United States Department of Agriculture
Animal and Plant Health Inspection Service
Center for Plant Health Science and Technology

Amylostereum areolatum (Fr.) Boidin
Sirex-Fungus

Pest Fact Sheet

Figure 1. Pine sapwood stained by *Amylostereum areolatum* growth (photo credit Paula Klasmer).

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INTRODUCTION

Sirex noctilio F., the Sirex woodwasp, and its symbiotic wood destroying fungus, *Amylostereum areolatum*, are native to Eurasia and North Africa (CPC, 2005). During the fall of 2004, *Sirex noctilio* was trapped in New York State (Hoebeke *et al*. 2005). *Sirex noctilio* has been found in wide ranging areas of the world and across many hardiness zones, suggesting that *S. noctilio* would be able to establish where its host (pines) occur (USDA, 2007). Pines are found throughout the United States, with the highest concentrations in the South, followed the West, Northeast and North Central States, respectively. This insect-disease complex is a possible threat to pine trees in the conterminous United States, especially Monterey pine (*Pinus radiata*) and loblolly pine (*P. taeda*) (USDA, 2007). Plantations of both of these species growing in foreign countries have experienced extensive damage from the *S. noctilio*/*A. areolatum* pest complex. The insect causes damage principally by the injection of a phytotoxic mucus and inoculum of the wood decay fungi *A. areolatum* into living pine trees at oviposition. The fungus is carried internally in mycangia of adult female woodwasps which vector the fungus to its tree hosts. The fungus and the mucus weaken and kill the tree. Detection of *S. noctilio* led to the initiation of the Sirex Biological Control Program, which focuses on establishing the nematode *Beddingia* (= *Deladenus*) *siricidicola*,the primary biological control agent for *S. noctilio*. *B. siricidicola* has two distinct forms: a feeding and parasitic form. In its fungus-feeding form, *B. siricidicola* feeds on *A. areolatum* within infected pine trees. In its parasitic form, the nematode lives within the woodwasp. *Beddingia siricidicola* parasitizes four species of *Sirex* as well as two related Siricid species (Bedding, 2005).*Beddingia siricidicola* can be mass reared on cultures of *A. areolatum* for subsequent use as an *S. noctilio* biological control agent.

This fact sheet discusses the fungus, *Amylostereum areolatum*, and its relationship with the *Sirex noctilio* wasp and the nematode *Beddingia siricidicola.*

IDENTITY
Name: *Amylostereum areolatum* (Farr *et al*. 2006)
Common Disease Name: Sirex fungus
Taxonomy: Phylum: Basidiomycetes; Class: Hymenomycetes; Order: Russulales; Family: Stereaceae

HOST RANGE
The reported hosts of *Amylostereum areolatum* are as follows:

Abies alba (silver fir), *Abies* sp.(firs), *Cryptomeria japonica* (Japanese cedar), *Larix decidua* (European larch), *Larix kaempferi* (Japanese larch), *Picea abies* (Norway spruce), *Picea neoveitchii*, *Picea sitchensis* (Sitka spruce), *Picea* sp. (spruce), *Pinus contorta* (lodgepole pine), *Pinus echinata* (shortleaf pine), *Pinus elliottii* (slash pine), *Pinus muricata* (bishop pine), *Pinus nigra s*ubsp. *laricio* (Corsican pine), *Pinus nigra* subsp. *nigra* (European black pine), *Pinus palustris* (longleaf pine), *Pinus patula* (Mexican weeping pine), *Pinus pinaster* (maritime pine), *Pinus ponderosa* (ponderosa pine), *Pinus radiata* (Monterey pine), *Pinus strobus* (eastern white pine), *Pinus sylvestris* (Scots pine), *Pinus taeda* (loblolly pine), *Pseudotsuga menziesii* (Douglas-fir)

Geographic Distribution

Figure 2 shows the potential global geographic distribution of *A. areolatum*, which is based on the distribution of *S. noctilio*. *Sirex noctilio* occurs in nearly all European countries and generally is considered a minor pest. The woodwasp has been reported from Austria, Belgium, Cyprus, Czechoslovakia (former), Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Norway, Poland, Portugal, Azores, Romania, Russian Federation (localized), Serbia, Spain (Canary Islands), and the United Kingdom (CPC, 2006). In Asia and Africa, *S. noctilio* occurs in Mongolia and South Africa (CPC, 2006). In South America, *S. noctilio* is a major pest in Argentina, Brazil (Parana, Rio Grande Do Sul, and Santa Caterina), Uruguay, and Chile (CPC, 2006). In Oceania, *S. noctilio* occurs in Australia and New Zealand (CPC, 2006).

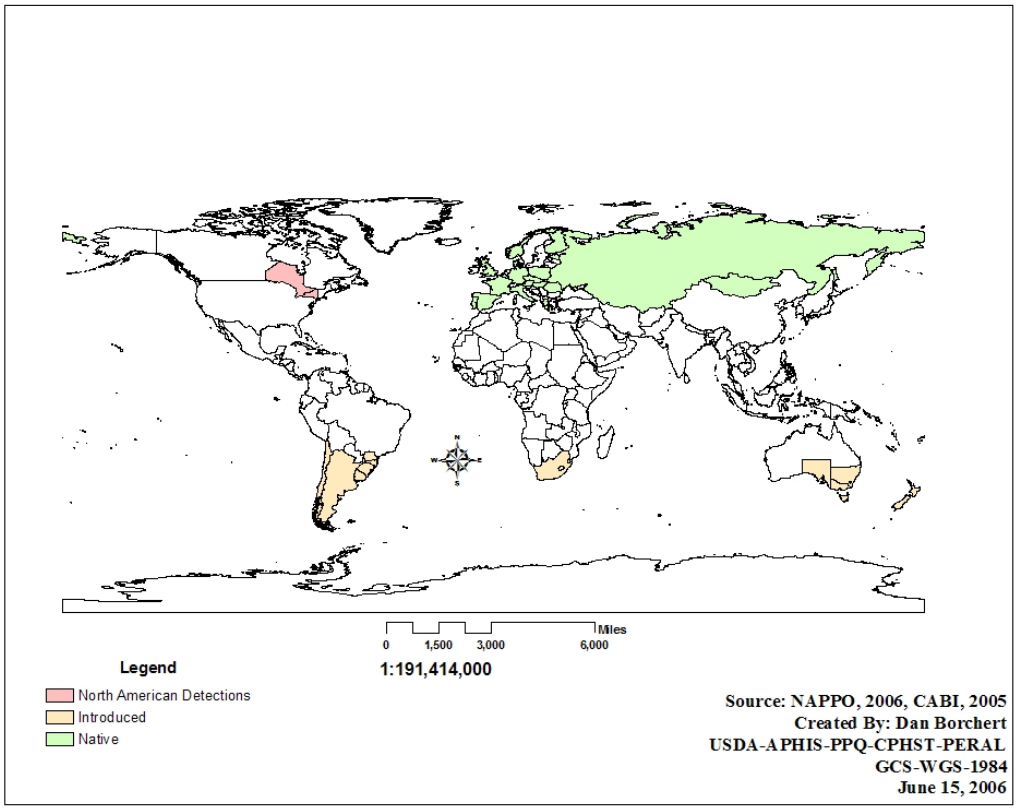

Figure 2. Worldwide distribution of *S. noctilio* (CPC, 2006, APHIS 2007).

Current Distribution in the United States and Canada
To date, *S. noctilio* has been detected in 28 New York counties, four counties in Pennsylvania and one county in Michigan (USDA, 2007). Additionally, *S. noctilio* has been found in the Canadian province of Ontario (CFIA, 2006). Figure 3 displays the United States and Canadian counties where *S. noctilio* has been detected.

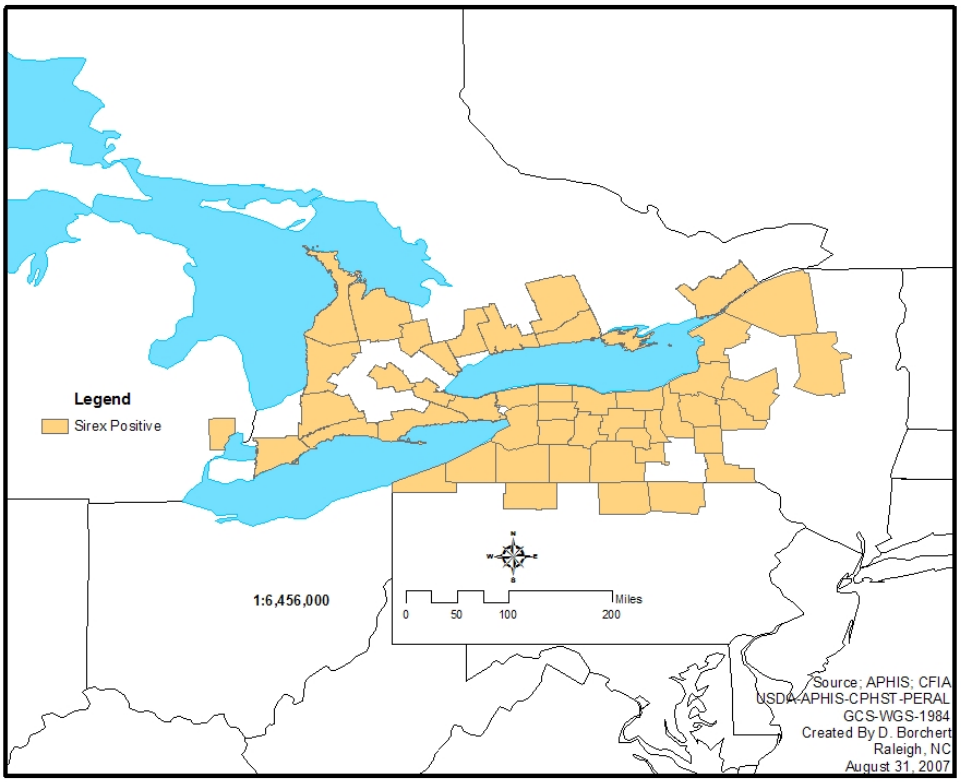

Figure 3. North American counties/municipalities where *S. noctilio* has been detected (CFIA,2006; APHIS, 2007)

Biology of Symbiotes
The saprophytic fungus, *A. areolatum*, the woodwasp, *S. noctilio*, and the parasitic nematode, *B. siricidicola*, have a complex relationship. The fungal oidia of *A. areolatum* are carried to new hosts by the adult female in a specialized organ (Morgan and Stewart, 1966). In turn, the *S. noctilio* wasp relies on the wood decaying and desiccating action of *A. areolatum* to create conditions and food ideal for the establishment and growth of its larvae (Figure 4). Juvenile *B. siricidicola* nematodes feed and multiply on *A. areolatum* mycelium, but when conditions are suitable and *S. noctilio* larvae are present, the nematodes change into a parasitic form and parasitize the larvae. The parasitic form of *B. siricidicola* multiplies within the eggs of *S. noctilio* females and is dispersed upon wasp emergence and oviposition into new trees (Neumann *et al.* 1987).

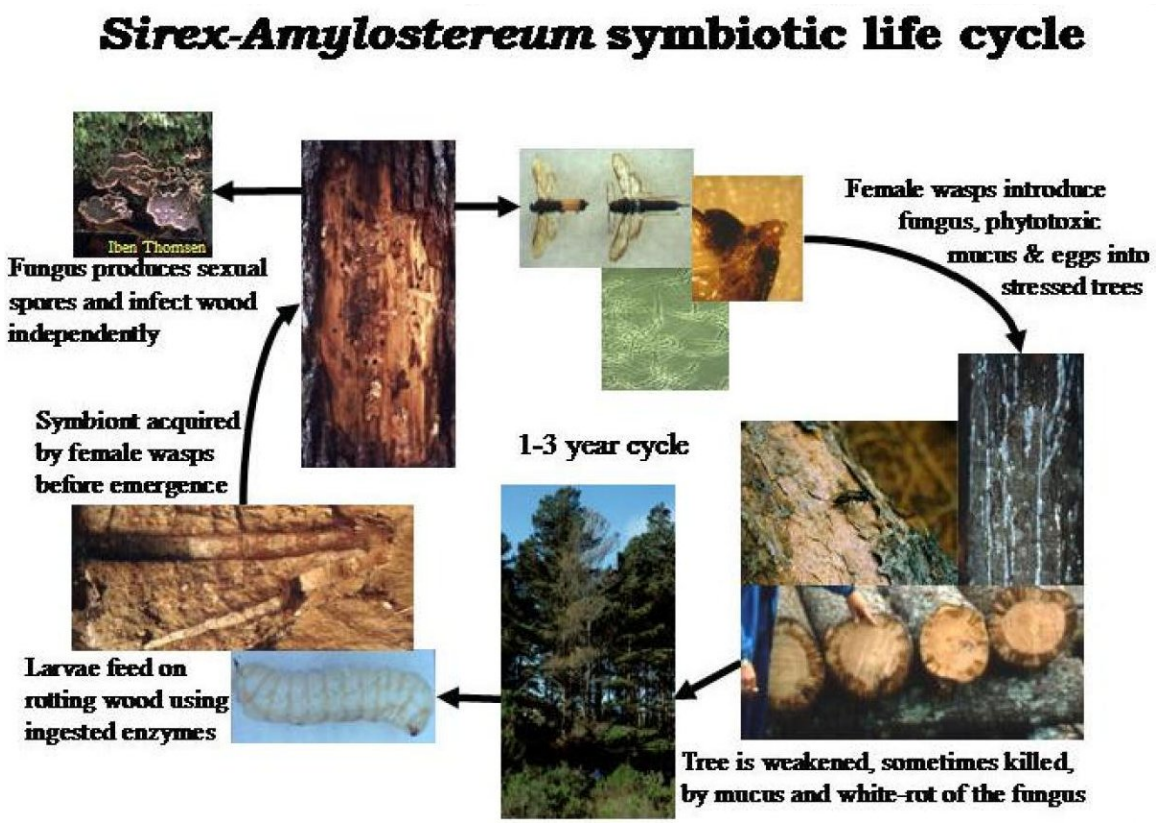

Figure 4. The complex life-cycle of *S. noctilio* and *A. areolatum* (Slippers, 2003)

***Amylostereum areolatum*:** *Amylostereum areolatum* relies on *S. noctilio* for dispersal and inoculation into the tree; in turn, the wasp relies on the fungus for wood breakdown and food (Slippers *et al*., 2003). The fungus is a saprophyte that occasionally occurs on naturally fallen trunks and stumps of *Pinus* spp., *Picea* spp. and *Abies* spp. Following infection in living trees, the fungus continues to spread and develop, resulting in extensive and persistent decay columns, which may remain active within the tree up to 17 years (Vasiliauskas and Stenlid, 1999). In the phloem and outer sapwood of predisposed and mucus-stressed trees, conditions are usually favorable for the germination and growth of *A. areolatum*. Subsequent growth of the fungal pathogen leads to cell death in the phloem and cambium due to wood desiccation. *Amylostereum areolatum* hyphae invade water conducting and supporting tracheids via pits or by dissolving cell walls at points of contact. Within tracheids, fungal spread is significantly faster along the wood grain than in radial or tangential directions across the grain (Fig. 5) (Vasiliauskas, 1999).

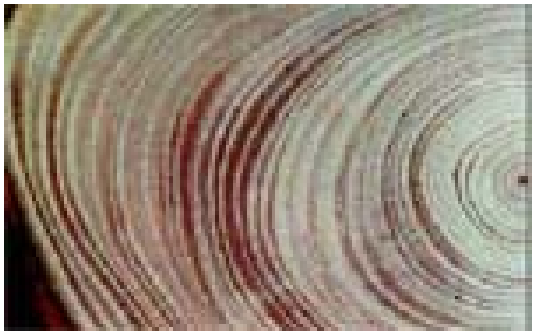

Figure 5. *Amylostereum areolatum* infection in growth rings of an infected tree.

***Sirex noctilio*:** Physiological stress factors, such as damage from wind, hail, lightning, human activities, defoliators, drought, and inter-tree competition, typically predispose trees to attack by *S. noctilio*. *Sirex noctilio* females are attracted to stressed trees, and the wasps deposit toxic mucus, fungus and eggs preferentially in those trees. The toxic mucus injected into the outer sapwood increases the susceptibility of a tree to drought and other stresses. The mucus is translocated into the trees foliage, where it reduces photosynthesis and nutrient translocation. Symptoms caused by toxic mucus injection include leaf wilt, discoloration, and defoliation (Figure 6). Additionally, *S. noctilio* females can inject healthy trees with toxic mucus alone, causing the trees to be physiologically stressed, and this stress conditions the trees for future attacks. The mucus and fungus act together to kill the tree, while the *S. noctilio* larvae feed on the *A. areolatum* fungus (Coutts, 1968a, Coutts, 1968b).

Figure 6. Typical of Sirex damage caused by injected toxic mucus.

***Beddingia siricidicola*:** Juvenile *B. siricidicola* nematodes typically feed on the actively growing edges of the *A. areolatum* fungal mass. After sufficient drying of the wood, the nematodes breed wherever fungus is growing, usually within the tracheids, between wood and bark, within resin canals, and within the *S. noctilio* galleries, where fungal growth is often dense. *Beddingia siricidicola* produces large populations within the host trees, which facilitates infection of *S. noctilio* larvae. Ten to 20 generations of the fungus feeding *B. siricidicola* can develop in a year, and this form has been utilized in the laboratory to culture and mass rear this nematode. To date, hundreds of millions of nematodes have been distributed throughout *S. noctilio* infested Australian forests with great success (Bedding and Iede, 2005).

Movement and Dispersal

Amylostereum areolatum is vectored by *S. noctilio*. The spread of the fungus can be facilitated by exports of infested wood and wood products from infested areas. Seasonal flight and wind can also contribute to fungal dispersal.

Environmental Impact

The *S. noctilio* / *A. areolatum* complex is a high risk invasive species where pines are present in the United States. The spread of *S. noctilio* could result in widespread mortality of pine trees resulting in negative economic and environmental impacts (non-target species and threatened and endangered species). Its eradication is not considered feasible; therefore, regulations and management are important to slow its movement, and prevent the occurrence of outbreaks that could result in significant loss of pine timber. Effective management will involve an integrated approach of the following methods: restricting movement of untreated wood and wood products; monitoring of *S. noctilio* population through aerial and ground survey; improving silvicultural practices; and utilization of biological control agents, (*e.g., B. siricidicola)* (USDA, 2007).

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