Insects in conifer logs

Their association to the polypore fungi *Amyloporia sinuosa, A. xantha* and *Neoantrodia serialis* and impact of aggregations of wood

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Insects in conifer logs -their association to the polypore fungi *Amyloporia sinuosa, A. xantha* and *Neoantrodia serialis* and impact of aggregations of wood

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Abstract

A large number of insects are associated with polypores. They can be monophagous, polyphagous and use several fungal hosts, or be parasites on the insects utilize the fungus. The insect assemblage for some polypores is well investigated but there is still a lack of knowledge for many species. The aim with this study was to bring further knowledge of the insect fauna associated with the widespread, resupinate polypore species *Amyloporia sinuosa, A. xantha* and *Neoantrodia serialis*. Another aim is to investigate how the spatial distribution of dead wood impact the occurrence of the species. The distribution of dead wood has earlier been shown to be an important factor for some saproxylic insects.

A total of 101 conifer log samples (*A. sinuosa* (n=36), *A. xantha* (n=14), *N. serialis* (n=51) were collected in Uppland, Sweden for rearing. At each sampling site the volume of dead wood was noted in three different scales (10, 30 and 50 m). From the end of April to middle of September 2022 in total 2510 insect individuals emerged belonging to more than 116 species (Nematocera and most Hymenoptera species were not identified). The two *Amyloporia* polypores shared many insect species, with *Peltis ferruginea, Cixidia lapponica* and *C. confinis* as the most frequent. The insect community of *N. serialis* was very different from that of *Amyloporia,* with *Montescardia tessulatella* and *Cis dentatus* as the most frequent insects. The difference in species assemblage is likely explained by the distant phylogenetic relationship between the polypore genera.

Two unexpected findings were the Tineidae moths *Nemapogon fungivorellus* (9 individuals in 3 *N. serialis* samples) and *Agnathosia sandoeensis* (2 individuals in an *A. xantha* sample). *N. fungivorellus* is not previously known for that host and *A. sandoeensis* was found in mainland Sweden for the first time and was previously only known from three locations in the world. The impact of dead wood volume was not clearly visible, with a possible exception for the Ptinidae beetle *Stagetus borealis*. A likely explanation for this result is a small sampling size and the few occurrences of many species.

Keywords: polypores, dead wood volume, *Amyloporia sinuosa, A. xantha, Neoantrodia serialis, Nemapogon fungivorellus, Agnathosia sandoeensis.*

Table of contents

1. Introduction

Almost all native forests in Europe are to varying degrees affected by forestry (Vanbergen et al. 2005). Changed habitat quality and fragmentation affect the forests biodiversity with decreasing populations of many species (Hanski 2011). In Sweden, logging together with regrowth of previously open land have the largest negative impact on red listed species (Eide 2020). One of the most important factors for biodiversity in boreal forests is the volume and different qualities of dead wood. In Sweden about one third of all forest living species are associated with dead wood (Dahlberg & Stokland 2004). However, the amount of dead wood in managed forests is in general only a few percent of what is found in old-growth forests (Siitonen 2001). A large proportion of the dead wood associated species are insects. Some of them, for example many bark beetles (Scolytidae) and longhorn beetles (Cerambycidae) species, are living directly off the wood or bark when it is freshly dead. But many are also associated with bracket fungi (polypores) directly or indirectly as parasites on saproxylic insects (Dahlberg & Stokland 2004).

Insects associated with bracket fungi can be highly polyphagous with many different hosts or monophagous and use a specific fungal species (Orledge & Reynolds 2005). Insect species living in bracket fungi are also normally more host specific than species living in other fungi (Hanski 1989). Closely related fungal species share in general more saproxylic insect species than more distant related species (Jonsell & Nordlander 2004). Except for the phylogeny, the hyphal structure is also important to explain the occurrences (Paviour-Smith 1960).

The insect communities for some bracket fungi hosts are quite well investigated (Schigel 2009, 2012), especially for the common and widespread species *Fomes fomentarius*, *Fomitopsis pinicola* and *Piptoporus betulinus* (e.g., Fossli & Andersen 1998 (Ciidae), Jonsell & Nordlander 2004, Thunes 1994 (Coleoptera), and Økland 1995). *Daedalea quercina*, *Mensularia radiata* and *Rhodofomes roseus* are additional examples of polypores that have been studied in detail regarding their hosted insect species (Jonsell et.al. 2016, Komonen 2001; Komonen et.al. 2012). The previously mentioned species have well developed, large fruiting bodies and are easy to collect. Garpebring (2004) studied the beetle assemblage connected with the resupinate polypore *Amyloporia xantha* on pine and compared with wood without fungal occurrences. However, fungi with resupinate and thinner fruiting bodies of this kind seem to have been less well investigated than fungi with large fruiting bodies. In this study I focus on insects and their associations with the three resupinate, brown-rotting polypores *Amyloporia sinuosa, A. xantha* and *Neoantrodia serialis*, which are common and well distributed on coniferous wood in northern Europe.

Except for the presence of a suitable host, habitat fragmentation and amount of suitable substrate could have an impact on the occurrence and frequency of species (Fahrig 2003). The Lepidoptera species *Agnathosia mendicella* and especially its parasite *Phytomyptera cingulata* were less frequent on *R. roseus* fruiting bodies in fragmented forests in Finland (Komonen et.al. 2000). The occurrence of the Tenebrionidae beetle species *Bolitophagus reticulatus* and *B. cornotus,* negatively correlated with basidiocarp *(F. fomentarius)* isolation on several spatial scales, up to forest island scale (Kehler & Bondrup-Nielsen 1999; Rukke & Midtgaard 1998; Svendrup-Thygeson & Midgaard 1998). For some insect species, previous studies have shown a connection between wood abundance and the occurrence of saproxylic insects. The occurrence of another Tenebrionidae beetle species, *Upis ceramboides*, which develop under bark on white-rotted birches, has been shown to positively correlate with higher birch wood abundance and aggregated wood on clear cuts in Sweden (Naalisvaara 2013; Rubene 2014; Wikars & Orrmalm 2005). Another study showing that different wood insects in Switzerland favour aggregated wood is Schiegg (2000). To my knowledge no previous studies have been conducted on the impact of wood distribution on the occurrences of saproxylic insects living on *A. sinuosa, A. xantha* and *N. serialis*. However, *Calitys scabra* which is connected to *A. sinuosa* and *A. xantha* is assumed to have a limited dispersal ability and benefit from aggregated wood (Ardatabanken SLU 2023a, Wikars 2014).

A good understanding of species with knowledge of the impact of wood volume can be used in nature conservation. Large volume of aggregated dead wood is for example created by spruce bark beetle (*Ips typographus*) outbreaks. When outbreaks occur, as in many places in Sweden in recent years (Jonsell 2022), it is relevant to know if the wood should always be carried away to prevent further spreading of *I. typographus*. Are large volumes of aggregated dead coniferous wood important for the occurrence of insect species or is it enough with more sparse and scattered logs? The aims of this study were to find out:

1. What insect species that are associated with *A. sinuosa, A. xantha, N. serialis* on coniferous.
2. How the insect communities of the polypore hosts differ from each other.
3. How the spatial distribution of dead wood impacts the occurrence of these species.

2. Material and Methods

2.1 Study species

Amyloporia sinuosa (Fr.) Rajchenb, Gorjón & Pildain, *A. xantha* (Fr.) Bondartsev & Singerand and *Neoantrodia serialis* (Fr.) Audet are all common fungal species in northern Europe, causing brown rot in coniferous wood. In Sweden *A. sinuosa* is common on both Norway spruce *(Picea abietis)* and Scots pine *(Pinus sylvestris)*. *Amyloporia xantha* is common on pine and more rarely occurs on spruce and deciduous trees. *Neoantrodia serialis* is most common on spruce but can rarely occur on other trees as well. All species form resupinate whitish fruit bodies, even if *N. serialis* also commonly forms carps with a brown upper surface (Ryman & Holmåsen 1984). All species formerly belonged to *Antrodia*, but recent phylogenetic studies have placed them in different genera. *A. sinuosa* is sometimes brought to its own genus: *Adustoporia* (Audet 2017; Liu et.al. 2022). However, *Adustoporia* and *Amyloporia* form a monophyletic group and are not very closely related to *Neoantrodia* (Rajchenberg 2011; Runnel et.al. 2019).

2.2 Study areas

The sampling of wood took place in Uppsala and Knivsta municipalities in the county of Uppland, Sweden. The area is located in the hemiboreal vegetation zone (Ahti et.al. 1968). Three nature reserves, Norra Lunsen, Hågadalen-Nåsten and Tjäderleksmossen, were visited as well as forests owned by Holmen skog AB (fig.1).

The reserves were chosen because of their large size and high frequency of mature forests which made it possible to sample wood of different qualities (e.g., polypore species, tree species and surrounding wood volume) from the same area. The investigated forests owned by Holmen Skog AB were found by observation of orthophotos from Lantmäteriet (Swedish Land Survey) and field visits. Here I also searched for larger areas with mature coniferous forests.

The reserves are partially old growth forests and partially managed by modern forestry. Scots pine (from here just referred to as pine) dominates in higher parts, while Norway spruce (from here just referred to as spruce) is more common in lower parts as well as some deciduous trees (Länsstyrelsen Uppsala 2008; Uppsala kommun 1998; Uppsala kommun 2003). The forests owned by Holmen skog were similar to the forests in the reserves. The forests varied in age and proportions of tree species, with some more dominated by spruce and some more dominated by pine. An area west of Tjäderleksmossen nature reserve belonging to Holmen skog AB during sampling were later integrated with the reserve (Länsstyrelsen Uppsala 2022).

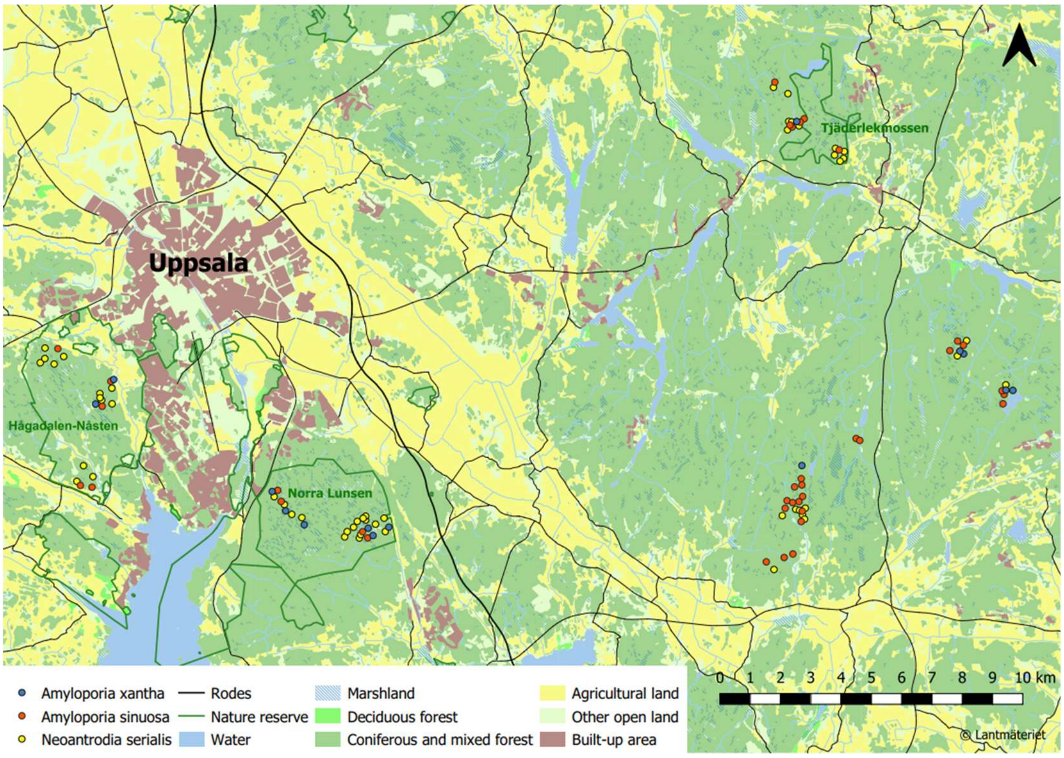

Figure 1. Sites where pieces of wood were sampled. Each dot represents a sampled log, and the color shows the polypore species.

2.3 Field sampling

During March and April 2022 coniferous wood containing *A. sinuosa*, *A. xantha* and *N. serialis* were searched for and collected. The number of logs sampled in each site was based on time constraints as well as by reaching similar numbers between the sites, although some sites were limited by their size. When a log with an occurrence of one of the study species was found, a 55 cm long part of the log was sawed off at a place where it was between 10 and 30 cm thick. For each sampled piece of wood, the variables described in table 1 were noted. Generally, the first encountered log hosting a relevant polypore was sampled. Additional logs for sampling in each site were chosen when encountered, if they hosted one of the study species and were at least 100 meters away from previously sampled logs, in order to avoid counting the same surrounding logs for different samples. Sometimes many logs with the same polypore species and similar amount of surrounding wood were sampled in an area. Then I searched for more variety in polypore species and wood volume instead of choosing the first log found 100 meters or more from the previous sample spot. All sampled logs occurred in semi closed or closed forests to avoid a large impact of light on the insect occurrences. At places with >10 logs within 10 meters from the sampling spot, the logs between 10 and 50 meters away were only counted and not measured. The volume at this distance was generated by multiplying the number of logs with the average volume of the logs within 10 meters. This was done to save time at the places with the largest wood volumes.

A total of 101 wood samples containing *A. sinuosa* (n=36), *A. xantha* (n=14) or *N. serialis* (n=51) were collected. All *A. xantha* sampled were growing on pine, all *N. serialis* were growing on spruce and *A. sinuosa* were growing on either spruce (n=20) or pine (n=16). Only logs with typical and living fruiting bodies were sampled to ensure a correct identification.

Table 1. Predictor variables noted at each sampling site.

Variable	**Description**
Tree species*	*Picea abietis* or *Pinus sylvestris.*
Polypore species*	*A. sinuosa, A. xantha* or *N. serialis.*
Other basidiocarps	Occurrence of other species at the same log. Other species on the same pieces of sampled wood is avoided.
Diameter**	Diameter of wood sample.
Volume log**	Total volume of log that was sampled from.
Ground contact**	If the sampled wood has contact with the ground: yes (1), no (0).
Light**	Closed forest (2), semi closed forest (1). Ocularly estimated.
Moisture**	Study of vegetation: dry (1), mesic (2), moist (3), wet (4).
Decay class**	Scale (1-6) based on how deep a knife can penetrate the sampled wood (se Siitonen & Saaristo 2000).
Decay class surrounding	Most decayed log within 10, 30 and 50 m from the sample site. Measured as above.
Wood volume**	Volume of wood, diameter >10cm, within 10, 30 and 50 m from the sample site.
Picea volume	As wood volume but only spruce wood.
Pinus volume	As wood volume but only pine wood.
Polypore wood volume	As above but wood with occurrence of *A. sinuosa, A. xantha* or *N. serialis.*

*Parameters included in Fisher's exact tests.

** Parameters included in generalized linear models.

2.4 Rearing and identification of insects

The sampled log pieces were placed in plywood boxes (60 x 30 x 30 cm and 60 x 35 x 35 cm) under roof in a mesh building (fig. 2) which approximately had outdoor temperature. The last wood piece was placed in a box on April 15th. Each box had a hole with an inserted glass vial. Most emerged insects searched for the light and entered the vial. The insects were collected from the vials weekly in late May to middle of July and less frequently the rest of the study period. Lepidoptera were placed in a freezer while the rest of the insects were kept in ethanol. The boxes were emptied and searched for remaining insects between 8th and 16th September. Insects on the wood sample, at the bottom of the box and on the sealing tape were then collected.

Insects were identified to species with some exceptions due to time restriction and limited knowledge. Nematocera were only identified to order and Hymenoptera were with some exceptions identified to suborder. Some fragmented individuals or difficult species in other orders were also identified to a taxon above species level. Literature used for identification was primarily Hansen et.al. (1908-1965) for Coleoptera and Bengtsson et.al. (2008) for Lepidoptera. Brachycera and two frequent species of Parasitica were sent away to experts for identification. When required for a correct identification, genitalia preparation was used. This was applied, for example, to distinguish *Nemapogon cloacellus* from *N. wolffiellus* and *Rhyncolus elongatus* from *R. sculpturatus*. The nomenclature used follows Dyntaxa (Artdatabanken SLU 2023b). All species were reported to Artportalen.se (Swedish Species Observation System) and are searchable under the project name: *Insects associated with Amyloporia sinuosa, A. xantha and Neoantrodia serialis*.

Figure 2. Some of the plywood boxes used for rearing, with glass vials and ethanol jars visible.

2.5 Statistics

For the statistical tests, R software version 4.2.2 was used (R Core Team 2022). Species occurring in six samples, or more were considered to contain enough data to be analysed.

2.5.1 Association to host

Whether there was difference in the proportion of occupied logs was analysed with a Fisher's exact test, for which the fisher.test() function in R stats package was used (R Core Team 2022). Both the importance of the polypore and the tree species were tested.

2.5.2 Spatial distribution of dead wood

The impact of spatial distribution of dead wood on the occurrence of the most common insects were tested with generalized linear models. One model was made for each insect species at each distance (10, 30 and 50 m) from the sampling site. The following predictor variables were used: diameter, log volume, ground contact, light, moisture, decay class and wood volume, on corresponding distance from the sampling spot. This resulted in 69 models (23 species x 3 distances) with seven variables in each. The predictor variable decay class surroundings were not used because the wood in the highest class (6) was found in almost all spots and was therefore not a good indicator for continuity of dead wood. The correlation between the other predictor variables was tested using Pearson's and Kendall's coefficients depending on the type of variable according to Khamis (2008) (cor.test() function; R stats package; R Core Team 2022). Polypore wood volume was strongly correlating (>0.7) with the total wood volume and therefore not kept in the model (correlation threshold according to Dormann et.al. 2012). The total wood volume was chosen accounting for the fact that other polypore species than the investigated ones could contain the studied insects. There is also the possibility that the wood could contain polypores without having fruiting bodies. Another possibility is that old dead wood could have had previous polypore occurrences and therefore have an impact on the insect occurrences. The other predictor variables had a low degree of correlation, in general <0.4, and were therefore kept in the model (Dormann et.al. 2012). In addition to the correlation between predictor variables, correlation between sites and predictor variables was tested and found to be small. The sites probably have different dead wood history which could have led to false results if it correlated too much with other variables.

The results obtained by Fisher's exact test regarding host association were used to choose the type of wood used in the models. If an insect species were shown to be absent or close to absent from wood of a certain tree species or fungus species that type of wood was excluded in the models for the species. The models were validated by inspecting the residuals (simulateResiduals(), testOverdispersion(); DHARMa package; Hartig 2022). Overdispersion was detected for some of the models. In those cases, a quasipoisson distribution was used instead of Poisson. An Anova type II Wald chi-square test was used to test significance of the variables in the model (Anova(); car package; Fox & Weisberg 2019).

Results

In total 2510 insect individuals were observed, belonging to 94 identified species and some higher taxa (Tab. 2). Since insects in some groups, especially Hymenoptera and Diptera, were not identified to species the true number of species is higher. The most common insect order in the samples was Lepidoptera with 775 individuals, because of the most common species: *Montescardia tessulatella* with 681 individuals. The most species rich and second individual rich order was Coleoptera with 65 species and 603 individuals. Of the emerged species, 24 were occurring in six logs or more. Of them, 23 species were analysed further. *Acrocercops brongniardellus* were observed overwintering in the boxes in large numbers where they were stored and has nothing to do with the wood.

Table 2. Emerged insect species, and in some cases higher taxa, from polypores (A. sinuosa (sampled logs(n)=36), A. xantha (n=14), N. serialis (n=51)) on either spruce (n=71) or pine (n=30). No account has been taken to that some species only overwintered in the logs.

Family	**Species**	**Tot.**	**Occurrences**	**Individuals**				
				A. sinuosa	***A. xantha***	***N. serialis***	***P. abies***	***P. sylvestris***
Coleoptera		**603**		217	90	296	437	166
Carabidae	*Bembidion lampros*	1	1			1	1	
Carabidae	*Pterostichus diligens*	1	1	1				1
Carabidae	*Oxypselaphus obscurus*	2	2	2			1	1
Carabidae	*Harpalus affinis*	2	2	2			1	1
Silphidae	*Phosphuga atrata*	20	10	16		4	18	2
Staphylinidae	*Dropephylla linearis*	4	3	2		2	4	
Staphylinidae	*Sepedophilus testaceus*	1	1		1			1
Scirtidae	*Contacyphon variabilis*	1	1		1			1
Scirtidae	*Contacyphon padi*	2	2			2	2	
Elateridae	*Denticollis linearis*	2	2	1		1	2	
Elateridae	*Ampedus sanguineus*	1	1			1	1	
Elateridae	*Ampedus pomorum*	2	2	1	1			2
Elateridae	*Ampedus balteatus*	1	1		1			1
Elateridae	*Ampedus tristis*	1	1	1				1
Elateridae	*Melanotus sp.***	4	4		1	3	3	1
Eucnemidae	*Hylis cariniceps*	1	1			1	1	
Ptinidae	*Ptinus subpillosus*	1	1			1	1	
Ptinidae	*Anobium punctatum*	4	4			4	4	
Ptinidae	*Hadrobregmus pertinax*	1	1	1				1
Ptinidae	*Stagetus borealis*	9	6	9			1	8
Ptinidae	*Dorcatoma punctulata*	1	1	1			1	
Trogossitidae	*Calitys scabra*	16	6	6	10			16
Trogossitidae	*Peltis ferruginea*	153	38	75	47	31	83	70
Trogossitidae	*Thymalus limbatus*	6	3	2		4	4	2
Trogossitidae	*Grynocharis oblonga*	1	1			1	1	

Table 2. (Continued).

Family	Species	Tot. Ind.	Occurrences	Individuals				
				A. sinuosa	*A. xantha*	*N. serialis*	*P. abies*	*P. sylvestris*
Coleoptera		**603**		217	90	296	437	166
Dasytidae	*Dasytes caeruleus*	2	2			2	2	
Monotomidae	*Rhizophagus depressus*	1	1			1	1	
Silvanidae	*Dendrophagus crenatus*	1	1			1	1	
Erotylidae	*Dacne bipustulata*	1	1			1	1	
Phalacridae	*Olibrus bicolor*	1	1			1	1	
Cerylonidae	*Cerylon histeroides*	1	1	1				1
Coccinellidae	*Scymnus frontalis*	1	1			1	1	
Coccinellidae	*Myrrha octodecimguttata*	1	1			1	1	
Latridiidae	*Corticaria serrata*	22	14	4	4	14	15	7
Latridiidae	*Corticaria longicollis*	22	13	8		14	18	4
Ciidae	*Cis castaneus*	4	2	3	1		3	1
Ciidae	*Cis glabratus*	10	7	6		4	10	
Ciidae	*Cis quadridens*	1	1	1			1	
Ciidae	*Cis punctulatus*	5	4	4		1	3	2
Ciidae	*Cis dentatus*	97	32	6		91	97	
Ciidae	*Ennearthron cornutum*	24	10	8	5	11	12	12
Scraptiidae	*Anaspis marginicollis*	16	10	5	1	10	14	2
Scraptiidae	*Anaspis thoracica*	13	9	7	1	5	10	3
Scraptiidae	*Anaspis rufilabris*	25	13	16	3	6	21	4
Tetratomidae	*Hallomenus binotatus*	2	2		1	1	1	1
Tetratomidae	*Hallomenus axillaris*	8	5			8	8	
Cerambycidae	*Stictoleptura rubra*	4	4			4	4	
Cerambycidae	*Anastrangalia sanguinolenta*	4	4	2		2	2	2
Chrysomelidae	*Plagiosterna aenea*	1	1	1			1	
Chrysomelidae	*Phratora vitellinae*	2	2	1		1	2	
Anthribidae	*Anthribus nebulosus*	2	2	1		1	2	
Apionidae	*Catapion seniculus*	1	1			1	1	
Apionidae	*Betulapion simile*	2	1			2	2	
Curculionidae	*Sitona lineatus*	1	1	1			1	
Curculionidae	*Sitona humeralis*	1	1	1			1	
Curculionidae	*Anthonomus phyllocola*	1	1		1			1
Curculionidae	*Brachonyx pineti*	1	1	1			1	
Curculionidae	*Rhyncolus elongatus*	2	1	2				2
Curculionidae	*Rhyncolus ater*	43	27	11	9	23	32	11
Curculionidae	*Rhyncolus sculpturatus*	18	12	3	2	13	15	3
Curculionidae	*Ips typographus*	4	4	2		2	3	1
Curculionidae	*Crypturgus cinereus*	9	4			9	9	
Curculionidae	*Crypturgus hispidulus*	11	5	2		9	11	
Diptera		**246**		92	34	120	180	66
Asilidae	*Choerades marginatus*	11	8	6	3	2	6	5
Brachycera	*Brachycera*	3	2	2		1	1	2
Dolichopodidae	*Gymnopternus metallicus*	7	3	5	2		2	5
Dolichopodidae	*Medetera sp.*	1	1	1				1
Empididae	*Rhamphomyia marginata*	5	3		2	3	3	2
Hybotidae	*Euthyneura albipennis*	3	3	1		2	3	
Hybotidae	*Euthyneura myrtilli*	8	4		2	6	6	2
Iteaphilidae	*Iteaphila furcata*	1	1			1	1	
Iteaphilidae	*Iteaphila nitidula*	6	4	4		2	6	
Lonchaeidae	*Lonchaea obscuritarsis*	1	1			1	1	
Lonchaeidae	*Lonchaea sp.*	7	4	1		6	7	
Milichiidae	*Phyllomyza securicornis*	1	1	1			1	
Muscidae	*Coenosia intermedia*	1	1			1	1	
Mythiocomyiidae	*Glabellula arctica*	4	2	1	3			4
Nematocera	*Nematocera spp.*	181	74	67	22	92	137	41

Table 2. (Continued).

Family	Species	Tot. Ind.	Occurrences	Individuals				
				A. sinuosa	*A. xantha*	*N. serialis*	*P. abies*	*P. sylvestris*
Diptera		**246**		92	34	120	180	66
Phoridae	*Phoridae sp.*	1	1			1	1	
Syrphidae	*Microdon analis*	4	1	4				4
Tachinidae	*Elodea ambulatoria*	2	2			2	2	
Tachinidae	*Phytomyptera cingulata*	1	1	1			1	
Tachinidae	*Siphona sp.*	1	1	1			1	
Hemiptera		**420**		275	95	50	149	271
Acalypta	*Acalypta sp.**	1	1	1			1	
Achilidae	*Cixidia confinis*	141	22	62	71	8	30	111
Achilidae	*Cixidia lapponica*	246	28	216	25	5	80	166
Aradidae	*Aradus betulinus*	37	15	1		36	37	
Aradidae	*Aradus obtectus*	1	1			1	1	
Hymenoptera		**433**		209	42	182	266	167
Aculeata	*Aculeata spp.*	16	7	6	2	8	13	3
Braconidae	*Bassus calculator*	33	8			33	33	
Crabronidae	*Crossocerus sp.*	1	1			1	1	
Formicidae	*Formicidae spp.*	178	12	149	9	20	68	110
Parasitica	*Parasitica spp.*	178	76	51	31	96	127	51
Perilampidae	*Perilampus polypori*	23	9			23	23	
Symphyta	*Symphyta sp.*	1	1			1	1	
Lepidoptera		**775**		25	12	738	760	15
Gracillariidae	*Acrocercops brongniardellus*	26	23	10	4	12	20	6
Erebidae	*Parascotia fuliginaria*	3	3	3			3	
Pyralidae	*Dioryctria simplicella*	1	1		1			1
Tineidae	*Agnathosia mendicella*	9	5			9	9	
Tineidae	*Agnathosia sandoeensis*	2	1		2			2
Tineidae	*Archinemapogon yildizae*	6	5	2		4	6	
Tineidae	*Nemapogon cloacellus*	35	12	7	5	23	29	6
Tineidae	*Nemapogon fungivorellus*	9	3			9	9	
Tineidae	*Montescardia tessulatella*	681	42			681	681	
Tineidae	*Tineidae sp.**	2	1	2			2	
Tortricidae	*Epinotia tedella*	1	1	1			1	
Raphidioptera		**27**		15	4	8	20	7
Raphidiidae	*Phaeostigma notata*	5	5	3	1	1	4	1
Raphidiidae	*Xanthostigma xanthostigma*	22	13	12	3	7	16	6
	Total	**2510**		838	278	1394	1812	698

** Fragmented or very worn individuals.*

*** Only larvae observed.*

2.6 Association to host

Of the studied insects, polypore species was significantly important ($p<0.05$) for ten species when tested with Fishers exact test (Tab. 3). The parasitoid wasps *Bassus calculator* (number of occurrences(n)=8, p=0.012) and *Perilampus polypori* (n=9, p=0.008) and the moth *Montescardia tessulatella* (n=42, p<0.001) were found exclusively on *N. serialis*. Two other species that were significantly more common on *N. serialis* were *Cis dentatus* (n=32, p<0.001) with 29 of 32 occurrences and *Aradus betulinus* (n=15, p=0.001) with 14 of 15 occurrences on this substrate. The only species that exclusively occurred on *A. sinuosa* was *Stagetus borealis* (n=6, p=0.005). *Calitys scabra* (n=6, p=0.007), *Peltis ferruginea* (n=38, p=0.003), *Cixidia confinis* (n=22, p<0.001) and *Cixidia lapponica* (n=28, p<0.001) preferred *A. sinuosa* and *A. xantha* before *N. serialis.* Of the species found on both *A. sinuosa* and *A. xantha*, *C. scabra* was the only species that was never found on *N. serialis*.

For most species that were significantly more associated with one or two polypore species, the Fisher's test also showed significant association with a tree species. *C. dentatus* (p<0.001), *A. betulinus* (p=0.005), *M. tessulatella* (p<0.001) were exclusively and significantly associated with spruce. Other species exclusively found on spruce were: *Cis glabratus* (n=7, p=0.101), *B. calculator* (0.101) and *P. polypori* (0.054). However, the number of occurrences were not enough to give significant values. Another species close to significance, preferring spruce was *Rhyncolus ater* (n=27, p=0.053). On pine *C. scabra* (p<0.001), *S. borealis* (p=0.005), *C. confinis* (p<0.001) and *C. lapponica* (p<0.001) were significantly associated, *C. scabra* exclusively occurred on pine.

Two species occurring in more than four samples (*Agnathosia mendicella* and *Hallomenus axillaris*) were found exclusively in samples with *N. serialis*. It is likely that these species also are more associated with *N. serialis* than with the *Amyloporia* species even if the number of occurrences is less than six.

Table 3. Number of occurrences for each polypore and tree species. Insect species observed in ≥ 6 sampled logs is shown. P-values were obtained with Fisher's exact test. Significant values are in bold.

Species	Polypore species				Tree species		
	A. sinuosa n=36	***A. xantha*** n=14	***N.serialis*** n=51	**p-value**	***P. abies*** n=71	***P.sylvestris*** n=30	**p-value**
Coleoptera							
Phosphuga atrata	6		4	0.208	8	2	0.719
Stagetus borealis	6			**0.005**	1	5	**0.008**
Calitys scabra	3	3		**0.007**		6	**<0.001**
Peltis ferruginea	20	7	11	**0.003**	26	12	0.823
Corticaria serrata	3	2	9	0.48	10	4	1
Corticaria longicollis	4		9	0.272	10	3	0.75
Cis glabratus	4		3	0.561	7		0.101
Cis dentatus	3		29	**<0.001**	32		**<0.001**
Ennearthron cornutum	4	1	5	1	6	4	0.478
Anaspis marginicollis	3	1	6	0.899	8	2	0.719
Anaspis thoracica	4	1	4	0.888	6	3	1
Anaspis rufilabris	6	3	4	0.25	9	4	1
Rhyncolus ater	9	2	16	0.498	23	4	0.053
Rhyncolus sculpturatus	3	1	8	0.575	10	2	0.502
Diptera							
Choerades marginatus	5	1	2	0.183	5	3	0.692
Hemiptera							
Aradus betulinus	1		14	**0.001**	15		**0.005**
Cixidia confinis	12	8	2	**<0.001**	8	14	**<0.001**
Cixidia lapponica	18	6	4	**<0.001**	12	16	**<0.001**
Hymenoptera							
Bassus calculator			8	**0.012**	8		0.101
Perilampus polypori			9	**0.008**	9		0.054
Lepidoptera							
Nemapogon cloacellus	5	2	5	0.759	9	3	1
Montescardia tessulatella			42	**<0.001**	42		**<0.001**
Raphidioptera							
Xanthostigma xanthostigma	6	2	5	0.649	10	3	0.75

2.7 Spatial distribution of dead wood

The results from the model and Anova tests (App. 1) shows significant impact of wood volume at all distances for *Anaspis marginicollis* (p(10)<0.001, p(30)=0.002, p(50)=0.044) and *Rhyncolus sculpturatus* (p(10)<0.001, p(30)=0.004, p(50)=0.037). Significant impact can also be detected at 10 and 30 m for *Corticaria serrata* (p(10)=0.009, p(30)=0.044), at 10 and 50 m for *Phosphuga atrata* (p(10)=0.014, p(50)=0.030) and at the closest distant for *Corticaria longicollis* (p(10)=0.036) and *Stagetus borealis* (p(10)=0.011). However, when plotted out a positive and clear impact of higher dead wood volume can only be detected for *S. borealis* (fig. 3-5 C). Among the other predictor variables (App 1 & 3), there is none that seems to influence clearly more than others on the insect occurrences (dead wood volume included).

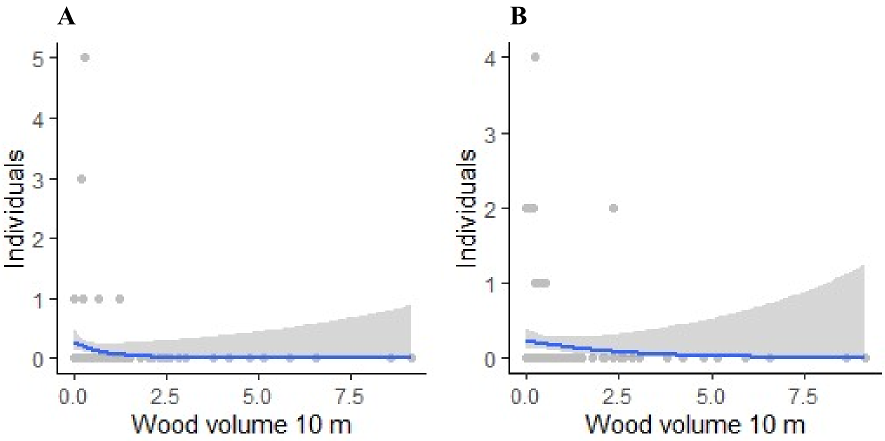

*Figure 3. Impact of total coniferous wood volume for Anaspis marginicollis **(A)** and Rhyncolus sculpturatus **(B)**. Y-axis shows number of individuals in each sample and x-axis shows the wood volume in m*^{3} *at distance 10 m from the log used for rearing. The blue line indicates a univariate regression using poisson distribution. The impact of the other wood distances is similar and shown in Appendix 2.*

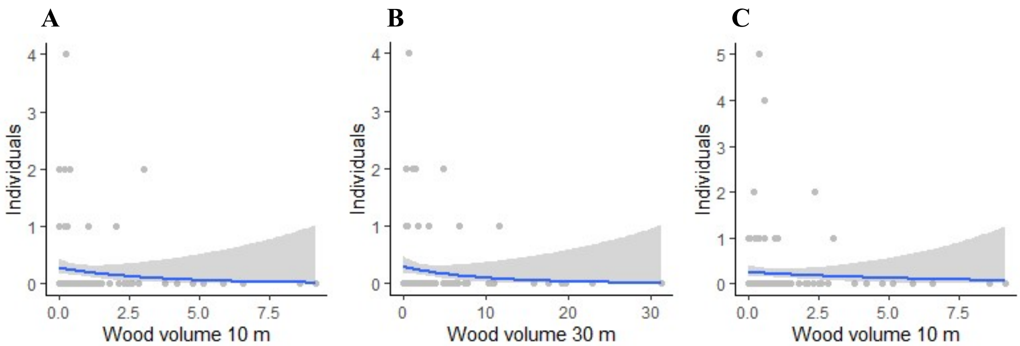

*Figure 4. Impact of total coniferous wood volume for Corticaria serrata **(A, B)** and Corticaria longicollis **(C)**. Y-axis shows number of individuals in each sample and x-axis shows the wood volume in m*^{3} *at different distance from the log sampled for rearing. The distances shown are the distances which gave significant values in the models (app. 1) the other distances are shown in appendix 2. The blue line indicates a univariate regression using poisson distribution.*

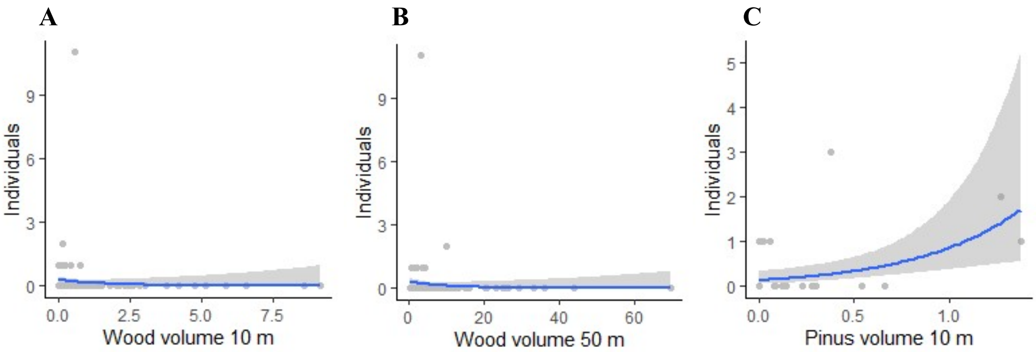

Figure 5. Impact of total coniferous wood volume for Phosphuga atrata ***(A, B)*** *and impact of pine wood volume for Stagetus borealis* ***(C)****. Y-axis shows number of individuals in each sample and x-axis shows the wood volume in m^3 at different distance from the log sampled for rearing. The distances shown are the distances which gave significant values in the models (app. 1) the other distances are shown in appendix 2. The blue line indicates a univariate regression using poisson distribution.*

Discussion

2.8 Insect species and their polypore host associations

The insect communities of the polypore hosts varied a lot. The two *Amyloporia* species shared many insect species, with *Peltis ferruginea* (54 % of sampled logs), *Cixidia lapponica* (48%) and *C. confinis* (40%) as the most frequent. The insect community of *N. serialis* was very different from that of *Amyloporia,* with *Montescardia tessulatella* (82%) and *Cis dentatus* (57%) as the most frequent insects. The only more frequent species that was exclusively reared from just one *Amyloporia* host was *S. borealis* from *A. sinuosa*, but the number of occurrences for this species was quite low (n=6). The sharing of species is consistent with phylogenetic relatedness (Jonsell & Nordlander 2004) since the two *Amyloporia* species are closely related to each other but not with *Neoantrodia* (e.g., Liu 2022).

The Lepidoptera assemblage of *N. serialis* shares similarities with what Komonen et.al. (2012) have found for the fungus *Daedalea quercina,* which creates a brown rot on oak *(Quercus)* wood. These two polypore species are closer related to each other phylogenetically than to Amyloporia. However, they are not each other's closest relatives (Liu 2022). On both *N. serialis* and *D. quercina*, *M. tessulatella* is the most frequent insect with occurrences in 48 % of the study sites of Komonen et.al. (2012) and in 82 % of sampled logs with *N. serialis* in this study. Also, *A. mendicella* was found in *D. quercina* in Komonen et.al. (2012). In my study *A. mendicella* was found exclusively in *N. serialis* samples with 9 specimens in 5 logs. *Nemapogon cloacellus* is another species which is common in *N. serialis* and occurring in *D. quercina.* This species, however, seems to be truly polyphagous since it is also common on the *Amyloporia* species in this study.

The most unexpected species *N. serialis* and *D. quercina* are hosting in common is *Nemapogon fungivorellus*. This species has been considered specific for *D. quercina* on oak (e.g., Bengtsson et al. 2008; Gaedike 2015; Jaworski 2014; Petersen 1969). However, the species has once been reared out from *Piptoporus betulinus* in Sweden (Buhl 2016) and there are uncertain sources of other fungal hosts from Germany (Bengtsson et al. 2008). *Nemapogon fungivorellus* seems to be a rare species in Europe with few occurrences in each country (GBIF Secretariat

2022) and is red listed in, for example Norway (EN), Sweden (VU) and Finland (CR) (Ahrné 2020; Elven 2021; Hyvärinen 2019). If *Piptoporus betulinus* is a common host for the species, it would probably have been observed before, since the polypore is well represented in rearing studies (e.g., Jonsell & Nordlander 2004; Økland1995). It is possible that *N. fungivorellus* becomes less strictly monophagous in an area where it is more frequent and choose to utilize other hosts than *D. quercina*. My observations are within the natural range of oak and not far north of earlier observations of *N. fungivorellus* (Liljeblad 2023). Of the specimens reared out, 4 were from a forest part bordering an agricultural landscape with oaks nearby (HÅ05). However, the other two locations were not surrounded by numerous oaks. Two specimens were from an old growth coniferous forest with only sparse and scattered occurrences of oak in the surroundings (HN04) and 3 specimens were from a managed coniferous forest with absence or close to absence of oaks at least closer than 1 kilometer away (HS16). If *N. serialis* is more than a sporadic host for *N. fungivorellus*, the moth could possibly be more common than previously known. *N. serialis* is a more common and more distributed species than *D. quercina* in northern Europe. It would therefore be interesting to sample *N. serialis* for rearing outside the distribution area for oak and *D. quercina*.

An even more closely related species to *N. serialis* than *D. quercina* is *Rhodofomes roseus* (Liu 2022) which is studied in rearing studies from Finland (see Komonen 2001 and Komonen et.al. 2000). The insect assemblage of this species also shares similarities with that of *N. serialis*. The most dominating species in *R. roseus* was *A. mendicella* and its parasite fly *Phytomyptera cingulata* was frequent as well (Komonen 2001). These species were found in *N. serialis* as well, even if *Phytomyptera cingulata* was found in a sample of *A. sinuosa* with *N. cloacellus* as the only observed Tineidae species. *Montescardia tessulatella* also occurred in *R. roseus,* and *Cis dentatus* was the most frequent beetle (Komonen 2001) just as in *N. serialis*. *Cis dentatus* was, however, not found at all in *D. quercina* (Komonen et.al. 2012) and was not common in the *Amyloporia* samples in this study (8% of *A. sinuosa* samples).

The insect community of the two *Amyloporia* species differed from *N. serialis* by not having a Lepidoptera as a dominant species. Instead, the coleopteran *Peltis ferruginea* and the two Hemiptera species, *C. lapponica* and *C. confinis*, were common. The two *Cixidia* species were often found together in the same sample which is interesting since competition should occur between two closely related species. However, has been observed before for the species (e.g., Linnavuori 1951). The frequency is also interesting since the species have been considered as very rare (Ossiannilsson 1978) but the occurrence has probably been underestimated before (Ahnlund & Lindhe 1992). For *P. ferruginea, C. lapponica* and *C. confinis* the tree species seems less important than the polypore. They were as frequent in *A. sinuosa* on both spruce and pine.

The occurrence of *Agnathosia sandoeensis* is the first observation in mainland Sweden. From Sweden it is known from Gotska sandön in the Baltic Sea where it was first described (Jonasson 1977). Elsewhere in the world the species is only known from a location in Latvia (Sulcs 1979) and a location in Austria (Wieser & Zeller 2013). My two specimens were reared out from a pine log with *A. xantha* which is the same substrate as previously known (Bengtsson et al. 2008; Jonasson 1977). The log was located in a small opening in an old growth mixed pine and spruce forest in the Tjäderleksmossen nature reserve. Both the Swedish observations are from protected areas with high biological values. This together with the very few observations indicate that it is a rare species with high habitat requirements. Unfortunately, the number of sampled *A. xantha* are few in this study, only 14 logs. Garpebring (2004) who also studied *A. xantha* only investigated the Coleoptera assemblage. The real distribution of *A. sandoeensis*, as well as its ecology, is still poorly known. Most species being numerous on *A. xantha* are also occurring on *A. sinuosa*. This has not been shown for *A. sandoeensis*, but the data is still too small to surely say it is monophagous for *A. xantha*. However, a strict monophagy could be one of the reasons to the rareness of the species.

The only parasitic wasps *(Parasitica)* identified were *Bassus calculator* and *Perilampus polypori.* Both were exclusively reared from *N. serialis*. *B. calculator* is known as an endoparasite on Tenidae species in polypores (Erdoğan & Beyarslan 2006). The host in this study was probably *M. tessulatella* since that species occurred in all samples with *B. calculator*. The other species, *P. polypori* is a hyperparasite and was, for example, a frequent species in *Mensularia radiata* (Jonsell et.al. 2016). The host of *P. polypori* is impossible to know from the current study since only a small part of the Parasitica species were identified. However, *M. tessulatella* were observed in all samples with *P. polypori* as well and is probably the host of the host. *B. calculator* were observed in 5 of 9 samples with *P. polypori*.

Among the reared beetles only five individuals of two species were Staphylinidae; *Dropephylla linearis* and *Sepedophilus testaceus.* This is surprisingly few compared to other studies (e.g., Komonen et.al. 2012; Jonsell et.al. 2016). It is unlikely that they are less common in the polypores of this study, while more likely that the boxes were not completely sealed. Many of the Staphylinidae species are small and slender. Some Formicidae observed outside the boxes indicated that small insects could escape from some of the boxes later in the season when the tape started to loosen. This could also have impacted the number of individuals found in other species groups. However, it is previously known that rearing boxes are not an effective method for rearing of Staphylinidae, for example rearing sacks are better (Jonsell & Hansson 2007).

2.9 Impact of wood volume

We expected some species to benefit from large aggregations of wood. However, the models do not show a large impact of the wood volume on the occurrences of the insect species (App. 1 & 3). Significant impact of wood at any distance from the sampled log was shown for *A. marginicollis, R. sculpturatus, C. serrata*, *P. atrata*, *C. longicollis* and *S. borealis.* However, when observing the univariate regressions for wood (Fig. 3-5) and the summery of the generalized linear models (App. 3) a positive impact of larger wood volumes can only be detected for S. borealis.

A slightly negative impact of higher wood volume, which is detected for the other species with significant p-values, should likely be considered as no impact. It is unlikely that a higher volume of wood is negative for saproxylic insects. Since the impact appears to be small in the univariate regressions it is, however, strange that the models give significant values. Even if outliers are deleted and the distribution is changed from poisson to quasipoisson or negative binomial the significant p-values remains.

The species with significantly negative impact of wood have in common that they have few occurrences and are highly polyphagous. Since all three polypore species and both tree species are possible hosts, wood of any quality is kept in the models. This together with the few occurrences leads to many zero values. Species which are frequent and highly monophagous is for example *M. tessulatella* and *C. dentatus* on *N. serialis* and *C. confinis* and *C. lapponica* on the *Amyloporia* species. All these species seam to benefit from aggregated wood in the univariate regressions (app. 2) even if it is not enough to be significant (app. 1). This result is more expected and indicates that many zero values combined with few occurrences is a problem. Six occurrences, which was used as limit for the analyses was probably too low to yield a reliable result from the glm models.

The only species with a significant positive impact of wood is *S. borealis* in the 10 m class (app. 1). This is also supported in the univariate regression (fig. 5 C) which makes the result more reliable. However, *S. borealis* is a species with very few occurrences, only six, and the volume of pine at the sampling spots are small compared to spruce. Consequently, the two samples with the largest surrounding pine wood volume containing the species have a high influence on the regression line. The small pine wood volume, especially in the 10 m zone, also makes the impact of coincidence large. The impact of pine wood volume cannot be that clearly detected in the 30 m and 50 m zone which could indicate the effects of coincidence, but it could also be explained by species benefiting from aggregated wood in the very close surrounding. To conclude anything, further studies with more occurrence data are needed.

Calitys scabra is assumed to benefit from aggregated wood (Ardatabanken SLU 2023a; Wikars 2014), however this is to my knowledge not tested in existing studies. My study does not indicate such a relationship, but this is not surprising since the number of occurrences is only six, like for *S. borealis*. Also, the pine wood found was not aggregated but more spread out without accumulations. Maybe, the frequency of *Calitys scabra* and the number of specimens would be higher in more aggregated wood if locations with large dead pine wood volume were visited in the study.

It is possible that species with many observations in this study are better than for example *Upis ceramboides* and *Bolitophagus reticulatus* (see e.g., Rubene 2014; Rukke & Midtgaard 1998) at dispersing over short distances. However, this study only investigates the impact of dead wood volume at distances up to 50 m. It is also possible that the wood volume if measured in a larger scale would explain the occurrences better. What could also have a large impact is the continuity of dead wood in the landscape (e.g., Jonsell & Nordlander 2002; Schiegg 2000) which this study does not take into account.

The impact of other predictor variables (App. 1 & 3) is likely more reliable only for the monophagous species with many occurrences, as for the wood volume. When *M. tessulatella*, *C. dentatus*, and the two *Cixidia* species are observed, light is significantly important for *C. dentatus*, diameter for *M. tessulatella* and decay class for both these species. Significant values for these predictor variables and not for the wood volume could be explained by that these variables are more important for the species. If the occurrences *C. dentatus* and *M. tessulatella* are not depending on the aggregation of dead wood, it could be one explanation to why they are frequent species.

2.10 Conclusions and further studies

The insect species communities of *A. sinuosa* and *A. xantha* are very similar. The insect assemblage hosting *N. serialis* is instead more similar to other visually different but phylogenetically more closely related polypores. The two Lepidopteran species, *Agnathosia sandoeensis* and *Nemapogon fungivorellus* were unexpected findings that shows that little is still known about the insect species assemblage connected with polypores. There is more to discover about the distributions of saproxylic species, their host preferences and how they react to factors such as dead wood volume. This study is rather small with only 101 samples and from a spatially limited area. It would be valuable with samples of the same polypore species in other parts of Sweden and Europe. Then we could find out if *A. sandoeensis* is strictly monophagous for *A. xantha* and if *N. serialis* is a distributed host for *N. fungivorellus*. If so, the distribution of *N. fungivorellus* is maybe not limited of the distribution of *Daedalea quercina* and oak.

With more dead wood volume data, it would also be possible to better understand the dispersal ability of the investigated species, especially if volume of wood is measured at a larger area and if wood continuity is taken into consideration. More studies and more extensive studies implementing what is mentioned above would contribute valuable knowledge for nature conservation.

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Populärvetenskaplig sammanfattning

Ungefär en tredjedel av de skogslevande arterna utnyttjar död ved. Exempelvis är veden en viktig levnadsmiljö för många insektsarter. Många av insekterna lever inte av själva veden, utan äter i stället av svampar som i sin tur finns i eller på veden. I många fall kan de också parasitera på andra insekter i veden. Trots att ved och svamp är så viktigt för insekterna i skogen saknas en hel del kunskap om vilka insekter som är knutna till vissa svampar. I denna studie undersökte jag vilka insekter som lever av timmerticka, citronticka och knölticka, tre vanliga vedsvampar på gran och tall i Sverige. Dessutom undersöktes hur viktig mängden ved i omgivningen är för insekterna. Det är något man har sett är viktigt för att förstå varför vissa andra insekter finns där de finns.

För att undersöka vilka insekter som trivs med svamparna samlades vedbitar med de tre arterna in på olika platser i Uppsala och Knivsta kommun och lades i lådor under vårvintern. Dessutom antecknades mängden ved inom 10, 30 och 50 meters avstånd från den insamlade vedbiten. På sommaren kläcktes insekterna och kunde artbestämmas. Totalt hittades 2510 insekter av fler än 116 arter. Timmerticka och citronticka som är närbesläktade hade många gemensamma arter medan knölticka som inte är lika nära släkt hade ett helt annat insektsamhälle knutet till sig.

De mest oväntade upptäckterna i studien var två fjärilar; korkmusslingsmal och tallsvampmal. Sedan tidigare visste man inte att kormusslingsmal, som är en rödlistad art, också kunde leva på knölticka. Sedan tidigare har man nästan enbart hittat den på korkmussling som växer på död ekved. Tallsvampmal är en mycket sällsynt art som lever på citronticka och nu för första gången hittades på svenska fastlandet. Sedan tidigare är den bara känd från tre platser i hela världen. Hur mängden ved påverkade de olika arterna var svårt att avgöra i studien. Positiv påverkan kunde bara ses för timmerticksgnagare. Antingen samlades för lite ved in eller så har vedvolymen inom 50 meter liten påverkan för de andra insektsarterna.

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Appendix 1

Table A1. The different predictor variables impact on the occurrences of insect species with >6 observations. Results from Anova type II Wald chi-square test on the generalized linear models. Significant p-values are in bold.

		10 m			30 m			50 m		
Species	**Variable**	**LR Chisq**	**df**	**p-value**	**LR Chisq**	**df**	**p-value**	**LR Chisq**	**df**	**p-value**
Phosphuga atrata										
	Wood volume	6.051	1	**0.014**	1.669	1	0.196	4.73	1	**0.03**
	Diameter	0.206	1	0.65	1.052	1	0.305	1.38	1	0.24
	Volume	<0.001	1	0.999	0.079	1	0.778	0.069	1	0.792
	Decay class	6.315	4	0.177	5.499	4	0.24	8.938	4	0.063
	Moisture	8.753	3	**0.033**	7.262	3	0.064	11.805	3	**0.008**
	Light	0.027	1	0.869	0.066	1	0.797	0.095	1	0.758
	Ground contact	5.021	1	**0.025**	3.243	1	0.072	3.725	1	0.054
Stagetus borealis										
	Pinus volume	6.534	1	**0.011**	7.206	1	**0.007**	0.102	1	0.749
	Diameter	0.028	1	0.867	0.711	1	0.399	0.55	1	0.458
	Volume	0.186	1	0.666	0.022	1	0.881	0.117	1	0.732
	Decay class	7.048	2	**0.029**	15.129	2	**<0.001**	10.694	2	**0.005**
	Moisture	2.543	3	0.468	11.953	3	**0.008**	8.092	3	**0.044**
	Light	6.522	1	**0.011**	20.275	1	**<0.001**	19.696	1	**<0.001**
	Ground contact	4.415	1	**0.036**	7.049	1	**0.008**	1.402	1	0.236
Calitys scabra										
	Pinus volume	2.367	1	0.124	0.844	1	0.358	1.52	1	0.218
	Diameter	0.508	1	0.476	0.004	1	0.951	0.246	1	0.62
	Volume	1.067	1	0.302	0.004	1	0.951	0.096	1	0.756
	Decay class	0.589	2	0.745	1.486	2	0.476	1.596	2	0.45
	Moisture	1.616	3	0.656	1.76	3	0.624	2.33	3	0.507
	Light	4.041	1	**0.044**	1.804	1	0.179	0.531	1	0.466
	Ground contact	0.718	1	0.397	0.149	1	0.699	0.139	1	0.709
Peltis ferruginea										
	Wood volume	0.156	1	0.693	<0.001	1	0.983	0.001	1	0.971
	Diameter	0.916	1	0.339	0.844	1	0.358	0.845	1	0.358
	Volume	0.012	1	0.912	0.002	1	0.968	0.002	1	0.964
	Decay class	2.814	4	0.589	2.909	4	0.573	2.922	4	0.571
	Moisture	3.143	3	0.37	3.121	3	0.373	3.106	3	0.376
	Light	1.077	1	0.299	1.108	1	0.293	1.097	1	0.295
	Ground contact	4.342	1	**0.037**	4.376	1	**0.036**	4.382	1	**0.036**
Corticaria serrata										
	Wood volume	6.919	1	**0.009**	4.039	1	**0.044**	3.132	1	0.077
	Diameter	0.092	1	0.761	0.083	1	0.773	0.107	1	0.744
	Volume	0.776	1	0.378	0.714	1	0.398	0.612	1	0.434
	Decay class	15.533	4	**0.004**	10.679	4	**0.03**	10.977	4	**0.027**
	Moisture	6.74	3	0.081	5.603	3	0.133	6.096	3	0.107
	Light	0.179	1	0.673	0.259	1	0.611	0.33	1	0.566
	Ground contact	0.045	1	0.831	0.193	1	0.661	0.197	1	0.657

Table A1. (Continued).

Species	Variable	10 m			30 m			50 m		
		LR Chisq	**df**	**p-value**	**LR Chisq**	**df**	**p-value**	**LR Chisq**	**df**	**p-value**
Corticaria longicollis										
	Wood volume	4.389	1	**0.036**	2.452	1	0.117	0.885	1	0.347
	Diameter	7.971	1	**0.005**	7.419	1	**0.006**	6.924	1	**0.009**
	Volume	0.836	1	0.361	1.155	1	0.282	0.965	1	0.326
	Decay class	9.845	4	**0.043**	9.503	4	**0.05**	9.274	4	0.055
	Moisture	8.281	3	**0.041**	8.304	3	**0.04**	7.716	3	0.052
	Light	1.044	1	0.307	1.307	1	0.253	1.553	1	0.213
	Ground contact	4.113	1	**0.043**	4.167	1	**0.041**	4.252	1	**0.039**
Cis glabratus										
	Picea volume	0.04	1	0.841	0.32	1	0.572	1.278	1	0.258
	Diameter	<0.001	1	0.996	0.003	1	0.958	0.003	1	0.955
	Volume	0.02	1	0.888	<0.001	1	0.999	0.028	1	0.867
	Decay class	6.013	4	0.198	6.25	4	0.181	6.46	4	0.167
	Moisture	3.217	3	0.359	2.95	3	0.399	2.491	3	0.477
	Light	0.388	1	0.533	0.434	1	0.51	0.575	1	0.448
	Ground contact	3.797	1	0.051	3.881	1	**0.049**	4.24	1	**0.039**
Cis dentatus										
	Picea volume	0.166	1	0.684	0.874	1	0.35	0.833	1	0.361
	Diameter	1.24	1	0.265	0.664	1	0.415	0.658	1	0.417
	Volume	1.757	1	0.185	0.917	1	0.338	0.885	1	0.347
	Decay class	9.959	4	**0.041**	7.742	4	0.102	7.524	4	0.111
	Moisture	1.83	3	0.608	2.233	3	0.525	2.252	3	0.522
	Light	3.493	1	0.062	4.218	1	**0.04**	4.185	1	**0.041**
	Ground contact	0.989	1	0.32	1.372	1	0.241	1.427	1	0.232
Anaspis marginicollis										
	Wood volume	11.191	1	**<0.001**	9.492	1	**0.002**	4.059	1	**0.044**
	Diameter	0.423	1	0.515	0.616	1	0.433	0.195	1	0.659
	Volume	0.298	1	0.585	0.139	1	0.71	0.293	1	0.589
	Decay class	11.561	4	**0.021**	7.685	4	0.104	7.462	4	0.113
	Moisture	9.865	3	**0.02**	10.299	3	**0.016**	8.667	3	**0.034**
	Light	0.005	1	0.946	0.841	1	0.359	0.797	1	0.372
	Ground contact	4.476	1	**0.034**	3.28	1	0.07	4.137	1	**0.042**
Anaspis thoracica										
	Wood volume	<0.001	1	0.99	0.241	1	0.624	0.5	1	0.48
	Diameter	0.281	1	0.596	0.337	1	0.561	0.353	1	0.552
	Volume	0.028	1	0.867	0	1	0.998	0.004	1	0.95
	Decay class	4.964	4	0.291	5.127	4	0.274	5.139	4	0.273
	Moisture	5.17	3	0.16	5.245	3	0.155	5.233	3	0.156
	Light	1.511	1	0.219	1.444	1	0.229	1.366	1	0.242
	Ground contact	0.264	1	0.607	0.264	1	0.607	0.263	1	0.608
Anaspis rufilabris										
	Wood volume	0.002	1	0.967	0.485	1	0.486	1.208	1	0.272
	Diameter	10.561	1	**0.001**	11.001	1	**<0.001**	11.238	1	**<0.001**
	Volume	0.752	1	0.386	0.358	1	0.55	0.206	1	0.65
	Decay class	6.403	4	0.171	6.314	4	0.177	6.061	4	0.195
	Moisture	9.958	3	**0.019**	8.142	3	**0.043**	7.52	3	0.057
	Light	23.606	1	**<0.001**	23.94	1	**<0.001**	23.509	1	**<0.001**
	Ground contact	2.732	1	0.098	1.735	1	0.188	1.451	1	0.228

Table A1. (Continued).

Species	Variable	10 m			30 m			50 m		
		LR Chisq	**df**	**p-value**	**LR Chisq**	**df**	**p-value**	**LR Chisq**	**df**	**p-value**
Rhyncolus ater										
	Wood volume	0.275	1	0.6	0.078	1	0.781	0.091	1	0.762
	Diameter	0.179	1	0.672	0.186	1	0.666	0.184	1	0.668
	Volume	0.192	1	0.661	0.138	1	0.71	0.143	1	0.705
	Decay class	3.897	4	0.42	3.891	4	0.421	3.943	4	0.414
	Moisture	3.934	3	0.269	4.02	3	0.259	3.977	3	0.264
	Light	0.138	1	0.71	0.108	1	0.742	0.113	1	0.736
	Ground contact	1.754	1	0.185	1.787	1	0.181	1.795	1	0.18
Rhynculus sculpturatus										
	Wood volume	10.416	1	**<0.001**	8.121	1	**0.004**	4.354	1	**0.037**
	Diameter	2.24	1	0.135	2.423	1	0.12	3.437	1	0.064
	Volume	10.314	1	**<0.001**	11.68	1	**<0.001**	9.979	1	**0.002**
	Decay class	1.472	4	0.832	1.718	4	0.787	2.174	4	0.704
	Moisture	3.067	3	0.381	2.829	3	0.419	2.28	3	0.516
	Light	1.496	1	0.221	1.297	1	0.255	0.985	1	0.321
	Ground contact	1.528	1	0.216	1.419	1	0.234	1.006	1	0.316
Choerades marginatus										
	Wood volume	1.85	1	0.174	0.534	1	0.465	0.507	1	0.477
	Diameter	0.021	1	0.886	0.003	1	0.957	0.001	1	0.981
	Volume	0.502	1	0.479	0.301	1	0.583	0.305	1	0.581
	Decay class	10.016	4	**0.04**	8.889	4	0.064	8.894	4	0.064
	Moisture	3.206	3	0.361	3.37	3	0.338	3.229	3	0.358
	Light	0.098	1	0.754	0.209	1	0.647	0.16	1	0.689
	Ground contact	0.985	1	0.321	0.703	1	0.402	0.666	1	0.414
Aradus betulinus										
	Picea volume	0.052	1	0.82	0.012	1	0.913	0.198	1	0.657
	Diameter	5.567	1	**0.018**	5.403	1	**0.02**	5.862	1	**0.015**
	Volume	0.286	1	0.593	0.264	1	0.607	0.639	1	0.424
	Decay class	1.249	4	0.87	1.256	4	0.869	1.207	4	0.877
	Moisture	13.655	3	**0.003**	13.807	3	**0.003**	13.899	3	**0.003**
	Light	0.118	1	0.731	0.094	1	0.759	0.027	1	0.869
	Ground contact	0.468	1	0.494	0.468	1	0.494	0.688	1	0.407
Cixidia confinis										
	Pinus volume	0.443	1	0.506	0.557	1	0.456	0.015	1	0.902
	Diameter	0.054	1	0.816	0.062	1	0.804	0.043	1	0.837
	Volume	0.923	1	0.337	1.297	1	0.255	0.974	1	0.324
	Decay class	0.236	2	0.889	0.258	2	0.879	0.426	2	0.808
	Moisture	0.49	3	0.921	0.497	3	0.92	0.539	3	0.91
	Light	0.338	1	0.561	0.265	1	0.607	0.193	1	0.661
	Ground contact	0.826	1	0.364	0.946	1	0.331	1.145	1	0.285
Cixidia lapponica										
	Pinus volume	0.873	1	0.35	0.418	1	0.518	0.492	1	0.483
	Diameter	0.029	1	0.864	0.027	1	0.869	0.044	1	0.834
	Volume	0.015	1	0.902	0.115	1	0.735	0.109	1	0.742
	Decay class	1.05	2	0.592	0.829	2	0.661	0.785	2	0.675
	Moisture	3.353	3	0.34	3.571	3	0.312	3.202	3	0.362
	Light	0.393	1	0.531	0.639	1	0.424	0.527	1	0.468
	Ground contact	<0.001	1	0.985	0.006	1	0.937	0.011	1	0.915

Table A1. (Continued).

Species	Variable	10 m LR Chisq	df	p-value	30 m LR Chisq	df	p-value	50 m LR Chisq	df	p-value
Bassus calcurator										
	Picea volume	0.349	1	0.555	1.341	1	0.247	0.944	1	0.331
	Diameter	0.112	1	0.738	0.424	1	0.515	0.345	1	0.557
	Volume	2.078	1	0.149	2.957	1	0.086	2.469	1	0.116
	Decay class	1.334	4	0.856	0.614	4	0.962	0.591	4	0.964
	Moisture	2.554	3	0.466	3.346	3	0.341	2.872	3	0.412
	Light	1.767	1	0.184	2.375	1	0.123	2.046	1	0.153
	Ground contact	0.129	1	0.72	0.387	1	0.534	0.346	1	0.556
Perilampus polypori										
	Picea volume	0.673	1	0.412	0.234	1	0.629	0.007	1	0.934
	Diameter	0.377	1	0.539	0.489	1	0.484	0.713	1	0.399
	Volume	0.408	1	0.523	0.208	1	0.648	0.048	1	0.826
	Decay class	3.52	4	0.475	3.344	4	0.502	3.042	4	0.551
	Moisture	2.757	3	0.431	2.883	3	0.41	3.119	3	0.374
	Light	0.193	1	0.66	0.168	1	0.682	0.109	1	0.741
	Ground contact	0.195	1	0.659	0.231	1	0.631	0.336	1	0.562
Nemapogon cloacellus										
	Wood volume	3.11	1	0.078	0.746	1	0.388	0.181	1	0.671
	Diameter	0.075	1	0.784	0.138	1	0.71	0.205	1	0.651
	Volume	0.035	1	0.851	0.08	1	0.778	0.269	1	0.604
	Decay class	17.159	4	**0.002**	13.92	4	0.008	13.897	4	**0.008**
	Moisture	1.487	3	0.685	2.326	3	0.508	2.563	3	0.464
	Light	0.014	1	0.906	0.013	1	0.91	0.005	1	0.945
	Ground contact	1.351	1	0.245	1.045	1	0.307	0.996	1	0.318
Montescardia tessulatella										
	Picea volume	1.142	1	0.285	2.823	1	0.093	2.192	1	0.139
	Diameter	4.521	1	**0.033**	5.675	1	**0.017**	3.907	1	**0.048**
	Volume	0.248	1	0.618	0.813	1	0.367	0.747	1	0.387
	Decay class	10.551	4	**0.032**	11.227	4	**0.024**	15.151	4	**0.004**
	Moisture	1.457	3	0.692	1.576	3	0.665	4.504	3	0.212
	Light	1.196	1	0.274	1.433	1	0.231	0.821	1	0.365
	Ground contact	2.955	1	0.086	4.089	1	**0.043**	3.499	1	0.061
Xanthostigma xanthostigma										
	Wood volume	0.581	1	0.446	0.123	1	0.726	0.598	1	0.439
	Diameter	0.698	1	0.403	0.638	1	0.424	0.645	1	0.422
	Volume	0.934	1	0.334	0.965	1	0.326	0.807	1	0.369
	Decay class	5.24	4	0.264	5.697	4	0.223	5.48	4	0.241
	Moisture	4.489	3	0.213	5.156	3	0.161	4.456	3	0.216
	Light	0.023	1	0.879	0.02	1	0.886	0.028	1	0.867
	Ground contact	0.003	1	0.953	<0.001	1	0.985	0.001	1	0.973

Appendix 2

Impact of coniferous wood volume for species with six or more occurrences. Y-axis shows number of individuals in each sample and x-axis shows the wood volume in m^3 at different distance from the log sampled for rearing. The blue line indicates a univariate regression using poisson distribution.

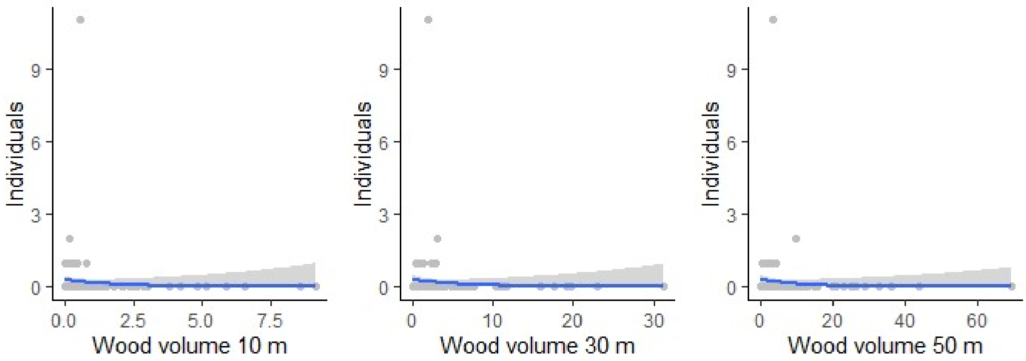

Figure A1. Phosphuga atrata

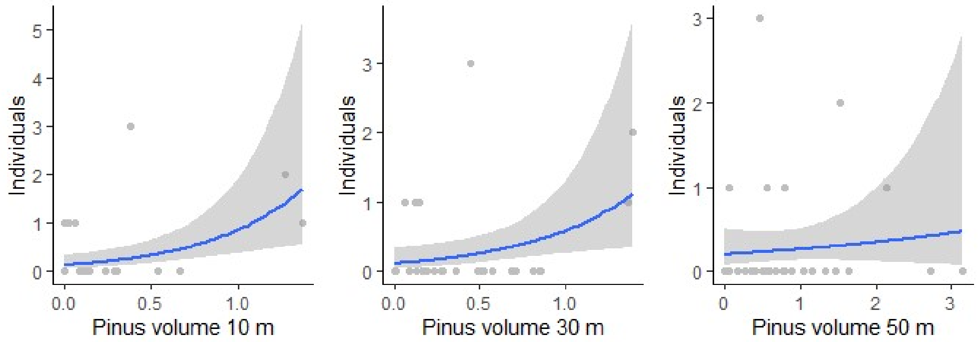

Figure A2. Stagetus borealis

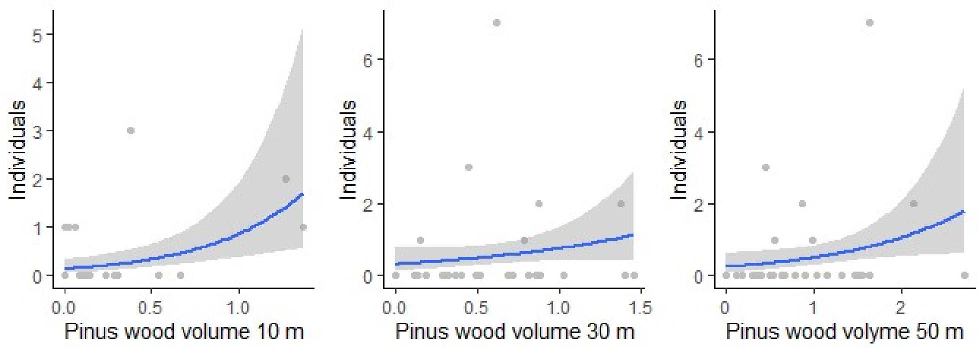

Figure A3. Calitys scabra

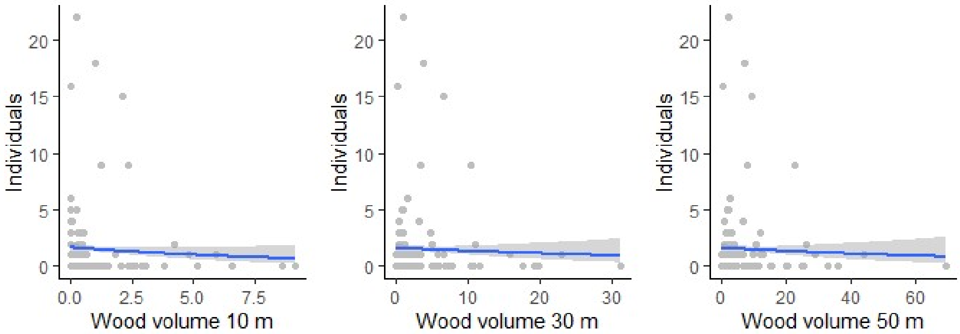

Figure A4. Peltis ferruginea

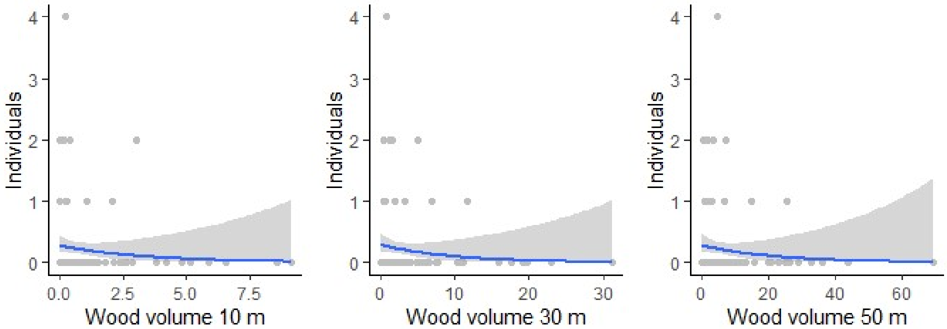

Figure A5. Corticaria serrata

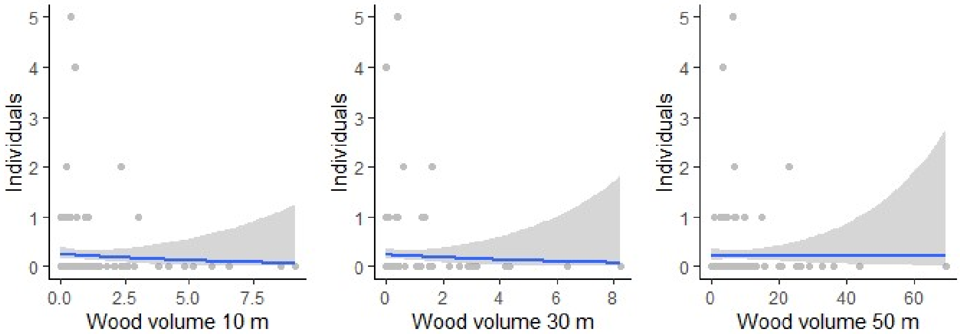

Figure A6. Corticaria longicollis

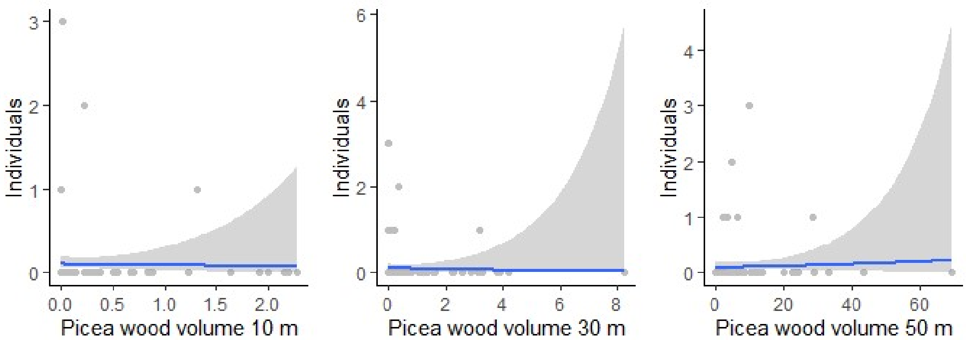

Figure A7. Cis glabratus

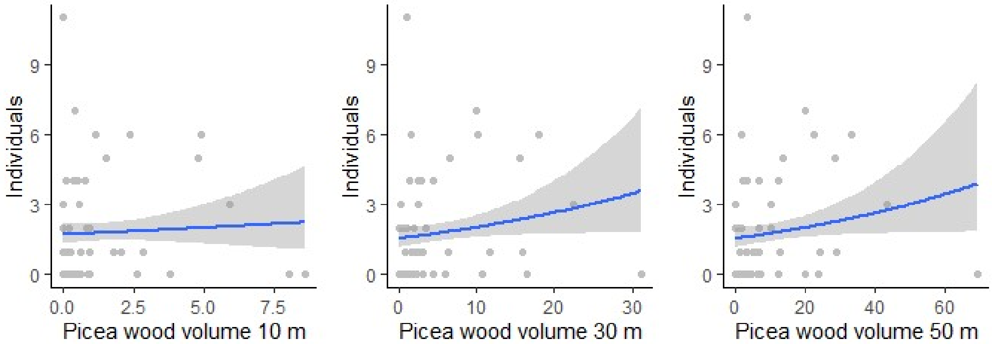

Figure A8. Cis dentatus

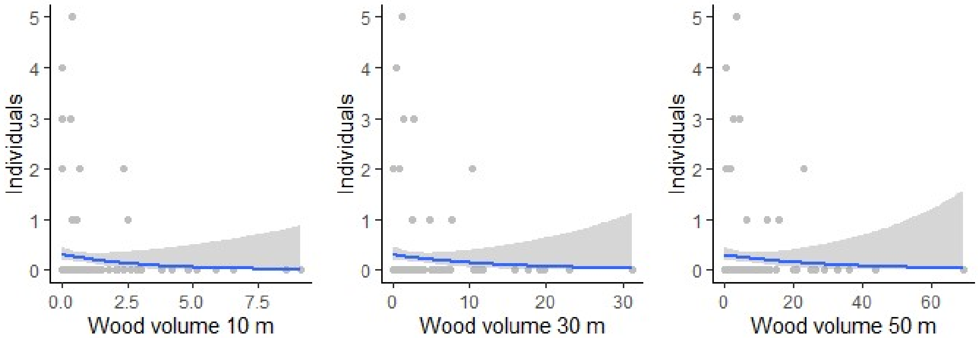

Figure A9. Ennearthron cornutum

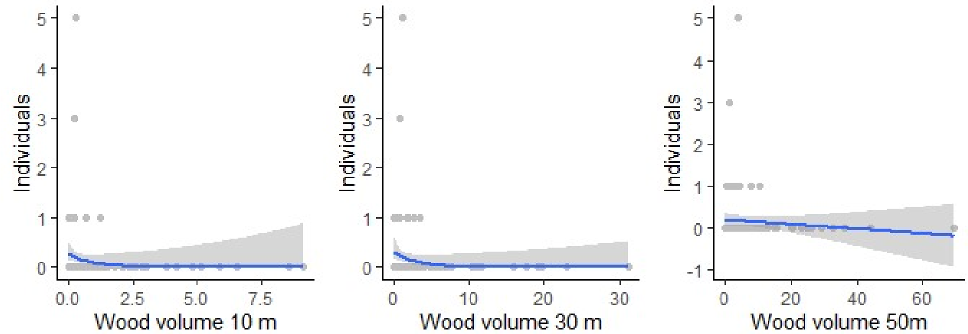

Figure A10. Anaspis marginicollis

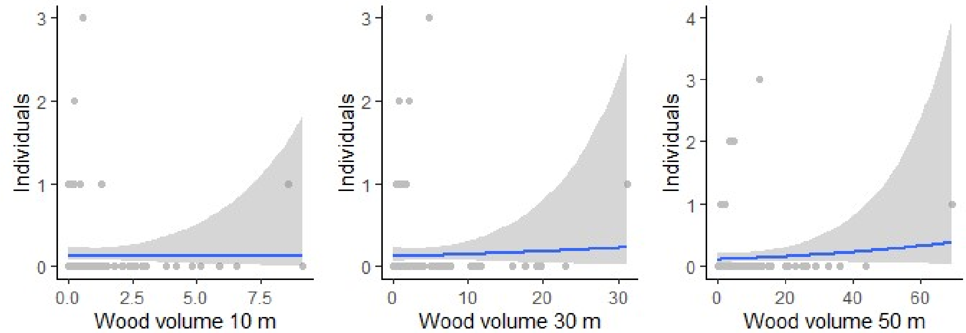

Figure A11. Anaspis thoracica

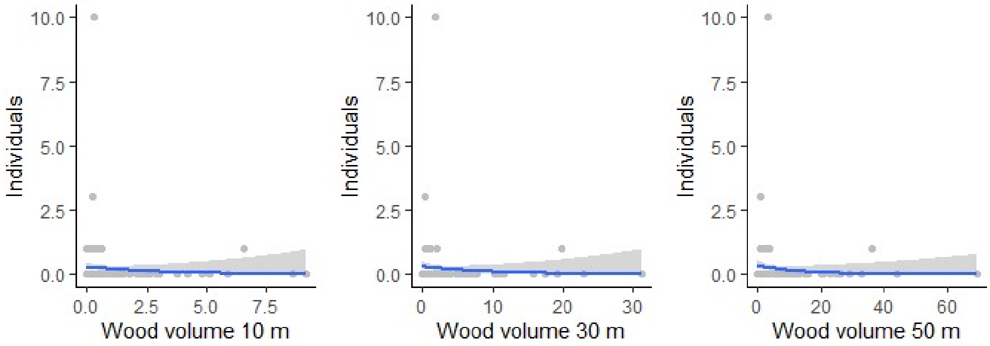

Figure A12. Anaspis rufilabris

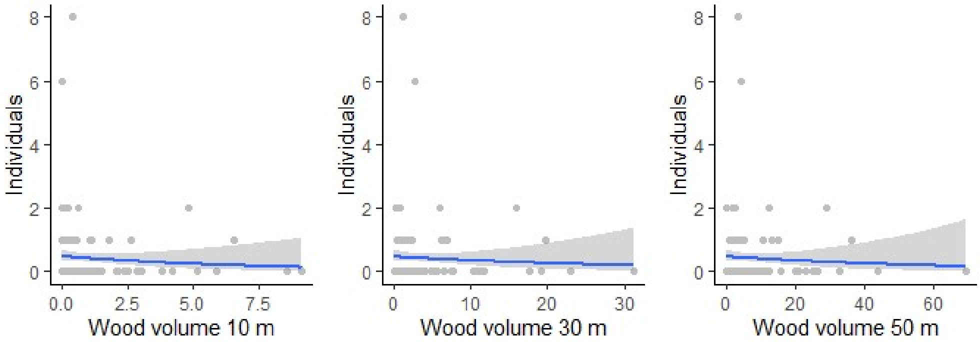

Figure A13. Rhyncolus ater

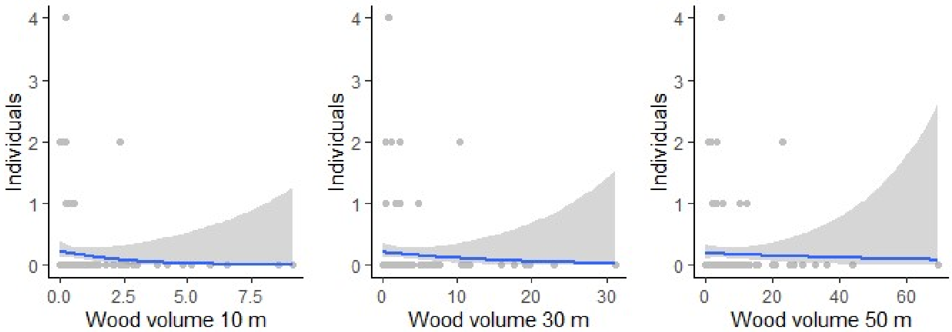

Figure A14. Rhyncolus sculpturatus

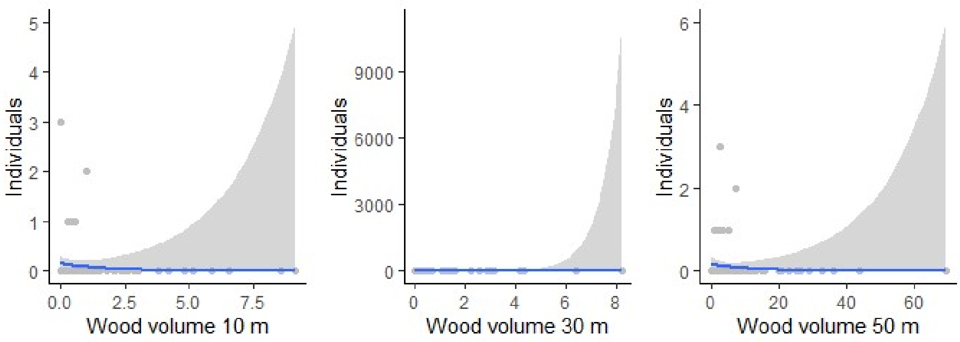

Figure A15. Choerades marginatus

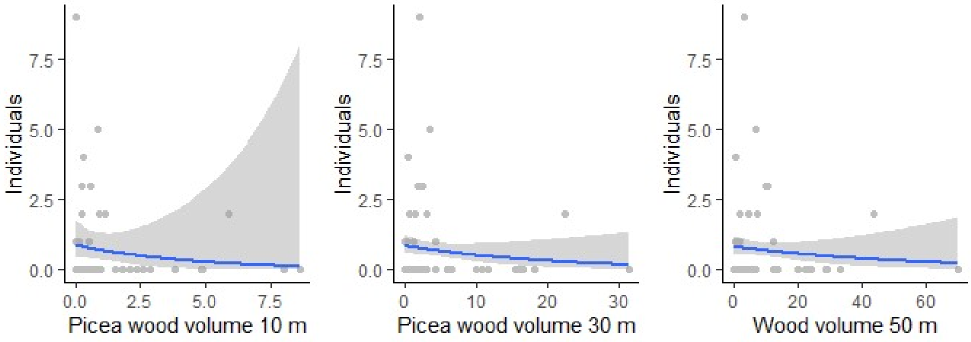

Figure A16. Aradus betulinus

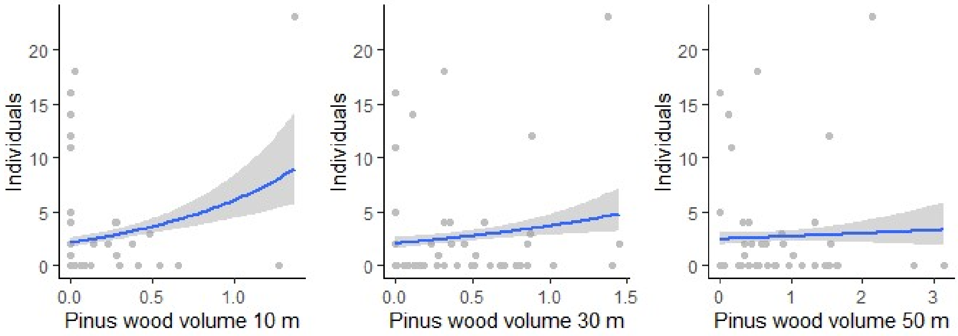

Figure A17. Cixidia confinis

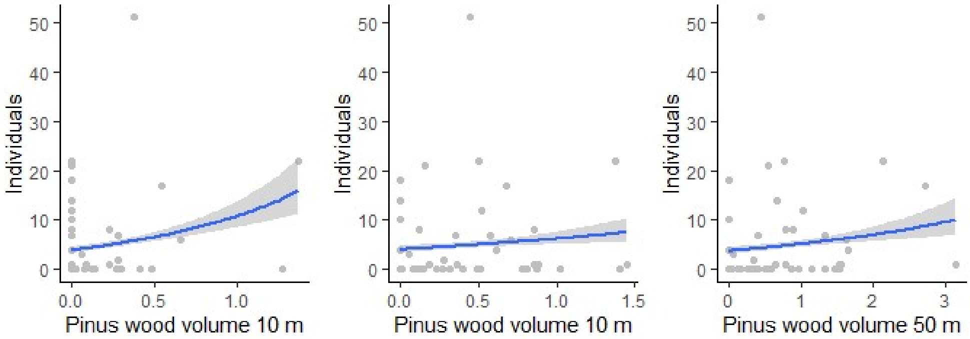

Figure A18. Cixidia lapponica

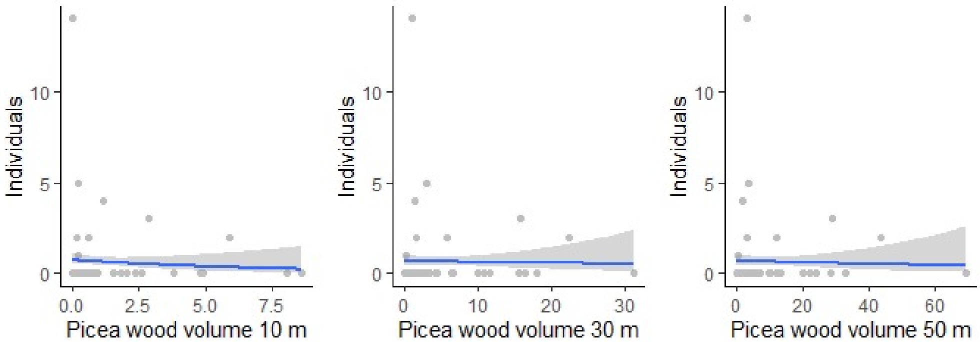

Figure A19. Bassus calculator

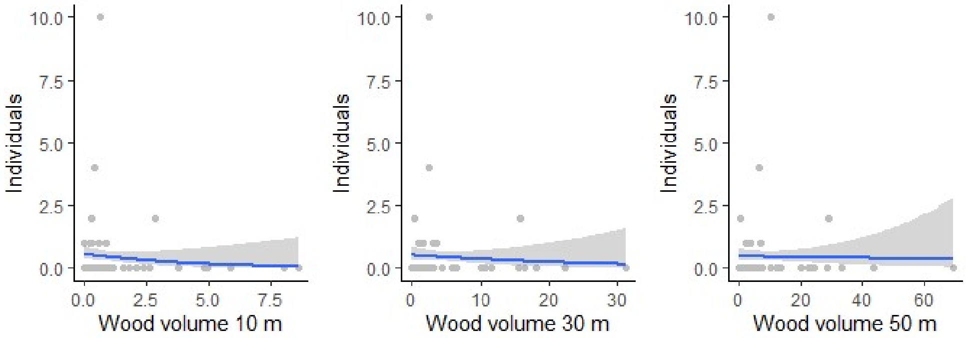

Figure A20. Perilampus polypori

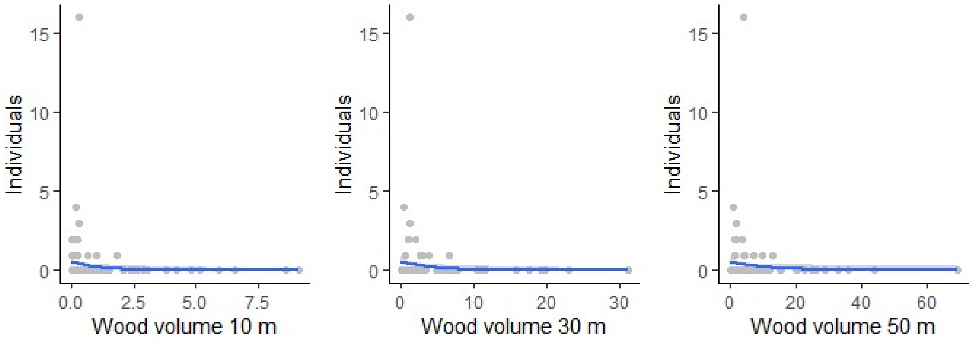

Figure A21. Nemapogon cloacellus

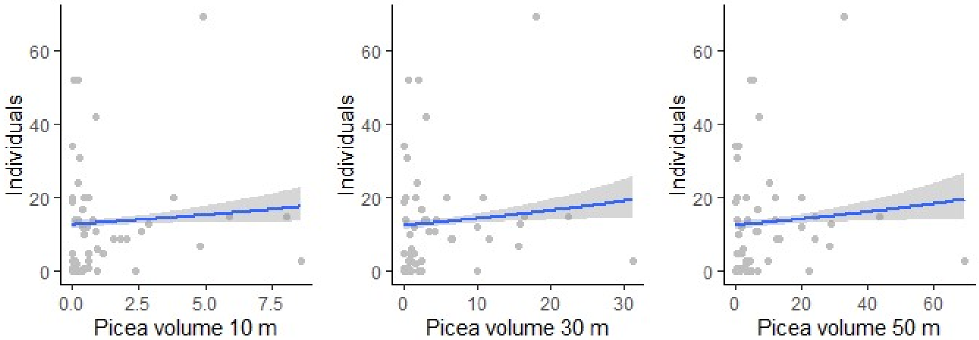

Figure A22. Montescardia tessulatella

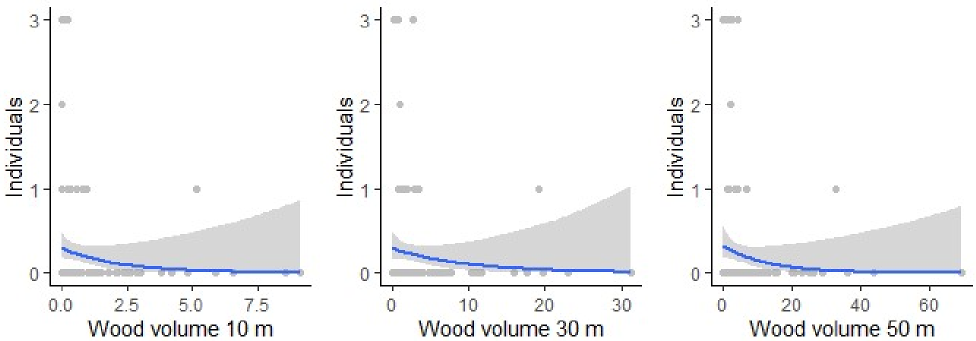

Figure A23. Xanthostigma xanthostigma

Appendix 3

Table A2. The different predictor variables impact on the occurrences of insect species with >6 observations. Results from general linear models. Each distance (10, 30 and 50 m) for each species represents a model.

		10 m		30 m		50 m	
Species	**Variable**	**estimate**	**std.error**	**estimate**	**std.error**	**estimate**	**std.error**
Phosphuga atrata							
	(Intercept)	-7,66	1840,03	-10,35	1791,87	-9,95	1519,45
	Wood volume	-2,4	1,47	-0,25	0,24	-0,21	0,13
	Diameter	10,57	23,18	19,09	18,76	18,38	15,69
	Volume	0	4,03	-1,05	3,84	-0,82	3,18
	Decay class 1	5,64	5260,81	9,21	5122,44	9,26	4326,99
	Decay class 2	-2,69	4446,19	-5,43	4329,25	-5,52	3656,97
	Decay class 3	3,59	2630,4	4,46	2561,22	4,77	2163,49
	Decay class 4	-0,89	994,2	-1,2	968,05	-0,87	817,72
	Moisture 1	-12,04	2358,55	-11,87	2298,2	-11,98	1981,89
	Moisture 2	2,21	786,19	2,25	766,07	2,13	660,63
	Moisture 3	5,27	786,19	4,7	766,07	4,74	660,63
	Light 1	-0,11	0,65	-0,17	0,65	-0,16	0,52
	Ground contact 1	-0,98	0,44	-0,8	0,46	-0,7	0,38
Stagetus borealis							
	(Intercept)	-30,39	10696,96	-26,55	4090,24	-25,55	4353,19
	Pinus volume	3,51	2,15	1,72	0,73	-0,13	0,39
	Diameter	5,78	34,33	-16,15	19,82	-16,85	22,71
	Volume	-4,18	9,64	0,87	5,88	2,23	6,52
	Decay class 1	15,59	12791,15	14,8	4918,77	15	5547,68
	Decay class 2	-9,65	7384,97	-9,11	2839,85	-8,66	3202,96
	Moisture 1	8,34	6509,18	7,86	2424,24	8,69	2292,03
	Moisture 2	9,53	6509,18	9,98	2424,24	9,97	2292,03
	Moisture 3	-10,8	12036,04	-9,08	4732,3	-9,5	5306,91
	Light 1	10,94	5974,7	10,46	2340,22	10,59	2618,69
	Ground contact 1	1,83	1,56	0,95	0,42	0,34	0,3
Calitys scabra							
	(Intercept)	-9,5	2125,05	-11,05	2876,76	-12,87	2735,72
	Pinus volume	4,06	3,43	1,78	2,16	1,52	1,35
	Diameter	-21,78	34,55	-1,17	19,19	7,96	16,09
	Volume	7,28	8,09	0,23	3,69	-1,11	3,68
	Decay class 1	-0,72	1,56	-1,32	1,3	-1,12	1,06
	Decay class 2	-0,89	1,78	-0,04	1,17	-0,39	1,21
	Moisture 1	7,98	2125,04	8,28	2876,76	8,38	2735,72
	Moisture 2	9,32	2125,04	9,63	2876,76	9,66	2735,72
	Moisture 3	-10,24	4834,48	-9,06	7365,91	-9,88	7439,65
	Light 1	-1,68	1,18	-0,68	0,5	-0,39	0,53
	Ground contact 1	1,1	1,48	0,33	0,88	0,29	0,81

Table A2. (Continued).

		10 m		30 m		50 m	
Species	**Variable**	**estimate**	**std.error**	**estimate**	**std.error**	**estimate**	**std.error**
Peltis ferruginea							
	(Intercept)	-4,56	418,62	-4,56	422,84	-4,56	422,57
	Wood volume	-0,07	0,18	0	0,06	0	0,03
	Diameter	6,87	7,15	6,56	7,1	6,56	7,1
	Volume	0,18	1,64	0,07	1,71	0,08	1,71
	Decay class 1	9,91	1323,79	9,97	1337,14	9,98	1336,27
	Decay class 2	-7,42	1118,81	-7,46	1130,09	-7,46	1129,35
	Decay class 3	4,55	661,9	4,58	668,57	4,58	668,13
	Decay class 4	-1,88	250,17	-1,89	252,7	-1,89	252,53
	Moisture 1	1	0,65	1,02	0,66	1,02	0,66
	Moisture 2	-0,05	0,45	-0,05	0,46	-0,05	0,46
	Moisture 3	0,2	0,53	0,18	0,54	0,18	0,54
	Light 1	-0,26	0,25	-0,26	0,25	-0,26	0,25
	Ground contact 1	0,96	0,62	0,98	0,63	0,98	0,63
Corticaria serrata							
	(Intercept)	-13,98	2127,22	-14,38	2345,6	-14,5	2291,25
	Wood volume	-0,92	0,61	-0,18	0,13	-0,07	0,05
	diameter	2,62	8,64	2,51	8,72	2,65	8,12
	Volume	1,55	1,73	1,52	1,75	1,3	1,61
	Decay class 1	-14,2	2234,83	-13,12	2513,04	-12,98	2446,73
	Decay class 2	-8,04	1888,77	-9,06	2123,91	-9,13	2067,86
	Decay class 3	-6,83	1117,41	-6,48	1256,52	-6,44	1223,37
	Decay class 4	-2,64	422,34	-2,83	474,92	-2,87	462,39
	Moisture 1	-9,74	5219,77	-9,72	5719,18	-9,71	5547,49
	Moisture 2	9,42	2006,4	9,45	2206,87	9,51	2156,66
	Moisture 3	9,44	2006,4	9,41	2206,87	9,38	2156,66
	Light 1	0,13	0,32	0,18	0,35	0,19	0,34
	Ground contact 1	-0,08	0,36	-0,17	0,37	-0,16	0,36
Corticaria longicollis							
	(Intercept)	-12,1	902,51	-12,24	874,32	-12,22	889,82
	Wood volume	-0,44	0,29	-0,11	0,08	-0,03	0,03
	diameter	23,38	8,22	22,74	8,3	21,6	8,11
	Volume	1,08	1,16	1,3	1,18	1,2	1,19
	Decay class 1	4,01	817,34	4,65	821,78	4,82	810,41
	Decay class 2	6,46	690,78	5,91	694,53	5,83	684,92
	Decay class 3	-12,07	1634,68	-11,95	1643,55	-11,89	1620,82
	Decay class 4	9,15	1235,71	9,16	1242,41	9,12	1225,23
	Moisture 1	5,28	739,8	5,3	703,07	5,36	727,37
	Moisture 2	3,53	739,79	3,47	703,07	3,54	727,37
	Moisture 3	4,55	739,79	4,52	703,07	4,43	727,37
	Light 1	-0,28	0,28	-0,31	0,27	-0,34	0,27
	Ground contact 1	-0,62	0,3	-0,64	0,3	-0,65	0,31

Table A2. (Continued).

Species	Variable	10 m estimate	10 m std.error	30 m estimate	30 m std.error	50 m estimate	50 m std.error
Cis glabratus							
	(Intercept)	-19,23	3726,45	-19,32	3727,87	-19,41	3682,3
	Picea volume	0,06	0,3	0,05	0,08	0,05	0,04
	Diameter	0,06	11,79	0,61	11,57	0,64	11,31
	Volume	0,34	2,39	0	2,43	-0,41	2,47
	Decay class 1	12,44	9829,54	12,27	9829,54	12,05	9829,54
	Decay class 2	-8,64	8307,48	-8,45	8307,48	-8,29	8307,48
	Decay class 3	6,14	4914,77	6,09	4914,77	6,04	4914,77
	Decay class 4	-2,79	1857,61	-2,86	1857,61	-2,94	1857,61
	Moisture 1	-12,87	3944,21	-12,8	3943,69	-12,68	3929,78
	Moisture 2	3,99	1314,74	3,99	1314,56	4	1309,93
	Moisture 3	3,71	1314,74	3,7	1314,56	3,67	1309,93
	Light 1	-0,24	0,39	-0,25	0,39	-0,29	0,39
	Ground contact 1	9	1579,84	9,02	1583,33	9,09	1476,98
Cis dentatus							
	(Intercept)	-3,13	419,51	-3,36	419,57	-3,36	419,2
	Picea volume	0,05	0,11	0,03	0,03	0,02	0,02
	Diameter	-6,69	6,06	-5,1	6,29	-5,1	6,32
	Volume	1,67	1,22	1,25	1,27	1,25	1,29
	Decay class 1	10,53	1326,61	10,37	1326,8	10,35	1325,63
	Decay class 2	-10,04	1121,19	-9,81	1121,35	-9,78	1120,37
	Decay class 3	4,92	663,31	4,95	663,4	4,96	662,82
	Decay class 4	-1,44	250,71	-1,44	250,74	-1,44	250,52
	Moisture 1	-0,26	1,29	-0,19	1,29	-0,18	1,29
	Moisture 2	0,37	0,49	0,39	0,49	0,38	0,49
	Moisture 3	-0,27	0,59	-0,32	0,59	-0,34	0,59
	Light 1	-0,37	0,2	-0,42	0,21	-0,41	0,21
	Ground contact 1	0,29	0,32	0,36	0,33	0,37	0,33
Ennearthron cornutum							
	(Intercept)	-16,86	3550,57	-17,03	3536,49	-17,07	3542,95
	Wood volume	-0,33	0,29	-0,08	0,08	-0,03	0,04
	Diameter	-12,31	7,54	-11,88	7,33	-11,55	7,3
	Volume	1,87	1,76	1,67	1,8	1,33	1,74
	Decay class 1	11,61	9829,54	11,97	9829,54	11,93	9829,54
	Decay class 2	-9,02	8307,48	-9,27	8307,48	-9,21	8307,48
	Decay class 3	7,24	4914,77	7,32	4914,77	7,29	4914,77
	Decay class 4	-1,5	1857,61	-1,52	1857,61	-1,5	1857,61
	Moisture 1	5,73	1024,01	5,79	1022,92	5,8	1027,33
	Moisture 2	3,82	1024,01	3,82	1022,92	3,86	1027,33
	Moisture 3	4,51	1024,01	4,44	1022,92	4,44	1027,33
	Light 1	0,75	0,33	0,73	0,33	0,72	0,33
	Ground contact 1	9,36	1376,94	9,38	1341,05	9,39	1354,66

Table A2. (Continued).

Species	Variable	10 m estimate	10 m std.error	30 m estimate	30 m std.error	50 m estimate	50 m std.error
Ennearthron cornutum							
	(Intercept)	-16,86	3550,57	-17,03	3536,49	-17,07	3542,95
	Wood volume	-0,33	0,29	-0,08	0,08	-0,03	0,04
	Diameter	-12,31	7,54	-11,88	7,33	-11,55	7,3
	Volume	1,87	1,76	1,67	1,8	1,33	1,74
	Decay class 1	11,61	9829,54	11,97	9829,54	11,93	9829,54
	Decay class 2	-9,02	8307,48	-9,27	8307,48	-9,21	8307,48
	Decay class 3	7,24	4914,77	7,32	4914,77	7,29	4914,77
	Decay class 4	-1,5	1857,61	-1,52	1857,61	-1,5	1857,61
	Moisture 1	5,73	1024,01	5,79	1022,92	5,8	1027,33
	Moisture 2	3,82	1024,01	3,82	1022,92	3,86	1027,33
	Moisture 3	4,51	1024,01	4,44	1022,92	4,44	1027,33
	Light 1	0,75	0,33	0,73	0,33	0,72	0,33
	Ground contact 1	9,36	1376,94	9,38	1341,05	9,39	1354,66
Anaspis marginicollis							
	(Intercept)	-50,23	5705,23	-23,25	5771,29	-22,33	3527,98
	Wood volume	-2,47	1,24	-0,57	0,27	-0,14	0,08
	Diameter	7,64	11,84	8,31	10,55	3,89	8,89
	Volume	2,47	4,54	1,39	3,73	1,63	2,97
	Decay class 1	-3,37	16425,75	-10,53	20520,51	-11,44	12446,94
	Decay class 2	-17,72	13882,29	7,92	5208,79	7,94	3161,72
	Decay class 3	-0,66	8212,87	6,96	5208,79	6,78	3161,72
	Decay class 4	-5	3104,17	7,33	5208,79	7,35	3161,72
	Moisture 1	30,93	2359,9	4,3	1434,35	4,07	920,72
	Moisture 2	30,56	2359,89	3,97	1434,35	3,94	920,72
	Moisture 3	32,12	2359,89	5,9	1434,35	5,48	920,72
	Light 1	0,03	0,4	0,35	0,38	0,3	0,34
	Ground contact 1	10,36	4496,25	9,22	2029,5	8,85	1265,88
Anaspis thoracica							
	(Intercept)	-14,49	2147,38	-14,54	2146,59	-14,53	2146,34
	Wood volume	0	0,18	0,02	0,05	0,02	0,02
	Diameter	4,86	9,13	5,31	9,09	5,43	9,1
	Volume	0,32	1,89	0	1,97	-0,13	2,02
	Decay class 1	11,26	5961,92	11,16	5961,92	11,07	5961,92
	Decay class 2	-7,99	5038,74	-7,88	5038,74	-7,82	5038,74
	Decay class 3	5,45	2980,96	5,43	2980,96	5,41	2980,96
	Decay class 4	-2,19	1126,7	-2,22	1126,7	-2,22	1126,7
	Moisture 1	-8,77	2788,38	-8,72	2787,82	-8,69	2787,78
	Moisture 2	8,17	1028	8,16	1026,35	8,15	1025,83
	Moisture 3	-8,37	1671,18	-8,4	1661,91	-8,41	1658,76
	Light 1	0,43	0,36	0,42	0,36	0,41	0,36
	Ground contact 1	-0,18	0,34	-0,18	0,34	-0,18	0,34

Table A2. (Continued).

Species	Variable	10 m estimate	10 m std.error	30 m estimate	30 m std.error	50 m estimate	50 m std.error
Anaspis rufilabris							
	(Intercept)	-5,6	2003,28	-5,27	2002,3	-5,15	2002,82
	Wood volume	0,01	0,3	-0,07	0,1	-0,06	0,06
	Diameter	-32,64	11,57	-34,21	11,99	-34,87	12,03
	Volume	-3,18	4,03	-2,35	4,12	-1,82	4,14
	Decay class 1	9,45	5961,92	9,7	5961,92	9,96	5961,92
	Decay class 2	-9,87	5038,74	-10,03	5038,74	-10,2	5038,74
	Decay class 3	5,71	2980,96	5,77	2980,96	5,84	2980,96
	Decay class 4	-2,27	1126,7	-2,21	1126,7	-2,19	1126,7
	Moisture 1	-12,2	2031,8	-12,27	2023,08	-12,33	2027,66
	Moisture 2	5,06	677,27	4,98	674,36	4,95	675,89
	Moisture 3	3,18	677,27	3,27	674,36	3,32	675,89
	Light 1	-1,45	0,41	-1,45	0,4	-1,43	0,4
	Ground contact 1	0,7	0,52	0,61	0,54	0,56	0,54
Rhyncolus ater							
	(Intercept)	-3,28	361,25	-3,32	361,76	-3,32	361,62
	Wood volume	-0,1	0,19	-0,02	0,06	-0,01	0,03
	Diameter	-3,22	7,62	-3,27	7,6	-3,25	7,59
	Volume	0,74	1,64	0,65	1,7	0,65	1,68
	Decay class 1	9,42	1142,36	9,52	1143,99	9,54	1143,52
	Decay class 2	-7,21	965,47	-7,28	966,85	-7,28	966,45
	Decay class 3	5,2	571,18	5,22	572	5,23	571,76
	Decay class 4	-1,7	215,89	-1,71	216,19	-1,71	216,11
	Moisture 1	0,88	0,55	0,91	0,55	0,9	0,55
	Moisture 2	-0,59	0,38	-0,58	0,38	-0,58	0,38
	Moisture 3	-0,39	0,54	-0,42	0,54	-0,42	0,54
	Light 1	0,1	0,26	0,08	0,26	0,09	0,26
	Ground contact 1	0,46	0,39	0,47	0,39	0,47	0,39
Rhynculus sculpturatus							
	(Intercept)	-12,02	1271,55	-12,39	1275,44	-12,59	1275,82
	Wood volume	-0,97	0,47	-0,23	0,11	-0,07	0,04
	Diameter	13,1	8,8	12,8	8,29	14,32	7,78
	Volume	4,6	1,51	4,87	1,51	4,09	1,29
	Decay class 1	9,83	3616,08	11,2	3616,08	11,35	3616,08
	Decay class 2	-8,41	3056,15	-9,51	3056,15	-9,43	3056,15
	Decay class 3	5,55	1808,04	6,01	1808,04	5,97	1808,04
	Decay class 4	-2,24	683,38	-2,41	683,38	-2,51	683,38
	Moisture 1	-12,02	1668,26	-11,88	1694,74	-11,87	1697,32
	Moisture 2	3,33	556,09	3,31	564,91	3,44	565,77
	Moisture 3	4,07	556,09	4,01	564,91	3,91	565,77
	Light 1	0,37	0,31	0,33	0,3	0,29	0,29
	Ground contact 1	0,55	0,48	0,52	0,47	0,41	0,44

Table A2. (Continued).

Species	Variable	10 m estimate	10 m std.error	30 m estimate	30 m std.error	50 m estimate	50 m std.error
Choerades marginatus							
	(Intercept)	-12,33	3294,1	-12,83	3299,78	-12,81	3302,05
	Wood volume	-0,73	0,69	-0,1	0,16	-0,05	0,08
	Diameter	2,05	14,23	0,69	12,89	0,29	12,59
	Volume	-2,35	3,73	-1,71	3,39	-1,67	3,29
	Decay class 1	9,96	9829,54	11,3	9829,54	11,4	9829,54
	Decay class 2	2,14	8403,3	0,9	8406,26	0,81	8405,72
	Decay class 3	4,99	4914,77	5,53	4914,77	5,58	4914,77
	Decay class 4	-14,26	2516,52	-14,54	2534,26	-14,55	2531,04
	Moisture 1	4,96	982,32	5,02	997,71	4,98	1005,84
	Moisture 2	4,65	982,32	4,67	997,71	4,67	1005,84
	Moisture 3	3,61	982,32	3,44	997,71	3,45	1005,84
	Light 1	-0,11	0,34	-0,16	0,35	-0,14	0,35
	Ground contact 1	-0,35	0,34	-0,3	0,34	-0,29	0,34
Aradus betulinus							
	(Intercept)	-14,48	2233,26	-14,52	2257,82	-14,69	2267,38
	Picea volume	-0,05	0,22	-0,01	0,08	0,02	0,04
	Diameter	18,9	7,99	19	8,15	20,22	8,38
	Volume	-1,2	2,32	-1,26	2,53	-2,06	2,71
	Decay class 1	-1,05	6337,28	-1,01	6381,84	-1,15	6413,81
	Decay class 2	-18,05	5355,98	-18,08	5393,64	-17,68	5420,66
	Decay class 3	-0,34	3168,64	-0,32	3190,92	-0,31	3206,9
	Decay class 4	-4,22	1197,63	-4,24	1206,05	-4,2	1212,1
	Moisture 1	6,6	985,56	6,65	1012,39	6,76	1013,57
	Moisture 2	3,55	985,56	3,57	1012,39	3,62	1013,57
	Moisture 3	3,43	985,56	3,4	1012,39	3,3	1013,57
	Light 1	0,13	0,37	0,11	0,37	0,06	0,38
	Ground contact 1	0,46	0,75	0,46	0,77	0,59	0,82
Cixidia confinis							
	(Intercept)	0,96	1,52	0,92	1,51	1,09	1,69
	Pinus volume	0,55	0,82	0,52	0,68	0,06	0,46
	Diameter	3,06	12,97	3,25	12,89	2,96	14,16
	Volume	-4,28	5,01	-5	5,01	-4,78	5,43
	Decay class 1	0,27	0,85	0,22	0,86	0,32	0,88
	Decay class 2	0,11	0,64	0,16	0,62	0,19	0,64
	Moisture 1	0,36	0,87	0,3	0,86	0,31	0,89
	Moisture 2	0,21	0,53	0,25	0,53	0,27	0,54
	Moisture 3	-0,34	0,8	-0,29	0,81	-0,35	0,83
	Light 1	-0,23	0,4	-0,2	0,38	-0,17	0,39
	Ground contact 1	-0,36	0,38	-0,37	0,38	-0,41	0,38
Cixidia lapponica							
	(Intercept)	0,71	1,45	0,73	1,54	0,8	1,55
	Pinus volume	0,67	0,71	0,44	0,68	0,27	0,38
	Diameter	-1,74	10,23	-1,75	10,63	-2,33	11,19
	Volume	-0,33	2,74	-0,94	2,85	-0,98	3,07
	Decay class 1	0,77	0,85	0,72	0,88	0,71	0,91
	Decay class 2	-0,39	0,59	-0,31	0,6	-0,36	0,63
	Moisture 1	-0,32	1,26	-0,38	1,3	-0,38	1,34
	Moisture 2	0,91	0,82	0,97	0,86	0,99	0,88
	Moisture 3	1,09	0,91	1,18	0,97	1,07	0,99
	Light 1	0,2	0,32	0,26	0,32	0,24	0,33
	Ground contact 1	0,01	0,31	-0,02	0,31	-0,03	0,31

Table A2. (Continued).

Species	Variable	10 m estimate	10 m std.error	30 m estimate	30 m std.error	50 m estimate	50 m std.error
Bassus calcurator							
	(Intercept)	-11,05	2692,6	-11,76	2665,06	-11,75	2812,35
	Picea volume	0,24	0,38	0,12	0,1	0,06	0,06
	Diameter	5,15	15,17	11,06	16,62	10,64	17,79
	Volume	-6,87	5,27	-8,92	5,92	-8,54	6,06
	Decay class 1	-1,13	5851,11	-1,75	5645,31	-1,78	6009,14
	Decay class 2	-15,53	4945,09	-14,26	4771,16	-14,39	5078,65
	Decay class 3	-0,96	2925,56	-0,92	2822,66	-0,95	3004,57
	Decay class 4	-2,59	1105,76	-2,57	1066,86	-2,57	1135,62
	Moisture 1	-12,34	5868,45	-11,95	5936,37	-11,96	6219,74
	Moisture 2	4,91	1956,15	5,13	1978,79	5,07	2073,25
	Moisture 3	2,82	1956,15	2,51	1978,79	2,48	2073,25
	Light 1	-0,63	0,49	-0,81	0,55	-0,79	0,59
	Ground contact 1	0,3	0,89	0,52	0,92	0,52	0,98
Perilampus polypori							
	(Intercept)	-19,39	5476,46	-18,64	3393,2	-18,82	3400,42
	Picea volume	-0,25	0,33	-0,04	0,08	0	0,04
	Diameter	7	11,27	7,97	11,29	9,48	11,14
	Volume	2,12	3,17	1,51	3,17	0,73	3,23
	Decay class 1	0,28	11722,28	0,37	7304,46	0,21	7314,66
	Decay class 2	-20,45	9907,14	-19,35	6173,39	-19,03	6182,02
	Decay class 3	-0,78	5861,14	-0,75	3652,23	-0,78	3657,33
	Decay class 4	-4,87	2215,3	-4,6	1380,41	-4,59	1382,34
	Moisture 1	-9,29	11760,06	-8,67	7218,9	-8,6	7220,63
	Moisture 2	9,15	4031,18	8,7	2485,62	8,75	2492,48
	Moisture 3	-8,87	4919,88	-8,57	3109,76	-8,69	3160,19
	Light 1	0,2	0,46	0,19	0,46	0,15	0,46
	Ground contact 1	0,36	0,88	0,4	0,91	0,5	0,96
Nemapogon cloacellus							
	(Intercept)	-4,23	390,2	-4,81	418,48	-4,89	426,7
	Wood volume	-0,88	0,68	-0,12	0,16	-0,03	0,07
	Diameter	2,9	10,63	3,62	9,73	4,22	9,28
	Volume	-0,62	3,38	-0,88	3,2	-1,51	3,06
	Decay class 1	6,56	1233,93	7,71	1323,34	7,6	1349,34
	Decay class 2	-6,06	1042,86	-6,98	1118,42	-6,85	1140,4
	Decay class 3	4,79	616,96	5,26	661,67	5,22	674,67
	Decay class 4	-3,25	233,19	-3,49	250,09	-3,52	255
	Moisture 1	-0,1	1,27	0,03	1,37	0,06	1,4
	Moisture 2	0,35	0,63	0,41	0,67	0,43	0,68
	Moisture 3	-0,81	1	-1,11	1,07	-1,19	1,09
	Light 1	-0,04	0,37	-0,04	0,39	-0,03	0,39
	Ground contact 1	0,59	0,59	0,54	0,61	0,54	0,62

Table A2. (Continued).

		10 m		30 m		50 m	
Species	**Variable**	**estimate**	**std.error**	**estimate**	**std.error**	**estimate**	**std.error**
Montescardia tessulatella							
	(Intercept)	-7,48	1354,47	-7,66	1339,49	-16,59	806 476
	Picea volume	0,1	0,09	0,05	0,03	0,03	0,02
	Diameter	9,81	4,61	11,11	4,68	10,7	4,95
	Volume	-0,57	1,17	-1,06	1,22	-1,27	1,16
	Decay class 1	-11,27	2083,06	-11,5	2072,18	-24,09	11 429 060
	Decay class 2	-9,59	1760,51	-9,26	1751,31	-19,66	965 931
	Decay class 3	-5,8	1041,53	-5,84	1036,09	-12,06	571 453
	Decay class 4	-2,79	393,66	-2,77	391,6	-4,95	215 988
	Moisture 1	-12,76	3550,51	-12,75	3504,8	-28,47	21 628 762
	Moisture 2	4,43	1183,5	4,44	1168,27	9,63	720 958
	Moisture 3	4,2	1183,5	4,18	1168,27	9,44	720 958
	Light 1	-0,19	0,17	-0,21	0,17	-0,19	0,18
	Ground contact 1	0,51	0,33	0,61	0,34	0,54	0,26
Xanthostigma xanthostigma							
	(Intercept)	-8,11	1556,4	-8,18	1493,25	-8,17	1528,72
	Wood volume	-0,29	0,45	-0,04	0,11	-0,05	0,07
	Diameter	9,48	11,12	8,47	10,34	8,82	10,73
	Volume	-2,98	3,42	-2,99	3,35	-2,7	3,31
	Decay class 1	14,34	4807,03	14,76	4609,32	14,85	4721,08
	Decay class 2	-2,22	4062,69	-2,56	3895,58	-2,64	3990,04
	Decay class 3	-5,69	2678,12	-5,57	2574,24	-5,51	2631,26
	Decay class 4	6,03	1289,39	6	1244,16	6,02	1267,62
	Moisture 1	1,37	0,68	1,41	0,66	1,33	0,68
	Moisture 2	-0,37	0,55	-0,39	0,53	-0,41	0,54
	Moisture 3	-0,23	0,74	-0,27	0,71	-0,24	0,73
	Light 1	0,05	0,35	0,05	0,33	0,06	0,34
	Ground contact 1	-0,02	0,37	0,01	0,36	0,01	0,36

Appendix 4

Pictures of the most unexpected species of the study: *Agnathosia sandoeensis* and *Nemapogon fungivorellus*.

Figure A24. One of two reared individuals of Agnathosia sandoeensis.

Figure A25. Nemapogon fungivorellus from above.

Figure A25. Two reared individuals of N. fungivorellus

Figure A26. Part of male genitalia from N. fungivorellus.

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