SECTION 4
ENTOMOLOGY

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Initial Survey of Leafhopper Damage to Patented Red Maples

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Nature of Work: Tree nurserymen in South Carolina have recognized an increased incidence of damage to the terminal growth of patented red maples in late spring and early summer for several years. The damage is characterized by curling of foliage, often with marginal necrosis and stunting of terminal growth. Similar symptoms are associated with the vascular feeding of leafhoppers on certain maples and a few other ornamental trees (Johnson and Lyon 1988). Therefore, growers who normally make a single application of chlorpyrifos or lindane for borer control have increased their spray regimes to as many as five weekly insecticide applications against the suspected leafhopper pests.

In the spring, l99l, we made a systematic survey of the damage incidence in a four county area of South Carolina where tree farms are concentrated. In fields of October Glory and Red Sunset cultivars, we sampled terminals at random for leafhoppers by quickly approaching and enveloping terminals in l gallon freezer bags and clipping and sealing them for return to the laboratory to identity insects associated with damaged terminals. Ten fields also were systematically assessed for damage by rating 15 trees in three randomly selected blocks of five trees each per field. Trees were rated by percent of terminals damaged and by a damage severity rating (scale l to 3) where l = few leaves curled and little or no necrosis, 2 = several leaves curled and some necrosis evident, 3 = all leaves curled, necrosis and stunting easily evident by visual scan. A damage index was calculated by multiplying the percent damage by the damage rating. Following the damage assessment, yellow sticky cards (3 X 5 inch) were susperlded in 10 trees from each of two fields for a one week period from 18 to 25 June.

Results and Discussion: The potato leafhopper, Empoasca fabae (Harris), was present in densities of at least one leafhopper per terminal in most fields showing significant damage symptoms. The presence of a high percentage of nymphs on the underside of foliage in early to mid-June indicated that the damage was caused by the first invading adult population and a developing second generation of leafhoppers. Table 1 shows the results of subsequent damage assessments in each field and associated treatment histories. Though damage was prevalent throughout the survey region, considerable variation was evident in the percentage of terminals affected as well as the severity of damage. The damage index (scale 0 - 300) gives a relative indication of the intensity of damage within a field. In older trees, damage was primarily confined to upper terminals, and those that had been in the fieLd four or more years had relatively low damage indices. In trees exhibiting a second flush of growth, damage was noticeable on leaves of the first flush only.

Because of interfield variation. it was not clear whether treatment with chlorpyrifos had any impact on damage expression. Few leafhoppers could be dislodged by limb shaking in fields where treatment was known, and they were readily dislodged in all but Field 7 of the unknown treatments. However, Carlson (1980) demonstrated that few leafhoppers could cause considerable stunting in Norway maples.

Variation between fields was high, and some untreated fields sustained low levels of damage.

The average numbers of leafhoppers trapped per sticky card in late June were 20 and 16 potato leafhoppers per card, respectively, for fields l and 2. Coefficients of variation were similar (49.1 and 41.8, respectively), and the range in captures was 5 to 36 leafhoppers/card.

Siqnificance to Industry: Growers should be aware of the potential damage to red maples that may result from the feeding of potato leafhoppers in the field, but they should also consider prophylactic treatments as potentially unnecessary. The survey introduces a need for research on a new problem in tree nurseries in the region, including the development of uniform pest monitoring strategies and treatment thresholds.

Literature Cited

1. Carlson, K. D. 1980. Early testing for resistance to verticillium wilt and potato leafhopper feeding in Norway and sugar maples. Master's Thesis. State University of New York, Syracuse.

2. Johnson, W. T. and H. H. Lyon. 1988. Insects That Feed on Trees and Shrubs. Comstock Publ., Cornell Univ. Press, Ithaca.

Table 1. Assessment of leafhopper damage [Means (± SE)] by location and treatment history.

Field ID*	Years in Field	Treatments **	% Terminals Damaged	Damage Rating	Damage Index
1	2	Untreated	98 (±1.5)	2.8 (±0.1)	275 (±l2)
2	3	Untreated	99 (± 0.7)	2.4 (±0.1)	239 (±13)
3	3	1 at >1 LH/teminal	95 (± 2.1)	1.7 (±0.2)	161 (±18)
4	4	l at ~ lLH/terminal	81 (± 5.6)	1.3(±0.1)	113(±16)
5	5	Unknown	63 (± 4.0)	1.2 (±0.1)	79 (±11)
6	2	Unknown	74 (± 6.3)	1.7 (±0.2)	141 (±25)
7	3	Unknown	100 (± 0.0)	2.7 (±0.1)	273 (±12)
8	3	5 at <1 LH/terminal	53 (± 4.9)	1.6 (±0.1)	93 (±12)
9	4	Untreated	49 (± 5.9)	1.2 (±0.1)	64 (±10)
10	3	1 at ~ lLH/terminal	29 (± 6.6)	0.9 (±0.1)	33 (±10)

* Fields 1-3 in Oconee Co., 4-5 in Pickens Co., 6-7 in Anderson Co., and 8-10 in Abbeville Co., SC.

** Treatment history, where known, in numbers of applications (chlorpyrifos) and pest density (LH/terminal)

Life History of the Crapemyrtle Aphid

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Nature of Work: Crapemyrtles, Laqerstroemia spp., are among the most predominant and popular ornamentals in the Southeast. All varieties of L. indica are susceptible to infestation by the crapemyrtle aphid, Tinocallis kahawaluokalani (Kirkaldy), and infested plants often become blackened with sooty molds that develop on the aphids honeydew secretions during the summer. The crapemyrtle aphid is distributed wherever crapemyrtle is found: China, Japan, Formosa, Hawaii, and North America, but little is known about its biology.

We initiated a study of the aphid s life history in the winter, 1989-90, by collecting whole plants for systematic observations on the overwintering egg stage. Plants were sectioned into 10 cm (2 inch) lengths from the terminals to the trunks, and measurements were recorded on stem size, location within the plant, egg placement and number of eggs per section.

Subsequent development of the population was monitored in the field through 1990-91, and samples of leaves and aphids were returned to the laboratory weekly for evaluations of developmental stages, fecundity, longevity, and determination of seasonal morphological types. Laboratory colonies were maintained on detached leaves held on water agar plates as described by Reilly and Tedders (1990).

Results and Discussion: A summary of the life cycle is given in Fig. 1. The crapemyrtle aphid is monoecious, completing its life cycle on a single host, and holocyclic, having a sexual stage. Eqgs, which are deposited on stems in the fall, are placed primarily in cracks and crevices along the stems, often in loose clusters of about four eggs, though sometimes singly, and relatively exposed. They are oval and shiny black in appearance, with featureless surfaces. The largest numbers of eggs are found near the terminals, a function of the greater amount of surface area available for oviposition. Our plots averaged about 2 eggs/inch of stem along the region of greatest density (first 15 inches) of stem measured from the ends of terminals, but eggs were found as far as 5 ft from the end of the nearest terminal.

Eclosion of eggs occurs at about the time of leaf break which is in late March for upstate SC. Each egg produces a first generation female, the fundatrix, which is a dispersal form that moves to a new leaf on the plant. The crapemyrtle aphid fundatrix is morphologically identical to her offspring, the subsequent summer forms known as virqinoparae.

Virginoparae are viviparous ("giving live birth"), parthenoaenetic ("virgin birth") females that are rather striking in appearance. They produce no eggs (externally), and no males are present. Their offspring are genetic clones of the female parent. All adults are winged and yellow with numerous dark tubercles, the most predominant of which is a two-pronged hump that separates the wings, which are held almost horizontally at rest. The virginoparae have a remarkable reproductive rate, and many generations are produced throughout the spring and summer. Populations may seem to "explode overnight" due to their geometric population growth rate which continues from April through September. A number of regulating mechanisms act on the seasonal changes in population, including predators and aphid response to decreasing host plant suitability when infestation levels are high. The potential for dispersal is high because all adults are alate (winged) and fly readily when disturbed, especially in summer temperatures.

As day:night light cycles equalize in September, many of the virginoparae produce morphologically identical but physiologically altered female offspring called sexuparae. Sexuparae "give birth" only to specialized sexual forms, both male and female, known as sexuales. By mid-October, most field specimens are sexuales. Males are similar in appearance to their female parents, but they have smaller abdomens and noticeably darker coloration. Female sexuparae, called oviparae, are wingless with a deeper olive color than the summer forms, even in the developmental stages. After mating with males on the leaf surfaces, the oviparae produce the overwintering egg. They are prevalent throughout October and November. The oviparae migrate to various locations on the plants for egg deposition.

Sexuales are produced in a 1:1 ratio. Males live an average of 7 days (range l-20 days), and oviparae live 8 days (range 4-14 days). Each ovipara deposits an average of 4 eggs (range l-6). The eggs are yellowish when deposited but darken within a few hours.

Aphid development proceeds through four nymphal instars to the adult (Fig. 2). Developmental time is temperature dependent, requiring 14 days from birth to adult at 18°C and 5 days at 32°C. The development profile shown in Fig. 2 is for 26°C. Adult longevity may be as long as 34 days but averages about 17 days on viable leaves in the laboratory.

Fig. 3 shows the average production of offspring by virginoparae throughout the adult life span. At 26°C, a peak production of 7 nymphs/day occurs within a few days of adulthood, and is maintained until the parent is about 10 days in stage. Thereafter a steady decline in births occurs for the duration of adult life.

Significance to industry: The description of the life cycle is offered as information for understanding of crape myrtle's only key insect pest. Because of the high reproductive and dispersal proclivity of crape myrtle aphids, however, nurserymen should consider the inherent difficulty in attempting short term control measures against virginoparous forms. Alternative measures, such as resistant varieties, augmentation of biological controls, or reproductive control may offer greater long term success in interruption of the life cycle.

Literature Cited

1. Reilly, C. C. and W. L. Tedders. 1990. A detached-leaf method to study pecan aphid behavior and biology. Entomol. Sci. 25: 85-88.

Fig. 1. Life history of the crapemyrtle aphid.

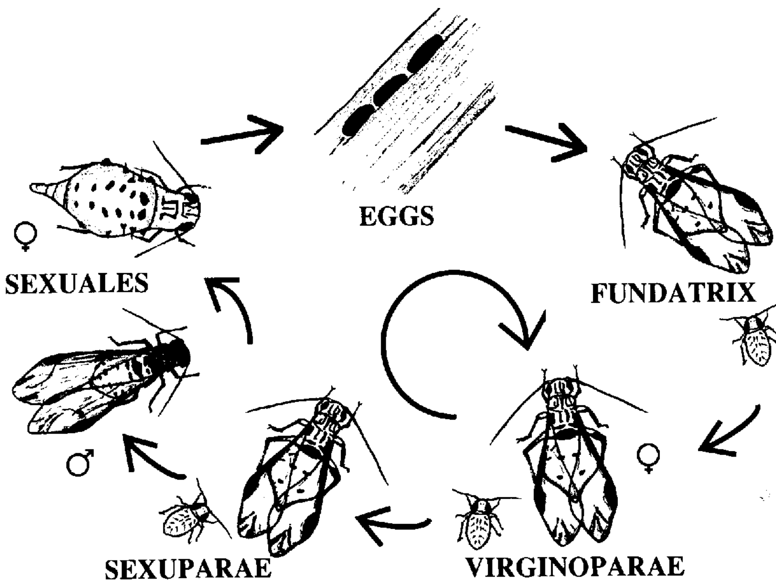


Fig. 2. Development profile for the crapemyrtle aphid showing time in each stage. I-IV are nymphal instars.

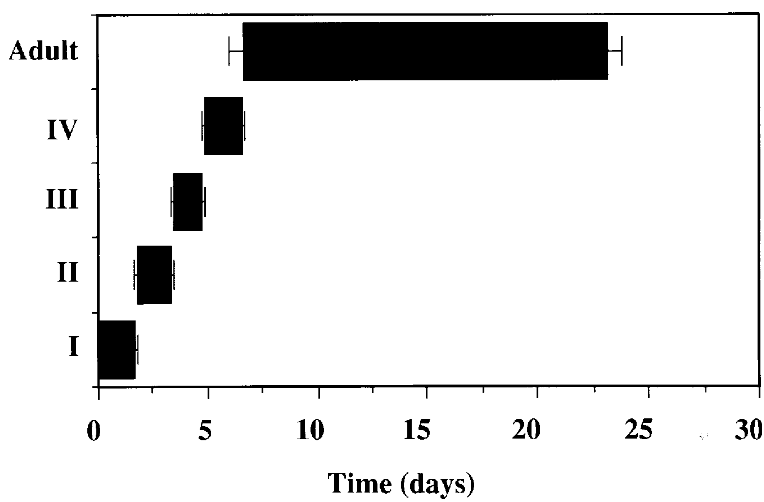
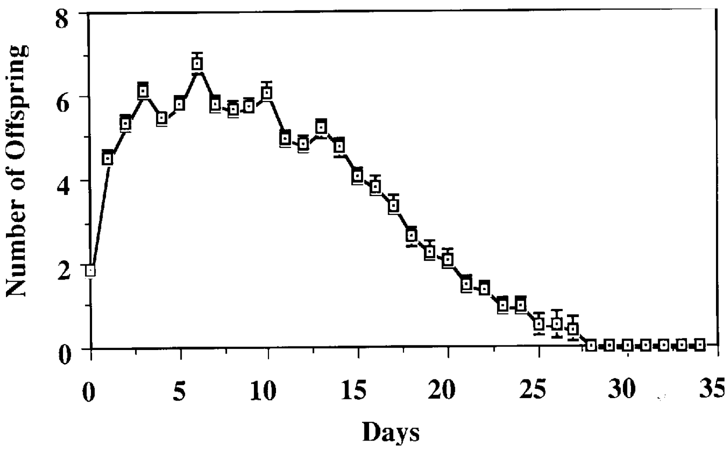


Fig. 3. Crapemyrtle aphid fecundity (offspring production) per day as a function of longevity in the adult stage.



Biology and Ecology of the Azalea Stem Borer, Oberea myops

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Nature of Work: The azalea stem borer, Oberea myops Haldeman, is a long-horned beetle (Coleoptera: Cerambycidae) that can develop on a wide range of ericaceous hosts, including cultivated and native rhododendrons, mountain laurel, evergreen and deciduous azaleas, Pieris, sourwood, and blueberry (Driggers 1929, Lehman 1984, Galle 1987, Johnson & Lyon 1988). Johnson & Lyon (1988) report that O. myops is a native insect which is likely to be found throughout the host range of its ericaceous hosts. Over the last several years, this beetle has been increasingly reported as a pest in both nursery and landscape materials, and in blueberries.

Seasonal activity of O. myops was monitored at Mountain Creek Rhododendrons (Marietta, SC) and at Hurricane Gap Nursery (Zirconia, NC) during June and July 1989. Adult beetles were collected at both sites. Oviposition activity also was monitored by collecting stems with oviposition damage and returning them to the laboratory at Clemson University (Clemson, SC).

Twenty seven borers were used to monitor developmental rates in 'English roseum' rhododendrons. Nineteen of these were from eggs directly oviposited into the plants, while eight were from eggs laid in other varieties that were cleft grafted onto

'English roseum' plants. To allow natural oviposition, eight six-year-old 'English roseum' plants, in 56.8 liter (15 gallon) containers, were placed at two locations (6 in one group and 2 in the other) within the nursery at Mountain Creek Rhododendrons on 23 June 1989. These plants were checked once or twice weekly through 31 July for oviposition wounds. All oviposition sites were marked when first observed. By 31 July, no oviposition had been observed for two weeks and the plants were returned to the research facility at Clemson University. Of the 24 naturally occurring oviposition wounds on these plants, 19 borers hatched and began feeding. In addition, ten stems known to contain borers were removed from plants in the nursery and cleft grafted onto six-year-old, container grown 'English roseum' plants maintained in a screen-house at Clemson University. Within two weeks, eight of these larvae had bored into healthy wood below the graft while the remaining two died.

Results and Discussion: Adults are slender beetles averaging 16.2 mm (5/8 inch) in length and are active from late May through mid-July. They are copper colored with three brown stripes running the length of the wing covers. There are two black spots on the "shoulders" of the wing covers and two more on the plate between the wing covers and head. The kidney-bean shaped black eyes are at the base of elongate black antennae. Adults feed primarily on the underside of leaf midribs and on the outer tissues of new stems. Although feeding results in leaf curling, this damage is primarily aesthetic.

Prior to oviposition, the female chews two girdles around new growth stems. Distance between girdles ranges from 8 to 26 mm (5/16 to 1 1/16 inches). The female then places an egg under the bark. Eggs are cream colored, average 4 mm (5/32 inch) in length and require approximately 10 days to hatch under natural (June - July) conditions. Oviposition activity generally does not result in immediate stem wilting in rhododendron, although it does cause rapid wilting ("flagging") in girdled stems in hosts such as native azaleas and blueberries. Tips receiving oviposition wounds eventually die and fall from the plant.

Upon hatching larvae bore in the girdled tip for a brief period then turn and move down into healthy wood below the lower girdle. It is generally not until larval feeding begins that wilting is observed in rhododendron. Girdled tips generally break from the plant at the lower girdle shortly after larvae move into healthy wood.

As larvae bore through the stem, they regularly open small (1 mm; 1/32 inch) holes in the stem from which sawdust-like waste (frass) is expelled. The distance between these holes averages 9.2 cm (3 5/8 inches). Larvae moved an average distance, beyond the lowest girdle, of 53.0 cm (20 13/16 inches) during the first season. As frass is expelled from these holes, it accumulates in leaf axils, on leaf surfaces and on the soil surface and can be used to locate active borers. In small plants borers often reach the crown where they generally hollow out a large area while completing development. In larger plants, where borers complete development before reaching the crown a large exit hole is chewed in the stem. In either case larvae leave the plant and pupate in leaf litter or soil.

After 3 November no larval activity was observed until the following spring. In three plants, major damage was sustained as borers in the stems girdled outward from the tunnel to the bark. Although this may not result in immediately obvious damage, these branches break off under heavy rain, snow or windy conditions. Borers that did not complete development during the first summer initiated feeding activity during May of their second year as larvae. Two-year larvae followed the same pattern during the second summer as was observed during the first. Several of these two-year larvae reached the crown of large plants by the end of their second year. Feeding damage in the crown often results in the loss of the entire plant.

At this time, the most efficient control strategies for this pest are cultural techniques aimed at larval control. In mid- to late summer as borers begin to feed in new growth, stem wilting and expelled waste are obvious. Infested stems should be pruned from the plant at this time. The stem should be cut below the lowest hole opened by the borer. Borers (immatures) can not disperse from pruned stems to healthy plants. Pruned stems can simply be dropped in the bed if desired (Driggers 1929), although Lehman (1984) suggests removing and burning infested material. After pruning, the stem below the cut should be examined to ensure that the borer remains in the portion that was removed.

If a hole remains in the center of the stem the borer has migrated below the cut and further pruning may be used to remove it. Two alternative approaches, which may be effective if the borer remains in the plant below the cut, are also useful if a borer is discovered in an older part of the plant that would not be amenable to pruning. In this case the borer can be killed either by slowly inserting a thin, flexible, wire into the tunnel until the bottom is reached, or some lightweight oil can be placed into the tunnel which will suffocate the borer. The wire technique was utilized extensively in blueberries in New Jersey in the 1920's (Driggers 1929) and is recommended by Galle (1987) for use in azaleas. Phil Marucci (personal communication) has reported that growers used the oil technique in blueberries in New Jersey in the early to mid-1900's. Both the wire and oil technique requires a cut stem in order to be effective. Holes opened by the borer for waste expulsion usually cannot be used for insertion of the wire or oil as they are typically not oriented at a downward angle. Inserting a wire into one of these holes may result in the wire going up toward the stem tip rather than down the tunnel to where the borer is located.

Significance to Industry: Oberea myops has the potential to be a serious pest of both nursery stock and ornamental plantings of azaleas, rhododendrons, and Pieris. Based on our contacts with producers of ericaceous plant materials, damage due to this beetle appears to be increasing.

Literature Cited

1. Driggers, B. F. 1929. Notes on the life history and habits of the blueberry stem borer, Oberea mypos Hald., on cultivated blueberries. J. New York Entomol. Soc. 37: 67-73.

2. Galle, F. C. 1987. Azaleas. Timber Press. Portland, OR. 519 pp.

3. Johnson, W. T. & H. H. Lyon. 1988. Insects that feed on trees and shrubs. 2nd ed. Cornell Univ. Press, Ithaca, NY. 556 pp.

4. Lehman, R. D. 1984. Azalea stem borer, Oberea myops Haldeman. Pennsylvania Dept. of Agric. Bureau Plant Industry. Entomol. Circ. 86.

Low vs. High Volume Sprays For Control of Nantucket Pine Tip Moth on Virginia Pine

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Nature of Work: Virginia pine (Pinus virginiana) is grown extensively throughout the Southeast and sold for Christmas trees. Larvae of Nantucket pine tip moths destroy the Christmas tree shape and reduce tree height by tunneling in the stems of new growth (3). The goal of tip moth control programs, once trees are shaped, is to protect the main terminal, thus maintaining the "Christmas tree" shape.

Currently growers apply insecticide sprays three to six times a season depending upon the number and incidence of tip moth generations that occur in their area. Proper timing of applications is critical, and is best accomplished by use of pheromone trap data. Dimilin® (diflubenzuron), an insect growth regulator, and Mavrik® (fluvalinate), a synthetic pyrethroid insecticide, are registered for tip moth control.

Studies with Dimilin® (2) and field tests with Mavrik® have indicated that properly timed applications are effective in controlling tip moths. Spray applications for tip moth control are often time consuming and expensive. Studies with loblolly pines indicate tip moth infestations may be highest at the tops of trees (1), where protection of the terminal is desired. Previous field studies indicated excellent tip moth control with properly timed insecticide applications made over the tops of trees as a mist. This procedure, as opposed to the usual "point of drip," whole tree applications, reduced spray gallons per acre and application time.

A study was conducted in Lee County, Alabama, in 1987 to compare the effectiveness of Dimilin® and Mavrik® treatments for tip moth control made on second-field year Virginia pine Christmas trees as "over-the-top" only or "point-of-drip" applications. Treatments directed at tip moth generations 1-3 were timed with pheromone trap data and applied March 25, May 19, and June 26. Treatments (replicated four times, 10 trees per replication) were applied with hand-pumped compressed air sprayers. Counts of infested terminals within randomized block treatments were made May 19, June 26, and July 29. Low volume, "over-the-top" sprays were applied as 1 gallon per 840-tree acre. High volume, "point-of-drip" sprays were applied as 16 gallons per 840-tree acre.

Results and Discussion: All treatments in this test controlled tip moths. Therefore, the lower volume, "over-the-top" sprays were as effective as the higher volume, "point-of-drip" sprays. Application time was reduced by the lower volume sprays. No phytotoxicity was observed. The grower substituted shearing for the fourth (final) tip moth treatment.

Table 1. Average Numbers of Damaged Terminals per Average 10-Tree Plots and Percent Control from Final Treatment of Second-Year Virginia Pine Christmas Trees Treated with Dimilin® or Mavrik® At Low or High Volumes of Water.

Treatment	Rate/ 840-tree acre	Water acre	Average no. damaged terminals			Percent control 7/29
			5/19	6/26	7/29	
	oz.	gal.				
Dimilin 25W	2	1	0.00	0.00	0.00	100.00
Dimilin 25W	4	1	.00	.30	.00	100.00
Dimilin 25W	2	16	.00	.00	.00	100.00
Dimilin 25W	4	16	.30	.00	.80	95.08
Dimilin 4F	1	1	.00	.30	.30	94.60
Dimilin 4F	2	1	.00	.00	.30	94.60
Dimilin 4F	1	16	.30	.30	.30	94.60
Dimilin 4F	2	16	.00	.00	.30	94.60
Mavrik AF	3.3	1	.00	.30	.30	94.60
Mavrik AF	6.6	1	.00	.00	.00	100.00
Mavrik AF	3.3	16	.00	.30	.30	94.60
Mavrik AF	6.6	16	.00	.00	.30	94.60
Control (untreated)			4.00	6.00	5.50	

Dimilin 4F is an unregistered, experimental formulation. % control determined by Abbott's formula.

Significance to Industry: Properly-timed applications of Dimilin® or Mavrik® to Virginia pine plantings using low volume, "over-the-top" only sprays can control Nantucket pine tip moth as well as high volume, whole tree treatments. Savings in time and labor result in more cost-effective control programs.

Literature Cited

1. Berisford, C.W. 1967. Infestation rate and damage by the Nantucket pine tip moth in six loblolly pine stand categories. Forest Science, Vol. 13, No. 4, pp. 428-438.

2. Richmond, J.A. and P. A. Cunningham. 1982. Evaluation of diflubenzuron against egg and larval stages of the Nantucket pine tip moth. J. Georgia Entomol. Soc. Vol. 18, No. 2, pp. 280-284.

3. Yates, H. O. 1960. The Nantucket pine moth, a literature review. U.S. Forest Serv., Southeast. Forest Expt. Sta., Sta. Paper 115. 19 pp.

Evaluation of Insecticides for Orangestriped Oakworm Control, 1990

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Virginia

Nature of Work: The orangestriped oakworm, Anisota senatoria (J. E. Smith) has become a serious pest of oaks in sections of Norfolk, Va. since 1985. This insect has a wide distribution. It occurs throughout the eastern U. S., and has been reported as far west as Wisconsin and Michigan and as far south as Georgia and Kansas. Oaks are the preferred hosts, but they will feed on birch, hickory, and maple.

Oakworm adult moths first appear in late June in eastern Virginia and deposit clusters of 200- 500 yellow eggs on the undersides of leaves. The egg-laying period can last a month. The eggs hatch in a week and the gregarious greenish-yellow larvae defoliate a whole branch before moving to another. Mature 2 inch black caterpillars with the distinctive eight orange stripes consume all of the leaf except the main vein. In 1990, the damage was reported to be severe in areas of eastern Virginia.

Seven insecticide treatments were evaluated for control on August 15, 1990. A plot of 21 willow oaks (Quercus phellos L.) averaging 6 feet in height were sprayed to runoff utilizing a CO_2 compressed air sprayer at 30 psi. Oakworm larval counts on treated oaks (3 replicates per treatment) were made 3 h post-treatment. Temperature at time of treatment was 80°F and 1.09 inches of rainfall fell between application and evaluation.

Results and Discussions: Table 1 shows that excellent control was achieved with all 3 rates of Tame, as well as Tame plus Orthene. Talstar also provided control, not siginificantly different than the aforementioned treatments. Rainfall subsequent to application negatively affected control with Dipel. No phytotoxicity was observed.

Table 1.- Evaluation of survival of orangestriped oakworm, 1990.

Treatment and lb(ai) per 100 gal.		Percent survival
Talstar 80F	0.06	17.1a*
Tame 2.40 EC	0.1	4.0a
Tame 2.40 EC	0.2	2.8a
Tame 2.40 EC	0.3	0.0a
Tame 2.40 EC +	0.2	
Orthene 75 SP	0.35	0.0a
Orthene 75 SP	0.35	49.0b
Dursban 50WP	0.5	66.4b
Dipel @ 2tbsp/gal.		91.4c

* Means followed by the same letter are not significantly different (P>0.05, DMRT); data transformed using arcsine transformation prior to analysis.

Impact of Late Season Insect Defoliation on Tree Growth

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Nature of Work: The orangestriped oakworm, Anisota senatoria (J. E. Smith) (Lepidoptera: Saturniidae) is a native insect and pest of both forest and urban plantings throughout the northeastern and southern United States (2). Severe defoliation in August has occurred on the same urban oaks over consecutive years in Norfolk, VA and on nursery grown oaks (1). Tree care practitioners, nurserymen, and researchers alike have suggested that A. senatoria defoliation is of little consequence because it occurs so late in the summer (3). Our objectives were to evaluate this late season defoliation on trees grown in a nursery environment and trees in the urban landscape.

Nursery conditions were simulated by planting pin oaks, Quercus palustris, northern red oaks, Q. rubra, and willow oaks, Q, phellos, in grow bags (Root Control Inc., Oklahoma City, OK) on March 25, 1987 in a randomized complete block design (5 blocks). Trees in grow bags received 2 oz. of 18-6-12 Osmocote in April 1987-88 and were placed on daily drip irrigation. Treatments (0, 1, 2, 3, and 4 years of defoliation) consisted of placing A. senatoria larvae on trees in August of each year (1987-1990) in numbers sufficient to cause 100% defoliation. Tree height and caliper were measured on June 13, 1988-90. Trees were removed in October, 1990 and roots contained in grow bags plus escape roots were dried and weighed. Pin oaks in the urban landscape were sampled four times a year (December, March, May, and September). Two primary roots per tree were collected and analyzed for percent starch content. Treatments were 0, 24, and 100% defoliation.

Results and Discussion: Pin oaks grown in grow bags that received 3 and 4 consecutive defoliations had significantly less top growth than trees that received 0 or 1 defoliation (Table 1). Willow oaks that received 3 and 4 defoliations had significantly less top growth than trees that received no defoliation, and northern red oaks showed no significant differences in top growth (Table 2). Pin oaks that received 2, 3, and 4 defoliations were the only trees that showed a significant reduction in caliper. Furthermore, pin oaks that received 4 defoliations were the only trees that had a significantly lower below ground dry weight (grow bag plus escape roots) (0.4±0.06 lbs) than trees that received no defoliation (4.2±1.5 lbs). Landscape pin oaks that received 3, 4, and 5 defoliations had significantly lower mean root starch content than trees that received no defoliation over all sample dates (Table 2). Starch has been shown to be an accurate indicator of tree vigor, and reduced starch often suggests unhealthy, stressed trees (4).

Significance to Industry: Late season defoliation can adversely affect oak tree vigor, especially of pin oak; therefore, infestations of A. senatoria should be controlled both in the nursery and in landscapes.

Literature Cited

1. Coffelt, M. A. & P. B. Schultz. 1990. Development of an aesthetic injury level to decrease pesticide use against orangestriped oakworm (Lepidoptera: Saturniidae) in an urban pest management project. J. Econ. Entomol. 83: 20440-2049.

2. Johnson, W. T. & H. H. Lyon. 1988. Insects that feed on trees and shrubs, 2nd ed. Cornell University Press, Ithaca, New York.

3. Stimmel, J. F. 1988. Orangestriped oakworm, Anisota senatoria (J. E. Smith). Reg. Hort., Entomol. Cir. No. 127, 14:23-24.

4. Wargo, P. M. 1981. Defoliation and tree growth, pp. 225-33. In C. C. Doane & M. L. McManus [eds.], The gypsy moth: research toward integrated pest management. USDA For. Serv., Technical Bulletin 1584.

Table 1. Mean top and caliper growth of three oak species defoliated by A. senatoria, 1987-1990.

	Mean ± SEM					
No. yrs. 100% defol.	Pin Oak top growth	N[y]	N. Red Oak top growth	N	Willow Oak top growth	N
0	36.8±4.6a[z]	20	14.0±3.la	15	45.4±3.6a	17
1	37.2±4.0a	10	15.0±3.4a	9	39.2±5.7ab	10
2	27.9±2.8ab	15	16.2±4.4a	11	36.8±4.2abc	15
3	24.8±5.3b	10	8.9±2.4a	8	32.5±2.8bc	10
4	14.3±3.2b	5	5.9±1.6a	3	25.6±4.0c	5
	caliper growth		caliper growth		caliper growth	
0	0.6±0.04a	20	0.1±0.04a	15	0.6±0.04a	17
1	0.5±0.04a	10	0.1±0.04a	9	0.6±0.04a	10
2	0.3±0.04b	15	0.1±0.04a	11	0.4±0.04a	15
3	0.2±0.04b	10	0.1±0.04a	8	0.5±0.04a	10
4	0.2±0.04b	5	0.1±0.04a	3	0.5±0.04a	5

[y] N=number of replications. Growth in inches.

[z] =*Means* within columns followed by the same letter are not significantly different (P>0.05: Student-Newman-Keuls test).

Table 2. Mean percent root starch content in pin oak trees defoliated by A. senatoria, 1988-1990.

Sample dates	Mean ± SEM percent starch (dry weight)				
	Check	Mean of 24% def.	No. of 100% defoliations 3	4	5
Dec. 1988	6.6±0.8aZ	4.8±1.0ab	2.9±0.8b		
Mar. 1989	5.0±0.8a	1.9±0.5b	1.7±0.3b		
May 1989	3.9±0.5a	3.5±0.3a	2.5±0.2b		
Sep. 1989	9.4±1.8a	6.5±1.3a		1.9±0.8b	
Dec. 1989	1.6±0.2a	1.6±0.2a		0.9±0.lb	
Mar. 1990	2.6±0.5a	1.8±0.3ab		1.2±0.2b	
May 1990	3.6±0.sa	1.2±0.3b		1.1±0.2b	
Sep. 1990	13.7±1.9a	13.0±1.4a			7.0±1.3b
Dec. 1990	17.0±1.5a	12.9±2.2a			3.5±1.3b

Number of replications = 7 trees (check and 24%); 9 trees (100%).

[z] = Means within rows followed by the same letter are not significantly different (P>0.05; Waller-Duncan k-ratio) after arcsine transformation.

Phenology and Parasitism of the Native Holly Leafminer in Georgia

S.K. Braman
Georgia

Nature of Work: Early season development and emergence of the native holly leafminer, *Phytomyza ilicicola* Loew, and its parasitoids were examined in central Georgia during 1989, and 1991. The native holly leafminer (NHL), an agromyzid fly, is a serious pest of American holly, *Ilex opaca* Aiton, in the eastern United States. Damage to leaves is caused by adult feeding and oviposition punctures, and by larval feeding within the leaf mine. At least six hymenopterous parasitoids have been reared from NHL pupae Kulp 1968, Stegmaier 1971). A comprehensive investigation of the relative importance of various sources of mortality in regulating NHL populations in Kentucky revealed only one predominant parasitoid attacking the larval stage and an additional pupal parasitoid (Potter 1985, Potter and Gordon 1985). The objective of this study was to determine the timing of emergence of NHL and relative abundance and degree of parasitism of this pest in Georgia.

Timing of emergence and incidence of parasitism of NHL was determined in 1989 by collecting leaves containing mines from four trees on March 28, April 4, April 14, and April 24. Pupae from which no insects had yet emerged were held in plastic containers in an environmental chamber until that event took place. Proportion of flies or parasitoids emerged on the date of collection to the total number of flies or parasitoids in the sample could then be calculated. During 1991, 100 mined leaves were tagged on January 29 and observed weekly for insect development and emergence in the landscape. NHL and parasitoid emergence holes from the mined leaves are distinctive (Potter and Gordon 1985) and permitted determination of the contents of a mine after the inhabitant had emerged.

Results and Discussion: Flies emerged from only 21% of the 461 pupae examined during 1989. During 1991 flies emerged from 14% of the tagged leaves. During 1989 and 1991 63, and 79% of the NHL were parasitized. The most abundant parasitoid was *Opius striativentris* Gahan accounting for 74% of the parasitized NHL during 1989. During 1989 the majority of NHL emerged between the March 28 and April 4 samples (Table 1). NHL began to emerge between the March 26 and April 1, 1991 samples (Table 2). Parasitoids continued to emerge during April and May.

Although parasitism does not reduce the aesthetic damage caused by NHL (Potter and Gordon 1985), high levels of parasitism by O. *striativentris* and additional species suggest the potential for enhancement of their influence in reducing NHL population levels.

Literature Cited

1. Kulp, L.A. 1968. The taxonomic status of dipterous holly leafminers (Diptera: Agromyzidae). Univ. Md. Agr. Exp. Sta. Bull. A-155, 42 pp.

2. Potter, D.A. 1985. Population regulation of the native holly leafminer, *Phytomyza ilicicola* Loew (Diptera: Agromyzidae), on American holly. Oecologia 66: 499-505.

3. Potter, D. A. and F. C. Gordon. 1985. Parasites associated with native holly leafminer, *Phytomyza ilicicola* Loew (Diptera: Agromyzidae), on American holly in Kentucky. J. Kansas Entomol. Soc. 58: 727-730.

4. Stegmaier, C. E. 1971. Parasites of *Phytomyza vomitoriae* and *Phytomyza ilicicola* (Diptera: Agromyzidae) from Florida. Fla. Entomol. 54: 187-188.

Table 1. 1989 Native holly leaf miner development and parasitism.

	Mar. 29	Apr. 4	Apr. 14	Apr. 24
NHL emerged	5	28	17	16
	-- -- -- --(13%)	-- -- -- (100%)	-- -- -- (100%)	-- -- -- (100%)
Total NHL emerged and reared	38	28	17	16
Opius emerged	29	52	61	45
	-- -- (57%)	-- -- (93%)	-- -- (98%)	- - (100%)
Total Opius emerged and reared	51	56	62	45

Table 2. 1991 Native holly leafminer development and parasitism

Date	NHL larvae	NHL pupae	NHL* adults emerged	parasitoids* emerqed
Jan. 29	97	1	0	2
Feb. 4	92	6	0	2
Feb. 11	78	20	0	2
Feb. 20	41	56	0	3
Feb. 27	26	71	0	3
Mar. 5	20	77	0	3
Mar. 11	18	79	0	3
Mar. 18	18	78	0	4
Mar. 26	15	81	0	4
Apr. 1**	14	68	5	12
Apr. 8	10	64	9	16
Apr. 15	10	60	9	20
Apr. 22	4	57	9	21
Apr. 29	2	34	9	31
May 2	0	31	9	31
May 14	1	18	9	40
May 23	1	17	9	40
Jun. 10	1	15	9	42
Jun. 17	1	13	9	42

* Cumulative number emerged per 100 leaf sample

** Leaf abscission beginning April l resulted in the loss of tagged leaves.

Soaps and Oils, A New (Old) Alternative to Conventional Insecticides

Ronald D. Oetting, Peter B. Schultz, Joyce G. Latimer, Beverly Sparks, and Will Hudson

Georgia and Virginia

Nature of Work: There has been a move to reduce the use of conventional insecticides over the last few years as a result of problems with pesticide resistance, registration, increased regulations, and concerns over groundwater contamination by pesticides, worker safety, and pesticide residues on food. Soaps and oils are not new methods of managing pest populations but there is a renewed interest in their use (3,4) and several companies are looking at developing and marketing these materials. They were effective against several ornamental pests of herbaceous and woody plants (1,4,5). They were also compatible with the use of natural enemies in a management program on ornamentals (6). However, they had a reputation for being phytotoxic to plants and inconsistent in performance. The phytotoxicity was exaggerated and most materials could be used safely on woody plants (2,7). Application rates of 1 or 2% were safely applied to vegetables with no phytotoxicity but higher rates did result in some plant damage (1). Therefore, application rates must be established for more sensitive plants such as ornamentals. Much of the inconsistency was a result of the lack of good coverage. These materials must come in contact with the target pest during application.

The purpose of our experiments was to determine a usage rate and pattern that was safe on these plants. Three types of experiments were conducted to determine potential problems with phytotoxicity. The first was to compare high volume (HV) with low volume (LV) application, the second was on outdoor fall chrysanthemum production, and the third was a series of poinsettia experiments.

Two experiments were conducted on bedding plants. In the first experiment 10 different bedding plants were treated with Sunspray Ultrafine Oil® comparing a standard HV application at 85 psi and a LV electrostatic application using the same amount of oil in 5% of the spray volume of the HV application. Applications rates were lX, 2X, and 4X for HV and 1 to 6X for LV with 3 repeat applications at a 7 day interval. Each plot was a single plant and replicated 6 times.

A second experiment was conducted on ten fall chrysanthemum cultivars: Allure, Bravo, Dark Grenadine, Debonair, Donna, Illusion, Red Remarkable, Stardom, Tolima, and Viking. Identical experiments were conducted at the Georgia Experiment Station, Griffin and the Hampton Roads Experiment Station, Virginia Beach, VA. The purpose of this experiment was to determine if weekly applications would be efficacious without damaging chrysanthemums and also to determine if application of a PGR (B-Nine®) would affect phytotoxicity. The treatments were Insecticidal SoapR (Safer) 1% and 3%, Sunspray Ultrafine 1% and 3%, Soap 1%

+ Oil 1%, and Margosan-O® 0.64% compared with a standard Dursban® 50W (0.5 lb AI/100 gal) and a water check. The plots each contained 4 standard 8 inch chrysanthemum pans with 1 plant each and were replicated 3 times.

The last experiments were conducted on greenhouse grown poinsettias at 3 locations in Georgia: Griffin, Jefferson, and Tifton. The soaps and oils were applied at 1, 2, 3, or 4% to top white, hot pink, lilo or V-14 red poinsettias. The treatments were Insecticidal Soap, WRL-10 and WRL-11 Soap (Whitmire), Sunspray Ultrafine Oil, Unipar Oil® and Savol Oil® (Uniroyal), Nim Oil® and Margosan-O® (W.R. Grace), and Volck Oil®. Repeat applications were made and the plants evaluated for phytotoxicity each week.

Results and Discussion: In the first experiment, comparing application by high and low volume, there was no damage to bedding plants following the 1% application rate. However, with repeat application of 1% there was a significant increase in phytotoxicity following high volume application but only very slight damage on celosia and tomato with low volume. The difference in phytotoxicity resulting from application with the two techniques was very noticeable following repeat applications at the highest rate of 4X high volume and 6X low volume (Table 1). There was not as much phytotoxicity as a result of the application of oil by low volume electrostatic spraying.

There was no visable phytotoxicity following repeat applications of the treatments on fall chrysanthemums in Georgia or Virginia. There was a low level of insect damage and phytotoxicity on all treatments. The treatments were terminated soon after the buds were showing color. There was low level damage to the cultivars where flowers were open.

There was low level phytotoxicity following the application of soaps and oils to poinsettias. Most of the treatments were safe to use at the 1% to 3% rates for one application. However the amount of phytotoxicity increased above the low level that would not effect marketability (rating level below 2) at the 4% rate and with repeat application of some materials (Table 2). The soap and oils tested could be safely used at a 1% or 2% rate for one application and most could safely be used for repeat application at a 7 day interval. However, it would be best to include soaps and oils as a part of a rotation of insecticides for whitefly control on poinsettias.

Significance to Industry: Soaps and oils provide an alternative for growers to conventional insecticides. They can safely be used on tender plants such as bedding plants if they are applied at the 1% or 2% rate and repeat application are not used for an extended period of time. These materials are more safe to the environment and the applicator than conventional insecticides.

Literature Cited

1. Butler, G.D. and T.J. Henneberry. 1991. Effect of oil sprays on sweetpotato whitefly and phytotoxicity on watermelons, squash and cucumbers. Southwest. Entomol. 16: 63-72.

2. Gill, S.A., J.A. Davidson, and M.P. Raupp. 1990. Oil's well. Amer. Nurserymen (Feb 1): 72-77.

3. Johnson, W.T. 1991. Rediscovering horticultural oils. Amer. Nurserymen (Jan 1): 78-83.

4. Nielson, D.G. 1991. A rational approach. Amer. Nurserymen (Apr 15): 92-97.

5. Osborne, L.S. 1984. Soap spray: an alternative to a conventional acaricide for controlling the twospotted spider mite in greenhouses. J. Econ. Entomol. 77: 734-737.

6. Osborne, L.S. and F.L. Petitt. 1985. Insecticidal soap and the predatory mite, *Phytoseiulus persimilis,* used in management of the twospotted spider mite on greenhouse grown foliage plants. J. Econ. Entomol. 78: 687-691.

7. Tippins, H.H. 1974. Nonrelationship between oil sprays and damage to ornamental plants during extreme temperatures. J. GA. Entomol. Soc. 9: 51-53.

Table 1. Phytotoxicity following application of Sunspray Ultrafine Oil on bedding plants with a 4X concentration applied by high volume and a 6X application resulting from 6 consecutive applications on the same plants by low volume electrostatic spraying.

	Damage Following Three Applications	
Plant	High Volume (4X)	Electrostatic (6X)
Aster	2-IC,TN,LD	0
Begonia	3-IC,8t	0
Celosia	4-L,8t,LD	3-TN
Egg Plant	3-NG,L,TN	0
Marigold	4-LN,LD,TN,L	0
Pepper, Bell	5-NG,Cp,TN,MC	0
Petunia	3-NG,F	0
Pinks	2-TN	0
Salvia	4-MC,F,L,IC	4-MN,IC,F
Tomato	5-LN,D,NG,IC	5-IC,MN

Rating Scale: 0=no damage to 6=very severe. Cp=cupping of leaf, D=dead plant, F=flower necrosis, IC=interveinal chlorosis, L=leaf chlorosis, LD=leaf drop, LN=leaf necrosis, MC=marginal necrosis, MN=marginal necrosis, NG=distorted new growth, St=stunting, TN=tip necrosis.

Table 2. Summary of the phytotoxicity observed following the application of soaps and oils on poinsettias at three locations in Georgia. Results are expressed as an average of all trials on four different cultivars. Repeat Applications represent 3 or more applications at a 7 day interval. Rating Scale O=no damage to 6=Severe damage.

	Mean Phytotoxicity Rating							
	1 Application				Repeat Applications			
Treatment	1%	2%	3%	4%	1%	2%	3%	4%
Insecticidal Soap	0.8	1.3	1.2	2.3	1.2	2.9	3.4	3.2
WRL-10 80ap	1.7	--	1.6	--	2.9	--	2.6	--
WRL-11 80ap	0.3	0.2	0.3	1.4	1.7	1.8	1.4	2.7
Sunspray Ultrafine Oil	0.2	0.2	0.4	0.1	1.3	1.7	2.0	1.8
Unipar Oil	0.7	0.8	1.5	1.0	1.5	1.5	1.6	2.8
Nim Oil	0.1	0.2	0.2	0.4	1.3	1.5	1.2	2.0
Volck Oil	0.7	0.1	-	2.2	1.0	2.3	-	2.7

Phytotoxicity of Talstar® on Finished Poinsettias: Effects of Application Rate And Ortho X-77®

Barney A. Coats, David Tatum, and James Jarrett
Mississippi

Nature of Work: Controlling whiteflies on poinsettias *(Euphorbia pulcherrima)* is a problem faced by many greenhouse growers. Plants are generally not sprayed with pesticides after bract coloration because of phytotoxicity or undesirable residue. The purpose of this study was to determine phytotoxicity of Talstar® flowable insecticide/miticide (FMC Corporation, Philadelphia, PA) at four application rates with or without Ortho X-77® Spreader (Valent U.S.A. Corp., Walnut Creek, CA) to colored bracts of six poinsettia cultivars.

A 4 (Talstar® application rate) x 2 (with or without Ortho X-77®) x 6 (cultivars) factorial experiment, where each treatment was replicated 3 times, was initiated January 14, 1991. Talstar® was applied to 'Gutbier™ V-14 Glory', 'Gutbier™ V-17 Angelika White', 'Gutbier™ V-17 Angelika Marble', 'Gutbier™ V-17 Angelika Pink', 'Eckespoint® Pink Peppermint', and 'Eckespoint® Jingle Bells 3' six inch finished poinsettias at rates of 0, 8, 12, and 16 fl. oz./100 gal. water, which corresponded to 0, 1, 1.5, and 2 times (X) the recommended rate. Applications of Talstar® were made with or without the addition of Ortho X-77® spreader at 8 fl. oz./100 gal. water. Plants were sprayed to run-off using a 3 gallon compressed air sprayer. Treatments were applied under overcast conditions at a greenhouse air temperature of 70°F.

Four days following treatment application, phytotoxicity ratings were visually determined. These ratings were based on a scale from 1 to 5 where l=bract and leaf necrosis, 2=partial bract and leaf necrosis, 3=marginal bract and leaf necrosis, 4=minimal bract and leaf necrosis, 5=no damage.

Results and Discussion: All poinsettia cultivars, regardless of Talstar® application rate, exhibited bract and/or leaf phytotoxicity in response to Ortho X-77® spreader (Table 1). Plants treated with only Ortho X-77® exhibited severe bract and leaf damage. This indicates that Ortho X-77® was probably responsible for phytotoxicity observed on the Talstar® treated poinsettias. The degree of phytotoxocity was cultivar dependent (Table 1). In the absence of Ortho X-77® spreader phytotoxicity due to Talstar® application rate was not observed (Table 1). If applied at recommended rates, Talstar® can be used for whitefly control on poinsettias exhibiting bract coloration without concern for phytotoxicity.

Significance to Industry: This research indicated that Ortho X-77® spreader caused undesirable phytotoxicity to bracts and leaves of six cultivars of finished poinsettias. Talstar® insecticide/miticide can be applied without Ortho X-77® spreader to poinsettias during the final production stages.

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Table 1. Phytotoxicity ratings of six poinsettia *(Euphorbia pulcherrima)* cultivars in response to application rates of Talstar® with and without Ortho X-77® spreader.

Cultivar	Talstar® Application Rate	Ortho X-77® Spreader with	without
		Phytotoxicity Rating[z]	
V-14 Glory	0X	1.00[y]	5.00
	1.0X	1.00	5.00
	1.5X	1.00	5.00
	2.0X	1.00	5.00
Angelika Marble	0X	1.67	5.00
	1.0X	2.00	5.00
	1.5X	3.00	4.67
	2.0X	2.00	5.00
Pink Peppermint	0X	1.00	5.00
	1.0X	1.33	5.00
	1.5X	2.33	5.00
	2.0X	2.00	5.00
Angelika Pink	0X	1.33	5.00
	1.0X	1.00	4.67
	1.5X	1.33	5.00
	2.0X	1.67	5.00
Jingle Bells 3	0X	1.00	5.00
	1.0X	1.00	5.00
	1.5X	1.00	5.00
	2.0X	1.00	5.00
Angelika White	0X	1.33	5.00
	1.0X	1.00	5.00
	1.5X	1.33	4.67
	2.0X	1.33	5.00
LSD (=0. 05)		0.64	0. 33

[z] Phytotoxicity ratings based on a scale from 1 to 5 where 1=bract and leaf necrosis, 2=partial bract and leaf necrosis, 3=marginal bract and leaf necrosis, 4=minimal bract and leaf necrosis, and 5= no damage.

[y] Means of phytotoxicity ratings averaged over three replications.

Evaluation of Bagworm Control Strategies, 1990

P. B. Schultz and M. A. Coffelt
Virginia

Nature of Work: The bagworm, Thridopteryx ephemeraeformis (Haworth), is a polyphagous defoliator that prefers evergreen species as hosts. Arborvitae, Leyland cypress and juniper are highly susceptible; however, many species of deciduous and evergreen ornamentals are damaged. Bagworms occur throughout the eastern U. S., and are found as far west as Texas and as far north as New York. Severe defoliation often results, which may cause death of the host.

Larvae hatch beginning in late May to early June (depending on spring temperatures) from the bags in which females had lived and oviposited the previous year. The larvae usually remain on the host, but can be carried for short distances by the wind on silk threads. The larvae begin constructing bags composed of silken threads and bits of foliage shortly after hatching, and the bags increase in size as the larvae grow, reaching 2 inches in length at maturity. The male moth leaves the bag and mates with the female in the bag. The bagworm has only one generation a year, overwintering as eggs in the bag.

When practical, light infestations of bagworm can be controlled by hand-picking between August and the following May. Chemical control of bagworm is effective in early summer when the larvae are small, but declines in effectiveness as the larvae become large. Nine insecticide treatments and an untreated check were evaluated for control of the bagworm on July 10, 1990 Insecticides were applied to field-grown Leyland Cypress, Cupressocyparis leylandii, approximately 6 meters high located at the Hampton Roads Agricultural Experiment Station in Virginia Beach, Va. Infested areas of trees were sprayed to runoff (approximately 0.5 liters per tree) with a CO_2 sprayer at 30 psi. Three days after application, 15 bagworm larvae were collected from each of three replicates per treatment. Survival was determined by counting the number of live larvae 7 days post-treatment. Temperature at time of treatment was 86°F and plants were irrigated 3 times per day for 60 minutes (approximately 1 inch of water per day) using an overhead sprinkler system.

Results and Discussion: The results indicated that Talstar and all rates of Tame alone and in combination with Orthene provided excellent control. CGA-237218 is an insect growth regulator, and control after such a short interval was not expected. No phytotoxicity was observed.

Table 1. - Evaluation of bagworm survival with selected insecticides, 1990.

Treatment and lb(ai) per 100 gal.		Mean bagworm survival
Talstar 80F	0.06	0.0a*
Tame 2.40 EC	0.1	0.0a
Tame 2.40 EC	0.2	0.0a
Tame 2.40 EC	0.3	0.0a
Tame 2.40 EC +	0.2	
Orthene 75 SP	0.35	0.0a
Orthene 75 SP	0.35	1.0ab
CGA-237218 50WP	0.25	3.3bc
CGA-237218 50WP	0.5	3.3bc
CGA-237218 50WP	1.0	4.3c
Check	-	9.3d

* Means followed by the same letter are not significantly different (P>0.05, DMRT).

Insecticides and Acaricides Registered for Use On Ornamentals Plants

Russell F. Mizell, III, William Hudson and Beverly Sparks
Florida and Georgia

Nature of Work: Relatively few insecticides and acaricides are registered for use on ornamental plants. Those still available should be managed judiciously to retain their efficacy and preserve the environment and worker safety. The chemical industry and the availability of chemical pesticides is changing at a dramatic rate. The reregistration process dictated by EPA is forcing the industry to make immediate decisions as to which chemicals will be supported. More often than not the decisions is based on economic criteria rather than biological or environmental factors.

Ornamentals, nursery or landscape plants, are a minor use or specialty crop. Therefore, ornamentals are not always a highly profitable market for the industry. Becauce of this, we can expect to lose pesticides in the future, and fewer new pesticides are likely to registered for ornamentals. Growers should maintain current information on the availability of pesticides and their labeling. Pesticide distributors should have current industry information for growers concerning pesticides withdrawn from registration and use of available stocks. This paper presents a list of insecticides and acaricides available (to the best of our knowledge) for use on container and field-grown ornamentals. Remember the **LABEL IS THE LAW** and the pesticides on this list may become unavailable at anytime. It is the grower's responsibility to use pesticides in a legal and safe manner.

Table 1: Insecticides and acaricides registered for use on woody ornamentals and field-grown trees.

Pesticide Common Name	Trade Name	Class[1]	Comment
abamectin	Affirm, Avid 0.15EC	N	Affirm is fire ant bait; Avid for mites, leafminers and whitefly
acephate	Orthene	P	Broad spectrum, systemic
azedarachtin	Margosan-O	N	Neem oil
azinphosmethyl'*	Guthion 25, 2L	O	Broad spectrum
Bacillus thuringiensis	Dipel, Trident	N	Caterpillar disease
bendiocarb	Dycarb, Turcam	C	Broad spectrum
bifenthrin	Talstar 10WP	P	Mites, aphids, whiteflies
carbaryl	Sevin 4F, 80S, SL XLR, 50W	C	Broad spectrum
carbofuran*	Furadan 4F	C	Root weevils only
chlorpyrifos	Dursban 2E	O	Borers, broad spectrum
Horticultural oils	various	N	Dormant and summer, scale, aphids, mites, whitefly
cryolite	Kryocide	I	Fluorine family, caterpillars, katydids
cyfluthrin	Tempo 2, 20W	P	Aphids, caterpillars, whiteflies
diazinon	Diazinon 4E, 50W, AG500	O	Broad spectrum
diazinon	Knox Out 2FM	O	Encapsulated formulation
dicofol	Kelthane 35WP	CH	Mites
dienchlor	Pentac AF, 50WP	CH	Mites
diflubenzuron"	Dimilin 25 WP	IGR	Caterpillars, beetle larvae
dimethoate	Cygon 2EC	O	Systemic, broad spectrum
dinocap	Karathane WD	CH	Roses only, powdery mildew
disulfoton*	Di-Syston 15G	O	Granular systemic, broad spectrum
endosulfan	Thiodan 3EC, 50WP	O	Borers, broad spectrum
esfenvalerate*	Asana 1.9EC	P	Caterpillars, aphids, sawflies
ethion	ethion	O	- -
fenbutulin-oxide	Vendex 4L, 50WP	M	Mites
fenoxycarb	Logic (Award)	IGR	Fire ant bait
fenpropathrin	Tame 2.4EC	P	Mites, mealybugs, broad spectrum
fluvalinate	Mavrik AF	P	Mites, aphids, whiteflies
hydramethylnon	Amdro	O	Fire ant bait
kinoprene	Enstar 5E	IGR	Whiteflies, aphids, scale insects
lindane	Lindane 40% EC	CH	Borers, beetles, caterpillars

Pesticide Common Name	Trade Name	Class[1]	Comment
malathion	Cythion 57%, Malathion 4EC, 25WP	O	Broad spectrum
methaldehyde	methaldehyde	M	Slug and snail control
methidathion*	Supracide 2E	O	Broad spectrum
methiocarb	Mesurol	C	Available as WP, bait for slug & snail control
methomyl*	Lannate 1.9L, 90S	C	Thrips, caterpilars, beetles, whiteflies
methoxychlor	Marlate 50WP	CH	Beetles, caterpillars, leaflhoppers
methyl isothiocyanate	VORLEX	CH	Soil fumigant
naled	Dibrom	O	Caterpillars
nicotine sulfate	Black Leaf 40	N	Broad spectrum
oxydemeton-methyl*	Metasystox-R	P	Broad spectrum, systemic
oxythioquinox	Morestan 25WP	M	Mites
oxamyl*	Vydate L	C	Nematocide, aphids, mites, leafminers
permethrin*	Ambush 2.4EC	P	Caterpillars, aphids, sawflies
permethrin*	Pounce 3.2EC	P	Aphids, beetles, caterpillars, white flies
phosmet	Imidan 50WP	O	Caterpillars, weevils
propargite	Omite CR, 30W, Ornamite 30WP	P	Mites
pyrethrin	Pyrenone CS, Pyrellin	N	Broad spectrum, quick knockdown, short residual
resmethrin	Resmethrin EC	P	Caterpillars, aphids, beetles
Soap, insecticidal	Safer's	N	Mites, aphids, scale, several brands
sumithion	Pestroy	P	Broad spectrum
trichlorfon	Dylox, Proxol	O	Caterpillars, grubs

* Indicates pesticides are restricted use and require applicator's license to use.

[1] CIass:
N = "natural" product (plant derivatives, bacterial preparation, etc.)
C = carbamate
P = pyrethroid
CH = chlorinated hydrocarbon
I = inorganic
O = organic phosphate
IGR = Insect growth regulator
M = miscellaneous

Releases of Biological Control Agents for Area-Wide Management of Musk Thistle in Commercial Nurseries in Tennessee

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Nature of Work: Musk thistle, Carduus thoermeri (Weinmann), is native to Europe and was introduced into North America in the late 1800's (1). This noxious weed is an important pest in nurseries, pastures, unused farmland, suburban residences, and along highway and railroad right-of-ways, and unkept ditchbanks in Tennessee.

Musk thistle, infesting thousands of acres of land, has become increasingly important to agriculture in Tennessee. Thistle infestations commonly occur in nursery fields, where chemical control may not be feasible because of the many different types of nursery stock. Because many of the herbicides recommended for thistle control also may damage nursery plants, growers are confronted with a management dilemma. Cultural control tactics, such as hoeing, are labor intensive and time consuming. Thistle grows in many areas that are inaccessible and impractical for herbicide use or cultural control; thus, management of thistle over a large area is hindered. Because of the problems associated with the area-wide management of thistle, a biological control program, using plant-feeding weevils, was initiated in several areas in Tennessee (3). The goal of this program is to combine current methods of thistle control with biological control to provide a long-term, area-wide, economical, and environmentally safe means of maintaining thistle populations at acceptable levels in Tennessee.

Two species of weevils, the head weevil [Rhinocyllus conicus Froelich] and the rosette weevil [Trichosirocalus horridus (Panzer)], have been released in several states, including Virginia and Maryland, and have been successful in reducing infestations of musk thistle in the United States. The initial introduction of the head weevil into the United States originated from France and Italy (1, 2). Adult head weevils were released in Virginia in the spring of 1969, and by 1975, had reduced musk thistle in the area of release by 95% (2). The rosette weevil was introduced into the United States from Italy and was approved for release in the United States in 1974 (1). Head weevil larvae feed within the plant buds and destroy developing seeds, while the rosette weevil feeds on the rosette.

The University of Tennessee and the Tennessee Department of Transportation have initiated a cooperative, multi-year effort to establish the head weevil and the rosette weevil into all thistle-infested counties in Tennessee. The head weevil was released at ca. 60 thistle-infested sites in 24 counties in eastern and middle Tennessee during 1989, 1990, and 1991, while the rosette weevil was released at ca. 15 thistle-infested sites (Fig. 1). Several sites have been established as breeding areas for these two weevil species and individuals will be collected from these sites and distributed into other thistle-infested areas, particularly nursery fields. Research is underway to assess the establishment, development, and impact of these plant-feeding weevils on musk thistle in Tennessee.

Results and Discussion: At the one-month post-release count in 1989, eggs of the head weevil were found on thistle plants at each location, with 10 to 80% of the plants infested at each site (Fig. 2). At one-year post-release, head weevil populations were found at 9 of 11 release sites, and by 1990, head weevils had been found to survive and reproduce at the 11 original release sites. The numbers of head weevil eggs/plant were generally low; however, 44 to 55 eggs/plant were found at site 5 (Fig. 3). Head weevil eggs were generally found on the plants from late April to early July. Redistribution of weevil populations from breeding areas to thistle-infested areas should encourage the establishment and reproduction of weevils into all thistle-infested areas.

The compatibility among chemical herbicides, mowing and these plant-feeding weevils provides an important advantage to the use of this strategy for management of thistle from a broad perspective incorporating several control tactics (4). These plant-feeding weevils should move into those thistle-infested areas, e.g., nursery fields, that cannot be (or are not) treated with chemical herbicides or those areas where mowing is impractical.

Because of the successful survival and reproduction of the head weevil in the release areas, a four-year program of further redistribution and establishment of these weevils throughout the thistle-infested areas of Tennessee was implemented during 1991. Rapid redistribution and establishment of weevils in nurseries, in agricultural and residential areas, and along highways should provide maximum opportunities for reduction of musk thistle using biological control.

Significance to Industry: Once established, these plant-feeding weevils should become an integral part of an integrated management program directed against musk thistle. By reducing seed production and proliferation, these weevils should help to provide an area-wide reduction of musk thistle. This cooperative IPM program, combining several control tactics, e.g., chemical herbicides, mowing, and plant-feeding weevils, to reduce plant density and overall seed dispersal, should provide a long-term, area-wide, economical, and environmentally compatible method of maintaining thistle populations at acceptable levels in Tennessee. Thistle reduction should improve land use and increase profitability for nursery growers.

Literature Cited

1. Batra, S. W. T., J. R. Coulson, P. H. Dunn, and P. E. Boldt. 1981. Insects and fungi associated with Carduus thistles (Compositae). U. S. Dept. Agric., Tech. Bull. No. 1616, 100 pp.

2. Kok L. T. and W. W. Surles. 1975. Successful biocontrol of musk thistle by an introduced weevil, Rhinocyllus conicus. Environ. Entomol. 4:1025-1027.

3. Lambdin, P. L. and J. F. Grant. 1989. Biological control of musk thistle in Tennessee: Introduction of plant-feeding weevils. Univ. Tennessee Agric. Expt. Stn., Res. Rpt. 89-16 (July), 7 pp.

4. Trumble, J. T. and L. T. Kok. 1979. Compatibility of Rhinocyllus conicus and 2,4-D (LVA) for musk thistle control. Environ. Entomol. 8:421-422.

Figure 1. Location of sites where the head weevil, Rhinocyllus conicus, was released during 1989-91.

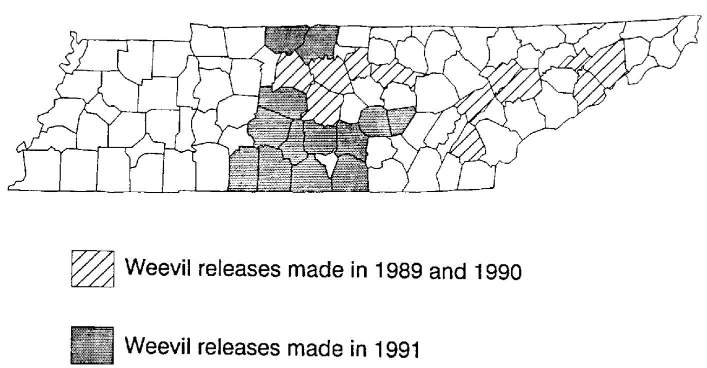


Figure 2. Infestation of thistle plants by head weevils at each location during 1989 (one month post-release) and 1990 (one year post-release).

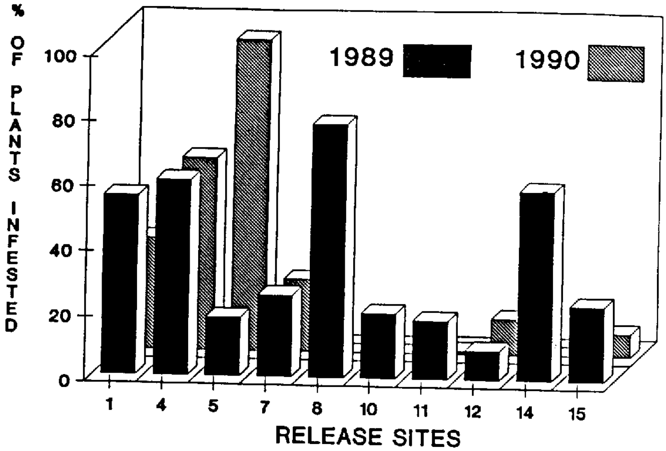
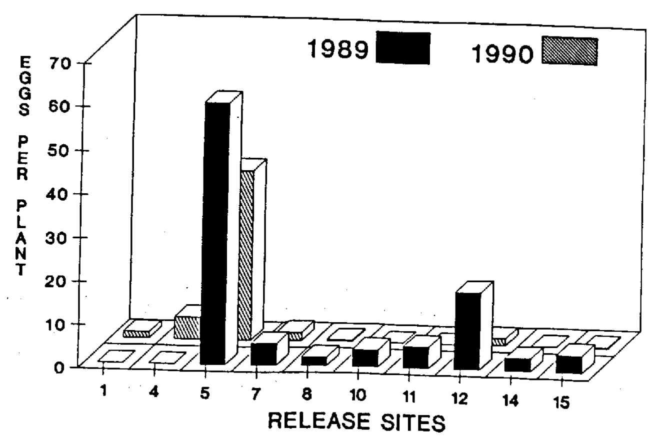


Figure 2. Average number of head weevil eggs/plant at each location during 1989 (one month post-release) and 1990 (one year post-release).



Release of the Korean Lady Beetle, *Chilocorus kuwanae,* for Control of Several Coccids on Ornamentals in Tennessee

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Nature of Work: The euonymous scale, *Unaspis euonymi* (Comstock), is a serious pest of species of *Euonymous,* a popular ornamental border plant grown throughout the U.S. First instars tend to settle on the stems and twigs and the underside of the leaves; males that settle on the leaves tend to position themselves along the veins. This species has 3 generations/year-in Tennessee and will eventually encrust the host plant if left uncontrolled. Damage to the plant is primarily from sap extraction resulting in die-back of foliage and eventually death of the infested stems and twigs.

Because of the difficulty in controlling this pest, species of *Euonymous* have often been replaced by growers with other ornamental plantings, and some nurseries have reduced or eliminated production of *Euonymous.* However, a lady beetle predator, *Chilocorus kuwanae* Silvestri, was recently imported from Asia and has successfully controlled localized infestations of U. *euonymi* in several parts of the U.S. (Drea and Hendrickson 1988). In addition, this lady beetle is known to feed on several other scale insects including: *Ceroplastes japonicus* Green, *Chrysomphalus bifasciculatus* Ferris, *Hemiberlesia pitsophila* Takagi, *Lepidosaphes corni* Takahashi, *Parlatoria zizyphus* Lucas, *Quadraspidiotus macroporanus* Takagi, *Q. perniciosus* Comstock, and *Unaspis yanonensis.*

Results and Discussion: In 1990, high densities of U. *euonymi* were significantly reduced on E. *japonica* Thunberg by C. *kuwanae.* Releases of the lady beetle were made in June 1990 at two sites (25 adults/site) onto heavily infested plants in Knox Co., TN. By September, fewer than 100 live scale insects were observed in the release sites. The plants once again began to produce foliage, a condition that had not occurred during the spring and summer.

Both larvae and adults of the lady beetle feed on males and females of the euonymous scale in field and laboratory conditions. The lady beetle appeared to feed on more prey than they could eat. In laboratory tests, male and female pairs, maintained in plexiglas cages, fed daily on or damaged 30 (10-92) female and 147 (52-309) male scale insects over a 29 day period. Individuals of this predator have been reported to feed on 1340-2610 specimens of H. *pitysophila* in China (Wu et. al 1989), and 44-1085 U. *yanonensis* in Japan (Yasumatsu 1971).

In laboratory observations of 25 specimens, a continuous increase in weight gain was recorded from 0.0009 (0.0001-0.005) g for first instars to 0.0078 (0.005-0.015) g for adults. Adult size was 3.5 (2.9-4.3) mm in length and 2.9 (2.7-3.2) mm in width.

The fecundity of the lady beetle increased as prey consumption increased which may in part explain the dramatic impact on scale-infested plants. Females deposited their eggs (usually one/ ovipositional site) inside the exuviae of the prey, in cracks of limbs, twigs and debris, and occasionally on the leaves. Two mated females produced 45 and 65 eggs, respectively, over a 25 day period under laboratory conditions. Egg eclosion occurred 4-6 days after oviposition.

As the prey population diminished within the sites, the lady beetles began to leave in search of prey. By late September 1990, no lady beetles were observed in the release sites. However, at one site, two females of C. *kuwanae* were collected on 8 February, one on 18 March and one on 2 April 1991. Yasumatsu (1971) reported that the lady beetles overwinter in the adult stage near the area of scale insect infestation, and actively search for prey when the temperature rises above 10°C.

One of the disadvantages of this predator is the encyrtid parasite, *Homalotylus flaminius* Dalman, that attacks the first and second instars. However, mass-rearing under laboratory conditions should effectively produce parasite-free populations of the predator. Therefore, inundative releases of the lady beetle into scale-infested areas can play an important role in the control of selected coccid species in nursery and ornamental plantings.

Significance to Industry: Augmentation (mass rearing of beneficial agents to suppress pest populations) of C. *kuwanae* may provide a managerial approach for control of selected species of scale insects over large infested regions. The use of this biological control agent can potentially provide an environmentally safe, non-toxic, and non-polluting method for management of scale insect pest populations within nurseries, greenhouses, ornamental gardens, etc. Because of the ease in which this species may be reared, it may also possess economic benefit as a candidate for mass rearing and distribution by commercial insectaries.

Literature Cited

1. Drea, J.J. and R.M Hendrickson. 1988. Exotic predators. Amer. Nurserymen. 168:66-71.

2. Wu, W.J., S.P. Chen, and H.Y. Wei. 1989. Functional response of *Chilocorus kuwanae* Silvestn to *Hemiberlesia pitysophila* Takagi. Natural Enemies of Insects. 11:28-30.

3. Yasumatsu, K. 1971. On some biological control problems in Japan. Israel J. Entomol. 6:301-305.