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Beetle attraction to sporocarps and wood infected with mycelia of decay fungi in old-growth spruce forests of northern Sweden

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Abstract

Many saproxylic beetles do not feed on wood directly but on fungi colonizing the wood. The volume of decaying wood has decreased drastically in Scandinavian managed forest landscapes in recent years, so improved knowledge on the interactions between beetles and wood-decaying fungi is important for the long-term persistence of these trophic partners. Sporocarps of polypores are known to emit volatiles attracting both fungivorous and predatory beetles, but it is unknown whether some beetles are also attracted to odours from the mycelia. The aim of this experiment was to test the attraction of beetles to volatiles from the sporocarps and mycelia of wood-decaying fungi. In a randomized block design, six substrate types: *Fomitopsis pinicola* sporocarp, *F. pinicola* mycelium-infected wood, *Fomitopsis rosea* sporocarp, *F. rosea* mycelium-infected wood, *Phellinus chrysoloma* sporocarp and *Phlebia centrifuga* mycelium-infected wood were attached separately to specially designed window traps in four old-growth spruce forests in northern Sweden. Empty traps and traps with sterilised wood were used as controls. We found no significant differences in the species richness or abundance of saproxylic beetles between the control and sterilised wood and the fungal substrates. However, two abundant species showed significant preferences for one substrate type. The bark beetle *Dryocoetes autographus* preferred *F. rosea* mycelium-infected wood and the rove beetle *Lordithon lunulatus* preferred fruiting bodies of *F. pinicola*. The results indicate that some species do discriminate between volatiles emitted by different polypore species and also between volatiles emitted by the sporocarps and mycelia from the same species. Our data indicate a hitherto unknown interdependence between *D. autographus* and *F. rosea*. We conclude that present knowledge on interactions between beetles and wood-decaying fungi is limited and further studies are needed to enhance our ability to design appropriate conservation strategies in the forest landscape.

Keywords: Beetle-fungi interactions; Saproxylic beetles; Wood-decaying fungi; Fungal volatiles; Substrate demands

1. Introduction

The ecological triangle made up by dead wood, beetles and fungi includes a wide range of interactions. For example, sporocarps and mycelia can serve as feeding and breeding grounds for beetles that may also act as vectors for the dispersal of both spores and mycelia, thus enhancing colonization of the cambium by the fungal partner (Harrington et al., 1981; Pettey and Shaw, 1986; Paine et al., 1997; Hsiau and Harrington, 2003; Six, 2003; Sallé et al., 2005). However, whether beetles act as passive or active vectors may vary and is often not known (Harrington et al., 1981; Gilbertson, 1984).

An understanding of these interactions is important as dead wood constitutes one of the most important structural components for maintaining biodiversity in boreal forest ecosystems (Harmon et al., 1986; Esseen et al., 1997; Siitonen, 2001). In Sweden, intensive forest management has led to a drastic reduction in the amount of dead wood (Fridman and Walheim, 2000), especially the amount of coarse wood (Linder and Östlund, 1998; Jonsson et al., 2005). This loss of habitat has resulted in marked population declines and a reduced diversity of wood-decaying fungi and associated insects. More than 250 of the wood-decaying fungi on the Swedish red-list (mainly polypores) and more than 500 forest insect species

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depend on specific habitat elements, mainly old trees, logs and snags for their survival (Berg et al., 1994; Jonsell et al., 1998; Gärdenfors, 2005).

The beetle community on sporocarps of various polypore species has been studied intensively in the Nordic countries (e.g. Jonsell and Nordlander, 1995; Økland, 1995; Fossli and Andersen, 1998; Jonsell et al., 2001; Komonen, 2001; Komonen et al., 2004). In most cases, closely related polypores support similar beetle faunas (Jonsell and Nordlander, 1995), but the closely related species *Fomitopsis pinicola* (Swartz: Fries) Karst. and *Fomitopsis rosea* (Alb. & Schwein.) P. Karst. host different species assemblages (Økland and Hågvar, 1994; Komonen, 2001). Other features of the sporocarp that affect the species assemblage include its physical structure (Pavior-Smith, 1960), developmental stage (Thunes, 1994) and persistence after death (Økland, 1995). Further, the type of rot caused by fungi determines which beetles colonize the wood (Araya, 1993a,b; Kaila et al., 1994).

A number of studies have shown that saproxylic beetles may be attracted by volatiles emitted either by the wood (Schroeder and Lindelöw, 1989; Schroeder, 1993; Jonsell et al., 2003), or by the host in response to fungal infection (McLeod et al., 2005). Furthermore, wood infected with active decay fungi emit more volatiles (ethanol and monoterpenes) than wood without active decay fungi (Gara et al., 1993). Additionally, wood infected by different fungi (Olberg and Andersen, 2000) or rot may host different species (Araya, 1993a,b; Kaila et al., 1994). Studies on wood-decaying polypores have previously tested the attraction of beetles to the odour of sporocarps (Jonsell and Nordlander, 1995; Fäldt et al., 1999; Olberg and Andersen, 2000). However, no previous study has tested whether wood infected by the mycelium of polypores also attracts beetles. A large number of cambium feeding beetles also feed on mycelia, so we predict that some beetle species are attracted to smell from the mycelium. We used window traps baited with sterilised wood, sporocarps or wood discs infected with growing mycelium from four different wood-decaying fungi to address the following questions:

1. Are more beetle species and individuals attracted to the odour of sporocarps and/or mycelium-infected wood than to sterilised wood?
2. Do sporocarps and mycelium-infected wood of the same polypore species attract different beetle species?

2. Materials and methods

2.1. The wood fungi

We used four different species of wood-decaying fungi. They were chosen as they were likely to host different assemblages of beetles. For example, *Cis glabratus* Mellie and *Cis quadridens* Mellie are associated with *F. pinicola* (Økland, 1995), and *Cis dentatus* Mellie with *F. rosea* (Komonen, 2001) and *Antrodia serialis* (Fr.) Donk. (Reibnitz, 1999). The experiment included both rare and common species as well as species with annual and perennial sporocarps. We included both brown rot and white rot fungi because the type of rot is known to affect the composition of the beetle fauna (Araya, 1993b).

F. pinicola is one of the most common polypores in the coniferous forest regions of the northern hemisphere. It has perennial sporocarps and causes brown rot on both coniferous and deciduous trees and is able to live both as parasite and saprotroph (Ryvarden and Gilbertson, 1993).

F. rosea occurs in the boreal zone of Europe, Asia and North America and in the mountainous areas in continental Europe. *F. rosea* has perennial sporocarps and causes brown rot on coarse spruce logs (Ryvarden and Gilbertson, 1993). It is a common, characteristic species in old-growth spruce forests (Edman and Jonsson, 2001; Penttilä et al., 2004) but it has been negatively affected by forestry and is now Red-Listed in the category near threatened (NT) in Sweden (Larsson, 1997; Gärdenfors, 2005). The present occurrence in Finland and Sweden reflects the distribution of remaining old-growth forest (Renvall, 1995; Larsson, 1997).

Phellinus chrysoloma (Fr.) Donk is a cosmopolitan polypore (Ryvarden and Gilbertson, 1994), and in Sweden it is rather common in the northern parts, but its abundance decreases towards the south, where it is quite rare (Nitare, 2000). It has perennial sporocarps and grows on both living and dead spruce and causes white pocket rot (Ryvarden and Gilbertson, 1994).

Phlebia centrifuga P. Karst. is a corticoid fungus that is found in northeast and central Europe, Siberia and North America. *Phlebia centrifuga* has resupinate, annual sporocarps and causes white rot (Ryvarden and Gilbertson, 1994). It is confined to old-growth spruce forests in the northern boreal zone and is considered as near threatened (NT) in Sweden (Larsson, 1997; Gärdenfors, 2005).

2.2. Study area

The study was performed in four old-growth forest reserves, within a radius of 15 km, in the counties of Västerbotten, Ångermanland and Lapland in northern Sweden. The forests were: Björnlandet (63°57′N; 18°05′E), Trolltjärn (63°50′N; 18°05′E) and two different sites in the Gammtratten reserve, here referred to as Gammtratten A (63°51′N; 18°07′E), and Gammtratten B (63°51′N; 18°10′E). All sites are situated in the boreal zone (Ahti et al., 1968). The altitude ranged between 300 m a.s.l. (Trolltjärn) and 450 m a.s.l. (Gammtratten B). The sites were all old-growth spruce (*Picea abies* (L.) Karst.) dominated forests of the *Myrtillus* type (Ebeling, 1978), and surrounded by managed forests in different age classes. The four study areas all have large amounts of dead wood providing suitable habitats for both wood-decaying fungi, including the species used in the experiment, and saproxylic beetles.

2.3. Experimental design

The experiment was set up in a randomized block design with eight substrate types per block, viz. control (empty mesh bag), sterilised wood, *F. pinicola* sporocarp, *F. pinicola* mycelium-infected wood, *F. rosea* sporocarp, *F. rosea* mycelium-infected