BIOLOGICAL CONTROL OF *SIREX NOCTILIO* IN NORTH AMERICA BY *BEDDINGIA SIRICIDICOLA*: 2008 UPDATE

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ABSTRACT

The European woodwasp, *Sirex noctilio* F., was discovered in Oswego County, New York, in the autumn of 2004. The woodwasp is apparently not under effective natural control, is already distributed over a wide area in North America, and because it is a killer of relatively healthy trees, poses a serious threat to pine forests and plantations in the United States and Canada if not controlled. Its most effective natural enemy is a parasitic nematode, *Beddingia (Deladenus) siricidicola* (Bedding). This nematode has been used successfully as a biological control agent in management programs throughout the southern hemisphere where *Sirex* woodwasp has invaded. The nematode's unique life history facilitates its use as a management tool. Dependent upon physical conditions, it can develop into either of two forms. The mycophagous form feeds on the *Sirex* symbiotic fungus, *Amylostereum areolatum* (Fries) Boidin, as it builds populations inside a woodwasp-attacked tree. The parasitic form attacks *S. noctilio* larvae and ultimately sterilizes the emerging woodwasp females. We provide an update on our recent activities to utilize the nematode in a developing biological control program, including the identification of a native strain of *B. siricidicola*, results of controlled nematode releases during the past three seasons, and consideration of potential impacts of the biological control program on nontarget siricid species.

Our biological control program uses the highly pathogenic "Kamona strain" of *B. siricidicola* obtained from Ecogrow, the licensed nematode producer in Australia. However, as early as 2006, we found a nematode already infecting woodwasp larvae and adults in our study plots. This "native strain" was similar in appearance to the Kamona strain, and we speculated that it entered North America along with *S. noctilio*. As revealed by numerous trapping and rearing studies from 2006 to 2008, it is already present throughout an 80-km radius of Syracuse, NY. Our colleagues in the Canadian Forest Service (CFS) reported a similar strain in 2008 and identified it as *B. siricidicola* using DNA analysis. With the help of a CFS scientist, we identified our native strain as a match to *B. siricidicola* and to the Canadian strain, but not to the Kamona strain. Clearly, the presence of a strain of the same species that we are releasing poses a challenge to our evaluation of the effects of the Kamona strain as a biological control agent and necessitates the development of powerful molecular tools for discriminating nematode strains.

We have conducted three controlled releases in autumn during the 2006/7, 2007/8, and 2008/9 seasons. The goals of the studies were to test the Australian inoculation method, to assess the establishment of Australian nematodes in American pine species, and to evaluate overwintering survival of the exotic nematodes under North American conditions. The releases were "controlled" so that no nematodes could escape into the environment. Trees were inoculated in the fall, and billet samples were taken in winter for rearing of *Sirex* adults in the lab. All remaining tree materials were destroyed before insect emergence in the spring. Controlled releases were necessary for several reasons. First, the environmental assessment from APHIS Environmental Services that was needed for a full release was not finished by the first release date in November 2006. Second, we bought bulk nematodes from Ecogrow in 2006 for direct field release and did not want to risk releasing an aggressive strain of *A. areolatum* that was present with the nematode. Third, we were sensitive to concerns in the environmental community as to possible (albeit unlikely) impacts of the nematode on nontarget native siricids.

The controlled release in 2006 was carried out on 93 red and Scots pines, which were inoculated with Ecogrow nematodes in early November. It seems very likely

that the nematodes in this release did not establish in the trees because of cold temperatures late in the season. The subsequent two releases in 2007 and 2008 were made on red and Scots pines (95 and 85, respectively) with nematodes grown in the Otis Lab on a New York isolate of the fungus. Because they were made early, in early October and late September, respectively, it seems highly likely that the nematodes survived and established, although samples from the 2007 release are still being dissected and those from the 2008 release are still in the field.

Billet samples from the first release produced 2,224 *Sirex* adults, 810 *Ibalia leucospoides* (Hochenwarth) adults, and 56 *Rhyssa lineolata* L. adults. The overall rate of infection by the nematode was just 5.0 percent, whereas the overall rates of parasitism were 26.2 percent by *I. leucospoides* and 1.8 percent by *R. lineolata*. Releases were made in five sites in Onondaga, Oswego, and Madison Counties, NY, four of which contained Scots pines and one of which contained red pine. Rates of parasitism by *I. leucospoides* ranged from 23.7 percent to 32.9 percent across sites, whereas those by *R. lineolata* ranged from 0.0 percent to 12.0 percent. Rates of infection by nematodes ranged from 4.4 percent to 12.6 percent for the Scots pine sites, whereas the infection rate at the single red pine site was just 0.8 percent. This suggests real differences between the two pine species as hosts for *B. siricidicola.*

Controlled releases were carried out in 2007 in Oswego and Onondaga Counties, NY, in three sites containing Scots pine and one site containing red pine. To date, just 22 percent of the emerging *Sirex* adults have been dissected, but the preliminary results compared with those of 2006 suggest that nematodes established in 2007. Nematode infection rates ranged from 13.0 to 51.0 percent in the Scots pines, and the infection rate was 8.2 percent in the red pine site. Another small release was made in mid-October of 2007 in Macomb County, Michigan, near the first trap catch of *S. noctilio* in that state. In all, five naturally struck Scots pine trees were sampled, and they produced 15 *Sirex* adults, none of which were infected by nematodes.

Possible effects of the nematode biological control program on nontarget native borer species, especially siricids, continue to concern the environmental community. Eastern North America has three native siricid species that use *Pinus* species as hosts: *Sirex edwardsii* Brullé, *S. nigricornis* F., and *Urocerus cressoni* Norton. The fungal symbiont of these species is the key to understanding their susceptibility to *B. siricidicola.* Two species of *Amylostereum* are commonly associated with siricids worldwide. *Amylostereum chailletii* (Pers. ex Fries) is native to North America, whereas *A. areolatum* is native to Europe. The nematode lives only on *A. areolatum.* Thus, siricids living on *A. chailletii* have a refuge from nematode parasitism. The three pine-feeding native siricids are likely to use *A. chailletii* because of their North American origin and not to be exposed to the nematode. Other than these, the primary species of nontarget concern among the siricids of eastern North America is *Xeris spectrum* (L.). It does not have a fungal symbiont and may feed on either *A. areolatum* or *A. chailletii*, thus rendering it susceptible to the nematode.

We suggest a strategy for evaluating the susceptibility of native siricids more rigorously. First, we should concentrate our efforts initially on the pine-feeding species, as they are closest taxonomically and in microhabitat to *S. noctilio*. Second, we should document the fungal symbionts of those species through field collections over a wide area. Third, we should verify experimentally that the Kamona strain does not develop and reproduce on *A. chailletii*. Although published literature suggests that it does not, this experimental work will be replicated at the Otis Lab. Fourth, if a siricid species is associated only with *A. chailletii* and *B. siricidicola* cannot live on *A. chailletii*, then we infer that the species is unlikely to be susceptible to the nematode. Finally, it is important to survey the native siricids widely for infections by the "native" nematode to investigate their more general susceptibility to nematode infection. Trapping studies in our lab during 2007 and 2008, despite capturing large numbers of infected *S. noctilio*, failed for the most part to find nematode infections among the native *Sirex* and *Urocerus* species that were trapped. The exceptions were two (of 13) specimens of *U. cressoni* in the 2008 collection that were infected by nematodes, whose identity is currently unknown. In addition to these studies, dissections of over 900 insects emerging in the 2007 controlled release study found no parasitism by *B. siricidicola*.