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Macrofungi of oligotrophic Scots pine forests in northern Finland

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As part of the Lapland Forest Damage Project, permanent sampling plots in oligotrophic dry pine forests with sparse birch or spruce undergrowth were established in Finnish Lapland. One additional site was established in northern Norway. Sporocarps were collected from 14 plots in autumns 1991–1994. All together 207 fungus species were identified, 167 of them stipitate fungi and 40 corticioid or polyporoid species. Seventy-two fungus species were found at only one site, and 44 species at two or three sites. The remaining 91 species (47%), which were found at more than three sites, may be considered as common in the northern boreal pine forests of eastern Fennoscandia. Fifteen of these species were not especially associated with pine. Fifty-five per cent of all species were mycorrhizal, but as much as 70% of the common ones. In total, about 152 species were associated with pine. Ninety of these were mycorrhizal species, eight of them perhaps also mycorrhizal with birch or spruce; 44 were wood decomposers and 18 humicular species, decomposing mainly pine needles; 14 saprophytic species lived amongst mosses. The ectomycorrhizal genus *Cortinarius* was overwhelmingly most rich in species, with about 35 distinguished taxa. Of humicular saprophytic species 75% belonged to the family Tricholomataceae. The 58 wood decomposers mostly belonged to Corticiaceae and Polyporaceae. Only one basidiolichen, one coprophilous and one mycophilous species were found. The average annual yield of sporocarps was 4600 g dw ha^{-1}. The variation from one year to the next was marked, with the most productive year being 1993 (9685 g dw ha^{-1}) and the poorest 1994 (1115 g dw ha^{-1}). Four species, *Suillus variegatus*, *Lactarius rufus*, *Russula decolorans* and *R. paludosa*, were responsible for 75% of the total yield in the best year. All of them are mycorrhizal and edible. The average annual yield of edible species was 3170 g dw ha^{-1}, nearly 70% of the total yield. Four genera produced 85% of the yield, namely *Cortinarius* which accounted for 20%, *Lactarius* for 26%, *Russula* for 15% and *Suillus* for 27%. The proportion of mycorrhizal fungi was 98%.

Key words: Ascomycota, Basidiomycota, boreal pine forests, decomposer, macrofungi, mycorrhiza, saprophytic, yield

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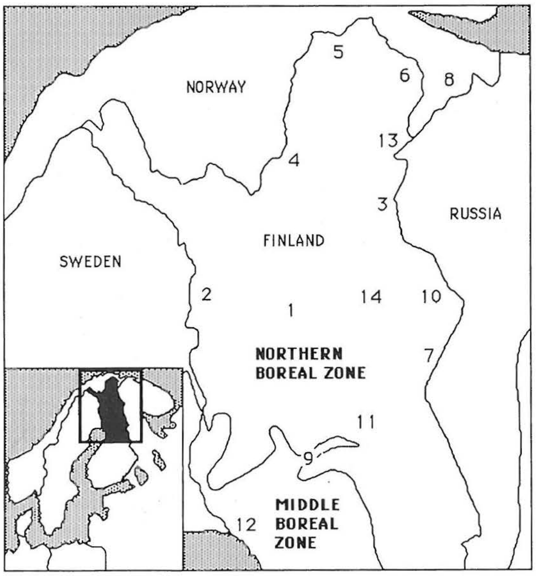
Introduction

Dry oligotrophic Scots pine (*Pinus sylvestris*) forests account for about 3 700 000 ha (75%) of all forest in the province of Lapland, northern Finland (Aarne 1994). Our knowledge of the fungal species inhabiting these dry pine forests is scant. Moreover, there are some poorly known genera, rich in species, which are responsible for a large proportion of the fungal yield. The genus *Cortinarius* is an example (Soop 1993a). Some less abundant genera, such as *Hebeloma* and *Inocybe*, are poorly known, too.

Studies dealing with the yield of macrofungi were recently briefly reviewed in this journal (Salo 1993) and the information will not be repeated. The yield of macrofungi in northern Finland was measured in Scots pine forests between 1976 and 1978 (Ohenoja & Koistinen 1984), and further south, mainly in the province of Oulu, in 1976–1988 (Ohenoja 1993). These studies serve as a basis for the present, similar investigation in the area.

In the present study macrofungi and their yield in northern Scots pine forests were investigated in the autumns of 1991–1994. Saprophytic and parasitic microfungi were not included, although some of these, such as *Exobasidium splendens*, occurred at nearly all sites. This article will serve as a basis for forthcoming, more detailed investigations on the composition and structure of macrofungal communities in northern Finland and their relationship to various environmental variables.

Fig. 1. Study sites and their location in northern Finland. 1 = Aska, 2 = Muonio, 3 = Raja-Jooseppi, 4 = Kirakkajärvi, 5 = Svanvik, 6 = Angeli, 7 = Kevo, 8 = Naruska, 9 = Tennilä, 10 = Värriö, 11 Keminmaa, 12 = Kessi, 13 = Lokka and 14 = Kemijärvi. The boundary between the middle and northern boreal zones is according to Ahti et al. (1968).



Material and methods

According to Tuhkanen (1984), the study sites are located in intermediate parts between oceanic and continental sectors in the northern boreal zone, except for the two southernmost sites, which are located in the middle boreal zone (Fig. 1).

The altitude of the study sites varies between 45 and 280 m above sea level, the mean being 180 m. Only one site, Keminmaa, is under 100 m a.s.l. The mean annual temperature is −1.2°C, the mean effective temperature sum (the sum of daily mean temperatures >5°C) 750°C (600–950°C) and the mean annual rainfall 450 mm in 1960–1990. The climatological data presented in Table 1 were calculated according to Ojansuu & Henttonen (1983), and do not extend to Norway. More climatological data are provided in Kolkki (1966).

According to Kalela's (1961) Finnish forest site types the studied forests mainly represented Uliginosum–Vaccinium–Empetrum type; a few forests were of Cladina type or Uliginosum–Empetrum–Myrtillus type, and two was of Ledum–Myrtillus type. Due to intensive reindeer grazing, the ground vegetation is very heterogeneous, however (Fig. 2). It is mainly composed of a mosaic *Cladina–Cladonia–Dicranum–Pleurozium* carpet. Further details concerning the vegetation are provided in Väre et al. (1995).

Scots pine is the dominant tree species at all sites and the only one at two of the sites. The age of the Scots pines varies between 100 and 200 years. Most of the sites also include Norway spruce (*Picea abies*, 5 sites) or downy birch (*Betula pubescens*, 9 sites), or both of these (3 sites) as an undergrowth (Table 1). In most cases Norway spruces and downy birches are seedlings or young saplings, under three metres in height. Hereafter, these tree species will be referred to as birch, pine and spruce.

Sporocarps of fungi were collected at 14 permanent sites (Fig. 1), once in 1991 and 1992 in the first week of September and twice in 1993 and 1994, between the last week of August and the second week of September. At site eight, sporocarps were collected in 1992–1994. Species occurring early or very late in the season may therefore not be represented in the data. The area of each study site was 600 m^2. Sporocarps were dried in an air-conditioned oven at 40°C for 1–2 days and weighed at room conditions. Biomasses are given in g dw ha^{-1}. Corticiaceous and most polyporous Aphyllophorales were collected only in 1994 and were not weighed. Life forms and mycorrhizal plant associates were evaluated on the basis of field notes and the literature (Trappe 1962, Molina et al. 1987, Hansen & Knudsen 1992).

The total sporocarp yield of pine forests in the province of Lapland was estimated from information on the area of dry oligotrophic pine forest land and the age structure of stands for 1983–93 given in the Yearbook of Forest Statistics (Aarne 1994). Forests more than 40 years old were used in the calculations based on assumption that their fungal yield is similar to that of the aged stands of our study.

If a species occurred each year at each site, its occurrence percentage was 100 (see Table 2). A species was considered to be common (more precisely, widely distributed) at the study sites if it occurred at more than three sites.

Table 1. Climatological data: annual precipitation mm yr^{-1} (mm), mean annual temperature (t), effective temperatature sum (Σt, the sum of daily average temperatures >5°C). Pine growth data: number of mature trees ha^{-1} (number), basal area m^2 ha^{-1} (ba), breast height diameter cm (bhd), height m (h), volume m^3 ha^{-1} (vol). Number of pine, birch and spruce saplings ha^{-1}. Explanation of site numbers are given in Fig. 1.

Site	climatological data			pine growth data					number of saplings		
	mm	t	St	number	ba	bhd	h	vol	pine	birch	spruce
1	500	-1.0	795	1231	13.7	11.9	10.6	80		17	
2	445	-1.7	718	450	17.6	22.3	15.0	135	3333		
3	439	-1.3	723	383	10.7	18.9	11.7	62	1333	17	
4	393	-1.7	660	633	11.8	15.4	8.7	60	333	67	
5	393	-1.8	628	500	13.7	18.7	8.3	64	83	100	
6	418	-1.5	644	467	8.5	15.2	7.2	33	833	67	
7	517	-1.4	751	133	6.3	24.5	14.4	43			
8				1667	17.9	11.7	8.4	82	50		
9	513	0.0	894	1017	16.5	14.4	11.0	94		50	
10	508	-2.1	708	183	6.8	21.7	14.3	45	500	83	17
11	513	-0.9	781	600	23.2	22.2	15.2	180		417	67
12	511	0.8	985	667	22.2	20.6	12.1	137			67
13	403	-1.3	707	1017	11.7	12.1	8.4	55		83	
14	491	-1.7	720	417	9.9	17.4	12.3	63		100	33

Fig. 2. A study site at Salla, Naruska, heavily grazed by reindeer (18.7.1990).

Microscopic measurements were made on samples embedded in Melzer solution, by using 100 ¥ 15 magnification. Sporocarps from all stands in which the species was found were included in the measurements. Some *Cortinarius* of the subgenus *Dermocybe* were analysed by thin layer chromatography (Høiland 1984).

The nomenclature follows Hansen & Knudsen (1995) for Ascomycota and Dacrymycetales, and Hansen & Knudsen (1992) for Boletales, Agaricales and Russulales. Aphyllophorales sensu Jülich (1984) follows Gilbertson & Ryvarden (1986) for families within polyporoid genera, Eriksson & Ryvarden (1973, 1975, 1976), Eriksson et al. (1978, 1981, 1984), Hjortstam et al. (1988) for species in Corticiaceae, and Hallenberg (1985) for species in Coniophoraceae. Nomenclature for polyporoid species was adopted from Niemelä (1993) and that for hydnaceous species from Niemelä & Kotiranta (1993). Several collections are deposited in the herbarium, University of Oulu (OULU).

Results and discussion

A total of 207 taxa were found, 167 of them being stipitate and 40 resupinate or polyporous (Table 2). The maximum number of stipitate species (122) was found in 1993 (Table 3). Hintikka (1988) reported 80 stipitate species from pine forests in southern Finland, 75% of the mycorrhizal species and 55% of decomposers being the same as in the present study. Salo (1993) identified 232 macrofungi (Polyporales, Boletales, Agaricales, Russulales) from boreal upland forests and peatlands, including birch, pine and spruce forests. About 45% of these species were also found in the present study. Thus it seems that there is a fairly high overall similarity of the fungus species in different pine forest types in Finland. There was no clear geographical shift in the species composition from south to north; the number of species was lowest at Svanvik, Norway, which was the third northernmost study site.

Only five species belonged to Ascomycota, four of them to Helotiales, with two families and two genera. *Cenococcum geophilum* was a common imperfect species of Ascomycota. Basidiomycota included four classes: 1) Dacrymycetales with two species, 2) Aphyllophorales with seven families, 38 genera and 51 species, 3) Boletales with four families, seven genera and 13 species and 4) Agaricales with nine families, 34 genera and 135 species (Table 2). Two families, Cortinariaceae (52 species) and Tricholomataceae (44 species) included 47% of all species. Russulaceae included 18 identified species, Corticiaceae 17 and Poly-poraceae 16.

In total, 152 species were associated with pine. These included 90 mycorrhizal species, eight of them perhaps also mycorrhizal with birch or spruce, 44 wood decomposers and 18 pine litter decomposers (Table 4). These can be regarded as true specialists in northern oligotrophic pine forests. The seven common moss saprophytes (Table 4) may also occur in birch or spruce forests.

Although birch undergrowth was sparse, there were 26 species associated with it, 13 of them mycorrhizal and 13 wood decomposers (Table 4).

Four species were mycorrhizal with spruce and two wood decomposer were found growing on it. Living spruce, dead spruce trunks and other remnants of spruce were very rare at the study sites. In addition, there were 15 species which were mycorrhizal with birch, pine or spruce, or some combination of these (Table 4). In all 91 species were considered to be common at the study sites (Table 4); 72 species (including 22 resupinate or polyporous taxa) were found at only one site and 44 (including 10 corticious or polyporous taxa) were found at two or three sites (Table 2).

Life forms

Of all species, 115 (55%) were mycorrhizal and 90 were decomposers (including 40 resupinate and polyporoid species). The ratio was thus 1.4 (Table 4). Sixty-two of the common species (70%) were mycorrhizal and 28 were decomposers, for a ratio of 2.2. A higher proportion of the rare species were decomposers, taking advantage perhaps of rare substrates. The relationships is opposite to that of mesic sites, where decomposer species are more abundant (Ohenoja 1993, Ohenoja & Väre 1993, Salo 1993). This is mainly due to the more diverse substrate selection possibilities and the higher humidity than at the present study sites. Mossy sites (almost continuous *Pleurozium schreberi* carpet) always included more diverse decomposer fungal flora than did lichen dominated sites.

Mycorrhizal species. Ninety mycorrhizal species (including eight uncertain) were associated with

Table 2. Fungal species, and in parentheses number of species in taxonomic group. Yield (g dw ha^{-1}) is given as mean weight, maximum site specific weight (max) and maximum annual mean weight (max annu) for a particular year (yr) of measurement. The sum of the yields is given separately for species-rich genera and family. Occurrence is given as % of collections (4 years ¥ 14 sites), as maximum number of years (no yr) at a specific site and number of sites (no) at which species seen. Life forms are B, P, S = mycorrhizal with birch, pine and spruce, respectively; Pn = saprophytic in pine needles; M = saprophytic in mosses; Bw, Pw and Sw = saprophytic on birch, pine and spruce wood, respectively. Bl = basidiolichen, Co = coprophilous, My = mycophilous.

Order/Class/Family/Species	yield				occurrence			life form
	mean weight	max site	max annu	yr	%	no yr	no	
ASCOMYCOTA (5)								
Helotiales (4)	1.48							
Geoglossaceae (2)	0.12							
Spathularia flavida Pers.:Fr.	0.12	7	0.5	93	1.8	1	1	B, P, S
S. rufa Schmidel	0.006	3.5	0.2	93	1.8	1	1	B, P, S
Leotiaceae (2)	1.36							
Cudonia circinans (Pers.:Fr.) Fr.	0.26	8	0.06	93	3.6	1	2	B, P, S
C. confusa Bres.	1.1	35	3	93	12.5	2	6	B, P, S
Fungi Imperfecti (1)								
Cenococcum geophilum Fr.							1	P
BASIDIOMYCOTA (202)								
Dacrymycetales (2)								
Dacrymycetaceae (2)								
Dacrymyces stillatus Nees:Fr.							1	Pw
D. tortus (Willd.:Fr.) Fr.							2	Pw
Aphyllophorales (50)	170							
Clavariaceae (2)	0.002							
Clavariadelphus sp.	0.002	0.08	0.1	93	1.8	1	1	B, P, S
Clavulinopsis sp.	<0.001	0.02	0.02	93	1.8	1	1	Pn
Clavulinaceae (1)	0.2							
Clavulina cristata (Fr.) Schröt.	0.2	9	0.7	93	1.8	1	1	Pn
Thelephoraceae (7)	125							
Bankera fuligineoalba (Schmidt.:Fr.) Pouzar	19	385	34	91	16.1	3	2	P
Boletopsis grisea (Peck) Bondartsev & Singer	1.9	99	7	93	3.6	2	1	P
Hydnellum caeruleum (Hornem.) P. Karst.	52	1825	169	93	12.5	3	5	P
H. ferrugineum (Fr.:Fr.) P. Karst.	16	265	44	93	12.5	2	5	P
H. peckii Banker ex Peck	3.7	65	9	93	10.7	2	5	P
Phellodon tomentosus (L.:Fr.) Banker	29	1435	103	92	10.7	2	4	P
Thelephora terrestris Pers. ex Fr. 1	60	4	92	1.8	1	1	P	
Corticiaceae (17)								
Botryobasidium botryosum (Bres.) J. Erikss.							5	Pw
B. subcoronatum (v. Höhn. & Litsch.) Donk							3	Pw
Botryobasidium sp.							2	Pw
Ceraceomyces sublaevis (Bres.) Jülich coll.							1	Pw
Chaetoderma luna (Romell ex D. P. Rogers & H. S. Jacks.) Parmasto							7	Pw
Dacryobolus karstenii (Bres.) Oberw. ex Parmasto							1	Pw
Fibulomyces septentrionalis (J. Erikss.) Jülich							2	Pw
Hyphoderma praetermissum (P. Karst.) J. Erikss. & Å. Strid							5	Pw

Table 2. Contd.

Hyphodontia aspera (Fr.) J. Erikss.							2	Pw
H. subalutacea (P. Karst.) J. Erikss.							1	Pw
Phanerochaete sanguinea (Fr.) Pouz.							4	Pw
Piloderma croceum J. Erikss. & Hjortstam							5	Pw
Resinicium furfuraceum (Bres.) Parmasto							6	Pw
Sistotremastrum suecicum Litsch. ex J. Erikss.							4	Pw
Sphaerobasidium minutum (J. Erikss.) Oberw. ex Jülich							1	Pw
Stereum hirsutum (Willd.:Fr.) Gray							1	Bw
Trechispora farinacea (Pers.:Fr.) Liberta s. str.							1	Pw
T. subsphaerospora (Litsch.) Liberta							1	Pw
Coniophoraceae (3)								
Coniophora arida (Fr.) P. Karst.							1	Pw
C. fusispora (Cooke & Ellis) Sacc.							1	Pw
Leucogyrophana pulverulenta (Fr.) Ginns							1	Pw
Hymenochaetaceae (3)	44							
Coltricia perennis (L.:Fr.) Murrill	44	286	53	93	62.5	4	11	P, Pn
Phellinus cinereus (Niemelä) M. Fisch.							1	Bw
P. viticola (Schwein. ex Fr.) Donk							1	Pw
Polyporaceae (16)	0.2							
Amyloporia xantha (Fr.:Fr.) Bondartsev & Singer							7	Pw
Antrodia albobrunnea (Romell) Ryvarden							1	Pw
Fomes fomentarius (L.:Fr.) Fr.							1	Bw
Fomitopsis pinicola (Sw.:Fr.) P. Karst.							2	Pw
Gloeophyllum sepiarium (Wulfen:Fr.) P. Karst.							1	Pw
Junghuhnia luteoalba (P. Karst.) Ryvarden							1	Pw
Oligoporus sericeomollis (Romell) Bondartseva							3	Pw
Piptoporus betulinus (Bull.:Fr.) P. Karst.							1	Bw
Polyporus brumalis (Pers.:Fr.) Fr.	0.2	25	0.7	91	1.8	1	1	Bw
Postia cf. *lateritia* Renvall							2	Pw
Skeletocutis lenis (P. Karst.) Niemelä							1	Pw
S. lilacina A. David & Jean Keller							1	Sw
S. stellae (Pilát) Jean Keller							1	Pw
S. subincarnata (Peck) Jean Keller							1	Pw
Trichaptum abietinum (Pers.:Fr.) Ryvarden							1	Sw
T. hollii (J. C. Schmidt:Fr.) Kreisel							2	Pw
Boletales (13)	1375							
Paxillaceae (1)	8							
Paxillus involutus (Batsch:Fr.) Fr.	8	310	30	92	10.7	2	5	P
Boletaceae (5)	68							
Boletus subtomentosus L.: Fr. coll.	2.3	70	5	91	5.4	1	3	B, P
Leccinum spp.	65							
Leccinum scabrum (Bull.:Fr.) Gray coll.	17	340	36	93	10.7	1	5	B
L. variicolor Watling	0.1	5	0.3	92	1.8	1	1	B
L. versipelle (Fr.) Snell	31	360	52	93	17.9	3	8	B, P
L. vulpinum Watling	17	570	69	93	10.7	1	6	P
Rhizopogonaceae (1)	0.8							
Rhizopogon vulgaris (Vitt.) M. Lange	0.8	45	3	92	1.8	1	1	P
Gomphidiaceae (6)	1300							
Chroogomphus rutilus (Schaeff.:Fr.) O. K. Miller	33.7	633	100	92	62.5	4	14	P
Gomphidius glutinosus (Schaeff.:Fr.) Fr.	1.5	85	6	91	1.8	1	1	S
G. roseus (Fr.) Fr.	1.1	35	3	92	7.1	1	3	P
Suillus spp.	1260							
Suillus bovinus (L.:Fr.) Roussel	62	1220	201	92	26.8	3	8	P

Table 2. Contd.

S. luteus (L.:Fr.) Roussel	2.6	30	23	91	12.5	1	7	P
S. variegatus (Sw.:Fr.) O. Kuntze	1200	10500	3080	93	62.5	3	14	P
Agaricales (137)	3090							
Hygrophoraceae (7)	1.5							
Hygrocybe miniata (Fr.) P. Kumm.	0.005	2.5	0.2	93	1.8	1	1	M
H. psittacina (Schaeff.:Fr.) P. Kumm.	<0.001	0.3	0.02	94	1.8	1	1	M
Hygrophorus spp.	1.5							
Hygrophorus agathosmus (Fr.) Fr.	0.2	6	0.4	93	3.6	2	1	S
H. camarophyllus (Alb. & Schwein.:Fr.) Dumèe et al.	0.8	4.5	3	94	1.8	1	1	B, S
H. hypothejus (Fr.:Fr.) Fr.	0.12	7	0.5	92	1.8	1	1	P
H. karstenii Sacc. & Cub.	0.3	15	1	91	1.8	1	1	(P), S
H. olivaceoalbus (Fr.:Fr.) Fr.	0.12	6.5	93	0.5	1.8	1	1	B
Tricholomataceae (44)	200							
Armillaria borealis Marxmüller & Korhonen	2.0	110	8	91	1.8	1	1	B
Cantharellula umbonata (Gmel.:Fr.) Singer	3.5	76	11	92	14.3	4	5	M
Clitocybe diatreta (Fr.:Fr.) Gillet	0.7	14	2	91	14.3	3	6	M
C. vibecina (Fr.) Quél.	6.4	64	8	92	44.6	4	13	Pn
Collybia spp.	14							
Collybia butyracea (Bull.:Fr.) P. Kumm.	0.6	18	2	92	14.3	2	5	Pn
C. distorta (Fr.) Quél.	0.7	29	2	92	3.6	2	2	Pn
C. maculata (Alb. & Schw.:Fr.) P. Kumm.	5.1	81	7	94	18	2	8	Pn
C. peronata (Bolt.:Fr.) P. Kumm.	0.12	5	0.3	93	3.6	2	1	M
C. putilla (Fr.:Fr.) Singer	4.7	58	16	92	9	3	12	Pn
C. racemosa (Pers.:Fr.) Quél.	0.001	0.05	0.06	92	1.8	1	1	M
C. succinea (Fr.) Quél.	0.6	9	2	93	12.5	1	7	Pn
C. tuberosa (Bull.:Fr.) P. Kumm.	1.8	47	4.5	93	42.8	4	12	My
Cystoderma granulosum (Batsch:Fr.) Kühner	<0.001	0.8	0.06	92	1.8	4	1	M
C. jasonis (Cooke & Massee) Harmaja	3.2	30	6	92	39.3	4	11	M
Laccaria bicolor (Maire) Orton	25	125	53	93	67.9	4	13	P
Lyophyllum spp.	58							
Lyophyllum decastes (Pers.:Fr.) Orton	20	575	65	93	7.1	2	3	P
L. fumosum (Fr.:Fr.) Singer	38	455	80	93	19.6	2	9	P
L. semitale (Fr.) Kühner	2.3	75	6	92	12.5	2	5	Pn
Marasmius androsaceus (L.:Fr.) Fr.	1.1	15	4	93	21.4	2	10	Pn
Mycena spp.	2.8							
Mycena clavicularis (Fr.) Gillet	1.3	25	4	92	35.7	3	13	Pn
M. epipterygia (Scop.:Fr.) Gray	0.003	0.17	0.01	94	1.8	1	1	Pn
M. galericulata (Scop.:Fr.) Gray	0.004	1.5	0.1	93	5.4	1	3	Bw
M. galopus (Pers.:Fr.) P. Kumm.	<0.001	0.17	0.02	91	3.6	2	2	Pn
M. haematopus (Pers.:Fr.) P. Kumm.	0.11	0.2	0.04	93	3.6	1	2	Bw
M. laevigata (Lasch:Fr.) Gillet	1.3	25	2	91	12.5	3	5	Pw
M. sanguinolenta (Alb. & Schwein.:Fr.) P.Kumm.	<0.001	0.3	0.02	91	1.8	1	1	Pw
M. viridimarginata P. Karst.	<0.001	0.17	0.01	93	1.8	1	1	Pw
Omphaliaster asterosporus (J. E. Lange) Lamoure	0.001	0.8	0.06	93	1.8	1	1	M
Omphalina umbellifera (L.:Fr.) Quél.	0.9	15	2	93	32.1	4	8	Bl
Ripartites sp.	0.3	0.3	1	92	1.8	1	1	Pn
Tricholoma spp.	77							
Tricholoma aestuans (Fr.) Gillet	8.8	330	35	93	5.6	1	3	P
T. auratum (Fr.) Gillet ss. Bon	14	345	34	93	17.9	3	8	P
T. focale (Fr.) Ricken	14	545	39	92	7.1	2	3	P
T. imbricatum (Fr.:Fr.) P. Kumm.	2.4	135	10	91	1.8	1	1	P
T. nauseosum (Blytt) Kytövuori	2	115	8	91	1.8	1	1	P
T. pessundatum (Fr.) Quél.	14	615	57	92	5.6	2	2	P
T. portentosum (Fr.) Quél.	0.7	40	3	91	1.8	1	1	P
T. saponaceum (Fr.:Fr.) P. Kumm.	5.4	615	9	92	5.6	1	3	P

Table 2. Contd.

T. stans (Fr.) Sacc.	5.1	150	18	92	3.6	1	2	P
T. virgatum (Fr.:Fr.) P. Kumm.	1.8	100	7	93	1.8	1	1	P
T. viridilutescens Moser	11	475	34	92	3.6	2	1	P
Tricholomopsis decora (Fr.) Singer	0.2	6.5	0.55	92	3.6	1	2	Pw
T. rutilans (Schaeff.:Fr.) Singer	3.2	7.5	11	93	5.4	2	2	Pw
Xeromphalia campanella (Batsch:Fr.) Kühner & Maire	1.8	35	5	93	19.6	2	7	Pw
Pluteaceae (1)	0.8							
Pluteus atricapillus (Batsch) Fayod	0.8	30	2	94	10.7	1	2	Bw
Coprinaceae (1)	0.002							
Psathyrella sp.	0.002	1.2	0.08	92	1.8	1	1	Pn
Strophariaceae (9)	23							
Flammulaster limulatoides Orton	0.03	25	1	91	3.6	1	2	Pw
Hypholoma capnoides (Fr.) P. Kumm.	23	325	3	93	23.2	4	8	Pw
Phaeomarasmius borealis Rald	<0.001	0.17	0.01	94	1.8	1	1	Bw
Pholiota spp.	27							
Pholiota alnicola (Fr.:Fr.) Singer	18	395	28	94	14.3	3	6	Bw
P. heteroclita (Fr.:Fr.) Quél.	0.8	45	3	91	1.8	1	1	Bw
P. lubrica (Pers.:Fr.) Singer	1.2	50	5	91	3.6	1	2	Bw
P. mixta (Fr.) Singer	6.8	110	19	93	37.5	4	11	Pn
Stropharia hornemannii (Fr.:Fr.) Lundell	1.8	75	5	91	3.6	2	1	M
S. semiglobata (Batsch:Fr.) Quél.	0.001	1	0.06	91	1.8	1	1	Co
Cortinariaceae (52)	985							
Cortinarius spp.	940							
Cortinarius adalberti Favre	4	50	10	93	3.6	1	2	P
C. armeniacus Fr.	18	270	30	91	25.0	2	9	P
C. armillatus (Fr.:Fr.) Fr.	43	766	92	92	30.3	4	7	B
C. balteatus (Fr.) Fr.	12	154	31	93	16.1	3	6	P
C. biformis Fr.	93	755	67	94	220	9	14	P
C. brunneus (Pers.:Fr.) Fr.	170	1010	327	92	71.4	4	14	P
C. camphoratus (Fr.) Fr.	12	310	24	92	10.7	3	4	P
C. cinnamomeus (L.:Fr.) Fr.	8.1	67	19	92	46.4	3	13	P
C. claricolor (Fr.) Fr.	17	300	46	93	19.6	3	6	P
C. collinitus (Sow.:Fr.) Fr. ss. J. E. Lange	6.6	165	14	92	12.5	2	5	P
C. colus Fr.	0.4	6.5	0.8	93	21.4	2	6	P
C. croceus (Schaeff.) Bigeard & Guill.	22	150	35	91	73.2	4	14	P
C. gentilis (Fr.) Fr.	20	300	30	93	37.5	2	12	P, S
C. huronensis Ammirati & A. M. Sm. var. *olivaceus* Ammirati & A. M. Sm.	0.15	7.5	30	93	5.4	1	3	P
C. cf. *incisus* (Pers.:Fr.) Fr.	0.9	30	3	93	10.7	1	6	P
C. cf. *laetus* Moser	0.003	0.1	0.1	91	1.8	1	1	P
C. leucophanes P. Karst.	27	425	61	91	50	3	13	P
C. lux-nymphae Melot	41	433	72	93	44.6	4	12	P
C. mucosus (Bull.:Fr.) Kickx	68	460	112	92	60.7	4	14	P
C. niveoglobosus Lindstr.	0.5	30	2	92	1.8	2	1	B
C. obtusus (Fr.) Fr.	16	185	33	92	60.7	3	14	P
C. ochrophyllus Fr.	17	310	30	92	16.1	2	5	P
C. odhinnii Melot	13	160	37	92	42.9	4	12	P
C. paleaceus Fr.	0.8	36	3	91	7.1	2	3	B, (P)
C. paragaudis Fr. subsp. *paragaudis*	15	135	29	92	25.0	4	10	P
C. pholideus (Fr.:Fr.) Fr.	5.5	60	6	91	17.9	3	6	B
C. querciticus H. Lindstr.	24	410	42	92	12.5	4	4	P
C. raphanoides (Pers.:Fr.) Fr.	27	730	82	91	16.1	3	6	B
C. scaurus (Fr.:Fr.) Fr.	51	435	98	93	62.5	4	14	P
C. semisanguineus (Fr.) Gillet	140	990	243	92	76.8	4	14	P
C. stillatitius Fr.	3.3	50	6	93	16.1	2	5	P
C. talus Fr.	5.5	200	14	91	5.4	2	3	B, (P)

Table 2. Contd.

C. traganus (Fr.:Fr.) Fr.	52	75	104	93	33.9	3	11	P
C. vibratilis (Fr.) Fr.	17	260	52	92	53.4	3	14	P
Cortinarius sp.	2.6	100	12	92	3.6	1	2	P
Galerina spp.	2.2							
Galerina atkinsoniana A. M. Sm.	1.3	20	3	93	44.6	4	14	M
G. calyptrata Orton	0.17	3	0.5	93	17.9	4	8	M
G. camerina (Fr.) Kühner	0.002	1.3	0.1	91	3.6	1	1	Pw
G. marginata (Batsch) Kühner	0.02	6.5	0.05	91	3.6	1	2	Pw
G. mniophila (Lasch) Kühner	0.42	5.5	0.6	92	33.9	4	12	M
G. pumila (Pers.:Fr.) Singer	0.19	5.5	61	93	19.6	3	8	M
Gymnopilus penetrans (Fr.) Murr.	11	230	31	93	48.2	3	14	Pn
Hebeloma spp.	11							
Hebeloma birrus (Fr.) Sacc.	0.003	2	0.1	93	1.8	1	1	P
H. bryogenes Vesterholt	2.1	65	4	93	5.4	1	3	P, (B)
H. leucosarx Orton	8.7	200	22	92	12.5	3	5	P, (B)
Hebeloma sp.	0.003	1.5	1.5	92	1.8	1	1	P
Inocybe spp.	11							
Inocybe jacobi Kühner	0.003	0.15	0.01	93	1.8	1	1	P
I. lacera (Fr.) P. Kumm.	0.005	1.5	0.02	93	5.4	1	3	P
I. leptophylla G. F. Atk.	1.5	75	5.5	93	5.4	1	2	P
I. mixtilioides Kuyper ined.	0.005	2.5	0.2	94	1.8	1	1	P
I. soluta Velen.	7.5	70	10	94	33.9	4	9	P
I. subcarpta Kühner & Boursier	1.6	25	3	92	12.5	3	4	P
Rozites caperatus (Pers.:Fr.) Fr.	9.2	110	12	93	12.5	2	4	B
Crepidotaceae (1)	0.2							
Tubaria confragosa (Fr.) Kühner	0.2	10	0.7	93	1.8	1	1	Bw
Entolomataceae (2)	1.5							
Entoloma cetratum (Fr.:Fr.) Moser	1.4	25	3	92	44.6	4	10	P
E. turbidum (Fr.) Quél.	0.06	25	0.15	91	5.4	1	3	(B)
Russulales (18)								
Russulaceae (18)	1880							
Lactarius spp.	1200							
Lactarius helvus (Fr.) Fr.	1.5	45	6	91	3.6	1	2	P
L. mammosus (Fr. ex Weinm.) Fr.	24	150	38	93	48.2	1	11	P
L. musteus Fr.	4.1	70	9	93	8.9	2	4	P
L. necator (J. F. Gmel.:Fr.) Pers.	2.2	125	9	91	1.8	1	1	B
L. rufus (Scop.:Fr.) Fr.	1100	8630	2495	93	87.5	2	13	P
L. trivialis (Fr.:Fr.) Fr.	0.3	18	1	91	1.8	1	1	B
L. vietus (Fr.) Fr.	4.4	110	0.5	93	10.7	4	3	B
Russula spp.	680							
Russula adusta Fr.	3.0	165	12	91	1.8	1	1	P
R. aquosa Leclair	1.0	30	2	93	3.6	2	1	S
R. claroflava Grove	12	125	28	93	16.1	3	6	B
R. consobrina (Fr.:Fr.) Fr.	5.2	135	18	93	5.4	1	3	P
R. decolorans (Fr.) Fr.	340	3400	1095	93	39.3	3	12	P
R. paludosa Britz.	250	3450	785	93	23.2	4	9	P
R. roseipes Bres.	0.2	10	0.7	92	1.8	1	1	S
R. turci Bres. ss. Maire	1.2	25	5	93	5.4	1	3	P, (S)
R. vinosa Lindbl.	73	1235	170	93	19.6	3	7	P
R. xerampelina (Schaeff.) Fr. coll.	0.3	17	1.2	92	1.8	1	1	B, P, S
R. sp. sectio *Russula*	1.9	40	5	94	7.1	1	4	B, (P)

Table 3. Annual yield (g dw ha^{-1}) and number (no) of species of decomposer (D) and mycorrhizal (M) fungi in 1991–1994. Maximum yield (max yield) indicates number of species that had their highest yield in the given year. Common species include edible and mycorrhizal *Lactarius rufus, Russula decolorans, R. paludosa* and *Suillus variegatus.*

Year	yield		no		total		max yield		common species yield	common species proportion
	D	M	D	M	yield	no	D	M	g ha^{-1}	%
1991	105	2940	31	80	3045	111	12	20	1430	47
1992	85	4445	31	85	4530	116	15	39	1970	44
1993	155	9530	32	90	9685	122	18	54	7560	77
1994	70	52	24	52	1115	76	6	4	615	55
Mean	104	4490	30	77	4594	107			2870	62

Table 4. Number of species of different life forms. The number of common species is given in parentheses*. BL = basidiolichen, Dtot = total number of decomposers, Dw = wood decomposers, Dn = needle decomposers, Dm = moss decomposers, M = mycorrhizal species. Miscellaneous (Misc) mycorrhizal species are those for which the tree associate remained unknown, and miscellaneous decomposers include one coprophilous and one mycophilous species, and 14 moss decomposers. Two species occurred in two categories, making the sum of species 209 and 91, not 207 and 89.

Associate	BL	Dtot		Dw		Dn		Dm		M		Total	
Pine		63	(20)	45	(9)	18	(11)			83	(52)	146	(72)
Birch		13	(1)	13	(1)					13	(18)	26	(9)
Spruce		1		1						4		5	
Misc	1 (1)	16	(7)					14	(7)	15	(2)	32	(10)
Total	1 (1)	93	(28)	59	(10)	18	(11)	14	(7)	115	(62)	209	(91)

* Species that occurred at over three sites were regarded as common.

pine, 13 with birch, four with spruce and 15 with some combination of these (Table 4). About 10 mycorrhizal species within the mycorrhizal genera *Cortinarius*, *Entoloma*, and *Hebeloma* remained unidentified. Some 130 additional mycorrhizal fungal species amongst Agaricales and Boletales are associated with pine in Finland (Hansen & Knudsen 1992). These occur mainly on calcareous or mesic soil, or are mainly restricted to southern Finland. If mycorrhizal species of Ascomycota and Aphyllophorales are added as well, there are 250–300 mycorrhizal species associated with pine in Finland.

Hypogeous *Cenococcum geophilum* (Ascomycota, Fungi Imperfecti) and *Piloderma croceum* (Corticiaceae) occurred at all sites. These mycorrhizal species could be identified on the surface of pine root tips on the basis on rigid deeply intensively coloured black and yellow hyphae, respectively. At five sites *P. croceum* also produced sporocarps on a lower surface of decayed decorticated pine. *C. geophilum* has been found only in sterile form on the root surface of various tree species and as sclerotia in soil (Trappe 1971). Sclerotia were found in abundance in the present study.

All Ascomycota (1 common), Boletales (8 common) and Russulales (8 common) were mycorrhizal. In Boletales the overwhelmingly most common species was *Suillus variegatus*, and in Russulales *Lactarius rufus, Russula decolorans* and *R. paludosa* (Table 2). Aphyllophorales included both mycorrhizal (6 common) and decomposer species (10 common, all corticioid or polyporoid). The concept of life forms within Corticiaceae s. lat. is developing, however. The following genera have been reported to include mycorrhizal species: *Am-phinema, Byssocorticium, Ceratobasidium, Pilo-*

derma, Sistotrema, Thanateporus, Tylospora and *Ypsilonidium* (Taylor & Alexander 1991, Currah & Zelmer 1992). All these produce typical resupinate sporocarps on various plant material. All Thelephoraceae found in the present study were mycorrhizal with pine. Although the mycorrhizal status of Thelephoraceae has sometimes been questioned (Maas Geesteranus 1975), there now seems to be a consensus on the matter. The mycorrhiza of Thelephoraceae has been described in several instances (Agerer 1993) as well as its function (Entry et al. 1991).

Thelephora terrestris produced sporocarps at only one site. We were surprised to find the sporocarps so rare since these are common in manured soil in northern Finland, often in clear cut areas that have been ploughed (Väre 1989). Most of the sites in our study are heavily grazed by reindeer, and breaking of the soil surface could be suspected to stimulate sporocarp formation. *Coltricia perennis* is one of the characteristic species in lichen-rich pine forests of northern Finland. It is both mycorrhizal and saprophytic (Danielson 1984), a very peculiar feature, especially for a polyporoid species.

Among the Agaricales, Cortinariaceae and Tricholomataceae included both mycorrhizal and saprophytic species (35 common). Mycorrhizal species were especially common in the genus *Cortinarius* (29 common species, 45% of all common mycorrhizal species) and it may be described as a characteristic genus in northern pine forests in northeastern Fennoscandia, although fungal yield is higher in the genera *Suillus, Lactarius* and *Russula.* In Tricholomataceae there were four common mycorrhizal species, e.g. *Laccaria bicolor.* The number of *Tricholoma* species was 11, but only *T. auratum* was common. Hygrophoraceae was rare in dry pine forests. *Entoloma cetratum* in Entolomataceae is considered to be mycorrhizal, although the life form of most *Entoloma* is unknown.

Decomposer species. Humicular saprophytic species (all Agaricales) may be divided into two categories, 18 of them decomposing pine needles and 14 of them mosses (Table 4). The following families were represented: Cortinariaceae with four common moss decomposers, all *Galerina*, Tricholomataceae with 20 species (11 common species) and Strophariaceae with three species (one common, *Pholiota mixta*) (Table 2). Tricholomataceae included 75% of the humicular saprophytic species.

Cantharellula umbonata was the most productive moss decomposer. Ohenoja (1995) proposes that this species is mycorrhizal, but this should be studied. *C. umbonata* is fairly common (not every year) in Finland, but was infrequent in the present study. *C. umbonata* often grows amongst *Dicranum, Pleurozium* and *Polytrichum.* These mosses were reduced in size at most sites, however, due to trampling by reindeer, and *C. umbonata* was more common only at sites where grazing by reindeer was less intensive. *Clitocybe diatreta* and *Cystoderma jasonis* were other common moss decomposers.

Wood decomposers consisted of 58 (73% of all decomposers) species in Dacrymycetales, Aphyllophorales and Agaricales (Table 2). Forty-six species were growing on pine (Table 4). These included 37 Aphyllophorales, 12 of which were common species in Corticiaceae and Polyporaceae. The most common species were *Amyloporia xantha, Botryobasidium botryosum, Chaetoderma luna, Hyphoderma praetermissum, Phanerochaete sanguinea, Resinicium furfuraceum* and *Sistotremastrum suecicum.*

There were only few fallen trunks at the study sites. The average number of resupinate decomposer species per site was 6.5. Many species in this group are considered to be common in old dry pine heaths (Eriksson & Ryvarden 1973, 1975, 1976, Eriksson et al. 1978, 1981, 1984, Kotiranta & Niemelä 1981, Hallenberg 1985, Hjortstam et al. 1988, Niemelä 1993, Renvall et al. 1991, Renvall 1995). Among the rarer species, *Coniophora fusispora, Phellinus viticola* and *Skeletocutis stellae* were found at Raja-Jooseppi, *Boletopsis grisea* (ectomycorrhizal), *Skeletocutis lenis,* and *S. subincarnata* at Aska, *S. lilacina* at Lokka, *Postia* cf. *lateritia* at Muonio and Svanvik and *Antrodia albobrunnea* at Tennilä. *B. grisea* is fairly rare in Finland but in favourable years it is locally common especially in the north (Niemelä & Saarenoksa 1989).

Most of the resupinate species grew on decorticated wood on the lower surface of fallen pine trunks. *Botryobasidium botryosum, B. subcoronatum, Coniophora fusispora, Hyphoderma praetermissum* and *Sistotremastrum suecicum* were found growing on pine bark, the latter only once, however. *C. fusispora* has been found in Finland only twice before (Kotiranta & Larsson 1990, Kotiranta & Saarenoksa 1993). It prefers conifer wood (Hallenberg 1985). *Sceletocutis lilacina* grew on spruce bark.

Wood decomposing Agaricales were found in Cortinariaceae, Crepidotaceae, Strophariaceae and Tricholomataceae, altogether 22 species. Of these four were common: *Gymnopilus penetrans, Hypholoma capnoides, Mycena laevigata* and *Xeromphalia campanella.*

Stropharia semiglobata (Strophariaceae) was the only coprophilous species, collected once on reindeer dung. *Collybia tuberosa* (Tricholomataceae) was the only mycophilous species and was very common, occurring at 12 sites. The fungal substrate was not identified.

Basidiolichens. Omphalina umbellifera (Tricholomataceae) was the only basidiolichen in the study. It occurred at eight sites.

Notes on species

Four species are reported from Finland for the first time: *Cortinarius lux-nymphae, C. odhinnii, C. querciticus* and *Hebeloma bryogenes.* All these are apparently widely distributed in northern Finland, and the first two were common in dry pine heaths.

The following species are northernmost records in Finland, *Collybia racemosa* (Keminmaa, PeP), *Tricholoma imbricatum* (Angeli, InL), *Russula roseipes* and *R. turci* (Tennilä, PeP). The general distribution of many *Russula* species is poorly known.

Antrodia albobrunnea, Postia lateritia, Skeletocutis lenis and *S. stellae* are regarded as endangered in Finland (Kotiranta & Niemelä 1993), and *S. lilacina* will be included in the forthcoming list (Anttila et. al. 1995). It has been found five times before (Niemelä 1993, Anttila et al. 1995).

Except for one *Rhizopogon vulgaris* collection, all sporocarps were epigeous. This strenghtens the general view, that hypogeous species are rare in Fennoscandian boreal pine forests (Hansen & Knudsen 1992). Thirty soil samples were screened annually during the study at each site.

Most sites included a number of species, five on average, which were not found at other sites. For example, the only finds of *Spathularia flavida, S. rufa, Clavariadelphus* sp., *Clavulinopsis* sp., *Hygrocybe miniata, H. psittacina, Hygrophorus olivaceoalbus, Russula aquosa* and *R. xerampelina* were made at Ainijärvi. This selection indicates a higher moisture of soil, as does the presence of *Nephroma arcticum* and *Peltigera aphthosa* and scattered *Hylocomium splendens.* In turn several species chracteristic of very dry sites, e.g. *Coniophora fusispora, Junghuhnia luteoalba, Phellinus viticola, Pholiota heteroclita* and *Skeletocutis stellae,* were found only at Raja-Jooseppi. The same was true for Naruska, which was the only site for *Inocybe leptophylla, I. mixtilioides* and *Trechispora farinacea.*

There were on an average 69 species at each site in the years 1991–1994 inclusive, but annually only 29 (range 10–40). This shows once again, that several years are required for proper monitoring of fungal species.

Several of the species are poorly known in Finland, and are described in some detail below.

Tricholomataceae

L.decastes and *L. fumosum* were distinguished mainly on the basis of growth habit and the coloration of the cap cuticula. *L. fumosum* grew mainly solitary and *L. decastes* was usually fasciculate. Cap cuticula were of greyish or brown shade, respectively. *L. decastes* tended to be much more robust. No differences were found in spore size or shape.

Ripartites sp. Sporocarps were produced at one site, Aska. Decomposing litter, amongst *Dicranum* and *Pleurozium schreberi.* This taxon appears to be undescribed. It resembles *R. tricholoma* but is more robust and its spores are smaller, 2–3.3 µm, almost globose, echinulate. It favours drier sites than *R. tricholoma.*

T. auratum coll. produced sporocarps at eight sites, characterized by open ground due to reindeer grazing. Ground vegetation is dominated by mosaic *Cladonia* and *Dicranum* vegetation except at a few sites where *Pleurozium* dominates. *T. auratum* may include two different taxa, both mycorrhizal with pine.

Cortinarius subgenus *Telamonia*

C. adalberti is widely ditributed but uncommon in pine forests of Lapland. In Continental Europe *C. adalberti* is mycorrhizal with spruce (Arnold 1993), but in the present study it was associated with pine. Cap is 1–4 cm, hygrophanous, convex, pale clay brown to dark brown. Gills distinctly paler than cap. Stem 3–7 x 0.2–0.5 cm, light brown, finely fibrillose, base often pure white. Veil white. Flesh cream white to light brown. Spores (5.7)–7.2–(8.0) x (3.6)–4.4–(5.0) µm, Q=1.64, reddish brown, warted, ellipsoid ([n] = spores measured from 11 sporocarps). In some cases the spores were subglobose or broadly ellipsoid. Whether the sporocarps belong to another species cannot be decided in the present study. The characters fit well with those provided in Brandrud (1992) and Arnold (1993). *C. adalberti* is similar to *C. abietinus* and *C. lux-nymphae*, but the paler colour of gills than that of caps in *C. adalberti* seems to be a good distinguishing feature. The spores of *C. adalberti* are larger than those of *C. abietinus* or *C. lux-nymphae*.

C. armeniacus is one of the characteristic species of pine forests in Lapland. *C. armeniacus* is considered mycorrhizal with spruce and pine in Continental Europe (Arnold 1993); in the present study it was clearly associated with pine, but spruce cannot be excluded. Cap 2–7 cm, hygrophanous, convex, apricot to reddish brown. Gills ochre brown when young, later darker. Stem 3–8 x 0.5–1.5 cm, usually bulbous and not girdled, silky whitish when young, later becomes apricot brown, especially late in the season. Veil white. Flesh very light brown. Spores (7.0)–7.5–(9.0) x (4.0)–4.7–(7.8) µm, Q=1.6, usually reddish brown, slightly warted, ellipsoid (n=18). The characters fit well with those provided in Brandrud (1992) and Arnold (1993), but spores are slightly smaller, 8–10 x 5–6 µm on average. There was another *C. armeniacus*-like, small-spored (6.5 x 4.2 µm) taxon at Raja-Jooseppi and Tennilä, which had *Myxacium*-like cap.

C. biformis is one of the characteristic and most common species of pine forests in Lapland. In the present study it was mycorrhizal with pine. Cap is 2–6 cm, hygrophanous, grey brown to reddish brown. Stem 5–8 x 0.7–1.5 cm, white, usually slightly fibrillose, especially apex bluish. Veil sparse. Gills reddish brown when young. Flesh greyish to beige, when young with a violet coloration, without distinct taste or smell. Spores (6.2)–7.6–(9.2) x (4.3)–4.9–(5.5) µm, Q=1.6, usually reddish brown, warted, ellipsoid to broadly ellipsoid (n=50). The characters are in accordance with those provided by Soop (1990). This species is also typical in spruce forest (Soop 1990, Brandrud et al. 1994). Later Soop (1994) described var. *robustior* ined., a pine forest taxon. When dry or older, *C. biformis* looks like dirty *C. armeniaceus. C. tortuosus* (Fr.:Fr.) Fr., *C. triformis* Fr. ss. Moser and *C. privignoides* Henry are also very closely related and not distinguished in the present study. To conclude, what is now called *C. biformis* is perhaps heterogeneous, and requires further study.

C. cf. *incisus* produced sporocarps at six sites. It was mycorrhizal with pine in the present study, as it is in Continental Europe (Arnold 1993). Widely distributed but occasional. Since this taxon was not noted in the field, fresh characters are lacking. Cap is 1–3 cm. Stem 2–4 ¥ 0.2–0.4 cm. Spores (7.5)–8.3–(9.2) x (2.8)–3.8–(4.0) µm, Q=2.2, usually light brown, not distinctly warted, narrowly ellipsoid (n=5). Some other species with "boletoid" spores cannot be excluded for moment, viz. *C. fusisporus* Kühn., *C. heterosporus* Bres. and *C. semivestitus* Mos. All are mycorrhizal with pine (Arnold 1993). The present taxon more closely resembles *C. fusisporus* than *C. incisus* of Arnold (1993). *C. fusisporus* (Arnold 1993) and *C. incisus* (Brandrud 1992) seem to be very similar, however. Spores of *C. heterosporus* seem not to be identical with the present taxon, and spores of *C. semivestitus* are bigger (9–11 x 4–4.5 µm) (Arnold 1993). The taxon also resembled *C. lux-nymphae*.

C. cf. *laetus* produced sporocarps at one site, Muonio. Cap is 1.5 cm, dry, milk brown. Stem 3 x 0.2 cm, concolorous with the cap. Velum brown, sparse. Spores (7.2)–8.2–(9.2) x (4.0)–5.4–(4.0) µm, Q=1.52, brown, warted, ellipsoid (n=1).

C. lux-nymphae (Fig. 3) is one of the characteristic species of lichen-rich pine forests in southern Lapland. It was especially abundant at Tennilä. Cap is 1–4 cm, hygrophanous, convex to plane, pale brown (when dry) to dark brown (when moist), scaly especially when young, as in *C. paleaceus*. Gills brown to dark brown. Stem 1–2 x 0.2–0.4 cm, light brown to brown. Veil white. Flesh light brown to ochre when dry. Spores (5.4)–6.3–(7.0) x (2.9)–3.4–(4.1) µm, Q=1.88, usually very light brown, almost smooth, narrowly ellipsoid to ellipsoid (n=42). The characters fit well with those provided by Brandrud et al. (1994). A small *Telamonia* not reported in Finland before, very common in northern oligotrophic pine forests. A characteristic feature facilitating identification is the small and narrow spores. A closely related *C. abietinus* is mycorrhizal with spruce in Continental Europe (Arnold 1993).

C. odhinnii is one of the characteristic species of pine forests in Lapland. Mycorrhizal with pine in the present study. Cap is 1–4 cm, campanulate to convex, when fresh bright brown to orange brown, darkening when dry or dried. Gills paler than cap. Stem 4–8 x 0.4–0.8 cm, first white, but turns to golden yellow and yellowish brown. Veil white. Flesh yellowish to yellowish brown. Spores (6.2)–7.5–(9.5) x (3.2)–4.2–(5.4) µm, Q=1.79, usually reddish brown, slightly warted, ellipsoid (n=56). These characters fit fairly well with those provided by Brandrud et al. (1992), although variation in spore size is greater. It was sometimes difficult to judge between dried *C. lux-nymphae* and *C. odhinnii*, if not supported by field notes.

Fig. 3. *Cortinarius lux-nymphae*, mature sprocarps after rain (14.8.1993, Keminmaa).

C. paragaudis subsp. *paragaudis* resembled *C. armillatus*, and is regarded as rare in Finland (Brandrud 1992). In northern Finland it is widespread and not rare, however. At some sites it occurred each year. Spores (5.4)–6.7–(8.0) x (4.4)–5.3–(5.6) µm, Q=1.26, light brown to brown, and slightly warted to warted, broadly ellipsoid to subglobose (n=15). These characters fit well the descriptions in Brandrud et al. (1992) and Arnold (1993).

Cortinarius subgenus *Phlegmacium*

C. leucophanes is a characteristic species of dry pine forests in Lapland. Cap is 3–6 cm, viscid, not hygrophanous, milk brown to ivory white. Stem 4–7 x 0.5–0.9 cm, white and fibrillose when young, brown yellow when older. Velum white, abundant. Gills crowded, bright brown. Flesh white to brownish, without distinctive taste or smell. Spores (5.0)–5.7–(6.0) x (3.1)–3.4–(4.0) µm, Q=1.67, usually light brown, not distinctly warted, ellipsoid (n=20). The characters accord perfectly with those provided by Soop (1991). A recognizable species growing in most oligotrophic lichen heaths.

Cortinarius subgenus *Sericeocybe*

C. ochrophyllus is mycorrhizal with birch, as suggested by Moser (1983). *C. ochrophyllus* resembles *C. anomalus* (Soop 1986), but its gills are yellow brown, while those of *C. anomalus* are greyish brown with a violet shade. Cap of *C. ochrophyllus* cap remains milk brown, relatively bright ochraceous brown to greyish brown, stem is white, often with remnants of veil. Both the cap and stem are fibrillose. An olive shade appears in the light brown bottom colour of the dry cap and stem. Spores (6.2)–6.8–(8.7) x (4.3)–5.1–(6.2) µm, Q=1.33, usually reddish brown and distinctly warted, broadly ellipsoid to subglobose (n=7). The spore size is somewhat smaller than Moser (1983) reported. One collection (Kirakkajärvi) had smaller spores (not included in above), (4.7)–5.6–(6.2) x (3.9)–4.1–(4.8) µm, and the stem was whiter and fibrillose.

C. querciticus was mycorrhizal with pine in the present study. Very local, but produced sporocarps each year at one site, Lokka. Cap is 4–10 cm, dry, brownish with violet shade, silky fibrillose. Stem is 1.5–2.5 cm, bulbous, white fibrillose with strong violet coloration especially when young. Gills crowded. Flesh violet. Spores (7.0)–7.9–(8.3) x (4.3)–4.9–(5.8) µm, Q=1.61, usually brown, distinctly warted and ellipsoid (n=7). These characters fit well with descriptions in Soop (1993ab, as *C. pseudomalachius* Reumaux) and Brandrud et al. (1994).

Cortinarius sp. sporocarps were produced at two sites in 1992. This taxon was mycorrhizal with pine. Cap is 2–4 cm, dry. When dried, showing an olive shade in both stem and cap. Spores (6.5)–7.4–(9.1) x (4.1)–4.5–(5.4) µm, Q=1.64, brown, warted, ellipsoid (n=5).

Cortinarius subgenus *Leprocybe*

C. raphanoides is one of the characteristic species of pine forests with birch as undergrowth, and *C. raphanoides* clearly was mycorrhizal with birch. The yield was highest at sites with mosses dominating the ground vegetation (especially Kemijärvi). Cap is 1.5–6 cm, hygrophanous, surface silky, smooth, greyish brown to olive brown. In a few cases the coloration of cap was lighter, as Høiland (1980) has noted. Stem 5–8 x 0.7–1.0 cm, pale, usually slightly fibrillose, especially apex bluish. Veil grey brown. Gills olivaceous, with a cinnamon shade sometimes. At one site, Kemijärvi, it formed a fairy ring. Spores (7.0)–7.9–(8.0) x (4.0)–4.8–(5.0) µm, Q=1.65, ellipsoid, warted (n=10). Spore size is somewhat smaller than that reported by Moser (1983), but agrees with that reported by Høiland (1980).

Hebeloma

H. birrus produced sporocarps only at Muonio, where the soil is silty and the ground vegetation dominated by *Pleurozium schreberi*, *Dicranum fuscescens* and *D. polysetum*. Mycorrhizal with pine in the present study. Sect. Scabrispora or Birri (Vesterholt 1994, in. let.). Macroscopic details are presented in Vesterholt (1994). Spores were amygdaloid to ellipsoid, rugose, brown (7.7)–8.6–(9.2) x (4.6)–5.3–(6.2) µm, and cheilocystidia were short and cylindrical (n=1), in agreement with Vesterholt's description (1994). A poorly known species in Finland, but it seems to be fairly common in southern Sweden (Stridvall & Stridvall 1994), in moist places and at burnt-over ground. In Denmark it is fairly rare (Vesterholt 1994).

H. bryogenes (Fig. 4) produced sporocarps at three sites, which were dominated by *Pleurozium schreberi*, *Dicranum fuscescens* and *D. polysetum*. Mycorrhizal at least with pine. Sect. Denudata. Macroscopic details are presented in Vesterholt (1994). Spores slightly rugose, amygdaloid, brown (9.2)–10.1–(11.5) x (5.0)–5.8–(6.2) µm (n=5). Cheilocystidia cylindrical, narrow (4–6.5 µm) and long, up to 80 µm (n=5). These characters agree with that presented in Vesterholt (1993). It has been reported to be mycorrhizal with pine and spruce, especially at moist sites, e.g. amongst *Sphagnum* (Vesterholt 1993). Very common in Scandinavia (Vesterholt 1993, Stridvall & Stridvall 1994).

Both *H. bryogenes* and *H. leucosarx* were earlier named as *H. longicaudum*. *H. longicaudum* is considered a nomen dubium, however (Vesterholt 1993), and thus replaced by *H. leucosarx* (Vesterholt 1992). Both have been also confused with *H. crustuliniforme* (Bull.) Quél. *H. bryogenes* is widely distributed in mossy pine forests of northern Finland.

H. leucosarx produced sporocarps at five sites, which were dominated by *Pleurozium schreberi*. May be mycorrhizal with spruce, pine or birch. Birch and spruce occurred at three sites and pine at all five. Sect. Denudata. Macroscopic details are presented in Vesterholt (1992). Spores rugose, amygdaloid, brown (9.2)–10.2–(11.0) x (5.4)–6.3–(7.0) µm, cheilocystidia cylindric, 7–9 µm broad (n=8). These characters fit well with those presented in Vesterholt (1992, 1993). Microscopically *H. leucosarx* can be distinguished from *H. bryogenes* by broader cheilocystidia (Vesterholt 1993). *H. leucosarx* is common in Denmark (Vesterholt 1992) and southern Sweden (Stridvall & Stridvall 1994) and is widely distributed in mossy pine forests of northern Finland.

Hebeloma sp. Spores rugose, amygdaloid, light brown (11)–11.9–(13.0) x (6.2)–6.5–(7.0), cheilocystidia 7 µm broad (n=1). Resembles *H. leucosarx*.

Inocybe

Inocybe is fairly poorly known in oligotrophic pine forests in northern Finland, and only one of the species recognized here was included in the key to Nordic Macromycetes (Printz 1992). Macro- and microscopic details are provided in Vauras (1992).

I. jacobi produced sporocarps at one site, Muonio. Like *H. birrus*, it prefers silty soil (Vauras 1992). Evidently mycorrhizal with pine. Other species in the section prefer moist deciduous or spruce forests (Vauras 1992).

I. lacera produced sporocarps at three sites, which were dominated by various *Cladonia* species. Var. *heterosperma* grew in Ainijärvi together with var. *lacera*. Mycorrhizal with pine.

I. leptophylla produced sporocarps at two sites. In 1993 *I. leptophylla* was especially abundant at Naruska Both sites were dominated by various *Cladonia* species. Mycorrhizal with pine.

I. mixtiloides produced sporocarps at one site, Naruska, which is dominated by *Cladonia* spp. and *Dicranum fuscescens*. Mycorrhizal with pine.

I. soluta produced sporocarps at nine sites, which were dominated by various *Cladonia* species. Mycorrhizal with pine. Mostly occasional, but occurred each year at three sites. The most common *Inocybe* in the present study. Vauras (1992) considers *I. lacera* to be the most common *Inocybe* on the dry sandy soils of Finland (Vauras 1992), but also *I. subcarpta* was more common than *I. lacera* in the present study.

I. subcarpta produced sporocarps at four sites. The sporocarp yield was highest at the sites dominated by mosses, especially in Kemijärvi. Mycorrhizal with pine. In Nordic Macromycetes (Printz 1992) this species is presented as *I. boltonii*, but the valid name is *I. subcarpta* (Vauras 1992).

Russula

R. sp. in sectio *Russula* is an undescribed species resembling *R. emetica* but more common than it in northern Finland (J. Ruotsalainen, pers. comm.). It produced sporocarps at four sites, all of them characterized by mosaic lichen and moss vegetation. It is much more common than *R. emetica* in Finland (J. Ruotsalainen, pers. comm.). Mycorrhizal host is pine or birch or both. Spruce occurred at two sites.

Fig. 4. *Hebeloma bryogenes* (11.9.1993, Keminmaa).

The yield

The sporocarp yield varied markedly from one year to the next. The best season was 1993 with 9685 g dw ha^{-1}, and the poorest 1994 with 1115 g dw ha^{-1} (Table 3). The summer of 1994 was very dry in most parts of northern Finland, and perhaps this influenced the yield. Other years were fairly similar in temperature and rainfall. The annual yield was 4600 g dw ha^{-1} on average, and the range 40–18180 g dw ha^{-1}. Since the sporocarps were collected only once or twice, the total yield is certainly underestimated. On the basis of Paulus (1995), who followed the yield in northern Lapland for a longer period in 1992 and 1993 we estimate that yield in our study covers 75–80% of the total yield. The proportion may be lower in the southern than northern parts of our study area.

Not all species were abundant in 1993 (Table 3). The maximum yield in this year was mainly due to the four most common species – *Lactarius rufus* (2495 g dw $ha^{-1)}$, *Russula decolorans* (1095 g dw $ha^{-1)}$, *R. paludosa* (785 g dw $ha^{-1)}$, and *Suillus variegatus* (3080 g dw $ha^{-1)}$ – which were responsible for 75% of the total yield (Table 3). The proportion of mycorrhizal fungi was 97.6% of the total yield (93.7–98.4%). The yield was of the same magnitude as in earlier studies carried out in oligotrophic dryish pine forests of northern Fennoscandia (Ohenoja & Koistinen 1984, Mehus 1986, Ohenoja 1993), which further supports our contention, that the yield we observed covers most of the total yield. The species reported in these earlier studies were mostly the same as in our study, and as regards pine forests the yield was highest in dryish mossy sites. The total yield in oligotrophic dry pine forests over 40 years of age in the province of Lapland was estimated to be 13 million kg dw (about 130 million kg fw). An earlier estimate with all forest types included is close to this: 300 million kg fw (Kujala et al. 1987).

Agaricales, Boletales and Russulales dominated the yield. Agaricales was dominated by Cortinariaceae and Boletales by Gomphidiaceae. Four genera produced 85% of the fungal yield; *Cortinarius* accounted for 20%, *Lactarius* for 26%, *Russula* for 15% and *Suillus* for 27%. The two most productive species, *Lactarius rufus* and *Suillus variegatus*, accounted for 50% of the yield (Tables 3 and 5). *Cortinarius biformis*, *C. brunneus* and *C. semisanguineus* were the most productive species in the genus *Cortinarius* and *R. decolorans* and *R. paludosa* in *Russula*.

The yield was highest at the two southernmost study sites, which are located in the middle boreal zone (Fig. 1). The yield was lowest in eastern Lapland. The differences were also related to quality of vegetation, the yield being lower at dry lichen-rich sites than at mossy sites. These and other ecological aspects will be discussed in forthcoming articles.

Edible species

Species which are commonly consumed in Finland (for example edible *Cortinarius* were excluded) and which are of relevant size, were considered as edible fungi. The average annual yield of edible species was 3160 g dw ha^{-1}, nearly 70% of the measured total yield (Table 5). Between 1976 and 1978 the proportion was calculated to be 68% (Ohenoja & Koistinen 1984), with the edible species mostly the same as in the present study. Only one edible decomposer, *Hypholoma capnoides*, produced notable yields in the present study. Its average annual yield was 23 g dw ha^{-1}. In all, 27 edible mycorrhizal species produced sporocarps, but the annual yield was over 10 g dw ha^{-1} for only 12 of these. Other species may be locally of some value at certain years, however. *Lactarius rufus* produced 35% of the total edible yield, *Suillus variegatus* 38% and four species of the genus *Russula* 21%. As regards commercial picking of fungi in northern Finland, only *L. rufus*, *R. decolorans*, *R. paludosa*, *R. vinosa* and *S. variegatus* can be regarded as of any importance. Edible fungi and their yields are listed in Table 5.

Table 5. The most common edible fungal species, their mean annual yield (g dw ha^{-1}), their proportion of the edible species and of all species in 1991–1994, estimate in oligotrophic pine forests over 40 years old in the province of Lapland. Only species with average annual yield over 10 g dw ha^{-1} are included.

Species	mean g dw ha^{-1}	proportion of edible	proportion of total	Lapland total kg dw
Hypholoma capnoides	23	0.8	0.5	63 700
Lactarius mammosus	24	0.8	0.5	66 500
L. rufus	1100	34.5	23.9	3 046 700
Leccinum scabrum	17	0.6	0.4	47 100
L. versipelle	31	1.1	0.7	85 900
L. vulpinum	17	0.6	0.4	47 100
Russula claroflava	12	0.5	0.3	33 200
R. decolorans	340	10.7	7.4	941 700
R. paludosa	250	7.9	5.4	692 400
R. vinosa	73	2.4	1.6	202 200
Suillus bovinus	62	2.0	1.3	171 700
S. variegatus	1200	37.6	26.1	3 323 700
Tricholoma auratum	14	0.5	0.3	38 800
Total	3163	100.0	68.8	8 760 700

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