Biological control of clear-wing moths in alder and sycamore

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Many plant-boring insects are major pests of agricultural and horticultural crops. One group of plant borers is the sesiids belonging to the order Lepidoptera. The larvae bore into plant tissues and feed in galleries made in limbs, trunks, bark, or roots of trees, shrubs, herbs, and vines. Some of the most important sesiids attack trees, resulting in wood defects or structural weakening that may lead to tree mortality. A few sesiids tunnel in the bark; this tunneling does not kill the tree but gives it an unsightly appearance.

These borers can be controlled with chemical pesticides, by mechanical means, or with biological control agents. For chemical control, insecticides may be applied as a trunk spray or gallery injection. Mechanical control entails inserting a flexible wire into the gallery to puncture the larva and digging out the larva with a knife, or removing and burning weakened trees and infested branches. Biological control can be attained with the use of insect-parasitic, or entomogenous, nematodes such as *Steinernema feltiae* (=*Neoaplectana carpocapsae*) and *S. bibionis*, which are effective against borers in galleries in the heartwood.

Insect parasitic nematode

The nematode infects the host by entering through its mouth or anus into the gut or through its breathing holes (spiracles) and then penetrating directly into the body cavity. Once inside the body cavity, the nematode releases the symbiotic bacterium *Xenorhabdus nematophilus* which is in the nematode's gut. Bacterial infection proceeds quickly in the insect host, killing it within 48 hours. The nematodes mate and progeny are produced. As the resources within the dead insect are depleted, infective nematodes are produced, which leave the host and seek other insects.

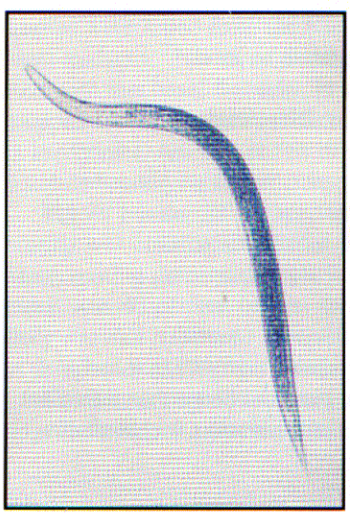
These nematodes infect only insects or their close relatives. Extensive safety tests have shown that the nematode-bacterial complex is not harmful to plants and vertebrates. These nematodes have been exempt from registration by the U.S. Environmental Protection Agency.

We compared the effectiveness of the nematode *S. feltiae* against *Synanthedon culiciformis*, a borer of heartwood in alders, and the nematodes *S. feltiae* and *S. bibionis* against *Synanthedon resplendens,* a bark borer of sycamores. Alder trees in Davis and sycamore trees in Riverside were treated in 1983 or 1984.

In September 1983, infested alder trees were sprayed with *S. feltiae*, with a Hudson sprayer at the rate of 6.5 or 11.5 million nematodes per tree, or with a 1-pint squirt bottle at the rate of 18,000 or 36,000 nematodes per gallery. Infested sycamore trees were treated by Hudson sprayer at the rate of 2.3 or 5.6 million *S. feltiae* per tree or 2.7 million *S. bibionis* per tree in October 1983 and at the rate of 11.3 million *S. feltiae* per tree or 8.6 million *S. bibionis* per tree in April 1984. The effectiveness of the nematodes was evaluated by observing frass production before and after treatment of the alder and sycamore trees, or by removing larvae from galleries in sycamore trees after treatment. Treatments were evaluated 7 to 14 days after nematode application.

Spraying alder trees with *S. feltiae* using the Hudson sprayer provided 77 to 84 percent borer control. Spot treatment of the galleries with the squirt bottle provided 86 to 93 percent borer control. In contrast, spraying sycamore trees with *S. feltiae* or *S. bibionis* in October 1983 did not control borers. Spraying trees in April 1984 resulted in 61 percent borer control with *S. feltiae* and 13 percent with *S. bibionis*. We concluded from this study that *Synanthedon culiciformis* in alders can be controlled with the nematode *Steinernema feltiae*; *Synanthedon resplendens* in sycamores is more difficult to control with *S. feltiae*, and timing is an important consideration when treating for this insect.

The positive results with the borers in alders can be attributed primarily to (1) the moist galleries allowing for nematode survival and finding a host, and (2) the large size of the gallery openings. *Synanthedon culiciformis* occurs in the moist heartwood and makes a large gallery opening (an average of 0.28 inch), allowing the nematodes to enter or be sprayed directly into the gallery. On the other hand, the poor results with borers in sycamores can be attributed primarily to (1) the drier galleries in the bark, and (2) the smaller size of the gallery openings (an average of 0.05 inch in October and 0.17 inch in April). The borers in sycamores are at maximum size in the spring, and the gallery openings reflect this. The nematodes, which are 0.02 to 0.04 inch in length, can enter or be sprayed into the larger galleries in the spring, but not into the smaller galleries in the fall. Better borer control



The entomogenous nematodes *Steinernema feltiae* attack larvae of clear-wing moths in galleries they have bored in alder trees, infecting them with a bacterium that kills the borers. The nematode-bacterium complex does not harm plants or vertebrates.

is thus obtained in the spring than in the fall. In our experiments, we found that *S. feltiae* was more effective than *S. bibionis* against the sycamore borer.

Based on our results, the city of Davis is evaluating the use of *S. feltiae* to control *Synanthedon culiciformis* in alders. Initial applications were made in March 1986. In addition, *S. feltiae* has been applied against another sesiid attacking newly planted ash trees in an industrial park in Sacramento. These examples demonstrate that there is considerable interest in the use of entomogenous nematodes to control these plant-boring pests.

Cost is high

The current cost of nematodes at $2.00 per million will undoubtedly prevent their widespread use and will limit their application to high-value trees by gallery treatment. At the rate of 20,000 nematodes per gallery, 50 galleries can be treated with one million nematodes. Assuming a high infestation of 15 active galleries per tree, three and one-third trees can be treated for $2.00.

Although the current costs of nematodes are high, research indicates that production costs can be reduced to less than 1 cent per million. When this kind of production can be met by commercial companies, the cost of the nematodes will also decline and may be comparable with chemical pesticides.

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