The Connecticut Agricultural Experiment Station, New Haven

Controlling Hemlock Scales With Least Environmental Impact

BY MARK S. McCLURE

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For more than a half century, hemlocks in southwestern Connecticut have been ravaged by two armored scale insects from Asia. The elongate hemlock scale, Fiorinia externa Ferris, and a circular hemlock scale, Nuculaspis tsugae (Marlatt), (Fig. 1) were accidentally introduced into the vicinity of New York City from Japan at the turn of this century and have subsequently spread into several northeastern states (Weiss 1914, Ferris 1936). In 1976, the infestation in Connecticut was confined to Fairfield County and a small residential section of New Haven (Fig. 2). During the past decade, the infestation has spread at the rate of 3 miles per year and now occupies five of the eight Connecticut counties (Fig. 2).

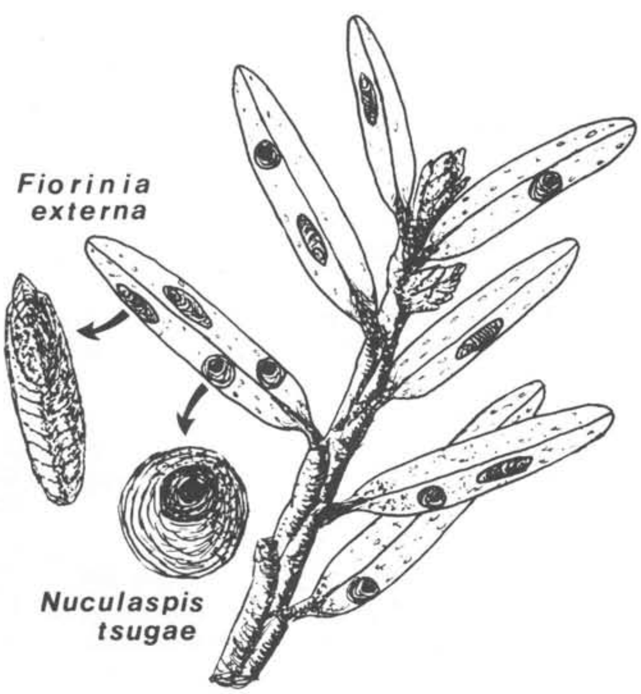

Fig. 1--Armored scale insects of hemlock.

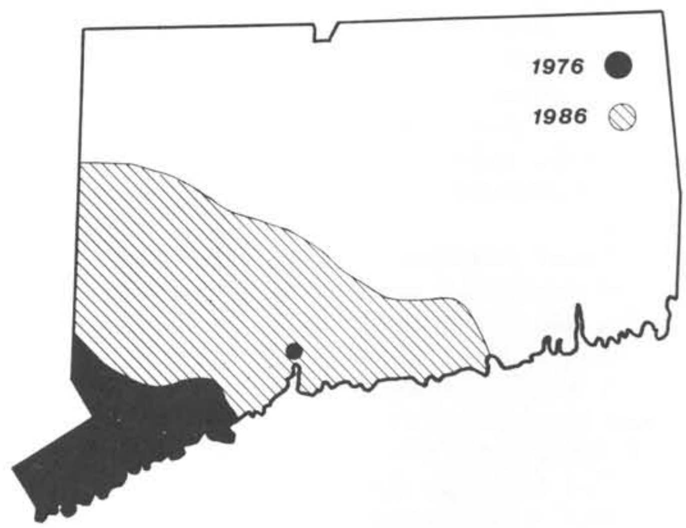

Fig. 2--Distribution of hemlock scales (Fiorinia externa and Nuculaspis tsugae) in Connecticut.

The principal host of both scales in the United States is Canada hemlock, Tsuga canadensis Carriere, but more than 40 other species of native and exotic conifers, including fir, pine and spruce, are also attacked (Appendix 1; McClure and Fergione 1977). Both scales feed on the needles of their hosts by removing cell fluids through piercing and sucking mouthparts. This causes foliage to discolor and drop prematurely and branches to die. Heavy infestations often kill forest and ornamental hemlocks within 10 years. Trees of every size and age and growing in a variety of different habitats have been attacked and injured by these scales. In 1984 I collected both scales throughout Japan on their native hemlocks, Tsuga diversifolia Masters and Tsuga sieboldii Carriere. However, unlike in Connecticut, scale densities in Japan were always very low and trees had no apparent injury (McClure 1986). I discovered that a natural enemy, Aspidiotiphagus citrinus Craw (Fig. 3), had a major role in controlling hemlock scales in their homeland. This same parasitoid also inhabits hemlock forests in Connecticut where it can have a significant impact on scale populations (McClure 1977a, 1981). Unfortunately, scales develop more slowly in Connecticut than in Japan, due to climatic differences, so that stages of the scale susceptible to attack by A. citrinus are not always present when parasitoids are searching for them (McClure 1978a). Consequently, scale populations in Connecticut remain uncontrolled and often attain injurious densities.

Numerous pesticides have controlled hemlock scales on ornamental trees. Among the more effective and widely used have been the foliar systemic insecticides acephate and dimethoate (McClure 1978b). Essential to the effectiveness of these insecticides, however, is that they be applied when scales are active young nymphs (also called crawlers), and that infested foliage be drenched with the pesticide.

Timing of application requires accurate determination of which scale is present and

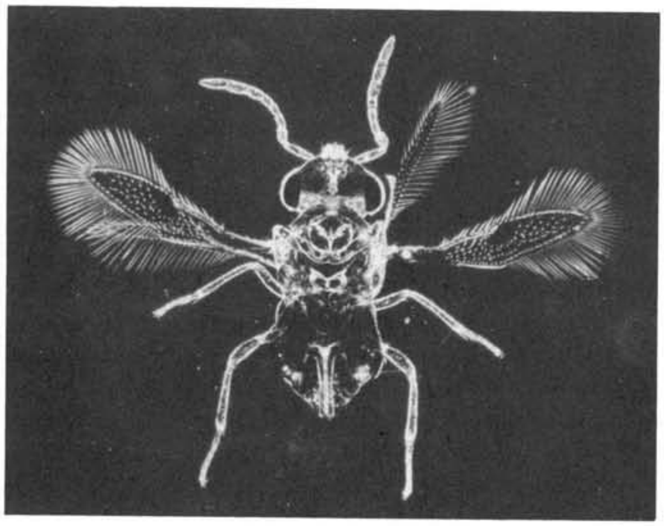

Fig. 3. Adult of the parasitoid Aspidiotiphagus citrinus, the principal natural enemy of hemlock scale.

knowledge of its seasonal development at the particular locality. In Connecticut, the best time to control F. externa is usually early to mid-June, while late June to early July is usually best for N. tsugae (McClure 1978a). However, I found that peak activity of crawlers of the same scale species could vary by as much as three weeks at two localities that were separated by only 8 km (McClure 1978a). To further compound the problem, depending upon the weather, F. externa sometimes produces a second generation in September, which may necessitate a second spray application. N. tsugae always produces a second generation with crawlers most active in mid-September (McClure 1978a). Consequently, predicting the best time to apply foliar systemic insecticides for hemlock scales often becomes a "hit-or-miss" proposition.

The application of pesticides in forests to control hemlock scales has been unsuccessful, and in most cases has actually worsened the problem. Tight forest canopies and the inaccessibility of infested trees make it virtually impossible to drench all foliage with insecticide. Spraying in the forest also kills natural enemies and allows the surviving scales to flourish in their absence (McClure 1977b). Applying dimethoate by soil injection can effectively control hemlock scales with minimal impact on natural enemies (McClure 1979), but laws currently prohibit such application because of the potential hazard to the environment.

Petroleum oil spray (also referred to as dormant oil or miscible oil), which was developed specifically to control scales and other overwintering insects on trees and shrubs, potentially offers an alternative means for controlling hemlock scales with less environmental impact. More than 30 times less toxic than either of the foliar systemic insecticides (Hayes 1982), petroleum oil, when applied as foliar spray in early spring prior to bud break, would also eliminate the guesswork involved with timing applications with peak activity of scale crawlers. Unfortunately, however, reports from arborists concerning the effectiveness of oil spray for controlling hemlock scales have been at best inconclusive and often discouraging. Amidst growing concern over the accumulation and persistence of toxic chemicals in the soil and ground water of

Connecticut (Waggoner 1986), I experimented during 1986 to determine whether the relatively nontoxic oil spray can control hemlock scales, and to assess its impact on the most important natural enemy, A. citrinus.

MATERIALS AND METHODS

One experiment was at this Station in New Haven. The plot, measuring 7m by 5m, consisted of 32 open-bottom concrete bins 0.9m square arranged in four rows of eight bins each oriented north to south. A space (1m by 7m) bisected the plot along its long dimension into two blocks of 16 bins each. Siebold hemlocks, T. sieboldii, which are now 13 years old were planted in 1981 into 12 bins in one of the two blocks, leaving the four middle bins vacant. Canada hemlocks of the same age were planted in 12 bins in the other block in the same manner. All trees were artificially infested with F. externa and N. tsugae in 1981. Both of these scales were abundant on all trees in 1986, but no parasites and predators were present. On April 3, 1986, prior to bud break, six Siebold and six Canada hemlocks were drenched with a 1 to 50 dilution of petroleum oil (Scalecide[TM]) using a Chapin[TM] 6-gallon insecticide sprayer. Six hemlocks of each species were not sprayed and served as controls. On June 17 five branches were sampled from each of five sprayed and unsprayed trees of both hemlock species. The number of living and dead individuals of each scale on 200 one-year-old needles (1985) of each branch was determined by microscopic examination. Differences in percent mortality of F. externa and N. tsugae and their densities on oil-sprayed and unsprayed hemlocks were tested for statistical significance by analysis of variance (ANOVA).

Another experiment was conducted in a heavily-infested mature forest of Canada hemlock located in Westport, Fairfield County, Connecticut to determine the effectiveness of foliar oil spray in a forest setting and its impact on natural enemies. The parasitoid, A. citrinus, was abundant at the time of this experiment. On April 25 when unparasitized scales and parasitoids developing within scale hosts were overwintering, a portion of each of five hemlocks was drenched with a 1 to 50 dilution of dormant oil using a Chapin[TM] 2-gallon pump sprayer. On June 13, five sprayed and five unsprayed branches were sampled from each tree, and the number of living and dead individuals of each scale on 200 one-year-old needles (1985) on each branch was determined by microscopic examination. In addition, 50g of foliage from each branch was placed in a parasitoid emergence cage, which consisted of a 1-liter cardboard mailing tube with a glass vial fitted at the side on the top. Adults of A. citrinus, upon maturation and emergence from their scale hosts, were attracted to light and so entered the vial where they could be collected easily. After two weeks, the number of adult parasitoids that emerged in each cage was counted. Differences in scale mortality and parasitoid emergence were tested for statistical significance using ANOVA.

RESULTS

A single application of dormant oil in April provided control of F. externa and N. tsugae on both hemlock species in the field plot (Table 1).

TABLE 1--EFFECTS OF OIL APPLICATION ON THE SURVIVORSHIP AND ABUNDANCE OF SCALES ON ORNAMENTAL CANADA AND SIEBOLD HEMLOCKS. NUMBERS ARE MEANS (± S.E.).

Tsuga species	Treatment	% mortality of scales F. externa	% mortality of scales N. tsugae	Scales per 200 needles
T. canadensis	Oil sprayed	99.8 ± 0.2	99.9 ± 0.2	0.2 ± 0.2
	Unsprayed	7.1 ± 1.6	9.8 ± 2.2	111.6 ± 4.8
T. sieboldii	Oil sprayed	99.8 ± 0.3	99.9 ± 0.1	0.1 ± 0.2
	Unsprayed	5.2 ± 0.9	9.3 ± 2.0	115.0 ± 7.7

TABLE 2--EFFECTS OF DORMANT OIL APPLICATION ON THE SURVIVORSHIP AND ABUNDANCE OF HEMLOCK SCALES AND THEIR PRINCIPAL PARASITOID ON FOREST CANADA HEMLOCKS. NUMBERS ARE MEANS (± S.E.).

Treatment	% mortality of scales		Scales per 200 needles	Parasitoids per 50g foliage
	F. externa	N. tsugae		
Oil sprayed	98.7 ± 1.2	97.9 ± 1.6	1.6 ± 0.4	13.0 ± 2.9
Unsprayed	6.8 ± 1.4	7.9 ± 1.3	157.6 ± 30.9	87.5 ± 9.1

More than 99% of both scales were dead on sprayed trees compared to less than 10% on unsprayed trees. Sprayed hemlocks were virtually free of living scales by June, whereas on controls scale densities exceeded 100 individuals per 200 needles (Table 1). All differences between sprayed and unsprayed trees were significant ($P<0.0005$). Similar results were obtained in the hemlock forest where a single application of oil in April killed more than 97% of both scales and reduced densities to less than two scales per 200 needles by June on sprayed branches (Table 2). Unfortunately, the oil application also significantly reduced parasitoid abundance; an average of 13 adults of A. citrinus emerged per 50g of foliage from sprayed trees compared to more than 87 adults per 50g of foliage from controls. All differences between sprayed and unsprayed hemlocks were significant ($P<0.0005$). Although the adverse effects of dormant oil on parasitoids are substantial, they are far less severe than those of foliar systemic insecticides, which kill nearly all natural enemies (McClure 1977b).

DISCUSSION

Controlling these introduced hemlock scales in the northeastern United States is a formidable task, especially in forests where pesticide application is difficult, if not impossible, and where the impact of natural enemies is inconsistent. Control of hemlock scales in the forest may await the discovery of a natural enemy whose seasonal development is more compatible with the scales than that of A. citrinus. Fortunately, pesticides provide a means for controlling these scales on ornamental hemlocks where foliage can be drenched. My experiments have shown that petroleum oil spray controls both hemlock scales with less guesswork, fewer applications, and less impact on beneficial insects than the much more toxic foliar systemic insecticides.

REFERENCES

Ferris, G.F. 1936. Contributions to our knowledge of the Coccoidea (Homoptera). Microentomol. 1:1-16.

Hayes, W.J., Jr. 1982. Pesticides studied in man. Williams and Wilkins, Baltimore, MD. 672p.

McClure, M.S. 1977a. Parasitism of the scale insect, Fiorinia externa (Homoptera: Diaspididae), by Aspidiotiphagus citrinus (Hymenoptera: Eulophidae) in a hemlock forest: Density dependence. Environ. Entomol. 6:551-5.

McClure, M.S. 1977b. Resurgence of the scale, Fiorinia externa (Homoptera: Diaspididae), on hemlock following insecticide application. Environ. Entom. 6:480-4.

McClure, M.S. and M.B. Fergione. 1977. Fiorinia externa and Tsugaspidiotus tsugae (Homoptera: Diaspididae): Distribution, abundance, and new hosts of two destructive scale insects of Eastern hemlock in Connecticut. Environ. Entomol. 6:807-11.

McClure, M.S. 1978a. Seasonal development of Fiorinia externa, Tsugaspidiotus tsugae (Homoptera: Diaspididae), and their parasite Aspidiotiphagus citrinus (Hymenoptera: Aphelinidae): Importance of parasite-host synchronism to the population dynamics of two scale pests of hemlock. Environ. Entomol. 7:863-70.

McClure, M.S. 1978b. Effectiveness of foliar systemic insecticides for controlling scales on forest and ornamental hemlock. Insecticide and Acaricide Tests 3:146-7.

McClure, M.S. 1979. Effectiveness of a soil-injected systemic insecticide for controlling sucking insects on red pine. Insecticide and Acaricide Tests 4:176-7.

McClure, M.S. 1981. Effects of voltinism, interspecific competition and parasitism on the population dynamics of the hemlock scales, Fiorinia externa and Tsugaspidiotus tsugae (Homoptera: Diaspididae) Ecol. Entomol. 6:47-54.

McClure, M.S. 1986. Population dynamics of Japanese hemlock scales: A comparison of endemic and exotic communities. Ecology 67:1411-21.

Waggoner, P.E. 1986. Where is the next strategic place to decrease pesticide use? Conn. Agric. Expt. Sta. Bull. 831. 6 pp.

Weiss, H.B. 1914. Notes on three imported insects occurring in New Jersey. J. Econ. Entomol. 7:250-1.

APPENDIX 1--HOSTS OF HEMLOCK SCALES.

Species*	Common name
Abies	FIR
alba Mill.	Silver
amabilis Forbes	Cascade
balsamae Mill.	Balsam
cephalonica Loud.	Greek
concolor Lindl. and Gord.	White
fargesii Franchet	Farges
holophylla Maxim.	Manchurian
homolepis Sieb. and Zucc.	Nikko
veitchii Lindl.	Veitch
Cedrus	CEDAR
atlantica Manetti (3)	Atlas
deodara Loud. (2)	Deodar
libani Lawson (2)	Lebanon
Picea	SPRUCE
abies Karst. (20)	Norway
asperata Masters (1)	Dragon
glauca Voss	White
glehni Masters	Saghalin
heterolepis Rhed. and Wil.	Red twig dragon
jezoensis Carr. (1)	Yezo
koyamai Shirasawa	Koyama
mariana Britt.	Black
omorika Pancic (2)	Serbian
orientalis Carr. (2)	Oriental
pungens Engelm. (10)	Colorado
smithiana Boiss.	Himalayan
Pinus	PINE
aristata Engelm.	Bristle cone
bungeana Zucc.	Lacebark
cembra L.	Swiss stone
densiflora Sieb. and Zucc. (3)	Japanese red
flexilis James (2)	Limber
mugo Turra (2)	Mugo
parviflora Sieb. and Zucc. (6)	Japanese white
pumila Regel	Dwarf stone
resinosa Ait.	Red
rigida Mill. (1)	Pitch
strobus L. (5)	White
sylvestris L. (7)	Scots
Pseudotsuga	
menziesii Britt. (4)	Douglas fir
Taxus	YEW
baccata L. (1)	European
cuspidata Sieb. and Zucc. (1)	Japanese
Tsuga	HEMLOCK
canadensis Carr. (25)	Canada
caroliniana Engelm.	Carolina
diversifolia Masters	Japanese
heterophylla Sarg.	Western
sieboldii Carr.	Siebold

* Numbers in parentheses are the numbers of additional varieties and/or forms of the conifer species on which mature scales occurred.

The Connecticut Agricultural Experiment Station, founded in 1875, is the first experiment station in America. It is chartered by the General Assembly to make scientific inquiries and experiments regarding plants and their pests, insects, soil and water, and to perform analyses for State agencies. The laboratories of the Station are in New Haven and Windsor; its Lockwood Farm is in Hamden. Single copies of bulletins are available free upon request to Publications; Box 1106; New Haven, Connecticut 06504. ISSN 0097-0905