

CHEMICAL ECOLOGY OF *SIREX NOCTILIO*

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ABSTRACT

The woodwasp *Sirex noctilio* Fabricius (Hymenoptera: Siricidae) is native to southern Europe, North Africa, and the Near East. It was detected as a pest at the beginning of the last century in New Zealand and has spread out to Australia, South America, South Africa, and North America since then. *Sirex* was found in New York State in 2004, and it reached Pennsylvania (Tioga County) last year. Three major host species in North America are red pine (*Pinus resinosa*), Scots pine (*P. sylvestris*), and white pine (*P. strobus*). Female wasps attack weak or stressed trees and lay up to 500 eggs 10-12 mm deep into the outer sapwood. Adults typically emerge the following year, but the larvae can spend over 2 or 3 years in the tree making galleries as they move. The fungal symbiont *Amylostereum aerolatum* is introduced into the tree by the female during oviposition and is necessary for larval growth and development. The fungus digests cellulose and lignin, disrupting the vascular system and thus killing the tree. Female wasps also inject mucus, which facilitates the spread of the fungus.

Although Siricids are well known for attacking stressed pine and many of the volatile components of pine resin have been shown to elicit response in the antenna of *S. noctilio* (Madden 1988, Simpson 1976, Simpson and McQuilkin 1976), it is still unclear what compounds attract the wasp to the host. To date, the most efficient way to monitor the spread of the woodwasp has been the use of girdled or herbicide-treated pine as a lure. The composition of the volatile blend emitted by the trunk differs from that emitted by the needles (Manninen et al. 2002), and it is the trunk volatiles that attract the females. Therefore, we have developed a non-destructive volatile collection system that can be used in the field to find the active components. Volatile organic compounds (VOCs) are trapped on a small filter containing a polymer adsorbent and are washed off with a solvent. The

solutions are analyzed at the lab using gas chromatography techniques.

Over the last 2 years, we have collected VOCs from trunks and needles of healthy and stressed Scots pine and red pine. Furthermore, volatiles have been collected from trees on which female wasps have oviposited. Compounds have been identified based on their retention index and mass spectrum. Typical compound groups are aromatics, green leaf volatiles (GLVs), monoterpene hydrocarbons, oxygenated monoterpenes, sesquiterpene hydrocarbons, and oxygenated sesquiterpenes. Major monoterpenes in both pine species are α -pinene (40-80% relative amount), β -pinene (1-20% relative amount), and δ -3-carene (1-50% relative amount). Red pine samples contain the oxygenated monoterpenes camphor and 3-pinanone in addition to the usual monoterpene hydrocarbons α -pinene, α -fenchene, camphene, β -pinene, β -myrcene, δ -3-carene, limonene, and β -phellandrene. In Scots pine, we distinguish between two different chemotypes: Δ -3-carene producers and non-producers (Thoss et al. 2007). The most abundant sesquiterpenes were α -longipinene, α -copaene, β -cubebene, α -muurolene, γ -cadinene, and δ -cadinene.

We found that the overall volatile emission of herbicide-treated pines was significantly higher than that of healthy ones. Moreover, the time span between the treatment and the date of volatile collection had an effect on the quantity of VOCs emitted. The samples from 2007 were collected 3-4 weeks after treatment and contained five times as much VOCs as the samples from 2006, collected 7-11 weeks after the treatment. The volatile profile of Scots pine needles is different from that of the trunk. The compounds 2-hexanol, hexanal, (*E*)-2-hexenal, (*Z*)-3-hexenal, eucalyptol, and (*E*)- β -farnesene are needle specific.

When female wasps were caged on Scots pine for 10 days, the volatile emission of the trunk below the caged area

increased within 5 days. After removal of the females, we observed elevated levels of monoterpenes over the previously caged area as well, although it might have been partially due to the resin flow induced by oviposition. Treated pines of the Δ -3-carene producing chemotype emitted increased amounts of α -pinene and Δ -3-carene, whereas the non-producer ones emitted increased amounts of α -pinene and β -pinene. Emission levels gradually decreased over 4 weeks after treatment.

Cuticular hydrocarbons (HCs) of insects are key compounds in nestmate and kin recognition as well as in courtship behavior (Wyatt 2003). Within the order of Hymenoptera, females of Vespidae wasps and parasitic wasps have been shown to use contact pheromones on their cuticle (Ayasse et al. 2001). Qualitative and quantitative differences were found in the cuticular hydrocarbons of the female and male woodwasp. Unsaturated hydrocarbons are more abundant in the female body wash, whereas methyl-branched hydrocarbons dominate in the male extract. Behavioral assays show that the mixture of female cuticular hydrocarbons extracted with hexane induces mating behavior of males. It is possible to separate the female cuticular HCs based on the degree of unsaturation and testing these fractions with males.

We have analyzed the volatile profile of herbicide-treated and healthy pines to investigate host location of the woodwasp *Sirex noctilio*. It seems to be primarily the quantity of VOCs emitted that distinguishes a stressed pine from a healthy one. Different doses of the major monoterpenes are being tested in trapping experiments. Moreover, we have behavioral evidence that the female body wash contains substances that act as mating stimulants. The identified active compounds could be used in trapping males, possibly in combination with a volatile lure.

Literature Cited

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