Morphological traits predict host-tree specialization in wood-inhabiting fungal communities

Purhonen Jenna[1,2*], Ovaskainen Otso[3,4], Halme Panu[1,2], Komonen Atte[1,2], Huhtinen Seppo[5], Kotiranta Heikki[6], Læssøe Thomas[7], & Abrego Nerea[8]

[1] Department of Biological and Environmental Science, University of Jyväskylä, P.O. Box 35, FI-40014 University of Jyväskylä, Finland

[2] School of Resource Wisdom, University of Jyväskylä, P.O. Box 35, FI-40014 University of Jyväskylä, Finland

[3] Organismal and Evolutionary Biology Research Programme, PO Box, 65, FI-00014 University of Helsinki, Finland

[4] Centre for Biodiversity Dynamics, Norwegian University of Science and Technology, N-7491 Trondheim, Norway

[5] Herbarium, Biodiversity Unit, University of Turku, FI-20014 Turku, Finland.

[6] Biodiversity Unit, Finnish Environment Institute, P.O. Box 140, FI-00251, Helsinki, Finland

[7] Department of Biology/Natural History Museum of Denmark, University of Copenhagen, Universitetsparken 15, Copenhagen 2100 Ø, Denmark

[8] Department of Agricultural Sciences, PO Box 27, FI-00014 University of Helsinki, Finland

*Corresponding author, jenna.purhonen@jyu.fi, +358442599515

Abstract

Tree species is one of the most important determinants of wood-inhabiting fungal community composition, yet its relationship with fungal reproductive and dispersal traits remains poorly understood. We studied fungal communities (total of 657 species) inhabiting broadleaved and coniferous dead wood (total of 192 logs) in 12 semi-natural boreal forests. We utilized a trait-based hierarchical joint species distribution model to examine how the relationship between dead wood quality and species occurrence correlates with reproductive and dispersal morphological traits. Broadleaved trees had higher species richness than conifers, due to discomycetoids and pyrenomycetoids specializing in them. Resupinate and pileate species were generally specialized in coniferous dead wood. Fungi inhabiting broadleaved trees had larger and more elongated spores than fungi in conifers. Spore size was larger and spore shape more spherical in species occupying large dead wood units. These results indicate the selective effect of dead wood quality, visible not only in species diversity, but also in reproductive and dispersal traits.

Index descriptors: broadleaved, coniferous, dead wood, functional trait, fruitbody, morphology, specialization, spore, tree species

INTRODUCTION

Functional traits in fungi can be defined as any morphological, physiological or phenological feature affecting the fitness of an individual fungus (Dawson et al., 2018). Knowledge of the relationship between species traits and species responses to environmental conditions provides understanding of the mechanisms influencing community assembly in different environments (McGill et al., 2006; Weiher et al., 2011). Although trait-based assessments of community-level responses in the fungal kingdom have lagged behind that of animal and plant communities, currently fungal ecological research is undergoing a proliferation of empirical and conceptual studies addressing this issue (Aguilar-Trigueros et al., 2015; Crowther et al., 2014; Dawson et al., 2018; Peay et al., 2008).

Wood-inhabiting fungi constitute a highly species-rich and functionally important group regulating nutrient cycling in forest ecosystems (Boddy et al., 2008; Dowding, 1981; Kahl et al., 2017; Stokland et al., 2012). Wood-inhabiting fungal communities strongly respond to changes in environmental variables such as climatic conditions (Bässler et al., 2010; Boddy and Heilmann-Clausen, 2008; Heilmann-Clausen et al., 2014; Heilmann-Clausen and Christensen, 2005; Lindblad, 2001; Pouska et al., 2017), resource quality (Abrego and Salcedo, 2013; Juutilainen et al., 2017; Küffer et al., 2008; Renvall, 1995) and habitat naturalness (Abrego and Salcedo, 2014; Bader et al., 1995; Lõhmus, 2011; Sippola et al., 2001; Sippola and Renvall, 1999). Given the strong responses of wood-inhabiting fungal communities to the environment and their high taxonomical and morphological diversity, many recent studies have focused on understanding how fungal functional diversity is influenced by environmental conditions (e.g. Abrego et al., 2017; Bässler et al., 2014; Caiafa et al., 2017; Calhim et al., 2018; Kauserud et al., 2011; Nordén et al., 2013; Norros et al., 2015).

Traits related to spore and fruitbody morphology are among the very few traits that are comprehensively available for wood-inhabiting fungi (Dawson et al., 2018). In previous studies, these traits have been found to be important in determining the occurrences of fungal species on dead wood of different sizes and decay stages (Abrego et al., 2017; Nordén et al., 2013). In terms of fruitbody morphology, wood-inhabiting fungal species with robust pileate and resupinate fruitbodies have been found to require large dead wood (Abrego et al., 2017; Bässler et al., 2016), while fungi with ramarioid fruitbodies and resupinate polypores require strongly decayed wood (Abrego et al., 2017). In terms of spore morphology, dead wood in advanced decay stages harbours more wood-inhabiting fungal species with thick-walled and ornamented spores (Abrego et al., 2017). The links between spore size and dead wood characteristics, however, remain unresolved. Nordén et al. (2013) found that spore size slightly decreased as log size increased, while Abrego et al. (2017) discovered that larger logs hold species with somewhat larger spores. The discrepancy in the results between the cited studies most likely arises from the differences in the taxonomical coverage and host-tree species.

Host-tree identity is an important determinant of the species composition of wood-inhabiting fungal communities (Krah et al., 2018b; Lumley et al., 2001; Ordynets et al., 2018; Rajala et al., 2010). In some cases, host-tree identity can determine wood-inhabiting fungal diversity more than microclimatic conditions and local dead wood amount or heterogeneity (Krah et al., 2018b). In general, broadleaved and coniferous dead trees hold quite distinct fungal communities, broadleaved trees being more species rich (Abrego et al., 2016; Rajala et al., 2010; Stokland, 2012a). According to Rajala et al. (2010), the higher species richness in broadleaved trees results from a higher diversity of Ascomycota. In spite of the clear influence of host-tree species on wood-inhabiting fungal community composition, to our knowledge, the effect of host tree identity on the functional composition of wood-inhabiting fungal communities has not been thoroughly investigated (but see Kauserud et al., 2008 for polypores).

Fennoscandian boreal forests represent a suitable ecosystem for studying the effect of host-tree identity on wood-inhabiting fungal communities. These forests are composed of a relatively small set of broadleaved and coniferous tree species, which all produce high amounts of dead wood (Esseen et al., 1997; Siitonen, 2001). In the southern boreal zone in Finland, (Ahti et al., 1968), the dominant tree species are Norway spruce (*Picea abies*, hereafter called spruce), Scots pine (*Pinus sylvestris*, pine), birches (*Betula* spp.) and European aspen (*Populus tremula,* aspen). While the fungal communities inhabiting dead spruce wood have been extensively studied (Edman et al., 2004; Kruys et al., 1999; Kubartová et al., 2012; Ottosson et al., 2015), the fungal communities inhabiting the other dominant tree species, especially birch and aspen, have been less studied (but see Lumley et al. 2001; Rajala et al. 2010; Ruokolainen et al. 2018).

The main aim of the present study is to evaluate how host-tree characteristics relate to the morphological composition of fruiting wood-inhabiting fungi. For this, we use an extensive dataset consisting of 657 species of non-lichenized fungi producing sexual fruitbodies. We surveyed large logs (base diameter > 15 cm) belonging to the four dominant tree species in Fennoscandian boreal forests (spruce, pine, birch and aspen) in 12 seminatural forest sites. More specifically, we determine how much of the variation in species occurrences is explained by the host-tree species and volume, and how much of the variation in community composition is explained by the morphological characteristics of the fruitbodies and spores.

We expected differences in trait composition to arise from the differences in the wood composition and distributional patterns of coniferous versus broadleaved trees. Coniferous and broadleaved wood differ in their chemical and physical characteristics, coniferous wood having generally higher amounts of toxic compounds for saproxylic organisms (Stokland, 2012a). In terms of distributional patterns, in Finnish boreal forests broadleaved trees are less abundant and show more clumped distributions than coniferous trees. Thus, the fungal species growing on each of the wood types should be well adapted to colonize and exploit the wood resources accordingly.

We hypothesized that the manner by which species exploit the wood resources is reflected in the morphological traits, as these may be linked to resource-use and dispersal strategies. Our main working hypotheses related to fruitbody morphology are: 1) species producing small-sized fruitbodies, such as some Ascomycota, are most prevalent on broadleaved wood because unlike other fungi, they are able to decompose bark through soft rot, and bark is more abundant in decomposing broadleaved logs than in coniferous logs; 2) Agaricoids are most prevalent on broadleaved wood, because they have lignin-decomposing enzymes (causing white rot) which are especially efficient in exploiting wood of broadleaved trees (Krah et al., 2018a); 3) Species with pileate and resupinate fruitbodies are expected to be equally prevalent in broadleaved and coniferous logs, because these include lineages which equally well decompose cellulose and mostly occur on coniferous logs (i.e. brown-rot fungi), or mainly decompose lignin and mostly occur on broadleaved logs (i.e. white-rot fungi) (Krah et al., 2018a). Our working hypothesis about how spore morphology is linked to host tree is that 4) coniferous trees host species with smaller spores because their wood is easier to penetrate, compared to wood of broadleaved trees (Kauserud et al., 2008); and 5) broadleaved trees with clumped distributions in the forest landscape (e.g. aspen) also have species with small-sized spores, because they should be able to disperse longer distances (Norros et al., 2014).

MATERIALS AND METHODS

Study sites and design

We carried out the study in central Finland, which belongs to the southern boreal vegetation zone (Ahti et al., 1968). All of the 12 study sites were spruce dominated forests characterized by *Myrtillus* or *Oxalis-Myrtillus* forest types (Cajander, 1949). All study sites were seminatural, and varied relatively little in their age and management history. To control for the quality variation among the study sites in the analyses, we used a forest naturalness index described in Supplementary material 1. From each forest, we chose four large (base diameter ≥ 15cm), naturally died, fallen logs of birch, spruce, pine and aspen (these species produce the majority of the coarse dead wood (diameter at breast height >10cm) in the area), in total 16 logs at each site and 192 logs in the whole study. To minimize the variation in log quality, only logs that had their decay stage between 2-4 (Renvall, 1995), and moss cover < 50% were selected. For each log, we measured the base and top diameter and the length of the logs, and calculated the volume by using the formula of a truncated cone.

Fungal data collection and identification

We thoroughly surveyed the fungal sexual fruitbodies on each study log. All fruitbodies from the same taxon within a study log were considered as one occurrence of the taxon. To better account for the species-specific variation in the timing and duration of fruitbody production (see Purhonen et al., 2017), two subsequent inspections were conducted for each log. The first inspection was performed between 21st of May and 6th of June, and the second between 20th of August and 26th of September. To enable multiple surveys of the same logs, moss and bark cover was left intact and the logs were not turned over. The fruitbodies were identified to species in the field or collected for microscopic identification (about 7500 specimens collected). When the species-level identification was not possible, we identified the specimens to the highest possible taxonomical level and named them with unique labels according to their morphology (e.g. pyrenomycete sp1, sp2 etc.). Some of the classified taxa include multiple species (i.e. species complexes), as their taxonomy is still unresolved. The nomenclature follows Index fungorum (Royal Botanic Gardens Kew et al., 2016).

Fungal trait data collection

The identified species were classified into seven groups according to their fruitbody morphology; agaricoids were species having a soft pileus and stipe (also pleurotoid fungi were grouped here). As discomycetoids, we classified species with disc- to cup-shaped fruitbodies. Pileates were species that grow as crusts over the log surface when young but majority of the fruitbody is a pileus or erected on the edges when adults. As pyrenomycetoids, we classified those fungi of which fruitbodies were organized in individual round or flask shaped bags (i.e. perithecia). Ramarioids had fruitbodies with branched structure. As resupinates, we classified those species that mostly grow as a crust over the log surface, but some may be slightly pileate as well. Stromatoids were fungi whose fruitbodies are organized round or flask shaped bags embedded in a hard mass-like structure.

For the spore morphology, we gathered information about spore length, width and presence of ornamentation (meaning that the surface of the spore is not smooth but has some texture) from the literature. For those specimens that we could only identify to the genus level, but still recognize as unique taxa, we measured the spore size and noted the shape during the identification procedure (see detailed description of the trait variable in Table 2.). The literature used for the spore morphology is listed in Supplementary Material 2.

To account for phylogenetic relationships between species, the phylogenetic relationships were estimated based on the taxonomic levels. As the data include a large number of poorly known species and species that are not yet described, it was not possible to use a quantitative phylogenetic tree. For each species, we included the taxonomic levels of the genus, family, order and class, using the Index Fungorum and Mycobank online databases (International Mycological Association, 2017; Royal Botanic Gardens Kew et al., 2017).

Statistical analyses

We analyzed the data with Hierarchical Modelling of Species Communities (HMSC; Ovaskainen et al., 2017). HMSC is a joint species distribution modelling framework (Warton et al., 2015) that enables the integration of data on species occurrences or abundances, environmental covariates, species traits and phylogenetic relationships, as well as the spatio-temporal nature of the study design (Ovaskainen et al., 2017).

In the HMSC analyses, the $n_y \times n_s$ response matrix **Y** consisted of presence-absences of the $n_s = 657$ species observed in the $n_y = 192$ logs, called henceforth sampling units. We modelled **Y** with probit-regression, including in the predictor matrix **X** the environmental covariates of the tree species (categorical variable with four levels: aspen, birch, spruce and pine), the size of the dead wood unit (log-transformed volume), decay class (categorical variable with two levels: decay class 2; and decay classes 3 and 4 combined, as only four logs had decay class four), and the forest naturalness index. We modelled the mapping from **X** to **Y** as a function of species traits and phylogenetic relationships following Abrego et al. (2017) and Ovaskainen et al. (2017). We included in the matrix of species traits **T** the fruitbody morphology (categorical variable with seven levels: agaricoid, discomycetoid, pileate, pyrenomycetoid, ramarioid, resupinate, stromatoid), the presence of ornamentation in the spores (categorical variable with two levels: yes or no), spore shape (log-transformed ratio of length to width), and spore size (log-transformed volume). In the absence of a quantitative phylogeny, we followed Abrego et al. (2017) and used as a proxy for the phylogenetic correlation matrix **C** a taxonomical correlation matrix, constructed from the five levels of class, order, family, genus and species, and assumed equal branch length for each level. As a community-level random effect, implemented through a latent variable approach (Ovaskainen et al., 2017, 2016), we included the study site, with 12 levels.

We fitted the model to the data using the HMSC-R package (Tikhonov et al., 2019). We assumed the default prior distributions, and sampled the posterior distribution for 150*thinning iterations, out of which the first 50*thinning iterations were discarded as burn-in. We used thinning=100 and thus run the MCMC chain for a total of 15,000 iterations. We assessed the convergence of the MCMC chain visually, and examining the convergence of the results between thinning=1, thinning=10, and thinning=100.

To examine host-tree specialization at the levels of species and functional groups, we used the fitted model to predict species occurrences to new sampling units that were standardized to be of average size and decay stage and consisted of each of the four host-tree species. To examine host-tree specialization at the species level, we used these predictions to classify the host-tree use of each fungal species to one of the following seven classes: generalist, coniferous generalist, spruce specialist, pine specialist, broadleaved generalist, birch specialist, and aspen specialist. We first classified the species as generalists, broadleaved species or coniferous species by asking whether the predicted mean occurrence probability over broadleaved trees (birch and aspen) was smaller or greater than that for coniferous trees (pine and spruce) with at least 95% posterior probability. We further classified the broadleaved species as aspen specialists, birch specialists or broadleaved generalists by examining if the occurrence probability on aspen was smaller or greater than that for birch with at least 95% posterior probability. Similarly, we classified the coniferous species as spruce specialists, pine specialists and coniferous generalists.

To examine host-use specialization at the functional group level, we counted for each seven host-tree use classes the numbers of species belonging to each of the seven fruitbody types. We then asked if a particular fruitbody type was over- or underrepresented in a given host-tree type by conducting a randomization test, in which we randomly permuted the fruitbody types among the species, and examined if the observed value was greater or smaller than the 95% quantile in 1000 randomizations. To examine the association among host-tree use and spore-related traits (presence of ornamentation and the shape and size of spores), we computed the posterior distributions of community-weighted mean traits for species predicted to occur on each of the four tree species.

RESULTS

Morphological traits and species richness

In total, we recorded 657 species in total, which occurred 5714 times (Appendix 1). A large proportion of the species was resupinates (288 species, 44%), followed by discomycetes (148, 22.5%), agaricoids (73, 11%), pyrenomycetoids (71, 11%), pileates (49, 7%), stromatoids (18, 3%), and ramarioids (10, 1.5%).

Aspen dead wood had the highest fungal species richness (239 spp.), followed by birch (221), spruce (209) and pine (186). All tree species shared 68 species, on top of which the two broadleaved species shared 107 species, the two conifers shared 70, whereas all other combinations of coniferous and broadleaved tree species shared less than 20 fungal species. Discomycetoids, pyrenomycetoids, ramarioids and stromatoids had significantly higher species richness on broadleaved host trees than on conifers (Supplementary Material 3).

Spore size (volume) and shape (length/width) showed a weak but statistically significant negative association (in linear regression, p=0.02, R^2=0.008). While pyrenomycetoids had the largest and most elongated spores, agaricoids had large and spherical spores, whereas pileates and resupinates had the smallest spores (Fig. 1).

Effects of environmental variables on community composition

The fitted joint species distribution model explained 6% of the variation in the fungal community composition, as measured by the average Tjur (2009) R^2 value over the species. Of the variables included in the model, host-tree species was by far the most important one, as 71% of the explained variation in species occurrence was attributed to it. The percentages of explained variation attributed to other variables were 15% for log-characteristics (size and decay class), 5% for forest naturalness, and 9% for the random effect of the site. Considering only associations that had at least 95% posterior support, the occurrence probability of 86 species increased and of 0 species decreased with the size of the log, 16 species preferred decay class 3 and 11 species decay class 2, and the occurrence probability of 10 species increased and of 1 species decreased with the increasing value of the naturalness index.

Among the 293 species that occurred at least four times in the data, 66 were generalists, 95 broadleaved generalists, 30 birch specialists, 14 aspen specialists, 41 coniferous specialists, 27 spruce specialists and 20 pine specialists (Fig. 2).

Effects of morphological traits on the responses to the environment

The traits explained 7% of the variation in the species responses to the environmental variables. The posterior mean of the phylogenetic signal parameter ρ was 0.20 and its 95% credibility interval was [0.11, 0.35]. As the prior for ρ has probability mass of 0.5 at $\rho = 0$ (no phylogenetic signal) and the remaining probability is distributed evenly in [0, 1], the model revealed a moderate but statistically well supported phylogenetic signal in species responses to environmental covariates. In other words, phylogenetically (taxonomically) related species showed more similar responses to the environmental covariates than could be predicted solely based on their traits. We recorded a large number of non-random associations between host-tree use and fruitbody type (Fig. 3). In particular, species with resupinate fruitbodies were typically conifer generalists, while species with pileate fruitbodies were often specialized to spruce. Species with discomycetoid fruitbody were typically broadleaved generalists, whereas species with pyrenomycetoid fruitbodies were often birch specialists.

The fungal species occurring on broadleaved dead wood had on the average larger spores than those occurring on coniferous dead wood (Fig. 4A). The fungal species occurring on aspen had the most elongated spores, whereas those occurring on spruce had the most spherical spores (Fig. 4B). The proportion of species with ornamented spores varied between 12% and 16% on all host trees, with birch having the largest and spruce the smallest proportion of species with ornamented spores (Fig. 4C). Larger logs had larger and more spherical spores, whereas smaller logs had smaller and more elongated spores (Fig. 4D-E). Spore ornamentation did not vary with log size (Fig. 4F).

DISCUSSION

Our study shows that the occurrence of fungal species in dead wood of different characteristics relates to the morphological traits of the fungal fruitbodies and sexual spores. While it is well known that many wood-inhabiting fungal species are specialized to certain host-tree species (Berglund et al., 2011; Küffer et al., 2008; Stokland et al., 2004; Stokland, 2012a), to our knowledge, this is the first time that the importance of the fruitbody and spore morphology in determining host-tree specialization is revealed. We next discuss in turn, how and why fruitbody and spore morphology are linked to host-tree identity.

Specialization to host-tree species was related to fruitbody morphology. In line with our hypothesis that species developing small-sized fruitbodies from the Ascomycota lineages are more prevalent on broadleaved wood, we found discomycetes to be specialized to broadleaved trees in general, and pyrenomycetes to birch in particular. This association may relate to the fact that broadleaved dead wood generally holds higher proportions of bark, which is possible to decompose only through the so called soft-rot carried out by some Ascomycota species (Stokland, 2012b). While we expected species with pileate and resupinate fruitbodies to be equally prevalent in broadleaved and coniferous wood, we found resupinate species to be specialized to conifer tree species in general and pileates to spruce in particular. Because of the small-scale of our study (forests from central Finland), it remains to be tested by larger scale studies whether this is a general pattern in wood-inhabiting fungal communities.

Our results also revealed an association between host tree species and spore size. Fungal species on broadleaved trees had on average larger spores than those inhabiting conifers. This result is in line with Kauserud et al. (2008) who found that polypore species inhabiting broadleaved dead wood had significantly larger spores than species inhabiting coniferous dead wood. They speculated that because coniferous trees are evolutionary older, their wood is easier to penetrate and thus colonizing spores do not need as much energy and inoculum potential as spores colonizing broadleaved trees. Our results show that this may also relate to the relationship between fruitbody morphology and spore size, as pyrenomycetoids had on average the largest and most elongated spores, and they were also as a group specialized on broadleaved trees (birch in particular).

We expected aspen dead trees to hold species with smaller spores, because these trees show clustered and isolated distributional patterns in the boreal forest landscape, and smaller spores are able to disperse larger distances (Norros et al., 2014). Yet, our results showed the contrary, the fungal species occurring on broadleaved dead wood having on average larger, and more specifically more elongated, spores. Some studies have suggested that spore elongation increases attachment to substrate (Calhim et al., 2018; Ingold, 1965). It remains to be tested what is the primary reason pushing larger spore size on species inhabiting broadleaved trees.

Considering the relationship between log characteristics and spore morphology, previous studies have reported weak and/or contrasting results (e. g. Nordén et al. 2013; Abrego et al. 2017). Interestingly, we found a clear relationship between spore size and shape and the log size. Species with spherical and large spores preferred large logs, whereas species with elongated and small spores preferred smaller logs. Bässler et al. (2014) hypothesized that wood-inhabiting fungal species with smaller and more elongated spores, follow the *r* reproductive strategy (sensu Grime 1988), and thus cope better in managed environments where dead wood items are typically smaller. We cannot conclude how spore morphology relates to the *K*/*r* reproductive strategy since we did not collect data about spore production. Yet, our results are in line with Bässler et al.'s (2014) hypothesis that species with smaller and more elongated spores occur more often in smaller dead trees; thus, their proportion can be expected to be higher in forests where most dead wood is small due to management actions (Abrego and Salcedo, 2013; Eräjää et al., 2010).

Spore ornamentation is not likely to influence airborne dispersal substantially (Hussein et al., 2013) but may be important for attaching to animal vectors for dispersal. Especially mycorrhizal species are characterized by ornamented spore walls (Halbwachs et al., 2015), which are suggested to aid in transportation to deeper soil layers via arthropod vectors (Calhim et al., 2018). As mycorrhizal species only utilize decaying logs for attaching their fruitbodies, it is logical that we did not find clear differences in spore ornamentation frequency between different tree species. However, the role of mycorrhizal fungi might be minor in the present study. The rationale is that the occurrence of mycorrhizal wood-inhabiting fungal species increases in the last decay stages (Mäkipää et al., 2017; Rajala et al., 2015), and our study included only intermediate decay stages. Moreover, the proportion of species with ornamented spores was equal in totally saprotrophic groups (ramarioids and stromatoids) and a group encompassing many mycorrhizal fungi (resupinates) (Kotiranta et al., 2009). However, we treated ornamentation as a bipartite yes/no variable although we acknowledge that there is a lot of variation within the different types of ornamentation and the role of different ornamentation types deserves more research attention.

We note that the vast majority of the variation in species occurrences at the level of logs was not explained by the fitted model. This result is in accordance with previous studies from temperate Europe (Abrego et al., 2017, 2014; Bässler et al., 2012), which concluded that random processes dominate in shaping wood-inhabiting fungal communities at small spatial scales. Most fungal species were rare (55% occurring three or fewer times), which is a common feature of ecological communities in which random processes are dominating (Vellend, 2016; White et al., 2006). However, there might be many other variables we did not include, but which could have improved the models predictive power, such as microclimatic factors or direct measurements on wood composition such as C/N ratio. This result was also partially influenced by the fact that we conducted only two surveys, one in each of the peak fruiting season in boreal forests (Abrego et al., 2016; Halme and Kotiaho, 2012; Purhonen et al., 2017). Since many wood-inhabiting fungi have ephemeral fruitbodies, repeating surveys over several years in the peak fruiting seasons would have decreased the proportion of rare species and thus increased the predictive power of our model. Also molecular surveys of mycelia would have possibly decreased the proportion of rare species and increased predictability of their occurrence (e.g. Kubartová *et al.* 2012; Mäkipää *et al.* 2017). However, in comparison to molecular surveys, fruitbody based surveys provide direct information about the "breeding" populations of fungi. As a large portion of the species groups in the present study is taxonomically poorly known, some of the results should be considered with caution. For example *Mollisia* sp., which were found to share several host-tree species, might indeed be specialized in different host trees (see also Runnel *et al.* 2014).

We found that broadleaved dead trees hold higher species richness than coniferous dead trees. In particular, aspen hosted the highest and pine the lowest species richness. Higher species richness in broadleaved trees may result from the lack of defensive chemicals that conifer tree species have, making them easier to colonize and decay (Hoppe et al., 2016; Stokland, 2012a). However, fungal fruiting patterns may differ between tree species, and thus to observe the true differences in species richness between tree species, fruitbody surveys should be accompanied with molecular data of mycelia within wood. Furthermore, different tree species have different residence times, and thus the total species richness may be higher for tree species with longer life-span as a log.

Conclusions

Our study showed that the occurrence of fungal species in dead wood of different characteristics is related to the morphological traits of fungi. Our results also revealed that specialization to host-tree species occurs at the level of fruitbody morphological groups, and that the size and shape of the fungal spores relate to the preference for logs of different sizes.

Acknowledgements

We are grateful to Katja Juutilainen for contributing to the fungal surveys, Titta Kauppinen for help with dead wood and trait data collection and Leena Nikolajev-Wikström for trait data collection. Anni Rintoo, Jorma Pennanen, Matti Kulju, Unto Söderholm, Timo Kosonen and Tea von Bonsdorff helped with identification of difficult fungal specimens. We want to thank also Panu Kuokkanen from Metsähallitus for providing the forest age information of the study sites. We also thank the two anonymous reviewers for their constructive comments on an earlier version of the manuscript. This study was funded by the Ministry of the Environment (PUTTE grant to Halme), the Finnish Foundation of Nature Conversation and the Finnish Cultural Foundation (grants to Purhonen), Academy of Finland (grants 309581 and 284601 to Ovaskainen and grant 308651 to Nerea Abrego), Jane and Aatos Erkko Foundation (grant to Ovaskainen), and Research Council of Norway through its Centres of Excellence Funding Scheme (223257) to Ovaskainen via Centre for Biodiversity Dynamics.

REFERENCES

Abrego, N., García-Baquero, G., Halme, P., Ovaskainen, O., Salcedo, I., 2014. Community turnover of wood-inhabiting fungi across hierarchical spatial scales. PLoS One 9, e103416. https://doi.org/10.1371/journal.pone.0103416

Abrego, N., Halme, P., Purhonen, J., Ovaskainen, O., 2016. Fruit body based inventories in wood-inhabiting fungi: Should we replicate in space or time? Fungal Ecol. 20, 225–232. https://doi.org/10.1016/j.funeco.2016.01.007

Abrego, N., Norberg, A., Ovaskainen, O., 2017. Measuring and predicting the influence of traits on the assembly processes of wood-inhabiting fungi. J. Ecol. https://doi.org/10.1111/1365-2745.12722

Abrego, N., Salcedo, I., 2014. Response of wood-inhabiting fungal community to fragmentation in a beech forest landscape. Fungal Ecol. 8, 18–27. https://doi.org/10.1016/j.funeco.2013.12.007

Abrego, N., Salcedo, I., 2013. Variety of woody debris as the factor influencing wood-inhabiting fungal richness and assemblages: Is it a question of quantity or quality? For. Ecol. Manage. 291, 377–385. https://doi.org/10.1016/j.foreco.2012.11.025

Aguilar-Trigueros, C.A., Hempel, S., Powell, J.R., Anderson, I.C., Antonovics, J., Bergmann, J., Cavagnaro, T.R., Chen, B., Hart, M.M., Klironomos, J., Petermann, J.S., Verbruggen, E., Veresoglou, S.D., Rillig, M.C., 2015. Branching out: Towards a trait-based understanding of fungal ecology. Fungal Biol. Rev. 29, 34–41. https://doi.org/10.1016/j.fbr.2015.03.001

Ahti, T., Hämet-Ahti, L., Jalas, J., 1968. Vegetation zones and their sections in northwestern Europe. Ann. Bot. Fenn. 5, 169–211.

Bader, P., Jansson, S., Jonsson, B.G., 1995. Wood-inhabiting fungi and substratum decline in selectively logged boreal spruce forests. Biol. Conserv. 72, 355–362. https://doi.org/10.1016/0006-3207(94)00029-P

Bässler, C., Ernst, R., Cadotte, M., Heibl, C., Müller, J., 2014. Near-to-nature logging influences fungal community assembly processes in a temperate forest. J. Appl. Ecol. 51, 939–948. https://doi.org/10.1111/1365-2664.12267

Bässler, C., Müller, J., Cadotte, M.W., Heibl, C., Bradtka, J.H., Thorn, S., Halbwachs, H., Forest, B., Park, N., Str, F., 2016. Functional response of lignicolous fungal guilds to bark beetle deforestation. Ecol. Indic. 65, 149–160. https://doi.org/10.1016/j.ecolind.2015.07.008

Bässler, C., Müller, J., Dziock, F., Brandl, R., 2010. Effects of resource availability and climate on the diversity of wood-decaying fungi. J. Ecol. 98, 822–832. https://doi.org/10.1111/j.1365-2745.2010.01669.x

Bässler, C., Müller, J., Svoboda, M., Lepšová, A., Hahn, C., Holzer, H., Pouska, V., 2012. Diversity of wood-decaying fungi under different disturbance regimes-A case study from spruce mountain forests. Biodivers. Conserv. 21, 33–49. https://doi.org/10.1007/s10531-011-0159-0

Berglund, H., Hottola, J., Penttilä, R., Siitonen, J., 2011. Linking substrate and habitat requirements of wood-inhabiting fungi to their regional extinction vulnerability. Ecography (Cop.). 34, 864–875. https://doi.org/10.1111/j.1600-0587.2010.06141.x

Boddy, L., Frankland, J.C., van West, P. (Eds.), 2008. Ecology of saprotrophic basidiomycetes. Elsevier Ltd, London.

Boddy, L., Heilmann-Clausen, J., 2008. Basidiomycete community development in temperate angiosperm wood, in: Boddy, L., Frankland, J.C., van West, P. (Eds.), Ecology of Saprotrophic Basidiomycetes. Elsevier, London, pp. 211–237.

Caiafa, M. V., Gómez-Hernández, M., Williams-Linera, G., Ramírez-Cruz, V., 2017. Functional diversity of macromycete communities along an environmental gradient in a Mexican seasonally dry tropical forest. Fungal Ecol. 28, 66–75. https://doi.org/10.1016/j.funeco.2017.04.005

Cajander, A.K., 1949. Forest types and their significance. Acta For. Fenn. 56, 1–69.

Calhim, S., Halme, P., Petersen, J.H., Læssøe, T., Bässler, C., Heilmann-Clausen, J., 2018. Fungal spore diversity reflects substrate-specific deposition challenges. Sci. Rep. 8, 1–9. https://doi.org/10.1038/s41598-018-23292-8

Crowther, T.W., Maynard, D.S., Crowther, T.R., Peccia, J., Smith, J.R., Bradford, M. a, 2014. Untangling the fungal niche: the trait-based approach. Front. Microbiol. 5, 579. https://doi.org/10.3389/fmicb.2014.00579

Dawson, S.K., Boddy, L., Halbwachs, H., Bässler, C., Crowther, T.W., Heilmann-Clausen, J., Nordén, J., Ovaskainen, O., Jönsson, M., 2018. Handbook for standardised measurement of macrofungal functional traits; a start with basidiomycete wood fungi. Funct. Ecol. doi: 10.1111/1365-2435.13239. https://doi.org/10.1111/1365-2435.13239

Dowding, P., 1981. Nutrient uptake and allocation during substrate exploitation by fungi, in: Wicklow, D.T., Carroll, G.C. (Eds.), The Fungal Community. Its Organization and Role in the Ecosystems. Marcel Dekker Inc, New York, pp. 612–636.

Edman, M., Kruys, N., Jonsson, B.G., 2004. Local Dispersal Sources Strongly Affect Colonization Patterns of Wood-Decaying Fungi on Spruce Logs. Ecol. Appl. 14, 893–

901.

Eräjää, S., Halme, P., Kotiaho, J.S., Markkanen, A., Toivanen, T., 2010. The volume and composition of dead wood on traditional and forest fuel harvested clear-cuts. Silva Fenn. 44, 203–211. https://doi.org/10.14214/sf.150

Esseen, P.A., Ehnström, B., Ericson, L., Sjöberg, K., 1997. Boreal forests. Ecol. Bull. 46, 16–47.

Grime, J.P., 1988. The C-S-R model of primary plant strategies – origins, implications and tests, in: Gottlieb, L.D., Jain, S. (Eds.), Plant Evolutionary Biology. Chapman and Hall, London, pp. 371–393.

Halbwachs, H., Brandl, R., Bässler, C., 2015. Spore wall traits of ectomycorrhizal and saprotrophic agarics may mirror their distinct lifestyles. Fungal Ecol. 17, 197–204. https://doi.org/10.1016/j.funeco.2014.10.003

Halme, P., Kotiaho, J.S., 2012. The importance of timing and number of surveys in fungal biodiversity research. Biodivers. Conserv. 21, 205–219. https://doi.org/10.1007/s10531-011-0176-z

Heilmann-Clausen, J., Aude, E., van Dort, K., Christensen, M., Piltaver, A., Veerkamp, M., Walleyn, R., Siller, I., Standovár, T., Ódor, P., 2014. Communities of wood-inhabiting bryophytes and fungi on dead beech logs in Europe - reflecting substrate quality or shaped by climate and forest conditions? J. Biogeogr. 41, 2269–2282. https://doi.org/10.1111/jbi.12388

Heilmann-Clausen, J., Christensen, M., 2005. Wood-inhabiting macrofungi in Danish beech-forests ? conflicting diversity patterns and their implications in a conservation perspective. Biol. Conserv. 122, 633–642. https://doi.org/10.1016/j.biocon.2004.10.001

Hoppe, B., Purahong, W., Wubet, T., Kahl, T., Bauhus, J., Arnstadt, T., Hofrichter, M., Buscot, F., Krüger, D., 2016. Linking molecular deadwood-inhabiting fungal diversity and community dynamics to ecosystem functions and processes in Central European forests. Fungal Divers. 77, 367–379. https://doi.org/10.1007/s13225-015-0341-x

Hussein, T., Norros, V., Hakala, J., Petäjä, T., Aalto, P.P., Rannik, Ü., Vesala, T., Ovaskainen, O., 2013. Species traits and inertial deposition of fungal spores. J. Aerosol Sci. 61, 81–98. https://doi.org/10.1016/j.jaerosci.2013.03.004

Ingold, C.T., 1965. Spore liberation. Oxford University Press, Oxford.

International Mycological Association, 2017. Mycobank [WWW Document]. http://www.mycobank.org/.

Juutilainen, K., Mönkkönen, M., Kotiranta, H., Halme, P., 2017. Resource use of wood-inhabiting fungi in different boreal forest types. Fungal Ecol. 27, 96–106. https://doi.org/10.1016/j.funeco.2017.03.003

Kahl, T., Arnstadt, T., Baber, K., Bässler, C., Bauhus, J., Borken, W., Buscot, F., Floren, A., Heibl, C., Hessenmöller, D., Hofrichter, M., Hoppe, B., Kellner, H., Krüger, D., Linsenmair, K.E., Matzner, E., Otto, P., Purahong, W., Seilwinder, C., Schulze, E.D., Wende, B., Weisser, W.W., Gossner, M.M., 2017. Wood decay rates of 13 temperate tree species in relation to wood properties, enzyme activities and organismic diversities. For. Ecol. Manage. 391, 86–95. https://doi.org/10.1016/j.foreco.2017.02.012

Kauserud, H., Colman, J.E., Ryvarden, L., 2008. Relationship between basidiospore size, shape and life history characteristics: a comparison of polypores. Fungal Ecol. 1, 19–23. https://doi.org/10.1016/j.funeco.2007.12.001

Kauserud, H., Heegaard, E., Halvorsen, R., Boddy, L., Høiland, K., Chr. Stenseth, N., 2011. Mushroom's spore size and time of fruiting are strongly related: Is moisture important? Biol. Lett. 7, 273–276. https://doi.org/10.1098/rsbl.2010.0820

Kotiranta, H., Saarenoksa, R., Kytövuori, I., 2009. Aphyllophoroid fungi of Finland. A check-list with ecology, distribution, and threat categories. Norrlinia 19, 1–223.

Krah, F.S., Bässler, C., Heibl, C., Soghigian, J., Schaefer, H., Hibbett, D.S., 2018a. Evolutionary dynamics of host specialization in wood-decay fungi. BMC Evol. Biol. 18, 1–13. https://doi.org/10.1186/s12862-018-1229-7

Krah, F.S., Seibold, S., Brandl, R., Baldrian, P., Müller, J., Bässler, C., 2018b. Independent effects of host and environment on the diversity of wood-inhabiting fungi. J. Ecol. 1–15. https://doi.org/10.1111/1365-2745.12939

Kruys, N., Fries, C., Jonsson, B.G., Lämås, T., Ståhl, G., 1999. Wood-inhabiting cryptogams on dead Norway spruce (Picea abies) trees in managed Swedish boreal forests. Can. J. For. Res. 29, 178–186. https://doi.org/10.1139/x98-191

Kubartová, A., Ottosson, E., Dahlberg, A., Stenlid, J., 2012. Patterns of fungal communities among and within decaying logs, revealed by 454 sequencing. Mol. Ecol. 21, 4514–4532. https://doi.org/10.1111/j.1365-294X.2012.05723.x

Küffer, N., Gillet, F., Senn-Irlet, B., Aragno, M., Job, D., 2008. Ecological determinants of fungal diversity on dead wood in European forests. Fungal Divers. 30, 83–95.

Lindblad, I., 2001. Diversity of poroid and some corticoid wood-inhabiting fungi along the rainfall gradient in tropical forests, Costa Rica. J. Trop. Ecol. 17, 353–369.

Lõhmus, A., 2011. Silviculture as a disturbance regime: The effects of clear-cutting, planting and thinning on polypore communities in mixed forests. J. For. Res. 16, 194–202. https://doi.org/10.1007/s10310-011-0256-7

Lumley, T.C., Gignac, L.D., Currah, R.S., 2001. Microfungus communities of white spruce and trembling aspen logs at different stages of decay in disturbed and undisturbed sites in the boreal mi×edwood region of Alberta. Can. J. Bot. 79, 76–92. https://doi.org/10.1139/cjb-79-1-76

Mäkipää, R., Rajala, T., Schigel, D., Rinne, K.T., Pennanen, T., Abrego, N., Ovaskainen, O., 2017. Interactions between soil- and dead wood-inhabiting fungal communities during the decay of Norway spruce logs. ISME J. 11, 1964–1974. https://doi.org/10.1038/ismej.2017.57

McGill, B.J., Enquist, B.J., Weiher, E., Westoby, M., 2006. Rebuilding community ecology from functional traits. Trends Ecol. Evol. 21, 178–185. https://doi.org/10.1016/j.tree.2006.02.002

Nordén, J., Penttilä, R., Siitonen, J., Tomppo, E., Ovaskainen, O., 2013. Specialist species of wood-inhabiting fungi struggle while generalists thrive in fragmented boreal forests. J. Ecol. 101, 701–712. https://doi.org/10.1111/1365-2745.12085

Norros, V., Karhu, E., Nordén, J., Vähätalo, A. V., Ovaskainen, O., 2015. Spore sensitivity to sunlight and freezing can restrict dispersal in wood-decay fungi. Ecol. Evol. 5, 3312–3326. https://doi.org/10.1002/ece3.1589

Norros, V., Rannik, Ü., Hussein, T., Petäjä, T., Vesala, T., Ovaskainen, O., 2014. Do small spores disperse further than large spores? Ecology 95, 1612–1621. https://doi.org/10.1890/13-0877.1

Ordynets, A., Heilmann-Clausen, J., Savchenko, A., Bässler, C., Volobuev, S., Akulov, O., Karadelev, M., Kotiranta, H., Saitta, A., Langer, E., Abrego, N., 2018. Do plant-based biogeographical regions shape aphyllophoroid fungal communities in Europe? J. Biogeogr. 45, 1182–1195. https://doi.org/10.1111/jbi.13203

Ottosson, E., Kubartova, A., Edman, M., Jönsson, M., Lindhe, A., Stenlid, J., Dahlberg, A., 2015. Diverse ecological roles within fungal communities in decomposing logs of Picea abies. FEMS Microbiol. Ecol. 91, 1–13. https://doi.org/10.1093/femsec/fiv012

Ovaskainen, O., Abrego, N., Halme, P., Dunson, D., 2016. Using latent variable models to identify large networks of species-to-species associations at different spatial scales. Methods Ecol. Evol. 7, 549–555. https://doi.org/10.1111/2041-210X.12501

Ovaskainen, O., Tikhonov, G., Norberg, A., Guillaume Blanchet, F., Duan, L., Dunson, D., Roslin, T., Abrego, N., 2017. How to make more out of community data? A conceptual framework and its implementation as models and software. Ecol. Lett. 20, 561–576. https://doi.org/10.1111/ele.12757

Peay, K.G., Kennedy, P.G., Bruns, T.D., 2008. Fungal community ecology: A hybrid beast with a molecular master. Bioscience 58, 799–810.

Pouska, V., Macek, P., Zíbarová, L., Ostrow, H., 2017. How does the richness of wood-decaying fungi relate to wood microclimate? Fungal Ecol. 27, 178–181. https://doi.org/10.1016/j.funeco.2016.06.006

Purhonen, J., Huhtinen, S., Kotiranta, H., Kotiaho, J.S., 2017. Detailed information on fruiting phenology provides new insights on wood-inhabiting fungal detection. Fungal Ecol. 27, 175–177. https://doi.org/10.1016/j.funeco.2016.06.007

Rajala, T., Peltoniemi, M., Pennanen, T., Mäkipää, R., 2010. Relationship between wood-inhabiting fungi determined by molecular analysis (denaturing gradient gel electrophoresis) and quality of decaying logs. Can. J. For. Res. 40, 2384–2397. https://doi.org/10.1139/X10-176

Rajala, T., Tuomivirta, T., Pennanen, T., Mäkipää, R., 2015. Habitat models of wood-inhabiting fungi along a decay gradient of Norway spruce logs. Fungal Ecol. 18, 48–55. https://doi.org/10.1016/j.funeco.2015.08.007

Renvall, P., 1995. Community structure and dynamics of wood-rotting Basidiomycetes on decomposing conifer trunks in northern Finland. Karstenia 35, 1–51.

Royal Botanic Gardens Kew, Landcare Research-NZ, Chinese Academy of Science, 2017. Index fungorum [WWW Document]. www.indexfungorum.org.

Royal Botanic Gardens Kew, Landcare Research-NZ, Chinese Academy of Science, 2015. Index Fungorum [WWW Document]. www.indexfungorum.org.

Runnel, K., Põldmaa, K., Lõhmus, A., 2014. “Old-forest fungi” are not always what they seem:

The case of Antrodia crassa. Fungal Ecol. 9, 27–33. https://doi.org/10.1016/j.funeco.2014.02.006

Ruokolainen, A., Shorohova, E., Penttilä, R., Kotkova, V., Kushnevskaya, H., 2018. A continuum of dead wood with various habitat elements maintains the diversity of wood-inhabiting fungi in an old-growth boreal forest. Eur. J. For. Res. https://doi.org/10.1007/s10342-018-1135-y. https://doi.org/10.1007/s10342-018-1135-y

Siitonen, J., 2001. Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example. Ecol. Bull. 49, 11–41.

Sippola, A.-L., Lehesvirta, T., Renvall, P., 2001. Effect of selective logging on coarse woody debris and diversity of wood-decaying polypores in eastern Finland. Ecol. Bull. 49, 243–254.

Sippola, A.L., Renvall, P., 1999. Wood-decomposing fungi and seed-tree cutting: A 40-year perspective. For. Ecol. Manage. 115, 183–201. https://doi.org/10.1016/S0378-1127(98)00398-3

Stokland, J.N., 2012a. Host-tree associattions, in: Stokland, J.N., Siitonen, J., Jonsson, B.G. (Eds.), Biodiversity in Dead Wood. Cambridge University Press, Cambridge, pp. 82–109.

Stokland, J.N., 2012b. Wood decomposition, in: Stokland, J.N., Siitonen, J., Jonsson, B.G. (Eds.), Biodiversity in Dead Wood. Cambridge University Press, Cambridge, pp. 10–28.

Stokland, J.N., Siitonen, J., Jonsson, B.G., 2012. Biodiversity on dead wood. Cambridge University Press, Cambridge.

Stokland, J.N., Tomter, S.M., Söderberg, U., 2004. Development of dead wood indicators for biodiversity monitoring: experiences from Scandinavia, in: Marchetti, M. (Ed.), Monitoring and Indicators of Forest Biodiversity in Europe, from Ideas to Operationality. EFI-Proceedings No. 51, pp. 207–226.

Tikhonov, G., Opedal, Ø., Lehikoinen, A., Ovaskainen, O., 2019. Joint species distribution modelling with HMSC-R. bioRxiv.

Tjur, T., 2009. Coefficients of determination in logistic regression models - A new proposal: The coefficient of discrimination. Am. Stat. 63, 366–372. https://doi.org/10.1198/tast.2009.08210

Vellend, M., 2016. The theory of ecological communities. Princeton University Press, New Jersey.

Warton, D.I., Blanchet, F.G., O'Hara, R.B., Ovaskainen, O., Taskinen, S., Walker, S.C., Hui, F.K.C., 2015. So Many Variables: Joint Modeling in Community Ecology. Trends Ecol. Evol. 30, 766–779. https://doi.org/10.1016/j.tree.2015.09.007

Weiher, E., Freund, D., Bunton, T., Stefanski, A., Lee, T., Bentivenga, S., 2011. Advances, challenges and a developing synthesis of ecological community assembly theory. Philos. Trans. R. Soc. B Biol. Sci. 366, 2403–2413. https://doi.org/10.1098/rstb.2011.0056

White, E.P., Adler, P.B., Lauenroth, W.K., Gill, R.A., Greenberg, D., Kaufman, D.M., Rassweiler, A., Rusak, J.A., Smith, M.D., Steinbeck, J.R., Waide, R.B., Yao, J., 2006. A comparison of the species time relationship across ecosystems and taxonomic groups. Oikos 112, 185–195. https://doi.org/10.1111/j.0030-1299.2006.14223.x

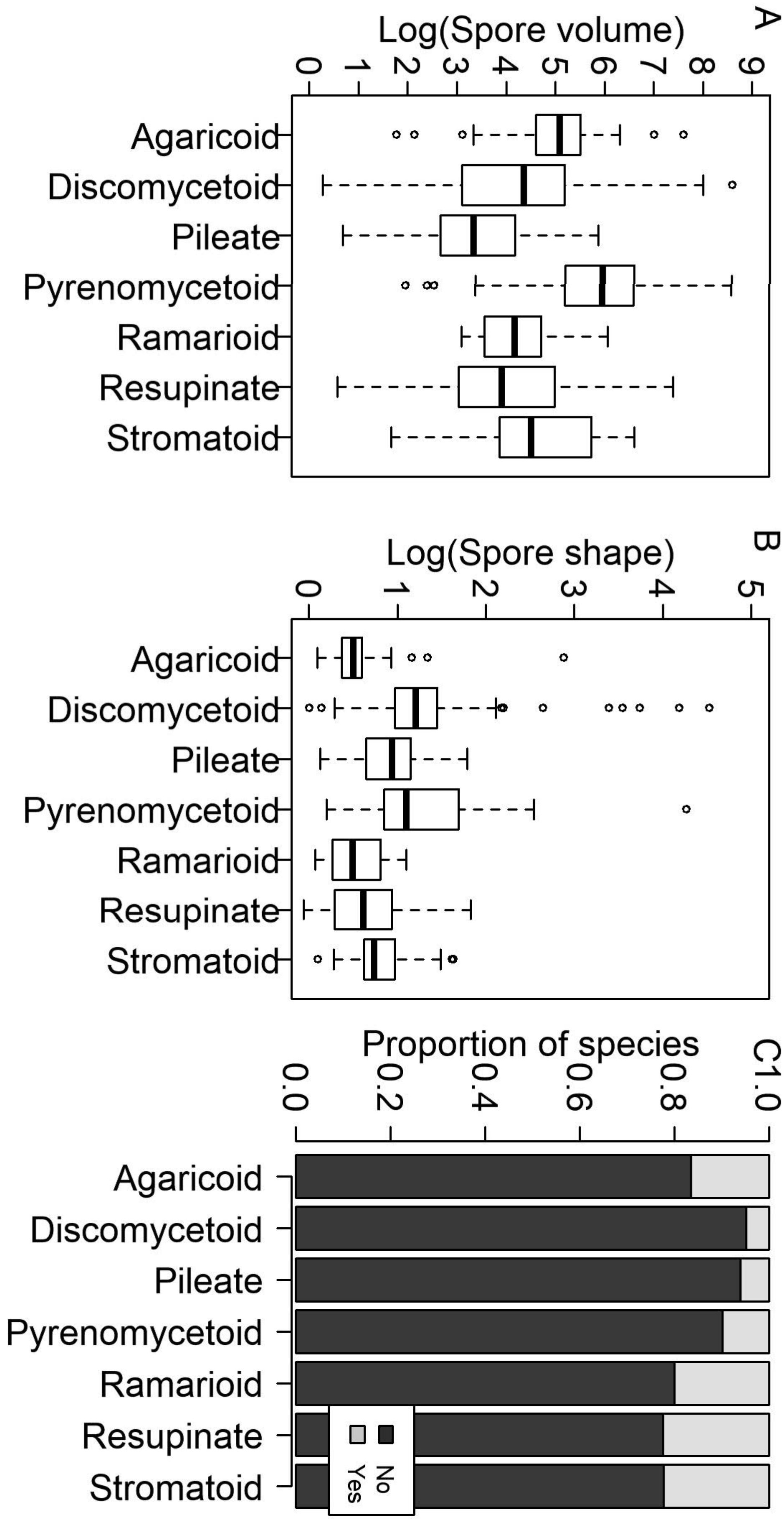
Figure captions:

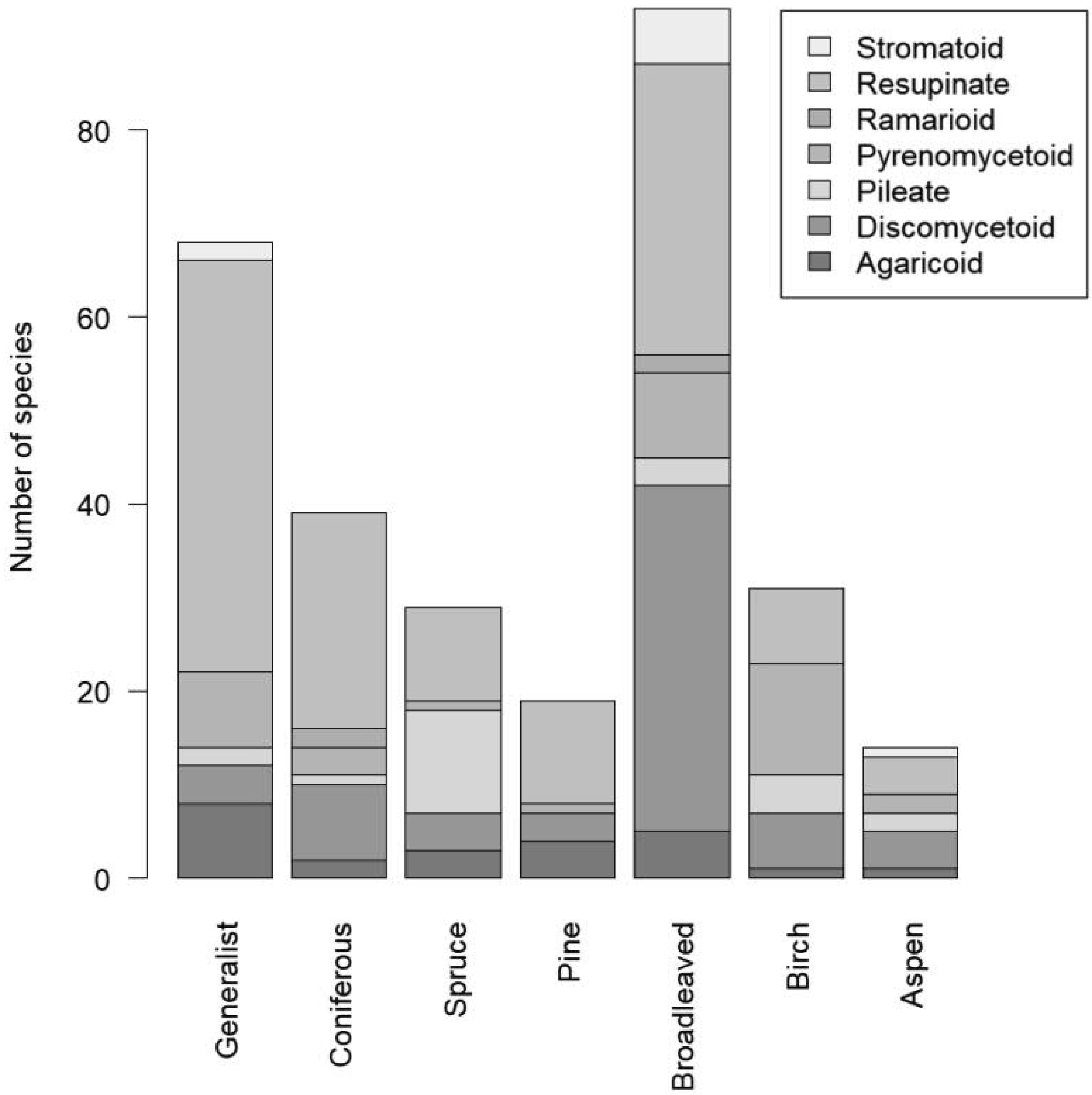
Fig. 1 Relationship between spore morphological traits and fruitbody types. The relationship between (A) the fruitbody type and spore volume, (B) spore shape, (C) and spore ornamentation.

Fig. 2 Numbers of host-tree generalist and specialist fungal species. The bars show the numbers of fungal species classified to the seven host-tree specialization classes, with colours representing different fruitbody types. Note that the figure includes only those species that occur at least four times in the data, as reliable classification for host-tree specialization is not possible for rare species.

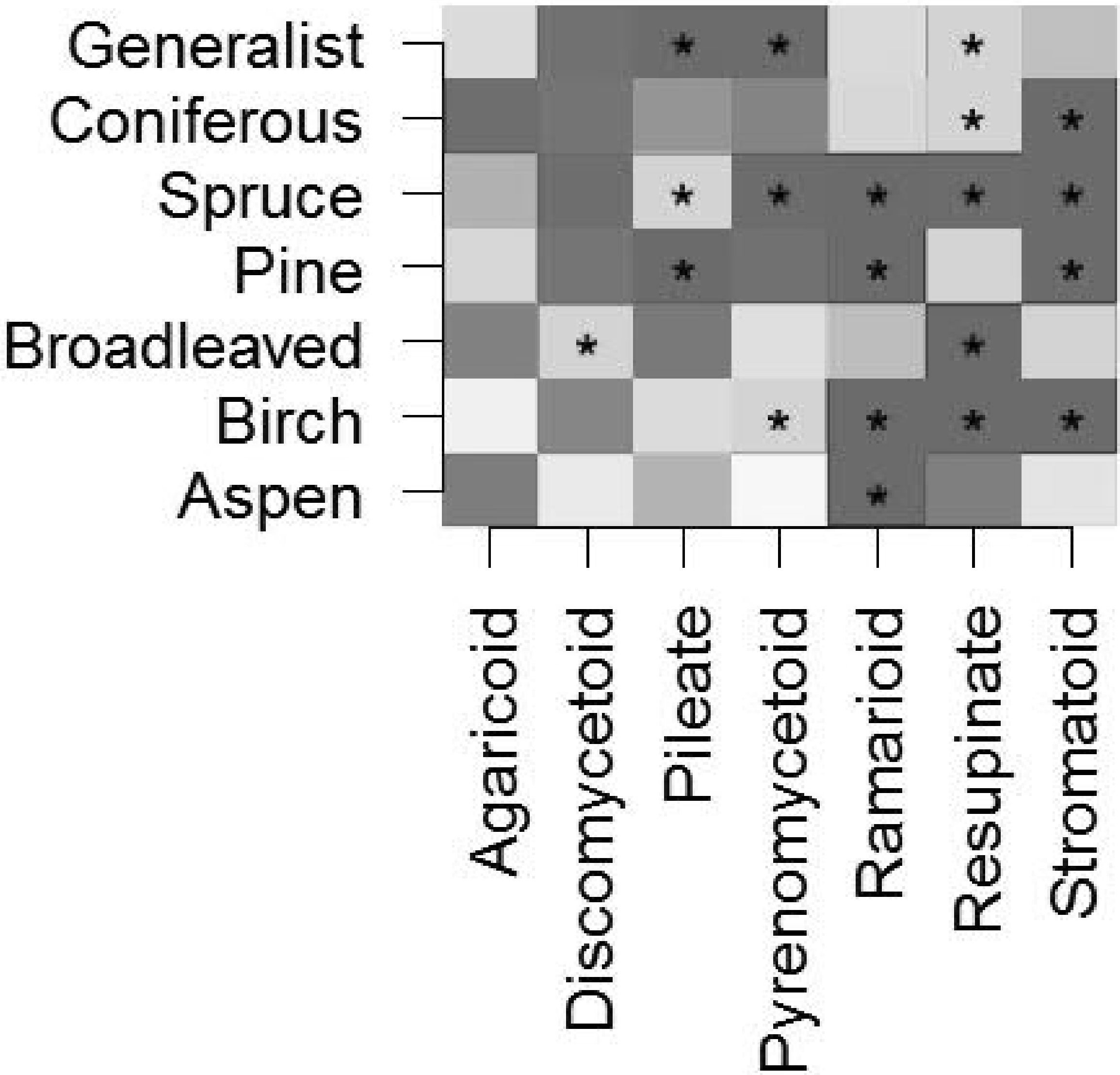
Fig. 3 Host-tree specialization-level of fungi with different fruitbody types. Green colours (respectively, red colours) indicate that the fungal species groups have a given host-tree classification more often (respectively, less often) than expected by random, the asterisks indicating those results that are supported by at least 95% posterior probability. Note that this analysis is restricted to those species that occur at least 4 times in the data.

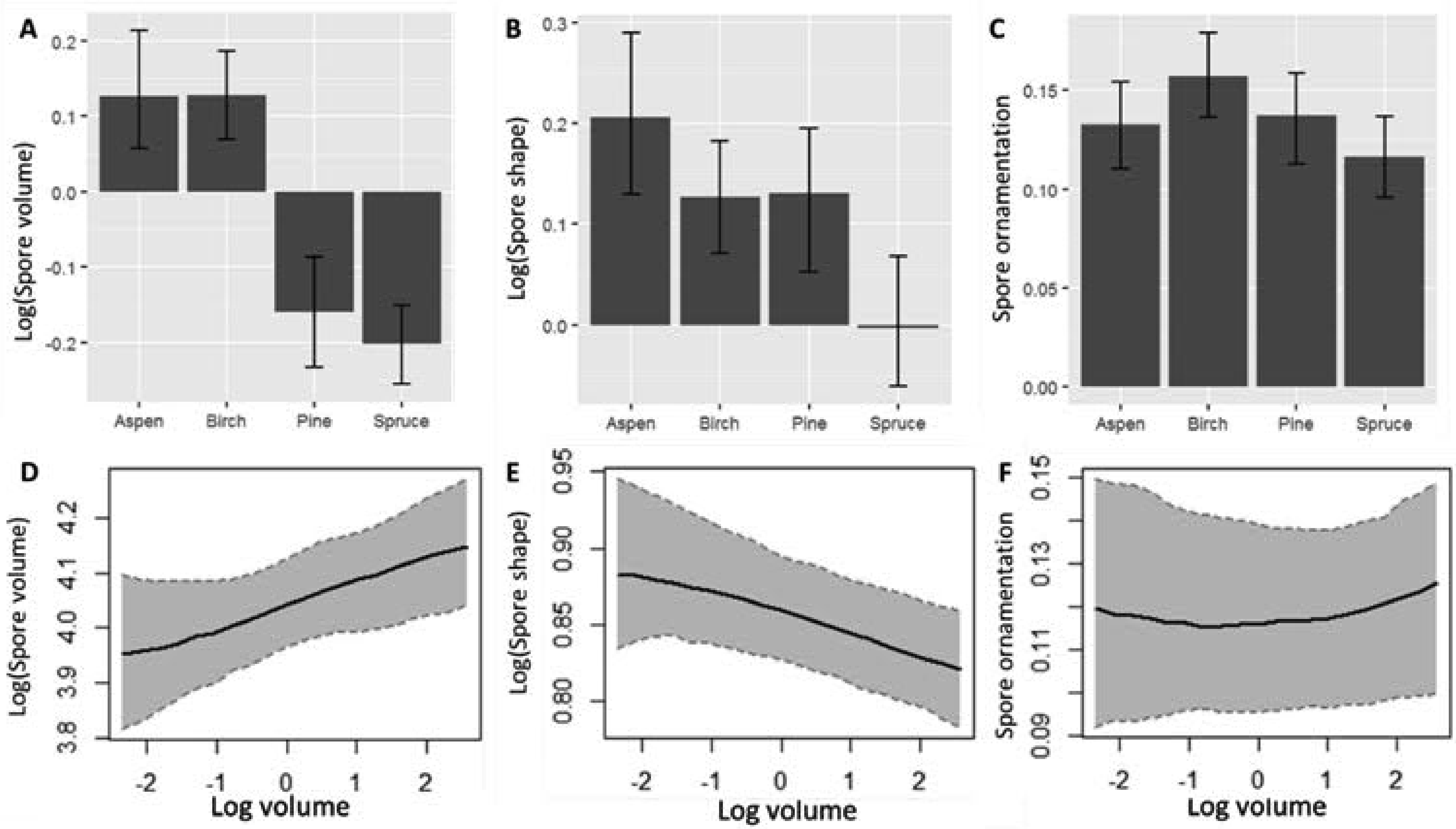
Fig. 4 Community-weighted mean spore trait values for different host-tree species (panels A-C) and for logs of different sizes (panels D-F). The first column shows the mean spore volume, the second column shows the mean spore shape, and the third column shows the mean proportions of species with ornamented spores. The error bars (panels A-C) and shaded areas (panels D-F) show the 95% credibility interval.


A
Log(Spore volume)
0
1
2
3
4
5
6
7
8
9
Agaricoid
Discomycetoid
Pileate
Pyrenomycetoid
Ramarioid
Resupinate
Stromatoid
B
Log(Spore shape)
0
1
2
3
4
5
Agaricoid
Discomycetoid
Pileate
Pyrenomycetoid
Ramarioid
Resupinate
Stromatoid
C
Proportion of species
0.0
0.2
0.4
0.6
0.8
1.0
Agaricoid
Discomycetoid
Pileate
Pyrenomycetoid
Ramarioid
Resupinate
Stromatoid
No
Yes



Stromatoid
Resupinate
Ramarioid
Pyrenomycetoid
Pileate
Discomycetoid
Agaricoid
Number of species
0
20
40
60
80
Generalist
Coniferous
Spruce
Pine
Broadleaved
Birch
Aspen


Generalist
Coniferous
Spruce
Pine
Broadleaved
Birch
Aspen
Agaricoid
Discomycetoid
Pileate
Pyrenomycetoid
Ramarioid
Resupinate
Stromatoid


A
Log(Spore volume)
0.2
0.1
0.0
-0.1
-0.2
Aspen
Birch
Pine
Spruce
B
Log(Spore shape)
0.3
0.2
0.1
0.0
Aspen
Birch
Pine
Spruce
C
Spore ornamentation
0.15
0.10
0.05
0.00
Aspen
Birch
Pine
Spruce
D
Log(Spore volume)
4.2
4.1
4.0
3.9
3.8
-2
-1
0
1
2
Log volume
E
Log(Spore shape)
0.95
0.90
0.85
0.80
-2
-1
0
1
2
Log volume
F
Spore ornamentation
0.15
0.13
0.11
0.09
-2
-1
0
1
2
Log volume

Morphological traits predict host-tree specialization in wood-inhabiting fungal communities

Purhonen Jenna, Ovaskainen Otso, Halme Panu, Komonen Atte, Huhtinen Seppo, Kotiranta Heikki, Læssøe Thomas, & Abrego Nerea

Supplementary Material 1

Detailed description of the forest naturalness index

The study site naturalness was calculated based on the average age of the dominating forest cover (data received from the State Forest Enterprise of Finland), the average amount of dead wood per hectare, and the average number of stumps per hectare. The dead wood and stump data were collected from four to eight, 50 meter in length and 10 meter wide, randomly placed transects. The transects were situated in the same forest stands in which the logs were surveyed for fungi. The number of transects varied depending on the characteristics of the study site. If there was clear within-site variation in the forest types surrounding the study logs, we established 2-4 additional transects. The transects were inspected for all dead wood units larger than 15 cm at the base. We measured the length, base diameter and top diameter (this information was later used for calculating the volume of the dead wood with the formula of a truncated cone) for standing and grounded dead wood. We also recorded the number of stumps. Transect data was then used to count average values for each of the variables at the transect level. We divided these values by 0.05 for estimating the average values per hectare. The sites were then sorted according to each of the above variable separately and a score from 1 to 12 was given depending on the site position. Sites with higher average age, more dead wood and fewer stumps were given more points and considered being more natural. The points of each forest were summed up to form the “forest naturalness index” (Table 1).

Table 1 The age of dominating forest cover in years and amount of deadwood (m^3/ha) and number of stumps per hectare for each study site. Corresponding naturalness index-value for each site is the sum of the points. The sites are sorted according to their Index-values from most natural to least.

Site	Age / Deadwood / Stumps	Points	Index
Latokuusikko	173 / 334 / 0	11 / 12 / 12	35
Pyhä-Häkki	272 / 98 / 39	12 / 9 / 11	32
Kalajanvuori	140 / 100 / 64	9/ 10 / 10	29
Kuusimäki	140 / 171 / 110	8/ 11 / 6	25
Kivetty	132 / 86 / 103	6 / 8 / 8	22
Lortikka	150 / 32 / 96	10 / 1 / 9	20
Leivonmäki	135 / 67 / 135	7 / 6 / 4	17
Ilmakkamäki	124 / 65 / 117	5 / 5 / 5	15
Vuorilampi	116 / 81 / 199	3 / 7 / 3	13
Vaarunvuori	104 / 37 / 106	2 / 2 / 7	11
Hallinmäki	119 / 59 / 259	4 / 3 / 2	9
Tikkamäki	84 / 60 / 303	1 / 4 / 1	6

Morphological traits predict host-tree specialization in wood-inhabiting fungal communities

Purhonen Jenna, Ovaskainen Otso, Halme Panu, Komonen Atte, Huhtinen Seppo, Kotiranta Heikki, Læssøe Thomas, & Abrego Nerea

Supplementary material 2

TABLE 1 List of detected species or taxonomic groups in alphabetical order. The trait data are shown for fruitbody type (7 categories, see Methods), spore volume (μm^3, calculated with the formula of using species-specific mean spore length and width), shape (species-specific mean length of the spore divided by its width) and ornamentation (Yes, No). The information was extracted from literature (below) or by measuring/ observing by the authors.

Species or taxa name	Fruit body type	Volume	Shape	Orn	Birch	Spruce	Pine	Aspen	Total
Acanthostigma sp1.	Pyrenomycetoid	96.40	2.24	No	-	1	-	1	2
Acrogenospora carmichaeliana	Pyrenomycetoid	1948.28	2.14	No	-	-	-	1	1
Actidium hysterioides	Pyrenomycetoid	57.65	6.44	No	-	12	1	-	13
Alutaceodontia alutacea	Resupinate	14.97	4.24	No	-	8	3	2	13
Amphinema byssoides	Resupinate	22.09	1.80	No	37	19	2	34	92
Amphisphaerella dispersella	Pyrenomycetoid	1526.81	2.67	No	-	-	-	1	1
Amphisphaeria bertiana	Pyrenomycetoid	174.95	2.44	No	1	-	-	-	1
Amylocorticiellum cremeoisabellinum	Resupinate	57.73	1.71	No	-	-	-	1	1
Amylocorticiellum subillaqueatum	Resupinate	15.90	1.78	No	-	-	-	1	1
Amylocorticium cebennence	Resupinate	26.84	3.00	No	-	1	1	-	2
Amylocorticium pedunculatum	Resupinate	37.33	1.38	No	-	-	1	-	1
Amylocystis lapponica	Pileate	53.31	2.64	No	-	3	-	-	3
Amyloporia sinuosa	Resupinate	10.96	3.41	No	-	9	13	-	22
Amylostereum chailletii	Pileate	41.58	2.55	No	-	7	-	1	8
Amyloxenasma grisellum	Resupinate	32.67	2.00	No	-	2	1	2	5
Annulohypoxylon multiforme	Stromatoid	177.21	2.11	No	12	-	-	8	20
Antrodia albobrunnea	Resupinate	11.23	3.18	No	-	-	1	-	1
Antrodia macra	Resupinate	96.26	2.52	No	-	-	-	3	3
Antrodia pulvinascens	Resupinate	52.60	2.14	No	-	-	-	1	1
Antrodia serialis	Pileate	40.09	2.45	No	-	39	1	-	40
Antrodia xantha	Resupinate	7.27	3.03	No	-	1	9	-	10
Antrodiella pallescens	Resupinate	10.21	1.89	No	1	-	-	-	1
Antrodiella romellii	Resupinate	14.91	1.67	No	2	-	-	-	2
Aphanobasidium pseudotsugae	Resupinate	71.79	1.73	No	-	11	25	-	36
Arachnopeziza aurata	Discomycetoid	199.69	29.51	No	17	-	-	11	28
Arachnopeziza cf aranea	Discomycetoid	58.90	4.80	No	1	-	-	1	2
Arachnopeziza cornuta	Discomycetoid	50.31	4.94	No	15	-	-	18	33

Arachnopeziza joannea	Discomycetoid	71.57	4.63	No	-	-	-	1	1
Arachnopeziza sp nov	Discomycetoid	105.85	4.84	No	-	-	-	1	1
Arachnopeziza sp1.	Discomycetoid	226.19	4.50	No	-	1	1	-	2
Arachnopeziza sp3.	Discomycetoid	88.36	4.17	No	-	-	1	-	1
Armillaria borealis	Agaricoid	152.17	1.55	No	1	-	1	-	2
Arrhenia epichysium	Agaricoid	106.40	1.76	No	-	-	-	1	1
Artomyces cristatus	Ramarioid	288.63	1.07	No	-	-	1	-	1
Artomyces pyxidatus	Ramarioid	22.30	1.62	Yes	-	-	-	6	6
Ascocorticium anomalum	Resupinate	10.22	2.43	No	-	-	2	-	2
Ascocoryne cylichnium	Discomycetoid	571.28	3.83	No	34	11	5	25	75
Ascocoryne sarcoides	Discomycetoid	238.56	3.33	No	1	3	12	1	17
Asterodon ferruginosus	Resupinate	75.40	1.50	No	3	-	1	1	5
Asterostroma laxum	Resupinate	269.39	1.00	Yes	-	-	1	-	1
Athelia acrospora	Resupinate	37.12	2.27	No	-	2	-	-	2
Athelia decipiens	Resupinate	39.40	1.46	No	8	27	10	6	51
Athelia epiphylla coll	Resupinate	292.13	1.96	No	3	-	-	3	6
Athelia neuhoffii	Resupinate	124.04	1.47	No	4	12	4	5	25
Athelopsis glaucina	Resupinate	37.77	4.22	No	-	-	-	1	1
Athelopsis subinconspicua	Resupinate	99.30	1.65	No	1	11	-	2	14
Auricularia auricula-judae	Discomycetoid	221.51	2.63	No	-	2	-	-	2
Basidiodendron caesiocinereum	Resupinate	453.96	0.94	Yes	2	6	1	-	9
Basidiodendron cinereum	Resupinate	365.60	1.36	No	1	-	1	2	4
Basidioradulum crustosum	Resupinate	32.67	2.00	No	5	1	-	3	9
Bertia moriformis	Pyrenomycetoid	1038.69	6.96	No	7	23	7	16	53
Bisporella citrina	Discomycetoid	85.53	3.03	No	23	-	-	26	49
Bjerkandera adusta	Pileate	28.21	1.73	No	-	-	-	3	3
Boidinia furfuracea	Resupinate	98.17	1.00	Yes	-	1	1	-	2
Bolbitius reticulatus	Agaricoid	168.35	2.00	No	1	-	-	-	1
Boliniaceae sp1.	Pyrenomycetoid	72.55	2.50	No	-	-	3	-	3
Botryobasidium botryosum	Resupinate	99.40	2.40	No	14	26	24	14	78
Botryobasidium conspersum	Resupinate	47.52	2.91	No	2	-	-	1	3
Botryobasidium intertextum	Resupinate	25.92	4.13	No	-	1	4	2	7
Botryobasidium laeve	Resupinate	53.92	2.00	Yes	3	-	-	-	3
Botryobasidium medium	Resupinate	249.46	1.91	No	1	1	3	-	5
Botryobasidium obtusisporum	Resupinate	177.21	2.11	No	-	1	-	-	1
Botryobasidium subcoronatum	Resupinate	40.09	2.45	No	26	32	27	20	105

Botryohypochnus isabellinus	Resupinate	482.33	1.00	Yes	12	3	4	12	31
Butyrea luteoalbum	Resupinate	11.71	2.56	No	-	7	6	-	13
Byssomerulius corium	Pileate	42.41	2.00	No	-	-	-	1	1
Byssoporia terrestris	Resupinate	43.30	1.29	No	-	1	-	2	3
Cabalodontia bresadolae	Resupinate	56.00	2.08	No	-	-	-	1	1
Cabalodontia cretacea	Resupinate	18.04	4.29	No	-	-	17	-	17
Cabalodontia subcretacea	Resupinate	11.49	4.33	No	-	-	2	-	2
Calocera cornea	Ramarioid	70.51	2.62	No	4	-	-	7	11
Calocera furcata	Ramarioid	101.02	3.00	No	-	8	4	-	12
Calocera viscosa	Ramarioid	113.10	2.25	No	-	1	-	-	1
Calycellina guttulifera	Discomycetoid	11.35	2.94	No	1	1	-	-	2
Calycellina ochracea	Discomycetoid	120.29	4.46	No	4	-	-	1	5
Calycellina sp1.	Discomycetoid	5.54	4.08	No	-	1	-	-	1
Calyptella sp1.	Discomycetoid	134.77	2.24	No	1	-	-	3	4
Camarops lutea/pugillus complex	Stromatoid	62.54	1.86	No	-	-	1	1	2
Camarops tubulina	Stromatoid	62.54	1.86	No	-	2	-	-	2
Capitotricha bicolor	Discomycetoid	14.14	5.33	No	7	-	-	5	12
Capronia cf mansonii	Pyrenomycetoid	1256.64	1.60	No	-	-	1	-	1
Capronia cf pilosella	Pyrenomycetoid	337.57	2.26	No	4	5	3	8	20
Capronia cf semi-immersa	Pyrenomycetoid	795.22	2.40	No	-	1	-	-	1
Capronia sp4.	Pyrenomycetoid	795.22	2.40	No	2	3	4	1	10
Capronia sp5.	Pyrenomycetoid	452.39	2.67	No	-	-	-	4	4
Ceraceomyces eludens	Resupinate	28.30	1.21	No	2	9	13	-	24
Ceraceomyces microsporus	Resupinate	19.30	1.18	No	1	5	9	3	18
Ceraceomyces serpens	Resupinate	18.89	2.11	No	2	1	4	2	9
Ceraceomyces tessulatus	Resupinate	87.96	1.75	No	5	4	2	-	11
Ceratosebacina longispora	Resupinate	314.16	6.25	No	1	-	-	-	1
Ceratosphaeria cf subferruginea	Pyrenomycetoid	551.35	3.25	No	-	-	-	1	1
Ceratosphaeria lampadophora	Pyrenomycetoid	692.72	11.90	No	1	-	-	2	3
Ceratosphaeria rhenana	Pyrenomycetoid	463.29	3.55	No	6	2	9	13	30
Ceratostomella rostrata	Pyrenomycetoid	12.63	3.00	No	5	-	-	-	5
Cerinomyces crustulinus	Resupinate	82.96	3.08	No	-	6	4	-	10
Cerioporus leptocephalus	Pileate	74.32	2.30	No	-	-	-	2	2
Cerioporus mollis	Pileate	105.83	3.14	No	-	-	-	7	7
Ceriporia excelsa	Resupinate	16.90	1.89	No	2	-	-	1	3
Ceriporia reticulata	Resupinate	53.01	2.50	No	-	-	-	1	1

Ceriporia viridans	Resupinate	12.57	2.00	No	2	-	-	1	3
Ceriporiopsis resinascens	Resupinate	31.32	2.27	No	-	-	-	5	5
Cerrena unicolor	Pileate	30.62	1.68	No	1	-	-	-	1
Chaetoderma luna	Resupinate	198.80	2.78	No	-	-	6	-	6
Chaetosphaeria cf cupulifera	Pyrenomycetoid	389.66	5.44	No	8	-	1	2	11
Chaetosphaeria myriocarpa	Pyrenomycetoid	29.45	2.40	No	-	-	-	1	1
Chaetosphaeria sp1.	Pyrenomycetoid	268.61	12.67	No	8	-	-	2	10
Chaetosphaeria sp2.	Pyrenomycetoid	191.69	3.07	No	-	-	-	1	1
Chaetosphaeria vermicularioides	Pyrenomycetoid	41.72	3.40	No	1	1	-	-	2
Cheimonophyllum candidissimum	Agaricoid	107.99	1.10	No	2	-	-	13	15
Chlorencoelia versiformis	Discomycetoid	91.89	4.33	No	-	-	-	3	3
Chlorociboria aeruginascens	Discomycetoid	13.83	3.29	No	8	-	-	9	17
Chlorociboria aeruginosa	Discomycetoid	81.29	3.83	No	-	-	-	1	1
Chrysomphalina chrysophylla	Agaricoid	249.46	1.91	No	-	-	1	-	1
Ciliolarina aff pinicola	Discomycetoid	125.66	2.50	No	-	1	1	-	2
Ciliolarina cf laetifica	Discomycetoid	23.06	2.58	No	-	5	1	-	6
Ciliolarina concortica	Discomycetoid	14.89	2.76	No	-	1	1	-	2
Ciliolarina neglecta	Discomycetoid	9.45	2.94	No	-	9	12	-	21
Ciliolarina sp1.	Discomycetoid	53.82	3.48	No	1	-	-	-	1
Cinereomyces lindbladii	Resupinate	16.96	2.70	No	-	1	-	-	1
Cistella cf geelmyedenii	Discomycetoid	17.01	3.16	No	-	1	-	-	1
Cistella cf improvisa	Discomycetoid	11.78	3.22	No	2	-	-	3	5
Cistella cf microspora	Discomycetoid	8.42	2.00	No	-	1	-	-	1
Cistella sp1.	Discomycetoid	25.98	3.57	No	1	-	-	1	2
Cistella sp2.	Discomycetoid	11.35	2.94	No	1	-	-	-	1
Cistella sp3.	Discomycetoid	15.71	2.50	No	-	-	-	1	1
Cistella sp4.	Discomycetoid	11.35	2.94	No	-	1	-	-	1
Cistella sp5.	Discomycetoid	5.97	3.46	No	-	-	-	1	1
Cistella sp6.	Discomycetoid	26.70	4.25	No	-	-	-	1	1
Cistella sp8.	Discomycetoid	57.92	4.72	No	1	-	-	-	1
Claussenomyces atrovirens	Discomycetoid	283.73	4.71	No	1	18	11	1	31
Clavulicium delectabile	Resupinate	307.88	1.14	Yes	-	-	1	-	1
Colacogloea peniophorae	Resupinate	94.25	1.88	No	-	-	1	-	1
Conferticium ochraceum	Resupinate	37.11	1.75	No	-	3	-	-	3
Conferticium ravum	Resupinate	92.21	1.53	Yes	-	-	-	1	1
Coniochaeta subcorticalis	Pyrenomycetoid	358.97	1.39	No	1	-	-	-	1

Coniophora arida	Resupinate	461.81	1.71	No	-	5	3	5	13
Coniophora olivacea	Resupinate	196.35	2.00	No	8	15	11	9	43
Coniophora puteana	Resupinate	348.42	1.62	No	-	4	2	4	10
Coronicium alboglaucum	Resupinate	41.58	2.55	No	-	-	-	1	1
Coronophora sp nov	Pyrenomycetoid	31.10	4.95	No	-	-	-	2	2
Corticium boreoroseum	Resupinate	181.62	1.85	No	-	1	-	-	1
Corticium polygonioides	Resupinate	142.35	1.45	No	-	1	-	5	6
Corticium roseum	Resupinate	1649.34	2.10	No	1	-	-	6	7
Crepidotus calolepis	Agaricoid	220.72	1.48	No	-	-	-	5	5
Crepidotus cesatii	Agaricoid	248.87	1.15	Yes	-	5	-	-	5
Crepidotus pallidus	Discomycetoid	123.26	1.72	Yes	8	-	-	8	16
Crepidotus subverrucisporus	Agaricoid	227.21	1.52	Yes	-	1	-	-	1
Crocicreas sp1.	Discomycetoid	5.77	4.25	No	-	-	-	1	1
Crustoderma corneum	Resupinate	177.21	2.11	No	-	-	1	-	1
Crustoderma dryinum	Resupinate	56.55	2.67	No	-	1	-	-	1
Crustoderma efibulatum	Resupinate	21.83	4.05	No	-	-	1	-	1
Cryptodiscus foveolaris	Discomycetoid	44.55	2.73	No	1	-	-	-	1
Cryptodiscus pallidus	Discomycetoid	198.61	3.29	No	-	-	-	1	1
Cryptodiscus pini	Discomycetoid	26.46	6.29	No	-	-	10	-	10
Cudonia confusa	Agaricoid	159.04	17.78	No	-	1	-	-	1
Cyathicula sp1.	Discomycetoid	381.70	5.33	No	-	-	1	1	2
Cyathicula sp2.	Discomycetoid	125.29	5.35	No	-	-	-	1	1
Cylindrobasidium evolvens	Resupinate	181.62	1.85	No	4	-	-	4	8
Cystoderma jasonis	Agaricoid	74.55	1.80	No	-	-	2	-	2
Dacrymyces adpressus	Discomycetoid	383.02	2.57	No	-	-	1	-	1
Dacrymyces lacrymalis	Discomycetoid	230.37	2.74	No	1	2	-	5	8
Dacrymyces macnabbii	Discomycetoid	89.00	2.64	No	-	7	8	1	16
Dacrymyces microsporus	Discomycetoid	89.00	2.64	No	-	10	3	3	16
Dacrymyces minor	Discomycetoid	166.69	2.76	No	4	6	-	6	16
Dacrymyces minutus	Discomycetoid	121.49	2.93	No	-	7	2	-	9
Dacrymyces ovisporus	Discomycetoid	1491.03	1.33	No	-	1	1	-	2
Dacrymyces sp1.	Discomycetoid	954.26	1.67	No	-	-	1	-	1
Dacrymyces sp2.	Discomycetoid	110.84	1.90	No	-	1	-	-	1
Dacrymyces stillatus	Discomycetoid	368.25	2.82	No	-	17	17	-	34
Dacrymyces tortus	Discomycetoid	138.06	3.33	No	-	8	16	-	24
Dacryobolus karstenii	Resupinate	7.51	3.89	No	-	2	3	-	5

Dacryobolus sudans	Resupinate	9.72	3.67	No	-	3	1	1	5
Daldinia concentrica	Stromatoid	753.98	1.88	No	1	-	-	-	1
Dialonectria cf episphaeria	Pyrenomycetoid	270.59	2.38	Yes	5	-	-	1	6
Diatrype stigma	Stromatoid	31.42	5.00	No	1	-	-	-	1
Diatrypella sp1.	Stromatoid	5.32	5.09	No	1	-	-	-	1
Dichostereum boreale	Resupinate	57.98	1.40	Yes	-	1	-	-	1
Ditiola peziziformis	Discomycetoid	1813.09	3.17	No	-	-	1	-	1
Durella melanochlora	Discomycetoid	239.23	2.84	No	6	-	-	7	13
Echinosphaeria canescens	Pyrenomycetoid	556.65	7.78	No	2	-	-	1	3
Echinosphaeria cincinnata	Pyrenomycetoid	261.34	2.00	No	2	1	1	-	4
Elmerina caryae	Resupinate	27.24	2.22	No	4	-	-	-	4
Endoxyla macrostoma	Pyrenomycetoid	67.73	3.93	No	-	1	-	-	1
Endoxyla parallela	Stromatoid	84.55	4.41	No	1	2	3	5	11
Endoxyla rostrata	Pyrenomycetoid	12.63	3.00	No	4	-	-	-	4
Entoloma depluens	Agaricoid	402.50	1.34	No	2	-	-	1	3
Eutypa flavovirens	Stromatoid	27.83	3.11	No	5	-	-	2	7
Exidia glandulosa	Discomycetoid	163.36	3.25	No	3	-	-	3	6
Exidia repansa	Discomycetoid	91.89	4.33	No	3	-	-	-	3
Exidia saccharina	Discomycetoid	135.30	3.27	No	-	-	1	-	1
Exidiopsis calcea	Resupinate	376.52	2.52	No	-	1	-	-	1
Exidiopsis effusa	Resupinate	218.68	3.06	No	-	-	-	1	1
Flagelloscypha sp1.	Discomycetoid	137.44	1.40	No	-	-	-	1	1
Flammulaster limulatus	Agaricoid	113.49	1.88	No	4	-	-	8	12
Flaviporus citrinellus	Resupinate	13.09	1.37	No	-	1	1	1	3
Fomes fomentarius	Pileate	356.37	2.73	No	40	-	-	5	45
Fomitopsis betulina	Pileate	9.72	3.67	No	2	-	-	-	2
Fomitopsis pinicola	Pileate	94.25	1.88	No	22	33	9	9	73
Fomitopsis rosea	Pileate	27.34	2.37	No	-	3	-	-	3
Galerina hypnorum	Agaricoid	194.83	1.71	Yes	-	2	-	-	2
Galerina marginata	Agaricoid	246.69	1.65	Yes	-	1	1	5	7
Galerina mniophila	Agaricoid	285.64	1.91	Yes	-	1	2	-	3
Galerina pumila	Agaricoid	332.22	1.96	No	-	-	1	-	1
Galerina stylifera	Agaricoid	111.33	1.56	No	-	1	2	2	5
Galzinia incrustans coll	Resupinate	15.71	2.50	No	2	1	2	5	10
Ganoderma applanatum	Pileate	209.35	1.48	Yes	-	-	-	1	1
Gelatoporia dichrous	Pileate	4.67	3.91	No	1	-	-	-	1

Globulicium hiemale	Resupinate	1194.49	1.00	No	-	21	16	-	37
Gloeocystidiellum convolvens	Resupinate	33.58	1.58	Yes	4	-	-	2	6
Gloeocystidiellum leucoxanthum	Resupinate	356.37	2.73	No	-	-	-	5	5
Gloeocystidiellum luridum	Resupinate	168.35	2.00	No	-	1	-	1	2
Gloeocystidiellum porosum	Resupinate	35.34	1.67	Yes	-	-	-	3	3
Gloeodontia subasperispora	Resupinate	15.90	1.78	Yes	-	1	1	-	2
Gloeophyllum sepiarium	Pileate	71.58	2.78	No	-	1	-	-	1
Gloeoporus pannocinctus	Resupinate	1.86	4.63	No	4	-	-	4	8
Gloeoporus taxicola	Resupinate	6.61	2.76	No	-	1	2	-	3
Gloiothele citrina	Resupinate	71.57	1.00	No	3	7	2	2	14
Glonium nitidum	Pyrenomycetoid	68.72	5.60	No	-	1	1	-	2
Godronia urceolus	Discomycetoid	110.45	41.67	No	1	-	-	-	1
Gorgoniceps aridula	Discomycetoid	308.15	34.44	No	-	-	1	-	1
Gorgoniceps hypothallosa	Discomycetoid	190.85	9.00	No	-	-	6	-	6
Gymnopilus penetrans	Agaricoid	141.76	1.68	Yes	8	6	18	3	35
Gymnopilus picreus	Agaricoid	268.61	1.58	Yes	-	1	6	-	7
Gymnopus androsaceus	Agaricoid	109.94	1.82	No	1	4	-	1	6
Gymnopus confluens	Agaricoid	69.75	2.07	No	1	-	-	-	1
Gymnopus dryophilus	Agaricoid	45.63	1.69	No	1	1	-	-	2
Gyromitra infula	Agaricoid	1095.85	2.48	No	-	1	-	4	5
Hamatocanthoscypha laricionis	Discomycetoid	13.15	3.73	No	-	1	-	-	1
Hamatocanthoscypha sp nov	Discomycetoid	38.78	3.16	No	-	-	-	1	1
Hamatocanthoscypha sp1.	Discomycetoid	15.27	3.33	No	1	-	-	-	1
Hamatocanthoscypha sp2.	Discomycetoid	26.23	3.14	No	2	-	-	3	5
Hamatocanthoscypha sp3.	Discomycetoid	10.43	3.93	No	-	-	1	-	1
Hamatocanthoscypha straminella	Discomycetoid	37.32	3.44	No	2	-	-	4	6
Helicobasidium sp1.	Resupinate	500.30	1.86	No	-	-	-	1	1
Helminthosphaeria aff carpathica	Pyrenomycetoid	285.10	2.18	No	-	1	1	-	2
Helminthosphaeria aff odontiae	Pyrenomycetoid	176.71	1.80	No	-	2	-	-	2
Helminthosphaeria aff pilifera	Pyrenomycetoid	238.12	2.10	No	-	-	1	-	1
Helminthosphaeria cf gibberosa	Pyrenomycetoid	464.56	2.15	No	2	-	2	-	4
Helminthosphaeria ludens	Pyrenomycetoid	1105.84	2.75	No	1	6	1	-	8
Helminthosphaeria sp1.	Pyrenomycetoid	320.74	2.45	No	-	-	-	1	1
Helminthosphaeriaceae sp nov.	Pyrenomycetoid	1269.11	2.29	Yes	-	3	5	-	8
Helvella macropus	Agaricoid	1991.57	2.19	Yes	-	-	-	1	1
Hemimycena sp1.	Agaricoid	268.61	1.58	No	1	-	-	-	1

Henningsomyces candidus	Discomycetoid	81.91	1.14	No	14	-	-	1	15
Henningsomyces pienikarva	Discomycetoid	81.91	1.14	No	-	1	1	-	2
Hericium cirrhatum	Pileate	28.27	1.33	No	-	-	-	1	1
Hericium coralloides	Ramarioid	35.26	1.31	Yes	-	-	-	1	1
Hilberina aff moseri	Pyrenomycetoid	692.72	11.90	No	-	1	-	-	1
Hilberina aff munkii	Pyrenomycetoid	326.73	6.50	No	1	-	-	1	2
Hilberina cf caudata	Pyrenomycetoid	596.90	11.88	No	1	2	-	-	3
Humaria hemisphaerica	Discomycetoid	2596.72	2.17	Yes	3	-	-	8	11
Hyalopeziza millepunctata	Discomycetoid	19.14	3.55	No	1	-	-	4	5
Hyaloscypha albohyalina	Discomycetoid	113.05	3.36	No	4	1	1	6	12
Hyaloscypha aureliella	Discomycetoid	40.50	3.30	No	-	46	46	-	92
Hyaloscypha diabolica	Discomycetoid	19.16	3.05	No	-	1	-	-	1
Hyaloscypha epiporia	Discomycetoid	28.04	2.93	No	-	3	-	-	3
Hyaloscypha fuckelii	Discomycetoid	38.04	3.10	No	19	1	1	17	38
Hyaloscypha intacta	Discomycetoid	105.83	3.14	No	6	-	-	18	24
Hyaloscypha latispora	Discomycetoid	83.71	2.19	No	1	-	-	-	1
Hyaloscypha leuconica	Discomycetoid	41.39	3.81	No	5	4	3	10	22
Hyaloscypha quercicola	Discomycetoid	41.72	3.40	No	1	-	-	-	1
Hyaloscypha sp1. nov.	Discomycetoid	14.77	2.35	No	1	-	-	-	1
Hyaloscypha spiralis	Discomycetoid	113.05	3.36	No	5	1	1	3	10
Hyaloscypha vitreola	Discomycetoid	113.05	3.36	No	21	-	-	7	28
Hymenochaete fuliginosa	Resupinate	18.06	2.88	No	-	3	-	-	3
Hymenochaetopsis tabacina	Pileate	28.23	2.30	No	-	-	-	2	2
Hymenoscyphus sp2.	Discomycetoid	139.51	4.14	No	-	-	-	1	1
Hymenoscyphus sp3.	Discomycetoid	427.65	3.27	No	-	-	1	-	1
Hymenoscyphus vikgultorum	Discomycetoid	123.70	5.83	No	1	-	-	-	1
Hyphoderma cremeoalbum	Resupinate	311.61	2.09	No	1	1	-	-	2
Hyphoderma definitum	Resupinate	103.70	3.85	No	-	4	5	-	9
Hyphoderma incrustatum	Resupinate	198.80	2.78	No	2	1	-	3	6
Hyphoderma obtusiforme	Resupinate	261.34	2.00	No	1	-	-	-	1
Hyphoderma occidentale	Resupinate	230.37	2.74	No	-	2	1	1	4
Hyphoderma roseocremeum	Resupinate	101.02	3.00	No	-	-	1	-	1
Hyphoderma setigerum	Resupinate	93.88	2.27	No	13	-	1	15	29
Hyphoderma sibiricum	Resupinate	127.23	1.78	No	-	1	-	-	1
Hyphodiscus hemiamyloideus	Discomycetoid	25.22	1.83	No	8	-	1	9	18
Hyphodiscus hymeniophilus	Discomycetoid	8.84	3.33	No	-	2	-	-	2

Hyphodontia abieticola	Resupinate	55.32	1.64	No	2	1	5	1	9
Hyphodontia alutaria	Resupinate	39.40	1.46	No	-	2	-	-	2
Hyphodontia barba-jovis	Resupinate	62.83	1.25	No	4	-	-	1	5
Hyphodontia curvispora	Resupinate	5.52	3.60	No	1	-	-	-	1
Hyphodontia efibulata	Resupinate	99.30	1.65	No	-	-	-	2	2
Hyphodontia pallidula	Resupinate	15.90	1.78	No	1	14	1	2	18
Hyphodontia subalutacea	Resupinate	16.84	4.00	No	12	2	9	12	35
Hypholoma fasciculare	Agaricoid	99.30	1.65	No	-	-	-	1	1
Hypholoma polytrichi	Agaricoid	127.23	1.78	No	1	-	-	-	1
Hypochnicium albostramineum	Resupinate	322.06	1.33	Yes	-	-	2	2	4
Hypochnicium bombycinum	Resupinate	404.09	1.50	No	-	-	-	3	3
Hypochnicium polonese	Resupinate	119.28	1.67	No	1	-	-	-	1
Hypochnicium punctulatum	Resupinate	106.32	1.26	Yes	2	3	5	1	11
Hypochnicium subrigescens	Resupinate	149.31	1.00	Yes	-	2	1	-	3
Hypochnicium wakefieldiae	Resupinate	188.26	1.26	Yes	-	2	4	-	6
Hypomyces rosellus	Resupinate	437.37	6.11	Yes	1	-	-	-	1
Hypomyces semitranslucens	Resupinate	372.13	4.42	Yes	-	3	-	1	4
Hypoxylon fuscum	Stromatoid	447.97	2.08	No	1	-	-	-	1
Hypoxylon rubiginosum	Stromatoid	215.98	2.20	No	1	-	-	8	9
Hysterium pulicare	Pyrenomycetoid	1256.64	3.13	No	32	-	-	3	35
Hysterographium fraxini	Pyrenomycetoid	5367.71	2.78	No	-	-	-	8	8
Immersiella caudata	Pyrenomycetoid	874.74	12.22	No	12	-	-	2	14
Inonotus obliquus	Resupinate	261.54	1.54	No	5	-	-	-	5
Irpex litschaueri	Resupinate	17.32	2.38	No	1	-	-	-	1
Ischnoderma benzoinum	Pileate	14.43	3.43	No	-	3	1	-	4
Jaapia ochroleuca	Resupinate	265.07	2.70	Yes	-	-	6	-	6
Junghuhnia collabens	Resupinate	6.42	2.19	No	-	1	-	-	1
Junghuhnia luteoalba	Resupinate	11.71	2.56	No	-	5	15	-	20
Kirschsteiniothelia cf atra	Pyrenomycetoid	2126.47	3.16	No	-	-	2	-	2
Kuehneromyces lignicola	Agaricoid	84.82	1.69	No	1	-	1	1	3
Kuehneromyces mutabilis	Agaricoid	84.82	1.69	No	-	-	-	1	1
Kurtia argillacea	Resupinate	119.28	1.67	No	9	5	6	11	31
Lachnella sp1.	Discomycetoid	63.54	2.47	No	-	-	-	1	1
Lachnum corticale	Discomycetoid	231.94	5.60	No	-	-	-	30	30
Lachnum pudibundum	Discomycetoid	25.13	4.00	No	-	-	-	1	1
Lachnum sp1.	Discomycetoid	25.24	4.33	No	12	3	-	12	27

Lachnum sp2.	Discomycetoid	23.81	3.79	No	-	-	-	3	3
Lachnum virgineum	Discomycetoid	24.19	4.86	No	16	-	-	13	29
Laetinaeria aff uvidula	Discomycetoid	434.92	1.94	No	-	-	-	1	1
Lasiosphaeria hirsuta/tuberculosa complex	Pyrenomycetoid	2156.90	10.00	Yes	13	-	-	17	30
Lasiosphaeria ovina	Pyrenomycetoid	565.49	11.25	No	4	-	-	9	13
Lasiosphaeria pyramidata	Pyrenomycetoid	628.32	12.50	No	1	-	-	-	1
Laxitextum bicolor	Pileate	23.32	1.90	Yes	4	-	-	2	6
Lentaria afflata	Ramarioid	60.13	1.79	No	-	-	-	1	1
Lentinellus castoreus	Agaricoid	28.27	1.33	Yes	1	-	-	-	1
Lentinellus flabelliformis	Agaricoid	60.75	1.47	Yes	1	-	-	-	1
Lentinellus micheneri	Agaricoid	60.75	1.47	Yes	1	-	-	1	2
Lentinellus ursinus	Agaricoid	28.27	1.33	Yes	3	-	-	-	3
Lentinus substrictus	Pileate	17.91	2.85	No	-	-	-	1	1
Lentomitella cirrhosa	Pyrenomycetoid	82.83	2.00	Yes	13	2	5	12	32
Lentomitella crinigera	Pyrenomycetoid	285.10	2.18	Yes	5	6	8	3	22
Lentomitella tomentosa	Pyrenomycetoid	481.15	2.23	No	2	-	-	1	3
Lenzites betulina	Pileate	27.00	2.20	No	1	-	-	1	2
Leptodontidium trabinellum	Discomycetoid	115.68	2.68	No	32	-	-	8	40
Leptoporus mollis	Pileate	20.72	2.48	No	-	2	-	-	2
Leptosporomyces galzinii	Resupinate	8.42	2.00	No	1	1	1	-	3
Leptosporomyces septentrionalis	Resupinate	15.03	3.57	No	-	1	-	1	2
Leucogyrophana romellii	Resupinate	41.48	1.54	No	-	2	1	-	3
Leucogyrophana sororia	Resupinate	25.24	1.55	No	-	5	2	-	7
Leucoscypha leucotricha	Discomycetoid	5366.72	2.24	Yes	-	1	1	-	2
Lophiostoma cf quadrinucleatum	Pyrenomycetoid	1325.60	2.95	No	-	-	-	3	3
Lophiostoma compressum	Pyrenomycetoid	1615.37	2.64	No	2	-	-	1	3
Lophiostoma curtum	Pyrenomycetoid	608.97	2.70	No	9	-	-	-	9
Lophiostoma sp1.	Pyrenomycetoid	345.25	4.92	No	-	-	-	6	6
Lophiotrema boreale	Pyrenomycetoid	169.63	3.64	No	6	-	-	6	12
Lophium mytilinum	Pyrenomycetoid	636.17	71.11	No	-	15	30	-	45
Megacollybia platyphylla	Agaricoid	350.90	1.17	No	2	-	-	-	2
Melanomma cf fuscidulum	Pyrenomycetoid	226.19	4.50	No	8	3	6	8	25
Melanomma pulvis-pyrius	Pyrenomycetoid	254.47	3.56	No	22	-	-	11	33
Melanomma subdispersum	Pyrenomycetoid	994.02	3.00	No	11	-	-	2	13
Melanopsamma pomiformis	Pyrenomycetoid	497.75	2.31	No	2	-	1	1	4

Melanospora caprina	Pyrenomycetoid	2393.01	1.56	No	-	1	-	1	2
Menispora cf glauca/caesia	Pyrenomycetoid	413.51	5.78	No	17	-	-	3	20
Merismodes anomala	Discomycetoid	1005.31	2.50	No	5	1	-	17	23
Merulius tremellosus	Pileate	5.22	3.40	No	1	-	-	2	3
Metulodontia nivea	Resupinate	37.33	1.38	No	1	1	-	1	3
Mollisia sp1.	Discomycetoid	33.80	3.78	No	47	34	43	45	169
Mollisia sp2.	Discomycetoid	316.42	2.18	No	16	-	-	1	17
Mollisia sp3.	Discomycetoid	129.27	3.53	No	2	-	-	-	2
Mollisia sp4.	Discomycetoid	18.85	3.00	No	2	-	-	4	6
Mucronella calva	Ramarioid	35.34	1.67	No	3	13	9	-	25
Mycena algeriensis	Agaricoid	220.72	1.48	No	-	1	-	-	1
Mycena amicta	Agaricoid	150.62	1.79	No	-	2	-	-	2
Mycena epipterygia	Agaricoid	298.65	1.38	No	1	20	2	-	23
Mycena galericulata	Agaricoid	451.59	1.42	No	2	-	-	3	5
Mycena galopus	Agaricoid	311.02	1.83	No	1	3	2	-	6
Mycena haematopus	Agaricoid	220.72	1.48	No	3	-	-	-	3
Mycena laevigata	Agaricoid	84.82	1.69	No	-	1	1	-	2
Mycena leptocephala	Agaricoid	186.53	1.90	No	-	1	-	1	2
Mycena metata/filopes	Agaricoid	186.53	1.90	No	2	3	3	-	8
Mycena rubromarginata	Agaricoid	331.83	1.54	No	-	14	8	1	23
Mycena sanguinolenta	Agaricoid	184.00	1.62	No	2	1	1	-	4
Mycena silvae-nigrae	Agaricoid	552.92	1.38	No	-	1	1	-	2
Mycena stipata	Agaricoid	306.80	1.60	No	-	4	22	-	26
Mycena tintinnabulum	Agaricoid	22.09	1.80	No	1	-	-	-	1
Mycena viridimarginata	Agaricoid	346.36	1.29	No	-	8	1	-	9
Mycoacia aurea	Resupinate	10.82	2.57	No	-	-	2	-	2
Mycoacia fuscoatra	Resupinate	21.87	2.44	No	3	-	-	1	4
Mytilinidion mytilinellum	Pyrenomycetoid	182.80	5.43	No	-	3	8	-	11
Myxarium sp1.	Discomycetoid	166.90	1.70	No	-	-	-	2	2
Natantiella ligneola	Pyrenomycetoid	124.25	3.00	No	5	-	-	5	10
Nectria peziza	Pyrenomycetoid	296.98	2.27	Yes	2	-	-	-	2
Nemania atropurpurea	Stromatoid	190.00	2.19	No	-	-	-	5	5
Nemania dark sp.	Stromatoid	313.87	2.16	No	1	-	-	4	5
Nemania genea	Stromatoid	423.77	2.63	No	-	1	-	-	1
Nemania serpens	Stromatoid	383.50	2.00	No	10	-	-	18	28
Neobulgaria lilacina	Discomycetoid	141.86	2.35	Yes	11	2	2	4	19

Neodasyscypha cerina	Discomycetoid	29.45	2.40	No	3	-	-	5	8
Niesslia sp.	Pyrenomycetoid	7.03	5.89	No	1	-	-	-	1
Oligoporus alni	Pileate	5.88	4.33	No	2	-	-	8	10
Orbilia auricolor	Discomycetoid	4.64	14.00	No	-	-	-	2	2
Orbilia delicatula	Discomycetoid	1.78	2.27	Yes	30	40	29	23	122
Orbilia sp1.	Discomycetoid	2.54	7.67	No	16	1	1	12	30
Orbilia sp2.	Discomycetoid	6.28	8.00	No	3	-	-	1	4
Orbilia sp3.	Discomycetoid	17.49	2.09	No	4	2	-	9	15
Orbilia sp4.	Discomycetoid	3.80	3.64	No	7	5	2	10	24
Orbilia sp5.	Discomycetoid	8.03	5.92	No	1	-	-	1	2
Orbilia sp6.	Discomycetoid	1.31	4.86	No	5	-	-	3	8
Orbilia sp7.	Discomycetoid	38.84	7.21	No	1	1	-	2	4
Orbilia sp8.	Discomycetoid	3.50	6.11	No	-	-	-	1	1
Otidea tuomikoskii	Agaricoid	303.95	1.79	No	1	-	-	-	1
Oxyporus corticola	Resupinate	56.45	1.42	No	1	-	-	9	10
Panellus mitis	Agaricoid	5.83	3.80	No	-	1	-	-	1
Panellus serotinus	Agaricoid	8.39	3.17	No	2	-	-	-	2
Panus conchatus	Agaricoid	44.18	2.08	No	1	-	-	-	1
Patinellaria sanguinea	Discomycetoid	70.51	2.62	No	25	-	-	24	49
Paullicorticium pearsonii	Resupinate	34.36	2.80	No	-	2	-	-	2
Paullicorticium seorsum	Resupinate	55.22	1.33	No	-	2	1	-	3
Peniophora incarnata	Resupinate	113.10	2.25	No	9	-	-	9	18
Peniophora laurentii	Resupinate	174.95	2.44	No	1	-	-	1	2
Peniophora nuda	Resupinate	53.46	3.27	No	3	-	-	-	3
Peniophora pithya	Resupinate	30.68	2.50	No	-	11	-	-	11
Peniophora polygonia	Resupinate	91.25	3.38	No	-	-	-	1	1
Peniophora violaceolivida	Resupinate	50.49	3.09	No	7	-	-	3	10
Peniophorella guttuliferum	Resupinate	68.44	2.54	No	3	-	-	1	4
Peniophorella pallida	Resupinate	56.55	2.67	No	-	2	7	-	9
Peniophorella praetermissa	Resupinate	177.21	2.11	No	19	31	21	24	95
Peniophorella pubera	Resupinate	120.58	2.00	No	10	2	1	4	17
Perenniporia subacida	Resupinate	54.44	1.26	No	-	-	-	1	1
Peziza cf arvernensis	Discomycetoid	1287.92	1.77	Yes	1	-	-	6	7
Pezizella sp1.	Discomycetoid	75.63	3.57	No	-	1	-	-	1
Pezizella sp2.	Discomycetoid	24.82	3.95	No	1	-	-	-	1
Phaeohelotium sp1.	Discomycetoid	44.18	3.60	No	1	-	-	-	1

Phaeohelotium sp2.	Discomycetoid	15.59	2.89	No	3	-	-	2	5
Phaeohelotium sp3.	Discomycetoid	14.46	2.68	No	-	-	2	-	2
Phanerochaete calotricha	Resupinate	15.90	1.78	No	-	-	-	1	1
Phanerochaete laevis	Resupinate	34.15	2.09	No	5	-	-	4	9
Phanerochaete sordida	Resupinate	35.64	2.18	No	9	4	1	5	19
Phanerochaete velutina	Resupinate	35.64	2.18	No	6	3	1	10	20
Phellinus ferrugineofuscus	Resupinate	6.94	2.90	No	-	22	-	-	22
Phellinus igniarius coll	Pileate	127.42	1.15	No	9	-	-	1	10
Phellinus laevigatus	Resupinate	46.03	1.31	No	9	-	-	-	9
Phellinus lundellii	Pileate	82.87	1.24	No	2	-	-	-	2
Phellinus nigrolimitatus	Pileate	21.87	2.44	No	-	7	1	-	8
Phellinus tremulae	Pileate	65.56	1.35	No	-	-	-	15	15
Phellinus viticola	Pileate	17.30	3.78	No	-	27	3	-	30
Phialocephala piceae	Discomycetoid	37.77	4.22	No	1	-	-	-	1
Phlebia centrifuga	Resupinate	44.55	2.73	No	-	2	-	-	2
Phlebia femsjoeensis	Resupinate	17.89	2.00	No	-	1	1	-	2
Phlebia lilascens coll	Resupinate	16.90	1.89	No	-	2	1	-	3
Phlebia livida	Resupinate	21.87	2.44	No	-	4	3	-	7
Phlebia radiata	Resupinate	10.82	2.57	No	1	1	1	-	3
Phlebia rufa	Resupinate	21.87	2.44	No	1	-	-	1	2
Phlebia segregata	Resupinate	25.84	2.89	No	1	4	-	4	9
Phlebia serialis	Resupinate	11.76	3.33	No	-	-	2	-	2
Phlebia subserialis	Resupinate	25.84	2.89	No	1	-	1	-	2
Phlebia subulata	Resupinate	28.21	1.73	No	-	7	-	-	7
Phlebia tuberculata	Resupinate	47.71	2.25	No	-	-	-	1	1
Phlebiella christiansenii	Pileate	92.21	1.53	Yes	2	5	4	-	11
Phlebiopsis gigantea	Resupinate	60.14	2.23	No	-	1	-	-	1
Phloeomana clavata	Agaricoid	212.06	1.25	No	-	2	-	-	2
Phloeomana hiemalis	Agaricoid	161.05	1.38	No	-	-	-	1	1
Phloeomana speirea	Agaricoid	161.99	1.65	No	1	-	-	-	1
Pholiota flammans	Agaricoid	22.09	1.80	No	-	-	1	-	1
Pholiota scamba	Agaricoid	184.00	1.62	No	-	3	1	-	4
Pholiota squarrosa	Agaricoid	99.30	1.65	No	-	-	-	1	1
Pholiota tuberculosa	Agaricoid	141.76	1.68	No	2	-	-	1	3
Piloderma bicolor	Resupinate	15.95	1.30	No	18	11	12	12	53
Piloderma byssinum	Resupinate	52.46	1.27	No	13	15	17	17	62

Piloderma olivaceum	Resupinate	15.95	1.30	No	1	2	4	1	8
Piloderma sp1.	Resupinate	29.81	1.27	No	1	-	-	1	2
Piloderma sphaerosporum	Resupinate	23.12	1.21	No	1	1	3	4	9
Pisorisporium sp.	Pyrenomycetoid	561.24	11.59	No	4	-	-	10	14
Platystomum obtectum	Pyrenomycetoid	1842.94	2.74	No	-	-	3	-	3
Pleurotus pulmonarius	Agaricoid	104.92	2.53	No	-	-	-	1	1
Pluteus cervinus	Agaricoid	158.03	1.39	No	15	-	-	3	18
Pluteus podospileus	Agaricoid	140.71	1.24	No	2	-	-	-	2
Pluteus semibulbosus	Agaricoid	160.37	1.23	No	1	-	-	1	2
Polydesmia pruinosa	Discomycetoid	278.33	3.89	No	3	-	-	8	11
Postia caesia coll.	Pileate	9.01	3.40	No	-	7	-	-	7
Postia fragilis	Pileate	10.28	3.52	No	1	1	3	-	5
Postia guttulata	Pileate	19.00	1.75	No	-	1	1	-	2
Postia leucomallella	Pileate	10.28	3.52	No	-	3	6	-	9
Postia ptychogaster	Resupinate	19.52	1.91	No	-	1	1	-	2
Postia rennyi	Resupinate	26.47	1.81	No	-	-	1	-	1
Postia sericeomollis	Resupinate	14.37	1.98	No	-	1	3	-	4
Postia tephroleuca	Pileate	8.39	3.17	No	1	6	3	-	10
Postia undosa	Pileate	9.62	3.29	No	-	-	-	1	1
Propolis farinosa	Discomycetoid	607.90	3.58	No	13	-	-	21	34
Propolis sp1.	Discomycetoid	2120.58	2.70	No	-	6	1	-	7
Protodontia piceicola	Resupinate	56.55	1.13	No	-	1	-	-	1
Protodontia subgelatinosa	Resupinate	115.18	1.37	No	5	-	-	-	5
Protounguicularia transiens	Discomycetoid	31.81	3.56	No	3	-	-	4	7
Pseudocosmospora vilior	Pyrenomycetoid	270.59	2.38	Yes	5	1	-	-	6
Pseudographis pinicola	Discomycetoid	2990.01	5.22	No	-	1	1	-	2
Pseudohydnum gelatinosum	Pileate	148.49	1.14	No	-	2	-	-	2
Pseudoplectania nigrella	Discomycetoid	1045.36	1.00	No	6	7	13	4	30
Pseudotomentella flavovirens	Resupinate	215.69	1.00	Yes	-	1	-	-	1
Pseudotomentella griseopergamacea	Resupinate	526.16	1.00	Yes	3	1	-	1	5
Pseudotomentella humicola	Resupinate	269.39	1.00	Yes	-	-	-	1	1
Pseudotomentella mucidula	Resupinate	331.34	1.00	Yes	1	-	2	-	3
Pseudotomentella nigra	Resupinate	572.56	1.00	Yes	-	-	-	2	2
Pseudotomentella tristis	Resupinate	307.88	1.14	Yes	1	-	2	3	6
Psilocistella cf conincola	Discomycetoid	38.61	2.36	No	-	-	1	-	1

Psilocistella obsoleta	Discomycetoid	3.99	2.60	No	1	-	-	-	1
Psilocistella sp tummakarva	Discomycetoid	22.51	3.10	No	-	-	-	1	1
Psilocistella sp2.	Discomycetoid	197.29	3.93	No	1	-	-	-	1
Psilocistella sp3.	Discomycetoid	7.85	3.64	No	-	-	-	3	3
Psilocistella sp4.	Discomycetoid	11.31	4.27	No	-	-	1	-	1
Psilocistella sp5.	Discomycetoid	85.53	3.03	No	-	-	-	3	3
Psilocistella sp6.	Discomycetoid	21.99	3.50	No	-	-	-	1	1
Pycnoporellus fulgens	Pileate	38.17	1.80	No	-	3	-	-	3
Radulomyces confluens	Resupinate	299.30	1.00	Yes	-	1	-	-	1
Rectipilus fasciculatus	Discomycetoid	40.64	1.92	No	-	-	1	-	1
Repetobasidium vile	Resupinate	34.36	2.80	No	1	-	-	-	1
Resinicium bicolor	Resupinate	44.18	2.08	No	6	18	12	12	48
Resinicium furfuraceum	Resupinate	31.18	1.91	No	-	13	27	4	44
Resupinatus poriaeformis	Resupinate	113.65	1.00	No	2	-	-	1	3
Rhizochaete sulphurina	Resupinate	29.70	1.82	No	-	-	3	1	4
Rhizochaete violascens	Resupinate	45.63	1.69	No	2	3	1	2	8
Rhizoctonia fusisporus	Resupinate	39.27	6.25	No	2	-	2	2	6
Rhizoctonia ochracea	Resupinate	307.88	1.14	No	-	-	-	1	1
Rhizoctonia pseudocornigerum	Resupinate	96.21	2.86	No	-	-	-	1	1
Rhodonia placenta	Resupinate	26.51	2.16	No	-	2	1	-	3
Roridomyces roridus	Agaricoid	186.07	2.21	No	-	-	1	-	1
Schizopora paradoxa	Resupinate	66.36	1.48	No	1	-	-	-	1
Scopuloides rimosa	Resupinate	9.62	2.29	No	5	1	-	-	6
Scutellinia scutellata	Discomycetoid	1758.11	1.68	Yes	3	-	-	5	8
Scytinostroma galactinum	Resupinate	23.32	1.90	No	-	-	-	2	2
Scytinostromella heterogenea	Resupinate	30.04	1.42	Yes	1	-	-	-	1
Sebacina grisea	Resupinate	178.92	2.50	No	1	-	-	-	1
Serpula himantioides	Resupinate	249.46	1.91	Yes	1	5	5	-	11
Sidera lunata	Resupinate	4.31	2.50	No	-	-	2	-	2
Simocybe centunculus	Agaricoid	142.35	1.45	No	3	-	-	5	8
Simocybe haustellaris	Agaricoid	201.95	1.55	No	2	-	-	1	3
Sistotrema aff binucleosporum	Resupinate	7.59	2.15	No	-	-	2	-	2
Sistotrema aff farinaceum	Resupinate	15.38	1.42	No	-	-	1	-	1
Sistotrema brinkmannii	Resupinate	14.72	2.02	No	17	3	3	17	40
Sistotrema coroniferum	Resupinate	23.86	2.67	No	-	-	-	1	1
Sistotrema coronilla	Resupinate	18.62	2.47	No	1	-	-	-	1

Sistotrema octosporum coll	Resupinate	29.70	1.82	No	4	-	1	3	8
Sistotrema porulosum	Resupinate	20.86	1.70	No	-	-	-	3	3
Sistotrema raduloides	Resupinate	53.01	2.50	No	4	-	-	2	6
Sistotrema resinicystidium	Resupinate	22.09	1.80	No	3	1	1	2	7
Sistotrema sernanderi	Resupinate	35.64	2.18	No	4	-	-	1	5
Sistotrema sp nov.	Resupinate	3.85	1.79	No	1	-	-	-	1
Sistotremastrum suecicum	Resupinate	12.63	3.00	No	-	-	6	-	6
Sistotremella perpusilla	Resupinate	15.90	1.78	No	-	-	1	-	1
Skeletocutis amorpha	Pileate	4.78	2.77	No	-	4	1	-	5
Skeletocutis biguttulata	Resupinate	8.24	3.82	No	-	-	20	-	20
Skeletocutis brevispora	Resupinate	5.15	2.67	No	-	5	-	-	5
Skeletocutis carneogrisea	Pileate	2.86	3.14	No	-	4	-	-	4
Skeletocutis kuehneri	Resupinate	1.78	4.44	No	-	6	-	-	6
Skeletocutis nivea	Pileate	1.99	6.00	No	1	-	-	1	2
Skeletocutis papyracea/subincarnata	Resupinate	7.43	3.10	No	-	9	9	-	18
Skeletocutis stellae	Resupinate	3.34	4.25	No	-	-	1	-	1
Sphaerobasidium minutum	Resupinate	37.33	1.38	No	-	1	1	-	2
Sphaerostilbella berkeleyana	Resupinate	105.83	3.14	Yes	1	-	-	-	1
Steccherinum lacerum	Resupinate	34.58	1.34	No	1	-	-	-	1
Steccherinum ochraceum	Resupinate	14.53	1.43	No	1	-	-	-	1
Stereum hirsutum	Pileate	45.95	2.17	No	13	-	-	1	14
Stereum rugosum	Pileate	186.53	1.90	No	6	-	-	-	6
Stereum sanguinolentum	Pileate	63.62	3.00	No	-	1	-	-	1
Stereum subtomentosum	Pileate	26.84	3.00	No	1	-	-	-	1
Stictis cf mollis	Discomycetoid	649.01	91.83	No	-	-	-	4	4
Stictis sp1.	Discomycetoid	77.90	65.22	No	1	-	-	1	2
Strossmayeria basitricha	Discomycetoid	414.69	8.25	No	1	-	-	-	1
Strossmayeria nigra	Discomycetoid	349.44	8.78	No	-	-	-	2	2
Stypella dubia	Resupinate	75.40	1.50	No	1	-	-	-	1
Stypella vermiformis	Resupinate	55.22	1.33	No	-	-	1	-	1
Subulicystidium longisporum	Resupinate	80.18	4.91	No	13	-	-	12	25
Suillosporium cystidiatum	Resupinate	163.36	3.25	No	-	-	1	-	1
Tapinella panuoides	Agaricoid	48.11	1.43	No	-	1	-	-	1
Tomentella badia	Resupinate	785.40	1.00	Yes	-	-	-	1	1
Tomentella botryoides	Resupinate	232.28	1.08	Yes	-	-	-	1	1

Tomentella brevispina	Resupinate	331.34	1.00	Yes	1	1	-	1	3
Tomentella bryophila	Resupinate	402.12	1.00	Yes	8	2	-	7	17
Tomentella cinerascens	Resupinate	113.65	1.00	Yes	2	1	-	2	5
Tomentella coerulea	Resupinate	259.44	1.07	Yes	-	-	-	1	1
Tomentella ellisii	Resupinate	304.17	1.26	Yes	1	-	2	-	3
Tomentella lapida	Resupinate	572.56	1.00	Yes	12	6	2	5	25
Tomentella lateritia	Resupinate	331.34	1.00	Yes	1	1	-	1	3
Tomentella lilacinogrisea	Resupinate	307.88	1.14	Yes	4	-	1	2	7
Tomentella sp1.	Resupinate	111.33	1.56	Yes	1	-	-	-	1
Tomentella sp2.	Resupinate	307.88	1.14	Yes	-	-	-	1	1
Tomentella stuposa	Resupinate	673.38	1.00	Yes	2	-	-	2	4
Tomentella sublilacina	Resupinate	364.47	1.10	Yes	6	8	2	3	19
Tomentella terrestris	Resupinate	346.43	1.23	Yes	2	2	2	1	7
Tomentella umbrinospora	Resupinate	288.63	1.07	Yes	1	-	-	-	1
Tomentella viridescens	Resupinate	331.34	1.00	Yes	-	1	1	-	2
Tomentella viridula	Resupinate	350.90	1.17	Yes	1	-	-	-	1
Tomentellopsis bresadolana	Resupinate	169.65	1.00	Yes	-	-	1	-	1
Tomentellopsis cf submollis	Resupinate	101.89	1.21	Yes	-	-	-	1	1
Tomentellopsis echinospora	Resupinate	98.17	1.00	Yes	1	-	-	-	1
Tomentellopsis nigra	Resupinate	572.56	1.00	Yes	1	-	1	1	3
Tomentellopsis sp1.	Resupinate	130.67	1.00	Yes	2	-	-	-	2
Trametes hirsuta	Pileate	22.24	2.66	No	1	-	-	2	3
Trametes ochracea	Pileate	39.51	2.56	No	3	-	-	8	11
Trametes pubescens	Pileate	28.19	2.77	No	-	-	-	2	2
Trechispora alnicola	Resupinate	24.44	1.28	Yes	-	-	1	-	1
Trechispora byssinella	Resupinate	14.91	1.67	No	1	2	-	1	4
Trechispora cohaerens	Resupinate	11.00	1.75	No	1	-	1	-	2
Trechispora farinacea	Resupinate	49.70	1.20	Yes	5	4	3	4	16
Trechispora hymenocystis	Resupinate	59.69	1.19	Yes	6	-	3	3	12
Trechispora kavinioides	Resupinate	13.92	1.56	No	1	1	-	-	2
Trechispora laevis	Resupinate	26.15	1.23	Yes	-	1	3	-	4
Trechispora microspora	Resupinate	35.26	1.31	Yes	2	2	2	1	7
Trechispora minima	Resupinate	35.60	1.06	Yes	-	-	1	1	2
Trechispora stellulata	Resupinate	22.97	1.08	Yes	-	3	-	-	3
Tremella foliacea	Ramarioid	436.35	1.19	No	1	-	-	-	1
Tretomyces cf microsporus	Resupinate	9.12	1.09	No	-	1	-	-	1

Trichaptum abietinum	Pileate	34.64	2.24	No	1	22	12	2	37
Trichoderma minutisporum/pachybasioides	Stromatoid	48.35	1.32	Yes	1	1	-	1	3
Trichoderma pulvinatum	Stromatoid	31.81	1.50	Yes	3	9	1	1	14
Trichoderma strictipile	Stromatoid	98.84	1.10	Yes	1	-	-	-	1
Trichoderma viride	Stromatoid	60.75	1.47	Yes	3	-	-	1	4
Tricholomopsis decora	Agaricoid	184.13	1.41	No	-	-	4	-	4
Trichophaeopsis bicuspis	Discomycetoid	1527.07	1.38	No	-	-	-	1	1
Trichosphaeria notabilis	Pyrenomycetoid	547.52	2.54	No	1	-	-	-	1
Tubaria conspersa	Agaricoid	214.23	1.43	No	1	-	-	5	6
Tubaria furfuracea	Agaricoid	178.59	1.57	No	3	1	1	2	7
Tubulicrinis accedens	Resupinate	30.76	1.53	No	1	2	5	-	8
Tubulicrinis angustus	Resupinate	26.94	5.00	No	-	1	-	-	1
Tubulicrinis borealis	Resupinate	18.85	3.00	No	-	28	15	-	43
Tubulicrinis calothtrix	Resupinate	16.84	4.00	No	1	17	13	3	34
Tubulicrinis chaetophorus	Resupinate	49.77	1.85	No	-	-	1	-	1
Tubulicrinis glebulosus	Resupinate	20.71	4.00	No	4	1	2	5	12
Tubulicrinis medius	Resupinate	16.84	4.00	No	-	1	14	-	15
Tubulicrinis propinquus	Resupinate	14.97	4.24	No	-	-	1	-	1
Tubulicrinis sororius	Resupinate	14.43	3.43	No	-	2	1	-	3
Tubulicrinis strangulatus	Resupinate	14.62	1.00	No	-	11	4	-	15
Tubulicrinis subulatus	Resupinate	16.84	4.00	No	1	12	38	8	59
Tulasnella albida	Resupinate	87.47	1.22	No	-	-	-	2	2
Tulasnella allantospora	Resupinate	49.00	3.00	No	-	-	-	1	1
Tulasnella brinkmannii	Resupinate	265.81	3.16	No	1	-	-	-	1
Tulasnella cf conidiata	Resupinate	384.85	1.43	No	-	-	-	2	2
Tulasnella cystidiophora	Resupinate	98.17	1.00	No	3	-	-	1	4
Tulasnella eichleriana	Resupinate	22.27	1.36	No	4	3	1	3	11
Tulasnella fuscoviolacea	Resupinate	170.24	2.82	No	-	-	-	1	1
Tulasnella pallida	Resupinate	259.67	1.74	No	-	1	-	-	1
Tulasnella subglobospora	Resupinate	248.87	1.15	No	-	-	1	-	1
Tulasnella tomaculum	Resupinate	32.67	2.00	No	-	-	-	1	1
Tulasnella violea	Resupinate	127.63	1.30	No	11	2	4	-	17
Tylospora asterophora	Resupinate	70.93	1.18	No	1	1	1	1	4
Tylospora fibrillosa	Resupinate	110.75	1.32	Yes	11	10	11	9	41
Tympanis sp1.	Discomycetoid	238.76	4.75	No	-	2	4	-	6

Urceolella sp nov.	Discomycetoid	61.14	2.61	No	-	-	-	1	1
Vaginatispora cf fuckelii	Pyrenomycetoid	182.21	3.63	No	4	-	-	10	14
Wallrothiella congregata	Pyrenomycetoid	10.93	1.22	No	-	1	-	-	1
Vararia investiens	Resupinate	82.96	3.08	No	1	-	-	-	1
Veluticeps abietina	Pileate	174.95	2.44	No	-	3	-	-	3
Xenasma pulverulentum	Resupinate	282.74	1.67	Yes	-	-	-	1	1
Xenasma rimicola	Resupinate	306.80	1.60	Yes	-	-	-	1	1
Xenasma tulasnelloideum	Resupinate	87.47	1.22	Yes	-	-	-	2	2
Xenasmatella borealis	Resupinate	45.63	1.69	Yes	-	-	1	-	1
Xenasmatella subflavidocrisea	Resupinate	15.90	1.78	Yes	-	-	1	-	1
Xenasmatella vaga	Resupinate	74.48	1.24	Yes	14	12	18	11	55
Xenolachne longicornis	Discomycetoid	87.11	3.23	No	-	-	1	1	2
Xeromphalina campanella	Agaricoid	67.35	2.00	No	-	1	1	-	2
Xeromphalina picta	Agaricoid	119.28	1.67	No	1	-	-	-	1
Xylodon asperus	Resupinate	60.75	1.47	No	3	6	6	6	21
Xylodon borealis	Resupinate	55.22	1.33	No	-	-	-	1	1
Xylodon brevisetus	Resupinate	37.33	1.38	No	5	32	26	3	66
Xylodon detriticus	Resupinate	74.48	1.24	No	2	-	-	7	9
Xylodon nespori	Resupinate	20.87	2.33	No	-	-	1	-	1
Xylodon radula	Resupinate	74.66	2.77	No	2	1	-	-	3
Xylodon rimosissimus	Resupinate	60.75	1.47	No	-	1	-	2	3
Xylodon sambuci	Resupinate	57.98	1.40	No	-	-	-	3	3
Total occurrence of species					1566	1422	1222	1504	5714

Consulted literature for fungal traits:

Baloch, E., Gilenstam, G., Wedin, M., 2009. Phylogeny ans classification of Cryptodiscus, with taxonimic synopsis of the Swedish species. Fungal Divers. 38, 51–68.

Bernicchia, A., Gorjon, S.P., 2010. Fungi Europaei nº 12: Corticiaceae s.l., Fungi Europaei. Candusso Edizioni, Alassio.

Boehm, E., Mugambi, G.K., Miller, a N., Huhndorf, S.M., Marincowitz, S., Spatafora, J.W., Schoch, C.L., 2009. A molecular phylogenetic reappraisal of the Hysteriaceae, Mytilinidiaceae and Gloniaceae (Pleosporomycetidae, Dothideomycetes) with keys to world species. Stud. Mycol. 64, 49–83S3. https://doi.org/10.3114/sim.2009.64.03

Breitenbach, J., Kränzlin, F., 1984. Fungi of Switzerland: Ascomycetes, Vol. 1. Verlag Mykologia, Luzern.

Dennis, R.W.G., 1960. British cup fungi and their allies. The Ray Society, London.

Ellis, M., Ellis, J.P., 1997. Microfungi on land plants: An identification handbook. The Richmond Publishing Co. Ltd., Slough.

Eriksson, J., Hjortstam, K., Ryvarden, L., 1984. The Corticiaceae of North Europe, Vol. 7. Fungiflora, Oslo.

Eriksson, J., Hjortstam, K., Ryvarden, L., 1981. The Corticiaceae of North Europe, Vol. 6. Fungiflora, Oslo.

Eriksson, J., Hjortstam, K., Ryvarden, L., 1978. The Corticiaceae of North Europe, Vol 5. Fungiflora, Oslo.

Eriksson, J., Ryvarden, L., 1976. The Corticiaceae of North Europe, Vol 4. Fungiflora, Oslo.

Eriksson, J., Ryvarden, L., 1975. The Corticiaceae of North Europe, Vol 3. Fungiflora, Oslo.

Eriksson, J., Ryvarden, L., 1973. The Corticiaceae of North Europe, Vol. 2. Fungiflora, Oslo.

Hansen, L., Knudsen, H., 2000. Nordic Macromycetes: Ascomycetes, Vol. 1. Nordsvamp, Copenhagen.

Hansen, L., Knudsen, H., 1997. Nordic Macromycetes: Heterobasidioid, Aphyllophoroid and Gastromycetoid Basidiomycetes, Vol.3. Nordsvamp, Copenhagen.

Hjortstam, K., Larsson, K.-H., Ryvarden, L., 1988. The Corticiaceae of North Europe, Vol. 8. Fungiflora, Oslo.

Huhtinen, S., 1989. A monograph of Hyaloscypha and allied genera. Karstenia 29, 45–252.

International Mycological Association, 2017. Mycobank [WWW Document]. http://www.mycobank.org/.

Knudsen, H., Vesterholt, J., 2008. Funga Nordica. Nordsvamp, Copenhagen.

Miller, A.N., Huhndorf, S.M., Fournier, J., 2014. Phylogenetic relationships of five uncommon species of *Lasiosphaeria* and three new species in the Helminthosphaeriaceae (Sordariomycetes). Mycologia 106, 505–524. https://doi.org/10.3852/13-223

Munk, A., 1957. Danish pyrenomycetes -A preliminary flora. Dansk Bot. Ark. 17, 1–491.

Niemelä, T., 2005. Käävät, puiden sienet. Norrlinia 13, 1–320.

Raitviir, A., 2004. Revised synopsis of the Hyaloscyphaceae. Scr. Mycol. 20, 1–132.

Raitviir, A., Huhtinen, S., 2002. A few out of many -interesting inoperculate, lignicolous discomycetes from Norway. Folia Cryptogam. Est. 39, 13–26.

Re, M., 2006. Molecular systematics of Ceratostomella sensu lato and morphologically similar fungi 98, 68–93.

Royal Botanic Gardens Kew, Landcare Research-NZ, Chinese Academy of Science, 2017. Index fungorum [WWW Document]. www.indexfungorum.org.

Sherwood, M.A., 1977. The Ostropalean fungi. Mycotaxon 5, 1–277.

Morphological traits predict host-tree specialization in wood-inhabiting fungal communities

Purhonen Jenna, Ovaskainen Otso, Halme Panu, Komonen Atte, Huhtinen Seppo, Kotiranta Heikki, Læssøe Thomas, & Abrego Nerea

Supplementary Material 3

TABLE 1 Kruskal-Wallis ANOVA chi-square test coefficients and P-values (df for all groups is 3) as well as P-values for Nemenyi pairwice comparisons of average species richness per log among the tree species for the total species richness and also separately for the fruitbody groups.

	Birch	Spruce	Pine	Birch	Spruce	Pine	Birch	Spruce	Pine
	All			Agaricoid			Discomycetoid		
	$\chi^2 = 17.602$		P < 0.001	$\chi^2 = 2.150$		P = 0.543	$\chi^2 = 94.978$		P < 0.001
Spruce	0.390	-	-	0.890	-	-	<0.001	-	-
Pine	0.001	0.155	-	1.000	0.940	-	<0.001	0.990	-
Aspen	0.809	0.904	0.026	0.930	0.550	0.87	0.930	<0.001	<0.001
	Pileate			Pyrenomycetoid			Ramarioid		
	$\chi^2 = 69.800$		P < 0.001	$\chi^2 = 64.233$		P < 0.001	$\chi^2 = 7.7601$		P = 0.051
Spruce	0.010	-	-	<0.001	-	-	0.056	-	-
Pine	0.000	<0.001	-	<0.001	0.984	-	0.720	0.468	-
Aspen	0.048	<0.001	0.461	0.268	<0.001	0.000	0.468	0.720	0.979
	Resupinate			Stromatoid					
	$\chi^2 = 19.879$		P < 0.001	$\chi^2 = 40.840$		P < 0.001			
Picea	0.012	-	-	0.0306	-	-			
Pinus	0.074	0.926	-	<0.001	0.448	-			
Populus	0.995	0.005	0.038	0.7908	0.001	<0.001			