Ecology of macrofungi in the beech woods of the Šumava mountains and Šumava foothills

Ekologie makromycetů v bučinách Šumavy a Šumavského podhůří

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The fungi of the order *Agaricales* s. l. and several families of ungilled fungi and gasteromycetes were studied in the beech woods of the southeastern part of the Šumava mountains and Šumava foothills (Czechoslovakia). Altogether, 230 species were recorded on 8 permanent plots (50 x 50 m) during the years 1988 - 1990. The terrestrial fungi were closely associated with a particular layer of the surface humus and substrate, and the lignicolous fungi were associated with wood in various stages of decay. The occurrence of mycorrhizal fungi was influenced above all by the mycorrhizal partner, altitude, and climate. The species composition, number of mycorrhizal and terrestrial species on the individual plots, and their share were determined by the humus type, microrelief, and the thickness of the detritus layer. The occurrence of lignicolous fungi was in close relation to the degree of naturalness of the wood, substrate diversity of the plot and the mesoclimate. The results are summarized in the mycosociological tables and compared by the use of cluster analysis and diagrams.

V bučinách jihovýchodní části Šumavy a Šumavského podhůří byly studovány houby řádu *Agaricales* s. l. a dále několik čeledí nelupenatých a břichatkovitých hub. Na 8 trvalých plochách o velikosti 50 x 50 m jsem během vegetačních sezón v letech 1988 - 1990 nalezl celkem 230 druhů hub. Terestrické druhy byly těsně vázány na určitou vrstvu nadložního humusu a substrát v této vrstvě, lignikolní druhy na dřevo v různých stadiích rozkladu. Výskyt mykorrhizních druhů byl ovlivněn především přítomností mykorrhizního partnera, nadmořskou výškou a klimatem. Druhové složení, počet mykorrhizních a terestrických hub na jednotlivých plochách a jejich poměr byl dán formou humusu, mikroreliéfem plochy a tloušťkou vrstvy detritu. Výskyt lignikolních druhů těsně koreloval se stupněm přirozenosti lesa, nabídkou substrátů na ploše a jejím mezoklimatem. Výsledky jsou shrnuty v syntetických mykocenologických tabulkách a porovnány pomocí grafů a shlukové analýzy.

Introduction

Mull, moder, and acid soil beech woods were in the past the typical climax woods communities of the Šumava mountains and Šumava foothills (Mikyška et al. 1968). Up to now they have been preserved only in small and scattered remains, especially in protected areas (state nature reserves the Boubín Virgin Forest, Zátoňská hora, Medvědice, Stožec, the Milešice Virgin Forest and protected nature monument Libín). However, only the mycoflora of the Boubín Virgin Forest is well known and described e. g. by Herink (1947), Kotlaba et Pouzar (1951) and Kubička (1960, 1973, 1982). The other natural as well as man influenced beech woods in this area have not been studied. Generally, both the mycoflora of Czechoslovak and European beech woods is well known and summarized e. g. by Lisiewska (1972, 1974), Darimont (1973), Dörfelt (1985), and Fellner (1985). The authors published summary tables and surveys of the occurrence of individual species in various types of beech woods. However, the knowledge of the relationship between the occurrence of macrofungi and soil properties is still insufficient. Some works mentioned above deal with this problem too, but it was thoroughly examined only by Tyler (1984, 1985) in the beech woods of southern Sweden. He found that the general indicator of the soil properties, which is of the most importance for the occurrence of macrofungi, is the metal ion saturation percentage and organic matter content of the topsoil.

The chief aim of this work is first to obtain a thorough survey of the occurence of the chosen groups of macrofungi in the beech woods of the Šumava mountains and Šumava foothills. Secondly, this study aims to reveal which ecological factors determine the species composition, number of species, and proportions of various ecological groups of fungi in these woods. Thus, the core of the work lies in the study of the relationship between fungi and habitat conditions (above all humus properties) on the permanent plots.

Material and methods

In the small and very heterogeneous remains of the beech woods in the Šumava mountains, the permanent plots (50 x 50 m) were selected according to the following criteria: the dominance of the beech *(Fagus silvatica)* in the tree layer (at least 90 % of the total canopy cover), the total canopy cover at least 75 %, herbaceous layer belonging to one association, and if possible, the presence of wood of all tree species occurring on the plot in various stages of decay and the presence of stands with similar tree species composition in the vicinity. The phytosociological relevés on the plots were made by using the Braun-Blanquet cover-abundance scale (in Mueller-Dombois et Ellenberg 1974). The nomenclature of the phytosociological units is according to Moravec et al. (1982).

Three soil profiles were made on each plot during 3 – 5 Mai 1990. After the litter layer had been carefully removed, three samples were taken on each plot from the surface humus (O_F and O_H) and three from the humous topsoil (A_h) using a small shovel. The samples were pooled to form two composite samples (the total weight of one composite sample was about 1 kg). The soil analysis was carried out in the laboratory of the Forestry and Game Management Research Institute in Jíloviště – Strnady. The < 2 mm fraction was dried out at room temperature and analyzed according to the following methods: 1) pH_{H_2O} – measured immediately by glass electrode in soil extract with distilled water, 2) pH_{KCl} – in extract with 1 M KCl after 24 hours, 3) exchangeable cations (Ca, Mg, K, Na) – in extract with 1 N NH_4Cl by the use of atomic absorption spectrometry, 4) the total N content – spectrophotometric analysis after mineralization according to Kjeldahl, 5) organic C content – titration by adding $Na_2S_2O_3$ after mineralization with the mixture of the sulphuric acid and potassium bichromate, 6) humus percentage – obtained from the C content by using the coefficient 1,724.

The layers of the surface humus (O) are designated in the text as layer L (O_L – litter layer), layer F (O_F – fermentation layer), and layer H (O_H – humification layer); the layers of the mineral soil as humous topsoil (A_h) and layer B. The layers L and F together are named detritus (D). The English terminology of the soil types is used according to FAO (1968, 1969), German and Czech synonyms according to Mückenhausen (1970) and Němeček, Smolíková et Kutílek (1990). The surface humus layers were distinguished after Babel (1971).

The plots were observed at least once or twice a month during the vegetation season. Five plots were observed for 3 years (1988 – 1990), and three plots for 2 years (1989, 1990). The study comprises species belonging to the *Agaricales* s. l., *Phallaceae, Lycoperdaceae, Cantharellaceae, Clavulinaceae* and *Hericiaceae*. All fruitbodies found were counted and their substrate and occurrence in particular soil layer was recorded (according to the location of the basal mycelium). All species were collected and examined microscopically. The determination of the difficult species was discussed with Dr. Pouzar. The genera *Marasmius, Collybia* and *Armillaria* were reexamined by Dr. V. Antonín, the species of genus *Russula* by Ing. J. Landa and the species of genus *Lactarius* by M. Beran. The main works used for the species identification were Jülich (1984), Moser (1978), Bas et al. (1988, 1990), and the monographs of the individual genera. The collections are deposited in the herbarium of the Department of Botany of the Charles University in Prague (PRC).

The number of fruitbodies of the individual species was added each year separately and expressed by using the following scale: 1 = 1 - 9, 2 = 10 - 99, 3 = 100 - 999. The use of a relatively rough scale was necessary because of the different number of "collecting days" on the individual plots. From the synthetic features of the mycosociological units (Šmarda 1968, Darimont 1973, Fellner 1987), the constancy is used and expressed as the number of plots where the particular species was found at least once.

The cluster analysis of the similarity of the species composition on the individual plots was computed by means of the PC-ORD program (McCune 1987) according to Ward's method. The similarity of the species composition was computed by the use of Euclidean distance. The presence (expressed as +) of the species on the plot was transformed for PC-ORD program by means of FYTORD program (Brabec 1989) according to van der Maarel scale (Westhoff et van der Maarel 1973).

The following terms are used in the description of the habitat conditions:

Degree of naturalness of the wood (according to Westhoff 1983, slightly modified): 1) near natural wood - almost not influenced by man; 2) subnatural wood - the tree species composition is natural, the age and space structure was slightly changed by random cutting and clearing in the past; 3) managed subnatural wood - the tree species composition is natural, the age structure is homogeneous thanks to the regular cutting and clearing. The phases of development of the wood were determined according to Ellenberg (1988).

Substrate diversity for lignicolous fungi: 1) big - the wood of all tree species occurring on the plot in all stages of decay is present; 2) middle - only fallen beech, exceptionally spruce stems in initial stages of decay present; 3) small - only beech stumps are numerous, exceptionally fallen beech stems, the total amount of dead wood is small; 4) slight - only scattered beech stumps are present, exceptionally fresh fallen beech stems.

The microrelief: 1) regular - the soil surface is almost plane with uniform surface humus layer; 2) irregular - the soil surface with small elevations around big stones and fallen trees where the mineral soil is naked and with small depressions where the leaf litter is accumulated. The plot consists of a mosaic of different microhabitats.

The vicinity of the plot: 1) undisturbed - the plot is surrounded by the continuous wood with a similar tree species composition; 2) disturbed - in the vicinity is e. g. a clearing or a forest road.

The ecological groups of fungi: 1) M - ectomycorrhizal fungi, 2) Pl - lignicolous parasites, 3) S - saprophytic fungi: 3a) St - terrestrial fungi that can be subdivided more accurately into fungi growing in detritus (Sd - on substrate in layers L and F), humicolous fungi (Sh - in layers H or A_h) fungicolous fungi (Sf - on the remains of old fruitbodies in the soil). 3b) The second group of saprophytes is represented by the lignicolous fungi (Sl) living on dead wood.

Localization of the plots

The permanent plots were distributed in southern Bohemia (Czechoslovakia) in Prachatice district.

B 1 - Boubín 1: 2,6 km ESE of the Kubova huť village, E slope of the Bazum ridge (Bazumský hřbet = Pažení), 1100 - 1120 m above sea level.

B 2 - Boubín 2: 2,9 km SE of the Kubova huť village, SE slope of the Bazum ridge, 1060 - 1100 m a. s. l.

Z 1 - Zátoňská hora: 2 km E of the Zátoň village, SW slope of the Zátoň mountain, 960 - 990 m a. s. l.

M 1 - Medvědice: 2,4 km NNE of the Stožec village, NNE slope of the small ridge E of the hill of the Stožec mountain, 940 m a. s. l.

RH 1 - Radvanovický hřbet: 1,7 km NNE of the České Žleby village, E slope of the southern part of the Radvanovice ridge, 900 - 940 m a. s. l.

L 1 - Libín 1: 3,2 km SSE of the centre of Prachatice, NE slope of the Libín mountain, 930 - 950 m a. s. l.

L 2 - Libín 2: 2,9 km SSE of the centre of Prachatice, NE slope of the Libín mountain, 850 - 880 m a. s. l.

P 1 - U Piláta: 2,8 km S of the Vitějovice village, ENE slope of Nebahov mountain, 600 - 640 m a. s. l.

The precise localization of the plots in the stands is described by Holec (1991). The plots B 1 - RH 1 are located in the Šumava mountains, the plots L 1, L 2, and P 1 in the Šumava foothills.

Habitat conditions on the plots

The bedrock of all plots are the acid silicate rocks. On the plot P 1 occurs granulite, on the plots L 1 and L 2 migmatite (Čech et al. 1963). The bedrock on the plots B 1, B 2, Z 1 and RH 1 consists of biotitic paragneiss; on the plot M 1 of porphyric amphibole-biotitic granodiorite (Kodym et al. 1963).

Table 1 – Habitat conditions on the permanent plots.

Nebahov	Radvanovický hřbet	Stožec - Medvědice	Zátoňská hora	Libín		Boubín		locality
P 1	RH 1	M 1	Z 1	L 1	L 2	B 2	B 1	plot
Dentario enneaphylli - Fagetum						Calamagrostio villosae - Fagetum		association
submontane 600 - 640	lower montane 850 - 990					upper montane 1060 - 1120		vegetation belt altitude /m/
moderately warm MT 3	moderately cold CH 7					cold CH 6		climatic region /Quitt 1971/
acid brown forest soil /cambisol/						leptic podzol		soil type
moder	mull			moder - mull		raw humus		humus type
5 - 10 %			10 - 20 %					humus percentage/A_h/
4,3 - 4,8		4,2 - 4,4	4,3	4,2 - 4,4		4,0 - 4,2		pH_{H_2O}/A_h/
10,0 - 14,5			14,5 - 17	10 - 14,5	14,5 - 17,0			C/N ratio of the surface humus
thin			thick	thin	thick		thin	detritus layer /L + F/
managed subnatural wood		near natural wood		subnatural wood		near natural wood		degree of naturalness
optimal - terminal + 90	+ 80	terminal + 165	late terminal + 200	terminal + 135	+ 140	late terminal + 210	+ 210	phase of development, age
slight	small	big		middle		big		substr. diversity for lignic. fungi
irregular	regular		irregular		regular			microrelief
disturbed	undisturbed							vicinity of the plot

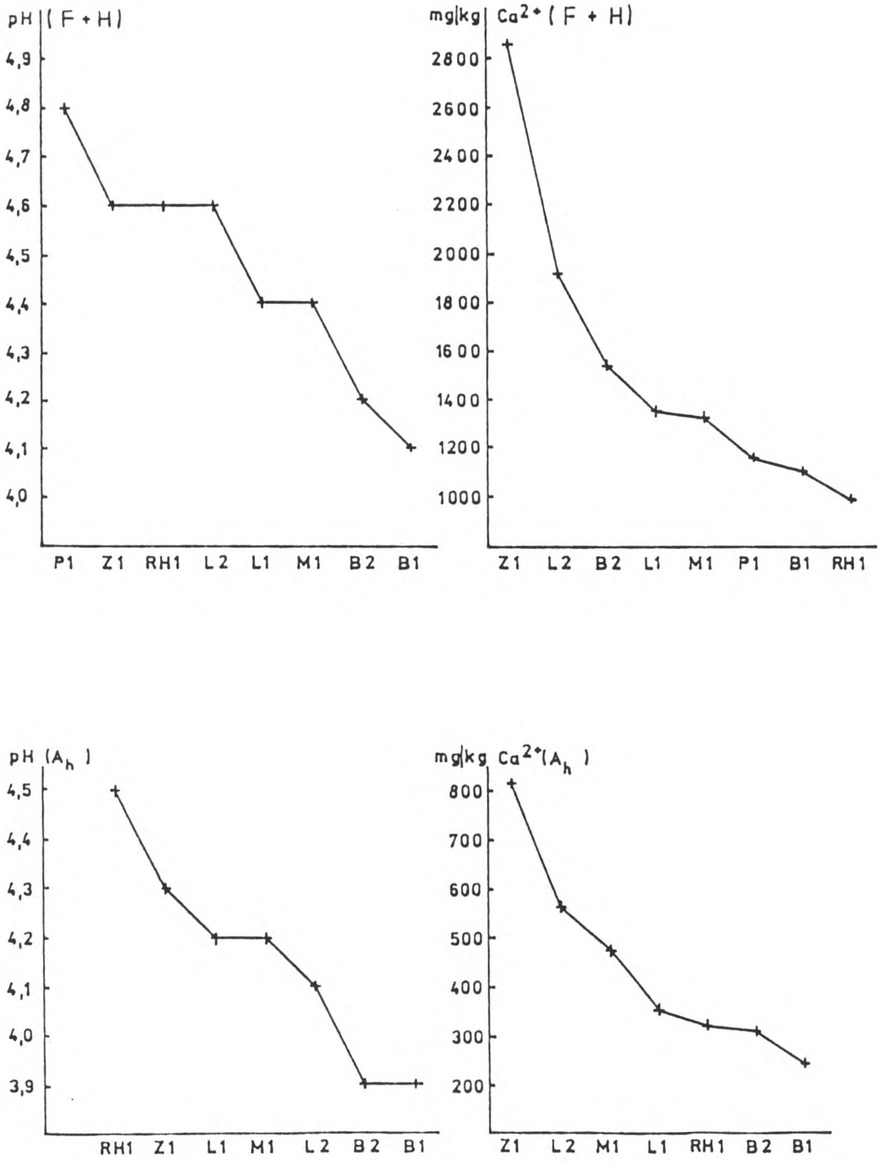

Fig. 1 – Gradients of the pH_{H_2O} – value and Ca content in the range of the permanent plots. The measurement was not carried out on the plot P 1 in the humous topsoil. F – fermentation layer, H – humification layer, A_h – humous topsoil.

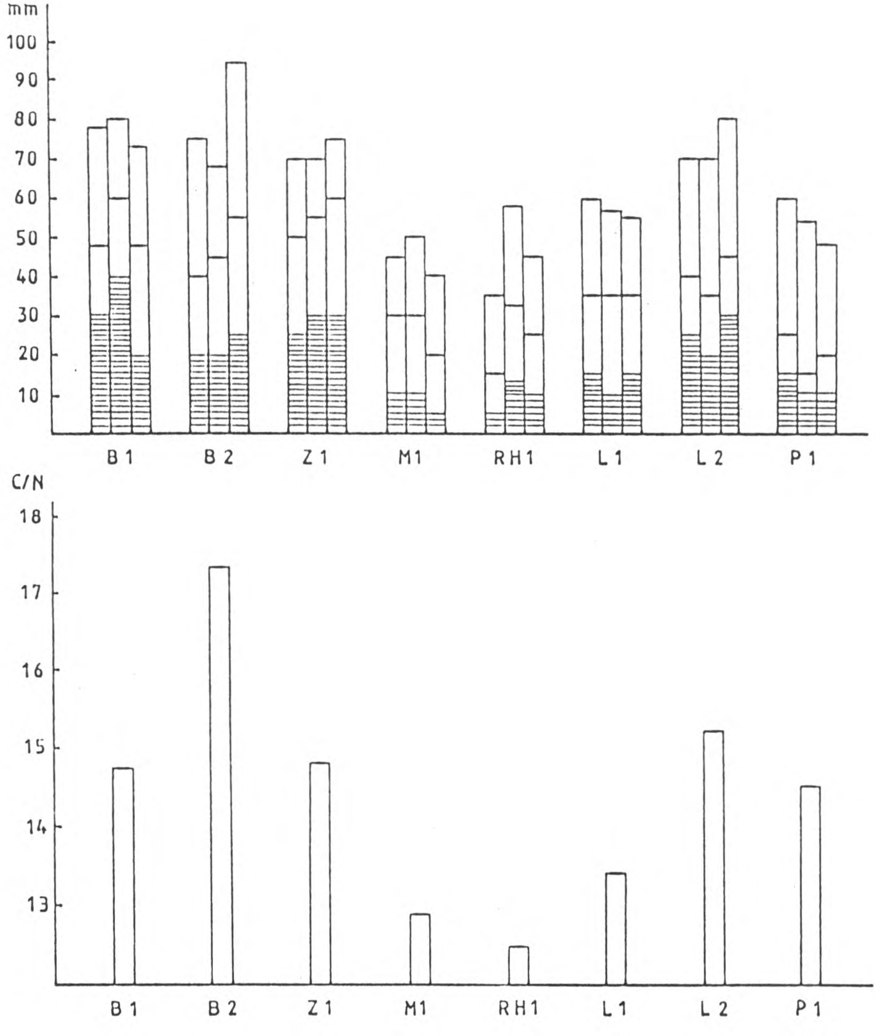

Fig. 2 – The thickness of the individual layers of the surface humus measured on three soil profiles per plot and the C/N ratio of the layers F + H. The upper graph: upper part of the bar – layer L, middler part – layer F (L + F = detritus), hatched part – layer H. Note the distinct correlation between these two factors.

The other ecological factors are summarized in table 1. The plots can be divided into three groups. The first group consists of acid soil beech woods of the association Calamagrostio villosae-Fagetum Mikyška 1972 in the montane belt (B 1, B 2). In the cold and humid climate at the altitude about 1100 m a. s. l., the raw humus of the intermediate form moder-mor develops. It is characterised by very low pH value (4,0 – 4,2) and by relatively high C/N ratio that shows only slight mineralization. Under such conditions the leptic podzol (Rosterde, kryptopodzol) with characteristic reddish-brown or rusty-brown layer B_{VS} develops here.

The second group involves the mull-moder and mull beech woods (brown earth-mull-moder beech woods and brown earth-mull beech woods according to Ellenberg 1988) of the association Dentario enneaphylli-Fagetum Oberdorfer ex W. et A. Matuszkiewicz 1960 in the montane belt (Z 1, M 1, RH 1, L 1, L 2). At the somewhat lower altitude and warmer climate and on the acid brown forest soils (Cambisol, Braunerde, kambizem oligobazická = hnědá lesní půda), the humus of the intermediate form moder-mull or true mull develops. It shows higher pH values (4,2 – 4,9) and more favourable C/N ratio than raw humus.

The third group involves the moder beech wood with very poor herbaceous layer in the submontane belt (P 1). The development of the moder is caused among others by the drying of the surface humus in summer as a consequence of warmer climate at the altitude about 600 m and the open area (clearing) in the vicinity.

Fig. 3 shows that the plant community is a very good indicator of the habitat conditions. The division of the plots almost agrees with the division mentioned above. However, it is obvious that on the basis of criteria mentioned above, the habitat conditions on many plots are very similar (Table 1). The other ecological factors are summarized in the middle part of table 1. The pH value increases from raw humus to mull (Fig. 1). The thickness of the detritus layer (Fig. 2) correlates with the C/N ratio because the plots B 2, L 2 and Z 1 with thick detritus layer show higher C/N ratio than the other plots (Table 1). The thick layer of leaf litter caused by very dense canopy cover releases by the decay a relatively high amount of Ca. This is very striking above all on the plot Z 1. (Fig. 1). It may be concluded that the humus form and the thickness of the surface humus layer are the most sensitive indicators of habitat conditions.

The last part of table 1 describes the changes in the tree species composition and in the space and age structure of the wood that were caused by forest management. The plots represent a range from the managed subnatural woods to near natural woods in optimal, terminal, or late terminal phase of development. All plots are located in continuous wood stands; only the plot P 1 is adjacent to the clearing. The hererogeneity of the plots P 1, Z 1, and L 1 is increased by the irregular microrelief that causes the changing of sites with thick layer of surface humus and sites with naked humous topsoil.

Results and discussion

The occurrence of the fungi on permanent plots and their association with the substrate

Mycorrhizal fungi

Their occurrence and constancy are given in table 2. From the total number of 72 species, 30 species were found only on one plot (41,7 %) and 12 on two plots (16,7 %). It means that more than one half of mycorrhizal fungi were the species with low constancy. These species are rare (e. g. *Russula salmoneolutea*) or associated only with specific habitat conditions or their fructification is sporadic. Ten species (12,5 %) occur on 6 – 8 plots: *Boletus fragilipes, Laccaria affinis, L. amethystea, Lactarius subdulcis, Russula cyanoxantha, R. ochroleuca, R. fellea, R. nigricans, Amanita rubescens,* and *Porphyrellus porphyrosporus.* They dominate by the number of fruitbodies too. The genera with the

Table 2 - The occurrence of the mycorrhizal fungi on the permanent plots.
The first number: number of years when the species was observed, the second number: number of fruitbodies recorded in the course of one year according to the scala mentioned in Material and Methods. C: constancy.

	B 1	B 2	Z 1	M1	RH 1	L 1	L 2	P 1	C
years of investigation	3	3	3	3	2	3	2	2	
Boletus fragilipes C. Martin	3.1-2	2.1-2	3.1-2	3.1-2	1.1	3.1-2	2.1-2	1.2	8
Laccaria affinis (Sing.) Bon	3.1-2	3.1-2	3.1	3.1-2	1.2	3.1-2	1.1	1.2	8
Laccaria amethystea (Bull.) Murrill	3.2	3.2	3.2	3.1-2	2.1	2.2	2.1-2	1.2	8
Lactarius subdulcis (Bull.: Fr.) S. F. Gray	3.2	3.2	3.2-3	3.1-2	2.1-2	3.1-2	2.1-2	1.1	8
Russula cyanoxantha (Schaeff.) Fr.	3.1	3.1	2.1	2.1	2.1	3.1	1.1	1.1	8
Russula ochroleuca Pers.	3.1-2	3.1-2	3.1-2	2.1	2.1	3.1-2	2.1	1.2	8
Amanita rubescens Pers. (: Fr.)	2.1	1.1	2.1	1.1	.	1.1	1.1	1.1	7
Russula fellea (Fr. : Fr.) Fr.	.	1.1	1.1	1.1	1.1	1.1	1.1	1.1	7
Russula nigricans Fr.	3.1-2	3.1	3.1	.	2.1	1.1	1.1	1.2	7
Porphyrellus porphyrosporus (Fr. in Fr. et Hök) Gilb.	2.1	3.1	2.1	2.1	.	.	1.1	1.1	6
Russula amethystina Quél.	.	2.1	3.1	2.1	.	.	2.1	1.1	5
Boletus subtomentosus L.	2.1	1.1	2.1	.	.	1.1	.	.	4
Hygrophorus eburneus (Bull.: Fr.) Fr.	.	1.1	1.1	.	2.1	1.1	.	.	4
Lactarius blennius (Fr.) Fr.	1.1	.	1.1	1.1	.	.	.	1.1	4
Russula brunneoviolacea Crawsh.	1.1	.	1.1	1.1	1.1	.	.	.	4
Russula laurocerasi Melzer	3.1	2.1	1.1	.	.	.	.	1.1	4
Russula mairei Sing.	2.1	3.1	.	.	.	.	1.1	1.1	4
Russula rigida Velen.	1.1	2.1	1.1	.	.	.	.	1.1	4
Russula aurora Krombh. sensu Melzer et Zvára	1.1	1.1	.	.	.	.	.	1.1	4
Boletus badius (Fr.) : Fr.	1.1	1.1	3.1.	.	.	.	.	.	3
Cortinarius delibutus Fr.	1.1	2.1-2	.	.	1.1	.	.	.	3
Hydnum rufescens Fr.	2.1.	.	.	2.1	.	.	.	1.1	3
Amanita battarrae Boud.	.	1.1	1.1	2.1.	.	.	.	.	3
Hygrophorus pustulatus (Pers.: Fr.) Fr.	1.1	.	.	2.1	1.1	.	.	.	3
Russula emetica (Schaeff.) Pers.: Fr.	.	.	.	.	.	1.1	1.1	1.1	3
Lactarius pallidus (Pers.: Fr.) Fr.	.	.	2.1	.	.	.	1.1	1.1	3
Lactarius ruginosus Romagn.	.	.	1.1	.	1.1	.	.	1.1	3
Russula vesca Fr.	.	.	.	.	2.1	2.1	.	1.1	3
Inocybe assimilata (Britz.) Sacc.	.	.	2.2	.	.	2.1-1	.	1.1	3
Amanita mappa (Batsch) Quél.	.	.	1.1	1.1	.	.	2.1	.	3

Laccaria proxima (Boud.) Pat.	1.1	1.1	.	.	.	.	.	.	2
Inocybe napipes Lange	3.1-2	2.1-2	.	.	.	.	.	.	2
Cantharellus tubaeformis (Bull.) : Fr.	3.1-2	.	1.2	.	.	.	.	.	2
Amanita gemmata (Fr.) Bertillon	1.1	.	1.1	.	.	.	.	.	2
Cortinarius sp. 4	3.1-2	.	1.1	.	.	.	.	.	2
Amanita submembranacea (Bon) Gröger	.	.	1.1	.	.	1.1	.	.	2
Inocybe geophylla (Fr.: Fr.) Kumm.	.	.	1.1	.	.	1.1	.	.	2
Gyroporus cyanescens (Bull.: Fr.) Quél.	.	.	.	2.1	.	2.1	.	.	2
Lactarius vellereus (Fr.) Fr.	.	.	2.1	.	.	.	.	1.1	2
Amanita phalloides (Fr.) Link	.	.	1.1	.	.	.	.	1.1	2
Boletus calopus Fr.	.	.	.	3.1	.	.	.	1.1	2
Tricholoma ustale (Fr.: Fr.) Kumm.	.	.	.	.	.	.	1.1	1.1	2
Amanita subalpina Moser	1.1	.	.	.	.	.	.	.	1
Hygrophorus hyacinthinus Quél.	1.1	.	.	.	.	.	.	.	1
Inocybe fuscidula Velen.	1.1	.	.	.	.	.	.	.	1
Lactarius ligniotus Fr.	1.1	.	.	.	.	.	.	.	1
Russula salmoneolutea Landa et Fellner	1.1	.	.	.	.	.	.	.	1
Cortinarius sp. 1	.	1.1	.	.	.	.	.	.	1
Russula xerampelina (Schaeff.) Fr.	.	1.1	.	.	.	.	.	.	1
Cortinarius sp. 2	.	.	1.1	.	.	.	.	.	1
Inocybe petiginosa (Fr.) Gill.	.	.	1.1	.	.	.	.	.	1
Hygrocybe sp.	.	.	1.1	.	.	.	.	.	1
Lactarius picinus Fr.	.	.	1.1	.	.	.	.	.	1
Russula chloroides (Krombh.) Bres.	.	.	1.1	.	.	.	.	.	1
Tricholoma columbetta (Fr.) Kumm.	.	.	1.1	.	.	.	.	.	1
Tylopilus felleus (Bull.: Fr.) P. Karst.	.	.	1.1	.	.	.	.	.	1
Russula lilacea Quél.	.	.	.	1.1	.	.	.	.	1
Russula nauseosa (Pers.) Fr.	.	.	.	.	1.1	.	.	.	1
Cortinarius sp.3	.	.	.	.	.	1.1	.	.	1
Hygrophorus penarius Fr.	.	.	.	.	.	1.1	.	.	1
Inocybe jacobi Kühn.	.	.	.	.	.	1.1	.	.	1
Inocybe soluta Velen.	.	.	.	.	.	1.1	.	.	1
Russula violeipes Quél.	.	.	.	.	.	3.1	.	.	1
Boletus edulis Bull.: Fr.	.	.	.	.	.	.	.	1.1	1
Lactarius piperatus (L.: Fr.) Pers.	.	.	.	.	.	.	.	1.1	1
Russula olivacea (Schaeff.) Pers.	.	.	.	.	.	.	.	1.1	1
Strobilomyces strobilaceus (Scop.: Fr.) Berk.	.	.	.	.	.	.	.	1.1	1
Cantharellus cibarius Fr.	.	.	.	.	.	.	.	1.1	1
Craterellus cornucopioides (L.) Pers.	.	.	.	.	.	.	.	1.1	1
Tricholoma saponaceum (Fr.) Kumm.	.	.	.	.	.	.	.	1.1	1
Tricholoma sulphureum (Bull.: Fr.) Kumm.	.	.	.	.	.	.	.	1.1	1
Tricholoma sciodes (Pers.) Martin	.	.	.	.	.	.	.	1.1	1

greatest number of species were *Russula* (19), *Lactarius* (8), *Amanita* (7), *Inocybe* (7), *Cortinarius* (5), *Tricholoma* (5), and *Boletus* (5).

The spruce *(Picea abies)* forms native and regular admixture on all plots. Fir *(Abies alba)* occurs on the plots B 1, B 2 and Z 1. Thus, it is not possible to decide explicitly if the species recorded form mycorrhizae with beech only. Consequently, the association with mycorrhizal partner is evaluated by using the literature data (e. g. Trappe 1962; Lisiewska 1972, 1974; Darimont 1973; Dörfelt 1973; Krieglsteiner 1980, 1987; Krieglsteiner et al. 1984; Kreisel et al. 1987).

The following species belong to the fungi associated above all with the beech: *Hygrophorus eburneus, L. pallidus, L. subdulcis, L. blennius, Russula fellea, R. mairei, R. olivacea, R. violeipes, R. salmoneolutea, Tricholoma ustale,* and *T. sciodes.* The following species recorded on the permanent plots are associated with beech and other deciduous trees: *Amanita phalloides, Inocybe petiginosa, I. jacobi, Hygrophorus penarius, Lactarius ruginosus, Russula aurora, Russula brunneoviolacea, R. laurocerasi, R. lilacea, R. rigida, Strobilomyces strobilaceus,* and *Tricholoma columbetta.* These 23 species make up only one third of the total number of species observed.

The admixture of coniferous trees on the permanent plots is slight but the influence on the occurrence of fungi is considerable. It enables the growth of the following "spruce" species: *Amanita battarrae, A. submembranacea, A. subalpina, Cantharellus tubaeformis, Hygrophorus hyacinthinus, H. pustulatus, Laccaria affinis, Lactarius ligniotus, L. picinus, Russula amethystina,* and *R. nauseosa* all of which represent 13 % of the total species number. The other species recorded (38 = 52,7 %) occur according to the literature both in deciduous and in coniferous or mixed woods.

The presence of species with the main centre of distribution in the montane belt is conspicious. They occur above all on the plot B 1 and B 2 and belong to the spruce symbionts: *Amanita submembranacea, A. subalpina, Hygrophorus hyacinthinus, Inocybe napipes, Lactarius ligniotus,* and *Russula amethystina.* In the spruce woods of the Boubín mountain, Lepšová (1988) recorded many species that occur on my plots: *Amanita rubescens, Amanita battarrae, Hygrophorus pustulatus, Boletus badius, Inocybe napipes, Lactarius ligniotus, Russula emetica,* and *R. ochroleuca.* These species grow here thanks to the presence of spruce and show that their occurrence is not restricted to pure spruce woods only.

From the beech woods in the colline belt of southern Moravia, Šmarda (1972) described the mycoassociation *Russulo (solari)-Lactarietum pallidae.* On his plots, species with the centre of distribution in colline and submontane belt dominate (e. g., *Boletus edulis, Craterellus cornucopioides, Russula olivacea, Strobilomyces strobilaceus, Tricholoma saponaceum, T. sciodes,* and *T. sulphureum*). In agreement with his results, these species were found only on the plot P 1 at the altitude of 600 m a. s. l. On the other hand, the species of the "lower altitudes" were observed in the montane belt at the altitude of 850 – 990 m: *Lactarius pallidus, L. ruginosus, Amanita phalloides, Inocybe jacobi, I. geophylla, I. petiginosa, Russula lilacea,* and *R. violeipes.* However, characteristic and dominant species of Šmarda's association as *Russula foetens, R. maculata, R. solaris, R. lepida,* and *Dermocybe cinnabarina* are lacking on my plots and seem to be restricted to lower altitudes. Fellner (1985) described the mycoassociation *Russulo salmoneoluteae-Amanitetum submembranaceae* from the beech woods of the Krkonoše mountains. Although its characteristic species almost all occur on my plots, the plots from Krkonoše differ by a smaller number of species (8 – 15, exceptionally 20) that relate to the wood damage caused by air pollution. The number of species on my plots was nearly two times higher (15 – 37). In addition, the species composition on the individual plots differs considerably (Fig. 3, Table 2) and cannot be identified with Fellner's association.

Terrestrial fungi

Their occurrence and constancy are given in table 3. From the total number of 69 species, 27 species were found on one plot only (39,1 %), and 11 species (15,5 %) on two plots. These species may be rare, or their fructification and occurrence on the plots is occasional. Ten species were observed on 6 – 8 plots (14 %): *Collybia asema, C. aquosa, C. peronata, Mycena galopus, M. pura, M. sanguinolenta, M. zephirus, Galerina* sp. 1, *Psathyrella friesii,* and *P. impexa.* The genera with the greatest number of species were *Mycena* (17), *Collybia* (12), *Clitocybe* (6), *Entoloma* (5), and *Psathyrella* (4).

The influence of the altitude on the occurrence of the individual species of terrestrial fungi was not so pronounced as in mycorrhizal fungi. Lisiewska (1972) observed the same situation in Poland where identical species grow in the low-lying as well as in the montane beech woods. However, the genera *Agaricus, Lepista,* and *Macrolepiota* mentioned by Šmarda (1972) from the beech wood in the colline belt were not found on my plots, obviously because of the acid to very acid surface humus and because of colder climate.

Species growing in layer L on almost undecayed beech leaves (Table 5): 6 species (8,7 % of the total number of terrestrial species on the plots) – *Collybia peronata, Clitocybe menthiodora, C. ditopus* (on the spruce needles), *Mycena mucor, M. stylobates, M. rorida.*

Species growing in the fermentation layer (F) on decaying beech leaves, bark, nuts, and herbaceous plants: 36 species (52,2 %); e. g. *Psathyrella friesii, P. impexa, Collybia aquosa, C. dryophila, Mycena cinerella, M. vitilis, M. zephirus,* and other species with index F (Table 5).

Species growing both in layer L and F (in detritus): 10 species (14,5 %) – *Collybia asema, C. confluens, C. hariolorum, Cystoderma carcharias, Marasmius androsaceus* (on

Table 3 - The occurrence of the terrestrial fungi on the permanenet plots.
Explanatory notes see Material and Methods and table 2.

	B 1	B 2	Z 1	M 1	RH 1	L 1	L 2	P 1	C
years of investigation	3	3	3	3	2	3	2	2	
Sh									
Clavulina cinerea (Bull.: Fr.) Schroet.	.	1.1	2.1-2	1.1	1.1	.	.	.	4
Entoloma conferendum (Britz.) Noordel.	.	.	.	.	1.1	1.1	1.1	1.1	4
Collybia maculata (Alb. et Schw.: Fr.) Kumm.	.	.	.	.	.	2.1	.	.	1
Pholiota gummosa (Lasch) Sing.	.	1.1	.	.	.	.	.	.	1
Armillaria bulbosa (Barla) Kile et Watling	.	.	1.2	.	.	.	.	.	1
Entoloma nitens (Velen.) Noordel.	.	.	.	.	.	.	1.1	.	1
Coprinus semitalis Orton	.	.	.	2.1	.	.	.	.	1
Clitocybe gibba (Pers.: Fr.) Kumm.	.	.	.	1.1	.	.	.	.	1
Sh - Sd									
Phallus impudicus L.: Pers.	.	.	.	.	.	1.1	2.1	2.1-2	3
Entoloma politum (Pers.: Fr.) Donk	.	.	.	.	1.1	.	.	.	1
Sd									
Collybia asema (Fr.: Fr.) Kumm.	2.1-2	3.1-2	3.2	3.1	2.1-2	2.1-2	1.1	1.1	8
Collybia peronata (Bolt.: Fr.) Kumm.	.	3.2-3	3.2	3.1-2	1.2	3.1-2	2.1-2	1.1	7
Mycena pura (Pers.: Fr.) Kumm.	1.3	1.1	2.1	2.1	2.1-2	1.1	1.1	.	7
Psathyrella friesii Kits van Wav.	2.1	1.1	2.1	2.1	1.2	2.1	1.1	.	7
Psathyrella impexa (Romagn.) Bon	1.1	1.1	1.1	3.1	1.1	1.1	1.1	.	7
Collybia aquosa (Bull.: Fr.) Kumm.	.	3.1-2	1.1	2.1	1.1	1.1	1.1	.	6
Galerina sp. 1	2.1	1.1	2.1	2.1	1.1	.	1.1	.	6
Mycena zephirus (Fr.: Fr.) Kumm.	2.1-2	3.1	2.1-2	2.1-2	.	1.1	1.1	.	6
Collybia confluens (Pers.: Fr.) Kumm.	.	1.1	1.1	3.1-2	1.1	.	1.2	.	5
Mycena amicta (Fr.) Quél.	3.1	1.1	1.1	2.1	.	2.1	.	.	5
Mycena cinerella P. Karst.	1.1	2.1	.	2.1	.	2.1	1.1	.	5
Mycena metata (Fr.) Kumm.	.	2.1	2.1	1.1	2.1	2.1	.	.	5
Collybia dryophila (Bull.: Fr.) Kumm.	.	.	1.1	2.1	2.1	.	1.1	.	4
Cystoderma carcharias (Pers.) Fayod	2.1	.	1.1	2.1	1.1	.	.	.	4
Flammulaster carpophilus (Fr.) Earle	1.1	1.1	.	3.1-2	.	.	1.1	.	4
Galerina sp. 2	2.1-2	2.1	1.1	.	1.1	.	.	.	4
Psilocybe crobulus (Fr.) M. Lange ex Sing.	2.1	1.1	1.1	1.1	.	.	.	.	4
Strobilurus esculentus (Wulf.: Fr.) Sing.	1.1	1.1	1.1	.	.	1.1	.	.	4

Mycena vitilis (Fr.) Quél.	1.1	1.1	.	2.1	.	.	.	.	3
Clitocybe langei Hora	1.1	2.1	.	.	1.1	.	.	.	3
Collybia tuberosa (Bull.: Fr.) Kumm.	3.1-2	.	2.1	2.1	.	.	.	.	3
Marasmius androsaceus (L.) Fr.	2.2	.	1.2	.	1.1	.	.	.	3
Mycena stylobates (Pers.: Fr.) Kumm.	1.1	.	.	1.1	.	1.1	.	.	3
Collybia hariolorum (DC.: Fr.) Quél.	.	.	1.2	.	.	2.1	2.1-2	.	3
Psathyrella murcida (Fr.) Kits van Vav.	.	.	1.1	2.1	.	.	1.1	.	3
Galerina atkinsoniana A. H. Smith	3.1	.	2.1-2	.	.	.	.	.	2
Collybia cookei (Bres.) J. D. Arnold	2.1-2	.	2.1	.	.	.	.	.	2
Collybia obscura Favre	1.1	.	.	.	1.1	.	.	.	2
Clitocybe menthiodora Harmaja	1.1	.	.	.	1.2	.	.	.	2
Pseudoclitocybe cyathiformis (Bull.: Fr.) Sing.	.	.	1.1	2.1	.	.	.	.	2
Mycena filopes (Bull.: Fr.) Kumm.	.	.	.	1.2	1.2	.	.	.	2
Clitocybe fragrans (With.: Fr.) Kumm.	.	.	1.1	.	1.1	.	.	.	2
Conocybe rickeniana Sing.	.	.	1.1	.	.	.	.	1.1	2
Mycena longiseta Höhn.	1.1	.	.	.	.	.	.	.	1
Mycena rorida (Scop.: Fr.) Quél.	1.1	.	.	.	.	.	.	.	1
Mycena mucor (Batsch : Fr.) Gill.	1.1	.	.	.	.	.	.	.	1
Nyctalis asterophora Fr.	1.1	.	.	.	.	.	.	.	1
Pluteus salicinus (Pers.: Fr.) Kumm.	.	.	1.1	.	.	.	.	.	1
Mycena capillaris (Schum.: Fr.) Kumm.	.	.	.	1.1	.	.	.	.	1
Mycena diosma Krieglsteiner et Schwöbel	.	.	.	1.1	.	.	.	.	1
Mycena flavescens Velen.	.	.	.	1.1	.	.	.	.	1
Coprinus domesticus (Bolt.: Fr.) S. F. Gray	.	.	.	3.1	.	.	.	.	1
Lycoperdon echinatum Pers.: Pers.	.	.	.	.	1.1	.	.	.	1
Marasmius cohaerens (Alb. et Schw.: Fr.) Cooke et Quél.	.	.	.	.	1.1	.	.	.	1
Clitocybe ditopus (Fr.: Fr.) Gill.	.	.	.	.	1.1	.	.	.	1
Entoloma nidorosum (Fr.) Quél.	.	.	.	.	1.1	.	.	.	1
Coprinus xanthothrix Romagn.	.	.	.	.	2.1	.	.	.	1
Marasmius rotula (Scop.: Fr.) Fr.	.	.	.	.	.	.	1.1	.	1
Tubaria sp.	.	.	.	.	.	.	1.1	.	1
Clitocybe clavipes (Pers.: Fr.) Kumm.	.	.	.	.	.	.	1.1	.	1
Mycena polyadelpha (Lasch) Kühn.	.	.	.	.	.	.	1.1	.	1
Collybia cirrhata (Schum.: Fr.) Kumm.	.	.	.	.	.	.	1.1	.	1
Sd - Sl									
Mycena galopus (Pers.: Fr.) Kumm.	3.1-3	2.1-2	2.1	3.1	2.1	3.1-2	1.1	.	7
Mycena sanguinolenta (Alb. et Schw.: Fr.) Kumm.	2.1-2	3.1-2	3.1-2	3.1-2	1.1	1.2	1.1	.	7
Entoloma cetratum (Fr.: Fr.) Moser	3.1	2.1	1.1	.	1.1	1.1	.	.	5
Stropharia aeruginosa (Curtis : Fr.) Quél.	1.1	.	1.1	.	.	.	.	.	2
Stropharia caerulea Kreisel	.	.	.	1.1	1.1	.	.	.	2
Agrocybe praecox (Pers.: Fr.) Kumm.	.	.	.	.	1.1	.	2.1-2	.	2
Psathyrella obtusata (Fr.) A. H. Smith	.	.	.	2.1	.	.	.	.	1

Table 4 - The occurrence of the lignicolous fungi on the permanent plots.
Explanatory notes see Material and Methods and table 2.

	B 1	B 2	Z 1	M 1	RH 1	L 1	L 2	P 1	C
years of investigation	3	3	3	3	2	3	2	2	
Sd - Sl									
Pholiota lenta (Pers.: Fr.) Sing.	3.1-2	3.2	3.1	3.1	1.1	1.1	2.1	2.1	8
Cystoderma longisporum (Kühn.) Heinem. et Thoen	3.1-	3.1	2.1	2.1	1.1	2.1	2.1	.	7
Sl									
Megacollybia platyphylla (Pers.: Fr.) Kotl. et Pouz.	1.1	2.1	3.1-2	3.1-2	2.1-2	3.1	2.1	2.2	8
Mycena galericulata (Scop.: Fr.) S. F. Gray	3.2	3.1-2	3.1-3	2.1-2	2.1-2	3.2-3	2.2	1.1	8
Mycena haematopus (Pers.: Fr.) Kumm.	3.2-3	3.1-2	2.1	2.1-2	1.1	2.2	2.1	1.1	8
Mycena renati Quél.	3.2-3	3.2	2.1	1.2	2.1-2	3.2-3	2.3	2.2-3	8
Oudemansiella mucida (Schrad.: Fr.) Höhn.	2.2	3.1-2	1.1	3.1	1.1	2.1	2.1	1.1	8
Pluteus atricapillus (Batsch) Fayod	3.2	2.1	3.1	3.1	2.1	3.1-2	2.1-2	1.2	8
Hypholoma sublateritium (Fr.) Quél.	1.1	1.2	.	1.2	2.2	1.1	2.1	1.2	7
Marasmius alliaceus (Jacq.: Fr.) Fr.	3.2	3.2	3.2	3.2	2.2	2.1	2.1	.	7
Galerina marginata (Batsch) Kühn.	3.2	1.1	2.1-2	2.1	1.1	1.1	.	.	6
Hypholoma fasciculare (Huds.: Fr.) Kumm.	.	1.2	1.2	1.1	2.3	2.2	.	1.2	6
Kuehneromyces mutabilis (Schaeff.: Fr.) Sing. et A. H. Smith	2.1-2	2.2	.	2.2	2.2-3	1.2	.	1.2	6
Mycena abramsi Murrill	1.1	2.2	1.1	1.1	.	2.1	1.1	.	6
Mycena maculata P. Karst.	2.1-2	1.1	2.1-2	1.1	2.1	.	.	.	5
Mycena polygramma (Bull.: Fr.) S. F. Gray	1.1	.	1.1	2.1	2.1	.	1.1	.	5
Polyporus varius (Pers.) Fr.	.	.	2.1	3.1	1.1	3.1	.	1.1	5
Xerula radicata (Relh.: Fr.) Dörfelt	.	.	2.1	1.1	2.1	.	1.1	1.1	5
Mycena crocata (Schrad.: Fr.) Kumm.	.	.	3.1	3.1	1.1	1.1	.	.	4
Mycena leptocephala (Pers.: Fr.) Gill.	2.1	.	1.1	1.1	1.1	.	.	.	4
Mycena rubromarginata (Fr.: Fr.) Kumm.	3.1-2	2.1	1.1	1.1	.	.	.	.	4
Mycena viridimarginata P. Karst.	2.1-2	3.1-2	.	1.1	.	2.1	.	.	4
Mycena viscosa (Secr.) R. Maire	3.2-3	1.1	2.1	1.1	.	.	.	.	4
Pluteus pouzarianus Sing.	3.1	1.1	1.1	.	.	.	1.1	.	4

Mycena stipata Maas Geesteranus et Schwöbel	2.1	3.1	1.1	.	.	.	.	.	3
Galerina triscopa (Fr.) Kühn.	3.1-2	1.1	.	.	.	1.1	.	.	3
Lycoperdon foetidum Bon.	1.1	1.1	1.1	.	.	.	.	.	3
Hericium flagellum (Scop.) Pers.	2.1	2.1	.	3.1	.	.	.	.	3
Hypholoma capnoides (Fr.: Fr.) Kumm.	3.2-3	3.1	.	.	1.1	.	.	.	3
Coprinus micaceus (Bull.: Fr.) Fr.	.	2.1	1.2	.	.	1.2	.	.	3
Lycoperdon perlatum Pers.: Pers.	2.1	.	1.1	.	.	.	.	1.1	3
Mycena arcangeliana Bres. in Barsali	.	.	2.2	3.1-3	2.2	.	.	.	3
Galerina pseudocamerina Sing.	2.1	1.1	.	.	.	.	.	.	2
Mycena purpureofusca (Peck) Sacc.	3.2	3.1-2	.	.	.	.	.	.	2
Panellus stypticus (Bull.: Fr.) P. Karst.	2.1	1.1	.	.	.	.	.	.	2
Tricholomopsis rutilans (Schaeff.: Fr.) Sing.	1.1	1.1	.	.	.	.	.	.	2
Galerina stylifera (Atk.) A. H. Smith et Sing.	.	1.1	1.1	.	.	.	.	.	2
Galerina sp. 3	.	3.1	2.1-2	.	.	.	.	.	2
Gymnopilus hybridus (Fr.: Fr.) Sing.	.	1.1	2.2	.	.	.	.	.	2
Pluteus punctipes Orton	1.1	.	.	1.1	.	.	.	.	2
Clitocybula lacerata (Scop.) Métrod	.	2.2	.	1.1	.	.	.	.	2
Xeromphalia campanella (Batsch : Fr.) R. Maire	1.2	.	.	2.3	.	.	.	.	2
Lycoperdon pyriforme Schaeff.: Pers.	.	2.1-2	.	1.2	.	.	.	.	2
Bolbitius aleuriatus (Fr.: Fr.) Sing.	1.1	.	.	1.1	.	.	.	.	2
Omphalina sp.	2.1-2	.	.	1.1	.	.	.	.	2
Phyllotopsis nidulans (Pers.: Fr.) Sing.	1.1	.	.	.	.	.	1.2	.	2
Hypholoma marginatum (Pers.) Schroet.	.	1.1	.	.	1.1	.	.	.	2
Tricholomopsis decora (Fr.) Sing.	.	.	2.1	.	1.1	.	.	.	2
Psathyrella piluliformis (Bull.: Fr.) Orton	.	.	.	.	2.2	.	.	1.1	2
Polyporus brumalis (Pers.) : Fr.	.	.	.	.	.	1.1	1.1	.	2
Galerina ampullaceocystis Orton	1.1	.	.	.	.	.	.	.	1
Crepidotus applanatus (Pers.) Kumm.	2.1	.	.	.	.	.	.	.	1
Crepidotus subsphaerosporus (Lange) Kühn. et Romagn.	1.1	.	.	.	.	.	.	.	1
Mycena picta (Fr.) Harmaja	2.1	.	.	.	.	.	.	.	1
Mycena epipterygia (Scop.: Fr.) S. F. Gray	1.1	.	.	.	.	.	.	.	1
Mycena fagetorum (Fr.) Gill.	1.1	.	.	.	.	.	.	.	1
Mycena silvae - nigrae Maas Geesteranus et Schwöbel	1.1	.	.	.	.	.	.	.	1

	B 1	B 2	Z 1	M 1	RH 1	L 1	L 2	P 1	C
years of investigation	3	3	3	3	2	3	2	2	
Omphalina epichysium (Pers.: Fr.) Quél.	2.1	.	.	.	.	.	.	.	1
Pleurotus ostreatus (Jacq.: Fr.) Kumm.	1.2	.	.	.	.	.	.	.	1
Pluteus roseipes Höhn.	1.1	.	.	.	.	.	.	.	1
Galerina sideroides (Fr.) Kühn.	.	1.1	.	.	.	.	.	.	1
Mycena olida Bres.	.	1.2	.	.	.	.	.	.	1
Mycena simia Kühn.	.	1.1	.	.	.	.	.	.	1
Mycena niveipes Murrill	.	1.1	.	.	.	.	.	.	1
Armillaria cepistipes Velen.	.	1.2	.	.	.	.	.	.	1
Pholiota flammans (Fr.) Kumm.	.	3.2	.	.	.	.	.	.	1
Pluteus atromarginatus (Sing.) Kühn.	.	1.1	.	.	.	.	.	.	1
Lentinellus cochleatus (Pers.: Fr.) P. Karst.	.	.	1.2	.	.	.	.	.	1
Entoloma hispidulum (M. Lange) Noordel.	.	.	1.1	.	.	.	.	.	1
Hydropus marginellus (Pers.: Fr.) Sing.	.	.	1.2	.	.	.	.	.	1
Hydropus trichodermus (Joss. in Kühn.) Sing.	.	.	1.1	.	.	.	.	.	1
Pholliota flammuloides Moser	.	.	2.2	.	.	.	.	.	1
Stropharia albocyanea (Fr.) Quél.	.	.	1.1	.	.	.	.	.	1
Hydropus subalpinus (Höhn.) Sing.	.	.	.	1.1	.	.	.	.	1
Lentinus adhaerens (Alb. et Schw.: Fr.) Fr.	.	.	.	2.1	.	.	.	.	1
Clitocybe lignatilis (Pers.: Fr.) P. Karst.	.	.	.	1.1	.	.	.	.	1
Pholiota astragalina (Fr.) Sing.	.	.	.	.	1.1	.	.	.	1
Psathyrella fragrans A. H. Smith	.	.	.	.	1.2	.	.	.	1
Psathyrella fulvescens var. brevicystis Kits van Wav.	.	.	.	.	.	1.1	.	.	1
Galerina cinctula Orton	.	.	.	.	.	1.1	.	.	1
Crepidotus mollis (Schaeff.: Fr.) Kumm.	.	.	.	.	.	1.1	.	.	1
Pluteus phlebophorus (Ditm.: Fr.) Kumm.	.	.	.	.	.	.	1.1	.	1
Pleurotus serotinus (Schrad.) Fr.	.	.	.	.	.	.	.	1.1	1
Pl - Sl									
Psathyrella sarcocephalus (Fr.) Sing.	1.1	1.1	3.2-3	1.2	.	.	.	.	4
Pholiota cerifera (P. Karst.) P. Karst.	.	.	.	.	1.2	2.1-2	1.1	.	3
Polyporus squamosus (Huds.) Fr.	.	.	.	2.1	.	1.1	1.1	.	3
Pl									
Armillaria ostoyae (Romagn.) Herink	1.1	1.1	.	.	.	.	.	.	2
Pholiota squarrosa (Müll.: Fr.) Kumm.	1.2	.	.	.	1.2	.	.	.	2
Pleurotus pulmonarius (Fr.) Quél.	.	.	2.1-3	.	.	.	1.1	.	2

needles), *Mycena amicta, M. galopus, M. metata, Mycena pura,* and *Strobilurus esculentus* (spruce cones).

Species growing in layer H or A_h: 10 species (14,5 %) - *Clavulina cinerea, Entoloma conferendum,* etc. (Table 5).

Species growing on the decaying mosses (on the soil surface, stones and fallen stems): 6 species (8,7 %) - *Galerina* sp. 1 and sp. 2, *G. atkinsoniana, Clitocybe langei, Pseudoclitocybe cyathiformis,* and *Lycoperdon echinatum.*

Fungicolous species: *Nyctalis asterophora, Collybia tuberosa.*

It is obvious that the individual species of terrestrial fungi are divided into various layers of the surface humus or humous topsoil and grow on specific substrate in these layers (e. g. leaves, bark, nuts, plant rests, cones). The microrelief is of a great importance for the occurrence of terrestrial fungi. In the depressions where the leaf litter is accumulated grows regularly e. g. *Collybia peronata,* on the flat sites where the layer F consists of mixture of beech leaves, bark, and small twigs occurs e. g. *Mycena amicta* and on the sites without surface humus e. g. *Clavulina cinerea* is to be found. Table 1 is the evidence of differences in humus form, thickness of the surface humus layer, microrelief and other properties of humus and soil. Consequently, the number of species and the species composition on the individual plots differ considerably.

The species growing in individual layers of the surface humus correspond to the various succession stages of the decay of the leaves and other components of detritus. Only a small number of species decompose the leaves in layer L. The most important members of these fungi are *Collybia asema* and above all *C. peronata.* The group of species growing in the fermentation layer is very numerous. This layer is the place of the greatest occurrence of mycelia and represents the layer with the highest biological activity. Fourty one species from the total number of terrestrial fungi recorded on all plots (69) occur on the distinguishable remains of beech leaves in the surface humus. The other species grow on substrate mentioned above.

Lignicolous fungi

Their occurrence and constancy are summarized in table 4. From the total number of 89 species found on all plots, 33 species (37,1 %) were recorded on one plot only and 21 (24,4 %) on two plots. It means that two thirds of lignicolous species were scarce within the framework of the plots. It is related to the small area investigated because the plot of 2500 m^2 cannot provide all substrate types in various stages of decay needed for the growth of some lignicolous species. Fourteen species occurred on 6 - 8 plots (15,7 % of the total number of lignicolous species): *Megacollybia platyphylla, Mycena galericulata, M. haematopus, M. renati, Oudemansiella mucida, Pholiota lenta, Pluteus atricapillus,* etc.

Table 5 - The occurrence of terrestrial fungi on substrates in various layers of surface humus and humous topsoil. C: constancy, H: H + Ah, ba: bark, co: spruce cones, dw: decaying wood, fr: old fruitbodies of Russula or Lactarius, gr: grass leaves, lv: beech leaves, mo: decaying mosses, nd: spruce needles, nu: beech nuts. The species growing on mosses can be observed on stones (sto), stumps (stu) or stems (ste). +: 1 - 5 records, ++: 6 - 20 records, +++: more than 20 records.

C	species	lay	substrate								
		er	lv	gr	nd	nu	co	ba	dw	mo	fr
	Sh										
4	Clavulina cinerea	H	+++								
4	Entoloma conferendum	H	+++								
1	Collybia maculata	H			+						
1	Pholiota gummosa	H	+								
1	Armillaria bulbosa	H	+								
1	Entoloma nitens	H	+								
1	Coprinus semitalis	H	+								
1	Clitocybe gibba	H	+								
	Sh - Sd										
3	Phallus impudicus	H	++								
		F	++								
3	Entoloma politum	H	+								
		F	+								
	Sd										
8	Collybia asema	L	+++								
7	Collybia peronata	L	+++								
		F	++								
7	Mycena pura	L	++								
7	Psathyrella friesii	F	+++						+		
		L	+								
7	Psathyrella impexa	F	+++						+		
6	Collybia aquosa	F	+++								
		H	+								
6	Galerina sp. 1	Sto								+++	
6	Mycena zephirus	F	+++	++		+		+	+		
5	Collybia confluens	F	+++						+		
		L	++								
5	Mycena amicta	F	++						+		
		L	++			+		+			
5	Mycena cinerella	F	+++				+				
5	Mycena metata	F	++						+		
4	Collybia dryophila	F	++								
4	Cystoderma carcharias	F	++						+		
		L	+		+						
4	Flammulaster carpophilus	F	++			++					
4	Galerina sp. 2	Ste								++	
4	Psilocybe crobulus	F		++					+		
		L		+							
4	Strobilurus esculentus	F					+				
		H					+				
3	Mycena vitilis	F	++					+	+		
3	Clitocybe langei	Sto								+	
3	Collybia tuberosa	F	++								+
3	Marasmius androsaceus	L			++						
		F						+	+		

C	species	layer	substrate								
			lv	gr	nd	nu	co	ba	dw	mo	fr
3	Mycena stylobates	L	++								
3	Collybia hariolorum	F	++								
		L	++								
3	Psathyrella murcida	F	++								
		L	+								
2	Galerina atkinsoniana	Sto								+	
		Stu								+	
2	Collybia cookei	F	++						+		
2	Collybia obscura	F	+								
2	Clitocybe menthiodora	L	+	+							
2	Pseudoclitocybe cyathiformis	Sto								+	
2	Mycena filopes	F	++						+		
2	Clitocybe fragrans	F	+								
2	Conocybe rickeniana	F	+						+		
1	Mycena longiseta	F	+								
1	Mycena rorida	L	+								
1	Mycena mucor	L	+								
1	Nyctalis asterophora	F									+
1	Pluteus salicinus	F	+								
1	Mycena capillaris	F	+								
1	Mycena diosma	F	+								
1	Mycena flavescens	F	+								
1	Coprinus domesticus	F	++								
		L	+								
1	Lycoperdon echinatum	Ste								+	
1	Marasmius cohaerens	F	+								
1	Clitocybe ditopus	L			+						
1	Entoloma nidorosum	F	+								
1	Coprinus xanthothrix	F	+								
1	Marasmius rotula	F									
1	Tubaria sp.	F	+								
1	Clitocybe clavipes	F	+								
1	Mycena polyadelpha	F	+								
1	Collybia cirrhata	F	+								
	Sd - Sl										
7	Mycena galopus	F	+++	++				++	++		
		L	++								
7	Mycena sanguinolenta	F	+++			++		+	++		
5	Entoloma cetratum	F	++						++		
2	Stropharia aeruginosa	F	+						+		
2	Stropharia caerulea	F	+						+		
2	Agrocybe praecox	F	++						+		
1	Psathyrella obtusata	F	+						+		

Table 6 - The occurrence of the lignicolous fungi on wood in various stages of decay. C: constancy, A: Abies alba, C: wood of conifers, F: Fagus silvatica, P: Picea abies br: branches, rt: roots of the living trees above the soil surface, se: fallen stems, ste: stems of the living trees, su: stumps, v: wood in soil, +: 1 - 5 records, ++: 6 - 20 records, +++: more than 20 records.

C	species	tree sp.	part of tree	stage of decay 1	2	3	4
	Sd - Sl						
8	Pholiota lenta	F	br,v			+++	++
	sometimes on beech leaves in layer L or F						
7	Cystoderma longisporum	F	se,su			++	+++
		A	se			+	+
	sometimes on decaying mosses on stones, wood and soil						
	Sl						
8	Megacollybia platyphylla	F	se,su,br,v		+	++	+++
	sometimes in layer F around the fallen beech stems						
8	Mycena galericulata	F	se,su,br,v		+	+++	++
8	Mycena haematopus	F	se,su,br,v		++	+++	+
8	Mycena renati	F	se,br,v		+++	++	+
8	Oudemansiella mucida	F	se,su,br	+++	++	+	+
8	Pluteus atricapillus	F	se,su,br,v		+	+++	++
7	Hypholoma sublateritium	F	se,su		++	+	+
7	Marasmius alliaceus	F	se,br,v		+	++	+++
6	Galerina marginata	F	se,su,br,v			+++	++
		C	su		+	++	+
6	Hypholoma fasciculare	F	se,su		+++	++	
		J	se		+	++	
6	Kuehneromyces mutabilis	F	se,su	+++	++	+	+
6	Mycena abramsi	C	se		+	+++	++
5	Mycena maculata	C	se,su			++	+++
5	Mycena polygramma	F	v				++
5	Polyporus varius	F	br	+	+++	+	
5	Xerula radicata	F	v				++
4	Mycena crocata	F	se,br,v				++
4	Mycena leptocephala	F	su			+	
		C	se			+	+
4	Mycena rubromarginata	C	se		+	++	+
4	Mycena viridimarginata	C	se,su			++	+++
4	Mycena viscosa	A	se,su,v		+++	+	+
4	Pluteus pouzarianus	C	se,su		++	+	+
3	Mycena stipata	F	se				+
		C	se		+		++
3	Galerina triscopa	F	se				+
		C	se			+	
3	Lycoperdon foetidum	F	se,su			+	+
3	Hericium flagellum	A	se			++	
3	Hypholoma capnoides	C	se,su		+	+++	+
3	Coprinus micaceus	F	se,su		+	++	
3	Lycoperdon perlatum	F	se,v			+	++
	observed also in layer L						
3	Mycena arcangeliana	F	se,su,br		+	++	+++
2	Galerina pseudocamerina	F	se			+	
		A	se				+
2	Mycena purpureofusca	C	se,su,v		++	+++	+
2	Panellus stypticus	F	se	+	+		
2	Tricholomopsis rutilans	C	se,su			+	+
2	Galerina stylifera	F	se			+	
		A	br			+	

C	species	tree sp.	part of tree	stage of decay 1	2	3	4
2	Galerina sp. 3	C	se			++	+
2	Gymnopilus hybridus	C	se,br			+	
2	Pluteus punctipes	F	se	+		+	
2	Clitocybula lacerata	C	se			+	+
2	Xeromphalia campanella	C	se,su			+	+
2	Lycoperdon pyriforme	F	se			+	
		A	su			+	
2	Bolbitius aleuriatus	F	se,su			+	+
2	Omphalina sp.	A	se,v				+
2	Phyllotopsis nidulans	F	se		+	+	
2	Hypholoma marginatum	C	su,br		+	+	
2	Tricholomopsis decora	C	se			+	+
2	Psathyrella piluliformis	F	se,su		+	+	
2	Polyporus brumalis	F	se,br		+		
1	Galerina ampullaceocystis	F	se,br				+
1	Crepidotus applanatus	F	se				+
1	Crepidotus subsphaero - sporus	A	se		+		
1	Mycena picta	F	se				+
	observed also in layer	F	on bark				
1	Mycena epipterygia	P	br		+		
1	Mycena fagetorum	F	v			+	
1	Mycena silvae - nigrae	A	su			+	
1	Omphalina epichysium	A	se			+	+
1	Pleurotus ostreatus	F	se	+			
1	Pluteus roseipes	A	se				+
1	Galerina sideroides	A	su			+	
1	Mycena olida	F	se		+		
1	Mycena simia	P	se		+		
1	Mycena niveipes	F	v				+
1	Armillaria cepistipes	F	se				+
1	Pholiota flammans	C	se			+	
1	Pluteus atromarginatus	C	se				+
1	Hydropus trichodermus	A	se			+	
1	Lentinellus cochleatus	A	su			+	
1	Entoloma hispidulum	P	v				+
1	Hydropus marginellus	A	su				++
1	Pholiota flammuloides	F	su			+	
1	Stropharia albocyanea	F	v				+
1	Hydropus subalpinus	F	br		+		
1	Lentinus adhaerens	C	su				+
1	Clitocybe lignatilis	F	se			+	
1	Pholiota astragalina	P	su				+
1	Psathyrella fragrans	F	se		+		
1	Psathyrella fulvescens	F	se				+
1	Galerina cinctula	F	v				+
1	Crepidotus mollis	F	se	+			
1	Pluteus phlebophorus	F	se		+		
1	Pleurotus serotinus	F	se		+		
	Pl - Sl						
4	Psathyrella sarcocephalus	F	ste				
3	Pholiota cerifera	F	ste,rt,se				
3	Polyporus squamosus	F	ste,se				
	Pl						
2	Armillaria ostoyae	P	rt				
2	Pholiota squarrosa	F	rt				
		A	rt				
2	Pleurotus pulmonarius	P	ste				

(Table 4). The genera with the greatest number of species were *Mycena* (21), *Galerina* (8), *Pholiota* (6), *Pluteus* (6), *Hypholoma* (4), and *Psathyrella* (4). Many species belong to critical or rare fungi, e. g. *Entoloma hispidulum, Hydropus trichoderma, Mycena picta, M. silvae-nigrae, Pluteus roseipes, Pholiota flammuloides,* and *Psathyrella fulvescens.*

On the high-lying plots B 1, B 2, and Z 1 (scarcely also on the plots M 1, L 1 and L 2), some montane species were found. However, they belong to the coniferous woods fungi: *Mycena viridimarginata, Pluteus pouzarianus, Hericium flagellum, Omphalina epichysium,* and *Hydropus marginellus.*

Only on the beech wood, 45 species were observed (50,5 %), e. g. above mentioned species with high constancy, *Polyporus varius, Mycena crocata, Coprinus micaceus,* etc. (Table 6).

On the coniferous wood, 33 species were found (37,1 %). On both spruce and fir wood 17 species were observed, e. g. *Mycena maculata, M. rubromarginata, Pluteus pouzarianus,* etc. Five species were recorded on the spruce wood only: *Armillaria ostoyae, Entoloma hispidulum, Mycena epipterygia, M. simia, Pholiota astragalina;* on the fir wood only there were 11 species: *Crepidotus subsphaerosporus, Galerina sideroides, Hericium flagellum, Hydropus marginellus, H. trichoderma, Lentinellus cochleatus, Mycena silvae-nigrae, M. viscosa, Omphalina epichysium,* and *Pluteus roseipes.*

On both deciduous and coniferous wood, 11 species were recorded (12,4 %): *Cystoderma longisporum, Galerina pseudocamerina, G. stylifera, G. triscopa, G. marginata, Hypholoma fasciculare, Lycoperdon pyriforme, Mycena leptocephala, M. stipata, Pleurotus pulmonarius,* and *Pholiota squarrosa.*

It is surprising that beech wood species make only 50 % of all species observed. The small admixture of spruce and fir wood causes the considerable increasing of species number, although the amount of beech wood on the plots is always higher.

On the wood in various stages of decay, a great number of mycoassociations were described and summarized e. g. by Darimont (1973), Runge (1980), Kreisel (1985), and Fellner (1988). These fungal communities are located on individual stems, stumps, and pieces of wood, and are characterized mostly by ascomycetes or species of the order *Aphyllophorales* s. l. The comparison with my plots is not possible, as these groups of fungi have not been studied and the species on one plot have been recorded on various substrate.

The occurrence of the fruitbodies of individual species was observed in dependence on the stage of wood decay. The fruitbodies were found mostly in more stages, but each species had a "peak" of its fructification in a particular stage (Table 6). These characteristic species of the individual stages of the wood decay are listed in the following survey. For the evaluation of the stage of wood decay, simple empirical scale based on easily recognizable features was used:

Stage 1: fresh-fallen stems, twigs and branches with bark and without any visible changes in the wood structure – *Oudemansiella mucida, Kuehneromyces mutabilis.*

Stage 2: wood without bark, the wood structure is slightly damaged but still hard – *Mycena renati, M. viscosa, Hypholoma fasciculare, H. sublateritium, Pleurotus pouzarianus,* and *Polyporus varius.*

Stage 3: rotten wood with distinct damaged structure, by the touch is soft, but the initial shape of stem or branch is still visible – *Mycena galericulata, M. haematopus, M. abramsi, M. rubromarginata, M. purpureofusca, Galerina marginata, Hericium flagellum, Hypholoma capnoides, Pholiota lenta,* and *Pluteus atricapillus.*

Stage 4: the wood structure is completely destroyed, the wood is soft, decayed into pulp and partly mixed with surface humus, the initial shape is not discernable – *Cystoderma longisporum, Megacollybia platyphylla, Marasmius alliaceus, Mycena crocata, M. arcangeliana, M. maculata, M. polygramma, M. stipata, M. viridimarginata,* and *Lycoperdon perlatum.*

The occurrence of fungi on the wood in various stages of decay studied e. g. Kuthan (1988) with the help of similar scale. His results are almost identical with those of mine. Kreisel (1961) and e. g. Runge (1975) distinguished the initial, optimal and final phase of fungal succession on dead wood. Stage 1 corresponds to the initial phase when the fungi of the order *Aphyllophorales* s. 1. should dominate and when only a small number of gilled fungi was observed (Table 6). Stage 2 seems to correspond to the beginning of optimal phase and stage 3 belong obviously to the late optimal phase or early final phase. Since stage 3, the number of species increases considerably. Stage 4 represents the final phase of succession where the great number of species were observed but mostly rare or in a small number of fruitbodies.

Relations between the ecological factors on the plots and the occurrence of fungi

The species with the constancy 6 – 8 have a relatively broad ecological amplitude in the range of the plots investigated because of the occurrence on plots that differ significantly in the habitat conditions. On the other hand, some species with constancy 1 – 4 were associated distinctly with specific ecological factors on some plots. Such species have seemingly narrower ecological amplitude in the range of beech woods investigated and can serve as ecological indicators of the habitat conditions.

Mycorrhizal fungi

Some species with lower constancy show a distinct preference for particular humus type that relates also to pH value and C/N ratio (Table 1). Only on the plots with mull or mull-moder (scarcely also on the plot P 1 with moder, but with the highest pH value of all plots), *Gyroporus cyanescens, Inocybe assimilata, I. geophylla, Lactarius pallidus, L. ruginosus, Amanita citrina,* and *A. submembranacea* were found. The same edaphic preference of these species observed Tyler (1984) with exception of *Amanita citrina* that he observed on more acid soils and *Lactarium ruginosus* that was not found by him. *Amanita submembranacea* seems to have no distinct preference for humus type, as it was found e. g. by Kubička (1982) in acid raw humus too. The next species associated with mull were *Inocybe geophylla* and *I. petiginosa.* They are regarded to be an element of the beech woods on calcareous soils (e. g. Dörfelt 1985, Kreisel et al. 1987). However, they can also grow in montane beech woods on acid silicate rocks, obviously thanks to the presence of the mull with favourable biological properties (Table 1).

To the plots with raw humus and moder, *Russula aurora* and *R. mairei* were confined. *Cantharellus tubaeformis, Cortinarius delibutus, Inocybe napipes,* and *Laccaria proxima* were observed only on the plots with raw humus. These observations agree with the data given by Tyler (1984). To this group belong also *Amanita subalpina, Hygrophorus hyacinthinus,* and *Lactarius ligniotus* that are associated with spruce.

The biggest number of species was recorded on the plots Z 1, P 1, and B 1 (Fig. 4). However, their species composition differs considerably (Fig. 3). On the plot B 1 occur many species associated with raw humus and observed also in spruce woods (Lepšová 1988). On the other hand, on the plot P 1 (600 - 640 m a. s. l.) there occur mainly species without distinct soil preference and growing above all in the colline and submontane belt. These species are almost lacking on other plots. The occurrence of *Amanita phalloides, Craterellus cornucopioides,* and *Strobilomyces strobilaceus* relates to the slight warm climate of this plot. Acidophilous species *Cantharellus cibarius* and *Boletus calopus* occur on places with naked humous topsoil whose pH was by 0,2 - 0,3 lower than the pH of surface humus (Holec 1991). Plot Z 1 represents somewhat heterogeneous habitat where the places with thick mull layer change with places without surface humus (Table 1). The community of mycorrhizal fungi is composed of a mixture of species with various ecological demands. Surprising is the presence of many species that should occur at lower altitude and milder climate. Their occurrence at the altitude of 990 m is obviously enabled by the sunny SW aspect of the plot. A relatively high Ca content of the surface humus (Fig. 1) corresponds to the occurrence of species mentioned above all on calcareous soils (*Inocybe geophylla, I. petiginosa, Lactarius ruginosus*). Their presence as well as the occurrence of many mull preferring species can be explicated by favourable properties of the mull that is the ''richest'' one of all plots. On the other hand, acidophilous species *Cantharellus tubaeformis* and *Tylopilus felleus* grow here on highly decayed wood in soil. The species *Laccaria affinis, Lactarius vellereus,* and *Inocybe* sp. div. prefer the sites with naked humous topsoil.

The smallest number of mycorrhizal species occurs on the plots M 1, RH 1, and L 2. Although the properties of the mull humus on the plots M 1 and RH 1 are very similar to that one on the plot Z 1, the number of species is considerably lower. The only difference of these plots is the microrelief. The plots M 1, RH 1, and L 2 are covered by a continuous layer of mull that is obviously unfavourable for the occurrence of some mycorrhizal species. The same results published Tyler (1984) and Kost et Haas (1989). They also observed that on sites with mull or big nutrient supply the number and percentage of mycorrhizal species is lower than on sites with ''poorer'' and more acid humus.

The only difference between the plots L 1 – L 2 and B 1 – B 2 is the thickness of the detritus layer that is bigger on the plots L 2 and B 2. The number of species on these plots is smaller than on the plots L 1 and B 1 with thin detritus layer.

All factors discussed are summarized in fig. 4. It is obvious that a great number of mycorrhizal species can be found in all vegetation belts of beech woods investigated. However, the species composition is different in every belt (Table 2, Fig. 3). The heterogeneity of the plot caused by irregular microrelief (Z 1, P 1, L 1) enables the occurrence of a greater number of species than the homogeneous layer of mull (M 1, RH 1). The cluster analysis show (Fig. 3) that the division of the plots based on the species composition of mycorrhizal fungi is very similar to that one based on the analysis of the plant relevés. It means that the occurrence of fungi on the plots is in close relation to the factors that determine also the species composition of the plant community.

The species composition and the number of species in beech woods represented by permanent plots is influenced above all by the following factors:

1 – The presence of the mycorrhizal partner. The species with high constancy do not require special habitat conditions. The only condition of their occurrence on the plots seems to be the presence of the partner tree species.

2 – The altitude together with the climate define above all the species composition. Some species were observed only in the montane belt, other species in the submontane belt. The distribution of these species over the altitude gradient was very distinct. Some species were observed at higher altitude than it is common for them (on mull).

3 – The humus type and the pH value influence mainly the species composition on the plot. The humus type preference of some species is very distinct. Such species were confined to mull and mull-moder or to raw humus only. Many species do not require a

specific humus type. The continuous layer of mull seems to be unfavourable for some mycorrhizal species.

4 – The microrelief and the thickness of the detritus layer. On the plots with regular microrelief (covered by continuous detritus layer), the number of species was smaller than on the plots with irregular microrelief where some mycorrhizal species occur on places with naked humification layer or humous topsoil. On the plots with thick detritus layer, the number of species is smaller in comparison with similar plots covered with a thin detritus layer. The thick layer of detritus seems to have an inhibition effect on the occurrence (or fructification?) of the mycorrhizal fungi.

The influence of the microclimate was not studied precisely, but its importance can be demonstrated on the plot P 1 where some warmth requiring species of the genera *Amanita, Boletus, Lactarius,* and *Russula* grow at the sunny margin of the plot that is adjacent to a clearing. The influence of other ecological factors was not studied.

Terrestrial fungi

In most terrestrial fungi, the distinct preference for the particular humus type was not observed. Generally, the correlation between the occurrence of individual species and ecological factors on the plot was less distinct than in the group of mycorrhizal fungi. The association of terrestrial fungi with substrates in individual layers of the surface humus was much more pronounced. The evaluation of the ecological demands of species with constancy 1 (66 % of the total number of terrestrial species) is not possible because of their scattered or rare occurrence. In addition, the distribution of many typical beech wood fungi at the locality seems to be random. Such species are not inevitably recorded on the relatively small plot investigated. Both Tyler (1984) and e. g. Lisiewska (1972) also did not observe the distinct humus type preference of terrestrial fungi. They found most species in a broad range of various beech woods. It is caused by the fact that beech leaves as the main substrate are present in all types of beech woods.

The species *Phallus impudicus* and *Collybia hariolorum* show the correlation of their occurrence with warmer climate of the plots in the Šumava foothills.

The biggest number of species was recorded on the plots Z 1, M 1 and RH 1 with mull (Fig. 5). Their fermentation layer is very diverse and consists of leaves, rests of plants, bark, and pieces of wood. The decay of surface humus proceeds continually thanks to the relatively favourable pH valaue, moderately cold and humid climate, and steady mesoclimate inside the near natural (''virgin'') wood (M 1, Z 1) or subnatural wood with dense canopy cover (RH 1). It represents very favourable conditions for the growth of terrestrial fungi as well as the continuous detritus layer (M 1, RH 1) or thick and diverse detritus layer (Z 1). The importance of factors mentioned results from the comparison with

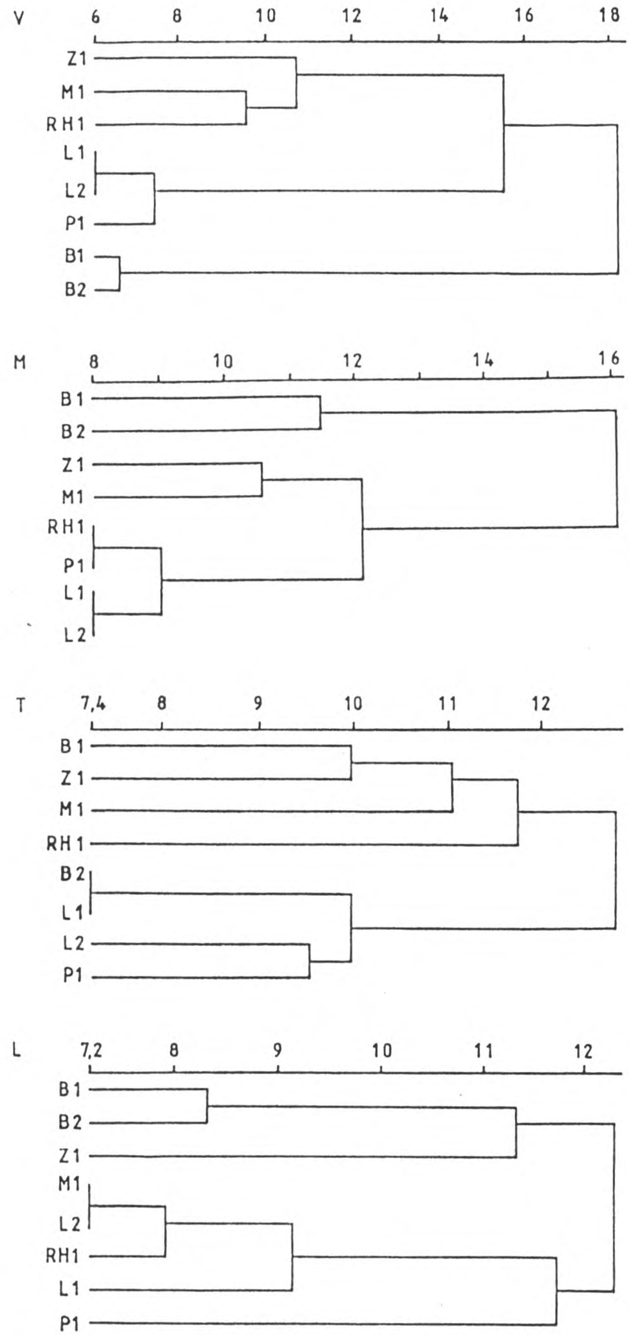

Fig. 3 – Cluster analysis of the similarity of the species composition on the permanent plots. The similarity is expressed by the use of the Euclidean distance. V – vascular plants (on the basis of phytosociological relevés), M – mycorrhizal fungi, T – terrestrial fungi, L – lignicolous fungi.

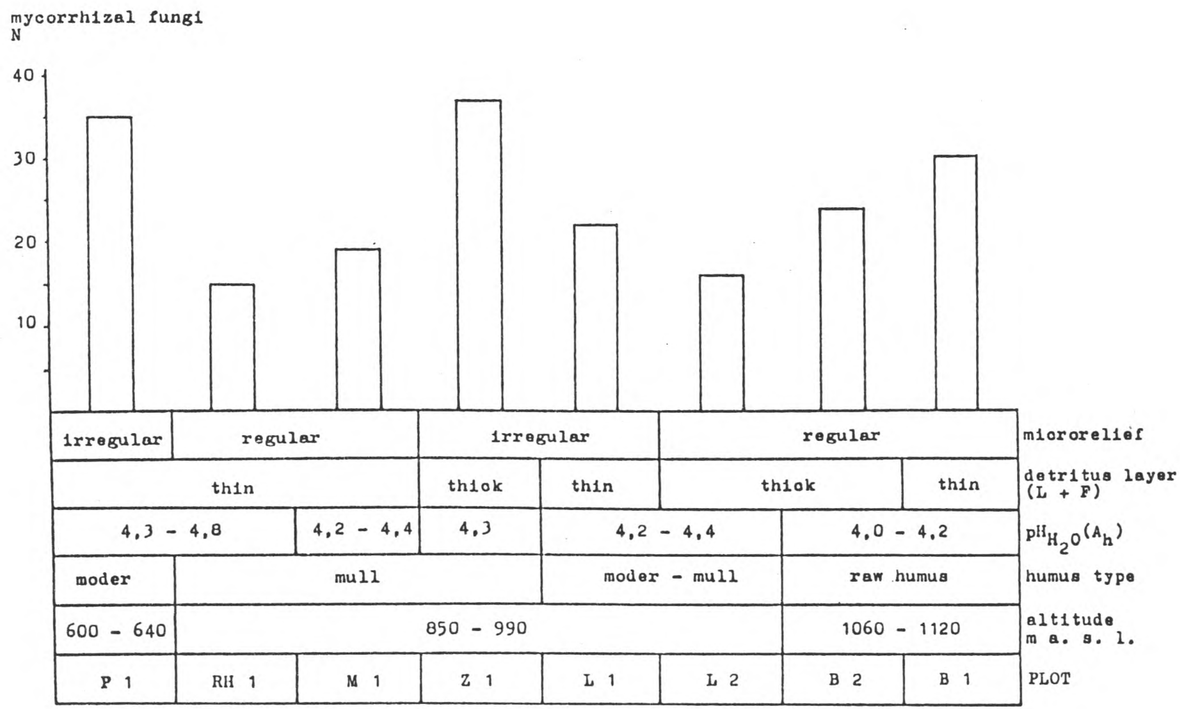

Fig. 4 – The most important factors that influence the species composition and number of mycorrhizal species in the beech woods represented by the permanent plots. N – number of species.

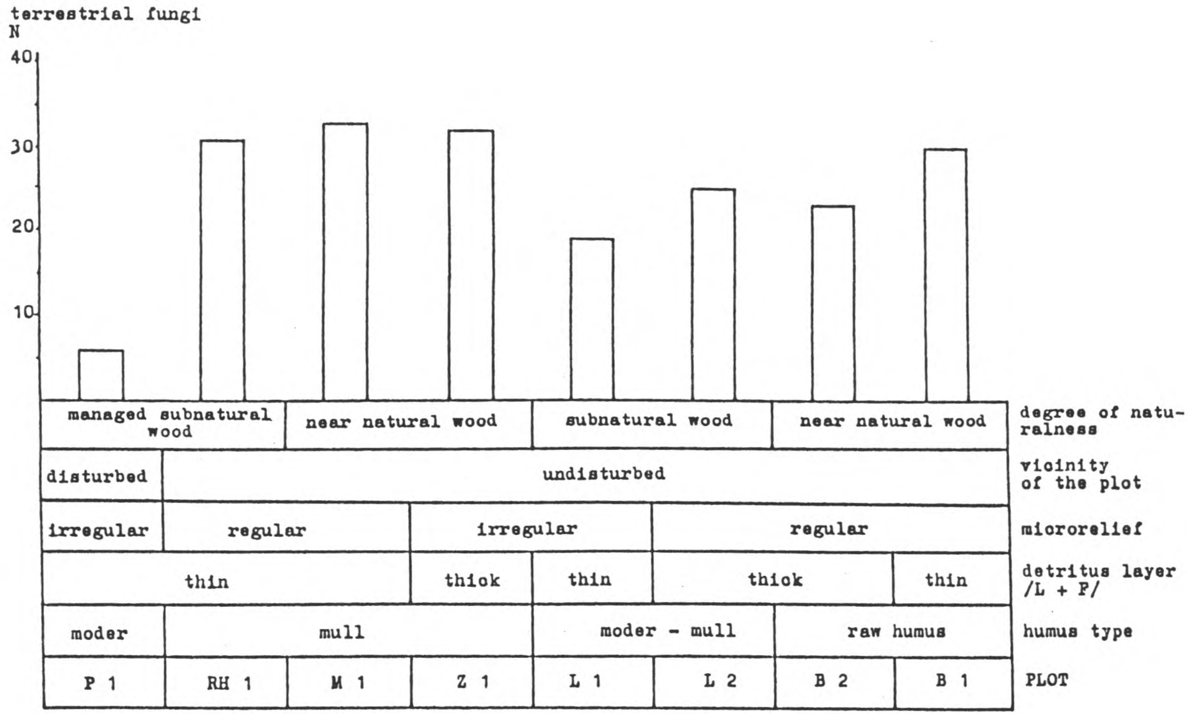

Fig. 5 - The most important factors that influence the species composition and number of terrestrial species in the beech woods represented by the permanent plots. N - number of species.

the plot P 1 where only 7 species of terrestrial fungi occur. The slight warm climate of the plot together with the open area in the vicinity cause the drying of the surface humus in summer. Such fluctuation of the mesoclimate and discontinuation of the decomposition is extremely unfavourable for the occurrence and fructification of the terrestrial fungi.

Fewer species were recorded on the plots with raw humus (B 1, B 2) and mull-moder (L 2). These humus types are not so favourable for the terrestrial fungi as mull. It shows distinctly the plot B 2 where the thick, uniform, and acid detritus layer enables the growth of only restricted number of species. The importance of the microrelief results from the comparison of the plots L 1 and L 2. The irregular microrelief on the plot L 1, where the places without detritus layer occur, relates to smaller number of species in comparison with the plot L 2 where the microrelief is regular.

According to the similarity of the species composition of the terrestrial fungi, the plots were divided into two main groups (Fig. 3). The first group consists of mull beech woods and the plot B 1, the second one of the the mull-moder, moder, and acid soil beech woods. The division of the plots is different from the division based on the similarity of the plant communities or communities of mycorrhizal fungi (Fig. 3). It means that the occurrence of the terrestrial fungi is determined by other combination of ecological factors than in the case of mycorrhizal fungi. The seemingly slight difference between plots B 1 and B 2 in the thickness of the humus layer causes the big difference of the species composition on these plots. The same effect has the microrelief on the plots L 1 and L 2. However, the second reason of these differences is the random occurrence of many terrestrial species, as was mentioned above.

The species composition and the number of species of terrestrial fungi in the beech woods represented by permanent plots is influenced above all by the following factors (Fig. 5):

1 – The humus type influences above all the number of species on the plot. Mull is the most favourable humus type for the occurrence of a great number of species including taxa with rare or random character of occurrence and distribution.

2 – The mesoclimate. The steady mesoclimate of near natural woods and subnatural woods with dense canopy cover form very favourable conditions for terrestrial fungi. On such plots they grow without the disturbing influence of the drying of the surface humus and without the big temperature and humidity fluctuations. These fluctuations are increased on the plot with open area in the vicinity and cause the reduction of the species number.

3 – The microrelief. The number of species is higher on the plots with homogeneous detritus layer caused by regular microrelief than on the plots where the detritus layer is removed in some sites because of the irregular microrelief. Thus, the space available for the terrestrial fungi is decreased, as most of species grow in the detritus layer.

4 – The thickness of the detritus layer. The thick layer of detritus represents a relatively uniform substrate for terrestrial fungi. On such plots (B 2, L 2), the number of species is smaller than on the plots with diverse mull layer (Z 1, M 1, and RH 1), where the proportions of the individual surface humus layers are well-balanced.

The other factors as microclimate, influence of the animals, etc. were not studied.

Lignicolous fungi

The biggest number of species was found in the near natural woods on the Boubín mountain (B 1, B 2). The big substrate diversity is combined with the steady mesoclimate of the natural wood (Fig. 6). In addition, these plots are located in an extensive complex of similar woods that represent natural refugium of many rare lignicolous macrofungi (Kubička 1973). Although the habitat conditions on the plots Z 1 and M 1 are very similar, these plots are located in small remains of near natural woods. It seems to be the cause of the smaller number of species observed.

The plots L 1 and L 2 (subnatural woods) and RH 1 (managed subnatural wood) are occupied by a considerably smaller number of species. It is in relation to the middle or small substrate diversity of these plots where only stumps and fresh fallen stems occur. The smallest number of lignicolous species was observed on the plot P 1 because of slight substrate diversity and big fluctuation of the mesoclimate that causes the drying of the wood in summer.

The occurrence of *Mycena crocata* on the plots with mull only is very interesting. It grows on small pieces of decaying wood in the soil. The association with mull was also observed by Tyler (1984).

The cluster analysis (Fig. 3) shows a similarity of the species composition on the plots B 1, B 2, and Z 1. These plots are located in the Boubin mountain group and are characterized by admixture of fir and spruce. The occurrence of species associated with coniferous and particularly fir wood delimitates this group of plots. On the other plots the fir absent and the spruce is present very scarcely. The plot P 1 differs by the occurrence of species frequent in the cultural woods (Table 4) and growing on wood in initial stages of decay.

Fig. 6 shows that the number of species and the presence of many rare and infrequent species are in close relation to the increasing degree of naturalness of the wood and increasing substrate diversity of the plot. The mesoclimate is also very important. It is influenced by the character of the wood on the plot and in the vicinity. The temperature and humidity fluctuations inside the wood effect unfavourably on the occurrence and fructification of lignicolous fungi. The other important factors such as the imission damage of wood or the composition of the substrate were not studied.

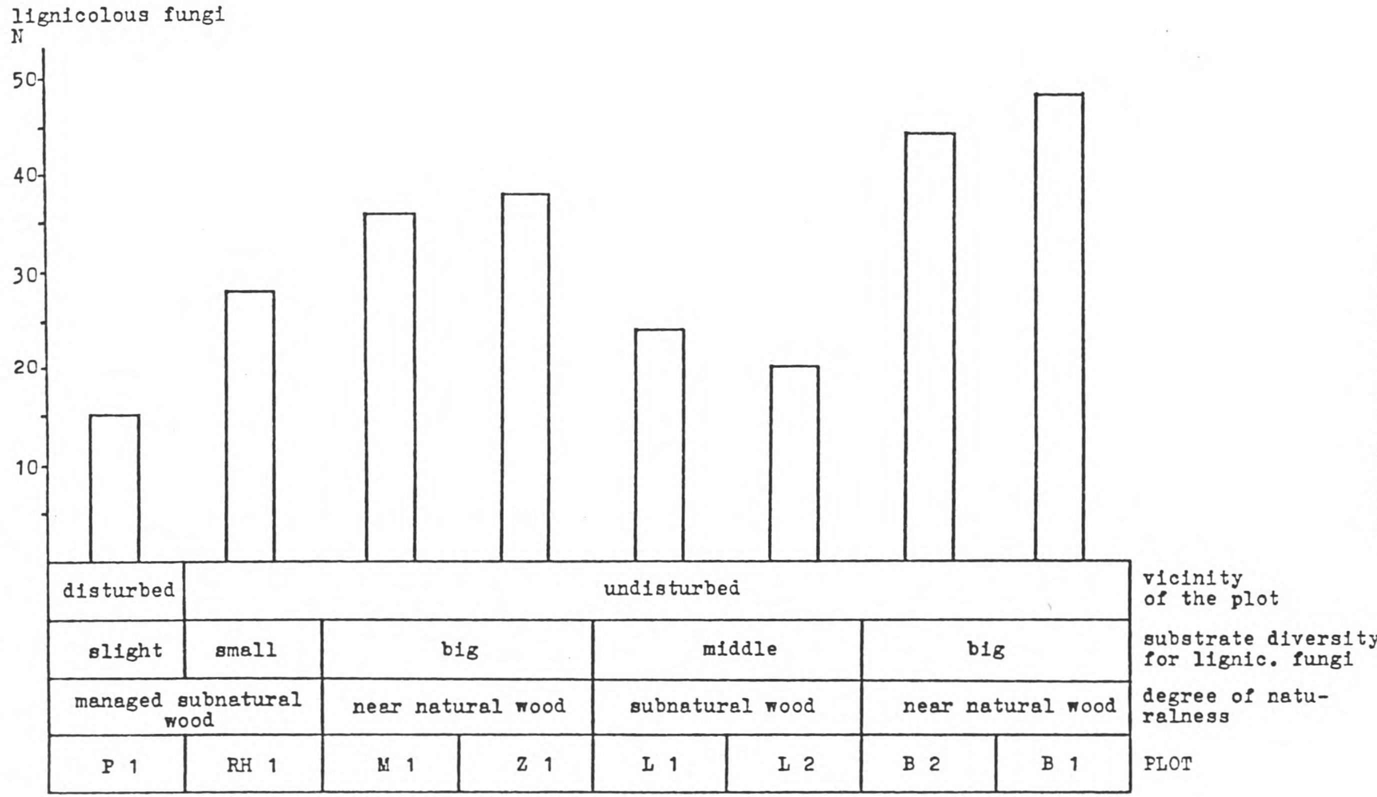

Fig. 6 – The most important factors that influence the species composition and number of lignicolous species in the beech woods represented by the permanent plots. N – number of species.

The share of the ecological groups of fungi on the plots

The share of the lignicolous species of the order Agaricales in the total number of species observed on individual plots rises along with the increasing degree of naturalness of the wood. In the managed subnatural wood it amounts to about 25 % (P 1), in the near natural woods to about 45 % (B 1, B 2). The causes have already been discussed. The proportion of the terrestrial and mycorrhizal species is determined above all by the properties of the surface humus. The thick detritus layer, the presence of mull, and regular microrelief prefer the occurrence of the terrestrial fungi and restrict the occurrence of many mycorrhizal species. It is clearly distinct on the plots M 1, RH 1, and L 2, where the share of terrestrial fungi is about 45 % and the share of mycorrhizal fungi about 25 % only. The ratio of the mycorrhizal and the terrestrial fungi varies from 1 : 1,6 to 1 : 2,1 in favour of terrestrial fungi. On the other hand, on the plots with mull (Z 1) and mull-moder (L 2), but with irregular microrelief the share of both terrestrial and mycorrhizal fungi is about 30 % and their ratio is approximately 1,2 : 1 in favour of mycorrhizal species. Thus, the considerable influence of the irregular microrelief (or in other words the heterogeneity of the plot surface) on the proportion of these two ecological groups of fungi is apparent. The ratio is 1 : 1 on the plots B 1 and B 2 with raw humus. It is obvious that the ratio of mycorrhizal and terrestrial fungi is closely related to the humus type and increases in favour of mycorrhizal fungi on the sites with acid raw humus. The same conclusion made Tyler (1984) who observed even an 70 % share of mycorrhizal species on the plots with strongly acid raw humus (pH_{KCl} 2,8 – 3,2). Kost et Haas (1989) also observed a small number of mycorrhizal species in the woods with mull or with big amount of nutrients in humus and soil. Fellner (1985) shows that in the beech woods of the Krkonoše mountains the mycorrhizal fungi form about 40 % of the total number of macrofungi recorded. In my case, 72 mycorrhizal species (31 %) were found on the plots in the Šumava mountains and Šumava foothills of the total number of 230 species. However, in both cases the percentage is not precise, because many ungilled and corticioid macrofungi as well as ascomycetes were not studied.

The conclusions mentioned are derived from the observations in almost undisturbed woods. The plot P 1 shows the importance of unsteady mesoclimate (in consequence of the clearing near the plot) on the occurrence of the mycorrhizal and terrestrial fungi. Their ratio 5,8 : 1 demonstrates that the habitat conditions are very unfavourable for the terrestrial fungi and that the occurrence of some terrestrial species is not possible under such conditions.

Conclusions

The total number of species recorded on all 8 plots is 230. The numbers of species on individual plots vary from 56 to 108. The number of species, the interesting species composition on the individual plots, and the occurrence of many rare fungi show that the beech woods of the Šumava mountains and the Šumava foothills are very valuable localities from the mycological viewpoint. They represent rare remains of natural vegetation with typical mycoflora of montane and submontane beech woods. In comparison with the mycoflora of imission damaged beech woods of the Krkonoše mountains, the mycoflora of the beech woods in the Šumava mountains seems to be still relatively undisturbed.

The influence of various ecological factors on the occurrence of fungi has been observed. The decisive role of the humus type, pH value, microrelief, and the thickness of the detritus layer on the occurrence, number of species, and ratio of the mycorrhizal and terrestrial fungi has been demonstrated. The occurrence and number of lignicolous species on the plot is in close relation to the degree of naturalness of the wood. These conclusions demonstrate the necessity of a detailed analysis of the habitat conditions that is of great importance for the right interpretation of ecological data concerning both the individual species and the ecological groups of macrofungi. Generally, the macrofungi can serve as good indicators of some ecological factors (e. g. the properties of the surface humus). Kost (1991), for example, came to the same conclusion.

The views of the status and role of the macromycetes in ecosystem were summarized and discussed e. g. by Apinis (1972), Kreisel (1985), and Fellner (1987). My field observations are in accordance with Apinis's opinion (Apinis 1972) that the fungal community in particular community of vascular plants in a particular site can be regarded as a complex of synusies. The synusies consist of species growing together, e. g. in individual layers of surface humus (L, F, H, A_h) or on specific substrate (e. g. wood in various stages of decay).

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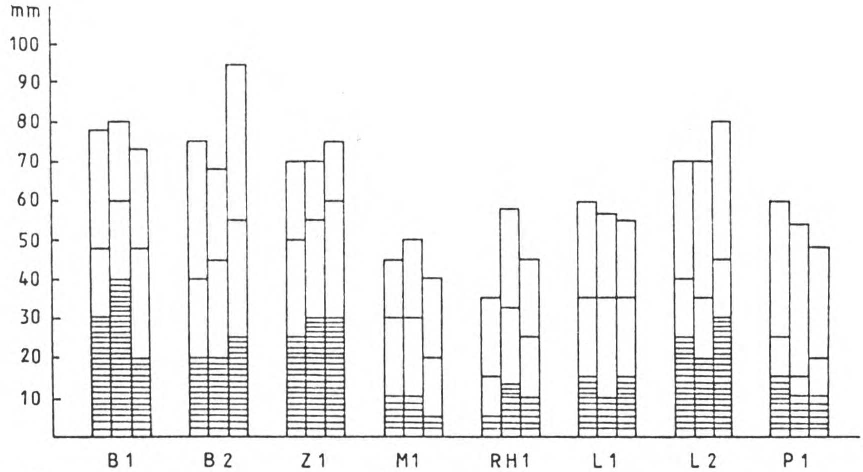
mm
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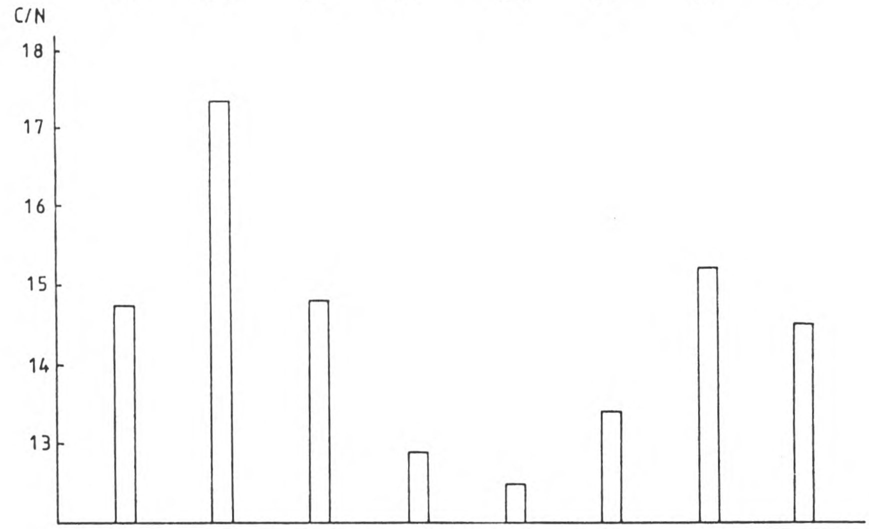
C/N
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B 2
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RH1
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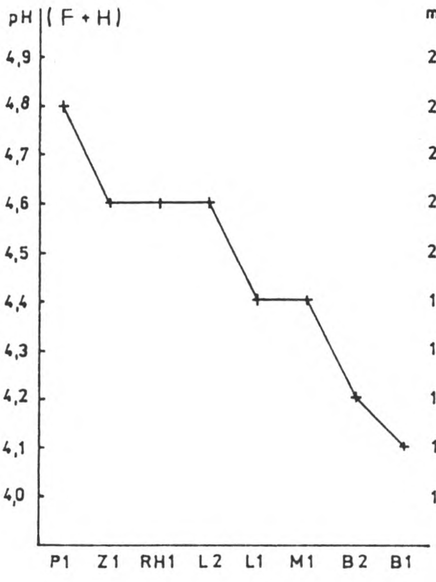
L 2
P 1


pH (F + H)
4,9
4,8
4,7
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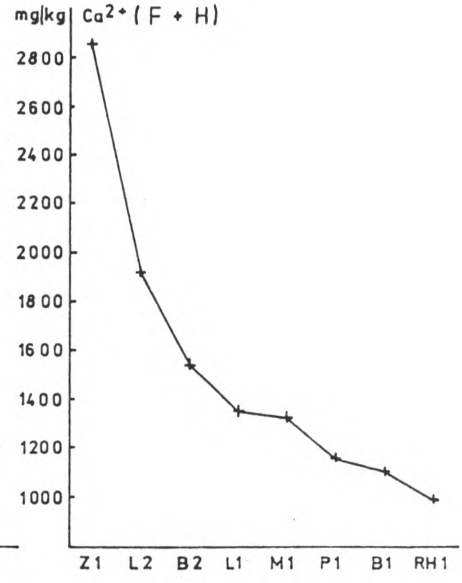
4,5
4,4
4,3
4,2
4,1
4,0
P1 Z1 RH1 L2 L1 M1 B2 B1


mg/kg Ca2+ (F + H)
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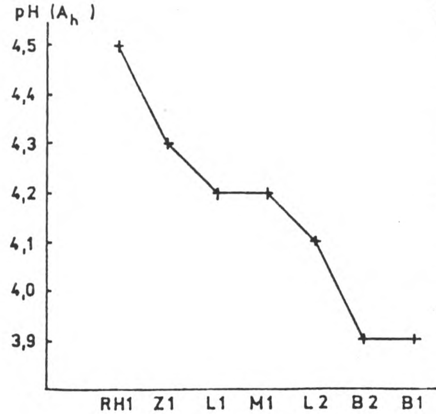
2600
2400
2200
2000
1800
1600
1400
1200
1000
Z1 L2 B2 L1 M1 P1 B1 RH1


pH (A_h)
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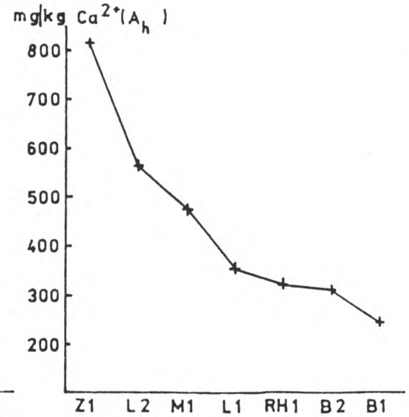
4,2
4,1
4,0
3,9
RH1 Z1 L1 M1 L2 B2 B1


mg/kg Ca2+(A_h)
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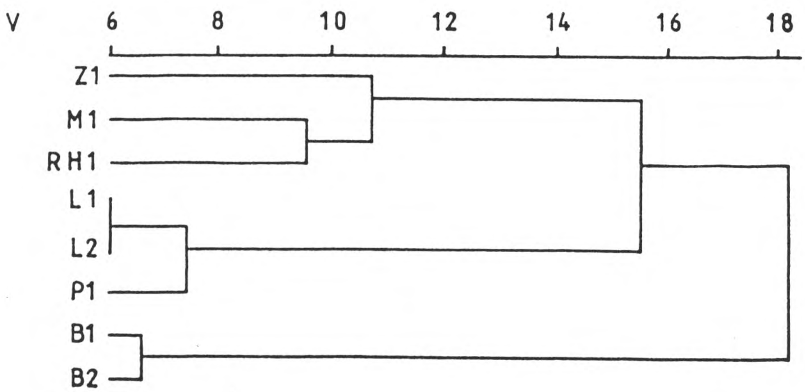
700
600
500
400
300
200
Z1 L2 M1 L1 RH1 B2 B1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Z1
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B1
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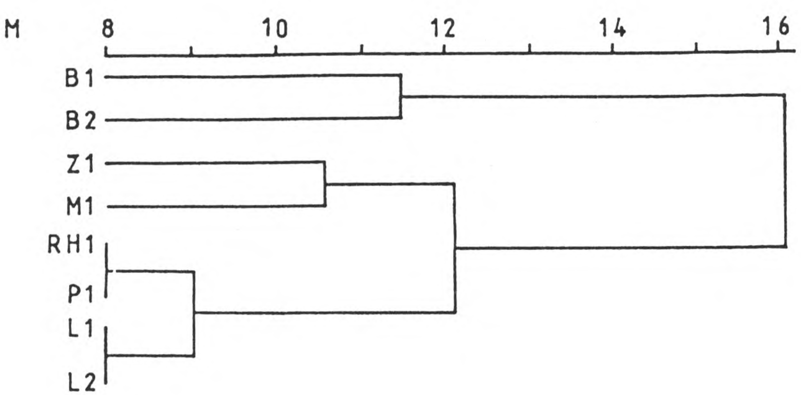
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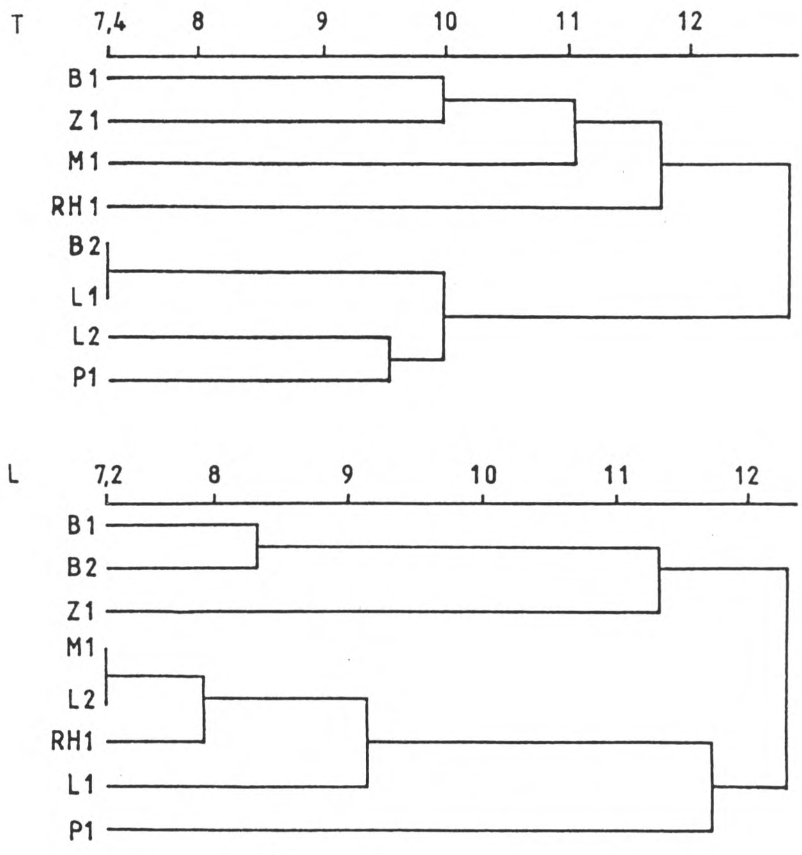
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12
B1
B2
Z1
M1
L2
RH1
L1
P1