid	Root dip	1	March	~ 26 ml	~ 0.82 g	----	----	0.0	2.6	0.0	0.0	----	92	1.1
Imidacloprid gel	Imidacloprid	Soil insertion	1	March	10 g	0.50 g	----	----	18.8	12.8	7.4	40.0	9.5	92	15.2
Merit FXT	Imidacloprid	Soil insertion	1	March	1 tablet	0.50 g	----	----	43.8	15.4	19.2	27.3	19.0	113	22.1
Merit FXT	Imidacloprid	Soil insertion	1	March	2 tablets	1.00 g	----	----	18.8	5.1	3.7	40.0	23.8	113	13.3
Merit FXT	Imidacloprid	Soil insertion	1	May	2 tablets	1.00 g	6.3	0.0	----	----	----	----	----	92	3.3
Arena 50WDG	Clothianidin	Drench	1	March	0.92 g	0.46 g	----	----	6.3	5.1	3.7	30.0	4.8	113	7.1
Arena 50WDG	Clothianidin	Drench	1	May	0.92 g	0.46 g	----	----	12.5	7.7	3.7	10.0	9.5	113	8.0
Flagship 25WG	Thiamethoxam	Drench	1	May	0.33 g	0.0812 g	----	----	12.5	20.5	14.8	30.0	19.0	113	18.6
Safari 20SG	Dinotefuran	Drench	1	May	6 g	1.20 g	----	----	0.0	10.3	7.4	40.0	9.5	113	10.6
Onyx Pro Insecticide	Bifenthrin	Full trunk spray	2	May	2.5X spray	2.5X spray	----	----	18.8	5.1	7.7	27.3	4.8	113	9.7
Dursban 2E	Chlorpyrifos	Full trunk spray	4	May & June	2X spray	2X spray	----	----	31.3	17.9	11.1	50.0	23.8	113	22.1
Dursban 4E	Chlorpyrifos	Full trunk spray	1	May	2X spray	2X spray	33.3	0.0	----	----	----	----	----	92	17.4
Dursban 4E	Chlorpyrifos	SW trunk spray	1	May	2X spray	2X spray	35.4	4.5	----	----	----	----	----	92	20.7
Dursban 4E	Chlorpyrifos	Trunk roll	1	May	2X wipe	2X wipe	41.7	0.0	----	----	----	----	----	92	21.7

[Z] Merit FXT is now marketed as CoreTect.

[Y] Allectus SC and Discus also contain bifenthrin and cyfluthrin, respectively.

[X] Tablets were inserted ~ 7.6 cm (3 in) into the soil and ~ 7.6 cm (3 in) from the trunk. Tablets in multiple tablet treatments were placed in separate holes that were equally spaced around the base of the tree. The imidacloprid gel was likewise applied, except a caulk gun was used to deliver the gel bead into the soil. Drenches were applied to the lower trunk and the soil at the base of the tree (~15 cm [5.9 in] circle around tree base). Dursban spray treatments were applied with a CO2 backpack sprayer to the point of runoff. Treatments with full trunk sprays had all sides sprayed, while the SW treatment was sprayed only on the southwest side of the trunk. The Dursban trunk roll treatment was applied using a paint roller. The Discus + Terrasorb root dips were prepared by mixing 45 g (1.6 oz) Terra-Sorb Fine Hydrogel in 11.7 liters (3 gal) of water and then adding 3.8 liters (1 gal) of Discus. Tree roots were dipped in the Discus + Terrasorb mixture with each tree removing about 105 g (3.7 oz) of material (based on weight change).

[W] All systemic treatments (i.e., acephate, imidacloprid, clothianidin, thiamethoxam, and dinotefuran) were applied one time at the beginning of the four-year evaluation period. Onyx Pro was applied once during each of the first two consecutive years. Dursban 2E was applied according to current extension recommendations (i.e., May and June treatments) during each of the first two consecutive years. Dursban 4E was applied only during the first year (i.e., not according to extension recommendations).

[V] All treatments were applied near the middle of the specified treatment month.

[U] For systemic imidacloprid drenches, product applied per tree was based on trunk diameter as recommended on the label. For other systemic insecticides, product applied per tree was based on manufacturer trial rates. For trunk sprays, it was determined that the CO2 backpack sprayer delivered ~ 70 ml total volume during the time required to treat all sides of the tree. However, the actually amount of Dursban reaching the trunk or spraying past the trunk was unknown. Both the Dursban 2E and Dursban 4E treatments were mixed at 2X the labeled rate. Onyx Pro was mixed at 2.5X the labeled rate.

[T] Flatheaded borer ratings were conducted in the fall and spring over a 4-year consecutive period from the first treatment date. The Autumn Flame (n = 48) and Franksred (n = 44) tests were initiated in 2005 and all other tests were initiated in 2006. Percentages are the total number of trees for a given treatment that had flatheaded borer injury at some point during the 4 year period. Flax Mill Majesty is a sugar maple cultivar. All other cultivars are red maples.

Seasonal Flight Activities of Economically Important Buprestid Beetle Species in Tennessee

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Significance to the Industry: In total, fruit, nut, shade and ornamental trees grown in Tennessee are valued at more than $82 million dollars in annual stock sales (6). Many of these tree species are known to be suitable as host plants for one or more flatheaded borer (family Buprestidae) beetle species. Drought and other environmental changes can increase tree stress and have a dramatic effect on host plant susceptibility (7). Among the principal concerns in ornamental shade tree production is the flatheaded appletree borer, *Chrysobothris femorata* (Olivier). Knowing precisely when adults emerge should aid growers in timing their seasonal applications of costly pesticides, which in turn will reduce human and environmental exposure to pesticides, as well as lower labor costs by eliminating unnecessary pesticide applications.

Nature of the work: Metallic wood-boring beetles (Coleoptera: Buprestidae) are a challenging problem for ornamental plant producers because of the destructive feeding habits of buprestid larvae. While these beetles provide a necessary function in natural ecosystems, primarily by acting with other organisms to enhance forest diversity and assist in decomposing woody material, several buprestids are economic pests of tree crops. Key species may cause direct death of some landscape trees and shrubs, as well as profit losses attributed to injured nursery crop stock. As the extent of Tennessee's buprestid fauna becomes clearer it is apparent little is known of the adult flight period of many important species in the state. This information can be essential when considering pest management options available to those tasked with managing population levels.

Buprestid attacks on commercially grown ornamental crops in Tennessee nurseries can be costly. *Chrysobothris femorata* (Olivier) is known to attack maple and dogwood trees resulting in thousands of dollars in losses each year from trunk scarring and inability to sell injured trees. In some cases both in nursery and landscape settings, direct tree mortality can occur. A South Carolina study reported *C. femorata* attack rates of nearly 30% on trees in untreated nursery plots (1). Other buprestid beetle species also rely on host plant species, which include many deciduous shade trees and ornamental plants grown by Tennessee nurseries. If inadequately controlled, these pests can cause significant aesthetic losses in landscapes and economic losses to growers (2). Despite the threat buprestid beetles pose in these habitats, little seasonal flight data is available for many key beetle species.

Absence of data regarding adult buprestid beetle seasonal activity is attributed to difficulty in catching adult beetles, which are notoriously fast fliers and constantly vigilant, as well as the close visual similarity of different beetle species that rely on different host plants. In addition, some buprestid beetles spend much of their time protected within plant canopies where netting them is difficult. Other species may be uncommon or have short flight times, thus requiring several years of focused collecting. Rearing buprestids from host material can also be difficult because resources (e.g. time, labor, facility space) must be committed for several months while waiting for larvae to mature. Many times during this process, larvae desiccate within their galleries and fail to emerge despite efforts made to obtain and maintain host plant material. Fortunately, advances in buprestid trapping methods have facilitated survey work in Tennessee and other states, thereby reducing the cost, time and resource inputs needed.

Specimens for this study were taken in middle and eastern Tennessee using purple corrugated plastic panel traps, similar to those deployed nationwide to delimit emerald ash borer (*Agrilus planipennis* Fairmaire) populations (3). Traps were coated with a sticky adhesive to trap beetles alighting on its surface. Beetles were removed weekly, after which the trap was stripped and coated with a fresh layer of adhesive. Some specimens were reared from host material or captured by net and hand as adults. Data on adult flight times also included specimens from collections housed in the Department of Entomology and Plant Pathology museum in Knoxville and in the Great Smoky Mountains National Park in Gatlinburg.

Results and Discussion: Many adult buprestids in Tennessee had long periods of flight activity (Fig. 1). As anticipated, adult flight activity of Tennessee buprestids begin earlier than those of the same species in more northern latitudes, with some species having extended flight activities in the south (4, 5). We hypothesize that a few species may overwinter as adults in warmer climates and become active when temperatures increase in late March and early April. Further investigation of species emerging in March may confirm that some buprestids overwinter as adults.

Flight times of *C. femorata* in Tennessee are similar to those reported in Oklahoma but last longer than flight activities reported in Kentucky and Michigan (4, 5). Flatheaded appletree borers are a significant pest of maple, but females also oviposit on dogwood. Both trees are major sources of revenue for Tennessee growers (6). Extended flight time of *C. femorata* in Tennessee means trees are more likely to be attacked, particularly when under stress, translating to greater potential for economic loss.

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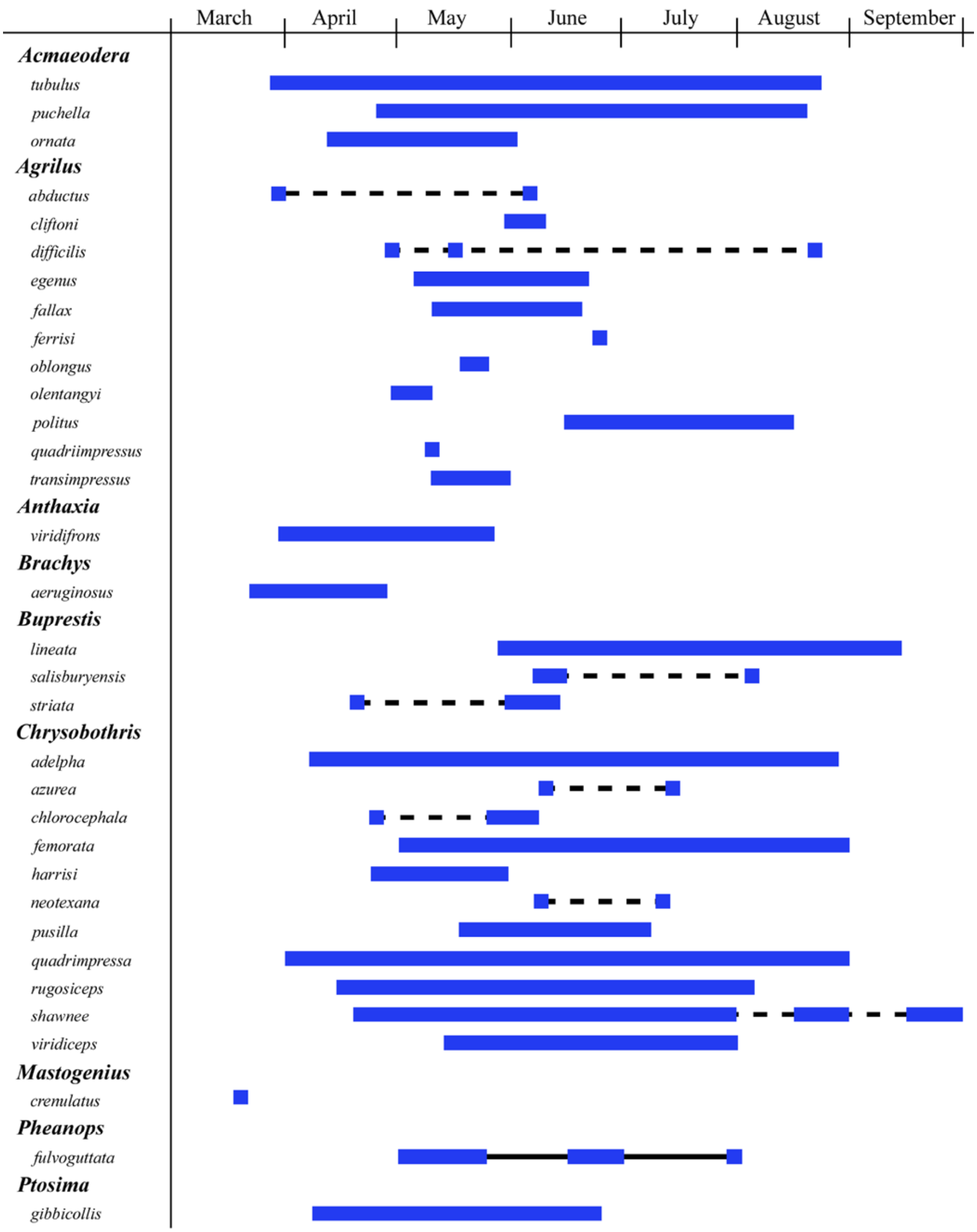

Figure 1. Adult flight activity of select buprestid wood boring beetles in Tennessee. Solid black lines indicate that beetles were directly collected from traps. Dashed black lines represent a gap in TN collection records. However, because these species have one generation per year, the adult beetles are likely to be active at that time.