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Fungivory of saproxylic Coleoptera: the mystery of rejected polypores

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Abstract

Seven old growth, mostly spruce- and pine-dominated, protected forests rich in dead wood were inventoried for polypores and polypore-associated beetles in Finland from 2001 to 2007; 116 of the 198 polypores were associated with either larvae or adult Coleoptera, and 82 polypore species were neither visited nor colonised by beetles. The reasons for host rejection are discussed.

Key words: beetles, mycophagy, Basidiomycetes, dead wood

1. Introduction

Fungi play a key nutritional role in many families of saproxylic Coleoptera, and are essential for specialised fungivores such as Ciidae (CROWSON 1982). Among lignicolous fungi, polypores have become one of the best-studied groups of Basidiomycetes (NIEMELÄ 2005). Since Benick (1952) reported beetles of 65 polypore species, the majority of the following studies in Europe have dealt with just a few easily recognised host fungi (for detailed literature review, see SCHIGEL 2009). From 2001 to 2009, polypore-beetle interactions in Finland were investigated, including Lapland in the northern boreal vegetation zone, northern Karelia and the Lake District in the southern boreal zone, and southern Finland, and the Åland Islands in the hemiboreal zone. The goal was to document the interactions of Coleoptera (fungivorous larvae and visiting adults) with polypore species (fruit bodies), also taking into account rare and poorly known fungi.

2. Material and methods

The data were collected during four investigations in Lapland, plus one in northern, two in eastern and two in southern Finland. Supplementary field collecting and rearings of beetles were made in various localities in southern Finland and the Åland Islands.

Fruit bodies of polypores (poroid non-bolete, mostly wood-decaying) Basidiomycota fungi were surveyed and examined for beetle larvae and adults. Adult Coleoptera were collected on the polypore fruit bodies in the field, while their larvae and pupae were reared into adults in the lab. Specimens that could not be identified with certainty were collected for microscopic study and dried in ventilated fungus dryers at 40–45 °C. The fungal nomenclature follows Niemelä (2005). Polypore specimens are preserved in the Herbarium of the Botanical Museum of the University of Helsinki (H).

The rearing chambers were kept at outdoor temperatures in a sheltered storage for two to three months, and then for an additional two to three months at room temperature. Afterwards, the rearing results were checked, the adult beetles preserved for identification, and the remaining larvae, if any, were left for one extra cycle of rearing. Details of methodology and practical advice on collecting and rearing fungivorous Coleoptera are given in a separate paper (SCHIGEL 2008).

3. Results

Among the 198 species (6501 specimens) of polypores, 116 species hosted 176 species of Coleoptera either as larvae or as adults. From 56 species of fungi, beetle larvae of 23 beetle species were reared (SCHIGEL 2009); 82 species (694 specimens) of polypores species were neither visited nor colonised by Coleoptera in spite of considerable attention paid to many such fungi (Table 1).

4. Discussion

Why are 41% of the studied fungi, i.e. more than a third of Finnish polypore mycota, are unsuitable for beetles at any life stage? Is there any sense in publishing negative results on species ecology? Even though the negative results in general are not frequently published (KOTZE *et al.* 2004), and species absences are particularly difficult to interpret, I believe that identifying the blank spots on the map of fungus-beetle interactions is a worthy effort, in order

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to contrast the positive data on host selection (SCHIGEL 2011) and to provoke further research in this field.

A number of explanations for absence of Coleoptera associated with polypores can be offered. Rejected polypores belonging to the genera where beetle associations are known may represent sampling artefacts that could be corrected with additional rearings. For example, fruit bodies of *Trichaptum laricinum* (N=17) were found intact in all cases, but this and closely related *Trichaptum species* are utilised by *Cis* sp., and are visited by a few other beetles (EHNSTRÖM / AXELSSON 2002). In contrast, the genus *Coltricia* in Finland includes species *C. perennis* and *C. cinnamomea*, and both species were never grazed or visited when living or dead.

The taxonomically discrete fungal genera, such as *Antrodia* and *Phellinus*, include species unattractive for beetles, while the congeneric species of these fungi are grazed when living and destroyed when dead. No beetles were recorded as associated with *Phellinus* (*Phellopilus*) *nigrolimitatus* (N=121), four unidentified Ciidae larvae on one occasion in *P.* (*Phellinidium*) *ferrugineofuscus* (N=137, Fig. 1), and a single *Orthoperus rogeri* was collected on *Antrodia* (*Amyloporia*) *xantha* (N=195). These species with relatively robust and long-lasting fruit bodies share habitats or, sometimes, the logs with other polypore species, which are actively visited by adult beetles, or host their larvae. It seems that living and dead fruit bodies of certain polypores are able to repel even the generalist species of Staphylinidae. In the data of Ollila (2005), *Antrodia xantha* (N=45) was also neglected by insect larvae, but attracted adult visitors belonging to nine species of beetles.

Figure 1: *Phellinus ferrugineofuscus*, one of the polypores with unknown beetle associations in Finland. The annual resupinate fruit body of this fungus may extend for several meters on the underside of a spruce log.

Another set of reasons for host rejection seems to be in the combination of fruit body thickness limiting space for larvae inside the fungus, and the ephemerality of the fruit body, selecting for the beetles with the fast-developing larvae. For example, as larvae of *Endomychus coccineus* (Linnaeus 1758) are living on the surface of the thin corticioid fungus *Chondrostereum purpureum* (Pers.) Pouzar, and larvae of *Triplax* spp. utilise ephemeral *Pleurotus* spp., the shape or the ephemerality alone does not prevent beetles from fungivory. At least 45 polypores ignored by Coleoptera are those species with annual, small, thin, ephemeral and autumnal fruit bodies with erratic fructification, which are found in sheltered, usually moist subcortical sites. Such were *Anomoporia kamtschatica, Byssoporia mollicula, Skeletocutis biguttulata, S. brevispora, S. kuehneri, S. papyracea, Trechispora hymenocystis, T. mollusca, Ceriporia reticulata, C. viridans, Porpomyces mucidus, Sistotrema alboluteum*, and *S. muscicola* (Table 1). Coleoptera also neglected the thin fruit bodies of *Cinereomyces lenis*; however, A.M. Hekkala (pers. comm.) recorded a single adult of *Cis dentatus* Mellie 1848. No beetles were found on *Skeletocutis amorpha* and *S. carneogrisea, cartilaginous Antrodiella pallasii, Physisporinus vitreus*, and *Spongiporus undosus* in spite of their exposed manner of growth. It may be speculated that rarity of the certain host fungi results in low beetle yields, but many of the rejected polypore species were so abundant that there must be some fundamental reasons behind this phenomenon. Most of the polypores, regardless of how common or rare, are readily consumed by beetles.

Paviour-Smith (1960) suggested that chemistry of a living fungal fruit body plays an important role in attracting and distracting beetles; several later studies confirmed this hypothesis (JONSELL / NORDLANDER 1995, FÄLDT *et al.* 1999). Since the majority of polypore fruit bodies are intact when living (except for the watery genera including *Inonotus, Laetiporus, Pycnoporellus, Amylocystis, Postia* and some other) and are heavily attacked when dead, it is likely that metabolically active fungi are able to chemically repel the colonisers. It is noteworthy that living fruit bodies of perennial polypores attract few beetle visitors for the most of the year, but during the sporulation time tens of beetle species and hundreds of individuals can be recorded on a single pileus. Even the weak odour perception of humans is able to detect the difference between sporulating and sterile fruit bodies of Fomes. Some of the species (such as *Phellinus ferrugineofuscus*, Fig. 1) may contain stronger repellents remaining in the dead fruit bodies. The successor polypore species *Junghuhnia collabens* growing on the trees decayed by *Phellinus ferrugineofuscus* and on its dead fruit bodies, is also rejected by Coleoptera.

Another set of reasons of host rejection may be caused by the condition of the fruit body of a host fungus and the habitat structure: in Europe, for example, dry and exposed fruit bodies of *Laetiporus sulphureus* are colonised by *Eledona agricola* (Herbst), whereas Diptera are more likely to colonise the fungus where it remains damp in shady situations. Similar patterns of host use by Coleoptera and Diptera are shown for many forest fungi in Finland (SCHIGEL 2011, JAKOVLEV 1994, JAKOVLEV 2011). Many of the fungi listed in Table 1 have not been recorded as hosts of Diptera, possibly in

Table 1: Finnish polypores with unknown associations to Coleoptera at larval or imaginal life stage. Species are listed according to N values = numbers of fungal specimens examined for adults in the field and attempted for rearing. This list of fungi includes both species ignored by beetles (higher N values, top of the list) and insufficiently sampled, mostly rare fungi. Species with beetle associations discovered outside Finland are marked with an asterisk.

Polypore species	**N**
Phellinus nigrolimitatus (Romell) Bourdot & Galzin	121
Skeletocutis biguttulata (Romell) Niemelä	39
Coltricia perennis (L.: Fr.) Murrill	35
Byssoporia mollicula (Bourdot) Larsen & Zak	34
Anomoporia kamtschatica (Parmasto) M. Bondartseva	33
Cinereomyces lenis (P. Karst.) Spirin	32
Antrodiella pallasii Renvall, Johannesson & Stenlid	31
Skeletocutis amorpha (Fr.) Kotl. & Pouzar	31*
Skeletocutis brevispora Niemelä	29
Spongiporus undosus (Peck) A. David	22
Antrodia macra (Sommerf.) Niemelä	17
Trichaptum laricinum (P. Karst.) Ryvarden	17
Albatrellus confluens (Alb. & Schwein.: Fr.) Kotl. & Pouzar	14
Skeletocutis carneogrisea A. David	14
Ceriporia reticulata (H. Hoffm.: Fr.) Domański	13
Heterobasidion annosum (Fr.) Bref.	13*
Skeletocutis kuehneri A. David	13
Skeletocutis papyracea A. David	13
Sistotrema muscicola (Pers.) S. Lundell	12*
Hyphodontia radula (Pers.: Fr.) E. Langer & Vesterholt	11
Junghuhnia collabens (Fr.) Ryvarden	11
Trechispora hymenocystis (Berk. & Broome) K.H. Larsson	10
Trechispora mollusca (Pers.: Fr.) Liberta	10
Porpomyces mucidus (Pers.: Fr.) Jülich	9
Ceriporia viridans (Berk. & Broome) Donk	8
Physisporinus vitreus (Pers.: Fr.) P. Karst.	8
Antrodia crassa (P. Karst.) Ryvarden	7
Antrodia sitchensis (Baxter) Gilb. & Ryvarden	7
Antrodiella citrinella Niemelä & Ryvarden	7
Skeletocutis chrysella Niemelä	7
Antrodiella romellii (Donk) Niemelä	6
Junghuhnia lacera (P. Karst.) Niemelä & Kinnunen	6
Oligoporus ptychogaster (F. Ludw.) Falck	6
Anomoporia bombycina (Fr.) Pouzar	5
Antrodia mellita Niemelä & Penttilä	5
Antrodia primaeva Renvall & Niemelä	5
Oligoporus parvus Renvall	5
Oligoporus rennyi (Berk. & Broome) Donk	5
Onnia tomentosa (Fr.) P. Karst.	5
Polyporus melanopus (Pers.: Fr.) Fr	5*
Antrodia heteromorpha (Fr.: Fr.) Donk	4
Ceriporia excelsa (S. Lundell) Parmasto	4
Diplomitoporus crustulinus (Bres.) Domański	4
Oligoporus floriformis (Quél.) Gilb. & Ryvarden	4
Sarcoporia polyspora P. Karst.	4
Sistotrema alboluteum (Bourdot & Galzin) Bondartsev & Singer	4
Trechispora candidissima (Schwein.) Bondartsev	4

Coltricia cinnamomea (Jacq.) Murrill	3
Pycnoporellus alboluteus (Ellis & Everh.) Kotl. & Pouzar	3
Skeletocutis borealis Niemelä	3
Skeletocutis lilacina A. David & Jean Keller	3
Albatrellus syringae (Parmasto) Pouzar	2
Anomoloma myceliosum (Peck) Niemelä & K.H. Larsson	2
Antrodiella americana Ryvarden & Gilb.	2
Boletopsis grisea (Peck) Bondartsev & Singer	2
Ceriporiopsis aneirina (Sommerf.) Domański	2
Fibroporia gossypium (Speg.) Parmasto	2
Gloeophyllum abietinum (Bull.: Fr.) P. Karst.	2
Irpex lacteus (Fr.: Fr.) Fr.	2*
Irpex oreophilus (Lindsey & Gilb.) Niemelä	2
Oligoporus balsaminus (Niemelä & Y.C. Dai) Niemelä	2
Oligoporus hibernicus (Berk. & Broome) Gilb.	2
Rigidoporus populinus (Schumach.: Fr.) Pouzar	2*
Antrodia ramentacea (Berk. & Broome) Donk	1
Ceriporia subreticulata Ryvarden	1
Daedaleopsis confragosa (Bolton: Fr.) J. Schröt.	1*
Fibroporia norrlandica (Berglund & Ryvarden) Niemelä	1
Gloeophyllum protractum (Fr.) Imazeki	1
Hapalopilus ochraceolateritius (Bondartsev) Bondartsev & Singer	1
Hyphodontia latitans (Bourd. & Galz.) E. Langer	1
Junghuhnia fimbriatella (Peck) Ryvarden	1
Oligoporus cerifluus (Berk. & M.A. Curtis) Ryvarden & Gilb.	1
Oligoporus mappa (Overh. & J. Lowe) Gilb. & Ryvarden	1
Oligoporus perdelicatus (Murill) Gilb. & Ryvarden	1
Oligoporus romelii (M. Pieri & B. Rivoire)	1
Phellinus tuberculosus (Baumg.) Niemelä	1*
Piloporia sajanensis (Parmasto) Niemelä	1
Polyporus tubaeformis (P. Karst.) Ryvarden & Gilb.	1
Rigidoporus obducens (Pers.: Fr.) Pouzar	1

some cases because of rarity of the fungus or difficulty of identification. Further south in Europe, the following polypores rejected by beetles in Finland are known as host fungi of Diptera (Peter Chandler, pers. comm., species of fungi are set in ***bold italics***, species of associated Dipetra *in italics*): ***Antrodiella romellii*** (*Lestodiplosis polypore*), ***Albatrellus confluens*** (*Lestodiplosis polypori, Camptodiplosis boleti, Forcipomyia ciliata*), ***Daedaleopsis confragosa*** (*Mycetophila sigmoides, Dynatosoma fuscicorne, Sciophila hirta, S. buxtoni*), ***Physisporinus vitreus*** (*Mycetophila fraterna*), ***Polyporus melanopus*** (*Mycetophila bialorussica, M. strigatoides, Camptodiplosis boleti, Lestodiplosis polypori, Seri obscuripennis*), ***Hapalopilus nidulans*** (*Keroplatus testaceus, Lestodiplosis polypori*), ***Physisporinus sanguinolentus*** (*Bolitophila pseudohybrida, Achyrolimonia decemmaculata, Mycodrosophila poecilogastra*), ***Albatrellus*** spp (wide range of Diptera including *Ula*, phorids, psychodids and sphaerocerids, but not fungus gnats), ***Antrodia sinuosa*** (*Mycomya marginata*).

There are also regional differences in host use, e.g. beetle fungivores of *Daedaleopsis confragosai* are unknown in Finland, but reported from Britain (ALEXANDER 2002) and Russia (SCHIGEL 2002). Information on beetles collected or reared from the mysterious substrata listed in Table 1 would be appreciated by the author.

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