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Macromycetes in communities of *Abies alba* on its range border in Central Poland

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The paper presents results of mycocoenological examinations conducted in four nature reserves with *Abies alba* in Central Poland (Lubiaszów, Kruszewiec, Łaznów and Gałków) in 1997-1999. A list of 288 fungi accompanying silver fir communities close to the northern limit of the occurrence of the species, including 38 species identified in associations with *Abies alba* in Poland for the first time, is given. Statistical analysis has shown that a relationship exists between macromycete diversity, tree stand structure and plant communities such as *Tilio-Carpinetum*, *Luzulo pilosae-Fagetum*, *Pino-Quercetum abietetosum*.

Key words: macromycetes, *Abies alba*, *Tilio-Carpinetum*, *Luzulo pilosae-Fagetum*, *Pino-Quercetum abietetosum*

INTRODUCTION

The silver fir, *Abies alba* Mill., is a mountain, lower subalpine forest species. Its localities are particularly noteworthy along its northern range limit in Central Poland, where the examinations were conducted, as it descends there the farthest into lowlands within its entire occurrence area. The tree stands investigated are situated from 174 to 220 m above sea level. *Abies alba* remains alive in the area on deep, fresh and damp soils, formed on the dispersed young rocks: clays and sands left by the Scandinavian glacier in the Quaternary period (Baliński 1996). In such edaphic conditions, the silver fir forms a flat rooting system that poorly protects it from windfalls and makes it susceptible to pathogenic invasion.

Abies alba has been an object of research interest for a long time. More than 800 publications on the species have appeared only in Poland. Białobok's (1983) collective monograph is one of the most important studies, offering a chapter investigating relationships between the tree and mycorrhizal, saprotrophic as well as parasitic fungi (Wojewoda 1983). Observations of macromycetes in silver fir forests have so far been conducted mainly in the far range of this species (Jahn 1968; Krieglsteiner 1979; Mugnai and Capretti 1987; Perini et al. 1995; Bu-

jakiewicz 1979; Domański 1962, Domański et al. 1967; Gumińska 1966; Lisiewska 1979). The borderland, low-lying communities of *Abies alba* have been poorly investigated in this respect. While a significant contribution to the knowledge of fungi of fir-tree forests along their eastern border of coverage was provided by Sałata (1972, 1977, 1978), such studies have not been conducted in Central Poland, and only brief references to the occurrence of several species accompanying firs in this region can be found in literature (Ławrynowicz 1973, 1978; Kałucka 1995; Skirgiełło 1970).

Owing to insufficient knowledge of fungi accompanying silver firs in Central Poland, the aim of the present paper is to:

- provide a list of fungi accompanying *Abies alba* close to the northern limit of its occurrence in Central Poland,
- investigate the relationship between macromycete diversity, tree stand structure and plant communities.

STUDY AREA

Four nature reserves: Lubiaszów, Kruszewiec, Łaznów and Gałków (Fig. 1), were selected. The reserves were established to provide legal protection of the most precious clusters of *Abies alba* in the region, close to the northern limit of its range. The reserves are situated in the Pilica river basin.

According to the geobotanic division by Szafer (1977), the study area belongs to Kraina Północnych Wysoczyzn Brzeżnych, Okręg Łódzko-Piotrkowski. According to the geobotanic division by Matuszkiewicz (1993), Lubiaszów, Łaznów, and Gałków are situated in Kraina Wysoczyzn Łódzko-Wieluńskich belonging to Dział Wyżyn Południowopolskich. The Kruszewiec reserve, on the other hand, is situated in Kraina Południowomazowiecko-Podlaska, part of the Dział Mazowiecko-Poleski.

According to the physical regionalisation by Kondracki (1994), the Lubiaszów and Kruszewiec reserves are situated in the mezoregion of the Równina Piotrkowska plain, while the Gałków and Łaznów reserves are situated in the area of the Wzniesienia Łódzkie uplands. The Równina Piotrkowska plain and the Wzniesienia Łódzkie uplands belong to the macroregion of Wzniesienia Południowmazowieckie, part of the subprovince of Niziny Środkowopolskie lowlands.

The Lubiaszów reserve is situated in the western part of the Puszcza Pilicka forest, 12 km east of the town of Piotrków Trybunalski. Covering 6.5 ha in 1945 when it was established, the reserve now occupies ca. 226 ha (Baliński 1996). The following plant communities were identified in the reserve: *Potentillo albae-Quercetum*, *Circaeo-Alnetum* and *Tilio-Carpinetum* (Urbanek 1959). A permanent plot (L I) for mycological studies was established in a *Tilio-Carpinetum* where immature *Abies alba* trees grow under crowns of oaks, firs, and birches (Tab. 1). The second plot (L II) includes single examples of huge silver firs, oaks, and hornbeams. The shrub layer is reduced.

The Kruszewiec reserve is situated in the northern part of the Równina Piotrkowska plain, 5 km north of the town of Tomaszów Mazowiecki. Established in 1979, it currently covers over 81 ha. According to Olaczek and Kurzac (1991), only one plant association occurs in the entire reserve. It is *Tilio-Carpinetum*, diversified into two subassociations: *Tilio-Carpinetum stachyetosum silvaticae* and *Tilio-Carpinetum typicum*. Rutowicz and Sowa (1978) identified the former as *Tilio-Carpinetum*

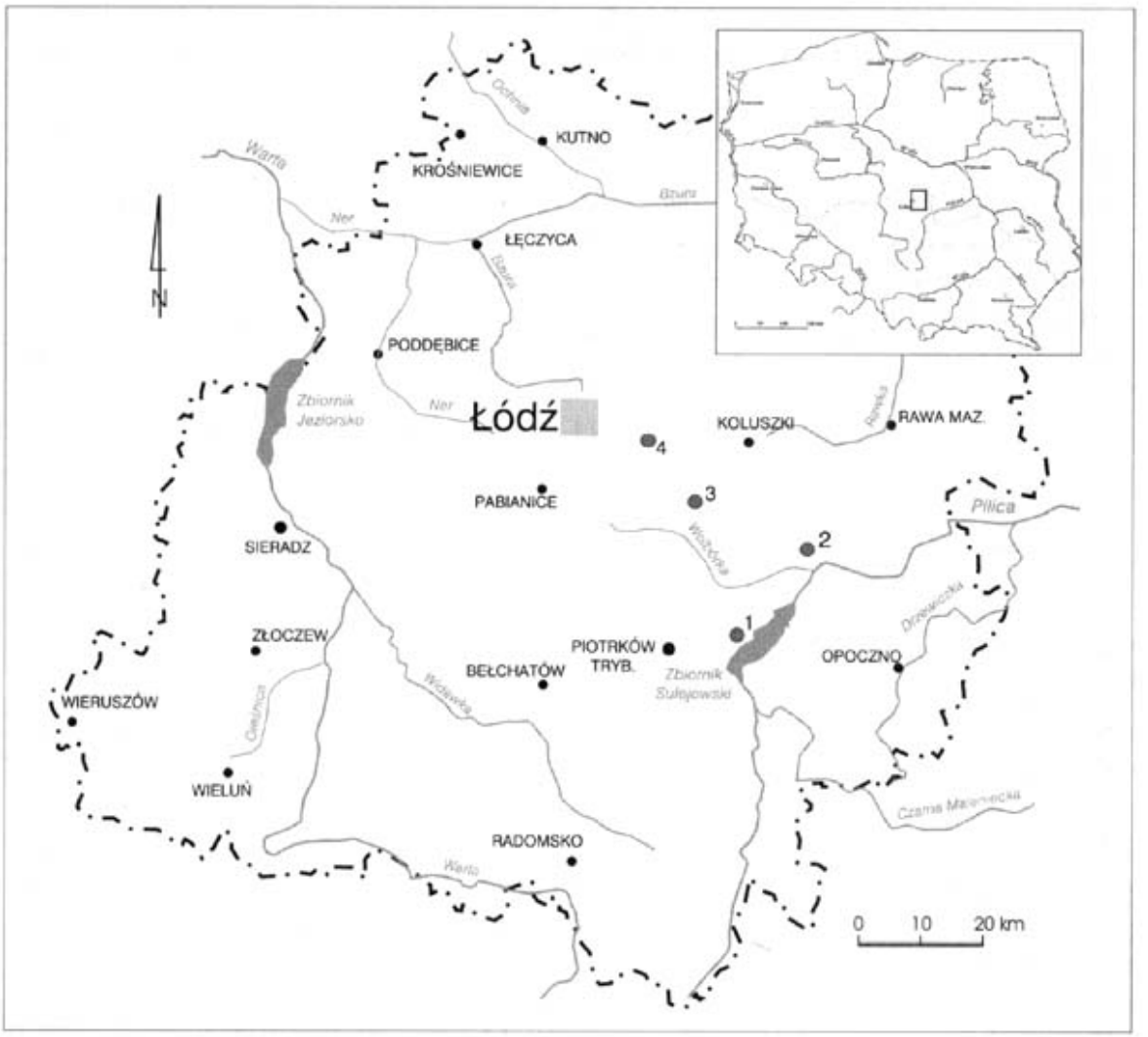

Fig. 1. Study area: 1 – reserve Lubiaszów (L), 2 – reserve Kruszewiec (K), 3 – reserve Łaznów (Ł), 4 – reserve Gałków (G).

abietetosum. Permanent plots are situated only in this association (Tab. 1). Plot one (K I) includes young sliver firs, 10-20 years' old, growing under crowns of oaks and hornbeams. Plot two (K II) was established in fir and hornbeam stands. Some of the *Abies alba* trees are over 160 years' old.

The Łaznów reserve is situated in the southern part of the Wzniesienia Łódzkie uplands, 8 km south–west of the town of Koluszki. It was established in 1979 together with the Kruszewiec reserve. There are four forest communities: *Tilio-Carpinetum abietetosum*, *Galio-Abietion*, *Pino-Quercetum abietetosum* and *Abies alba – Calamagrostis villosa* community (Jost-Jakubowska 1979). Permanent plots (Ł I and Ł II) are situated in *Pino-Quercetum abietetosum* [=*Querco-Pinetum*]. The second plot is characterised by an almost exclusive occurrence of the silver fir (Tab. 1).

The Gałków reserve is situated in the central part of the Wzniesienia Łódzkie uplands, 10 km east of the city of Łódź. It was established in 1958. In the 1960s, the participation of the silver fir in the tree stand was over 50%. The plant community in the reserve became at the time identified as *Galio-Abietion*, and its differences from *Fagetum carpaticum*, *Luzulo-Fagetum*, *Dentario enneaphylidis-Fagetum* were

Table 1
Floristic composition in the plots in the selected *Abies alba* reserves in Central Poland

Plot	L I	L II	K I	K II	Ł I	Ł II	G I	G II
Density of tree layer (%)	25	10	15	30	35	40	25	30
Density of shrub layer (%)	80	2	90	25	40	45	10	30
Cover of herb layer (%)	40	95	60	50	70	60	20	60
Cover of moss layer (%)	5	5	20	10	40	50	5	5
pH value in H_2O	4.4	3.7	3.7	4.3	3.7	3.8	4.1	3.9
Number of species	23	36	31	21	36	25	16	30
Tree layer								
Abies alba	2.2	2.1	1.1	2.2	2.2	2.2	1.1	2.1
Quercus robur	2.2	1.1	1.1	.	+.1	.	+.1	+.1
Carpinus betulus	.	1.1	1.1	1.1	.	.	.	+.1
Betula pendula	1.1	.	+.1	.	.	.	.	+.1
Fagus sylvatica	.	.	+.1	.	.	.	2.2	1.1
Tilia cordata	.	.	.	+.1	.	.	.	.
Populus tremula	.	.	.	+.1	.	.	.	.
Picea abies	.	.	.	.	1.1	+.1	.	.
Pinus sylvestris	.	.	.	.	1.1	.	+.1	+.1
Shrub layer								
Carpinus betulus	2.2	+.1	2.2	2.2	+.1	.	.	+.1
Abies alba	5.5	.	5.5	1.1	3.2	3.3	+.1	.
Sorbus aucuparia	1.1	.	2.1	.	.	1.1	.	3.3
Frangula alnus	+.1	.	+.1	.	+.1	1.1	.	.
Tilia cordata	+.1	.	.	1.1	.	.	.	.
Picea abies	.	.	+.1	+.1	.	+.1	.	.
Quercus robur	.	.	1.1	.	.	.	.	.
Fagus sylvatica	.	.	1.1	.	.	.	2.2	.
Betula pendula	.	.	+.1	.	2.1	.	.	.
Populus tremula	.	.	+.1	.	+.1	.	.	.
Pinus sylvestris	.	.	+.1	.	.	.	.	.
Herb layer								
Anemone nemorosa	1.3	3.3	2.4	4.5	+.2	.	2.3	3.4
Maianthemum bifolium	2.3	1.2	2.3	1.2	2.2	1.2	3.4	2.3
Milium effusum	2.2	2.3	2.2	1.2	+.2	+.2	+.2	1.2
Carpinus betulus	2.1	1.1	2.1	+.1	.	.	.	+.1
Abies alba	1.1	+.1	+.1	+.1	+.1	+.1	+.1	+.1
Sorbus aucuparia	1.1	+.1	+.1	.	1.1	1.1	+.1	.
Quercus robur	+.1	+.1	+.1	.	+.1	+.1	.	+.1
Oxalis acetosella	2.3	2.2	.	1.2	3.4	3.4	+.2	1.2
Tilia cordata	+.1	+.1	.	+.1	.	.	.	.
Carex sylvatica	+.2	.	+.2	+.2	.	.	.	.
Stellaria holostea	.	1.2	1.2	+.2	.	+.2	.	+.2
Moehringia trinervia	.	+.1	+.2	+.2	.	.	.	+.2
Populus tremula	.	+.1	+.1	+.1	.	.	.	.
Athyrium filix-femina	+.1	+.1	.	.	+.1	.	+.1	+.1

Galeobdolon luteum	+.2	1.2	.	.	+.1	1.1	.	1.2
Trientalis europaea	1.1	.	+.1	.	1.2	1.2	.	.
Vaccinium myrtillus	1.1	.	1.2	.	2.3	2.2	.	2.2
Gymnocarpium dryopteris	+.1	.	.	+.1	.	+.1	.	.
Juncus effusus	.	+.1	1.2	.	+.2	.	.	+.2
Betula pendula	.	+.1	+.1	.	+.1	+.1	.	+.1
Rubus sp.	.	1.1	.	+.1	1.1	1.1	+.1	+.1
Carex remota	.	1.2	.	+.2	.	.	.	.
Viola reichenbachiana	.	+.1	.	1.2	.	.	.	+.2
Dryopteris carthusiana	.	1.2	.	+.1	.	.	.	.
Luzula pilosa	.	.	1.2	+.2	1.2	1.2	1.2	1.2
Equisetum sylvaticum	.	.	+.1	+.1	.	.	.	.
Fagus sylvatica	.	.	+.1	+.1	.	.	1.1	+.1
Thelypteris palustris	+.1	.	.	.	.	.	+.2	+.1
Impatiens noli-tangere	.	2.3	.	.	.	.	.	.
Urtica dioica	.	1.1	.	.	+.1	.	.	.
Polygonatum odoratum	.	1.1	.	.	.	.	.	.
Paris quadrifolia	.	1.1	.	.	.	.	.	.
Galium odoratum	.	+.2	.	.	.	.	.	.
Adoxa moschatellina	.	+.2	.	.	.	.	.	.
Lathyrus vernus	.	+.1	.	.	.	.	.	.
Ranunculus lanuginosus	.	+.1	.	.	.	.	.	.
Aegopodium podagraria	.	+.1	.	.	.	.	.	.
Euonymus europaeus	.	+.1	.	.	.	.	.	.
Stachys sylvatica	.	+.1	.	.	.	.	.	.
Hepatica nobilis	.	+.1	.	.	.	.	.	.
Rumex obtusifolius	.	+.1	.	.	+.2	.	.	.
Carex nigra	.	.	+.2	.	.	.	.	.
Convalaria majalis	.	.	+.2	.	.	.	.	.
Salix sp.	.	.	+.1	.	.	.	.	.
Ajuga reptans	.	.	.	+.2	.	.	.	.
Poa nemoralis	.	.	.	+.2	.	.	.	+.2
Mycelis muralis	.	.	.	.	2.1	+.1	.	.
Lysimachia vulgaris	.	.	.	.	+.1	+.1	.	.
Dryopteris dilatata	.	.	.	.	+.1	1.1	.	.
Frangula alnus	.	.	.	.	+.1	+.1	.	+.1
Rumex acetosella	.	.	.	.	+.2	.	.	.
Anthoxantum odoratum	.	.	.	.	1.3	.	.	.
Poa pratensis	.	.	.	.	1.4	.	.	.
Fragaria vesca	.	.	.	.	+.1	.	.	.
Sambucus racemosa	.	.	.	.	+.1	+.1	+.1	+.1
Acer pseudoplatanus	.	.	.	.	+.1	.	.	.
Pinus sylvestris	.	.	.	.	+.1	.	.	.
Acer platanoides	.	.	.	.	.	.	.	+.1
Moss layer								
Polytrichum formosum	1.3	.	+.2	+.2	+.2	1.2	+.2	+.2

Tab. 1 cont.

			1	2	3	4	5	6	7	8
Plagiomnium affine	+.1	+.2	.	.	+.2		+.2	.		.
Herzogiella seligeri	+.1	+.1	.	.	.		.	.		.
Atrichum undulatum	.	.	+.2	+.2	.		.	.		+.2
Dicranella heteromala	.	.	+.2	+.2	+.2		.	.		.
Mnium sp.	.	.	+.2	+.2	.		.	.		.
Hypnum cupressiforme	+.2	.	.	.	.		.	+.2		+.2
Brachythecium salebrosum	+.2	.	.	.	.		.	.		+.2
Tetraphis pellucida	.	+.2	.	.	.		.	.		.
Sphagnum squarrosum	.	.	1.2	.	.		.	.		.
Pohlia nutans	.	.	+.2	.	+.2		+.2	.		.
Plagiothecium sp.	.	.	+.2	.	.		+.2	.		.
Thuidium sp.	.	.	.	.	+.2		.	.		.
Leucobrium glaucum	.	.	.	.	.		+.2	.		.
Orthodicranum montanum	.	.	.	.	.		.	.		+.2

underlined (Sowa and Olaczek 1971). At present, *Fagus sylvatica* prevails in the reserve, and phytosociological observations are suggestive of a presumptive formation of *Luzulo pilosae-Fagetum*. One permanent plot (G I) was established in such a community (Tab. 1). The second permanent plot (G II) is situated in a beech forest becoming a mixed fir and deciduous forest, near the border of the reserve.

MATERIAL AND METHODS

The studies were carried out in permanent plots, 1000 m^2 each, (according to Arnolds 1981), divided into 10 subplots. In each reserve, two plots were established in tree stands whose species composition and age structure differed. Carpophores of macromycetes were observed and collected on the average once a month in three vegetation seasons, from 1997 to 1999. Collected fruitbodies were identified using keys (e.g. Breitenbach and Kränzlin 1984-1995; Gumińska 1997; Jülich 1984; Lisiewska 1987; Ławrynowicz 1988; Moser 1978; Nespiak 1990; Skirgiełło 1991) that follow methods of the preparation of fungi and chemical reagents generally accepted in mycology. Records are deposited in the Herbarium Universitatis Lodzensis. Collected carpophores were classified in 3 trophic groups: mycorrhizal, saprotrophic, and parasitic, as well as 3 habitable groups: terrestrial, litter-inhabiting, and lignicolous. It was opted for the detailed presentation of the results in tables. The amount of collected fruitbodies has been also included into it (Tabs 2-4). Those data has been used for statistical analyses of the results. Statistical analyses were performed using *Statistica for Windows* (Statsoft 1999). In order to show a possible relationship between the number of produced fruitbodies and the selected environmental factors, nonparametric correlation Gamma was used.

It has been assumed that the fungi acknowledged as mycorrhizal (Michael, Hennig and Kreisel 1988) which have produced carpophores on plots with exclusive occurence of the silver fir are exactly connected with that species of trees. As far as saprotrophs are concerned a substratum they had risen on was analysed

very precisely. In the tables 2-4 fungi accompanying silver fir were marked with an asterisk.

A floristic lists of species with their degrees of cover on permanent plots expressed in the Braun-Blaquet scale were drawn up in June 1999 (Tab. 1).

RESULTS

Most macromycete species were recorded in Kruszewiec I (120) and Lubiaszów I (117), set up in a *Tilio-Carpinetum* association with young sliver firs growing under crowns of oaks. An almost complete concetration of tree crowns keeps sufficient, permanent humidity of soil and litter in these plots. A great diversity of microhabitats, i.e. coniferous and decidious litter, clusters of mosses, lying twigs and branches, logs and stumps of coniferous and decidious trees, is conducive to the developement of many fungal species. The smallest number of species was recorded in *Luzulo pilosae-Fagetum* (Gałków I – 61 species) and *Pino-Quercetum abietetosum* (Łaznów II – 69 species). The litter and the undergrowth in these plots are weakly differentiated; there is also lying wood. The tree stand is also less diversified.

The greatest number of mycorrhizal species occured in Kruszewiec I (and II) and Lubiaszów I, the smallest – in Gałków I and Łaznów II (Tab. 2). The results of statistical analyses have shown that the number of mycorrhizal species correlates with the number of tree species growing over specific subplots ($r_\gamma = 0.64$, $p \ll 0.0001$), and the number of fruitbodies correlates with number of trees ($r_\gamma = 0.44$, $p \ll 0.0001$). The number of carpophores found in localities of young fir-trees was 1.4 to 13.3 times greater than that in the other plots. These findings bear out the results of studies by Termoshuizen (1991), who has shown that the occurrence of fruitbodies in plots with young pines was 3.5 – 27 times as high as that in plots overgrown by old tree stands. Differences in the abundance of the carpophore formation between plots with young and old trees are connected with a smaller condensation of roots in older tree stands. In this respect, Kruszewiec I (38 mycorrhizal species; 1702 carpophores) and Lubiaszów I are the richest (34 mycorrhizal species; 1723 carpophores), while plot II in the Łaznów reserve is the poorest (Ł II - 21 mycorrhizal species; 503 carpophores). No parasitic species were recorded in this plot.

A total number of 287 macromycete species was identified in all the permanent plots. Saprotrophs were the most numerous group (203), and lignicolous fungi (120) prevailed over terricolous and litter-decomposing fungi (altogether 82). Mycorrhizal fungi were represented by 80 species. Eight collected species were parasitic. Carpophores collected from three of them (*Fomes fomentarius*, *Trametes versicolor*, *Phellinus hartigii*) were found more often on a dead substrate. 131 species (87 saprotrophs, 42 mycorrhizal species, 2 parasites) were directly associated with *Abies alba*. Mycorrhizal species such as *Laccaria laccata*, *L. amethystina*, *Lactarius mitissimus*, *L. camphoratus*, *Russula ochroleuca*, *R. livescens*, *Xerocomus badius*, and *Amanita rubescens* occurred commonly in all the reserves studied (Tab. 2). They are widespread symbionts not only of firs but also of other conifers, as well as deciduous trees in some cases (e.g. *R. ochroleuca*, *L. amethystina*). Species not recorded under firs in Poland so far are especially worth mentioning. These are: *Amanita citrina*, *Xerocomus subtomentosus*, *Dermocybe cinnamomeolutea*, *Russula olivascens*, *R. nauseosa*, *Laccaria amethystina*, *L. laccata L. bicolor*, *Tomentella terrestris*, and *Hebeloma truncatum*.

Table 2
Fruitbodies of mycorrhizal fungi collected in permanent plots (1997-1999)
* - Fungi associated with the silver fir

Plot	*Tilio-Carpinetum*				*Pino-Quercetum*		*Luzulo-Fagetum*	
	L I	L II	K I	K II	Ł I	Ł II	G I	G II
Number of observations	18	18	18	18	18	18	18	18
Number of species	34	25	38	42	27	21	20	36
	1	2	3	4	5	6	7	8
**Lactarius mitissimus* Fr.	485	7	169	232	141	113	1	78
**Russula ochroleuca* (Pers.) Fr.	151	14	1	27	184	113	29	32
**Laccaria laccata* (Scop.: Fr.) Bk. et Br.	197	61	133	41	112	43	4	32
**Laccaria amethystina* (Bolt. ex Hooker) Murr.	252	5	148	267	11	.	39	122
**Lactarius camphoratus* (Bull.) Fr.	46	1	401	78	12	20	.	3
**Xerocomus badius* (Fr.) Kühn. ex Gilb.	13	.	1	1	7	33	1	7
Lactarius quietus Fr.	169	3	34	104	.	.	1	340
**Amanita rubescens* (Pers.: Fr.) Gray	5	.	10	1	.	1	2	4
**Thelephora terrestris* Ehr. ex Willd.: Fr.	.	256	52	95	279	28	.	91
**Russula livescens* (Batsch) Quèl. ss. Bres.	.	1	3	5	1	.	3	12
**Xerocomus chrysenteron* (Bull. ex St. Amans) Quèl.	.	14	.	11	10	26	2	19
**Lycoperdon nigrescens* (Pers.: Pers.) Lloyd	.	1	.	17	12	1	4	4
**Russula fragilis* (Pers.: Fr.) Fr.	45	5	52	21	.	.	.	14
**Cantharellus tubaeformis* Fr.	120	3	92	.	4	2	.	.
**Paxillus involutus* (Batsch) Fr.	16	5	.	27	9	1	.	.
Lycoperdon perlatum Pers.: Pers.	2	3	.	21	.	.	31	2
**Amanita citrina* (Schff.) S. F. Gray	9	.	10	11	6	.	.	8
**Inocybe lanuginosa* (Bull.: Fr.) Kumm.	4	.	3	.	9	.	1	112
Russula integra L.: Fr. ss. R. Mre.	.	2	2	2	.	.	1	20
**Lycoperdon umbrinum* Pers.: Pers.	.	1	.	11	3	.	5	5
**Russula emetica* Fr.	36	113	.	38	.	.	.	19
Cortinarius hemitrichus Fr.	45	.	148	79	.	.	.	16
**Tylopilus felleus* (Bull.: Fr.) P. Karst.	1	.	8	.	3	10	.	.
**Xerocomus subtomentosus* (L.: Fr.) Quèl.	.	1	.	.	18	11	.	7
Russula cyanoxantha Schff.: Fr.	.	.	.	8	2	.	4	5
**Amanita pantherina* (DC: Fr.) Secr.	.	.	.	.	8	6	6	2
Lycoperdon molle Pers.: Pers.	2	8	.	12	.	.	.	.
**Russula vesca* Fr.	1	1	.	.	.	.	.	8
Craterellus cornucopioides (L.) Pers.	40	.	171	1	.	.	.	.
**Hebeloma hiemale* Bres.	9	.	36	10	.	.	.	.
**Amanita fulva* (Schff.) Pers.	19	.	14	.	1	.	.	.
**Inocybe oblectabilis* Britz.	9	.	.	24	.	4	.	.
**Russula nigricans* (Bull.) Fr.	10	.	.	9	.	.	.	13
Russula violeipes Quèl.	1	.	.	3	.	.	5	.
**Tomentella terrestris* (Berk. et Br.) Larsen	.	5	.	.	27	.	.	10
**Dermocybe cinnamomeolutea* (Orton) Mos.	.	.	19	.	4	62	.	.
**Amanita porphyria* (A. et S.: Fr.) Secr.	.	.	1	.	7	.	.	1
**Russula queletii* Fr. in Quèl.	.	.	.	.	11	2	.	10
Boletus edulis Bull.: Fr.	3	.	1	.	.	.	.	.

Inocybe umbrina Bres.	3	.	.	25	.	.	.	.
Russula raoultii Quèl.	3	.	.	12	.	.	.	.
Lactarius vellereus (Fr.) Fr.	2	.	.	6	.	.	.	.
**Lactarius necator* (J. F. Gmel.: Fr.) Pers.	15	.	.	.	.	9	.	.
Russula fellea Fr.	1	.	.	.	.	.	11	.
Inocybe asterospora Quèl.	7	.	.	.	.	.	.	1
Inocybe napipes Lge.	1	.	.	.	.	.	.	4
Lactarius circellatus Fr.	.	16	115	.	.	.	.	.
**Russula puellaris* Fr.	.	3	.	.	7	.	.	.
Scleroderma areolatum Ehrenb.	.	61	.	.	.	.	.	1
Leccinum griseum (Quèl.) Sing.	.	.	5	5	.	.	.	.
**Dermocybe semisanguinea* (Fr.) Mos.	.	.	5	1	.	.	.	.
**Dermocybe cinnamomea* (L.: Fr.) Wünsche	.	.	24	.	.	2	.	.
Amanita spissa (Fr.) Kumm.	.	.	1	.	.	.	.	1
**Russula olivascens* (Pers. ex Schw.) ss. Bres.	.	.	.	5	.	1	.	.
Russula heterophylla (Fr.) Fr.	.	.	.	8	.	.	2	.
Lepista nuda (Bull.: Fr.) Cke.	.	.	.	2	.	.	.	5
**Laccaria bicolor* (R. Mre.) Orton	.	.	.	.	.	15	.	2
Lactarius blennius Fr.	.	.	.	.	.	.	3	44
Hydnotrya tulasnei Berk et Br.	1	.	.	.	.	.	.	.
Russula amethystina Quèl.	.	1	.	.	.	.	.	.
Cortinarius bolaris (Pers.: Fr.) Fr.	.	.	15	.	.	.	.	.
Inocybe lucifuga (Fr.) Quèl.	.	.	4	.	.	.	.	.
Tricholoma imbricatum (Fr.: Fr.) Kumm.	.	.	3	.	.	.	.	.
**Cortinarius collinitus* Fr.	.	.	10	.	.	.	.	.
**Elaphomyces asperulus* Vitt.	.	.	3	.	.	.	.	.
Cortinarius armillatus (Fr.) Fr.	.	.	2	.	.	.	.	.
**Russula nauseosa* (Pers.) Fr.	.	.	2	.	.	.	.	.
Inocybe trivialis (Lge.) Mos.	.	.	2	.	.	.	.	.
**Russula viscida* Kudr.	.	.	1	.	.	.	.	.
Russula krombholzii Schaffer	.	.	1	.	.	.	.	.
Inocybe petiginosa (Fr.: Fr.) Gill.	.	.	.	35	.	.	.	.
Russula vitellina (Pers.) Fr.	.	.	.	6	.	.	.	.
Russula lepida Fr.	.	.	.	2	.	.	.	.
Lactarius volemus Fr.	.	.	.	4	.	.	.	.
Inocybe grammata Quèl.	.	.	.	4	.	.	.	.
Cortinarius evernius Fr.	.	.	.	2	.	.	.	.
Tricholoma sulphureum (Bull.: Fr.) Kumm.	.	.	.	1	.	.	.	.
**Hebeloma truncatum* (Schff.: Fr.) Kumm.	.	.	.	.	3	.	.	.
**Hygrophorus camarophyllus* (A. et S.: Fr.) Fr.	.	.	.	.	1	.	.	.
Russula azurea Bres.	.	.	.	.	.	.	.	2

Table 3
Fruitbodies of saprotrophic fungi collected in permanent plots (1997-1999)

Plot	*Tilio-Carpinetum*				*Pino-Quercetum*		*Luzulo-Fagetum*	
	L I	L II	K I	K II	Ł I	Ł II	G I	G II
Number of observations	18	18	18	18	18	18	18	18
Number of species	80	62	79	66	64	45	35	56
	1	2	3	4	5	6	7	8
Litter-inhabiting species								
**Mycena zephirus* (Fr.: Fr.) Kumm.	603	535	83	164	2031	665	951	2720
**Mycena galopoda* (Pers.: Fr.) Kumm.	61	2	74	2	275	165	4	8
**Collybia butyracea* (Bull.: Fr.) Quèl.	147	13	11	5	58	15	129	4
**Mycena sanguinolenta* (A. et S.: Fr.) Kumm.	189	63	124	16	244	25	256	52
**Mycena vitilis* (Fr.) Quèl.	245	93	171	8	13	.	11	11
**Collybia asema* Fr.	91	.	8	62	12	4	168	18
Collybia dryophila (Bull.: Fr.) Kumm.	7	3	15	6	.	.	2	4
Collybia peronata (Bolt.: Fr.) Sing.	10	5	.	4	3	.	138	78
**Mycena stylobates* (Pers.: Fr.) Kumm.	7	1	8	.	.	1	.	8
**Mycena viscosa* (Secr.) R. Mre.	2	.	79	4	.	.	5	7
**Mycena pura* (Pers.: Fr.) Kumm.	22	.	3	7	.	.	2	5
**Clitocybe vibecina* (Fr.) Quèl.	21	.	6	.	140	106	.	3
Cantharellula umbonata (Gmel.: Fr.) Sing.	8	.	.	.	62	4	5	14
Rickenella fibula (Bull.: Fr.) Raith.	40	98	.	.	41	7	.	.
**Cystoderma amianthinum* (Scop.: Fr.) Fay.	8	1	.	.	35	14	.	.
Galerina pumila (Pers.: Fr.) M. Lge. ex Sing.	20	.	101	.	3	2	.	.
**Mycena galopoda* v. *nigra* (Fl. Dan.)	8	.	3	.	24	1	.	.
**Clitocybe ditopa* (Fr.: Fr.) Gill.	3	.	.	.	39	18	.	3
Hymenoscyphus fructigenus (Bull.: Fr.) S. F. Gray	.	.	30	15	.	.	3875	20
Collybia tuberosa (Bull.: Fr.) Kumm.	4	.	20	6	.	.	.	.
Strobilurus stephanocystis (Hora) Sing.	.	.	.	.	15	2	4	.
**Collybia cirrhata* (Schum.: Fr.) Kumm.	21	15	.	.	.	.	.	.
**Clitocybe harmajae* Lam.	13	.	.	1	.	.	.	.
Collybia cookei (Bres.) J. D. Arnold	1500	.	.	.	20	.	.	.
Rickenella setipes (Fr.) Raith.	18	.	.	.	.	4	.	.
**Mycena amicta* (Fr.) Quèl.	.	.	1	2	.	.	.	.
**Mycena epipterygia* (Scop.: Fr.) S. F. Gray	.	.	155	.	3	.	.	.
Mycena aetites (Fr.) Quèl.	.	.	.	3	.	.	.	1
**Mycena metata* (Fr.) Kumm.	.	.	.	.	111	197	.	.
**Clitocybe obsoleta* (Batsch: Fr.) Quèl.	.	.	.	.	46	138	.	.
Galerina hypnorum (Schrank: Fr.) Kühn.	.	.	.	.	52	28	.	.
**Cystoderma jasonis* (Cke. et Moss.) Harmaja	.	.	.	.	23	5	.	.
**Mycena rorida* (Scop.: Fr.) Quèl.	.	.	.	.	18	2	.	.
Auriscalpium vulgare S. F. Gray	.	.	.	.	1	1	.	.
**Mycena vulgaris* (Pers.: Fr.) Quèl.	19	.	.	.	.	.	.	.
Trichophaea hemisphaeroides (Mounton) Graddon	23	.	.	.	.	.	.	.
Cystoderma carcharias (Pers. ex Secr.) Fay.	9	.	.	.	.	.	.	.

Xeromphalina cornui (Quèl.) Fav.	1	.	.	.	.	.	.	.
Psathyrella obtusata (Fr.) A. H. Smith.	1	.	.	.	.	.	.	.
Calyptella capula (Holmsk.: Fr.) Quèl.	150	.	.	.	.	.	.	.
**Panaeolus subbalteatus* (Bk. et Br.) Sacc.	10	.	.	.	.	.	.	.
**Marasmius rotula* (Scop.: Fr.) Fr.	6	.	.	.	.	.	.	.
Mycena speirea (Fr.: Fr.) Gill.	.	.	6	.	.	.	.	.
**Hypholoma myosotis* (Fr.) Mos.	.	.	3	.	.	.	.	.
**Hypholoma elongatipes* Peck	.	.	10	.	.	.	.	.
Hypholoma ericaeoides Orton	.	.	2	.	.	.	.	.
Entoloma juncinum (Kühn. et Romagn.) Noordel.	.	.	2	.	.	.	.	.
Bolbitius vitellinus (Pers.) Fr.	.	.	1	.	.	.	.	.
**Mycena flavoalba* (Fr.) Quèl.	.	.	1	.	.	.	.	.
Macroscyphus macropus Pers.: S. F. Gray	.	.	.	6	.	.	.	.
**Mycena aurantiomarginata* (Fr.) Quèl.	.	.	.	3	.	.	.	.
**Panaeolus sphinctrinus* (Fr.) Quèl.	.	.	.	2	.	.	.	.
Galerina calyptrata Orton	.	.	.	.	8	.	.	.
**Clitocybe suaveolens* (Schum.: Fr.) Kumm.	.	.	.	.	2	.	.	.
Galerina pruinatipes Smith	.	.	.	.	15	.	.	.
Psilocybe montana (Pers.: Fr.) Kumm.	.	.	.	.	6	.	.	.
Psilocybe tenax (Fr.) Kühn. et Romagn.	.	.	.	.	4	.	.	.
**Marasmius scorodonius* (Fr.) Fr.	.	.	.	.	1	.	.	.
Clitocybe clavipes (Pers.: Fr.) Kumm.	.	.	.	.	.	5	.	.
**Mycena debilis* (Fr.) Quèl.	.	.	.	.	.	5	.	.
**Marasmius androsaceus* (L.: Fr.) Fr.	.	.	.	.	.	1	.	.
Galerina pseudomycenopsis Pil.	.	.	.	.	.	.	2	.
Mycena tenella (Fr.) Quèl.	.	.	.	.	.	.	10	.
Mycena filopes (Bull.: Fr.) Kumm.	.	.	.	.	.	.	.	3
Marasmius saccharinus (Batsch) Fr.	.	.	.	.	.	.	.	1
Lignicolous species								
**Dacrymyces stillatus* Nees: Fr.	2240	2480	435	1270	1835	1575	845	5135
**Gymnopilus hybridus* (Fr.: Fr.) Sing.	300	1	25	59	11	45	.	59
**Oligoporus caesius* (Schrad.: Fr.) Gilb. et Ryv.	39	18	7	2	1	18	.	49
Schizopora paradoxa (Schrad.: Fr.) Donk s. l.	15	30	40	262	5	.	5	17
**Hypholoma fasciculare* (Huds.: Fr.) Kumm.	1347	.	104	21	32	2	47	4
Stereum hirsutum (Willd.: Fr.) S. F. Gray	4735	940	2083	27	500	.	.	56
Hypoxylon howeianum Peck	.	2210	3060	12150	50	.	5	40
Xylaria hypoxylon (L.: Fr.) Grev.	.	110	1121	355	230	.	165	15
Crepidotus variabilis (Pers.: Fr.) Kumm.	109	380	397	583	50	.	.	.
**Exidia plana* (Wigg. ex Schleich.) Donk	127	31	195	257	.	.	.	87
**Calocera viscosa* (Pers.: Fr.) Fr.	35	18	.	11	24	8	.	.
**Ramaria stricta* (Fr.) Quèl.	2	7	.	4	.	.	34	2
Nectria cinnabarina (Tode: Fr.) Fr.	50	.	150	50	.	.	1320	80
Pluteus atricapillus (Batsch) Fay.	.	13	8	16	.	.	1	6
Bjerkandera adusta (Willd.: Fr.) Fr.	.	31	90	.	3	.	45	202
**Stereum sanguinolentum* (A. et S.: Fr.) Fr.	.	120	.	5	61	60	.	110
Pezicula carpinea (Pers.) Tul.	10300	2150	300	5000	.	.	.	.
Peniophora cinerea (Pers.: Fr.) Cooke	4	4	25	69	.	.	.	.
**Pholiota lenta* (Pers.: Fr.) Sing.	136	87	1	.	.	.	.	2

Tab. 3 cont.

	1	2	3	4	5	6	7	8
Mollisia cinerea (Batsch ex Merat) Karst	110	50	.	100	.	.	.	190
**Aleurodiscus amorphus* (Pers. ex Purt.) Schroet.	200	20	.	.	4640	225	.	.
Cylindrobasidium evolvens (Fr.: Fr.) Jül.	30	.	62	10	.	.	.	16
Hypholoma sublateritium (Fr.) Quèl.	1	.	4	.	67	.	.	65
Galerina vittaeformis (Fr.) Sing.	5	.	45	.	.	14	8	.
**Oligoporus stipticus* (Pers.: Fr.) Gilb. et Ryv.	5	.	.	5	4	1	.	.
**Mycena alcalina* (Fr.) Kumm.	.	14	2	2	2	.	.	.
**Schizophyllum commune* Fr.: Fr.	.	.	204	80	2	.	.	1
**Mycena praecox* Vel.	.	.	11	.	2	3	1	.
Calocera cornea (Batsch: Fr.) Fr.	2	100	20	.	.	.	.	.
**Phellinus hartigii* (A. et S.) Bond.	10	37	.	2	.	.	.	.
**Kuehneromyces mutabilis* (Schff.: Fr.) Sing. et Smith	1	1	.	14	.	.	.	.
Galerina camerina (Fr.) Kühn.	31	8	.	.	8	.	.	.
Galerina triscopa (Fr.) Kühn.	6	20	.	.	6	.	.	.
**Trechispora farinacea* (Pers.: Fr.) Liberta s. l.	10	9	.	.	.	1	.	.
Tubaria conspersa (Pers.: Fr.) Fay.	10	.	242	5	.	.	.	.
**Merulius tremellosus* Fr.	4	.	13	.	.	.	.	20
Hapalopilus nidulans (Fr.) P. Karst.	11	.	11	.	.	.	.	3
**Lachnellula subtilissima* (Cke.) Dennis	450	.	.	.	1685	1600	.	.
Diatrype disciformis (Hoffm.: Fr.) Fr.	100	.	.	.	.	.	15650	220
Tremella mesenterica Retz. ex Hook.	.	39	10	55	.	.	.	.
**Hypholoma capnoides* (Fr.) Fr. Kumm.	.	488	1	.	.	2	.	.
**Mycena polygramma* (Bull.: Fr.) S. F. Gray	.	1	.	4	.	1	.	.
**Dacrymyces capitatus* Schw.	.	120	.	.	280	265	.	.
Trametes versicolor (L.: Fr.) Pil.	.	.	284	3	.	.	.	170
Lasiosphaeria spermoides (Hoffm.: Fr.) Cesati et de Notaris	.	.	5	.	.	.	117	27
**Pseudohydnum gelatinosum* (Scop.: Fr.) P. Karst.	.	.	.	.	.	13	10	188
**Gymnopilus stabilis* (Weinm.) Kühn. et Romagn.	6	72	.	.	.	.	.	.
**Fomitopsis pinicola* (Sw.: Fr.) P. Karst.	2	21	.	.	.	.	.	.
**Hyphoderma radula* (Fr.: Fr.) Donk	13	.	15	.	.	.	.	.
**Pluteus leoninus* (Schff.: Fr.) Kumm.	1	.	2	.	.	.	.	.
**Hyphodontia arguta* (Fr.) J. Erikss.	2	.	.	130	.	.	.	.
Steccherinum ochraceum (Pers.: Fr.) S. F. Gray	50	.	.	12	.	.	.	.
Piptoporus betulinus (Bull.: Fr.) P. Karst.	9	.	.	2	.	.	.	.
Mycena galericulata (Scop.: Fr.) S. F. Gray	.	1	6	.	.	.	.	.
Crucibulum laeve (Huds. ex Relh.) Kambly et al.	.	4	.	4	.	.	.	.
**Galerina marginata* (Fr.) Kühn.	.	1	.	1	.	.	.	.
**Pholiota flammans* (Fr.) Kumm.	.	4	.	.	10	.	.	.
**Panellus mitis* (Pers.: Fr.) Sing.	.	20	.	.	.	30	.	.
Daedalea quercina (L.: Fr.) Fr.	.	4	.	.	.	.	.	66
Polyporus brumalis (Pers.) Fr.	.	.	20	1	.	.	.	.
Peniophora incarnata (Pers.: Fr.) P. Karst.	.	.	17	5	.	.	.	.
Phaeomarasmius erinaceus (Fr.) Kühn.	.	.	1	1	.	.	.	.
Ascocoryne cylichnium (Tul.) Korf	.	.	90	.	30	.	.	.
Psathyrella hydrophila (Bull. ex Merat) R. Mre.	.	.	244	.	.	.	.	330

Sphaerobolus stellatus Tode: Pers.	.	.	40	.	.	.	.	20
**Trichaptum abietinum* (Pers.: Fr.) Ryv.	.	.	.	300	100	.	.	.
**Tricholomopsis rutilans* (Schff.: Fr.) Sing.	.	.	.	1	.	.	1	.
Oligoporus subcaesius (David) Ryv. et Gilb.	.	.	.	10	.	.	.	10
**Gymnopilus penetrans* (Fr.: Fr.) Murr.	.	.	.	.	14	4	.	.
Stereum rugosum (Pers.: Fr.) Fr.	.	.	.	.	132	.	10	.
Hypoxylon multiforme (Fr.) Fr.	110	.	.	.	.	.	.	.
Galerina heimansii Reijnd.	5	.	.	.	.	.	.	.
Protocrea farinosa (Bk. et Br.) Petch	20	.	.	.	.	.	.	.
Delicatula integrella (Pers.: Fr.) Fay.	15	.	.	.	.	.	.	.
Junghuhnia nitida (Pers.: Fr.) Ryv.	6	.	.	.	.	.	.	.
**Amylostereum chailletii* (Pers.: Fr.) Boid.	5	.	.	.	.	.	.	.
**Mycena rubromarginata* (Fr.: Fr.) Kumm.	1	.	.	.	.	.	.	.
Polyporus melanopus (Pers.) Fr.	1	.	.	.	.	.	.	.
**Lentinellus omphalodes* (Fr.) P. Karst.	.	192	.	.	.	.	.	.
**Hyphodontia spathulata* (Fr.) Parm.	.	120	.	.	.	.	.	.
**Lentinus adhaerens* (A. et S.: Fr.) Fr.	.	100	.	.	.	.	.	.
**Pseudoclitocybe cyathiformis* (Bull.: Fr.) Sing.	.	21	.	.	.	.	.	.
Tapesia fusca (Pers.: Merat) Fuck.	.	20	.	.	.	.	.	.
Hyphoderma roseocremeum (Bres.) Donk	.	4	.	.	.	.	.	.
Flammulina velutipes (Curt.: Fr.) Sing.	.	2	.	.	.	.	.	.
**Mycena purpureofusca* (Peck) Sacc.	.	1	.	.	.	.	.	.
Polyporus ciliatus (Fr.) Fr.	.	.	4	.	.	.	.	.
Trametes pubescens (Schum.: Fr.) Pil.	.	.	66	.	.	.	.	.
Lentinellus cochleatus (Pers.: Fr.) Karst.	.	.	44	.	.	.	.	.
Diatrype bullata (Hoffm.: Fr.) Tul.	.	.	300	.	.	.	.	.
Ascocoryne sarcoides (Jacq.) Groves et Wilson	.	.	50	.	.	.	.	.
Trametes hirsuta (Wulf.: Fr.) Pil.	.	.	20	.	.	.	.	.
Polyporus varius v. *nummularius* (Bull.) Fr.	.	.	1	.	.	.	.	.
Tyromyces chioneus (Fr.: Fr.) P. Karst.	.	.	1	.	.	.	.	.
Pluteus lutescens (Fr.) Bres.	.	.	1	.	.	.	.	.
Hirneola auricula-judae (Bull.: Fr.) Berk.	.	.	1	.	.	.	.	.
**Gerronema strombodes* (Bk. et Mont.) Sing.	.	.	1	.	.	.	.	.
Marasmiellus ramealis (Bull.: Fr.) Sing.	.	.	.	404	.	.	.	.
**Pholiota astragalina* (Fr.) Sing.	.	.	.	4	.	.	.	.
Fomes fomentarius (L.: Fr.) Fr.	.	.	.	2	.	.	.	.
**Craterocolla cerasi* (Tul.) Bref.	.	.	.	.	100	.	.	.
Scutellinia scutellata (L.: Fr.) Lamb.	.	.	.	.	80	.	.	.
**Gymnopilus sapineus* (Fr.) Mre.	.	.	.	.	11	.	.	.
Tubaria furfuracea (Pers.: Fr.) Gill.	.	.	.	.	5	.	.	.
**Gloeophyllum sepiarium* (Wulf.: Fr.) Karst.	.	.	.	.	4	.	.	.
Tubaria hiemalis Rom. ex Bon.	.	.	.	.	2	.	.	.
**Ganoderma lucidum* (Fr.) P. Karst.	.	.	.	.	1	.	.	.
**Xeromphalina campanella* (Batsch.: Fr.) R. Mre.	.	.	.	.	.	176	.	.
**Hyphodontia aspera* (Fr.) J. Erikss.	.	.	.	.	.	40	.	.
**Pluteus atromarginatus* (Konr.) Kühn.	.	.	.	.	.	1	.	.
Ustulina deusta (Hoffm.: Fr.) Petrak	.	.	.	.	.	.	120	.
Diatrype stigma (Hoffm.: Fr.) Fr.	.	.	.	.	.	.	40	.

Tab. 3 cont.

	1	2	3	4	5	6	7	8
Coprinus disseminatus (Pers.: Fr.) S. F. Gray	.	.	.	.	.	.	1	.
Peniophora quercina (Fr.) Cooke	.	.	.	.	.	.	.	35
**Hyphodontia breviseta* (Karst.) J. Erikss.	.	.	.	.	.	.	.	32
Hypocrea rufa (Pers.: Fr.) Fr.	.	.	.	.	.	.	.	50
Trametes gibbosa (Pers.: Fr.) Fr.	.	.	.	.	.	.	.	28
Hyphodontia nespori (Bres.) J. Erikss. et Hjortst. in J. Erikss. et Ryv.	.	.	.	.	.	.	.	5
Hyphoderma setigerum (Fr.) Donk	.	.	.	.	.	.	.	2
**Paxillus panuoides* Fr.	.	.	.	.	.	.	.	1
Terricolous species								
Clavulina cristata (Fr.) Schroet.	1	15	.	16	50	.	57	62
Hygrophoropsis aurantiaca (Wulf.: Fr.) R. Mre.	2	.	.	12	59	58	.	9
Clavulina cinerea (Fr.) Schroet.	.	24	.	.	.	.	4	52
Oudemansiella radicata (Relkan: Fr.) Sing.	.	.	.	5	.	.	3	1
Clitocybe gibba (Pers.: Fr.) Kumm.	.	.	.	4	3	14	.	.
Stropharia aeruginosa (Curt.: Fr.) Quèl.	.	.	1	.	25	.	.	.
Rhodophyllus clandestinus (Kühn. et Bours.) Romagn.	.	.	7	.	1	.	.	.
**Entoloma conferendum* (Britz.) Noordel. in Pers.	.	.	3	.	.	3	.	.
Entoloma sericeum f. *nolaniforme* (Kühn.) Noordel.	2	.	.	.	.	.	.	.
Rhodophyllus rhombisporus (Kühn. et Bours.) Romagn.	.	4	.	.	.	.	.	.
Entoloma coelestinum (Fr.) Hesler	.	1	.	.	.	.	.	.
**Macrolepiota rhacodes* (Vitt.) Sing.	.	1	.	.	.	.	.	.
Entoloma rhodocylix Lasch	.	.	3	.	.	.	.	.
Entoloma cetratum (Fr.) Mos.	.	.	2	.	.	.	.	.
Agaricus sylvicola (Vitt.) Sacc.	.	.	.	1	.	.	.	.
Clitopilus prunulus (Scop.: Fr.) Kumm.	.	.	.	1	.	.	.	.
Lepiota castanea Quèl.	.	.	.	.	1	.	.	.

Table 4

Fruitbodies of parasitic fungi collected in permanent plots (1997-1999)

Plot	Tilio-Carpinetum				Pino-Quercetum		Luzulo-Fagetum	
	L I	L II	K I	K II	Ł I	Ł II	G I	G II
Number of observations	18	18	18	18	18	18	18	18
Number of species	3	3	4	2	3	.	4	2
Armillaria mellea (Vahl in Fl. Dan.: Fr.) Karst.	130	468	3	8	5	.	32	1
**Heterobasidion annosum* (Fr.) Bref.	10	10	.	1	15	.	2	2
Fomes fomentarius (L.: Fr.) Fr.	5	3	.	.	.	.	11	.
Sparassis crispa (Wulf.) Fr.	.	.	1	.	.	.	1	.
Sclerotinia tuberosa (Hedw.) Fuck.	.	.	15	.	.	.	.	.
Trametes versicolor (L.: Fr.) Pil.	.	.	10	.	.	.	.	.
**Phellinus hartigii* (A. et S.) Bond.	.	.	.	.	2	.	.	.
Inonotus hastifer Pouz.	.	.	.	.	.	.	.	1

Fruitbodies of these species were found exclusively within reach of fir roots in the reserves investigated. However, carpophores of many fungi (e.g. *Lactarius salmonicolor*, *L. scrobiculatus*, *L. ichoratus*, *Tricholoma bufonium*), well-known from the range depth of the silver fir as well as its southern border (Comandini et al. 1998), were not found.

Litter-inhabiting saprotrophs in the plots were most frequently common species of the genus *Mycena*: *M. zephirus*, *M. sanguinolenta*, *M. galopoda*, *M. vitilis*, and *Collybia*: *C. butyracea*, and *C. asema* (Tab. 3). They were not substrate-specific, and developed equally frequently on the fir litter and the deciduous litter or dead herbal plants. The occurrence of *Collybia butyracea* and *Mycena vitilis* on the fir litter has not been described in Polish mycological literature so far. No information is also available on 15 other litter-decomposing species, collected from fir needles in the plots examined. These are: *Mycena pura*, *M. galopoda var. nigra*, *M. amicta*, *M. epipterygia*, *M. metata*, *M. debilis*, *Clitocybe ditopa*, *C. harmajae*, *C. obsoleta*, *Entoloma conferendum*, *Collybia cirrhata*, *Hypholoma elongatipes*, *H. myosotis*, *Panaeolus sphinctrinus* and *P. subbalteatus*.

As a result of the specific character of the plots, most lignicolous carpophores formed on dead fir wood. The only exceptions, because of a considerable admixture of deciduous trees in some plots, were *Schizopora paradoxa*, *Hypoxylon howeianum* and *Stereum hirsutum*, which fructified mainly on hornbeam branches and twigs.

Species such as *Dacrymyces stillatus*, *Hypholoma fasciculare*, *Gymnopilus hybridus*, *Postia caesia*, *Calocera viscosa* and *Pluteus cervinus* prevailed in the group of fungi that form fruitbodies on fir wood. They all occur commonly in other regions of Poland and in other types of forests. Species such as *Schizophyllum commune*, *Pholiota lenta*, *Mycena polygramma*, *Galerina camerina*, *Pluteus leoninus*, *Trechispora farinacea*, *Dacrymyces capitatus*, *Gymnopilus stabilis*, *Grandinia granulosa*, *G. spathulata*, and *Lentinellus omphalodes* had been recorded in Poland on fir wood for the first time.

DISCUSSION AND CONCLUSIONS

Macromycetes typical of firs, such as *Hericium coralloides* (Gumińska 1969; Bujakiewicz 1979; Stecki 1910; Wojewoda 1998; Domański et al. 1967; Sałata 1972, 1977; Sałata and Ostas 1975; Sałata and Flisińska 1991), *Hymenochaete mougeotii* (Bujakiewicz 1979; Gumińska 1966; Skirgiełło 1972; Sałata and Flisińska 1991; Wojewoda 1974, 1998, 1999; Domański et al. 1963; Sałata 1972, 1977, 1978; Sałata and Ostas 1975), *Ischnoderma resinosum* (Gumińska 1966, 1969; Domański 1961, 1962; Domański and Orlicz 1967; Domański et al. 1967; Sałata 1972, 1977), did not occur in the plots examined.

Armillaria mellea s.l. and *Heterobasidion annosum* were the most frequent parasites in the plots (Tab. 4). The latter, a dangerous parasite of pine and spruce forests, does not threaten firs. It occured only on rotten stumps in the plots examined.

The nature reserves protecting the silver fir near the northern limit of its occurrence also protect fungi accompanying it. Moreover, dead trees that remain in the ecosystem are conducive to the preservation of an abundance of saprotrophs, especially rare and threatened species.

Almost ten percents of the total number of the macromycete species found (27) is listed in the red list of threatened fungi (Wojewoda and Ławrynowicz 1992). A half of them are associated with *Abies alba*. Mycorrhizal species that occurred in the plots examined included, for instance, *Russula livescens* (I), *Boletus edulis*, and *Inocybe grammata* (both V).

Ten threatened species of litter-decomposing and terrestrial saprotrophs were found. They are classified as I: *Rhodophyllus rhombisporus*, *Rh. clandestinus*, *Entoloma juncinum*, *E. rhodocylix*, *Psilocybe tenax*, *Macrolepiota rhacodes*, and *Calyptella capula*. *Hypholoma ericaeoides* and *H. myosotis* belong to the V category, however *Mycena aurantiomarginata* is classed as R. The occurrence of *Macrolepiota rhacodes* under firs is interesting. In the present study, one carpophore was found under a mature fir in the well-lit plot of Lubiaszów II. A similar occurrence of the species was recorded in Roztocze (Sałata 1972) and the Góry Świętokrzyskie Mts (Lisiewska 1979). Two lignicolous saprotrophs represented the I category: *Phellinus hartigii*, which is associated exclusively with the fir, and *Galerina triscopa*. Species such as *Gymnopilus stabilis*, *Trametes pubescens*, and *Tyromyces chioneus* represented the V category in the plots. The R category was represented by such macromycetes as *Gerronema strombodes*, *Ganoderma lucidum*, *Lentinus adhaerens*, and *Phaeomarasmius erinaceus*, while the E category by *Dacrymyces capitatus*, *Craterocolla cerasi* and *Lentinus omphalodes*. All these species occurred on fir wood. The presence of *Craterocolla cerasi* on fir branches confirms Gumińska's suggestions, who found this species in the Pieniny mts. (Wojewoda 1977).

Two parasitic species are red-listed: *Sparassis crispa* (R) and *Inonotus hastifer* (I). The former developed carpophores at the base of a pine trunk and a pine stump. The connection of this species with *Abies alba* is already known. It was found on fir roots by Domański (1962) in the Góry Świętokrzyskie Mts and by Sałata (1977) on the Równina Kozienicka plain.

The present study has shown the relationship between *Abies alba* and 122 macromycete species in the reserves on the Równina Piotrkowska plain, and 95 on the Wzniesienia Łódzkie uplands. The number of 38 new species associated with *Abies alba* in Poland was identified, making the total number of known species accompanying *Abies alba* in Poland ca 500. The number should be considered indicative of a great diversity of fungi associated with the fir.

The present study as well as literature data suggest that the number of macromycetes accompanying the silver fir near the northern limit of its range is comparable to that of *Abies alba* associations in the depth of the range. The differences in the mycobiota of individual regions result from species diversity. They are brought about by diversified conditions that change together with latitude and altitude above sea level. The number of recorded species was most strongly dependent on the character of the plant community. *Tilio-Carpinetum* was the most abundant, while *Luzulo pilosae-Fagetum* was the poorest.

A broad ecological scale of *Albies alba* determines the abundance of fungi accompanying it. Because of the wide spectrum of tree species that accompany the silver fir, its mycobiota may outnumber the mycobiota of other coniferous trees. The development of susceptibility to the symbiotic combination with fungi that accompany other trees, especially conifers, may have influenced the evolutionary success of *Abies alba*. The mycobiota associated exclusively with the fir is very poor.

Mycorrhizal partners recognised as typical of highland firs, e.g. *Lactarius salmonicolor*, *L. bresadolianus*, *Tricholoma bufonium*, are absent in low-lying ecotypes of *Abies alba*. These ecotypes are vicarioused by fungi of lowlands and widespread in the temperate climate, accompanying other trees, mainly conifers. These are, for instance, *Lactarius mitissimus*, *Russula emetica*, *R. ochroleuca*, *Xerocomus badius*. Fir saprotrophs are represented relatively numerously, although many species occurring in thick forest complexes, e.g. *Hericium coralloides* and *Ischnoderma resinosum*, were not present.

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Makromycetes w zbiorowiskach z *Abies alba* na granicy zasięgu w Polsce Środkowej

Streszczenie

Jodła pospolita *Abies alba* Mill., jako gatunek dolnoreglowy zajmuje w Polsce Środkowej szczególne stanowiska. Schodzi tu najdalej na niziny w obrębie całego areału występowania. Celem pracy było poznanie gatunków grzybów makroskopowych związanych z jodłą przy północnej granicy jej zasięgu oraz zbadanie zależności między różnorodnością gatunkową grzybów a strukturą drzewostanu i zbiorowiskami roślinnymi z udziałem jodły. Do badań mikosocjologicznych prowadzonych w latach 1997-1999 wybrano cztery rezerwaty przyrody: Lubiaszów, Kruszewiewc, Łaznów i Gałków. Obserwacje prowadzono na ośmiu stałych powierzchniach, o wielkości 1000 m^2 każda, w zepołach *Tilio-Carpinetum*, *Luzulo pilosae-Fagetum* i *Pino-Quercetum abietetosum*. W ciągu trzech sezonów wegetacyjnych zidentyfikowano 288 gatunków grzybów makroskopowych. Największą różnorodnością makromycetes odznacza się grąd z udziałem jodły *Tilio-Carpinetum*, najmniejszą zaś buczyna z jodłą *Luzulo pilosae-Fagetum*, co dodatnio koreluje z liczbą gatunków drzew w tych zespołach. Różnice ilościowe analizowanych grzybów świadczą o ich zależności od struktury drzewostanu.

Łącznie na badanym terenie odnaleziono 131 gatunków towarzyszących jodle. Wśród nich 37 to gatunki, których związek z jodłą dotychczas nie był potwierdzony w Polsce. Nizinne ekotypy jodły pozbawione są partnerów mikoryzowych uznanych za gatunki „jodłowe" na obszarach górskich. Zastępują je grzyby obszarów nizinnych oraz szeroko rozpowszechnione w całej strefie klimatu umiarkowanego, towarzyszące innym drzewom, zwłaszcza iglastym. Saprotrofy „jodłowe" są licznie reprezentowane, chociaż zaznacza się brak gatunków puszczańskich.