

ADAPTING NEMATODE-BASED BIOLOGICAL CONTROL SYSTEMS TO NORTH AMERICAN POPULATIONS OF *SIREX NOCTILIO*

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ABSTRACT

The European woodwasp, *Sirex noctilio*, was found in Oswego County, NY, in 2004. During the past 6 years, surveys have revealed that it is distributed over a wide area of eastern North America. Because *S. noctilio* kills relatively healthy trees, it poses a serious threat to pine forests and plantations in the United States and Canada if it is not controlled. The parasitic nematode, *Beddingia (Deladenus) siricidicola*, is its most effective natural enemy. This nematode has been used as an agent in *Sirex* biological control programs throughout the Southern Hemisphere. Its use as a management tool is facilitated by its unique life history. The nematode can develop into either of two forms dependent upon physical conditions in a tree. The mycetophagous form feeds on the *Sirex* symbiotic fungus, *Amylostereum areolatum*, as it builds populations inside a tree. The parasitic form attacks *S. noctilio* larvae and ultimately sterilizes emerging woodwasp females. The following provides an update on activities in the past year to use the nematode in the USDA biological control program for *S. noctilio*.

The developing biological control program in USDA uses a highly infective strain of *B. siricidicola* from Australia called the Kamona strain. However, a North American nematode was discovered attacking *S. noctilio* in 2006 in New York and Ontario. The species was examined morphologically and identified as a strain of *B. siricidicola*. Molecular analysis has confirmed that it is *B. siricidicola*. The nematode is presumed to have entered North America with an invasion of *S. noctilio*, and it is well established in central New York State. The presence of a pre-existing strain of *B. siricidicola* complicates the development of a nematode biological control program because the North American and Kamona strains are

distinguishable only by molecular techniques. Thus, expensive and time-consuming analysis will be needed to discriminate between the two strains and evaluate the effectiveness of the Kamona strain in field studies. Another potential problem is that the two strains are likely to hybridize in the field. Hybrids will not be recognizable by the molecular techniques, and hybridization may dilute the high infectivity rate of the Kamona strain.

A useful characteristic of the Kamona strain in Australia is that juvenile nematodes enter the eggs of the *Sirex* female and sterilize them. However, other nematode strains do not sterilize eggs. Juveniles remain in the body cavity or along the egg sheaths but do not enter the egg. This phenomenon of “nonsterilization” has been observed in the North American strain in both the United States and Canada. It is not a desirable trait for a biological control program because the *Sirex* egg is not killed and the transmission of a few nematodes stuck to the outer surface of an egg does not efficiently disperse juveniles into new trees. It is currently not known whether the Kamona strain will also be nonsterilizing with the *Sirex* strain in North America.

Because of lingering concerns about possible effects of the Kamona strain on non-target siricid species, nematode releases over the past four seasons have been “controlled”: infested pine trees are inoculated with nematodes in the fall, sample billets are removed for rearing in late winter, and the remains of the trees are chipped before insect emergence in the spring. The general objectives of the four releases have been to test the inoculation method developed in Australia, assess the establishment of nematodes in American pine species, and evaluate overwintering survival of the Australian nematodes under winter conditions in North

America. In addition, the 2008 release was designed to investigate the nonsterilization problem, whereas the 2009 release was set up to compare three system components, including the infectivity of the Kamona and North American nematode strains in Scots pine, the Kamona strain infection rates in red and white pines, and the infection rates of the Kamona strain when grown on different fungus strains.

The 20 species and subspecies of Siricinae in North America have the greatest potential for impact by the biological control program and make up three genera: *Sirex*, *Urocerus*, and *Xeris*. All species attack conifers, and all *Sirex* species, as well as four *Urocerus* species, attack pines. The primary factor affecting exposure of a siricid species to *B. siricidicola* is its fungal symbiont. The two most common symbionts of siricids worldwide are *A. areolatum*, which apparently originated in Eurasia, and *A. chailletii*, which apparently originated in North America. *B. siricidicola* feeds only on *A. areolatum*. Thus, siricid species that feed on *A. chailletii*, including most of those in North America, effectively have a refuge from *B. siricidicola*.

Although the fungal associate of a siricid species appears to be the key to its susceptibility to *B. siricidicola*, the faithfulness of the association

between a woodwasp and a fungus is still a matter of debate. Recent work by Nielsen et al. (also reported by Hajek in this volume) provides some information. Contrary to expectations, they found that the North American species, *S. edwardsii*, emerged from the same tree as *S. noctilio*, carrying the same strain of *A. areolatum* as that species. Moreover, they reported that another North American species, *S. nigricornis*, emerged from the same part of the same tree but carrying *A. chailletii*. They also reported that the native species *S. nitidus* emerged from a spruce tree in Maine carrying *A. areolatum* and noted that this find was outside the currently known range of *S. noctilio*. The implications of this work are that the associations of North American siricids and their fungal symbionts are less clearcut than they appeared previously. Only a few other North American siricid species potentially may feed on wood colonized by *A. areolatum*. In particular, *Xeris* species are not associated with a fungus symbiont, but instead, oviposit in trees already attacked by another siricid species and inoculated with its fungus. In summary, according to the best available information, two native *Sirex* species and three *Xeris* subspecies that are associated with *A. areolatum* potentially may be exposed to *B. siricidicola* when it is released as a biological control agent.