Biological Control of Japanese Beetle in Michigan and the North Central United States

Author:
David Smitley, Department of Entomology

Industry Partners:
Michigan Turfgrass Foundation, Michigan Forestry and Parks Association

Funding:
Project GREEEN, Michigan Turfgrass Foundation, Michigan Forestry and Parks Association

Significance:
Japanese beetle (*Popillia japonica*) is one of the most destructive agricultural pests in Michigan. The nursery industry and blueberry growers are the most vulnerable. Losses in nursery sales are estimated at 10% per year ($100 million) because stock cannot be shipped to other states unless it is certified free of Japanese beetle. Blueberry growers could lose 50% of their crop in any given year without adequate control of Japanese beetle because blueberries cannot be sent to processing for yogurt and other products unless they are completely free of Japanese beetles.

Project Goal:
Reduce the pest status of Japanese beetle in Michigan, and ultimately in the North Central United States through the introduction of parasites and pathogens.

Project Description:
Japanese beetle populations are being intensively sampled at ten sites in southern Michigan. Adults and larvae are dissected to determine the proportion of individuals infected with pathogens or parasites. The incidence of parasites and pathogens in Michigan will be compared with a recent survey of natural enemies in Connecticut where Japanese beetle has been established for 70 years. Pathogens or parasites found to be absent in Michigan will be introduced to five of the ten research sites.

Progress Summary (April 1999 to July 2000):
- 40 potential study sites including parks, rest areas, blueberry farms, industrial lawns and golf courses were surveyed. Ten sites with the highest density of Japanese beetle larvae were selected (all ten were golf courses) and grouped into five pairs based on location and density of larvae.
- The Japanese beetle parasites *Tiphia vernalis* (a parasitic wasp) and *Istocheta* sp. (a parasitic fly), known to be active in Massachusetts and Connecticut, were absent in Michigan.
- *Ovavesicula*, a protozoan pathogen known to infect approximately 25% of Japanese beetle larvae in Connecticut was also absent in Michigan larvae.
- A Eugregarine (protozoan) digestive system parasite found in 42 of 49 locations in Connecticut (70% of Japanese beetle larvae infected) was only found at four of ten locations in Michigan.
- The parasitic fly, *Istocheta*, and the protozoan pathogens, *Ovavesicula* and a *Eugregarine* sp. were introduced at five study sites in Michigan.
- Two entomopathogenic nematodes, *Heterorhabditis bacteriophora* and *H. marelatus*, were applied at five sites to evaluate their persistence and long-term impact on Japanese beetle larvae.

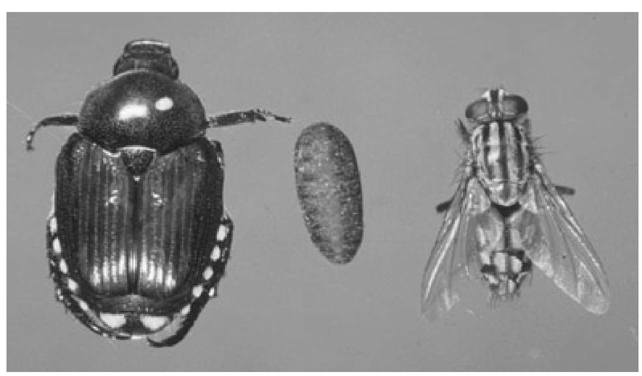

Fig. 1. Adult Japanese beetle (with egg of *Istocheta* fly on thorax), pupa and adult *Istocheta* fly. See larger color photo on page A-4.

Winter Mortality of Gypsy Moth Eggs in Michigan

Authors:

David Smitley and Deborah McCullough, Department of Entomology; Jeff Andresen, Department of Geography; Roger Mech, Michigan Department of Environmental Quality, and Ron Priest, Michigan Department of Agriculture.

Funding:

EPA Starr Grant

Significance:

The forestry and nursery industries in the Upper Peninsula of Michigan, Wisconsin and Minnesota are concerned about the spread of gypsy moth from the northern Lower Peninsula and isolated infestations along the Lake Michigan shoreline of the Upper Peninsula and Wisconsin. According to previous research, gypsy moth should not survive well in the interior of the Upper Peninsula, northern Wisconsin or Minnesota because of winter mortality of eggs. However, the northern lower peninsula of Michigan was heavily defoliated by gypsy moth in 1991 and 1992 despite a climate considered marginal for survival of gypsy moth eggs during the winter.

Project Goal:

Determine the effect of cold winter temperatures on the survival of gypsy moth eggs.

Project Description:

We investigated the impact of extreme cold events on egg hatch by collecting egg masses from trees within state forests located in Michigan counties with active gypsy moth populations in 1994 and 1996, the two coldest winters in the last ten years. In 1994, MDA and MDEQ examined egg masses from 47 locations (in 29 counties). In 1996, MSU collected egg masses from 12 locations (12 counties), including subsamples from above and below the snowline. Successful egg hatch was compared with the number of nights in January and February when the temperature dropped below -15° F.

Results:

Egg hatch from masses located 90 cm or more above ground was not as complete as egg hatch from masses close to the ground in regions with the coldest temperatures. More successful egg hatch close to the ground may be partially explained by snow cover. In three separate data sets, egg hatch was negatively correlated with the number of days in January and February when the temperature dropped below –15° F (r^2= 0.31, 0.62, and 0.54). The heaviest defoliation in the northern Lower Peninsula of Michigan occurred in years following a mild winter when temperatures dropped below –15° F less than four times.

We concluded that if the temperature drops below –15° F(-26° C) more than five times during the winter, significant egg mortality can be expected unless the egg masses are below snow cover during the cold events. These conditions are very unlikely to occur in Michigan south of a line from Saginaw west to Muskegon, and along the Lake Michigan shoreline anywhere in the state. However, there is nearly a 50% chance of significant winter mortality of gypsy moth eggs in any given year for the central northern Lower Peninsula and most of the Upper Peninsula (28° C isotherm in Fig. 2). Gypsy moth may spread into the Upper Peninsula, northern Wisconsin and Minnesota rapidly in years with mild winters, but nearly 100% mortality of eggs is expected in those regions during cold winters.

See graphs on pages 22 and 23.

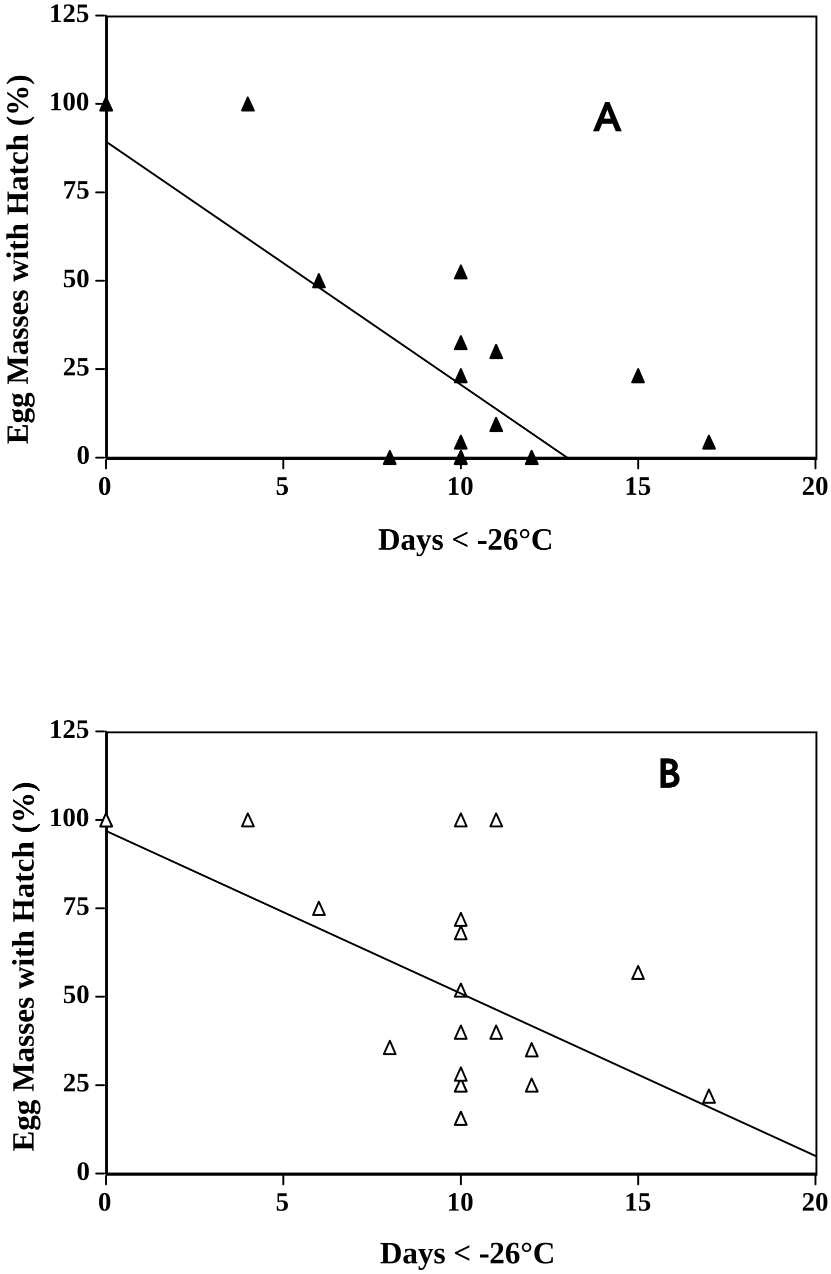

Fig. 1. Department of Natural Resources 1994. Impact of the number of days in January and February when the minimum temperature was –26 °C or less on gypsy moth egg hatch: (A) from masses >90 cm above ground and (B) from egg masses <90 cm above ground. Egg hatch is the proportion of egg masses with >5% hatch.

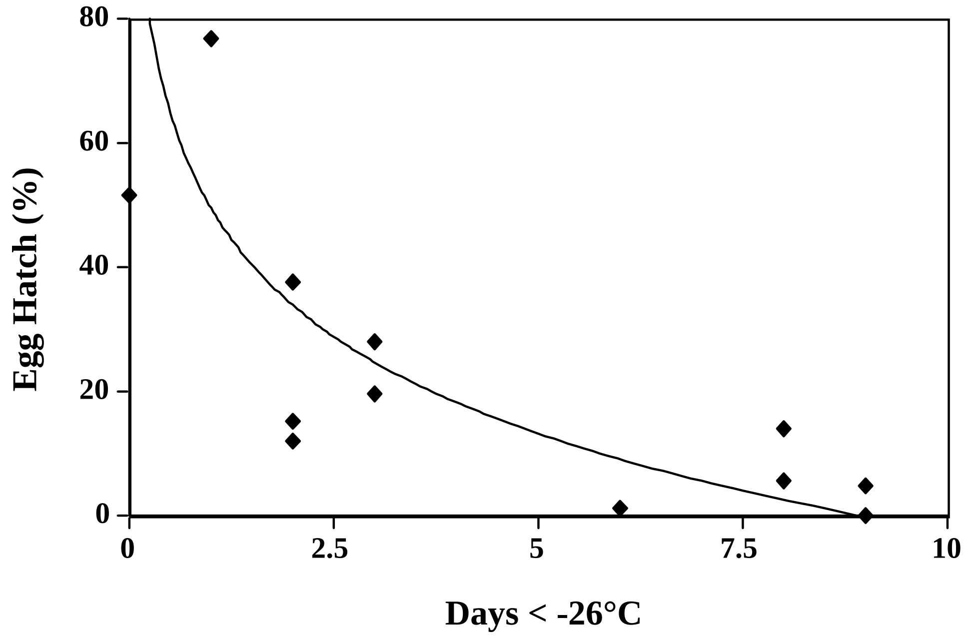

Fig. 2. Michigan State University 1996. Impact of the number of days when the temperature was -26°C (10.6°F) or less on gypsy moth egg hatch from all egg masses collected at each site. Egg hatch is the proportion of eggs that hatched.

Entomophaga maimaiga and Gypsy Moth in Michigan

Authors:
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Industry Partners:
Michigan Department of Natural Resources, USDA Forest Service, Cornell University

Funding:
Michigan Department of Natural Resources, USDA Forest Service

Introduction of Entomophaga maimaiga *into Michigan for biological control of gypsy moth:*

Entomophaga maimaiga is a fungal pathogen of gypsy moth that unexpectedly caused widespread disease and death of caterpillars in some New England states in 1988 and 1989. Before that time, it was only known from Japan and attempts to introduce it into the United States had failed. After the surprising collapse of gypsy moth in parts of Massachusetts and Connecticut due to *E. maimaiga*, we initiated a program to introduce it into Michigan. In 1991, before it was introduced, we did not find *Entomophaga* in 1,500 larvae collected from 50 locations in Michigan.

In 1991, we collected soil from forest sites in Massachusetts where gypsy moth larvae were heavily diseased. The soil, containing resting spores of the fungus, was introduced in replicated plots at research sites in Lake, Grand Traverse and Crawford Counties. Within two years, *E. maimaiga* infected 50-95% of the caterpillars at the research sites, contributing to a population collapse. In addition to the three research sites, *E. maimaiga* was introduced to 20 locations in Michigan by placing a quart of soil with resting spores around the base of a single tree.

Two years later, *E maimaiga*-infected caterpillars were found at all of the single tree inoculation sites and half a mile away, indicating that the pathogen had successfully established and had begun to spread on its own. Over the next three years *E. maimaiga* spread rapidly throughout Michigan, and was even found in some locations where we suspect it had been accidentally introduced through some other means than our own research. In 1996, five years after we introduced *E. maimaiga*, we conducted a survey to see how far it had spread. *Entomophaga* was found in 37 of 58 sites (64%) and had spread to just about every county in Michigan where gypsy moth is found. An average of 15% of the live larvae we collected from all sites in 1996 were infected with *Entomophaga*. It is likely that *Entomophaga* will continue to have a suppressive effect on gypsy moth in Michigan that adds to the impact of nuclear polyhedrosis virus (NPV) and other natural enemies, especially in years with frequent rain in May and June.

Impact of Entomophaga maimaiga *on gypsy moth in Michigan:*

In 1997, building populations of gypsy moth at pre-defoliation levels were studied at four locations in southeast Michigan. At each site plots were established in *Bacillus thuringiensis* (B.t.) spray blocks and in adjacent unsprayed blocks. Live larvae and cadavers were collected once per week from egg hatch to pupation. *E. maimaiga* epizootics were observed at all locations, even when the gypsy moth population density was very low. Cumulative infection rates from gypsy NPV were less than 10% at any site, while *E. maimaiga* infection levels ranged from 30 to 99%. *E. maimaiga* activity varied considerably from week to week, and cumulative mortality due to *E. maimaiga* for the season was much higher than infection levels or cadavers observed on any given sample date. Egg mass counts in the fall of 1997 were lower than in fall of 1996, indicating a decline in the gypsy moth populations at our study locations before any defoliation was observed.

In 1998, *E. maimaiga* was studied in the same way as in 1997, but at sites in Gladwin County. Dry conditions in 1998 resulted in limited activity of *E. maimaiga* (20% infection) and defoliation of plots not sprayed by B.t. Plots sprayed by B.t. were protected from defoliation.

Conclusion:

We concluded that in areas where *E. maimaiga* is well-established, gypsy moth populations may collapse due to high levels of infection in years with adequate rain. However, in drier years, or in locations where resting spores are not abundant, *E. maimaiga* may have little impact.

See color photos on page A-4.

Table 1. Incidence of *E. maimaiga* and gypsy moth nuclear polyhedrosis virus (NPV) at 50 sites in Michigan surveyed in 1991.

County	No. of locations sampled	% larvae infected with NPV [a]	% larvae infected with *E. maimaiga*
Midland	10	36.4 ± 17.4	0
Clare	10	39.6 ± 18.0	0
Gladwin	6	29.2 ± 10.1	0
Arenac	4	30.3 ± 15.4	0
Gratiot	2	45.0	0
Saginaw	1	69.0	0
Osceola	4	46.8 ± 15.3	0
Missaukee	3	39.0 ± 1.7	0
Lake	4	14.8 ± 6.2	0
Wexford	6	26.5 ± 17.1	0

Thirty larvae (3rd –5th instars) were sampled at each location. [a] Mean ± SD (standard deviation).

Table 2. Gypsy moth egg masses per 0.4 ha in April of 1994 in plots where *E. maimaiga* was introduced and in plots located 53, 300 and 425 meters away.

							Regression model[a]			
County	n	0 m	53 m	175 m	300 m	425 m	Model	r^2	P	F
Crawford	4	28 ± 10	43± 25	73± 52	75± 58	--------	y = 0.28x + 28	0.32	<0.006	9.5
Lake	4	5 ± 5	5 ± 10	18 ± 24	55 ± 44	28 ± 48	y = 0.09x + 4	0.22	<0.02	6.3
Grand Traverse	4	45 ± 24	143 ± 134	470 ± 134	443 ± 296	532 ± 167	y = 1.1x + 28	0.44	< 0.001	14.5

[a] In the regression model, y = egg masses per 0.4 hectare and x = distance (meters) away from plots where *E. maimaiga* was introduced.

Table 3. Recovery of *E. maimaiga* 2 years after introduction at single-tree release sites and 0.8 km (about 0.5 mi) away.
% cadavers with *E. maimaiga* resting spores and number of cadavers collected (n)

County- Site no.	At release point	0.8 km N	0.8 km S
Roscommon -1	92 (12)	0 (12)	8 (12)
Arenac- 1	83 (12)	(0)	8 (12)
Arenac- 2	100 (12)	25 (12)	42 (12)
Kalkaska -1	100 (12)	25 (12)	38 (3)
Kalkaska-2	100 (12)	75 (12)	------
Roscommon-2	100 (10)	(0)	0 (3)
Clare	0 (5)	(0)	------

Management of Fletcher Scale in Yews

Authors:

David Smitley, Department of Entomology and Gary Van Ee, Department of Agricultural Engineering

Industry Partners:

Michigan Nursery and Landscape Association, Zelenka Nursery

Funding:

Project GREEEN, Michigan Department of Agriculture

Significance:

Total sales for the nursery and landscape industry in Michigan, including retailers, is about $3.67 billion/year. Michigan nurseries produce and sell more yews than any other plant. Insects and diseases are often the most limiting factor in nursery production because plants shipped out of state must be certified as free of damaging pests. The greatest obstacle in growing yews and arborvitae is Fletcher scale. This 3 mm-long hemispherical brown scale is ubiquitous in nursery fields, despite insecticide applications targeted specifically for it. In any given year, as much as 30% of Michigan yew and arborvitae fields may be rejected for certification because of Fletcher scale.

At this time growers rely heavily on organophosphate insecticides that may soon be lost because of the Food Quality Protection Act. Pesticide application technology is also a problem. Nursery growers are applying insecticides in 200 gallons of water per acre. This requires large spray tanks that must be refilled frequently.

Project Goals:

- Develop highly effective insect management strategies for Fletcher scale and alternatives to products that may be lost due to implementation of FQPA.
- Research the most cost-efficient and effective methods of delivering pesticides.

Progress Report:

Develop highly effective management strategies for Fletcher scale and alternatives to organophosphate insecticides.

At this time, nursery growers depend heavily on Dursban, an organophosphate insecticide, for control of Fletcher scale. Efficacy tests in 1999 and 2000 indicate that Supracide works as well as Dursban for scale control, but Supracide is also an organophosphate (Table 1). Several insect growth regulators (Adept, Citation, and Precision) were also evaluated. Precison and Adept looked promising in 1999, but did not work well (50% control) in 2000 (Table 1). Flagship, tested for the first time against Fletcher scale in 2000, worked well (96% control). Flagship is a neonicotinyl insecticide that has a low impact on predators and non-target organisms. In this test it worked systemically after a soil directed application. Flagship looks very promising for control of Fletcher scale in 2001, assuming that federal registration is approved by that time.

Optimum timing for insecticide applications was investigated in a nursery field where Fletcher scale was sprayed in late April, late June, late August, and on all combinations of two of those spray dates. Scale density was determined from collecting foliage samples in April, late May, late June and October. The best time to apply foliar sprays is within a few weeks of crawler emergence. This year, crawlers emerged in late June and again in late August, making the June 28 and August 30 application dates the most effective. The late April treatment did not work well and the late July spray on top of the late June spray did not add any additional control over the late June spray by itself. This year, late June and late August were the best times to spray, and the combination of late June + late August gave the overall best results (98% control).

Develop a more efficient pesticide delivery system for yews.

Dr. Van Ee evaluated current pesticide application technology by applying Dursban through conventional nozzles at 200 gal of spray solution per acre and at 50 gal/acre. He also applied Dursban through a Proptec sprayer at 30 gal per acre. All treatments received the same amount of active ingredient per acre. Data collected in July 2000 indicates that Dursban applied in 50 gal/acre was just as effective or more so than Dursban applied in 200 gal/acre when the same amount of active ingredient per acre was applied. The Proptec sprayer also achieved excellent scale control using 30 gal/acre, although the final scale counts were slightly higher than in the 50 and 100 gal/acre treatments. These results suggest that nursery growers could achieve the same level of control with low volume and ultra low volume spray applications that require much less time and cost less to apply.

Table 1. Efficacy of insecticide treatments to yews in a nursery field for control of Fletcher scale in June and July, 2000.

Product	**Rate (formulated/A)**	**Application Method on June 28**	**Scales per 30" foliage on July 24th**	
Flagship 25 WG	12.7 oz/200 gal	Soil spray on June 1	1.2	a
Dursban 50 N	4.0 lb/50 gal	Foliar spray	1.2	a
Supracide 25 WP	4.0 lb/200 gal	Foliar spray	1.8	a
Dursban 50 N	4.0 lb/200 gal	Foliar spray	2.8	ab
Sevin 80 WSP	1.25 lb/200 gal	Foliar spray	3.0	abc
Flagship 25 WG	8.0 oz/200 gal	Foliar spray	3.0	abc
Orthene 97% TT&O	1.0 lb/200 gal	Foliar spray	6.0	abcd
Talstar F	40 oz/200 gal	Foliar spray	12.2	bcde
Endeavor 50 WDG	10 oz/200 gal	Foliar spray	11.8	cde
Distance 0.86 EC	24 oz/200 gal	Foliar spray	11.8	de
Precision 25 WP	8oz/200 gal	Foliar spray	20.3	de
Distance 0.86 EC	12 oz/200 gal	Foliar spray	16.3	e
Unsprayed check	——	——	27.0	e

Means followed by the same letter are not significantly different at P = 0.05 (LSD Test).

Table 2. Impact of timing of insecticide applications on efficacy of insecticide sprays for control of Fletcher scale on yews in nursery fields.

Treatment (App Date)	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 6**	**Mean**
June 28 + Aug 30	4	5	3	4	4	6	4.3
April 25 + Aug 30	17	13	14	18	12	2	12.7
August 30	24	20	17	6	25	44	22.7
June 28	17	11	29	23	24	41	24.2
June 28 + July 24	7	7	32	55	49	10	26.7
April 25	19	103	131	140	249	192	131.0
Control	204	78	86	384	306	272	221.0

Fate of Fletcher Scale in the Urban Landscape

Author:
David Smitley, Department of Entomology

Industry Partners:
Michigan Nursery and Landscape Association, Zelenka Nursery

Funding:
Project GREEEN, Michigan Department of Agriculture

Significance:

The greatest obstacle in growing yews and arborvitae is Fletcher scale. This 3-mm long hemi-spherical brown scale is ubiquitous in nursery fields, despite insecticide applications targeted specifically for it. In any given year, as much as 30% of Michigan yew and arborvitae fields may be rejected for certification because of Fletcher scale. Ironically, Fletcher scale appears to nearly disappear after yews are planted in the landscape. If Fletcher scale is not a threat to landscape plants, perhaps inspection standards should be relaxed to the point where a low population of scale is acceptable, while heavy infestations that detract from the appearance of plants or threaten plant health are restricted.

Project Goal:

Determine the fate of Fletcher scale on yews planted in the urban landscape.

Methods and Procedures:

In 1996, ten pairs of infested yews were dug from a nursery field. One of each pair was replanted into the nursery field while the other was brought to MSU and given to a volunteer to plant at home. Yews were only given to volunteers that promised not to use pesticides in the area where they planted the yew. One year later, Fletcher scale populations remained high on yews in the nursery field, and dropped to very low levels on yews planted by volunteers at home. In 1999, a similar experiment was conducted with 20 pairs of infested yews. Fletcher scale was counted on all plants before they were dug and three times per year after they were replanted in Lansing city parks or replanted back into the same nursery field.

Results:

Yews randomly selected from a nursery field for this experiment started with 80 scales per sample in July of 1996. Yews replanted into the same nursery field in 1996 remained heavily infested with Fletcher scale for the next two years while yews planted into urban yards lost their scale infestation rapidly, dropping to levels ¼ that of scale on nursery plants within the first six months. Three years later (in 1999), Fletcher scale populations on yews in the now abandoned nursery declined to 12.0 scales per sample (Table 1). On the same sample date (7-15-99), only 1.9 scales per sample were found on yews planted in urban yards. The experiment was repeated in 1999 with similar results. Fletcher scale began to disappear rapidly on yews planted in urban parks while scale on yews in the nursery field remained abundant.

Our results show that Fletcher scale is not an important pest in the urban landscape. Fletcher scale should be treated like aphids or spider mites, rather than a pest whose presence at low levels prohibit certification of nursery stock. Study results indicate that to require additional pesticide applications or restrict the shipment of yews infested with low levels of Fletcher scale may not be reasonable.

See color photo on page A-4.

Table 1. Fate of Fletcher scale on yews randomly dug from a nursery field and either replanted into the nursery or planted into the urban landscape. The experiment was repeated in 1999. Data are the mean number of scales per 30 inches of yew shoots.

Site/Year Planted	Fletcher scale sample on 7/15/99	Fletcher scale sampled on 11/1/99
Old Nursery - 1996	12.0	3.7
Urban Yard - 1996	1.9	0.8
New Nursery - 1999	35.0	15.0
Urban Park - 1999	20.0	2.4

Outbreaks of Cottony Maple Scale in Mosquito Control Districts

Authors:
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Partners and Funding:
Saginaw County Mosquito Control Program

Significance:

Cottony maple scale has become a problem on silver maple trees in Saginaw County over the last ten years. Some years seem worse than others and some cities experience worse infestations than others. In some cases, the undersides of branches are so heavily infested that they look like they are covered with snow. The scale insects produce large amounts of a sticky liquid waste product called honeydew. This becomes a problem when branches overhang sidewalks, streets, driveways and porches. Although silver maples do not die from cottony maple scale infestations, their growth may slow and the trees may begin to look thin. A joint project with the Saginaw County Mosquito Control Program was created in 1995 to collect data to determine if the mosquito control sprays had any connection with outbreaks of cottony maple scale.

Project Goal:

To look at the impact of mosquito control sprays on outbreaks of cottony maple scale

Project Description:

Five pairs of cities were selected for the study: five inside Saginaw County but within five miles of a county line; and five just outside the county as close as possible to one of the five cities inside the county: Frankenmuth/Vassar, Birch Run/Clio, Chesaning/Montrose, Oakley/Elsie and Merrill/Brechenridge. Twelve silver maple trees were flagged in each city and sampled every year by counting the number of egg masses on the terminal 1.0 m of each of ten branches per tree.

Results:

After five years, the trend is consistent: cottony maple scale populations in Saginaw County are ten to 20-fold higher than populations outside the county. City streets within the county are sprayed five to ten times per year with malathion, permethrin or sumithrin for control of adult mosquitoes. It is likely that the insecticides applied for mosquito control are suppressing natural enemies of cottony maple scale while having little effect on the scales themselves. The mosquito control program is very well accepted in Saginaw County and is expected to continue indefinitely. The directors of the mosquito control program are now looking for ways to minimize the impact of mosquito sprays on cottony maple scale predators. They will be considering minimizing the number of applications per year, choosing insecticides less toxic to predators, or choosing insecticides that cottony maple scale is not as resistant to.

See related graph on page 30.

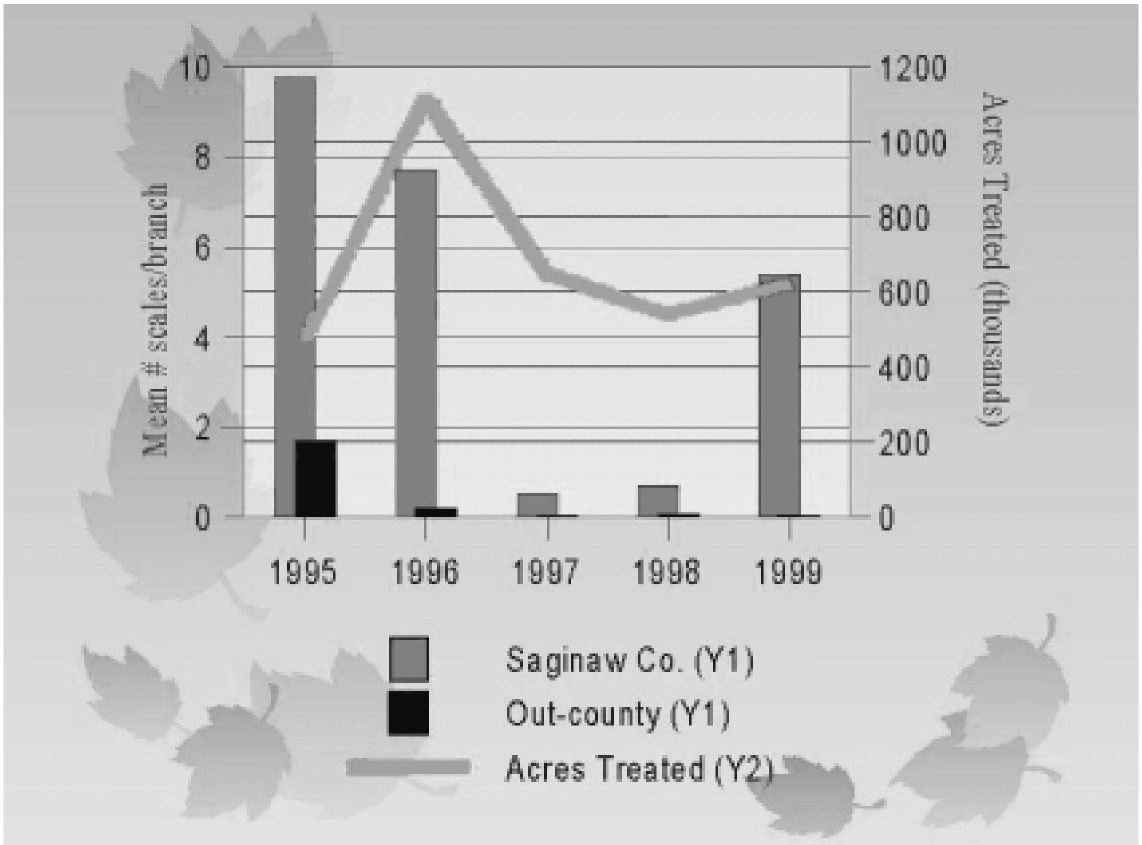

Fig. 1. Comparison of mean number of scales/branch on silver maple trees sampled in Saginaw County and out-county. A spray program to control mosquitos is in effect in Saginaw County, but not in the out-county areas.

Management of Black Vine Weevil in Nurseries

Authors:
David Smitley and Terrance Davis, Department of Entomology

Industry Partner:
Zelenka Nursery

Funding:
Michigan Department of Agriculture/ MSU Entomology Department

Significance:

Recent outbreaks of black vine weevil in fields of yews and in container production of *Euonymus fortunei* have damaged plants and resulted in restricted blocks. In some fields, insecticide treatments have failed to control the weevils and outbreaks have become so severe that thousands of plants have been killed from the larvae girdling the underground stem and eating the roots.

Project Goals:

- Review recommendations from Ohio and other states,
- Begin field-testing of the most promising products; and
- Assist in the development and registration of new products.

Procedures:

Research plots were established in an infested yew field where three tests were conducted. In the first test, Diazinon, Dylox, Sevin and Dursban were applied as soil-directed sprays for control of black vine weevil larvae in April. It rained the day the insecticides were applied (>0.5"), soaking the products into the root zone and thus providing the best possible circumstances for achieving adequate control. Yews in the test plots were dug in late May and the roots and soil examined for larvae and pupae.

In the second test, Talstar, Astro, Flagship, Supracide, Scimitar and Decathlon were applied as foliar sprays on July 20. Weevils were counted one, two and three weeks after application. Adult weevil control was also attempted with Flagship applied as a soil drench on May 31.

In the third test, Flagship, Marathon and Mach 2 were applied as soil-directed sprays to control young larvae soon after egg hatch. These three products are considered to be the best available insecticides for the control of white grubs and weevil larvae. They work best when applied just before eggs are laid. Marathon and Mach 2 were applied within a few days of June 1st and July 1st to determine the optimum timing for control of black vine weevil larvae. The new products (Mach 2 and Flagship) were also tested for phytotoxicity problems on a variety of nursery stock and perennials as part of the IR-4 label expansion process.

Results and Conclusions:

None of the four insecticides applied in the first test for control of black vine weevil larvae in April had any impact on the number of larvae found in the root system of test plants dug in late May (Table 1). However, Diazinon and Sevin reduced the number of European chafer larvae recovered. If Diazinon and Sevin worked for European chafer larvae but not black vine weevil larvae, we may be facing a problem with black vine weevil resistance to organophosphate (OP) and carbamate insecticides. This would explain why nursery growers have not had any success with using Dursban or Turcam for control of black vine weevil larvae.

In the second test for black vine adults, the foliar sprays were applied on July 20th, after adult activity had already peaked. The best time for adult sprays is probably from June 15th to June 30th in most years. Because of the late timing and surprisingly low number of adult weevils, the data were not as consistent as we would have liked, and no conclusions can be made. The nursery beds around our plots were sprayed several times with Talstar. It is possible that some of the Talstar drifted into our test plots, reducing the number of weevils. Even so, some trends in how well the products worked can be observed (Table 2). Talstar as a foliar spray and Flagship as a soil drench seem to be the most promising for control of black vine weevil adults. Talstar is a synthetic pyrethroid insecticide (SP) and Flagship is a neonicotinyl, similar in chemical structure to Marathon. Supracide (organophosphate), Scimitar (SP) and Decathlon (SP) did not work well for adult weevils in this test. This test will be repeated again next year (2001).

In the third test, where insecticides were applied to the soil surface for control of young larvae, we failed to find any black vine weevil larvae when the plants were dug in late September. Again, we suspect that some drift from the Talstar applications nearly eliminated successful egg laying by black vine weevil adults in our plots. Although we did not learn anything about how well these products work for control of black vine weevil larvae, we did learn that the nursery sprays (four foliar sprays of Talstar and Scimitar) worked well.

The new insecticides, Flagship and Mach 2, currently in development for use in nursery fields, were tested for phytotoxicity to azalea, barberry, potentilla, yew, pine, maple, chrysanthemum, day lily, Siberian iris, and pansy. Flagship did not cause injury to any of the test plants, even at a 4X rate. Mach 2 caused some yellowing of day lilies and some wilting of yarrow. No other problems were found.

Table 1. Insecticide control of black vine weevil and European chafer larvae when products were applied to the soil in a yew field on April 20th. Means followed by different letters are different at P = 0.05 level.

Treatment	Black Vine Weevil Larvae	European Chafer Larvae
Diazinon Ag 500 1 gal/A	38.3 a	0.0 a
Sevin 80 WSP 10 lb/A	24.5 a	0.0 a
Dylox 80 10 lb/A	31.3 a	1.3 b
Dursban TNP 2 gal/A	23.8 a	1.5 b
Control	29.8 a	1.5 b

Table 2. Insecticide control of black vine weevil adults. All products were applied as foliar sprays on July 20th, except one Flagship treatment that was applied as soil drench on May 31st. Data are the mean number of black vine weevil adults caught in pitfall traps 4 and 11 days after the foliar sprays.

Treatment	Black Vine Weevil Adults on July 24	Black Weevil Adults on July 31
Flagship 25 WG (May 31 soil drench)	3.0	2.0
Talstar	1.0	8.0
Astro	3.0	6.0
Flagship	3.0	11.0
Supracide	5.0	5.0
Scimitar	5.0	14.0
Decathlon	8.0	20.0
Control	7.0	1.0

Damage to Nursery Crops by the European Chafer: Immediate Strategies and Long-Term Solutions

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Significance:

The European chafer looks like a small June beetle and has the same type of larval stage; a c-shaped white grub that feeds on plant roots. It was discovered in the United States in Newark, New Jersey in 1940. It has now spread throughout the states of Connecticut, New York, Pennsylvania, Ohio and Michigan, where it is a devastating pest of home lawns, municipal turf, and sometimes nursery crops, wheat, alfalfa and pastures. European chafer has rapidly expanded its range across Michigan over the last 5 years, destroying most of the turf in some subdivisions in the greater Detroit area, Ann Arbor, Jackson, Lansing, and Grand Rapids. Although a devastating pest of home lawns, agricultural crops were not affected until last year when some injury was reported to nursery, wheat and alfalfa fields.

Because it was not previously considered a major agricultural pest, funding sources were not available in the past to address this problem. This spring, leaders of the lawn care industry joined with the nursery industry and field crop growers to request that Michigan State University make an emergency response to the explosion of European chafer damage in crop areas.

A proposal designed to investigate the extent of damage caused by European chafer in turf, nursery and field crops, and to identify immediate and long-term management strategies was provided with emergency funding by Michigan State University and Project GREEEN in June, 2000. A full proposal will be submitted in December of 2000.

Overall Project Goal:

Reduce nursery and perennial crop damage caused by the European chafer in Michigan, and ultimately in the North Central United States, by identifying new insecticide products that are safe and effective, determining when crops are at risk of being damaged, and by introducing pathogens and parasites from the eastern United States and Europe.

Objective 1*:* Assist in the field-testing and development of three new products specifically labeled for grub control in nurseries. Work with IR-4 to expand the number of nursery and landscape plant types that these products can be used on.

Objective 2: Determine the relationship between European chafer larval density and the extent of crop losses in arborvitae, spruce and yews.

Objective 3: Determine infection levels of pathogens and parasites of European chafer larvae in Michigan and in the eastern United States.

Objective 4: Identify new parasites and pathogens in Europe for potential importation into the United States.

Research Approach:

The most immediate problem for the nursery industry is the current lack of insecticide products specifically labeled for grub control in nurseries other than the price-prohibitive Marathon ($600/A). Another problem is that we do not know how many European chafer grubs must be present to seriously injure nursery crops, and therefore, we do not know when insecticides are necessary. These problems will be addressed immediately to provide nursery growers some tools to protect infested fields.

A long-term solution to the outbreak of European chafer in Michigan will be sought by utilizing our experience in introducing parasites and pathogens of Japanese beetle. We will determine what pathogens and parasites are most important in the eastern United States, where European chafer has transitioned through an outbreak phase into an endemic phase, and introduce them into Michigan if they are not here. We will also sample European chafer in Europe to find new candidates for introduction into the United States.

Progress in 2000:

Thanks to the emergency funding from project GREEEN we were able to begin research on European chafer this summer. Phytotoxicity testing was completed with Flagship and Mach 2. No phytotoxicity was observed on test plants. Both products should receive federal labeling from EPA within the next twelve months. Flagship, Mach 2, Marathon and Diazinon were applied to spruce trees in early July in a field heavily infested with European chafer. A total of 18 trees (six replications) were dug in early October and grubs counted (Table 1). Marathon and Flagship worked well (75% control) for control of European chafer larvae but Mach 2 didn't (0 % control).

In September and October, European chafer grubs were collected from infested turf near the Lansing airport and introduced into pots containing 1- to 2-foot tall spruce and arborvitae. Different numbers of grubs (5, 10 or 20) were seeded into each pot to determine the number of grubs that cause significant injury.

European chafer grubs will also be collected from ten locations in Michigan for dissection and pathogen analysis. Results will be compared with European chafer grubs obtained from Massachusetts. Finally, cooperators in Europe will be contacted for collecting European chafer grubs in 2001. Pathogens and parasites collected from European chafer grubs in Europe will be compared with the same in Michigan.

Table 1. Insecticide control of European chafer larvae in a spruce field.

Treatment	Mean Number of Larvae/Plant	SD
Flagship	0.8	0.8
Marathon	1.3	1.0
Mach 2	4.3	4.1
Control	3.0	2.8