CONTROLLING CLEARWING MOTHS WITH ENTOMOPATHOGENIC NEMATODES: THE DOGWOOD BORER CASE STUDY

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Currently 151 species of clearwing moths (Lepidoptera: Sesiidae) in 19 genera are recognized for North America north of Mexico (3). Some 22 species in 8 genera, including the dogwood borer (*Synanthedon scitula*), have attained sufficient economic importance to be accorded official common names by the Entomological Society of America (13).

Most of these day flying moths mimic wasps or bees in appearance and flight behavior. Adults may be recognized by the long narrow front wings, shorter and wider hind wings, and the absence of scales on most of the hind wings, or front and hind wings. Many species such as the dogwood borer, have distinctive color bands on the abdomen (4).

The larval stage of clearwing moths bores under bark in phloem and cambium tissues and is responsible for the characteristic damage to bark and underlying tissues observed on infested host trees and shrubs (4). Trees and shrubs infested each year with sufficiently large numbers of these borers eventually exhibit symptoms produced by girdling; i.e., dieback leading to plant death. These caterpillars are completely white except for dark brown heads, and a lighter brown pronotal shield just behind the head. The above features, plus the presence of paired clusters of ventral hooks (crochets) on most abdominal segments, easily distinguishes these pests from others such as flat and round headed beetle borers.

The host range for clearwing moths extends from trees and shrubs, to vines, vegetables and berries. Each species has its preferred host(s) and feeding site, i.e. roots, basal stalks, stems, trunks, or branches of annuals and herbaceous or woody perennials.

The dogwood borer occurs from southeastern Canada through the eastern half of the United States. Interestingly, oak is a reported preferred host, and not only the bark, but most gouty oak galls on a tree may be infested with developing dogwood borer larvae (1). The dogwood borer has the broadest host range of all clearwing moth borers. It attacks flowering cherry, chestnut, apple, mountain ash, hickory, pecan, willow, birch, bayberry, oak, hazel, myrtle, loquat, and others (4). Although not a pest of native dogwoods in forests, the dogwood borer is a common and sometimes serious pest of flowering dogwood, *Cornus florida*, in landscape settings. A recent survey in Tennessee of dogwood borer infestation levels showed ca. 60% in the urban habitat, ca. 7% in nursery blocks, and ca. 1% in forests (13). The level of infestation in landscapes has been shown to increase significantly with the amount of sunlight and wounding dogwoods receive (12). Even tight tree wrap may increase infestation by this pest (10).

The dogwood borer has one of the longest reproductive activity periods found among clearwing moth species in the U.S. One adult emergence generation a year has been reported. Flight activity, which roughly corresponds to egg laying activity, occurs from May through September in Maryland (6) and Kentucky (8) as determined by pheromone trapping of male moths.

The standard control strategy for clearwing moth borers involves using a pheromone trap to detect the first male appearance, and then spraying bark with a residual insecticide 10-14 days later, just before egg hatch (9). Newly hatched larvae that contact the insecticidal barrier as they chew through bark to reach cambium will die. A single, properly timed and thorough spring application

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with lindane, chlorpyrifos or endosulfan, provides excellent control of the dogwood borer (12).

Analysis of a recent survey received from 663 city tree managers throughout the U.S. yielded a list of the 10 most serious tree pests in the nation, and the 10 insecticides most often used to control them (15). The category, borer (presumably moth and beetle borers), ranked number four on a weighted scale. The residual insecticides lindane and chlorpyrifos (Dursban), commonly used to control borers, were ranked 6 and 7 among the top 10 pesticides on a similarly weighted scale. Clearly, an efficacious pesticide alternative for an important borer group, such as clearwing moth borers, could significantly reduce the pesticide volume applied to urban forests. We believe recent research indicates the entomopathogenic nematode *Steinernema carpocapsae* may be a valuable pesticide alternative for control of moth borers.

Several workers have summarized information concerning the use of steinernematid nematodes as biological control agents (2,5,11). Nematodes have limitations to their use for insect control. Sunlight, low humidity, and temperature extremes are detrimental to *S. carpocapsae*, and similar entomopathogenic nematodes. Therefore, it is easy to see why dark, moist borer galleries in plants may be ideal hunting sites for these nematodes. So far, research has indicated *S. carpocapsae* gives good control of moth boring larvae such as carpenterworms (7) and clearwing moths (6).

California researchers achieved 77-84% and 86-93% control of an alder clearwing moth (*Synanthedon culiciformis*) using *S. carpocapsae* as bark sprays and gallery treatments respectively. In the same study, spring bark sprays with *S. carpocapsae* gave 60% control of another clearwing moth (*Synanthedon resplendens*) in sycamore, while fall sprays failed to provide control. Dry bark conditions in fall were believed responsible for this failure. Applications of *S. carpocapsae* to birch provided 90% control of the western poplar clearwing moth (*Paranthene robiniae*) (6).

Materials and Methods

In 1987 a golf course in central Maryland was selected as a test site for the use of nematodes to control the dogwood borer because the manager believed he had serious borer problems and promised cooperation. The trees proved to be suffering mainly from mower damage, although frass was detected on the margins of some wounds. Because such wounds may have multiple infestations, we decided that a sampling technique was needed other than frass produced by larvae to insure accurate counts. We decided to use adult emergence counts. A cylinder was constructed from plastic screening and placed around the base of each tree. Duct tape was used to clamp the cylinder below and above the wound, and the vertical opening was taped and stapled shut. Weekly monitoring from May through July revealed few adult dogwood borers. One reason was the activity of small ants that dismembered and carried off trapped moths despite the screen mesh.

In 1989 this sampling technique was tested again, but on infested branches of large dogwood trees in Gettysburg National Historic Park. Again, few adult moths were found in the screen traps after weekly monitoring May through July. The reasons for this were not obvious. It became apparent that only destructive sampling of trees would allow accurate estimates of the abundance of borers and the efficacy of control tactics.

In 1990 Anthony's Nursery, Barnesville, MD, donated 20 infested dogwood trees to support this work. The selected trees were assumed to have moderate dogwood borer infestation levels because all were wounded by mowers, and most exhibited fresh frass around wounds. A Birchmeyer backpack pump sprayer was used to apply nematodes as a bark spray to run off. The rate of 500 nematodes/square inch, or ca. 151,000 nematodes per 4 feet of tree stem.

Commercially available nematodes (BioSafe 100) supplied by Biosys of Palo Alto, CA were used in this study. Nematodes mixed in 500 milliliters of water were applied only to the main stem up to about 4 feet above ground level. There were 10 trees treated with nematodes and 10 control trees which were sprayed with water. The 20 trees were of comparable sizes and averaged 2.75 inches in diameter at ground level. Application was made between 9:00 a.m. and 12:00 p.m. on August 28, 1990. The sky was cloudless and the average temperature and relative humidity were 85 degrees

F. and 55%, respectively. The spray water pH was 7.2. Much nematode activity in the residual spray solution was observed under magnification 3 hours after treatment.

Treatments were evaluated as follows. On October 23, 1990 we returned to the site and sawed down the 20 trees at ground level. Then stems were cut at the first major branch. The stem pieces, averaging 28.6 inches in length, were returned to the laboratory where careful bark removal revealed the dogwood borer larvae.

Results

At the completion of the study many of the trees were found to have no dogwood borer larvae. However, trees that were treated with nematodes were much less likely to support borers than untreated trees. Half of the untreated trees (50%) contained 2 or 3 living borers in the portion of the bole inspected while only 20% of the trees treated with nematodes had borers. Overall, the trees treated with nematodes supported significantly fewer borers than those sprayed with water (Kruskal-Wallis ANOVA, $p < 0.04$). The average number of borer larvae found in untreated trees was 1.30 and the average found in trees treated with nematodes was 0.20 (Table 1) This represents a reduction in borer abundance of about 84.6% associated with the application of nematodes.

Discussion

The first step in a landscape IPM program where flowering dogwoods are to be protected is prevention of a possible dogwood borer problem. To do this, select dogwoods believed to be resistant to attack by clearwing borers such as Korean dogwood, *Cornus kousa* (4). Dogwoods that are susceptible should be protected from bark wounding by mowers, weed whackers, or trimmers. Mulch barriers should be maintained around trees to prevent grass from growing near trunks. This will reduce the need to operate equipment near the boles of trees. Other cultural practices that promote tree vigor should be utilized.

Step two should be periodic monitoring of the bark through the activity period of the borer larva (basically the tree growing period) for signs of fresh frass around bark cracks and other wounds. Unfortunately, from our experience over several years, commercially available dogwood borer pheromone traps can not be relied on in Maryland for monitoring periods of adult moth flight activity.

If frass signs are detected, nematodes can be sprayed on bark concentrating on the areas showing signs of infestation. In light infestations, we suggest a fall application before heavy frosts appear. All egg laying for the current season should be over and this should kill the larvae that would overwinter to produce adults the following summer. In heavy infestations, where reproductive activity is high throughout the summer, as indicated by new frass signs on bark, a midsummer nematode spray may be warranted.

Depending on the number and size of the trees involved, application can be made to infested bark areas with a squirt bottle, hand held or backpack pump sprayer, or truck mounted hydraulic sprayer. Nematodes should not be applied with mist blowers. Remember that the mixed spray must be kept out of the sun and used within three hours. Evening may be the best time to spray. Temperatures should be between 55-85° F. Once the spray is mixed, place a few drops in a glass and check it with a hand lens to be sure the nematodes are moving, i.e. alive and hopefully infective. Do not waste time and money spraying dead nematodes.

Since the BioSafe 100 label does not yet contain a recommendation for clearwing moth borer control, the rate used will be up to the applicator. We used 500 nematodes per square inch of bark applied from ground level to a height of about 4 feet. Obvious bark cracks on large branches could be spot treated.

Table 1. Effect of *Steinernema carpocapsae* on the abundance of dogwood borer larvae in the boles of *Cornus florida*.

Treatment	Rate	No. living borers per bole
	(nematodes/sq. in. bark)	(mean ± s.e.)
S. carpocapsae	500	0.20 ± 0.20
Water	0	1.30 ± 0.45

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