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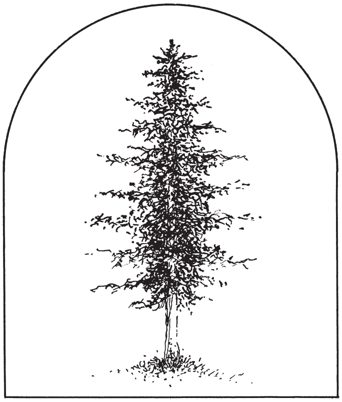

DIVERSITY OF *BASIDIOMYCETES* IN VARIOUS ECOSYSTEMS OF THE GÓRY ŚWIĘTOKRZYSKIE MTS.

JANUSZ ŁUSZCZYŃSKI

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ABSTRACT

Janusz ŁUSZCZYŃSKI. *Diversity of Basidiomycetes in Various Ecosystems of the Góry Świętokrzyskie Mts.* Monogr. Bot., Vol. 97, 218 pp., 2007.

Mycocoenological studies were conducted at 77 permanent research plots established in 14 leading forest communities and in three non-forest communities in the Góry Świętokrzyskie Mts. The greatest numbers of *Basidiomycetes* were recorded in phytocoenoses in the following plant communities: *Tilio-Carpinetum* (393 species), *Querco-Pinetum* (292 species) and *Dentario glandulosae-Fagetum* (268 species). Saprobionts dominated the mycobiota of the forest communities (593 species, that is 57% of the total number of species), including 332 species of pedobionts (32%), 251 species of xylobionts (24%) and 10 species of allobionts (0.9%). Furthermore, 375 species of mycorrhizal fungi (36% of the total number of the recorded species) and 59 species of parasites (6% of the total number of the mycobiota studied) were recorded.

The current species composition of *Basidiomycetes* in the Góry Świętokrzyskie Mts. has been influenced by the location of the area in relation to the adjacent geographical regions, climatic conditions, natural topography, geological structure and plant cover as well as human economy. *Abies alba, Acer pseudoplatanus, Fagus sylvatica, Larix decidua* ssp. *polonica* and *Picea abies,* which encourage the development of mountain fungi, influence the biota of *Basidiomycetes* in particular. The occurrence of 87 species of the mountain element sensu lato was recorded. Trophic relationships between *Basidiomycetes* and 34 species of vascular plants as well as 11 genera of mosses were analysed. The most numerous groups of fungi accompany pine trees (114 species), beech trees (105 species), fir trees (102 species) and oak trees (100 species). Despite significant damage, well-preserved and fairly intact forest areas are still found in the Góry Świętokrzyskie Mts. They now serve as refugia of *Albatrellus confluens, Bankera fuligineoalba, Fomitopsis officinalis, Hericium coralloides, H. flagellum, Pycnoporellus fulgens, Skeletocutis odora* and *S. stellae*. Both natural and anthropogenic factors determine the changes of the mycological profile in the Góry Świętokrzyskie Mts. Some of the newly arrived *Basidiomycetes* have features of expansive species, for instance *Clathrus archeri, Mutinus ravenelii* and *Psilocybe rugosoannulata*.

Key words: macrofungi; mycocoenoses; old-growth forest fungi; expansive, synanthropic and threatened fungi; C. Poland

1. INTRODUCTION

The Góry Świętokrzyskie Mts. offer some of the most interesting nature areas in Poland. Old and eroded, they are unique both locally and in Europe. A great variety of habitats, resulting from the diverse and complex geological structure, natural topography and plant cover, creates conditions favourable for the development of an impressive and varied biota of *Basidiomycetes*. Human economy has been an important factor that influences the preservation of fungal diversity. Its traces, dating back to the Neolithic period, spanning the times of ancient and medieval mining or metallurgy, are still visible in the study area while mining of rock raw material persistently continues. The interest in the plant cover and fungi of the Góry Świętokrzyskie Mts. goes back to the 19th century. The natural forests of the Puszcza Świętokrzyska Forest have been reduced both in size and degree. Beech, beech-fir and fir forests are some of the most characteristic natural communities in the region. The most natural section of the forest, fondly known as the Puszcza Jodłowa Forest, the name inherited from Polish literary works, is now protected within the Świętokrzyski National Park. In spite of considerable forest deformations, a range of diverse fungi still find suitable habitats here. Equally interesting habitats of this interesting and still underexplored mycobiota can be found in semi-natural communities of meadows as well as xerothermic and psammophilous grasslands.

The great richness of the contemporary biota of *Basidiomycetes* and the changes that have been taking place together with those of the plant cover have been at the centre of the present author's studies for almost 20 years. Different mycological elements conditioned by geographical, ecological and biocoenotic factors have occurred and competed in the Góry Świętokrzyskie Mts. over this period. The occurrence of mountain fungi makes the mycological profile of the area similar to the mycobiota and forest biocoenoses of the Carpathian Mts. while it also shows an affinity with lowland biocoenoses. A great diversity of both forests and non-forest ecosystems provides an excellent opportunity to study the correlation between the behaviour of *Basidiomycetes* and the level of a biocoenosis' natural state. Mycocoenological studies aim at investigating and defining the role of fungi in biocoenoses. *Basidiomycetes* belong to sensitive natural indicators of ecological and biocoenotic changes, which makes them particularly suitable for this type of research.

The history of mycocoenological studies boasts a fairly long tradition that spans a period of 95 years in Europe (Eddelbüttel 1911; Haas 1932) and 50 years in Poland (Nespiak 1956). Despite this background, as well as a rich body of the literature on the subject, there is a great need to continue studies of this type (Ławrynowicz *et al.* 2004). The scope and depth of knowledge of mycocoenoses in relation to plant communities vary and are still insufficient in the case of some types of forest communities. Mycosociological studies in the Góry Świętokrzyskie Mts. have so far been conducted at small plots and are by no means representative of the entire region (Lisiewska 1978a; Łuszczyński 1998, 2000a, b, c, 2001, 2004a, b, 2006).

This project is the first mycocoenological monograph study of the Góry Świętokrzyskie Mts., a vast and physiographically well-differentiated area. A critical list of *Basiodiomycetes* is a necessary supplement of the monograph (Łuszczyński 2007a, in print).

Fungi of the class *Basidiomycetes* sensu Kirk *et al.* (2001) in the Góry Świętokrzyskie Mts. mesoregion (Kondracki 2000) are examined in this study.

The aims of this project are as follows:

- to investigate and describe the diversity of *Basidiomycetes* in the study area, their ecological differentiation as regards the habitats they occupy, functions they perform and their biocoenotic significance in relation to the diversity of plants in the study area;
- to define the indicator value of fungi for the assessment of their relationship with specific plant communities;
- to define threats and to assess the direction of quantitative and qualitative changes that have taken place in recent years;
- to identify similarities and differences between the mycobiota studied in the project and that of the adjacent mesoregions in Poland.

2. STUDY AREA

Location and borders. As specified in the physico-geographical regional division of Poland (Kondracki 2000), the study area is located in the province of the Wyżyny Polskie Uplands, Wyżyna Małopolska Upland subprovince and in the Wyżyna Kielecka Upland macroregion. The Góry Świętokrzyskie Mts. constitute a mesoregion within the Wyżyna Kielecka Upland, which is divided into 12 microregions (Fig. 1), and cover an area of 1680 km^2. Their geological structure, natural topography and plant cover development are greatly diverse. They form a grill-like system of major mountain ranges and valleys, distributed along the NW-SE axis 80 km long and 27 km wide. The area is situated between

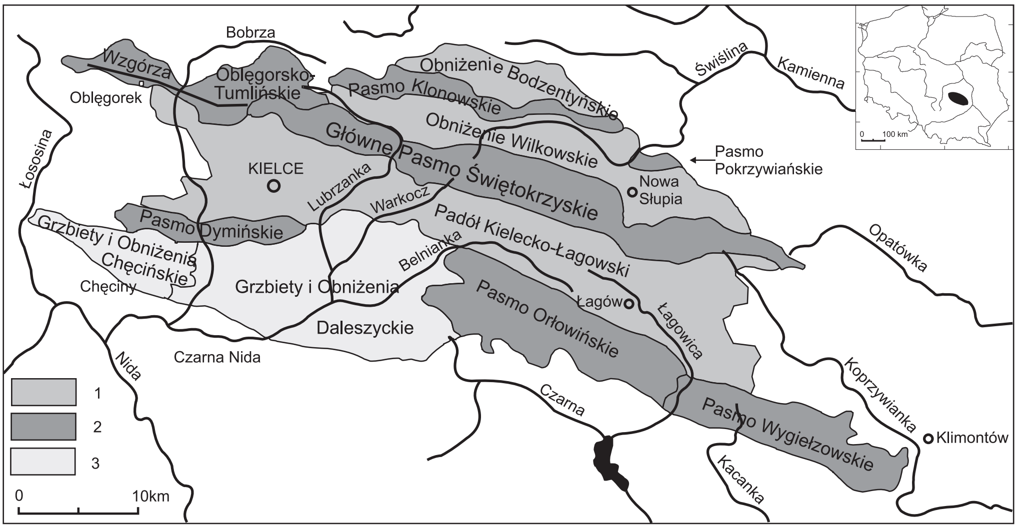


Fig. 1. Physico-geographical microregions in the Góry Świętokrzyskie Mts. (acc. to Balwirczak-Jakubowska & Czarnecki 1989)
1 – valleys; 2 – ranges; 3 – Grzbiety and Obniżenia Daleszyckie Ranges and Depressions

20°17’53” and 21°20’ E and between 50°30’ and 51°00’N. It is located in the administrative Świętokrzyskie voivodeship, the Kielce poviat and the western part of the Opatów poviat. According to the geobotanic division of Poland (Szafer 1977), it belongs to the Kraina Świętokrzyska Land, comprising almost the entire Łysogóry Region (with the exception of a small section in the northern part) and the SE part of the Chęciny Region.

Lie of the land and geological structure. The Góry Świętokrzyskie Mts. are old, low and eroded mountains with outcrops of the oldest layers. They are classed by geographers as uplands. The lie of the land reflects the parallel and alternate network of mountain ridges and valleys. It corresponds to the system of rocks characterised by varying resistance to erosion processes and is associated with the direction of successive orogenies: Caldeonian, Variscan and Alpine orogenies (Fig. 2). The name of the mountains derives from the geological structure and not from the landscape. Monadnock ridges and depressions are characteristic elements of the local topography. Upper Cambrian quartzites, sandstones and slates, forming the hills of the Pasmo Świętokrzyskie Ridge, constitute the core of the mesoregion. The range is divided into three parts: Pasmo Masłowskie Ridge, Pasmo Łysogórskie Ridge and Pasmo Jeleniowskie Ridge. Their peaks exceed 500 m, Łysica (612 m), Łysa Góra (595 m) and Szczytniak (554 m), and their height complies with the definition of low mountains. The slopes are covered by block fields known as screes. The entire area of the Pasmo Łysogórskie Ridge has been protected as the Świętokrzyski National Park since 1950. The Pasmo Masłowskie Ridge, culminating in Klonówka (473 m), continues the Łysogóry towards the north-west. The Wzgórza Oblęgorsko-Tumlińskie Hills continue the Pasmo Świętokrzyskie Ridge towards NW. They are formed by Lower Triassic sandstones deposited on Paleozoic rocks. The Pasmo Klonowskie Ridge, formed by Lower Devonian sandstones, with the highest peak Bukowa Góra (482 m), runs parallel to the Pasmo Łysogórskie Ridge north of it. Lower parts of the slopes in this ridge are covered by loess deposits. The eastern part of the ridge was incorporated into the Świętokrzyski National Park in 1996.

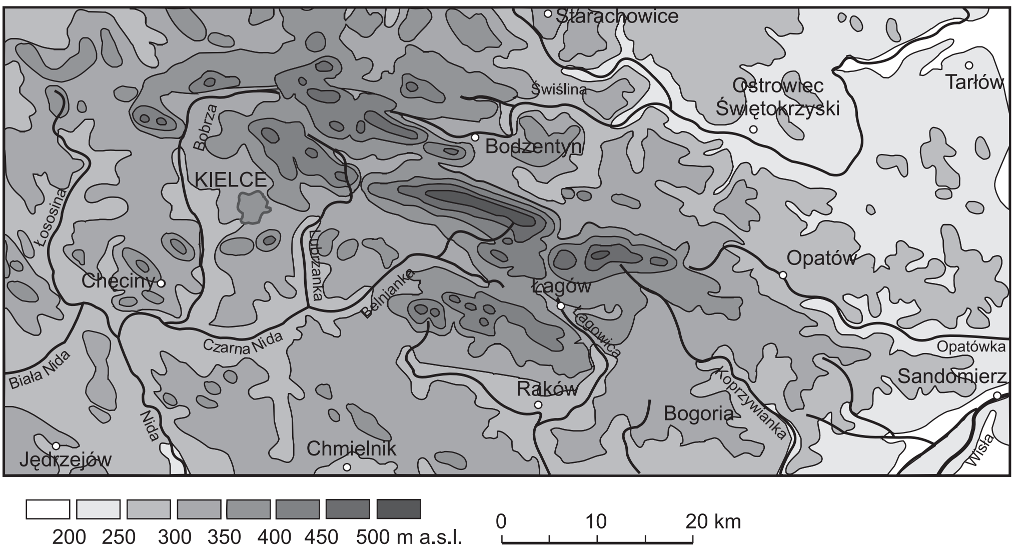


Fig. 2. Hypsometry of Góry Świętokrzyskie Mts. (acc. to Wróblewski 1970)

The Pasmo Dymińskie Ridge, formed by Lower Cambrian slates and sandstones on which loess is deposited in the lower sections in the western part, stretches on the southern side. Mt Telegraf (406 m), located within Kielce, is the highest peak.

The Wzgórza Chęcińskie Hills, formed by limestones and dolomites of the Middle Devon and Jurassic limestones, constitute the western wing of the mesoregion. The Łososina and Nida Rivers flowing around the Hills form the borders of the Góry Świętokrzyskie Mts. in the west and south-west.

Three microregions: Wzgórza Daleszyckie Hills, Pasmo Orłowińskie Ridge and Pasmo Wygiełzowskie Ridge, constitute the southern part of the mesoregion. The former is formed mostly by Cambrian and Devonian deposits. Mt Otrocz (372 m), the highest point, is surrounded by the valleys of the Lubrzanka and Warkocz rivers. The Pasmo Orłowińskie Ridge (Mt Kiełki, 462 m) stretches between the gorges of the Belnianka and Łagowianka Rivers. It is formed by Silurian, Lower Devonian and Cambrian deposits. The Białe Ługi peat bog developed in the depression between the Orłowińskie Ridge and Mt Kamień. The Pasmo Wygiełzowskie Ridge, delimited by the Koprzywnianka valley in the east, constitutes the south-eastern section of the mesoregion. The terrain is plateau-like, formed by Cambrian deposits covered by loess deposits. Its features resemble those of the adjacent Wyżyna Sandomierska Valley.

Parallel valleys stretch between hill ridges, the Padół Kielecko-Łagowski Vale being the largest. It is 40 km long and from 4 to 5 km wide. Its bottom is lined with Quaternary deposits that cover rocks of the Middle and Upper Devonian period characterised by low resistance (marls and limestones) and Lower Carboniferous sandstones and slates. The vast valleys are divided by the Bobrza, Silnica, Lubrzanka, Belnianka and Łagowianka Rivers. Relict hills, built of limestones that form the Pasmo Kadzielniańskie Ridge, are clearly defined in the flat landscape of the Padół Kielecko-Łagowski Vale. The Vale is delimited by the Pasmo Świętokrzyskie Ridge in the north and a series of smaller ridges: Pasmo Dymińskie Ridge, Wzgórza Daleszyckie Hills, Pasmo Orłowińskie Ridge and Pasmo Wygiełzowskie Ridge, in the south. The city of Kielce is located in the western part of the valley.

The Obniżenie Wilkowskie Depression lies between the Pasmo Świętokrzyskie Ridge in the north and the Pasmo Klonowskie Ridge in the south. The valley is about 40 km long and 3-5 km wide. It was formed from the soft Silurian slates and covered by Quaternary deposits: sands and clays. The town of Nowa Słupia is located in the eastern part of the valley.

The Obniżenie Bodzentyńskie Depression stretches along the northern margins of the Góry Świętokrzyskie Mts. The valley, lined by loess in its great part, is deposited on Upper and Middle Devonian slates, marls and limestones. The terrain cuts in between the Pasmo Klonowskie Ridge on the southern side and the Płaskowyż Suchedniowski Plateau to the north-east. The town of Bodzentyn, the management office of the Świętokrzyski National Park, is the main centre of settlement.

Soils. The central areas of the Góry Świętokrzyskie Mts. are characterised by the occurrence of cool, moist soils poor in calcium. Therefore, their fertility is low, and the soils are often shallow and cannot be cultivated, which consequently encourages forest preservation. Acid or weakly acid podzols, covered mostly by coniferous vegetation, dominate. Soils at the initial development stage form in the peak parts of ridges and hummocks, which is conditioned by the presence of hard flatrocks, quite resistant to erosion processes.

These soils are rocky, shallow and strongly permeated by rain waters. Lithic leptosols, leptic mollisols and albic leptosols in the screes, remnants of the Pleistocene periglacial environment, play an important role (Kowalkowski 2000). At present, the majority of vast scree surfaces have been transformed into leptic mollisols and have been colonised by the forest. Soils of this type are mostly encountered in the Pasmo Łysogórskie and Pasmo Jeleniowskie Rigdes. Podzols do not usually form large surfaces at lower elevations but occur together with cambisols as mosaics. Due to their fertility, the latter are cultivated, and only steeper slopes are wooded. Eastern and north-eastern edges, bordering with the Wyżyna Sandomierska Upland, are characterised by the participation of the loess cover, and the soils, belonging to cambisols, are fertile and cultivated. Forest fragments have been preserved only on steep, eroding slopes that cannot be cultivated for technical reasons. Rendzinas have formed in the areas where carbonate rocks reach the topsoil. Such soils mostly occur in the Chęciny Region. Only initial rendzic leptosols are not cultivated and are colonised by xerothermic grasslands or forests.

Soils in the northern part of the mesoregion are less fertile; these are mostly podzols, haplic arenosols, luvisols, and less frequently cambisols.

Hydrogenic fluvisols form in river valleys. Because of the small size of such valleys, soils of this type do not play a major role. On the other hand, stagnic gleysols and gleysols, peat soils are important in large valleys, such as for instance the Dolina Wilkowska or Dębniańska Valleys. The occurrence of hydrogenic soils in the depressions in the Wzgórza Daleszyckie Hills, where two large peat bog complexes, in the Białe Ługi complex and near Słopiec, have developed, is also noteworthy (Głazek 1985a; Głazek & Wolak 1991; Przemyski & Polinowska 2001; Żurek *et al.* 2001).

Long-established local human economy has significantly influenced soil-forming processes. Opencast mining of rock resources and metal ores, as well as cement dust emissions over the last decades, have encouraged the formation of secondary industrial soils across considerable areas. These processes have been described by, for instance, Kowalkowski *et al.* (1993) and Świercz (1997).

Calcareous soils are of great importance for the development of the mycobiota. Some *Basidiomycetes* are highly calcicolous and are strongly attached to such soils while others prefer soils rich in calcareous salts.

Surface waters. The Góry Świętokrzyskie Mts. are the main hydrogeological node in the catchment basin of the middle section of the Vistula. The waters from the area are delivered by two of its tributaries: the Kamienna and the Nida Rivers. The upland character of the mesoregion causes a high fall of rivers and streams. Despite its altitude and weight, the Pasmo Świętokrzyskie Ridge is a drainage divide (Kupczyk *et al.* 2000). A significant part of the waters flowing out from the northern slopes of the mountains flows through gorges to the southern part of the Ridge. Gorges are formed by tributaries of the Nida: the Lubrzanka, Sufraganiec, Bobrza and Łososina Rivers (Kowalski 1990). Some waters flow through the massif from the south to its northern part through the Słupianka gorge valley. Its frequent discrepancies from the layout of the mountain ranges and numerous gorges are characteristic features of the river network which creates a so-called grid system. Gorge valleys are connected with a system of tectonic faults and rock substrate fracturing. Valley sections in the gorge fragments are deep and narrow, and wide and with vast bottom parts outside them. There are no natural lakes in the mesoregion, and only artificial retention tanks, formed on larger rivers (the Bobrza, Lubrzanka and Silnica Rivers), occur in the area.

Climate. The climate in the Góry Świętokrzyskie Mts. is diversified and depends on the elevation and the topography. The climate of the Pasmo Świętokrzyskie Ridge, and especially the Pasmo Łysogórskie Ridge, seems to diverge from that of the entire mesoregion. It resembles the climate of the Beskid Niski Mts. and the Beskid Sądecki Mts., and somewhat corresponds to the conditions in the Suwałki region and Kashubia. The mean annual air temperature is 5.8°C on Mt Święty Krzyż (Fig. 3), and July is the warmest month (Olszewski *et al.* 2000). Thermal air currents resemble those of the vicinity of Suwałki from mid-autumn to the end of early spring (January –4.6°C). Thermal air currents in the summer period resemble those occurring in central Finland (July 16.0°C). The severity of the climate is reflected in the length of thermal seasons: summer lasts 57 days on Święty Krzyż on average and winter is over twice as long (121 days). The vegetative period lasts ca. 187 days. Atmospheric thaws occur in each season. December is the most thaw month and March is the least thaw month. The number of days when the thaw occurs is similar to that recorded in the Sudeten Mts., the Carpathians and the Suwałki region. The peak parts of the Łysogóry annually receive from 800 to 850 mm of precipitation on average, and areas at lower altitudes, for instance in the vicinity of the Serwis forest or Celiny village (250-300 m a.s.l.) - 550-600 mm. The number of precipitation days is 174 on Święty Krzyż and 148 in Bodzentyn. The annual precipitation sum has been decreasing over the last few decades. The deficit was over 900 mm between 1981 and 1990, which is a value greater than the annual precipitation on Święty Krzyż (Fig. 4).

Areas below 300 m receive smaller amounts of precipitation. For instance, the annual precipitation sum is 617 mm in Bodzentyn, and 60% of it is recorded in the vegetation

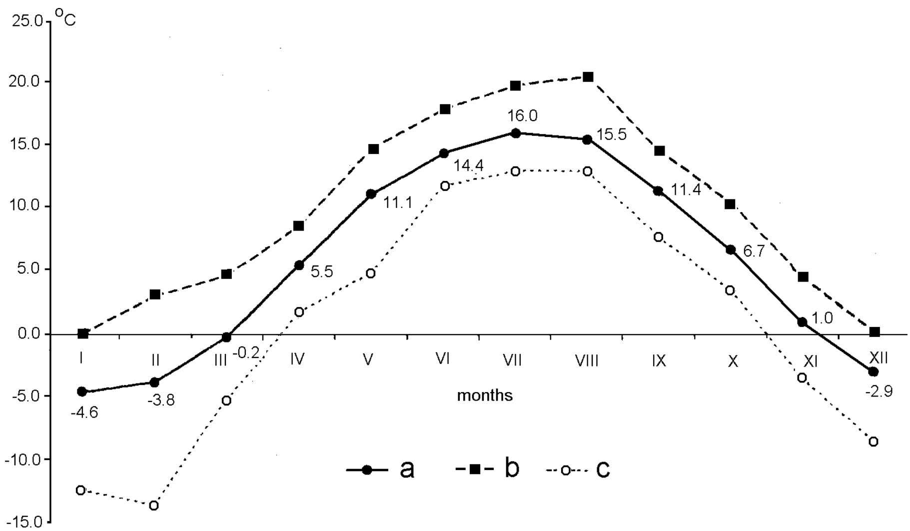


Fig. 3. Mean annual temperatures at the Święty Krzyż station between 1955 and 1997 (acc. to Olszewski *et al.* 2000)
a – mean; b – maximum; c – minimum

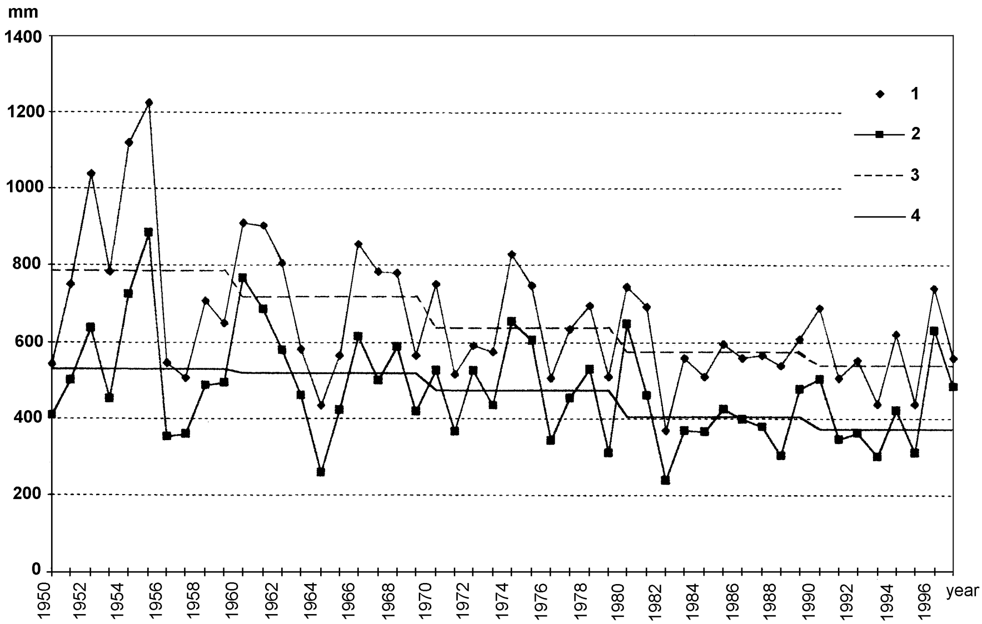


Fig. 4. Mean annual precipitation sums at the Bodzentyn station between 1950 and 1997 (acc. to Gądek 2006)
1 – annual precipitation sums; 2 – precipitation sums during a vegetative period; 3 – mean annual precipitation sum; 4 – mean precipitation sum during vegetative periods over a decade

months (IV-IX). Similar precipitation values are reported in the vicinity of the Pasmo Świętokrzyskie Ridge. Precipitation ranges between 600 and 670 mm in the western part of the mesoregion. The number of precipitation days is 150-160, and the greatest precipitation values occur in summer months (June and July). The smallest precipitation is in October and March (ca 40 mm). 469 mm, i.e. from 70 to 78% of precipitation, is recorded in the vegetative period (IV-X). The mean annual precipitation was 624.6 mm in Kielce between 1989-2000. The greatest amounts of precipitation were recorded in June and July when they reached ca. 82 mm each month. The mean annual air temperature was 7.4°C. The vegetative period lasts about 210 day.

The south-eastern parts of the Pasmo Wygiełzowskie Ridge are the warmest and driest areas in the mesoregion. The mean annual temperature is 7.5°C, and annual precipitation is only 506-520 mm. The vegetative period lasts 210-220 days.

Observations conducted at the climatological station on Święty Krzyż over 40 years provide relevant climate variability data and show certain noticeable trends. They confirm general climate warming and a significant decrease in annual and seasonal precipitation sums. Precipitation in the warm half year was affected to a greater extent (Olszewski *et al.* 1992, 2000).

Vegetation. The influence of the geological structure of the mesoregion, elevation and human economy on the current vegetation profile have been critical. Forests cover 35-40% of the area, mostly ridges and hill slopes, and other areas are not used for agricultural purposes. Almost all native tree species growing in Poland occur in the stands. The Góry Świętokrzyskie Mts. are located on the northern limits of the occurrence range of important tree species: beech, sycamore, fir and spruce. They are a large and important occurrence centre of *Larix decidua* ssp. *polonica*. The presence of these tree species is of great importance for the species composition of fungi.

A relatively high elevation results in the formation of two vegetation belts. The vertical arrangement of the belts is caused by the present edaphic conditions rather than by climatic differences. The border between the belts runs at 350 m above sea level on northern slopes and 450 m on southern slopes (Danielewicz 2000). Higher belts are overgrown with fir, beech and beech-fir forest communities. The communities resemble deciduous and coniferous forests of the lower subalpine forest in the Carpathians. Oak-hornbeam, pine forests and mixed forests as well as communities similar to those growing in the adjacent lowland areas develop in the lower belt. The "layering" of the forest community system is the greatest in the Pasmo Świętokrzyskie Ridge. Calcium-free rocks or rocks low in calcium make local soils acid, moist and cool. This is reflected in the species composition of plant communities. The *Abietetum polonicum* fir forests growing in the ridge parts develop on acid cambisols and muck gleysols, and are floristically poor. Fir-beech forests in the region represent a poor variant of the Carpathian beech forests of lower altitudes (Szafer 1977). Phytosociologically, beech forests belong to various plant communities of the *Fagion sylvaticae* alliance. The lowland *Luzulo-Fagetum* beech forest covers vast areas. Patches of the *Dentario glandulosae-Fagetum* beech forest, which is identified with the submontane form of this community, are significantly less frequent. Its two habitat and floristic variants are differentiated: a typical variant on mesic and moderately fertile habitats and a variant with *Allium ursinum* in fertile and damp habitats near streams. Beech forests with *Dentaria enneaphyllos*, which resemble the Sudetian *Dentario enneaphylli-Fagetum* beech forests, are also floristically interesting (Bróż 1992). The best patches of beech forests outside the Świętokrzyski National Park have been preserved in the Pasmo Cisowsko-Orłowińskie Ridge and the Pasmo Jeleniowskie Ridge. Beech tree-stands with the oak-hornbeam field layer occur in the Pasmo Zgórskie Ridge and in patches in the Pasmo Posłowickie Ridge.

Narrow strips of *Sorbetum sanctae-crucianum* (local rowan tree) have developed along the border dividing the scree and the forest. These are mostly shrub formations, sometimes with single fir trees, beeches, sycamores and spruces. The community is floristically poor, and coniferous species prevail.

Pine forests dominate at lower elevations. Depending on the groundwater level, they are differentiated into dry, mesic, humid and boggy coniferous forests. Mesic coniferous forests which are divided into two communities, *Leucobryo-Pinetum* and *Peucedano-Pinetum*, depending on the habitat, floristic and phytosociological composition, dominate as regards the surface. Humid coniferous forests, *Molinio-Pinetum*, and boggy coniferous forests, *Calamagrostio villosae-Pinetum* and *Vaccinio uliginosi-Pinetum*, occupy significantly smaller areas. They occur in, for instance, the Mokry Bór reserve in the Świętokrzyski National Park. The boggy coniferous forest *Vaccinio uliginosi-Pinetum* is additionally well developed in the Białe Ługi (Przemyski & Polinowska 2001) and Słopiec reserves (Głazek 1985a). Patches of *Calamagrostio villosae-Pinetum* are encountered relatively rarely and belong to the eastern Polish variety of this community where firs play an important role.

Mixed *Querco-Pinetum* forests are popular communities across the entire study area. Two variants characteristic of the Góry Świętokrzyskie Mts. can be differentiated in the floristic composition: with *Abies alba* and with *Larix decidua* ssp. *polonica*. The former is a phytocoenosis type widespread almost in the entire area while the latter occurs on Chełmowa Góra Mt in the Świętokrzyski National Park.

Oak-hornbeam forests occur quite rarely. The *Tilio-Carpinetum* is divided into four subassociations depending on the floristic type and habitat: *T.-C. corydaletosum*, *T.-C. stachyetosum sylvaticae*, *T.-C. typicum* and *T.-C. abietetosum* (Głazek & Wolak 1991). Larger patches of this community are preserved in the Pasmo Łysogórskie Ridge, in the Dolina Czarnej Wody, Dolina Psarki, Dolina Pokrzywianki, Dolina Słupianki Valleys, and on Chełmowa Góra Mt, in the Jastrzębi Dół nature reserve, in the Pasmo Dymińskie, Pasmo Cisowskie (Mt Września), Pasmo Masłowskie (Mt Wierzejska) Ridges.

Fraxino-Alnetum carrs have developed in the valleys of larger rivers and streams. The majority of phytocoenoses have been strongly deformed as a result of human economy. Fragments of this community preserved better occur in protected areas, in the Świętokrzyski National Park (in the Dolina Dębniańska and Dolina Wilkowska Valleys), in the Białe Ługi reserve, and in the Pasmo Klonowskie Ridge outside it. The surviving phytocoenoses are natural, and the tree-stand is composed mostly by *Alnus glutinosa*.

Lithological factors strongly influence the development of the flora and vegetation in the western part of the study area. Calcareous rocks (limestones and partly dolomites) forming low hills on which warm and carbonate soils develop are the main features of the area. These habitats are covered by thermophilous and xerothermic plant communities. The majority of hills have been completely deforested. Forests, mostly thermophilous oak-hornbeam forests, thermophilous oak forests, mixed forests and pine forests, have only partly survived. Artificial pine cultivations have been introduced as part of secondary forestation in the past decades. A divergent status of the geological profile and the development of the plant cover in this part of the area is, for instance, reflected in the geobotanic regionalisation where it is classed as a separate region, the Chęciny Region, in the Kraina Świętokrzyska Land (Szafer 1977). Pine forests of the *Peucedano-Pinetum* type grow mostly in valleys, on sandy soils. Richer habitats of foothills are covered by floristically rich, mixed forests belonging to the *Serratulo-Pinetum.* Patches of the thermophilous oak forest *Potentillo-Quercetum* develop at higher elevations on southern slopes. Northern slopes are occupied by *Tilio-Carpinetum melittetosum* and forests similar to *Aceri-Tilietum* (Bróż 1992). Xerothermic grasslands of the class *Festuco-Brometea* and fringe communities of the class *Trifolio-Geranietea* with rare plants have developed on deforested hills used as pastures (Głazek 1987).

Changes of the plant cover versus human economy. The Góry Świętokrzyskie Mts. have been greatly influenced by the long-standing local anthropogenic activity. The availability of mineral resources has encouraged a significant development of mining and metallurgy while the wood from local forests has been used as a source of energy in metallurgic processes. While its intensity has varied over the years, this form of economy is still practised in the area.

Deforestation processes have also been connected with the development of settlement and agriculture (Fig. 5). However, glass metallurgy which required considerable amounts of wood as fuel and ash as the flux particularly affected the changes in the landscape and species composition of tree stands. Beech wood, and less frequently pine or spruce wood, was used by the local industry. According to Wyrobisz (1968), there were 20 glass factories in the Góry Świętokrzyskie Mts. in the 16th and 17th centuries. Two glass factories in the Bodzentyn demesne of the Kraków bishops (16th-17th century) and a glass factory in Bodzentyn

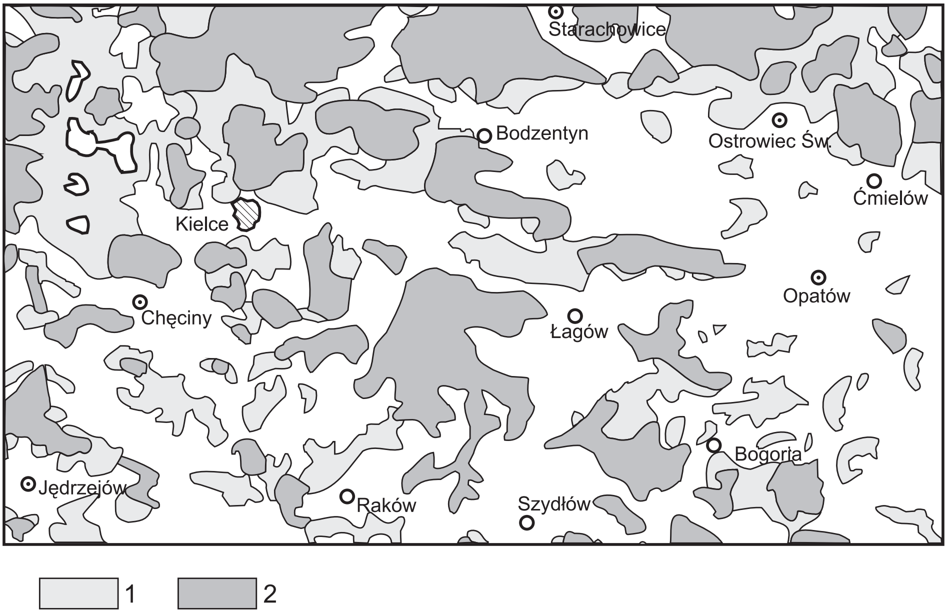


Fig. 5. Changes of forested areas between 1839 and 1939 (acc. to Nowacka 1970, modified)
1 – forests in 1839; 2 – forests in 1939

(second half of the 18th century), Ciekoty (Klonowska) glass factory in the Kielce demesne (18th century), a glass factory near Kakonin (17th century – beginning of the 18th century), as well as a glass factory opened in the Cisów demesne at the foot of Łysa Góra Mt (17th century), probably within the following villages: Stara Huta, Nowa Huta or Huta Szklana, operated in the study area or in its direct vicinity.

Glass factories used ample amounts of wood, thus contributing to a complete destruction of stands or the elimination of trees suitable for glass production, for instance beech, and therefore to an increase in local fir forests at the expense of beech forests. This is documented by written records and seems possible given similar soil conditions under beech and fir forests.

Tree felling and cattle grazing, persistent since the 16th century, especially in the Kraków bishopric, conducted by the local population hired to work in mining and metallurgic factories, influenced the old-growth communities (Barański 1971).

Hieronim Benedict's map of Western Galicia of 1808 in the scale 1:172 800 shows that the study area had a rich network of roads at the time, and nearly all towns that can be found on contemporary maps already existed. However, the number of forests at the beginning of the 19th century was greater than at present.

As a result of long-term social and economic processes, especially in the 20th century, far-reaching and adverse vegetation changes have taken place (Gądek 2000). These mostly comprise: deformation of natural forest communities by excessive wood acquisition and introduction of new components or their transformation into monocultures, almost complete deforestation of the areas constituting the protection zone, changes in water relationships resulting from inadequately performed or completely unnecessary land drainage processes, high area penetration by local population, which leads to illegal grazing, tree felling and poaching, as well as the penetration of the area by tourists.

The present profile of the mesoregion is greatly determined by the rock material industry. It is concentrated in the Chęciny Region, which covers ca 670 km^2 and is known as the Kielce Region of Carbonate Material Mining [„Kielecki Okręg Eksploatacji Surowców Węglanowych"], popularly called "the White Basin" [„Białe Zagłębie"]. A large-scale acquisition of building materials causes irreversible changes in the natural landscape.

3. HISTORY OF MYCOLOGICAL RESEARCH IN THE GÓRY ŚWIĘTOKRZYSKIE MTS.

The history of research into *Basidiomycetes* in the Góry Świętokrzyskie Mts. goes back to the first half of the 18th century, that is to pre-Linnaean times. First reports on selected macromycetes are given by Rzączyński (1721). When listing medical plants, this Jesuit reported a few fungal names, such as *Agaricum* or *Fungus officinarum*, giving the latter a name in Polish (*modrzewowa gębka*) and indicating some localities of the species. He also provided names of other fungi, mostly in Polish: *rydz, poddąbki* (which he called *fungus albus piperatus*), *kozaki* or *koziory, kozlaki, pieczarki, burchawki* or *prochawki, żagwie, hupki, podsadki, olszówki, hołubki, syroiczki, węzowki* and *wełnianki*; he did not, however, specify their localities.

Further mycological findings were not reported until some 100-150 years later. Jastrzębowski (1829), a florist, specifies not only plants but also fungal species such as *Geastrum coronatum, Phallus impudicus* and *Sarcodon imbricatum*. This period can hardly be considered influential from the mycological point of view.

First mycological studies in the Góry Świętokrzyskie Mts. were conducted by Berdau (1876) and Błoński (1890) in the 19th century. These scholars list ca 260 species from the area of Łyse Góry, Łysica, Święty Krzyż as well as local forests.

In the first half of the 20th century, random mycological observations were conducted by Moesz (1920), a Hungarian mycologists serving in the Austro-Hungarian army, stationed near Kielce, where he collected 21 species of *Basidiomycetes*. Phytopathologist Orłoś (1935) reported in print some parasitic *Basidiomycetes* in the period between the world wars. Individual localities of species in the Góry Świętokrzyskie Mts. were reported by Skirgiełło (1939) in a study on Polish *Boletaceae* and *Polyporaceae*.

Mycological observations and studies have been carried out almost exclusively in the Świętokrzyski National Park after World War II. Pachlewski (1953, 1955) reports three species in his description of the mycorrhizae formed by seedlings of the Polish larch on Chełmowa Góra Mt and 13 species in his studies on fir mycorrhizae in the Pasmo Łysogórskie Ridge. Lignicolous fungi in the area of Łysica were also studied by S. Domański (1962), who listed 77 taxa of *Basidiomycetes*. Lisiewska (1966a) briefly outlined macrofungi in the Góry Świętokrzyskie Mts. in the guide written for the 4th Congress of European Mycologists, which was held in Poland in 1966. Czech mycologists, Kotlaba & Lazebníček (1967), participants of the 4th Congress of European Mycologists, reported 12 rare species from the area of the National Park, while an anonymous author published 77 species in the proceedings of the 4th Congress (Anonymous 1968). First mycocoenological studies were conducted in the 1960s and 1970s by LISIEWSKA (1978a, 1979). LISIEWSKA studied the participation of macromycetes in eight main forest communities of the Świętokrzyski National Park at 13 permanent research plots and reported 364 taxa (352 species, 8 varieties and 4 forms). In 1963-1965, studies were also conducted by Z. DOMAŃSKI, who collected 219 species. The results of these studies, however, were not published and the herbarium material is deposited in the Department of Plant Systematics and Geography, Warsaw University. Although sometimes the locality is not specified and the reports are given for the entire Góry Świętokrzyskie Mts., individual localities of *Basidiomycetes* in the study area have been reported by some authors in the series Flora Polska Grzyby (Mycota): *Polyporaceae, Hymenochaetaceae, Stereaceae*, hydnoid fungi (*Hydnaceae* and *Steccherinaceae*) (S. DOMAŃSKI 1965, 1981, 1991a, b; S. DOMAŃSKI *et al.* 1967), *Boletaceae, Pluteaceae, Russulaceae* (SKIRGIEŁŁO 1960, 1991, 1998a, 1999), *Tremellales* (WOJEWODA 1977a, b, 1979a), *Mycena* (LISIEWSKA 1987), on gasteroid fungi (*Gasteromycetidae*) (RUDNICKA-JEZIERSKA 1991), *Cortinarius* and *Inocybe* (NESPIAK 1975, 1981, 1990), *Hygrophoraceae* (GUMIŃSKA 1997), *Ganodermataceae* (SOKÓŁ 2000), as well as in studies on the geographical distribution of selected fungal species in Poland (SKIRGIEŁŁO 1965, 1967, 1970, 1972, 1976, 1986). Names of basidiomycete species can also be found in the results of lichenological studies conducted in the Świętokrzyski National Park, from where they were reported as lichenicolous fungi, that are lichen parasites (ŁUBEK 2002; ŁUBEK & CIEŚLIŃSKI 2004). Individual localities of fungi reported from the Góry Świętokrzyskie Mts. are given in various studies: *Antrodiella citrinella* (NIEMELÄ & RYVARDEN 1983; PIĄTEK 2001), *Botryobasidium aureum* (HALLENBERG 1978, *leg. Hallenberg & Larsson*; PIĄTEK & MIŚKIEWICZ 2000), *Clathrus archeri* (SAŁATA & JAKUBOWSKA 1987; KIERASIŃSKI 1992), *Pycnoporellus fulgens* (PIĄTEK 2003), *Ramaria polonica* (PETERSEN 1975, *leg. Donk & Wojewoda*), *Strobilurus* (KOMOROWSKA 2006), *Tulasnella pallida* (WOJEWODA 2003), *Xerula pudens* (RONIKIER 2005a), *X. radicata* (RONIKIER 2005b, *leg. Komorowska*).

The area of the Góry Świętokrzyskie Mts. has been investigated by the present author since 1986. Results of studies dealing with various ecosystems, both natural and urbanised, have been published, and individual fungi new to Poland or interesting species have been reported (ŁUSZCZYŃSKI 1993a, b, 1997, 1998, 1999a, 2000a, b, 2001, 2002, 2003, 2004a, b, 2006, 2007a, b in print). A number of unpublished dissertations for the bachelor's degree and theses for the master's degree that analyse the role and participation of *Basidiomycetes* in the Góry Świętokrzyskie Mts. have been written under the author's supervision at the Higher School of Education in Kielce, later the Świętokrzyska Academy (ROZMIAREK 1982; DUDA 1998; MACIASZCZYK 1998; PODGÓRSKA 1998; GRZEGOLEC 2001; JAWORSKA 2001; KORCYL 2001; GĄSIOR 2002; SZAREK 2002; WOSZCZYNA 2002; GDULA 2003, 2005; CHUCHMAŁA 2004; SOŁTYS 2004; ZAPAŁA 2004).

4. MATERIAL AND METHODS

Mycological studies were conducted in different natural, semi-natural and anthropogenic ecostystems. Field studies, carried out over a period of 20 years from 1986 until 2006 in the entire mesoregion, were used in the project. Mycocoenological studies were conducted using a modified mycosociological method. A total of 77 permanent research plots, 400 m^2

each, were established in 14 leading forest plant communities in the mesoregion. The surface area of 400 m^2 is mostly used for research purposes in Poland to allow for comparative results analysis. A total of 2511 observations were performed, that is 33 observations per each plot on average. Research plots were permanently marked and their phytosociological profile was described. Mycological observations were conducted once a month from March until July and 2-3 times a month from August until November. The mycobiota was recorded, including the abundance of fruitbodies, on a 3-degree scale, upon each observation (Jahn *et al*. 1967). Fungi growing on all types of substrates were recorded.

The division into terrestrial, litter-inhabiting, bryophilous and lignicolous fungi is used in the present study. Terrestrial fungi are further divided into mycorrhizal fungi and saprobionts. Mycological relevés are presented in collective tables showing the biota of *Basidiomycetes* in individual plant communities. The number of records at a given plot (first digit) and the abundance of fruitbodies are given for each species. The "X" symbol, which corresponds to the sum of all observations at a specific plot, is used for species producing permanent fruitbodies. The participation of fungi in individual communities and the phytosociological degree of constancy according to the Braun-Blanquet method were used to organise the species in the tables. The degree of constancy was not calculated for fewer than 10 relevés and the number of plots where a given species occurred is provided instead.

The floristic composition and phytosociological relationships occurring at plots were illustrated using phytosociological relevés conducted with the commonly used Braun-Blanquet method and are given in tables.

The nomenclature of cardiovascular plants is given after Mirek *et al.* (2002), mosses after Ochyra *et al.* (2003), lichens after Fałtynowicz (2003), while the syntaxonomic status of the phytocoenosis studied is given after Matuszkiewicz (2006).

Supplementary observations and collections of fungi were conducted outside permanent research plots using the field cartogram method. A network of squares within the ATPOL grid (Zając A. 1978) was superimposed on the study area, and the basic square, 10 km^2, was further divided into four smaller squares, each side of 5 km (Fig. 6). The entire

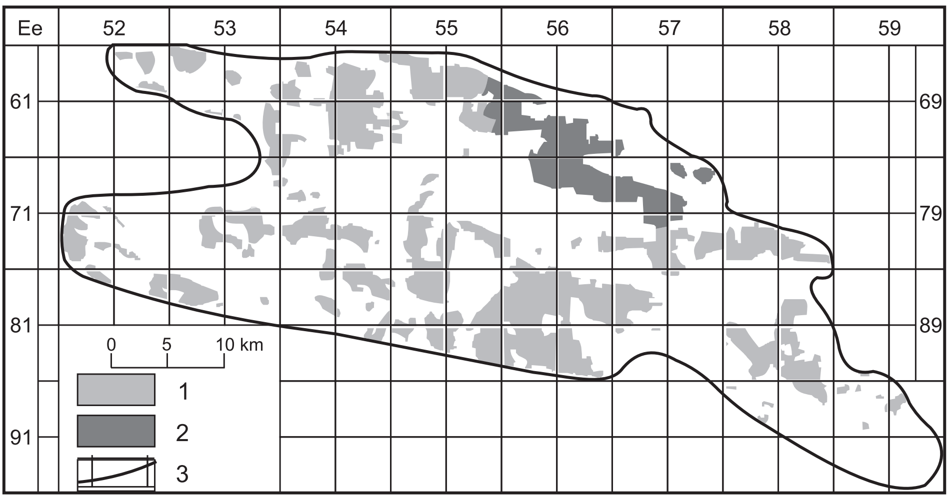


Fig. 6. Study area in the ATPOL grid squares
1 – forests; 2 – forests in the Świętokrzyski National Park; 3 – borders of the study area

mesoregion was covered with a system of 72 squares, 25 km^2 each, where further information on fungi was collected using the route method. Each locality was always recorded in detail using a topogram (tree-stand maps and topographic maps in the scale 1:10 000), and the substrate, plant community and collection date were noted. Examinations were conducted in natural and anthropogenic areas.

Over 9 700 individual, one-time mycological observations were conducted outside permanent research plots throughout the project. A full list of *Basidiomycetes* in the Góry Świętokrzyskie Mts. comprising 1 048 species, 35 varieties and forms, will be published separately (Łuszczyński 2007a, in print).

The systematic position of fungi was accepted after Kirk *et al.* (2001), the nomenclature of agaricoid fungi according to Hansen & Knudsen (1992), as well as supplements according to: Alessio (1985, 1991), Antonín & Noordeloos (1993, 1997), Arnolds (1990a, b, 1995), Bas (1983, 1995, 1999), Basso (1999), Candusso (1997), Candusso & Lanzoni (1990), Cappelli (1984), Holec (2001), Kuyper (1986), Maas Geesteranus (1992), Noordeloos (1988, 1992, 1999), Noordeloos & Christensen (1999), Noordeloos & Kuyper (1995), Orton (1986), Sarnari (1998), Stangl (1989), aphyllophoroidal fungi according to Eriksson & Ryvarden (1973, 1975, 1976), Eriksson *et al.* (1978, 1981, 1984), Hansen & Knudsen (1997), Jülich (1984), Jülich & Stalpers (1980), Petersen (1975, 1981), Ryvarden & Gilbertson (1993, 1994), gasteromycetoid fungi according to Hansen & Knudsen (1997), Jülich (1984), Sunhede (1990), dacryomycetoid fungi according to McNabb (1965, 1973) and Reid (1974), ceratobasidioid, tremelloid and tulasnelloid fungi according to Roberts (1993, 1995) and Wojewoda (2003).

5. *BASIDIOMYCETES* AND PLANT COMMUNITIES

5.1. Syntaxonomic classification of the examined plant communities

Cl. *Koelerio glaucae-Corynephoretea canescentis* Klika in Klika et Novak 1941
O. *Corynephoretalia canescentis* R.Tx. 1937
All. *Corynephorion canescentis* Klika 1934
Community with ***Corynephorus canescens***
Cl. *Molinio-Arrhenatheretea* R.Tx. 1937
O. *Arrhenatheretalia* Pawł. 1928
All. *Arrhenatherion elatioris* (Br.-Bl. 1925) Koch 1926
Ass. ***Arrhenatheretum elatioris*** Br.-Bl. ex Scherr. 1925
Cl. *Festuco-Brometea* Br.-Bl. et R.Tx. 1943
O. *Festucetalia valesiacae* Br.-Bl. et R.Tx. 1943
All. *Cirsio-Brachypodion pinnati* Hadač et Klika 1944 em. Krausch 1961
Ass. ***Thalictro-Salvietum pratensis*** Medw.-Korn. 1959
Cl. *Oxycocco-Sphagnetea* Br.-Bl. et R.Tx. 1943
O. *Sphagnetalia magellanici* (Pawł. 1928) Moore (1964) 1968
All. *Sphagnion magellanici* Kästner et Flössner 1933 em. Dierss. 1975
Ass. ***Sphagnetum magellanici*** (Malc. 1929) Kästner et Flössner 1933
Cl. *Vaccinio-Piceetea* Br.-Bl. 1939
O. *Cladonio-Vaccinietalia* Kiell.-Lund 1967
All. *Dicrano-Pinion* Libb. 1933

Suball. *Dicrano-Pinenion* Seibert in Oberd. (ed.) 1992
Ass. ***Cladonio-Pinetum*** Juraszek 1927
Peucedano-Pinetum W.Mat. (1962) 1973
Leucobryo-Pinetum W.Mat. (1962) 1973
Querco roboris-Pinetum (W.Mat. 1981) J.Mat. 1988
Serratulo-Pinetum (W.Mat. 1981) J.Mat. 1988
Suball. *Piceo-Vaccinienion uliginosi* Seibert in Oberd. (ed.) 1992
Ass. ***Vaccinio uliginosi-Pinetum*** Kleist 1929
O. *Vaccinio-Piceetalia* Br.-Bl. 1939
All. *Piceion abietis* Pawł. et al. 1928
Suball. *Vaccinio-Abietetion* Oberd. 1962
Ass. ***Abietetum polonicum*** (Dziub. 1928) Br.-Bl. et Vlieg. 1939
Community ***Abies alba-Sphagnum girgensohnii***
Cl. *Querco-Fagetea* Br.-Bl. et Vlieg. 1937
O. *Quercetalia pubescenti-petraeae* Klika 1933 corr. Moravec in Beg. et Theurill 1984
All. *Potentillo albae-Quercion petraeae* Zól et Jakucs n. nov. Jakucs 1967
Ass. ***Potentillo albae-Quercetum*** Libb. 1933
O. *Fagetalia sylvaticae* Pawł. in Pawł., Sokoł. et Wall. 1928
All. *Alno-Ulmion* Br.-Bl. et R. Tx. 1943
Suball. *Alnenion glutinoso-incanae* Oberd. 1953
Ass. ***Fraxino-Alnetum*** W.Mat. 1952
All. *Carpinion betuli* Issl. 1931 em. Oberd. 1953
Ass. ***Tilio cordatae-Carpinetum betuli*** Tracz. 1962
All. *Fagion sylvaticae* R.Tx. et Diem. 1936
Suball. *Luzulo-Fagenion* (Lohm. ex R.Tx. 1954) Oberd. 1957
Ass. ***Luzulo pilosae-Fagetum*** W.Mat. et A.Mat. 1973
Suball. *Dentario glandulosae-Fagenion* Oberd. et Müller 1984
Ass. ***Dentario glandulosae-Fagetum*** W.Mat. 1964 ex Guzikowa et Kornaś 1969

5. 2. Non-forest communities

Community with *Corynephorus canescens*

Habitat and phytosociological description. The psammophilous grassland with *Corynephorus canescens* grows on dunes and loose sands in the valleys of the Bobrza, Silnica and Sufraganiec Rivers. Dry, usually deep, loose and well-aerated sands are exposed to direct solar radiation. Soils that are formed are very much deficient in humus, and their pH is acidic (from 4 to 5). The structure of phytocoenoses in this community is very simple but also variable. The grass *Corynephorus canescens* dominates, and infrequent species of spermatophytes such as *Spergula vernalis, Anthoxanthum odoratum, Erophila verna, Festuca rubra, Hieracium pilosella, Potentilla argentea, Rumex acetosella, Scleranthus perennis, Thymus serpyllum* and *Trifolium arvense*, as well as mosses and lichens: *Ceratodon purpureus, Polytrichum piliferum, Niphotrichum canescens* and *Syntrichia ruralis*, and *Cladonia arbuscula* ssp. *mitis* occur in the gaps between grass tufts.

Dead remains of vascular plants and cryptogams undergo deflation, which hinders humus accumulation and the development of litter-inhabiting fungi.

Mycological description. Although *Basidiomycetes* in phytocoenoses with *Corynephorus canescens* were observed for three years, only 18 species were collected. Despite the scarcity of the mycobiota, the ecological character of these biocoenoses is very clearly defined, and saprobes and thermophilous fungi dominate. A special role is played by gasteroid fungi: *Bovista dermoxantha, B. nigrescens, B. plumbea, B. tomentosa, Calvatia excipuliformis, Cyathus olla*, *Geastrum minimum, Scleroderma citrinum* and *Tulostoma brumale*, which constitute 50% of the species recorded. The genus *Bovista* differentiates the mycobiota of extremely dry and warm habitats of psammophilous grasslands. *Arrhenia glauca, A. spathulata* and *Tulostoma brumale* can be considered differential species, at least locally. The two former bryophilous species develop fruitbodies on branches of *Niphotrichum canescens* and *Syntrichia ruralis*, mosses strongly associated with sparse grasslands of the class *Koelerio-Corynephoretea*. The latter grows both in psammophilous and xerothermic grasslands. According to Krieglsteiner (1999), the three species are characteristic of the *Xerobromion* alliance.

Psammophilous grasslands are habitats of thermophilis fungi that also occur in xerophilous and dry forms of pine forests. *Entoloma sericeum, Laccaria proxima* and *Scleroderma citrinum* are connective species between both biocoenoses. According to Krieglsteiner (1999), the two former are characteristic of *Spergulo vernalis-Corynephoretum*. The latter is a mycorrhizal symbiont of *Pinus,* and occurs in coniferous forests more frequently than outside them. *Crinipellis scabella, Geastrum minimum*, *Hygrocybe persistens* and *Vascellum pratense* are connective elements with xerothermic grasslands of the class *Festuco-Brometea*. *Geastrum minimum* is a fairly rare thermophilous fungus that is recorded more often in xerothermic grasslands; however, it also grows in *Peucedano-Pinetum* and in pine greenwoods in the study area. The presence of some thermophilous fungi typical of coniferous forests in psammophilous grasslands shows a genetic similarity between arenicolous communities and dry pine forests.

Fruitbodies of *Crinipellis scabella* occur abundantly on grass blades. A mass occurrence of fruitbodies is also characteristic of *Marasmius oreades* and *Vascellum pratense*, fungi characterised by a very broad ecological scale. Although they mostly grow in non-forest communities, they were also recorded in pine forests.

Arrhenatheretum elatioris

Habitat and phytosociological description. Phytocoenoses of the *Arrhenatheretum elatioris* community studied in the project are situated in the valleys of the Bobrza and Sufraganiec Rivers. The community grows on hapli-gleyic cambisols and mineral gleysols. The pH of these soils is neutral or slightly acidic (pH 6.4-7.2); mull humus is also present. The floristic composition is fairly consistent and similar in the patches examined.

Arrhenatherum elatius, Geranium pratensis and *Pastinaca sativa* are characteristic species. However, species of the order *Arrhenatheretalia*: *Achillea millefolium, Bellis perennis, Dactylis glomerata, Daucus carota, Leontodon autumnalis, Lotus corniculatus, Taraxacum officinale* s.l., and of the class *Molinio-Arrhenatheretea*: *Alopecurus pratensis, Festuca pratensis, Lychnis flos-cuculi, Plantago lanceolata, Poa pratensis, Ranunculus acris, Rumex acetosa, Sanguisorba officinalis* and *Vicia cracca* play the main role in the structure of the phytocoenoses studied. The participation of species typical of moist meadows, such as *Juncus articulatus, J. effusus* and *Polygonum bistorta*, is observed in slightly depressed places. The moss layer is poorly developed or it does not occur.

Mycological description. Fungi growing in mesic *Arrhenatheretum elatioris* meadows were observed at two plots for four years. A total of 25 species were collected, including 17 exclusive species. The other species were typical of both xerothermic and psammophilous grasslands. Non-forest terrestrial saprobionts dominate. The composition of *Basidiomycetes* clearly depends on the usage type of respective meadows. Hay meadows exploited intensively and fertilised with mineral matter compounds differ from grasslands used extensively mown in the first part of the season and grazed afterwards. Coprophilous and nitrophilous fungi, for instance *Coprinus cinereus, C. plicatilis, Panaeolus acuminatus, P. foenisecii, P. sphinctrinus* and *Psilocybe semiglobata*, occur in the latter. Fruitbodies are produced by saprobionts: *Agrocybe praecox, Agaricus arvensis*, *Bovista aestivalis, Hygrocybe conica, Langermannia gigantea, Lycoperdon lividum* and *Psilocybe coronilla* on humic soils. Despite the fact that they grow in open grassland communities representing different syntaxa, the importance of these fungi for this community is not that of characteristic species while nitrophilous fungi have a differential value. A similar value can be assigned to *Langermannia gigantea*, which also shows features of a nitrophilous fungus. They clearly differentiate the basidiomycete mycobiota in *Arrhenatheretum elatioris* meadows from that in dry psammophilous and xerothermic grasslands. Although these phytocoenoses are sometimes used for grazing, habitat conditions, and soil moisture in particular, influence the species composition of fungi. *Agaricus campestris, Bovista nigrescens, Camarophyllus virgineus, Hygrocybe persistens, Lepista personata, Marasmius oreades* and *Vascellum pratense* are some of the species characterised by a great tolerance to moisture requirements. These saprobionts were recorded in xerothermic and psammophilous grasslands as well as in *Arrhnatheretum elatoris*. *Marasmius oreades*, which very often forms characteristic linear forms, so-called fairy rings, produces fruitbodies most numerously. This type of mycelium development was observed in many other sites outside the study area (cf. Rudnicka-Jezierska 1971; Gumińska 1976a, 1989; Sadowska 1979). *Lepista personata* also produced similar forms although on a smaller scale.

The composition of fungal species in this community is similar to that described from the Ojców National Park although it is poorer (Wojewoda 1975). The mycobiota of meadows in the Pieniny National Park is different and significantly richer (Gumińska 1972, 1976a, b, 1981, 1990, 1992a, b). Many species that have not been recorded in Poland outside the Pieniny Mts. or are known in Poland only from individual localities occur there.

Thalictro-Salvietum pratensis

Habitat and phytosociological description. Xerothermic grasslands belonging to *Thalictro-Salvietum pratensis* develop on southern slopes of Mt Sosnówka in the Pasmo Chęcińskie Ridge (Głazek 1987). The community covers southern slopes of deforested calcareous hills. The soils belong to Jurassic rendzic leptosols, mollic leptosols and cambic leptosols, with a deep and medium-deep level of humus accumulation. The pH of mull humus in these soils is slightly alkaline (7.6).

The species richness of plants makes this community abundant, which results in an almost complete surface cover. *Brachypodium pinnatum*, with a slightly smaller quantitative participation of *Agropyron intermedium, Aster amellus, Anthericum ramosum, Plantago media, Prunella grandiflora, Salvia pratensis* and *S. verticillata, Seseli annuum, Thesium linophyllon* and others, are dominant species. The grasslands are floristically somewhat less rich than typical meadow steppe grasslands developing in the Nida River Valley. Although they do not have species characteristic of it, they belong to *Thalictro-Salvietum pratensis* because of the overall flora composition and ecological conditions. The development degree of the moss layer varies and the layer forms small patches where *Brachythecium* *salebrosum, Hypnum cupressiforme, Syntrichia ruralis* and *Abietinella abietina*, for instance, occur in some places.

Thalictro-Salvietum grasslands are used for grazing. Pasturage is very intensive, which leads to natural fertilisation and trampling. Artificial plantings and grassland forestation should also be noted. *Pinus sylvestris, Quercus petraea* and *Q. robur* have been introduced particularly intensively, resulting in the occurrence of fungi dependent on these trees, mycorrhizal species and saprobionts. Burning dry plant remains in grasslands in the spring period is yet another unfavourable phenomenon. Such fires often cause a complete destruction of the substrate necessary for the development of pedobionts and litter-inhabiting saprobionts, and, consequently, their disappearance.

Mycological description. *Basidiomycetes* in xerothermic grasslands belonging to *Thalictro-Salvietum* were studied for four years. A total of 38 species were collected. Of them, 16 species were recorded only in the meadow steppe while the others in meadow and psammophilous communities, in pastures and in warm forms of pine forests and other forests. Steppe fungi, xerothermic fungi and thermophilous fungi determine the mycobiota in the meadow steppe. *Leucopaxillus lepistoides*, considered by Moser (1983) to be a typical steppe species, is particularly interesting, and the locality in the Chęciny Region is the second one in Poland (Łuszczyński 2006). The fungus is on the northern limit of its geographical range. It develops in thermophilous steppe grasslands in Southern Europe (Hinkova & Stoičev 1983; Camboni & Migliozzi 2001). The occurrence of typical steppe elements in the Polish mycobiota is very rare. Thermophilous fungi whose ecological scales and distribution ranges are much broader occur significantly more often and in greater numbers.

Calcicolous and thermophilous fungi are of particular importance for xerothermic grasslands belonging to the *Cirsio-Brachypodion* alliance and can be considered species characteristic of this syntaxon. *Conocybe sienophylla, Entoloma incanum, Hygrocybe konradii, H. reae, Lepiota alba* and *Leucopaxillus lepistoides* have these features. Certain doubts concerning the indicator value of *Entoloma incanum*, which was also recorded in the *Potentillo-Quercetum* phytocoenoses, can be raised. The present author's knowledge and observations of xerothermic grasslands in the Niecka Nidziańska Basin and the Chęciny Region show that the optimum conditions for this fungus are connected with grasslands belonging to the *Cirsio-Brachypodion* alliance. Similarly to the participation of xerothermic plants in thermophilous oak forests, the presence of this species is indicative of a close genetic connection between these biocoenoses. *Leucopaxillus lepistoides* and *Conocybe sienophylla* have the greatest value of characteristic species. The latter, new to Poland, is a rare fungus of Southern Europe associated with xerothermic grasslands according to Hausknecht (pers. comm.).

Highly interesting species with slightly broader occurrence ranges can also be found in *Thalictro-Salvietum* grasslands, for instance *Agaricus bernardii, Bovista dermoxantha, Camarophyllus russocoriaceus, C. subradiatus, C. virgineus, Hygrocybe insipida, H. konradii* and *H. persistens*. *Arrhenia retiruga*, a calcicolous species associated with xerothermic grasslands (Krieglsteiner 1999) was recorded in *Hypnum cupressiforme* patches; it had not been recorded in Poland for almost 100 years (Wojewoda 2003). *Camarophyllus virgineus*, *Crinipellis scabella*, *Lepista personata* and *Marasmius oreades* produced the greatest numbers of fruitbodies.

Pine plantings in grasslands strongly influence the species composition of fungi as well as plants, and result in the occurrence of the pine's mycorrhizal fungi and saprobionts. *Rhizopogon obtextus*, *Suillus collinitus*, *S. granulatus* and *Tricholoma orirubens* were recorded as mycorrhizal symbionts. *Strobilurus tenacellus* produced numerous fruitbodies on fallen pine cones.

Fruitbodies of *Boletus luridus* and *Hebeloma radicosum* grew under plantings of *Quercus petraea*.

Sphagnetum magellanici

Habitat and phytosociological description. Mycological research plots in the *Sphagnetum magellanici* community were established in the Białe Ługi Reserve. The raised bog develops on peat-muck soils and gleyic peat soils. They are characterised by a high humus content, strong acidification (pH from 3.5 to 4.5), and are poor in mineral compounds (Żurek *et al.* 2001). The water and soil relations lead to the development of highly oligotrophic habitats and, consequently, a floristic deficiency. The development of the community structure is typical, with a characteristic system of tussocks and hollows. Tussocks reach ca. 45 cm in height. The peat-bog phytocoenosis is covered with dwarf trees of *Pinus sylvestris, Betula pubescens* and *B. pendula* which form a spaced stand reaching a density of 50 to 65%. The shrub layer is poorly developed and consists of saplings of stand-forming species with *Salix cinerea* also present, although rarely. *Andromeda polypholia, Eriophorum vaginatum* and *Oxycoccus palustri*s, species characteristic of *Sphagnetum magellanici*, as well as *Ledum palustre* and *Vaccinium uliginosum* mostly occur in the field layer in tussocks. *Carex nigra, C. lasiocarpa* and *Eriophorum angustifolium*, characteristic species of fens and transition mires, grow in hollows. A very dense blanket covering the entire surface constitutes the moss layer. *Sphagnum magellanicum* and *Polytrichum strictum*, species characteristic of the community, dominate the tussocks while *S. fallax* occurs on the slopes and bottoms of small hollows. A full floristic composition of the research plots is given in Table 1.

As a result of the ombrophilous water economy, the raised bog is characterised by great fluctuations of the water level. The water level rises in the spring after thaws and causes bog flooding, similarly to continuing rainfalls in the autumn. The water level in the peat bog falls by 40-50 cm below the bog level in the summer (Przemyski & Polinowska 2001). The amount of dead wood is important for fungi, especially xylobionts. Only few dead logs and branches of pines and birches were found at the research plots. Fallen coniferous needles and leaves of deciduous trees, shrubs and undershrubs do not form the litter layer but are grown over with moss stems.

Mycological description. *Basidiomycetes* of the *Sphagnetum magellanici* were examined at four permanent research plots over a period of three years. A total of 120 mycological observations were conducted and 59 species were collected (Tab. 2): 20 terrestrial species, 20 xylobionts, 9 litter-inhabiting species and 11 bryophilous species (Fig. 7). The number of species at individual plots ranged between 17 and 34. The fungal biota of this community is definitely typical of coniferous forests, which is expressed by the greatest similarity to that of *Leucobryo-Pinetum*, with which it shares 67.8% species (Fig. 8). The ecological type of *Basidiomycetes* in the raised bog is strongly emphasised by a group of 11 exclusive species, constituting 18.6% of the total number and including the greatest number of sphagnophi-

Table 1
Sphagnetum magellanici

Successive number		1	2	3	4
Number of plot		3	4	7	11
Date		10.06.1997			25.05.2001
Locality		Białe Ługi			
Density of tree layer	a in %	50	50	60	50
Density of shrub layer	b in %	30	10	-	-
Cover of herb layer	c in %	80	90	90	80
Cover of moss layer	d in %	100	100	100	100
Number of plant species		24	11	25	14
Surface of investigated plots in m^2		400			
Ch. *Sphagnetum magellanici*, Ch. *Sphagnetalia magellanici*					
Oxyccocus palustris		3.3	3.3	3.3	3.4
Eriophorum vaginatum		1.2	3.3	2.2	1.2
Andromeda polifolia		+	1.1	1.2	1.2
Sphagnum magellanicum	d	3.3	3.3	5.5	.
Polytrichum strictum	d	1.2	.	.	1.2
Others					
Pinus sylvestris	b_1	4.4	3.4	4.4	3.3
Pinus sylvestris	b_2	.	1.1	.	.
Betula pubescens	b_1	1.1	1.1	1.2	2.2
Betula pubescens	b_2	2.2	+	.	.
Betula pubescens	c	+	.	.	.
Betula pendula	b_1	.	.	+	.
Quercus robur	c	+	.	.	.
Salix cinerea	b	.	.	.	+.2
Calluna vulgaris		.	1.2	1.2	.
Carex nigra		.	2.2	+	1.2
Carex lasiocarpa		+	+	+	.
Eriophorum latifolium		.	.	.	3.4
Ledum palustre		2.2	2.3	2.3	2.2
Luzula pilosa		.	.	+.2	.
Vaccinium myrtillus		1.2	.	+	.
Vaccinium uliginosum		2.2	2.3	2.3	2.2
Vaccinium vitis-idaea		+	.	+.2	.
Sphagnum fallax	d	4.3	4.3	5.5	5.5
Sphagnum capillifolium	d	.	.	.	1.2
Polytrichum commune	d	.	.	.	1.2
Pleurozium schreberi	d	1.2	.	.	.

Table 2
Fungi in *Sphagnetum magellanici*

Number of plot		3	4	7	11	Frequency
Locality		Białe Ługi				
Density of tree layer	a in %	50	50	60	50	
Density of shrub layer	b in %	30	10	-	-	
Cover of herb layer	c in %	80	90	90	80	
Cover of moss layer	d in %	100	100	100	100	
Surface of investigated plots in m^2		400				
Number of observations		30	30	30	30	
Number of plant species		24	11	25	14	
Number of fungi species		34	22	24	17	
Fungi on peat						
Russula emetica		5r	5r	1n	2n	4
Laccaria laccata		4r-a	4r-a	2r	2n	4
Lactarius helvus		.	3n	2r	2r	3
Lactarius rufus		2n	2r	.	.	2
Russula decolorans		2r	.	4r	.	2
Leccinum niveum		.	3n	3r	.	2
Suillus flavidus		.	1r	3r	.	2
Leccinum scabrum		.	.	2r	1r	2
Cortinarius semisanguineus		4n-a	.	.	.	1
Cortinarius pholideus		3n	.	.	.	1
Amanita muscaria		2r	.	.	.	1
Lactarius mitissimus		.	2n	.	.	1
Lactarius camphoratus		.	.	2a	.	1
Russula xerampelina		.	.	1r	.	1
Paxillus involutus		.	.	1r	.	1
Laccaria amethystea		.	.	.	1n	1
Lactarius necator		.	.	.	1r	1
Leccinum versipelle		.	.	.	1r	1
Russula aeruginea		.	.	.	1r	1
Xerocomus badius		.	.	.	1r	1
Fungi on wood						
Tricholomopsis rutilans		1r	1r	.	.	2
Lentinus lepideus		1r	1r	.	.	2
Trichaptum fuscoviolaceum		xn	.	xn	.	2
Stereum hirsutum		xn	.	xn	.	2
Panellus mitis		2n	.	1n	.	2
Cerrena unicolor		xr	.	.	.	1
Fomitopsis pinicola		xr	.	.	.	1
Trichaptum abietinum		xn	.	.	.	1
Mycena galericulata		5n	.	.	.	1
Gymnopilus penetrans		3n	.	.	.	1

Tab. 2 cont.

Diplomitoporus flavescens	2r	.	.	.	1
Crepidotus versutus	1r	.	.	.	1
Daedaleopsis confragosa	.	xn	.	.	1
Psilocybe capnoides	.	2n	.	.	1
Dichomitus squalens	.	1r		.	1
Bjerkandera adusta	.	.	xa	.	1
Pholiota flammans	.	.	2r	.	1
Piptoporus betulinus	.	.	.	xr	1
Trametes versicolor	.	.	.	xn	1
Trametes ochracea	.	.	.	xn	1
Fungi on litter					
Mycena epipterygia	2n	2n	.	2r-n	3
Mycena galopus	6r-a	6r-n	6r-a	.	3
Setulipes androsaceus	12n-a	.	6a	.	2
Strobilurus stephanocystis	.	4a	4a	.	2
Mycena metata	1n	.	.	.	1
Marasmius sp.1	.	1r	.	.	1
Marasmius epiphyllus	.	.	2a	.	1
Clitocybe dealbata	.	.	.	1r	1
Fungi among mosses					
Tephrocybe palustris	8a	8a	8a	9n-a	4
Omphalina sphagnicola	3r	2r	1n	2r	4
Galerina paludosa	6n-a	6n-a	.	7n-a	3
Psilocybe polytrichi	2n	.	3a	.	2
Cantharellula umbonata	1n	.	.	.	1
Entoloma formosum	3n	.	.	.	1
Entoloma xanthochroum	2n	.	.	.	1
Galerina hypnorum	3a	.	.	.	1
Rickenella fibula	1n	.	.	.	1
Psilocybe elongata	.	2n	.	.	1
Galerina sphagnorum	.	.	6a	.	1

lous species (Fig. 9). Macromycetes are an important quantitative group in the *Sphagnetum magellanici* biocoenosis and outnumber vascular plants in a ratio of 3.5:1.

Terrestrial fungi develop the mycelium and fruitbodies on the peat soil. The species recorded at permanent plots are mycorrhizal fungi. The composition of mycorrhizal fungi was mostly determined by the participation of pines and birches with which fungi could form mycorrhizae. Therefore, terrestrial fungi resemble pedobionts in *Leucobryo-Pinetum* (75% species in common) the most, and other coniferous forest communities, for instance *Abies alba-Sphagnum girgensohnii* (50%) as well as *Abietetum polonicum* and *Vaccinio uliginosi-Pinetum* (45% each) (Fig. 10). Exclusive species: *Leccinum niveum*, *L. versipelle* and *Suillus flavidus*, differentiate the community the best. However, the diagnostic value of these species varies. *Leccinum versipelle*, a *Betula pendula* symbiont, was also recor-

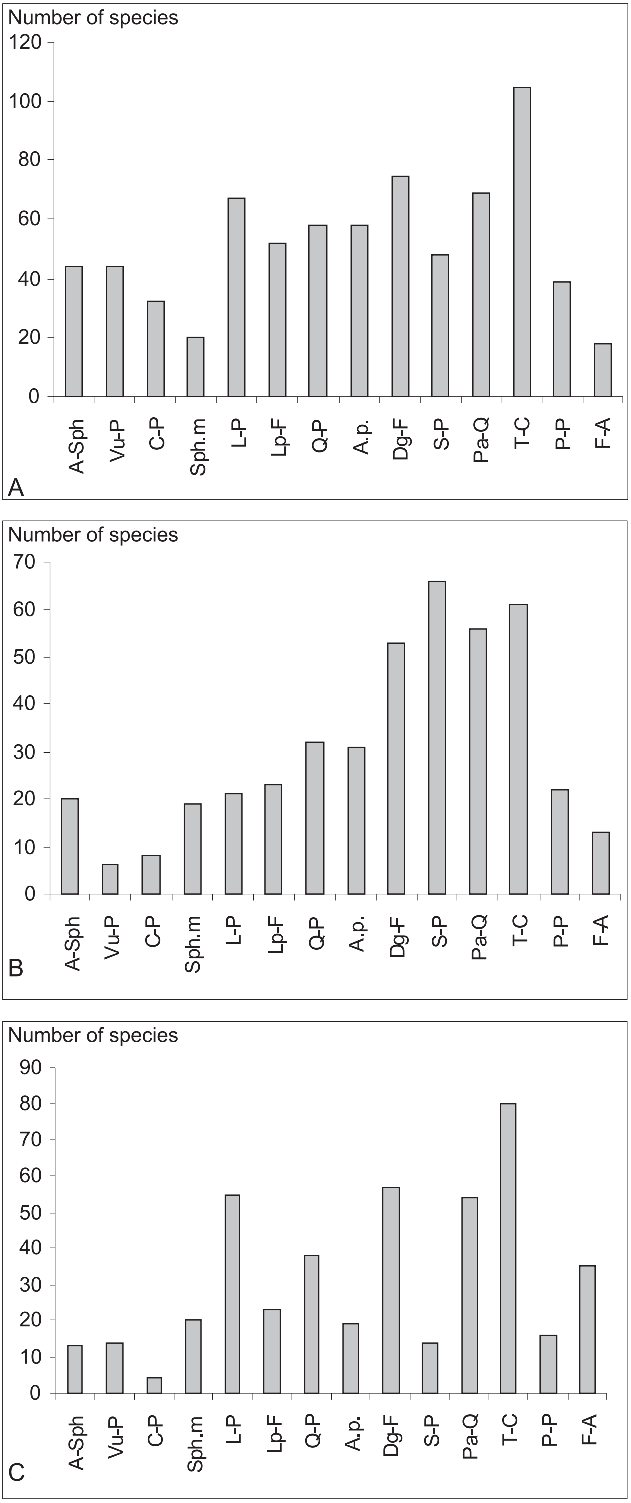
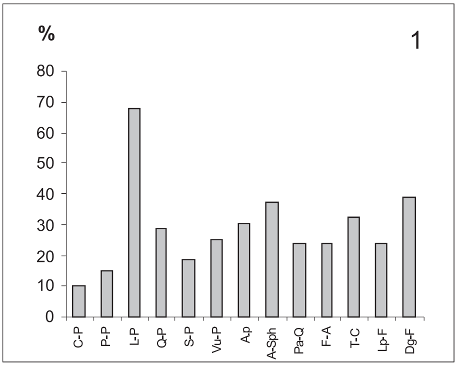


Fig. 7. Occurrence of terrestrial fungi (A), litter-inhabiting and bryophilous fungi (B) and xylobionts (C) in the examined plant communities

A-Sph – *Abies alba-Sphagnum girgensohnii* community; Vu-P – *Vaccinio uliginosi-Pinetum*; C-P – *Cladonio-Pinetum*; Sph.m. – *Sphagnetum magellanici*; L-P – *Leucobryo-Pinetum*; Lp-F – *Luzulo pilosae-Fagetum*; Q-P – *Querco roboris-Pinetum*; A.p. – *Abietetum polonicum*; Dg-F – *Dentario glandulosae-Fagetum*; S-P – *Serratulo-Pinetum*; Pa-Q – *Potentillo albae-Quercetum*; T-C – *Tilio-Carpinetum*; P-P – *Peucedano-Pinetum*; F-A – *Fraxino-Alnetum*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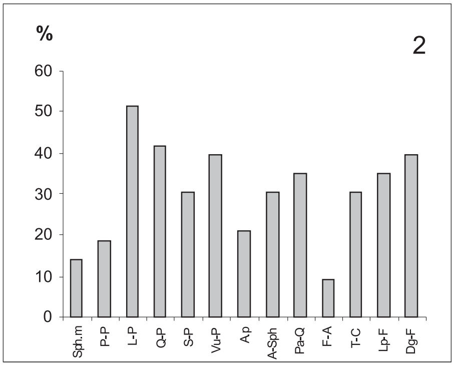
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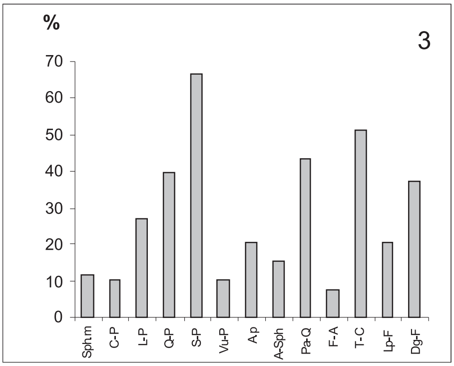
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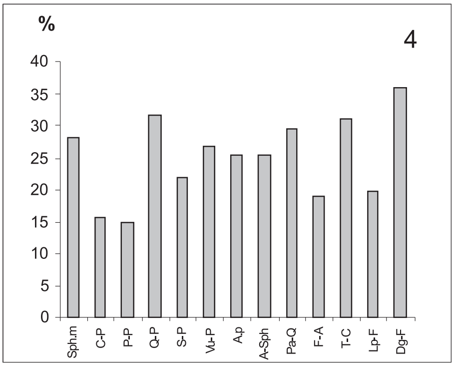
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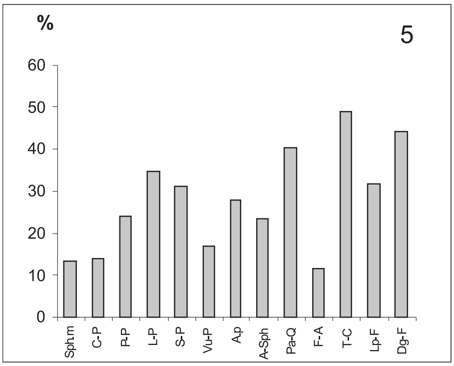
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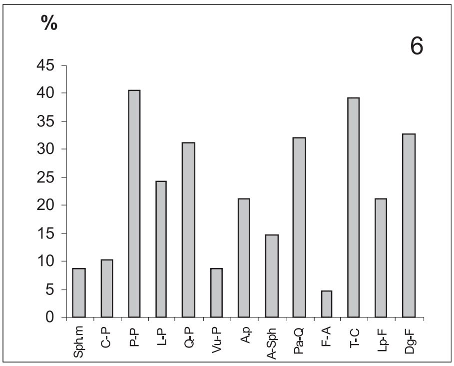
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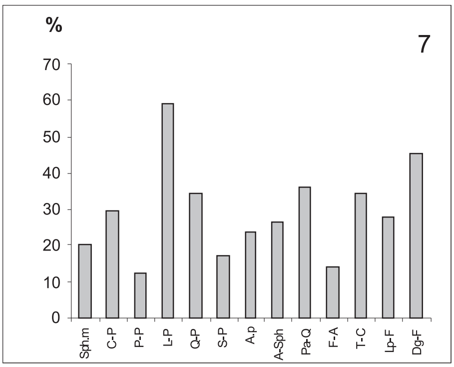
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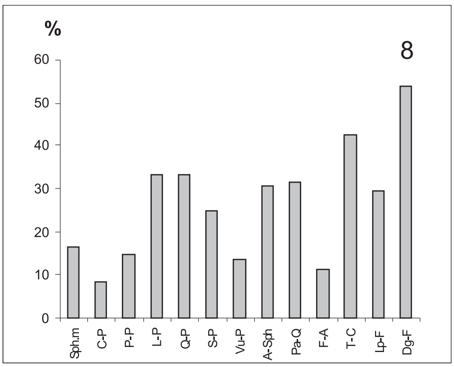
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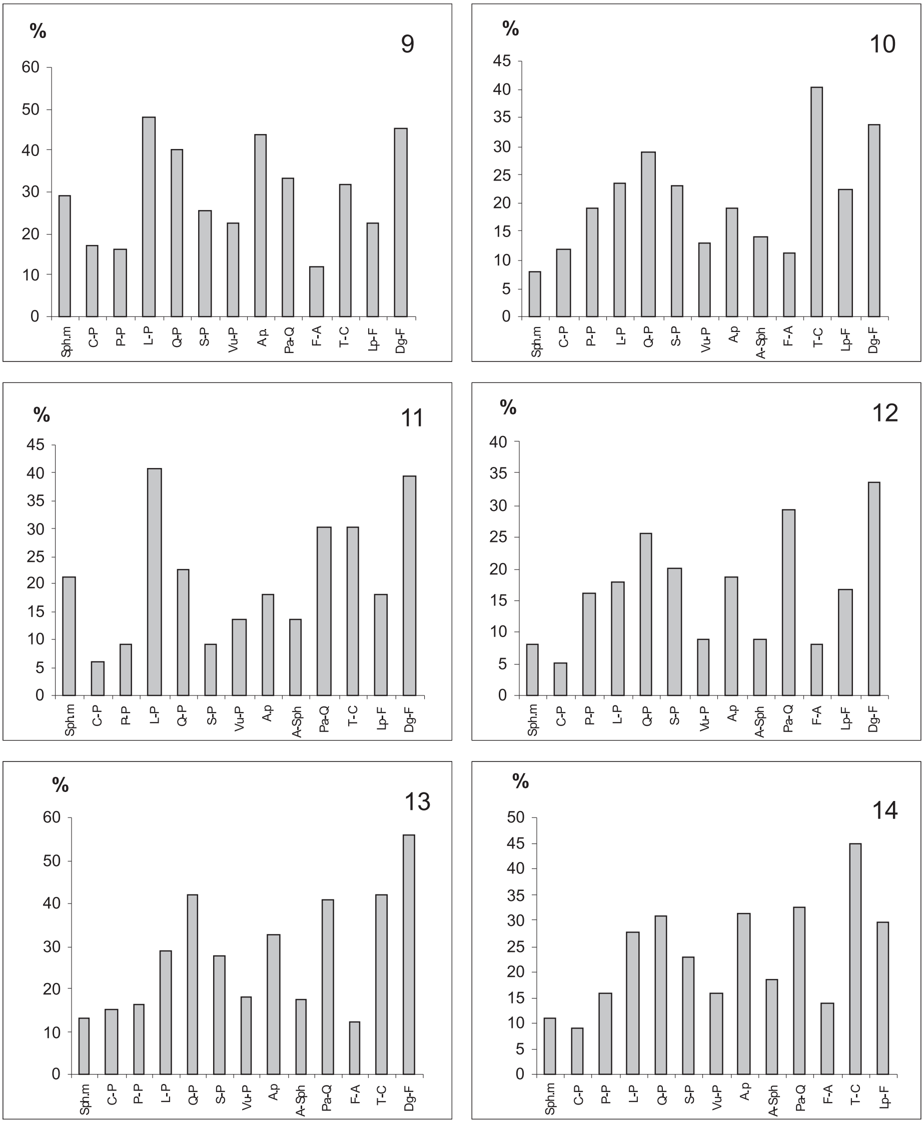


Fig. 8. The mycobiota in the examined plant communities: similarities
1 – *Sphagnetum magellanici*; 2 – *Cladonio-Pinetum*; 3 – *Peucedano-Pinetum*; 4 – *Leucobryo-Pinetum*; 5 – *Querco roboris-Pinetum*; 6 – *Serratulo-Pinetum*; 7 – *Vaccinio uliginosi-Pinetum*; 8 – *Abietetum polonicum*; 9 – *Abies alba-Sphagnum girgensohnii* community; 10 – *Potentillo albae-Quercetum*; 11 – *Fraxino-Alnetum*; 12 – *Tilio-Carpinetum*; 13 – *Luzulo pilosae-Fagetum*; 14 – *Dentario glandulosae-Fagetum*. Below the diagrams: Sph.m. – *Sphagnetum magellanici*; C-P – *Cladonio-Pinetum*; P-P – *Peucedano-Pinetum*; L-P – *Leucobryo-Pinetum*; Q-P – *Querco roboris-Pinetum*; S-P – *Serratulo-Pinetum*; Vu-P – *Vaccinio uliginosi-Pinetum*; A.p. – *Abietetum polonicum*; A-Sph – *Abies alba-Sphagnum girgensohnii* community; Pa-Q – *Potentillo albae-Quercetum*; F-A – *Fraxino-Alnetum*; T-C – *Tilio-Carpinetum*; Lp-F – *Luzulo pilosae-Fagetum*; Dg-F – *Dentario glandulosae-Fagetum*

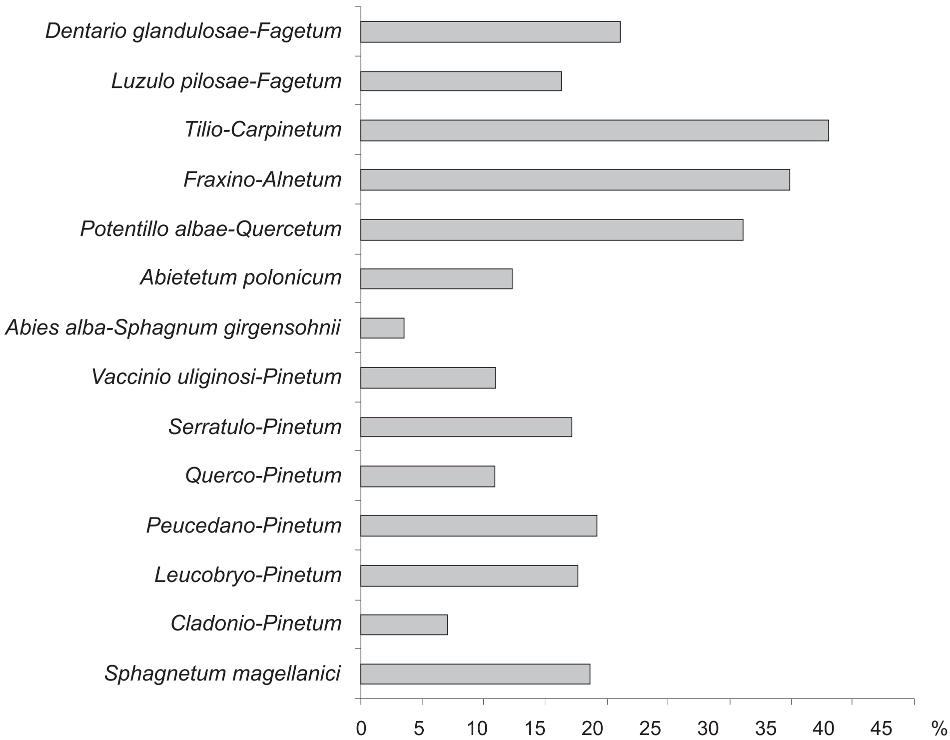


Fig. 9. Percentage participation of exclusive species of *Basidiomycetes* in the examined plant communities

ded in other plant communities, such as *Peucedano-Pinetum* and *Querco-Pinetum*, in the Góry Świętokrzyskie Mts. It is a common fungus and, as a birch symbiont, it is encountered in many plant communities. The ecological scale of *Leccinum niveum*, which was recorded only in the *Vaccinio uliginosi-Pinetum* outside the community in question in the Góry Świętokrzyskie Mts., is significantly narrower. Above the regional level, the fungus is quite rare and associated mostly with humid, boggy coniferous forest communities where *Sphagnum* is present and peat bogs of the class *Oxycocco-Sphagnetea* with the participation of birches. *Suillus variegatus,* a *Pinus* symbiont, was recorded exclusively in the *Sphagnetum magellanici* community in the study area. In Poland, the fungus occurs mostly in raised bogs, and seems to find the optimum conditions in this habitat type. Therefore, it may be considered to be a locally characteristic species of the *Sphagnetum magellanici*. Similar observations and conclusions concerning the diagnostic value of *Leccinum niveum* and *Suillus flavidus* are presented by Flisińska (1988, 1995).

Laccaria laccata, Lactarius helvus, Russula decolorans and *R. emetica* were the most frequently recorded pedobionts in the community at the observation plots.

Litter-inhabiting fungi are the smallest ecological group in the raised bog. Their biota is typical of coniferous forest communities and resembles that of *Leucobryo-Pinetum* the most (8 species in common), and, further, *Abietetum polonicum*, the *Abies alba-Sphagnum girgensohnii* and *Querco-Pinetum* communities, with which it has six species in common (Fig. 11). These fungi are very common and also grow in other forest communities. The status of *Setulipes androsaceus* is that of an exclusive species at the research plots.

However, it was collected in various coniferous forest communities, and its exclusive character is therefore irrelevant.

Bryophilous fungi which constitute 18.6% of all *Basidiomycetes* in the community are an important group in the biocoenosis of the raised bog. Species associated with mosses of the genus *Sphagnum* dominate among them. The following species of sphagnophilous fungi were recorded: *Entoloma formosum, E. xanthochroum, Galerina sphagnorum, Tephrocybe palustre* and *Omphalina sphagnicola*. Exclusive species, that is *Entoloma xanthochroum, Galerina sphagnorum* and *Omphalina sphagnicola*, are of diagnostic value for the study bog. The two latter are also considered by FRIEDRICH (1994) to be good locally characteristic species of *Sphagnetum magellanici*. *Entoloma xanthochroum*, previously known only from the Góry Świętokrzyskie Mts. and recorded exclusively in the community in question, has the highest syntaxonomic value, that of a characteristic species. The other two bryophiles may be treated as regionally characteristic as they were not collected outside the community in the study area. However, they were also recorded in other boggy communities, both open and forest ones. Undoubtedly, the centre of their occurrence is concentrated in the communities of boggy coniferous forests as well as raised bogs and transition mires, with a high presence of species belonging to the genus *Sphagnum*. The character of species of bryophiles encountered outside the plots studied in the peat bog, such as *Entoloma formosum* and *Tephrocybe palustris*, recorded in the Góry Świętokrzyskie Mts. in the *Vaccinio uliginosi-Pinetum* boggy forest, is similar.

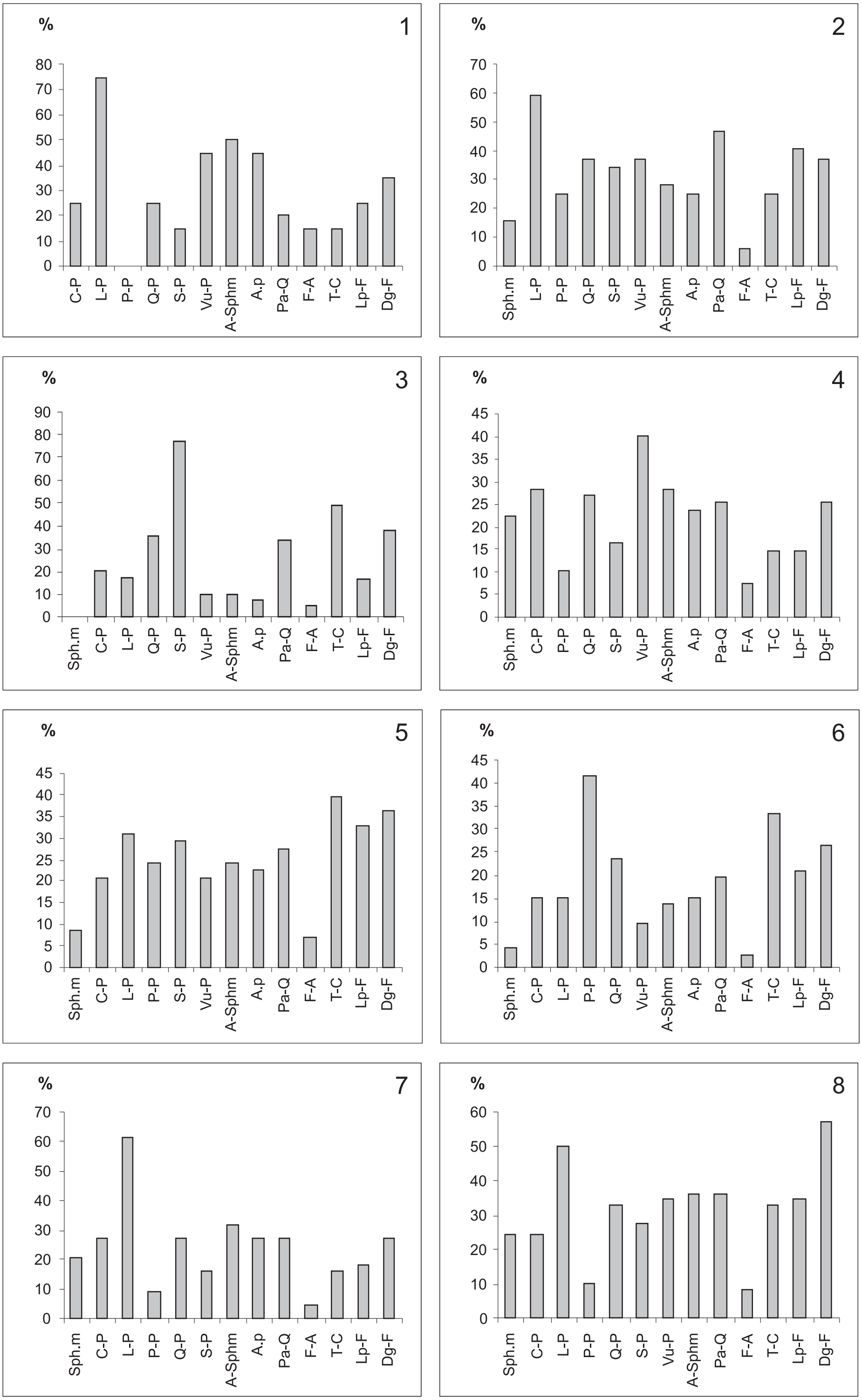
Galerina paludosa, Omphalina sphagnicola and *Tephrocybe palustris* were characterised by the greatest frequency and greatest fruitbodies productivity among the fungi discussed above.

Lignicolous fungi are associated with dead pine and birch wood. Similarly to the above fungi, they are typical of coniferous forests and resemble the fungi occurring in the *Leucobryo-Pinetum* forest, with which they share 75% species (Fig. 12). A great resemblance to deciduous forests, for instance to the oak-hornbeam forest (60% of species in common) due to ubiquitous fungi, is interesting. *Crepidotus versutus* and *Dichomitus squalens* are species exclusive to this community. They are rare not only in the Góry Świętokrzyskie Mts. but also in Poland. *Crepidotus versutus* occurs mostly on fallen twigs of deciduous trees and less frequently on remains of coniferous trees, as, for instance, in the Białe Ługi reserve, on *Pinus*. *Dichomitus squalens* is associated with coniferous wood, *Pinus*, among others. It is a rare species in Europe and occurs in areas influenced by the continental climate. Despite the rare occurrence of both fungi and their exclusive presence in the discussed community in the raised bog, they cannot be assigned the value of characteristic species. The occurrence range of both is greater than that in the discussed community, and they seem to be good differential species of the boggy coniferous forest and raised bogs.

Diplomitoporus flavescens, a saprobiont occurring on coniferous wood (*Pinus*), should also be mentioned. It was also recorded in patches of the *Leucobryo-Pinetum*. It is a good characteristic species of coniferous forest communities belonging to the *Dicrano-Pinion* alliance.

Parasitic *Basidiomycetes* do not play a major role either qualitatively or quantitatively. *Cerrena unicolor, Fomitopsis pinicola* and *Piptoporus betulinus*, occurring as saprobionts or weak parasites, were recorded only occasionally.

Lignicolous fungi recorded at the plots were characterised by a low frequency. Only five species were collected at two plots while the others were found only at individual plots.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%
C-P L-P P-P Q-P S-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
2
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Sph.m L-P P-P Q-P S-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
3
%
Sph.m C-P L-P Q-P S-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
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Sph.m C-P P-P Q-P S-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
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Sph.m C-P L-P P-P S-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
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Sph.m C-P L-P P-P Q-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
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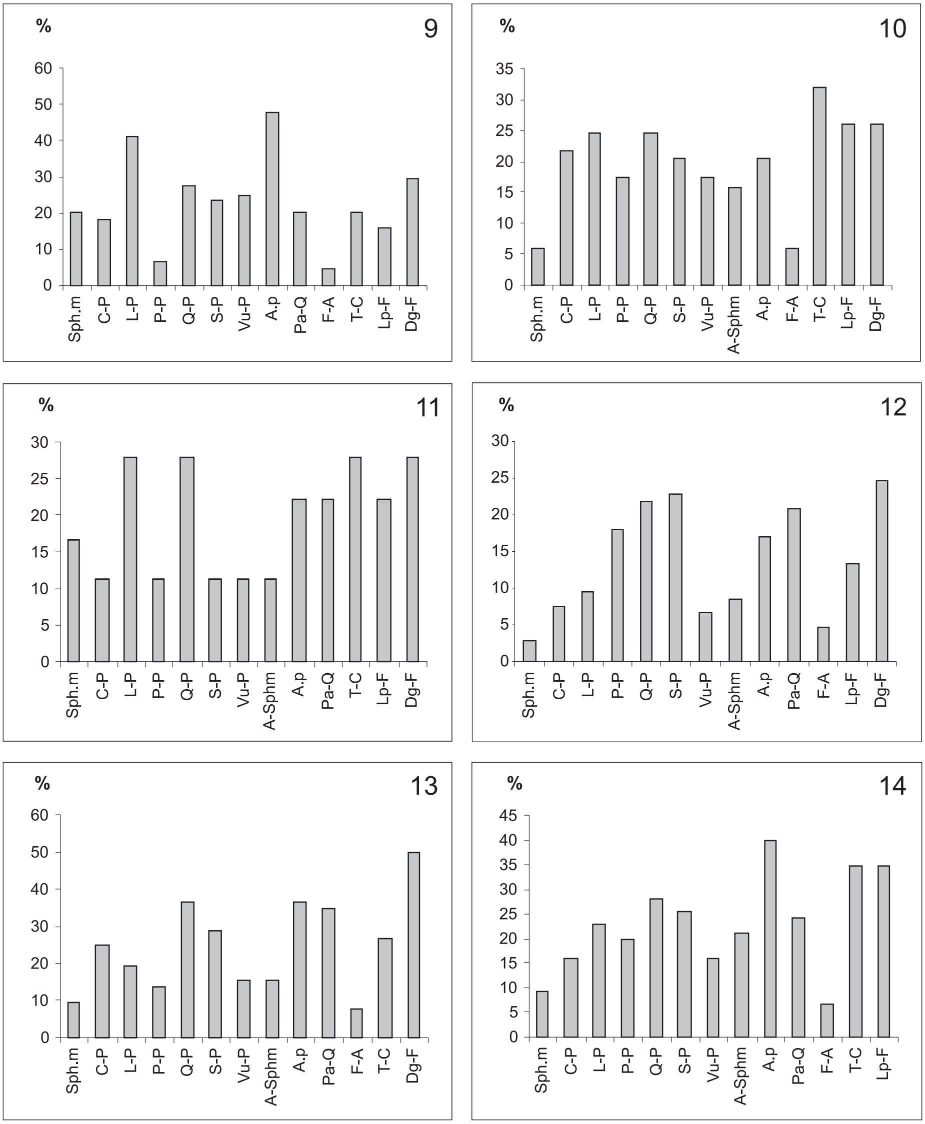
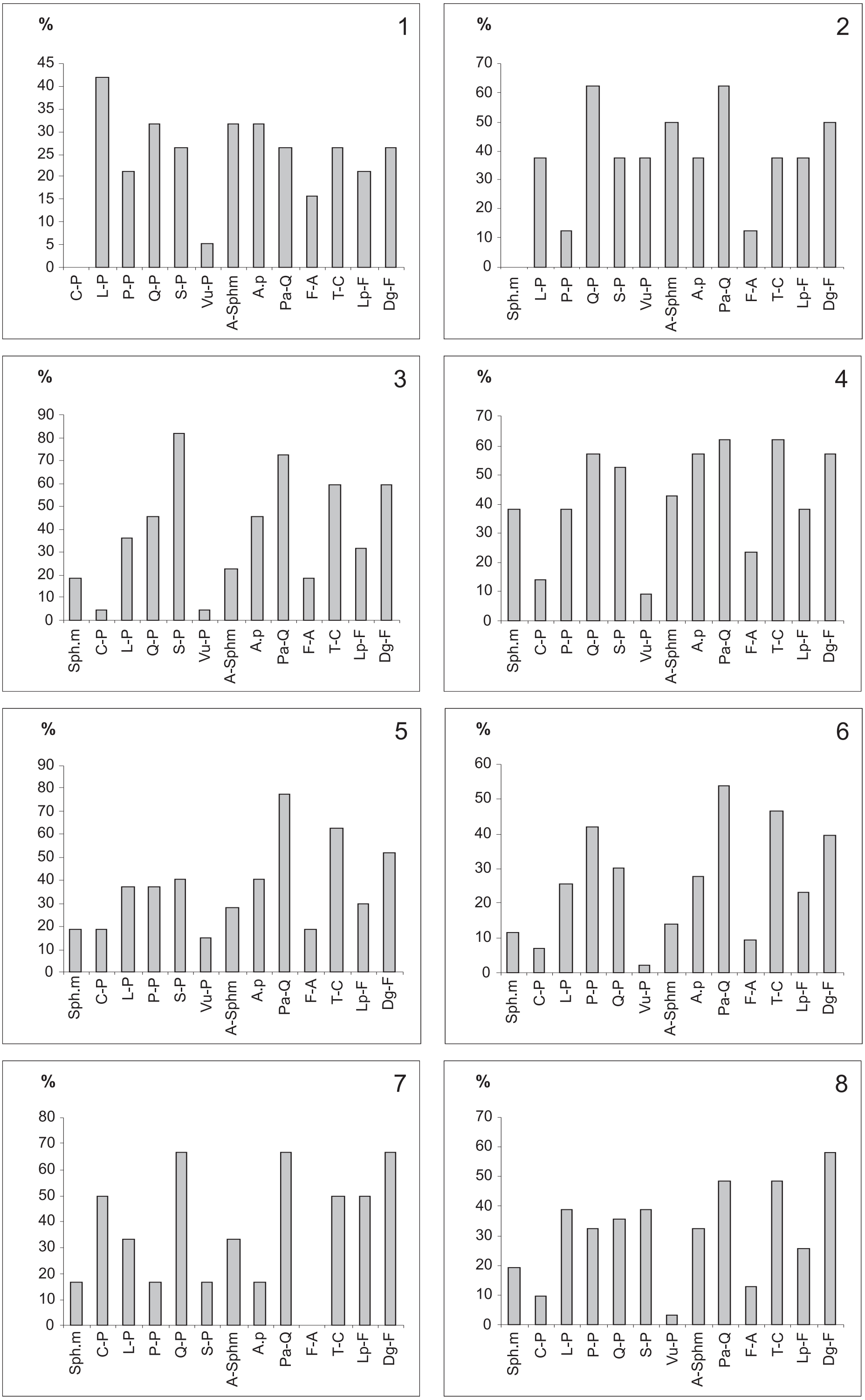


Fig. 10. Terrestrial fungi in the examined plant communities: similarities. Explanations see Fig. 8



%
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C-P L-P P-P Q-P S-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
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2
70 60 50 40 30 20 10 0
Sph.m L-P P-P Q-P S-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
%
3
90 80 70 60 50 40 30 20 10 0
Sph.m C-P L-P Q-P S-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
%
4
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Sph.m C-P P-P Q-P S-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
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5
90 80 70 60 50 40 30 20 10 0
Sph.m C-P L-P P-P S-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
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6
60 50 40 30 20 10 0
Sph.m C-P L-P P-P Q-P Vu-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
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80 70 60 50 40 30 20 10 0
Sph.m C-P L-P P-P Q-P S-P A-Sphm A.p Pa-Q F-A T-C Lp-F Dg-F
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70 60 50 40 30 20 10 0
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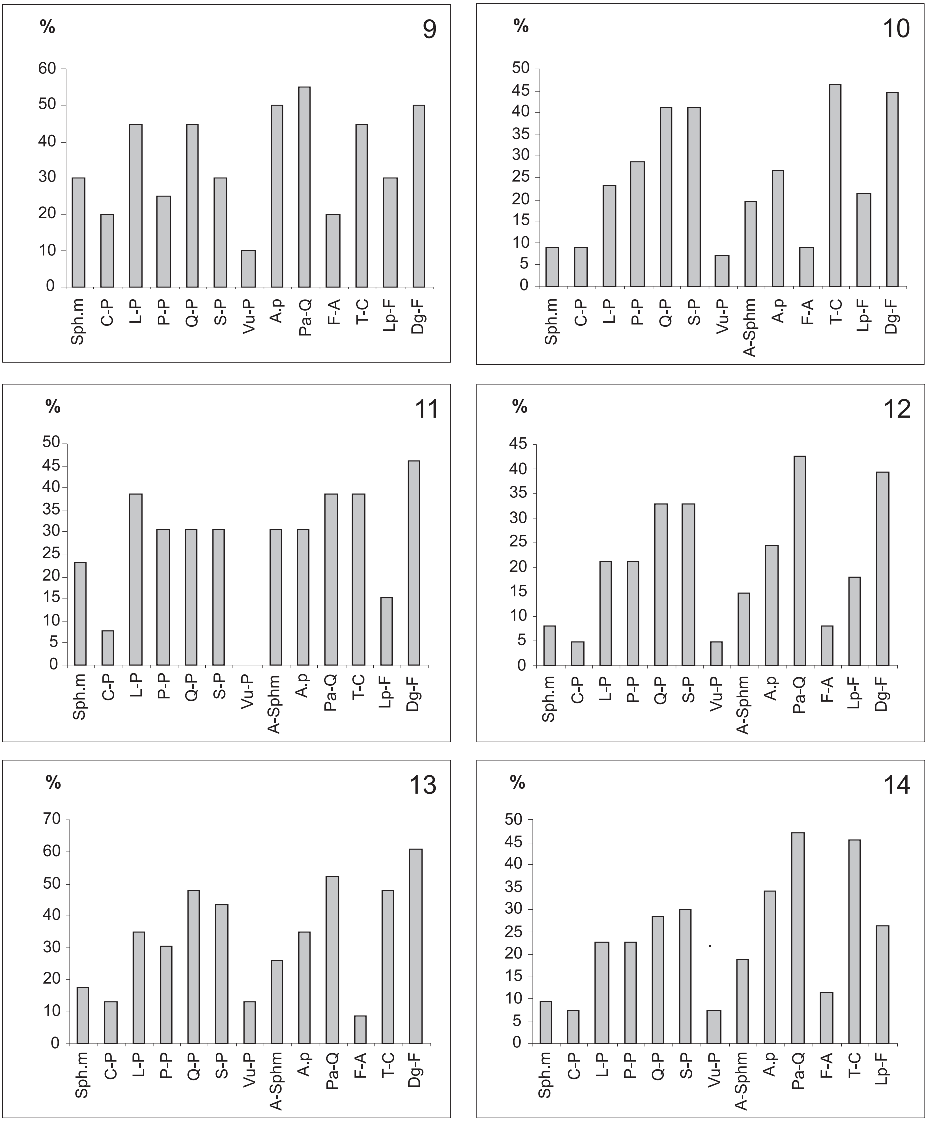
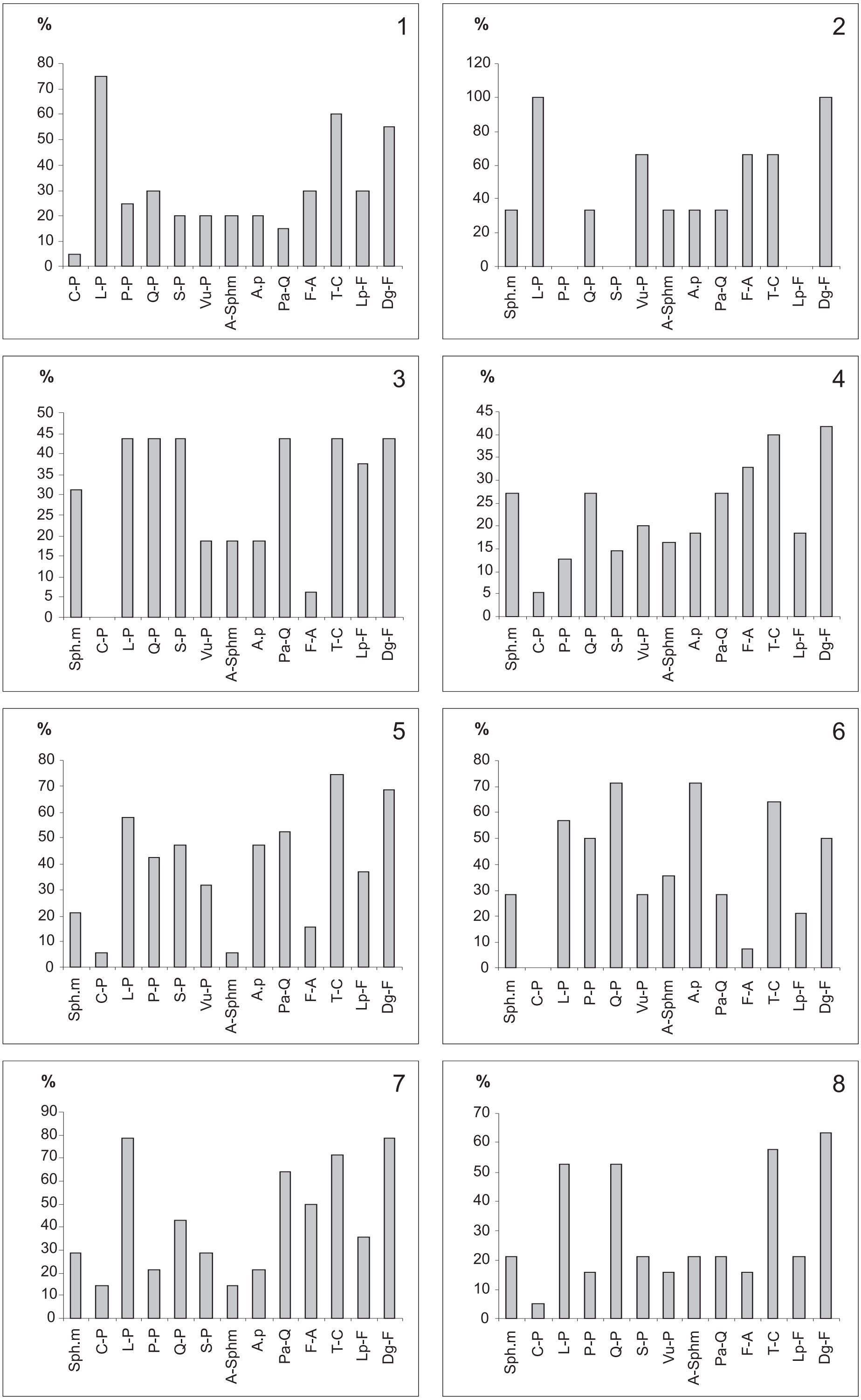


Fig. 11. Litter-inhabiting fungi in the examined plant communities: similarities. Explanations see Fig. 8


%
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40
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20
10
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C-P
L-P
P-P
Q-P
S-P
Vu-P
A-Sphm
A.p
Pa-Q
F-A
T-C
Lp-F
Dg-F
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20
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Sph.m
L-P
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Q-P
S-P
Vu-P
A-Sphm
A.p
Pa-Q
F-A
T-C
Lp-F
Dg-F
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Sph.m
C-P
L-P
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Vu-P
A-Sphm
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Pa-Q
F-A
T-C
Lp-F
Dg-F
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Sph.m
C-P
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Vu-P
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Pa-Q
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Lp-F
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Sph.m
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Sph.m
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Sph.m
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A-Sphm
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Pa-Q
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Lp-F
Dg-F
%
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Sph.m
C-P
L-P
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S-P
Vu-P
A-Sphm
Pa-Q
F-A
T-C
Lp-F
Dg-F

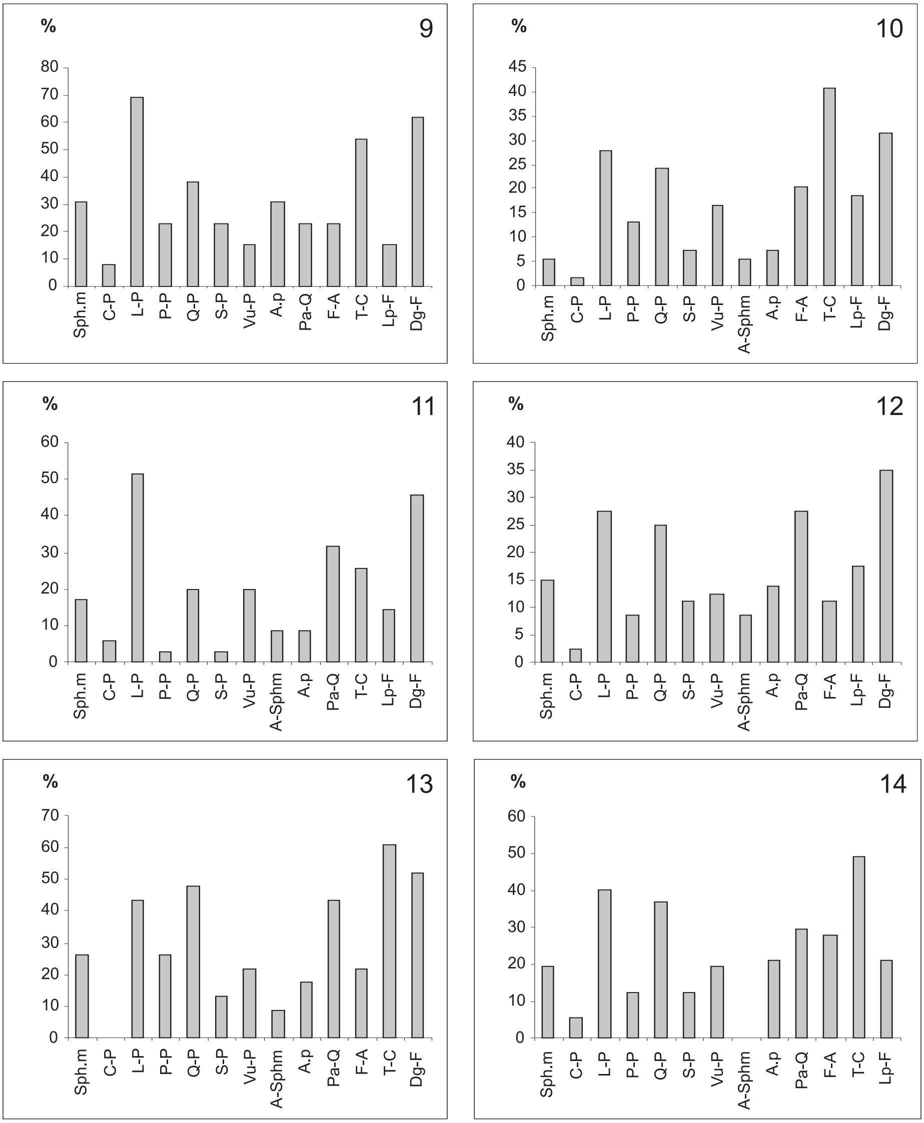

Fig. 12. Xylobionts in the examined plant communities: similarities. Explanations see Fig. 8

5.3. Forest communities

Cladonio-Pinetum

Habitat and phytosociological description. Mycological observations in *Cladonio-Pinetum* were conducted in the Białe Ługi reserve. The phytocoenosis of the dry midland coniferous forest developed on a small dune covering an area of a few ares in the central part of the peat bog surrounded by the raised bog, *Sphagnetum magellanici*, on one side and the boggy coniferous forest, *Vaccinio uliginosi-Pinetum*, on the other. Only *Pinus sylvestris* grows in the stand. *Betula pendula, B. pubescens, Quercus petraea, Fagus sylvatica, Frangula alnus* and *Picea abies* occur sporadically in the shrub layer together with pine saplings. The field layer is very poor with the participation of the following undergrowth: *Arctostaphylos uva-ursi, Calluna vulgaris, Vaccinium vitis-idaea,* and few sparsely distributed herbaceous plants, such as *Anthoxanthum odoratum, Festuca ovina* and *F. rubra*. The moss layer is abundant and dominated by numerous lichens, mostly of the genus *Cladonia*, for instance *C. furcata, C. chlorophaea, C. ciliata* var. *tenuis* and *Cetraria islandica*, species characteristic of the community, and mosses: *Pleurozium schreberi, Dicranum scoparium* and *D. undulatum*. The floristic composition of the plot is given in Table 3. The *Cladonio-Pinetum* forest colonises dry and oligotrophic habitats of deep and loose sands, strongly acidified in the topsoil part. The litter falling on the soil is composed of coniferous needles and small pine twigs, wind-blown deciduous leaves, remains of herbaceous plants, dead mosses and lichens. No larger lying tree fragments that could serve as the substrate for xylobionts were observed at the plot.

Mycological description. The biota of *Basidiomycetes* in the *Cladonio-Pinetum* was examined at one permanent research plot where 40 field observations were conducted over four years. A total of 43 species were collected (Tab. 4). The mycological profile of the forest community is the least numerous in the study area. The low number of fungal species is likely to result from difficult habitat conditions and the poor flora of this community which particularly adversely affects saprobic fungi. Nevertheless, the biota of this community shows characteristic features of coniferous forests and resembles fungi of the *Leucobryo-Pinetum* the most, with which it shares 51.1% species, and *Querco-Pinetum* – 41.9% (Fig. 8).

The role of *Basidiomycetes* in the structure of the *Cladonio-Pinetum* biocoenosis is important and the quantitative participation of fungi belonging to this group regularly exceeds the number of vascular plants in a ratio of 2.65:1.

Terrestrial fungi constitute the most numerous ecological group and comprise 32 species, that is 74.4% of the total number (Fig. 7a). Mycorrhizal fungi constitute 87.5% of all terrestrial fungi. Of them, only *Gyroporus cyanescens* is an exclusive species and characterises the community the best. It can be considered to be locally characteristic of the dry midland coniferous forest in the Góry Świętokrzyskie Mts. A symbiont of various tree species, mainly *Pinus*, but also *Betula*, *Fagus* and *Picea*, the fungus has been repeatedly recorded in different forest communities such as *Calamagrostio-Quercetum*, *Melico-Fagetum* or *Tilio-Carpinetum* in Poland (Lisiewska 1966b; Mamos 1986; Lisiewska & Płaczek 1993). Consequently, it cannot be assigned a significant diagnostic role above the regional level. Six other species also occur in the community; they were recorded only at one locality in other coniferous forest communities outside *Cladonio-Pinetum*. This group consists of the following species: *Coltricia perennis, Lactarius uvidus, Russula sardonia, Scleroderma*

Table 3

Cladonio-Pinetum

Number of plot		12
Date		25.05.2001
Locality		Białe Ługi
Density of tree layer	a in %	60
Density of shrub layer	b in %	15
Cover of herb layer	c in %	60
Cover of moss layer	d in %	80
Number of plant species		24
Surface of investigated plot in m^2		400
Ch. *Cladonio-Pinetum*		
Cetraria islandica	d	1.2
Cladonia chlorophaea	d	1.2
Cladonia coniocraea	d	+
Cladonia subulata	d	+
Cladonia fimbriata	d	+.2
Cladonia furcata	d	2.2
Cladonia glauca	d	+.2
Cladonia gracilis	d	+.2
Cladonia macilenta	d	+
Cladonia phyllophora	d	+.2
Cladonia rangiferina	d	+
Cladonia ciliata var. *tenuis*	d	1.2
Ch., *D *Vaccinio-Piceetea, Cladonio-Vaccinietalia*		
Pinus sylvestris	a	4.4
Pinus sylvestris	b	1.2
Pinus sylvestris	c	1.1
Vaccinium vitis-idaea		3.3
Vaccinium myrtillus		+
Vaccinium uliginosum		+
Melampyrum pratense		1.2
**Arctostaphylos uva-ursi*		1.2
Pleurozium schreberi	d	4.3
Dicranum scoparium	d	2.2
Leucobryum glaucum	d	1.2
Others		
Quercus petraea	b	+
Quercus petraea	c	+
Betula pubescens	b	1.1
Betula pubescens	c	+
Betula pendula	b	1.1
Fagus sylvatica	b	+
Frangula alnus	b	+

Tab. 3 cont.

Picea abies	b	+
Anthoxanthum odoratum	c	1.2
Calluna vulgaris		3.3
Carex ericetorum		+
Festuca ovina		+.2
Festuca rubra		+
Hieracium pilosella		+.2
Luzula campestris		+
Maianthemum bifolium		+.2
Rumex acetosella		+
Dicranum undulatum	d	3.3

Table 4
Fungi in *Cladonio-Pinetum*

Number of plot		12
Locality		Białe Ługi
Density of tree layer	a in %	60
Density of shrub layer	b in %	15
Cover of herb layer	c in %	60
Cover of moss layer	d in %	80
Surface of investigated plot in m^2		400
Number of observations		40
Number of plant species		25
Number of fungi species		44
Terrestrial fungi		
Scleroderma citrinum		6a
Coltricia perennis		4n
Cortinarius cinnamomeus		4n
Amanita citrina		3r
Cantharellus cibarius		3r-n
Russula cyanoxantha		3r
Suillus granulatus		3n-a
Tricholoma equestre		3r-n
Xerocomus badius		3r
Amanita muscaria		2r
Amanita rubescens		2r
Boletus edulis		2r
Gyroporus cyanescens		2r
Lactarius helvus		2r
Lycoperdon perlatum		2r
Russula vesca		2r
Russula xerampelina		2n
Scleroderma verrucosum		2r
Agaricus silvicola		1r
Amanita excelsa		1r

Tab. 4 cont.

Amanita fulva	1r
Amanita pantherina	1r
Amanita porphyria	1r
Calocybe gambosa	1n
Lactarius uvidus	1r
Leccinum scabrum	1r
Lepiota aspera	1r
Macrolepiota procera	1r
Ramaria abietina	1a
Russula claroflava	1r
Russula sardonia	1r
Suillus variegatus	1n
Fungi on wood	
Trametes hirsuta	xr
Trametes versicolor	xn
Xeromphalia campanella	1n
Fungi on litter	
Setulipes androsaceus	6a
Clitocybe gibba	3a
Gymnopus dryophilus	2r
Mycena pura	2n
Rhodocollybia butyracea var. *butyracea*	2n
Conocybe subpubescens	1r
Marasmius bulliardii	1n
Fungi among mosses	
Galerina hypnorum	1r

citrinum, Suillus variegatus and *Tricholoma equestre*. *Coltricia perennis, Scleroderma citrinum* and *Tricholoma equestr*e, which were also recorded in *Leucobryo-Pinetum*, are the most typical species of poor and sandy coniferous forest soils.

Scleroderma citrinum was the most frequently recorded species in the patch of the dry coniferous forest examined here. However, species recorded only once throughout the observation period constitute the most numerous group, that is 43.7%.

Only 8 species of litter-inhabiting and bryophilous fungi were recorded (Fig. 7b). The group does not seem to be specific to this community, and only *Conocybe subpubescens* can treated as exclusive. However, it does not appear to be an indicator fungus as it is reported from localities in different coniferous and deciduous forest communities in Poland (Wojewoda 2003). *Setulipes androsaceus*, which produced numerous fruitbodies on the litter of fallen pine needles, was the most frequently recorded species belonging to this group. Due to the presence of deciduous litter, *Marasmius bulliardii*, a species not very typical of coniferous forests, was also recorded. The biota of litter-inhabiting and bryophilous fungi in the discussed community is similar to that in *Abietetum polnicum, Querco-Pinetum* and

Potentillo-Quercetum having 5 species in common. The following saprobionts constitute this group: *Galerina hypnorum*, *Gymnopus dryophilus, Marasmius bulliardii, Mycena pura, Psilocybe aeruginosa, Rhodocollybia butyracea* var. *butyracea* and *Setulipes androsaceus*. These fungi are ubiquitous and occur in the majority of the forest communities examined. Only three species of xylobionts were observed: *Trametes hirsuta, T. versicolor* and *Xeromphalia campanella*. These fungi are very common, grow in different communities and are of no diagnostic value for this forest community (Fig. 7c).

Peucedano-Pinetum

Habitat and phytosociological description. Patches of the subcontinental mesic coniferous forest selected for mycological studies were established on the S slope of Mt Brusznia (Pasmo Kadzielniańskie Ridge), SE slope of Mt Telegraf (Pasmo Dymińskie Ridge), S slope of Mt Biesak, N slope of Mt Bugalanka and at the foothill of the N slope of Mt Pierścienica (Pasmo Posłowickie Ridge). Phytocoenoses in this community develop on light and medium haplic podzols, formed from loose sands, boulder clays and sands lying on Devonian limestone (Zaręba 1977). A high stand consists mostly of 70 to 100-year old *Pinus sylvestris* trees, rejuvenated artificially. The sub-canopy layer, very sparse, comprises single low birch, oak, rowan, fir, alder buckthorn and aspen trees. The field layer is formed by coniferous forest species, such as *Chimaphila* a species characteristic of the community, *Melampyrum pratense, Moneses uniflora, Orthilia secunda, Trientalis europaea, Vaccinium myrtillus, V. vitis-idaea* of the class *Vaccinio-Piceetea*. Some species of the class *Querco-Fagetea*, for instance *Carpinus betulus, Fagus sylvatica, Carex digitata* and *Viola reichenbachiana*, are also present in the phytocoenoses. Hornbeam and beech trees do not reach the highest tree layer. The moss layer is on the whole highly developed and dense (70-90%), and *Abietinella abietina, Brachythecium albicans, B. salebrosum, Hylocomium splendens* and *Pleurozium schreberi* dominate (Tab. 5).

The rich floristic composition of this community, and especially the presence of some species, for instance *Genista tinctoria, Orthilia secunda* and *Pimpinella saxifraga*, as well as comparable habitats, make these phytocoenoses similar to *Serratulo-Pinetum*. On the other hand, the occurrence of oaks, rowans, saplings of hornbeams, birches, alder buckthorns as well as *Agrostis capillaris* and *Festuca ovina* is indicative of their resemblance to *Querco-Pinetum*. These determinants significantly influence both floristic and mycological similarities to the forest communities listed above.

Single tree logs and infrequent larger branch pieces lie on the soil and in the litter. Numerous stumps of deciduous trees and pines, serving as the substrate for the development of lignicolous fungi, remain after forest maintenance works.

Mycological description. Fungi in the subcontinental mesic coniferous forest were examined at five research plots over a period of four years. A total of 200 observations were carried out and 78 species were collected (Tab. 6). Forty observations were conducted at each plot and between 14 and 30 species were recorded. Quantitatively, the biota of *Basidiomycetes* was one of the least numerous groups; a smaller number was recorded in the *Cladonio-Pinetum, Sphagnetum magellanici, Vaccinio uliginosi-Pinetum* and *Fraxino-Alnetum* (Fig. 8). This results is surprisingly low given the overall number of 199 species collected in this community, including areas outside permanent research plots. *Basidiomycetes* in *Peucedano-Pinetum* differ quite significantly from other communities: 15 exclusive species

Table 5

Peucedano-Pinetum

Successive number		1	2	3	4	5
Number of plot		7	8	9	13	14
Date				15.07.1992		
Locality				Kielce		
Density of tree layer	a in %	70	80	80	70	70
Density of shrub layer	b in %	10	30	10	20	20
Cover of herb layer	c in %	90	100	90	90	90
Cover of moss layer	d in %	90	95	70	90	90
Number of plant species		53	41	36	28	29
Exposure		SE	S	-	N	W
Inclination in degrees		5	10	0	15	20
Surface of investigated plots in m^2				400		
Ch., D.* *Peucedano-Pinetum,* Ch. *Dicrano-Pinion*						
Chimaphila umbellata		1.2	.	+	.	.
*Solidago virgaurea**		+	1.2	+	.	.
Ch. *Cladonio-Vaccinietalia,* Ch. *Vaccinio-Piceetea*						
Pinus sylvestris	a	4.4	4.5	5.5	4.4	4.4
Pinus sylvestris	c	.	+	.	.	1.1
Picea abies	b	.	.	.	1.1	+
Melampyrum pratense		2.3	.	+.2	2.2	2.2
Vaccinium myrtillus		1.2	.	+.2	4.4	4.4
Vaccinium vitis-idaea		.	.	1.2	1.2	1.2
Trientalis europaea		+.2	.	.	1.2	.
Orthilia secunda		.	+.2	.	1.2	.
Moneses uniflora		+	.	.	.	+
Pyrola minor		1.2	.	.	.	.
Pleurozium schreberi	d	3.3	3.3	.	1.2	1.2
Hylocomium splendens	d	.	.	.	4.4	4.4
Ch., D.* *Querco-Fagetea*						
Carpinus betulus	b	+	+	.	.	.
Fagus sylvatica	b	.	.	.	1.1	1.1
Campanula persicifolia		+	.	.	.	.
Carex digitata		.	1.2	.	.	.
Epipactis helleborine		+	.	.	.	.
Galium schultesii		.	.	.	+.2	.
Polygonatum multiflorum		.	+	.	+	.
Viola reichenbachiana		.	+	1.2	.	.
Others						
Abies alba	b	1.1	+	.	+	1.1
Quercus petraea	b	.	.	1.1	1.1	1.1
Quercus petraea	c	.	.	.	.	+

Tab. 5 cont.

Sorbus aucuparia	b	1.1	+	1.1	+	.
Sorbus aucuparia	c	.	.	.	.	1.1
Juniperus communis	b	1.1	2.1	.	.	.
Juniperus communis	c	.	+.2	.	.	.
Berberis vulgaris	c	.	+	.	.	.
Betula pendula	b	.	.	.	.	+
Crataegus monogyna	b	.	.	+	.	.
Frangula alnus	b	+	.	.	1.1	.
Frangula alnus	c	.	+	.	.	+
Populus tremula	b	.	.	.	+	+
Pyrus communis	c	+	.	.	.	.
Quercus robur	b	.	1.1	.	.	.
Festuca ovina	c	3.3	4.4	3.4	+.2	+.2
Fragaria vesca		2.2	2.2	2.2	1.2	1.2
Rubus idaeus		+.2	.	1.2	+.2	+.2
Taraxacum officinale		+.2	+.2	1.1	1.1	1.2
Hieracium pilosella		+.2	+.2	1.2	+	.
Veronica officinalis		+.2	+.2	1.2	.	.
Trifolium repens		+	+.2	1.2	.	.
Thymus pulegioides		1.2	1.2	+.2	.	.
Luzula pilosa		1.2	.	.	1.1	1.2
Plantago lanceolata		+	+	.	.	.
Agrostis capillaris		+.2	.	+.2	.	.
Cerastium holosteoides		1.1	1.2	1.2	.	.
Achillea millefolium		1.1	+.2	+.2	.	.
Trifolium medium		+.2	1.2	.	.	.
Vicia cracca		.	+.2	+.2	.	.
Hieracium lachenalii		.	.	1.1	.	.
Mycelis muralis		1.1	.	.	1.1	+
Hypericum perforatum		+	.	+	.	.
Maianthemum bifolium		2.3	.	.	.	+.2
Pteridium aquilinum		1.2	.	.	2.2	+.2
Anthoxanthum odoratum		1.2	.	.	.	.
Calluna vulgaris		1.2	1.2	.	.	+.2
Hypochoeris radicata		+.2	.	.	+	.
Pimpinella saxifraga		+	.	.	.	.
Veronica chamaedrys		+.2	.	.	.	.
Prunella vulgaris		+.2	.	.	.	.
Chamaecystisus ratisbonensis		.	3.2	.	.	.
Calamagrostis epigejos		.	+.2	.	.	+.2
Dactylis glomerata		.	.	1.2	.	.
Epilobium montanum		+	.	+.2	.	.
Genista tinctoria		+	.	.	.	.
Geum urbanum		.	+	+	.	+
Luzula campestris		+	+.2	.	.	.
Rumex acetosella		.	.	+	.	.

Torylis japonica		.	1.2	1.1	.	.
Botrichium lunaria		.	1.2	.	.	.
Carex ericetorum		+	.	.	.	.
Chamenerion angustifolium		+.2	.	.	.	.
Geranium robertianum		.	.	1.2	.	.
Geranium sylvaticum		+	.	.	.	.
Linaria vulgaris		.	+	.	.	.
Lotus corniculatus		.	.	+.2	.	.
Plantago maior		.	.	+	.	.
Ranunculus acris		+	+	.	.	.
Ranunculus repens		.	.	+.2	.	.
Rubus plicatilis		1.2	.	.	.	.
Rubus saxatilis		+.2	.	.	.	.
Senecio nemorensis		+	.	.	.	.
Brachythecium salebrosum	d	3.3	.	+.2	1.2	1.2
Plagiomnium affine	d	1.2	.	1.2	.	.
Abietinella abietina	d	.	2.2	.	.	2.2
Brachythecium albicans	d	.	4.3	4.4	.	.
Serpoleskea subtilis	d	.	+.2	.	.	.
Campylidium calcareum	d	.	+	.	.	.
Plagiomnium drummondii	d	.	1.2	.	.	.
Pseudoscleropodium purum	d	.	+.2	.	.	.
Brachythecium sp.	d	.	.	.	+.2	.
Rhytidiadelphus triquetrus	d	.	.	.	.	1.2

Table 6
Fungi in *Peucedano-Pinetum*

Successive number		1	2	3	4	5	Frequency
Number of plot		7	8	9	13	14	
Locality		Kielce					
Density of tree layer	a in %	70	80	80	70	70	
Density of shrub layer	b in %	10	30	10	20	20	
Cover of herb layer	c in %	90	100	90	90	90	
Cover of moss layer	d in %	90	95	70	90	90	
Exposure		SE	S	-	N	W	
Inclination in degrees		5	10	0	15	20	
Surface of investigated plots in m^2		400					
Number of observations		40	40	40	40	40	
Number of plant species		53	41	36	28	30	
Number of fungi species		27	21	14	30	25	
Terrestrial fungi							
Chroogomphus rutilus		2r	1r	.	3r-n	.	3
Ramaria eumorpha		4a	2r	.	2n	.	3
Inocybe subnudipes		1r	.	.	1r	2n	3
Lycoperdon perlatum		8n-a	.	6r-n	.	2r	3

Inocybe pseudodestricta	.	4a	.	4a	4a	3
Ramaria abietina	.	.	3n	3n	1r	3
Hebeloma truncatum	2n	2n	.	.	.	2
Hebeloma mesophaeum	.	3n	3n	.	.	2
Inocybe abjecta	.	2n	.	1n	.	2
Melanoleuca microcephala	.	1r	.	1n	.	2
Hebeloma claviceps	.	.	.	1r	1r	2
Hygrophoropsis aurantiaca	.	.	.	1r	2r	2
Lepista nuda	3r-n	.	.	.	6n-a	2
Amanita citrina	1r	.	.	.	.	1
Cantharellus cibarius	2r	.	.	.	.	1
Cortinarius cinnamomeoluteus	1r	.	.	.	.	1
Lepiota ventriosospora	1r	.	.	.	.	1
Melanoleuca graminicola	1r	.	.	.	.	1
Melanoleuca oreina	1n	.	.	.	.	1
Inocybe lacera	.	2a	.	.	.	1
Suillus granulatus	.	4r	.	.	.	1
Suillus luteus	.	4n	.	.	.	1
Tricholoma myomyces	.	2a	.	.	.	1
Tricholoma terreum	.	4r	.	.	.	1
Xerocomus pascuus	.	2r	.	.	.	1
Calocybe gambosa	.	.	3n	.	.	1
Hebeloma versipelle	.	.	3n	.	.	1
Lactarius deliciosus	.	.	2r	.	.	1
Lycoperdon lividum	.	.	2n	.	.	1
Thelephora caryophyllea	.	.	4r-n	.	.	1
Agaricus silvicola	.	.	.	1r	.	1
Hebeloma pumilum	.	.	.	1r	.	1
Inocybe inconcinna	.	.	.	2r-a	.	1
Inocybe mystica	.	.	.	1n	.	1
Lepiota cristata	.	.	.	1r	.	1
Melanoleuca melaleuca	.	.	.	1r	.	1
Ramaria corrugata	.	.	.	1r	.	1
Hebeloma hiemale	.	.	.	.	1r	1
Inocybe auricoma	.	.	.	.	2r-a	1
Inocybe geophylla var. *geophylla*	.	.	.	.	2n	1
Fungi on wood						
Crucibulum laeve	5a	3n	5r-a	.	.	3
Galerina marginata	1r	.	.	.	2n	2
Tricholomopsis rutilans	.	.	2n	1r	.	2
Galerina unicolor	4a	.	.	.	.	1
Gloeoporus taxicola	1r	.	.	.	.	1
Entoloma undatum	.	1r	.	.	.	1
Psilocybe fascicularis	.	.	.	8r-a	.	1
Trichaptum fuscoviolaceum	.	.	.	xn	.	1

Tab. 6 cont.

Ossicaulis lignatilis	.	.	.	1r	.	1
Pluteus godeyi	.	.	.	1r	.	1
Clavicorona pyxidata	.	.	.	1r	.	1
Trichaptum abietinum	.	.	.	.	xa	1
Stereum sanguinolentum	.	.	.	.	xn	1
Fomitopsis pinicola	.	.	.	.	xr	1
Stereum hirsutum	.	.	.	.	xn	1
Dacryomyces ovisporus	.	.	.	.	2n	1
Fungi on litter						
Strobilurus stephanocystis	4a	4a	4a	4a	4a	5
Strobilurus tenacellus	4a	4a	4a	4a	4a	5
Psilocybe aeruginosa	4r-n	4r-n	3r	4n	.	5
Auriscalpium vulgare	xr-a	.	xn-a	xr	xn	4
Mycena galopus	.	.	.	4a	4r-n	2
Clitocybe tornata	1r	1n	.	.	.	2
Mycena pura	4r-n	.	.	.	.	1
Mycena aetites	3n	.	.	.	.	1
Mycena leptocephala	2r	.	.	.	.	1
Mycena vitilis	2n	.	.	.	.	1
Clitocybe fragrans	1r	.	.	.	.	1
Hemimycena pseudogracilis	1r	.	.	.	.	1
Clitocybe subalutacea	.	1r	.	.	.	1
Mycena sanguinolenta	.	.	.	2r	.	1
Clitocybe dealbata	.	.	.	2n	.	1
Clitocybe metachroa	.	.	.	1r	.	1
Mycena zephirus	.	.	.	.	4a	1
Mycena epipterygia	.	.	.	.	3a	1
Mycena flavoalba	.	.	.	.	2n	1
Mycena atroalba	.	.	.	.	1r	1
Clitocybe serotina	.	.	.	.	1n	1

were recorded here, which constitutes 19.23% of all *Basidiomycetes* identified at research plots (Fig. 9). The subcontinental coniferous forest shares the greatest number of species with the *Serratulo-Pinetum*, as much as 66.7%.

Participation ratios of species of *Basidiomycetes* and vascular plants in the *Peucedano-Pinetum* diverge from those in other forest communities. Fungal species clearly outnumbered species of vascular plants at research plots in all the communities. The only exception was *Peucedano-Pinetum*, where the quantitative ratio of both groups was 1:1.

The terrestrial biota of *Basidiomycetes* consists of 41 species, dominated by mycorrhizal fungi that constitute 71.7% of this ecological group (Fig. 7a). Exclusive fungi constitute 17.1% of mycorrhizal fungi. *Hebeloma claviceps, Inocybe mystica, Ramaria corrugata* and *Melanoleuca oreina* are of the greatest diagnostic value. The latter three are very rare, known in Poland only from the Góry Świętokrzyskie Mts., where they were recorded exclusively in *Peucedano-Pinetum*. According to Stangl (1989), *Inocybe mystica* grows under deciduous species: beech, oak and elm, on humic soils and soils rich in calcium. The fungus finds habitat conditions favourable for its development in the area discussed here. *Melanoleuca oreina* and *Ramaria corrugata* occur under coniferous trees and shrubs, for instance *Pinus*. *Hebeloma claviceps*, a rare species, has been reported in *Peucedano-Pinetum* and *Tilio-Carpinetum* with *Pinus sylvestris* from different sites in Poland (Hołownia 1968; Łuszczyński 1997; Wojewoda *et al.* 1999). Therefore, the above terrestrial fungi appears to be characteristic of the *Peucedano-Pinetum* forest.

The group of terrestrial fungi occurring in *Peucedano-Pinetum* and analysed here resembles that in *Serratulo-Pinetum* the most and has 76.9% species in common with the latter community (Fig. 10). The following were recorded only in patches of these communities: *Hebeloma truncatum, Inocybe inconcinna, I. lacera, Lactarius deliciosus, Melanoleuca graminicola* and *M. microcephala*. Two further species: *Hebeloma mesophaeum* and *Inocybe subnudipes*, were also recorded in *Querco-Pinetum* outside the communities listed above, and three others, *Hebeloma pumilum, Melanoleuca melaleuca* and *Tricholoma terreum*, grew in *Peucedano-Pinetum*, *Serratulo-Pinetum* and *Tilio-Carpinetum*. Terrestrial fungi in the *Tilio-Carpinetum* show a great resemblance to the mycobiota of *Peucedano-Pinetum* and share 48.7% species.

A small resemblance degree between the biota of terrestrial *Basidiomycetes* in *Peucedano-Pinetum* and those in other coniferous forest communities, mostly below 20%, is interesting. This can be attributed to significant floristic and habitat differences. The floristic composition of phytocoenoses in *Peucedano-Pinetum* is richer, including, for instance, *Carpinus betulus* and *Corylus avellana*, with which fungi such as *Hebeloma pumilum* or *Inocybe auricoma* form mycorrhizae. Soils underlying *Peucedano-Pinetum* are richer in $CaCO_3$ than acid soils under other communities in coniferous forests. This is also confirmed by the presence of a few species preferring calcareous soils, for instance *Calocybe gambosa, Inocybe cryptocystis, Lepiota ventriosospora, Hebeloma hiemale, H. truncatum* and *Tricholoma terreum* in this community, and their absence in other coniferous forest communities.

The litter-inhabiting biota of *Basidiomycetes* in the research plots examined here comprises 21 species. Fallen pine needles, with fir and spruce needles also present, as well as fallen leaves of angiospermous trees and shrubs, grown over with mosses, and fallen twigs, constitute their substrate. Only one exclusive species, *Hemimycena pseudogracilis*, was recorded in this ecological group. It is a very rare fungus, previously recorded on Babia Góra Mt in the *Galio-Abietetum* (Bujakiewicz 1979). The species can be considered locally characteristic of the *Peucedano-Pinetum*.

As a result of the presence of deciduous trees and shrubs, the biota of fungi on litter also comprises species connected with deciduous forests. Similarly to terrestrial fungi, the greatest resemblance is observed between this association and *Serratulo-Pinetum*, as high as 81.8%, and only slightly lower to deciduous communities: *Potentillo-Quercetum* – 72.7% as well as *Dentario glandulosae-Fagetum* and *Tilio-Carpinetum* (59.1% each). Ubiquitous fungi as well as species associated with the pine which occurs in all the communities compared here constitute the core of this group. Consequently, *Strobilurus stephanocystis* and *S. tenacellus*, and further *Psilocybe aeruginosa, Lycoperdon perlatum* and *Auriscalpium vulgare* were characterised by both the greatest frequency and fruitbody productivity. Species of the genus *Mycena* (9 species – 42.8%) and *Clitocybe* (6 species – 28.5%) dominate the entire ecological group discussed here. *Mycena epipterygia, M. galopus* and *M. zephirus* showed a particularly high fruitbody productivity.

Lignicolous fungi constitute 20.5% of all *Basidiomycetes* in *Peucedano-Pinetum* (Fig. 7c). Wood of logs, trunks and thick branches of *Pinus sylvestris* was the substrate for a great majority of them (11 species) while deciduous wood was the source of nutrition of only five species. The participation of exclusive species is relatively high and equals 37.5% of this ecological group (Fig. 9). They are rare in Poland, and comprise the following saprobes: *Clavicorona pyxidata, Dacryomyces ovisporus, Entoloma undatum, Gloeoporus taxicola, Ossicaulis lignatilis* and *Pluteus godeyi*. However, only two of them, *Dacryomyces ovisporus* and *Gloeoporus taxicola,* can be assigned any syntaxonomic value for the community. Both are connected with coniferous wood, mostly with *Pinus*, and are attached to coniferous forest communities. *Dacryomyces ovisporus* was recorded in the *Peucedano-Pinetum* and *Querco-Pinetum* in different sites in Southern Poland (Wojewoda 1976a, 1991a; Łuszczyński 1993b) while *Gloeoporus taxicola* was recorded in different forest and shrub communities, mostly coniferous forest communities. Therefore, both species can be considered characteristic of the *Peucedano-Pinetum*, at least locally. Such value cannot be assigned to other exclusive species which are associated with the wood of deciduous species, *Fagus, Quercus* and others, and, consequently, occur in other forest communities.

Lignicolous fungi in this community resemble xylobionts growing in the *Querco-Pinetum* mixed forest the most, where 50% of species in common were recorded, as well as in *Dentario glandulosae-Fagetum, Leucobryo-Pinetum, Potentillo-Quercetum, Serratulo-Pinetum* and *Tilio-Carpinetum*, where 43.7% shared species were observed (Fig. 12). The great resemblance of xylobionts results primarily from the presence of similar tree species which reduce habitat differences identifiable among these communities.

Lignicolous fungi in the examined research plots were characterised by a relatively low repeatability. *Crucibulum laeve*, recorded at three plots, showed the greatest frequency, while other species were observed at one or two plots.

Leucobryo-Pinetum

Habitat and phytosociological description. Observations plots in *Leucobryo-Pinetum* were established in the Białe Ługi peat bog and forest complex. Phytocoenoses in this community develop on haplic podzols, formed from acid loose sands poor in mineral components. The development of mor humus varies, and a thick layer of raw humus is often present. Soil moisture also varies significantly, which causes a local habitat floristic differentiation of the coniferous forest. Research plots were established in sites characterised by different moisture gradients and groundwater levels.

There are four layers in the structure of the community. The stand is composed of one species, 60 to 80-year-old *Pinus sylvestris*, whose crown density reaches 70-80%. Saplings of *Abies alba, Betula pendula, B. pubescens, Fagus sylvatica, Frangula alnus, Populus tremula, Sorbus aucuparia, Picea abies, Quercus petraea* and *Q. robur* are found under the pine canopy in the shrub layer. The shrub density is low and ranges between 5 and 20%, sporadically reaching 40%. The development of the field layer varies and its density is from 20 to 80%. The highest density is shown by *Vaccinium myrtillus, V. vitis-idaea, Calluna vulgaris* and herbaceous plants, *Festuca ovina* and *Melampyrum pratense*. *Pyrola chlorantha* is species characteristic of the community. The moss layer is greatly developed and its surface cover ranges from 80 to 100%. Mosses characteristic of the class *Vaccinio-Piceetea*, for instance *Dicranum scoparium, Hylocomium splendens* and *Pleurozium schreberi*, have the highest quantity coefficients (Tab. 7).

The floristic features of the *Leucobryo-Pinetum* are similar to those of *Peucedano-Pinetum*. Since there are no good characteristic species, however, differential species are used to differentiate both syntaxa locally, that is subcontinental plants that are not present in the suboceanic mesic coniferous forest. Generally, *Leucobryo-Pinetum* is less abundant than the floristically richer *Peucedano-Pinetum* (Przemyski & Polinowska 2001). It develops on poorer soils, as reflected by its floristic composition.

The phytocoenoses discussed here develop in natural conditions. Dead trees lying on the forest floor with trunks and thick branches providing the substrate for xylobionts significantly contribute to the mycological profile of the area.

Mycological description. Fungi in the suboceanic mesic coniferous forest were examined at five permanent plots over three years. A total of 160 observations were conducted and 142 species of *Basidiomycetes* were collected (Tab. 8). Between 29 and 82 fungal species were recorded in individual patches. This relatively high qualitative differentiation of the fungal biota mostly results from the floristic deficiency of the ground cover and litter homogeneity as fungi on litter constitute a relatively small group comprising only 26 species. However, the total number of all *Basidiomycetes* identified in this community, including fungi recorded both at permanent plots and outside them, is 168.

The biota of *Basidiomycetes* in the community does not differ from the mycological profile of other communities. The participation of exclusive species is only 4%. It resembles the mycobiota of *Abietetum polonicum* and *Dentario glandulosae-Fagetum* the most, as expressed by the similarity of over 35% species (Fig. 8).

The biota of terrestrial fungi consists of 67 species of which mycorrhizal fungi constitute 94% (Fig. 7a). Exclusive species in this ecological group equal 21%. Of them, *Cortinarius mucosus*, which was recorded at the five research plots, is the most characteristic species of the community. Studies by Lisiewska (1979) also confirm a very strong attachment of this fungus to *Leucobryo-Pinetum* biocoenoses. Other species: *Bankera fuligineoalba, Cantharellula umbonata, Entoloma formosum, E. rhodocylix, Gomphidius roseus, Inocybe trivialis, Lactarius fluens, L. torminosus, L. trivialis* (at two plots), *Leccinum aurantiacum, Russula heterophylla,* were recorded once. Special attention should be paid to *Bankera fuligineoalba*, *Entoloma formosum, Inocybe trivialis,* rare species, associated with oligotrophic, acidophilic soils of pine forests, and can be treated as their locally characteristic species in the region. The occurrence of *Inocybe trivialis*, a fungus known only from the Góry Świętokrzyskie Mts. in Poland, should also be stressed.

The terrestrial fungi listed above mostly cannot be assigned the role of characteristic species above the regional level as they have been recorded in various pine forests usually belonging to the *Dicrano-Pinion* alliance. *Coltricia perennis, Boletus pinophilus, Cortinarius cinnamomeus, C. semisanguineus, Hygrophorus hypothejus, Lactarius vietus, L. helvus, Russula vinosa, Suillus variegatus, Thelephora terrestris* and *Tricholoma equestre* should be mentioned as species characteristic of *Dicrano-Pinion* and higher syntaxa growing in the patches discussed here.

The terrestrial biota of *Basidiomycetes* in *Leucobryo-Pinetum* phytocoenoses resembles *Abietetum polonicum* and *Vaccinio uliginosi-Pinetum* the most. It shares 29 species with the former (43.3% of fungi in this community) and 27 species with the latter (40.3%). *Cortinarius cinnamomeus, C. semisanguineus, Lactarius helvus* and *Russula decolorans*, which were recorded at five and four plots in *Leucobryo-Pinetum*, have the highest frequency among the fungi shared by the above communities.

A significant similarity exists between the community under discussion and terrestrial fungi in the *Cladonio-Pinetum*. Both had 19 species in common, that is 28.4% of the total

Table 7
Leucobryo-Pinetum

Successive number		1	2	3	4	5
Number of plot		1	2	5	6	8
Date		10.06.1997				
Locality		Białe Ługi				
Density of tree layer	a in %	70	80	70	70	70
Density of shrub layer	b in %	40	<5	20	5	5
Cover of herb layer	c in %	80	20	50	60	30
Cover of moss layer	d in %	90	100	80	80	90
Number of plant species		27	11	15	21	25
Surface of investigated plots in m^2		400				
ChAss. *Leucobryo-Pinetum,* ChAll. *Dicrano-Pinion*						
Pyrola chlorantha		.	.	.	+	+.2
Cladonia furcata	d	.	1.2	.	.	.
ChCl. *Vaccinio-Piceetea,* ChO. *Cladonio-Vaccinietalia*						
Pinus sylvestris	a	4.4	5.5	4.4	4.4	4.4
Pinus sylvestris	c	.	.	1.1	.	+
Vaccinium myrtillus		3.4	1.2	3.3	2.3	2.3
Vaccinium vitis-idaea		+	1.2	2.2	1.2	1.2
Trientalis europaea		+	.	.	1.2	.
Vaccinium uliginosum		.	+	.	+	.
Orthilia secunda		.	.	.	+	.
Pleurozium schreberi	d	4.4	5.4	4.4	2.3	3.3
Dicranum scoparium	d	1.2	1.2	.	1.2	1.2
Hylocomium splendens	d	1.2	.	.	3.4	2.3
Others						
Quercus robur	b	2.1	+	.	1.1	1.1
Quercus robur	c	.	+	+	.	.
Quercus petraea	b	.	.	.	.	1.1
Betula pubescens	b	1.2	.	1.1	.	.
Betula pubescens	c	.	.	.	.	+
Abies alba	b	.	.	+	.	.
Abies alba	c	+	.	.	.	.
Betula obscura	b	.	+	.	.	.
Betula pendula	b	2.1	.	.	+	.
Fagus sylvatica	b	+.2	.	.	.	.
Frangula alnus	b	1.1	.	.	.	.
Juniperus communis	b	+	.	.	1.2	+.2
Picea abies	b	1.1	.	2.1	1.2	.
Picea abies	c	+	.	.	.	.
Populus tremula	b	+	.	.	.	.
Populus tremula	c	.	.	.	.	+
Sorbus aucuparia	b	+	.	.	+	+

Tab. 7 cont.

Sorbus aucuparia	c	.	.	.	+	+
Lembotropis nigricans	c	.	.	.	.	1.2
Calluna vulgaris		1.2	.	1.2	2.2	1.2
Carex ericetorum		+	.	+	.	+.2
Festuca ovina		1.2	+	+.2	1.2	1.2
Melampyrum pratense		+.2	.	+	1.2	2.2
Pteridium aquilinum		1.2	.	+.2	1.2	.
Luzula pilosa		.	.	+	+	1.1
Anthoxanthum odoratum		.	.	+	.	+.2
Calamagrostis epigejos		1.2	.	.	.	.
Ledum palustre		+.2	.	.	.	.
Luzula campestris		+	.	.	.	.
Hieracium murorum		.	.	.	+	.
Hieracium pilosella		.	.	.	.	+.2
Moneses uniflora		.	.	.	.	+
Solidago virgaurea		.	.	.	.	+
Dicranum undulatum	d	.	1.2	.	.	1.2
Polytrichum commune	d	+.2	.	.	.	.
Sphagnum cuspidatum	d	1.2	.	.	.	.
Ptilidium pulcherimum	d	.	.	.	1.2	.
Polytrichum strictum	d	.	.	.	.	1.2

Table 8
Fungi in *Leucobryo-Pinetum*

Number of the plot		1	2	5	6	8	Frequency
Locality		Białe Ługi					
Density of tree layer	a in %	70	80	70	70	70	
Density of shrub layer	b in %	40	<5	20	5	5	
Cover of herb layer	c in %	80	20	50	60	30	
Cover of moss layer	d in %	90	100	80	80	90	
Surface of investigated plots in m^2		400					
Number of observations		32	32	32	32	32	
Number of plant species		27	11	15	21	25	
Number of fungi species		82	34	29	67	51	
Fungi on soil							
Cortinarius mucosus		2n	1r	2r	2n	1r	5
Laccaria laccata		6r	4n	6n	2r	4r	5
Lactarius helvus		4r	3n	5n-a	4n	4n	5
Russula decolorans		2r	1r	2n	2r	2r	5
Tylopilus felleus		1n	1r	1r	2r	1r	5
Amanita porphyria		1r	1r	.	1r	1r	4
Cortinarius cinnamomeus		1n	2n	.	2n	2r	4
Paxillus involutus		2r	2r	.	2n	2n	4
Suillus variegatus		3r	.	2r	2r	4r	4
Cortinarius semisanguineus		.	3n	5n-a	3n	3n	4

Tab. 8 cont.

Coltricia perennis	.	1n	1r	2r	2r	4
Laccaria amethystea	4n	3n	3r	.	.	3
Suillus bovinus	1r	1r	.	1r	.	3
Lactarius rufus	1r	2r	.	.	1r	3
Cantharellus cibarius	1n	2n	.	.	2n	3
Xerocomus subtomentosus	1r	.	1r	1r	1r	4
Amanita fulva	1r	.	.	1r	1r	3
Xerocomus badius	2n	.	.	3n	3n	3
Amanita muscaria	1n	.	.	1r	2n	3
Inocybe lanuginosa	.	2n-a	2n	.	2n	3
Amanita citrina	.	1r		1r	1r	3
Rozites caperatus	.	.	1r	1n	1r	3
Lactarius mitissimus	4n	5n	.	.	.	2
Entoloma turci	1r	.	.	1n	.	2
Lactarius camphoratus	1r	.	.	1r	.	2
Lactarius trivialis	1r	.	.	1r	.	2
Russula aeruginea	1r	.	.	1r	.	2
Russula virescens	2r	.	.	1r	.	2
Xerocomus pascuus	2n	.	.	1n	.	2
Thelephora terrestris	2n	.	.	.	1n	2
Hygrophorus hypothejus	.	3n	.	2n	.	2
Russula xerampelina	.	2r	.	1r	1r	3
Cantharellus tubaeformis	1a	.	.	.	.	1
Suillus luteus	.	.	.	.	4n	1
Inocybe trivialis	.	1r	.	.	.	1
Entoloma formosum	.	1r	.	.	.	1
Russula cyanoxantha	.	.	.	2n	.	1
Russula heterophylla	.	.	.	1n	.	1
Lactarius torminosus	.	.	.	3r-n	.	1
Entoloma speculum	.	.	.	1r	.	1
Thelephora palmata	.	.	.	1n	.	1
Cantharellula umbonata	.	.	.	1n	.	1
Amanita rubescens	.	.	.	.	1r-n	1
Bankera fuligineoalba	.	.	.	.	1r	1
Boletus edulis	.	.	.	.	3r	1
Boletus pinophilus	.	.	.	.	1r	1
Bovista dermoxantha	.	.	.	.	1n	1
Chroogomphus rutilus	.	.	.	.	2n	1
Lactarius fluens	.	.	.	.	1r	1
Russula amethystina	.	.	.	.	1r	1
Russula vinosa	.	.	.	.	1r	1
Tricholoma equestre	2n	.	.	.	3n	2
Lactarius vietus	1r	.	.	.	.	1
Leccinum aurantiacum	1r	.	.	.	.	1
Leccinum scabrum	2r	.	3r	.	.	2
Cortinarius (Telamonia) sp. 1	1r	.	.	.	.	1

Tab. 8 cont.

Cortinarius pholideus	2r	.	.	.	.	1
Entoloma rhodocylix	1r	.	.	.	.	1
Gomphidius roseus	1r	.	.	.	.	1
Inocybe napipes	1n	.	.	.	.	1
Russula claroflava	1r		.	.	.	1
Russula vitelina	.	.	1r	.	.	1
Fungi on wood						
Stereum hirsutum	xn	xn	xn	xn	.	4
Trichaptum abietinum	.	xn	xn	xn	.	3
Trichaptum fuscoviolaceum	xn	xn	xn	xn	.	4
Fomes fomentarius	xr	xr	xr	.	.	3
Psilocybe lateritia	1a	.	2n-a	.	2n	3
Gymnopilus picreus	2a	.	2a	.	.	2
Piptoporus betulinus	xr	xn	.	xn	.	3
Polyporus ciliatus	1r	2r	.	2r	.	3
Stereum sanguinolentum	xn	xn	.	xn	.	3
Trametes hirsuta	xn	.	xn	xn	.	3
Psilocybe capnoides	3a	.	.	4a	.	2
Tremella encephala	2n	.	.	2n	.	2
Tricholomopsis rutilans	2r	.	.	1r	2r	3
Paxillus atrotomentosus	.	.	.	1r	1r	2
Panellus mitis	.	.	.	2a	1a	2
Heterobasidium annosum	.	.	.	xr	xn	2
Cerrena unicolor	.	.	.	xr	.	1
Paxillus panuoides	.	.	.	2n	.	1
Pholiota astragalina	.	.	.	2n	.	1
Pholiota flammans	.	.	.	1n	.	1
Polyporus brumalis	.	.	.	2e	.	1
Trametes ochracea	.	.	.	xn	.	1
Tremella foliacea f. *succinea*	.	.	.	2n	.	1
Bjerkandera adusta	.	.	xa	.	.	1
Skeletocutis amorpha	.	.	1n	.	.	1
Phellinus pini	.	.	xn	.	.	1
Gloeophyllum odoratum	.	xr	.	.	.	1
Panellus stypticus	.	3n	.	.	.	1
Gymnopilus sapineus	.	3a	.	.	3n-a	2
Inonotus obliquus	.	xr	.	.	.	1
Gymnopilus penetrans	.	.	.	.	3a	1
Mycena tintinnabulum	4n-a	.	.	.		1
Lycoperdon pyriforme	3n-a	.	.	.	.	1
Antrodia serialis	1r	.	.	.	.	1
Armillaria ostoyae	8n-a	.	.	.	.	1
Daedalea quercina	xr	.	.	.	.	1
Datronia mollis	xr	.	.	.	.	1
Delicatula integrella	2n	.	.	.	.	1

Tab. 8 cont.

Diplomitoporus flavescens	3r	.	.	.	.	1
Fomitopsis pinicola	xn	.	.	.	.	1
Hymenochaete rubiginosa	xn	.	.	.	.	1
Pholiota mutabilis	3a	.	.	.	.	1
Pleurotus cornucopiae	2n	.	.	.	.	1
Pleurotus pulmonarius	1n	.	.	.	.	1
Pluteus pseudorobertii	1r	.	.	.	.	1
Psilocybe fascicularis	8a	.	.	.	.	1
Schizophyllum commune	xa	.	.	.	.	1
Stereum subtomentosum	xn	.	.	.	.	1
Dacryomyces stillatus	xa	.	xa	.	.	2
Trametes versicolor	xa	.	.	.	.	1
Tremella obscura	1r	.	.	.	.	1
Xeromphalia campanella	3n-a	.	.	.	.	1
Fungi on litter						
Setulipes androsaceus	9a	6n-a	10n	8a	6a	5
Strobilurus stephanocystis	6a	6a	6n	.	4n-a	4
Mycena galericulata	1r	1r	.	.	.	2
Mycena galopus	5n	.	.	5r-n	4r-n	3
Lycoperdon perlatum	5n	.	.	4r-a	.	2
Marasmius undatus	2n	.	.	1n	.	2
Auriscalpium vulgare	xn	.	.	xn	.	2
Gymnopus dryophilus	2r	.	.	.	.	1
Mycena aetites	2r	.	.	.	.	1
Mycena citrinomarginata	2r	.	.	.	.	1
Mycena stylobates	2r	.	.	.	.	1
Rhodocollybia maculata	.	1n	.	.	.	1
Cystoderma amianthinum	.	.	3n	4n	2n	3
Cystoderma carcharias	.	.	3n	.	.	1
Psilocybe aeruginosa	.	.	.	4r	3r	2
Mycena epipterygia	.	.	.	9n-a	12n-a	2
Gymnopus peronatus	.	.	.	4n	.	1
Mycena zephirus	.	.	.	5n-a	.	1
Psathyrella sarcocephala	.	.	.	1n	.	1
Mycena metata	.	.	.	3n	.	1
Mycena pura	.	.	.	2n	.	1
Marasmius epiphyllus	.	.	.	.	1n	1
Clitocybe fragilipes	.	.	.	.	1r	1
Fungi among mosses						
Rickenella setipes	2n	.	.	.	.	1
Galerina hypnorum	2n	.	.	.	2n	2
Rickenella fibula	.	.	.	.	3r-n	1
Galerina pumila	.	.	.	1n	3n	2
Psilocybe polytrichi	.	.	.	3n	.	1

number of terrestrial fungi (Fig. 10). *Coltricia perennis*, *Suillus variegatus* and *Tricholoma equestre*, which are also exclusive species in these coniferous communities, occurred with the greatest frequency. A surprisingly low similarity of the fungi in this ecological group was observed between *Leucobryo-Pinetum* and *Peucedano-Pinetum*. The two communities often either penetrate each other or border on each other while they share very few species of terrestrial fungi, only 7, that is 10.4%. A smaller number of fungi that the communities had in common was recorded only in the *Fraxino-Alnetum* – 5, that is 7.5%. This can be attributed to, for instance, a significant influence of the substrate and soil pH on the development of both the flora and terrestrial *Basidiomycetes*.

The following terrestrial fungi were recorded most frequently in the community examined here: *Laccaria laccata* – 22 records, *Lactarius helvus* – 20, *Cortinarius semisanguineus* – 14, *Suillus variegatus* – 11, *Russula decolorans* – 9, *Cortinarius mucosus*, and *Paxillus involutus* – 8. They were recorded at four and five research plots. Other terrestrial fungi were observed at three, two or one plot, and fungi recorded only at one plot are the most numerous group comprising 30 species, that is almost 45% of the total biota.

Litter-inhabiting and bryophilous saprobionts comprise 21 species, that is 14.8% of the total basidiomycete biota in this community (Fig. 7b). They develop on the litter formed mostly by pine needles, often grown over with mosses or grasses where other plants are also present. The biota of this ecological group is not very specific, as shown by only two exclusive species, *Clitocybe fragilipes* and *Marasmius undatus*. The former is especially interesting, so far known only from the Góry Świętokrzyskie Mts., where it was recorded also outside permanent plots in patches of both the mesic *Leucobryo-Pinetum* forest and *Peucedano-Pinetum*. This diminishes its indicator value as a characteristic species of *Leucobryo-Pinetum*. Although it is an exclusive species in this case, *Marasmius undatus* is of even smaller indicator value as it had also been recorded in mixed forests and oak-hornbeam forests (Lisiewska 1994).

The indistinct character of the biota of litter-inhabiting and bryophilous fungi in the community makes it similar to other forest communities, especially to *Abietetum polonicum, Potentillo-Quercetum* and *Tilio-Carpinetum* (Fig. 11). The number of species shared with *Abietetum polonicum* is 14, that is 66.7% of the biota growing on litter of the *Leucobryo-Pinetum*. No species exclusive to both communities were recorded; however, *Auriscalpium vulgare*, *Mycena epipterygia, M. galopus, Setulipes androsaceus* and *Strobilurus stephanocystis* were characterised by a high frequency in both. The similarity between the litter-inhabiting biota and the phytocoenoses in *Potentillo-Quercetum* and *Tilio-Carpinetum*, where 13 species in common were recorded in each case, that is 61.9%, is equally high. The frequency of *Gymnopus dryophilus, Mycena epipterygia, M. metata, M. pura* and *M. stylobates* is high in the three communities. The presence of these species is not specific to any of these communities, and they can be considered ubiquitous species. The development of fungal species typical of coniferous forests, for instance *Auriscalpium vulgare*, *Mycena galopus, Setulipes androsaceus* and *Strobilurus stephanocystis*, in the *Potentillo-Quercetum* and *Tilio-Carpinetum* is connected with the presence of *Pinus sylvestris* in the stands. What is interesting is the low degree of similarity between the litter-inhabiting biota and that in other floristically related coniferous communities, *Peucedano-Pinetum* and *Cladonio-Pinetum*, with which eight and three species, respectively, in common were recorded.

Setulipes androsaceus (39 times), *Strobilurus stephanocystis* (22 times), *Mycena epipterygia* (21 times) and *M. galopus* (14 times) were recorded most frequently and produced fruitbodies most abundantly.

Lignicolous fungi in the *Leucobryo-Pinetum* comprise 55 species, that is 38.7% of its total biota (Fig. 7c). Wood and living trees of *Pinus sylvestris* – 54.5%, and, further, *Betula pendula* – 29% as well as *Quercus petraea* and *Q. robur* (10.1%) provide the main substrate on which *Basidiomycetes* develop. There are 12 exclusive species in this community, that is 21.8% of this ecological group. It is less numerous than that in the *Dentario glandulosae-Fagetum*, *Potentillo-Quercetum* and *Tilio-Carpinetum*. *Antrodia serialis, Gloeophyllum odoratum, Gymnopilus picreus, Inonotus obliquus, Paxillus panuoides, Pluteus pseudorobertii, Psathyrella sarcocephala, Skeletocutis amorpha, Tremella encephala, T. foliacea* and *T. obscura* species exclusive to *Leucobryo-Pinetum*. Only G*ymnopilus picreus* can be assigned the local indicator value of species characteristic of *Leucobryo-Pinetum*. While *Pluteus pseudorobertii* was considered by Friedrich (1994) to be characteristic of this community, it is associated with deciduous species, such as *Alnus, Betula* and *Fagus*, and not with *Pinus*, and was recorded in deciduous forests more often than in coniferous ones. Other species do not represent any sytaxonomic value as they were recorded a number of times across different plant communities.

Xylobionts of the *Leucobryo-Pinetum* resemble lignicolous fungi in the *Dentario glandulosae-Fagetum*, sharing 41.8% species with it, and *Tilio-Carpinetum* – 40% in common (Fig. 12). This similarity results primarily form the presence of pines and firs in the stands of these deciduous forests, and the participation of birches, oaks and beeches in the suboceanic mesic coniferous forest. Only four species were exclusive to these communities: *Pholiota mutabilis*, in the three communities, *Pholiota astragalina* and *Pleurotus pulmonarius* in the patches of the Carpathian beech forest, and *Phellinus pini* in the *Tilio-Carpinetum*. Other species that the communities have in common have a broad ecological scale and are reported from several communities at the same time.

Saprobionts naturally dominate the group of lignicolous fungi in this community. *Psilocybe lateritia, Stereum sanguinolentum, Trichaptum abietinum, T. fuscoviolaceum* and *Tricholomopsis rutilans*, which produce fruitbodies on pine wood, as well as *Piptoporus betulinus, Polyporus ciliatus, Stereum hirsutum* and *Trametes hirsuta* occurring on birch wood and sporadically on oak wood, are some of the most common species. All these species were recorded at three or more permanent plots, and, additionally, throughout the observation period due to the permanent type of most fruitbodies. Six parasitic fungi were also recorded: *Armillaria ostoyae*, *Fomes fomentarius*, *Heterobasidion annosum*, *Inonotus obliquus*, *Phellinus pini* and *Piptoporus betulinus*. Parasitic fungi developing on other fungi growing in this forest community are particularly interesting. These are *Tremella encephala* parasitising on *Stereum sanguinolentum* and *Tremella obscura* parasitising on *Dacryomyces stillatus*.

Querco roboris-Pinetum

Habitat and phytosociological description. Patches of the *Querco-Pinetum* occur on flat terrains. They grow on strong silty-clay loams, sandy clays rich in sands and loesses. Soils are acid cambisols, leached brown soils and luvisols. Their reaction is acidic and ranges from 4.5 to 5.2, and they are rich in moder humus. The groundwater level varies and fluctuates between medium to quite deep, which affects soil moisture.

The tree stand can be divided into two layers, and consists of *Abies alba, Fagus sylvatica*, *Picea abies*, *Pinus sylvestris*, *Quercus petraea* and *Q. robur*. The crown cover ranges from 50 to 90%. As a result of the high participation of firs in tree stand and the dynamic pattern of its development, the phytocoenoses developed in this way are included in the variant with *Abies alba* (Głazek 1985a, b; Głazek & Wolak 1991). The cover of the shrub layer ranges from 0 to 30-40%. It consists of tree saplings and of *Crataegus monogyna, Frangula alnus, Juniperus communis, Populus tremula* and *Sorbus aucuparia*. The ground cover is usually well developed, and its density ranges from (5)60 to 80%; it usually consists of one layer, and of two layers where *Pteridium aquilinum* occurs. *Vaccinium myrtillus, Maianthemum bifolium* and *Oxalis acetosella* generally dominate the field layer. Species migrating of the class *Querco-Fagetea*: *Fagus sylvatica*, *Impatiens noli-tangere* and *Padus avium* are diagnostic species together with those typical of coniferous forests of the class *Vaccinio-Piceetea* and its lower syntaxa. Differential species that do not occur individually but in groups form a particularly important body of diagnostic fungi: *Anemone nemorosa, Corylus avellana, Euonymus verrucosa, Mycelis muralis* and *Viola reichenbachiana*. The development of the moss layer varies and its density ranges from very low to 30-40%. Diagnostically important species include coniferous forest mosses of the class *Vaccinio-Piceetea*: *Pleurozium schreberi, Dicranum scoparium*, and of the class *Querco-Fagetea* – *Atrichum undulatum* (Tab. 9).

A fairly well decomposed deciduous litter and different types of remaining wood fragments are observed in the phytocoenoses of the mixed coniferous forest. Lying logs of mostly firs and pines as well as stumps remaining after sanitary maintenance works provide suitable conditions for the development of xylobionts at some plots.

Mycological description. Fungi in the continental mixed forest were examined at five permanent plots where a total of 129 species were recorded, including 58 terrestrial species, 32 species on litter and 38 liginicolous species (Tab. 10). Between 27 and 42 observations were conducted in individual patches and a range of 31 to 59 species were collected. The mycobiota of the *Querco-Pinetum* differs from that in other forest communities by having 14 exclusive species, that is 10.8% (Fig. 9). Less numerous groups of exclusive species were recorded only in the *Abies alba-Sphagnum girgensohnii, Sphagnetum magellanici, Cladonio-Pinetum* and *Vaccinio uliginosi-Pinetum* communities, which is conditioned by the mixed character of the *Querco-Pinetum* phytocoenoses resembling mesophilous deciduous forests and coniferous forests. *Basidiomycetes* of this community show the greatest affinity with those found in deciduous forest communities: *Tilio-Carpinetum* – 63 species, i.e. 48.8%, *Dentario glandulosae-Fagetum* – 57 species (44.2%), *Potentillo-Quercetum* – 52 species (40.3%), as well as coniferous forest communities: *Abietetum polonicum* – 46 species, i.e. 35.6% and *Leucobryo-Pinetum* – 45 species (34.9%) (Fig. 8).

The terrestrial biota of this community comprises 58 species of which 82.7% is constituted by mycorrhizal fungi (Fig. 7a). Such a high indicator of mycorrhizal fungi can indicate a high natural character of the forest phytocoenoses discussed here and favourable correlations among biological components of biocoenoses in the *Querco-Pinetum*.

Of terrestrial fungi, six exclusive species were recorded, including four mycorrhizal fungi: *Chalciporus piperatus, Hebeloma vaccinum, Lactarius glyciosmus* and *Russula piceetorum*. *Chalciporus piperatus, Hebeloma vaccinum* and *Russula piceetorum* can be assigned the indicator value of species characteristic of the community discussed here. *Hebeloma vaccinum* is known only from the Góry Świętokrzyskie Mts. and was recorded exclusively in the examined forest community. The habitat and the phytocoenosis type where the fungus was observed correspond to habitat conditions reported by Krieglsteiner (1999) from Bavaria and by Moreno (1980) from Spain. *Russula piceetorum* is also a rare species and, outside the study area, is known from the vicinity of Mikołajki, where it was collected in a

Table 9
Querco roboris-Pinetum

Successive number		1	2	3	4
Number of plot		3	2	4	6
Date		16.08.1991	07.09.1990	29.08.1991	
Localities		Biesak Mt	Piaski	Cisów	
Density of tree layer	a in %	80	50	90	60
Density of shrub layer	b in %	30	30	+	40
Cover of herb layer	c in %	80	60	5	70
Cover of moss layer	d in %	+	30	40	5
Number of plant species		39	35	21	18
Surface of investigated plots in m²		400			
Ch. *Dicrano-Pinion*					
Pinus sylvestris	a	3.3	3.3	1.1	1.1
Ch., D. *Vaccinio-Piceetea*, *Vaccinio-Piceetalia*					
Picea abies	a	.	2.2	.	.
Picea abies	b	.	+	.	.
Picea abies	c	.	+	.	.
Pleurozium schreberi	d	.	1.2	.	.
Melampyrum pratense		+.2	+	.	1.2
Vaccinium myrtillus		3.4	2.2	+.2	4.4
Vaccinium vitis-idaea		.	1.2	.	.
Orthilia secunda		+.2	.	.	.
Pyrola minor		+.2	.	.	.
Lycopodium annotinum		.	+	.	.
Trientalis europaea		+.2	+.2	.	.
Dicranum scoparium	d	.	.	.	+.2
Ch., D.* *Querco-Fagetea*					
Corylus avellana	b	1.1	.	.	.
Corylus avellana	c	.	+.2	.	.
Fagus sylvatica	a	.	1.2	5.4	.
Fagus sylvatica	b	.	+	+	2.1
Fagus sylvatica	c	.	.	+	1.1
Padus avium	b	+	.	.	.
Anemone nemorosum		+	1.2	.	.
*Euonymus europaea**	b	2.1	.	.	.
Impatiens noli-tangere		+	.	+	.
Viola reichenbachiana		1.2	+	.	+
Atrichum undulatum	d	.	.	1.2	.
Others					
Abies alba	a	.	.	+.2	+.2
Abies alba	b	1.1	2.2	+.2	2.1
Abies alba	c	.	+	+	1.1

Tab. 9 cont.

Quercus robur	a	3.3	.	.	.
Quercus robur	b	+	+.2	.	.
Quercus petraea	a	.	.	2.2	4.4
Quercus petraea	c	.	.	+	1.1
Betula pendula	b	2.2	.	.	.
Crataegus monogyna	b	1.2	.	.	.
Frangula alnus	b	1.1	.	.	.
Frangula alnus	c	+	.	.	.
Juniperus communis	b	.	+	.	.
Malus sylvestris	b	1.1	.	.	.
Populus tremula	b	+	.	.	.
Populus tremula	c	.	.	.	+
Sambucus racemosa	c	.	+	.	.
Sorbus aucuparia	b	.	1.1	.	+
Sorbus aucuparia	c	+	+	.	+
Viburnum opulus	c	+	.	.	.
Agrostis vulgaris		.	+.2	.	.
Festuca ovina		.	+	.	.
Fragaria vesca		+.2	+.2	.	.
Athyrium filix-femina		.	+.2	.	.
Ajuga reptans		+	+	.	.
Calamagrostis villosa		1.2	.	.	.
Convallaria majalis		1.2	.	.	+.2
Dryopteris carthusiana		.	.	+.2	.
Hieracium lachenalii		+	1.1	.	+
Luzula pilosa		.	+	+	+
Luzula sylvatica		+	.	.	.
Lysimachia vulgaris		1.1	.	.	.
Maianthemum bifolium		3.3	3.3	+	1.2
Mycelis muralis		1.1	+	.	.
Oxalis acetosella		2.3	2.2	+	.
Polygonatum verticillatum		+.2	+.2	.	.
Potentilla erecta		+	.	.	.
Pteridium aquilinum		1.2	.	.	1.2
Rubus hirtus		.	+	.	+
Rubus idaeus		+.2	+	.	.
Torylis japonica		1.2	.	.	.
Veronica chamaedrys		.	+	.	.
Plagiomnium affine	d	+.2	+.2	.	.
Brachythecium salebrosum	d	.	+.2	.	.
Polytrichastrum formosum	d	.	1.2	2.2	1.2
Rhizomnium punctatum	d	.	2.2	+.2	.
Dicranella heteromalla	d	.	.	3.3	.
Herzogiella seligeri	d	.	.	+.2	.
Plagiothecium curvifolium	d	.	.	+.2	.
Pohlia nutans	d	.	.	+.2	.

Tab. 9 cont.

Hypnum cupressiforme	d	.	.	.	+.2
Calypogeia trichomanes	d	.	.	1.2	.
Lepidozia reptans	d	.	.	1.2	.
Plagiochila asplenioides	d	.	.	+	.
Georgia pellucida	d	.	.	+	.

Table 10
Fungi in *Querco roboris-Pinetum*

Number of the plot	6	4	6	6	16	Frequency
Localities	Biesak Mt	Cisów		Korzecko	Piaski	
Density of tree layer a in %	80	90	60	80	50	
Density of shrub layer b in %	30	+	40	30	30	
Cover of herb layer c in %	80	5	70	80	60	
Cover of moss layer d in %	+	40	5	20	30	
Exposure	N	SW	S	S	W	
Inclination in degrees	3	30	10	5	3	
Surface of investigated plots in m²	400	400	400	400	400	
Number of observations	42	30	30	27	27	
Number of plant species	37	34	20	37	18	
Number of fungi species	54	31	41	59	50	
Fungi on soil						
Laccaria laccata	3n	.	2r	2n	3n	4
Lactarius quietus	1r	1n	1n	2r	.	4
Xerocomus pascuus	3r	.	.	2n	1r	3
Lactarius vellereus	1r	1r	.	.	1r	3
Laccaria amethystea	1r	1n	.	.	1r	3
Lepista nuda	1n	.	1r	.	1r	3
Lycoperdon perlatum	3r	7r-n	.	2r	.	3
Amanita muscaria	2r	.	2r	.	1r	3
Lepista nebularis	2a	.	.	2n-a	2n	3
Amanita citrina			1r	1r	2r	3
Amanita porphyria	.	1r	.	2n	2r	3
Cantharellus cibarius	.	1n	1n	.	3n	3
Russula ochroleuca	.	3n	3n	1r	.	3
Amanita rubescens	.	1n	1r	2r	.	3
Russula vesca	.	3r-n	1r	.	.	2
Russula rosea	.	2r	2n	.	.	2
Xerocomus badius	.	2n	2n	.	.	2
Macrolepiota procera	.	.	1r	2r	.	2
Lactarius rufus	.	.	1r	1r	.	2
Leccinum aurantiacum	.	.	1r	.	.	1
Lepiota cristata	.	.	2r	1n	.	2
Lepista nuda	.	.	1r	1r	.	2
Suillus bovinus	.	.	.	1r	1r	2
Inocybe geophylla var. *lilacina*	.	.	.	1n	1r	2

Tab. 10 cont.

Chalciporus piperatus	2n	.	.	.	1n	2
Amanita pantherina	1r	.	.	.	.	1
Chroogomphus rutilus	1r	.	.	.	.	1
Coltricia perennis	3r	.	.	.	.	1
Hebeloma vaccinum	1r	.	.	.	.	1
Hebeloma hiemale	2n	.	.	.	.	1
Hebeloma mesophaeum	1r	.	.	.	.	1
Inocybe abjecta	1r	.	.	.	.	1
Inocybe geophylla var. *geophylla*	4n	.	.	.	.	1
Inocybe subnudipes	1r	.	.	.	.	1
Lactarius glyciosmus	2n	.	.	.	.	1
Lactarius necator	1r	.	.	.	.	1
Lepiota castanea	1n	.	.	.	.	1
Lycoperdon lividum	1r	.	.	.	.	1
Psathyrella canoceps	2n	.	.	.	.	1
Thelephora terrestris	2r	.	.	.	.	1
Tricholoma sulphureum	1n	.	.	.	.	1
Hygrophorus eburneus	.	1n	.	.	.	1
Inocybe lanuginosa	.	1n	.	.	.	1
Lactarius blennius	.	1r	.	.	.	1
Russula delica	.	1r	.		.	1
Russula fellea	.	1n	.	.	.	1
Russula mairei	.	1n	.	.	.	1
Russula piceetorum	.	1n	.	.	.	1
Hygrophoropsis aurantiaca	.	.	2r	.	.	1
Agaricus arvensis	.	.	1r	.	.	1
Agaricus silvicola	.	.	.	2r	.	1
Amanita fulva	.	.	.	3n	.	1
Craterellus cornucopioides	.	.	.	2n	.	1
Inocybe fastigiata	.	.	.	1n	.	1
Russula nigricans	.	.	.	1n	.	1
Russula virescens	.	.	.	1r	.	1
Clitocybe geotropa	.	.	.	.	1r	1
Cantharellus cinereus	.	.	.	.	1n	1
Fungi on wood						
Psilocybe fascicularis	8n-a	.	6n	.	6n-a	3
Stereum hirsutum	xn	.	xn	xn	xn	4
Mycena vitilis	1r	2r	1r	2r	.	4
Athelia arachnoidea			2r	2r	1r	3
Lycoperdon pyriforme	.	.	2n	2n	1r	3
Galerina marginata	.	.	2r	2r	2r	3
Dacryomyces stillatus	.	.	2n	2n-a	2n	3
Armillaria ostoyae	.	1a	4a	.	.	2
Xeromphalia campanella	.	1a	1a	.	.	2
Tricholomopsis rutilans	.	1n	.	.	1r	2

Tab. 10 cont.

Hymenochaete rubiginosa	.	.	xn	xn	.	2
Exidia plana	.	.	2n	2n	.	2
Crepidotus variabilis	.	.	1n	1r	.	2
Gymnopilus hybridus	.	.	.	1n	1n	2
Phellinus robustus	.	.	.	xr	xr	2
Trichaptum abietinum	.	.	.	xn	xn	2
Trichaptum fuscoviolaceum	xa	.	.	.	xa	2
Calocera furcata	1r	.	.	.	1r	2
Calocera viscosa	1n	.	.	.	1r	2
Phellinus hartigii	xr	.	.	.	xr	2
Auriculariopsis ampla	1n	.	.	.	.	1
Crucibulum laeve	1n	.	.	.	.	1
Hydropus marginellus	1r	.	.	.	.	1
Pholiota aurivella	2r	.	.	.	.	1
Psilocybe capnoides	1r	.	.	.	.	1
Daedaleopsis confragosa	.	.	xr	.	.	1
Megacollybia platyphylla	.	.	1n	.	.	1
Pluteus atricapillus	.	.	1n	.	.	1
Psilocybe lateritia	.	.	2n-a	.	.	1
Flammulina velutipes	.	.	.	1n	.	1
Fomes fomentarius	.	.	.	xr	.	1
Ganoderma applanatum	.	.	.	xr	.	1
Mycena galericulata				2r		1
Aleurodiscus amorphus	.	.	.	.	xn	1
Amphinema byssoides	.	.	.	.	xr	1
Amylostereum areolatum	.	.	.	.	xr	1
Heterobasidion annosum	.	.	.	.	xr	1
Stereum sanguinolentum	.	.	.	.	xn	1
Fungi on litter and among mosses						
Mycena galopus	5r-n	3n	.	2n	1n	4
Mycena pura	2r	1r	.	4n	3n	4
Mycena sanguinolenta	2n	1r	.	2r	1r	4
Mycena zephirus	3n	2n	2n	3n	.	4
Gymnopus dryophilus	6a	.	.	3n	7n-a	3
Auriscalpium vulgare	2n	.	.	3r	1n	3
Mycena epipterygia	2n	.	2n	4n	2n-a	3
Strobilurus stephanocystis	4n	.	.	.	4n	2
Psilocybe aeruginosa	1n	.	.	.	2n	2
Psathyrella piluliformis	1a	.	1a	.	.	2
Clitocybe metachroa	1r	.	.	2r	.	2
Strobilurus tenacellus	4n	.	.	3n	.	2
Clitocybe odora	2r	.	.	1r	.	2
Mycena leptocephala	1r	.	.	1r	.	2
Clitocybe langei	.	1n	1r	.	.	2
Marasmius epiphyllus	.	.	2n	2n	.	2

Tab. 10 cont.

Clitocybe gibba	.	.	2r	1r	.	2
Galerina hypnorum	.	2r	.	1r	2n	3
Gymnopus peronatus	.	.	.	2n	2n	2
Mycena rosea	.	.	.	2r	2r	2
Rhodocollybia butyracea var. *asema*	.	.	.	2r	1n	2
Rhodocollybia butyracea var. *butyracea*	.	.	.	2n	1n	2
Rickenella fibula	.	.	.	1r	1r	2
Setulipes androsaceus	.	.	.	3r-n	3n	2
Mycena acicula	2n	.	.	.	.	1
Gymnopus confluens	.	3n-a	.	.	.	1
Mycena galopus var. *nigra*	.	1n	.	.	.	1
Mycena polygramma	.	1n	.	.	.	1
Marasmius bulliardii	.	.	3n-a	.	.	1
Clitocybe candicans	.	.	.	1r	.	1
Geastrum minimum	.	.	.	1r	.	1
Tremella encephala	.	.	.	.	1n	1

mixed forest (Skirgiełło 1991). *Chalciporus piperatus* has been recorded in various forest communities, both deciduous and coniferous; in the Góry Świętokrzyskie Mts., however, it had been recorded only in coniferous forest communities in the *Peucedano-Pinetum* and *Querco-Pinetum*. Therefore, its diagnostic value is slightly lower than that of the other two species. The ecological scales of other exclusive species, such as *Agaricus arvensis, Clitocybe geotropa* and *Lactarius glyciosmus*, are significantly broader, and the fungi were recorded in different plant communities, forest and non-forest ones, and are not analysed as diagnostic species.

Terrestrial fungi are similar to those in *Tilio-Carpinetum*, with which they share 39.6% species, *Dentario glandulosae-Fagetum* – 36.2%, *Abietetum polonicum* – 2.8% and *Leucobryo-Pinetum* – 31% (Fig. 10). *Hygrophorus eburneus* and *Lepiota castanea* were recorded only in the mixed pine forest and in the oak-hornbeam forest. *Gymnopus confluens* connects the communities of the mixed coniferous forests with *Abietetum polonicum*, *Dentario glandulosae-Fagetum* and *Tilio-Carpinetum*, *Russula fellea* connects them with *Abietetum polonicum* and *Dentario glandulosae-Fagetum*, and *Suillus luteus* with *Leucobryo-Pinetum.* Fungi characterised by a broad ecological range that occur in the great majority of the examined forest communities, that is between 10 and 11, are indicative of the biota of terrestrial fungi that is intermediate between deciduous forest communities and those of coniferous forests. *Amanita citrina, Cantharellus cibarius, Laccaria amethystea, L. laccata* and *Lycoperdon perlatum* are connective species.

Of the 32 litter-inhabiting species in *Querco-Pinetum*, only *Psathyrella piluliformis* is an exclusive species. Five other species were also recorded outside the community only once; three (*Clitocybe odora, Geastrum minimum* and *Mycena galopus* var. *nigra*) in patches belonging to *Potentillo-Quercetum*, one (*Clitocybe langei*) in *Abietetum polonicum* and one (*Rickenella fibula*) in *Sphagnetum magellanici* (Fig. 7b). The biota of litter-inhabiting fungi of little specific value makes the community open-ended and determines its similarity to many other communities. It shows the greatest affinity with fungi of the *Potentillo-Quercetum*, with which it shares 77.8% species, as well as with those in *Tilio-Carpinetum* – 63% and in *Abietetum polonicum* and *Dentario glandulosae-Fagetum* (51.8% species). Numerous ubiquitous species, for instance *Gymnopus dryophilus, Mycena galopus, M. pura*, *Rhodocollybia butyracea* var. *butyracea* and *Psilocybe aeruginosa,* are present in the species composition of this ecological group and were recorded in the majority of the communities. At the same time, apart from the fungi listed above, *Mycena epipterygia, M. sanguinolenta* and *M. zephirus* are species that produce fruitbodies most abundantly in this community.

The biota of lignicolous *Basidiomycetes* in the *Querco-Pinetum* comprises 38 species (Fig. 7c). It is mostly associated with wood and living trees of *Abies alba, Betula pendula, Fagus sylvatica, Pinus sylvestris*, *Picea abies*, *Quercus robur* and *Q. petraea*. Unlike terrestrial and litter-inhabiting fungi in this ecological group, 7 exclusive species were recorded: *Aleurodiscus amorphus, Amphinema byssoides, Amylostereum areolatum, Athelia arachnoidea, Auriculariopsis ampla, Calocera furcata* and *Exidia plana*. It is difficult to name species that would be good indicators of this plant community since these fungi, associated with specific species or wood types, migrate to different plant communities. *Amphinema byssoides* and *Amylostereum areolatum* are characterised by a narrower ecological scale. These fungi grow on *Abies, Picea* and *Pinus*, and are therefore recorded most frequently in coniferous forest communities and in mixed forests. Additionally, their diagnostic value increases due to the fact they are rare in Poland and are recorded infrequently (Wojewoda 2003). Two other species, *Auriculariopsis ampla* and *Calocera furcata*, with slightly broader occurrence ranges, are also interesting. Special attention should also be paid to *Calocera furcata*, which was observed only in *Abietetum polonicum* outside the examined community. Therefore, *Amphinema byssoides, Amylostereum areolatum* and *Calocera furcata* can be considered locally characteristic of *Querco-Pinetum*.

The biota of xylobionts examined here resembles that of the following communities the most: *Tilio-Carpinetum* – 74.7%, *Dentario glandulosae-Fagetum* – 68.4%, *Leucobryo-Pinetum* – 57.9% and *Potentillo-Quercetum* – 52.6% (Fig. 12). These similarities result from the fact that trees such *Abies alba, Fagus sylvatica, Pinus sylvestris*, *Quercus petraea* and *Q. robur*, important for the development of lignicolous *Basidiomycetes*, migrate to the above forest communities providing suitable substrates for fungal development.

Fungi characterised by a very broad occurrence scale and recorded in the majority of the examined plant community constitute a very numerous group of species in the biota of xylobionts. The most common species are as follows: *Armillaria ostoyae, Fomitopsis pinicola, Psilocybe capnoides, P. fascicularis, Stereum hirsutum, Trametes hirsuta, Trichaptum fuscoviolaceum* and *Tricholomopsis rutilans*.

Serratulo-Pinetum

Habitat and phytosociological description. Research plots in *Serratulo-Pinetum* phytocoenoses were established on southern slopes of calcareous hills of the Pasmo Kadzielniańskie Ridge and Grząby Bolmińskie Ridge, where the terrain gradient does not exceed 5°. Patches of this community develop on rich clayey sands, deluvial clays lying on Jurassic limestones from which acid cambisols are formed. The topsoils are slightly acidic and their pH equals 5.2. They contain mull humus.

The stand consists of one layer and is composed of *Pinus sylvestris* whose crown cover ranges between 60 and 70% (Tab. 11). *Quercus petraea, Q. robur, Carpinus betulus* and *Betula pendula*, *Tilia platyphyllos* which do not reach the highest tree level occur in the shrub layer. Shrubs *Corylus avellana, Juniperus communis, Lonicera xylosteum* and other species, especially those belonging to the class *Rhamno-Prunetea*, that never form an abundant layer and whose cover equals from 5 to 30%, grow under them. The ground cover is usually well developed and floristically rich; its density ranges from 40 to 100%. Species typical of coniferous forests dominate in the relatively abundant ground cover: *Melampyrum pratense, Festuca ovina, F. rubra, Chamaecytisus ratisbonensis, Chimaphila umbellata*. Those are accompanied by plants of the class *Querco-Fagetea*: *Carex digitata, Viola reichenbachiana, Melica nutans* and *Lathyrus vernus*. This form of the mixed forest is characterised by a significant presence of thermophilous species of the classes *Festuco-Brometea* and *Trifolio-Geranietea: Origanum vulgare, Galium mollugo, Coronilla varia, Peucedanum oreoselinum, Euphorbia cyparissias, Helianthemum nummularium* ssp. *obscurum, Poa compressa* and *Ranunculus bulbosus*. The participation of these plants, as well as of *Genista tinctoria* and *Pimpinella saxifraga*, will differentiate the Sarmatian variant within this association (Matuszkiewicz 2006). This variant is greatly similar to the *Potentillo-Quercetum*, not only floristically but also mycologically. The moss layer develops abundantly covering the soil from 80 to 95%. Coniferous forest species, such as *Hylocomium splendens* and *Pleurozium schreberi*, dominate quantitatively.

Mycological description. *Basidiomycetes* in *Serratulo-Pinetum* were examined at six permanent plots where 204 observations were conducted for three years. A total of 128 species, including 72 terrestrial species, 42 litter-inhabiting species and 14 lignicolous species were collected (Tab. 12). Between 47 and 67 fungal species were recorded at individual research plots. Species exclusive to this community constitute 17.2% of the total biota in *Serratulo-Pinetum* (Fig. 9). *Basidiomycetes* of the subboreal mixed forest resemble fungi of the following communities the most: *Peucedano-Pinetum*, with which it shares 40.6%, *Tilio-Carpinetum* – 39.1%, *Dentario glandulosae-Fagetum* – 32.8%, *Potentillo-Quercetum* – 32% and *Querco-Pinetum* – 31.2% (Fig. 8). A relatively high similarity of the mycobiota in these five communities is indicative of the mixed type of fungi in *Serratulo-Pinetum,* where fungi and plants typical of coniferous forests as well as meso- and thermophilous deciduous forests occur.

The biocoenosis structure in this forest community is the only one to be characterised by a greater species richness of vascular plants than that of *Basidiomycetes* of all the communities examined in this project.

Terrestrial fungi which constitute 56.2% of the species collected at permanent plots are the most numerous group. Mycorrhizal fungi constitute 66.7% of this ecological group (Fig. 7a). Thirteen exclusive species were recorded: *Conocybe tenera, Cortinarius elegantior, C. glaucopus, C. multiformis, Cystodermella cinnabarinum, Inocybe bongardii, I. inodora, I. mixtilis, I. praetervisa, Melanoleuca amica, M. grammopodia, Psilocybe inuncta*. These are mostly very interesting and rare fungi, attached to various coniferous habitats. Significant preferences for $CaCO_3$ soil content in is an important feature of the biota of this community. As many as six significantly calcicolous species can be identified among exclusive fungi: *Cortinarius elegantior, C. glacopus, C. multiformis, Inocybe bongardii, I. inodora* and *I. mixtilis*, which, apart from *Inocybe bongardii*, are also associated with coniferous habitats. The presence of these fungi stresses the Sarmatian type of the *Serratulo-Pinetum* biocoenosis. In southern Germany, *Inocybe inodora* grows in xerothermic communities with pines (Krieglsteiner 1999). *Inocybe bongardii* is usually associated with fertile deciduous forests such as *Dentario glandulosae-Fagetum* and *Tilio-Carpinetum*, which emphasises the mixed type of the *Serratulo-Pinetum* biocoenosis in this case. The diagnostic value of characteristic species in the community, at least at the regional level, should undoubtedly be assigned

Table 11

Serratulo-Pinetum

Successive number		1	2	3	4	5	6
Number of plot		1	2	5	10	11	12
Date		24.06.2000			14.06.1993		
Localities		Milechowy reserve			Kielce		
Density of tree layer	a in %	70	70	65	70	70	60
Density of shrub layer	b in %	5	30	15	10	10	5
Cover of herb layer	c in %	40	70	50	95	100	90
Cover of moss layer	d in %	95	95	95	80	80	80
Number of plant species		56	68	60	51	60	45
Exposure		SW	SW	SW	S	S	-
Inclination in degrees		3	5	3	5	5	0
Surface of investigated plots in m^2		400					
ChAss. *Serratulo-Pinetum**, ChAll. *Dicrano-Pinion*							
*Orthilia secunda**		+	.	.	1.2	1.2	+.2
Chimaphila umbellata		1.1	1.2	1.1	.	1.2	+.2
Monotropa hypopitys		.	.	+	.	.	.
DAss. *Serratulo-Pinetum*							
Corylus avellana	b	.	+	.	+.2	.	+.2
Corylus avellana	c	.	.	+	.	.	.
Euonymus verrucosa	c	.	+	.	.	.	.
Melica nutans		+	+.2	.	.	.	.
Carex digitata		+	+	.	.	.	+.2
Pimpinella saxifraga		.	+	.	+	+.2	.
Genista tinctoria		.	.	.	2.3	2.2	.
Viola reichenbachiana		.	.	+	1.2	+.2	.
ChO. *Cladonio-Vaccinietalia*, ChCl. *Vaccinio-Piceetea*							
Pinus sylvestris	a	4.5	4.4	4.4	4.4	4.4	4.4
Pinus sylvestris	b	.	+	.	.	.	1.2
Pinus sylvestris	c	.	.	+	.	1.1	.
Melampyrum pratense		2.2	2.2	2.2	1.2	1.2	2.3
Vaccinium myrtillus		+.2	+.2	+.2	2.2	+.2	1.2
Vaccinium vitis-idaea		.	.	.	1.2	1.2	2.3
Pyrola minor		+	+.2	.	+.2	.	.
Hylocomium splendens	d	3.3	4.3	4.4	.	+.2	2.3
Pleurozium schreberi	d	3.3	3.3	3.3	4.4	3.4	3.4
ChCl. *Querco-Fagetea*							
Acer platanoides	b	.	+	+	.	.	.
Acer platanoides	c	+	.	+	.	.	.
Carpinus betulus	b	+	+	+	.	.	.
Carpinus betulus	c	+	.	.	.	.	.
Lonicera xylosteum	b	+	1.1	1.1	.	.	.
Tilia cordata	b	.	+	.	.	.	.
Tilia platyphyllos	b	+	.	+	.	.	.

Euonymus europaea	b	.	.	+	.	.	.
Cephalanthera bifolia		.	+	.	.	.	.
Lathyrus vernus		+	+.2	.	.	.	+
Potentilla alba		.	.	.	+.2	.	.
Viola hirta		+.2	1.1	+	.	+	.
ChCl. *Rhamno-Prunetea*							
Berberis vulgaris	c	.	.	+	.	.	.
Cornus sanguinea	b	.	+	+	.	+.2	.
Cornus sanguinea	c	+	+	.	.	.	.
Crataegus monogyna	b	.	+	.	.	.	.
Crataegus monogyna	c	.	.	.	+	.	.
Prunus spinosa	b	.	+	+	.	.	.
Rhamnus catharticus	b	.	.	+	.	.	.
Rosa canina	b	.	+	+	+	+	.
Rosa canina	c	+	.	.	.	.	.
Viburnum opulus	b	.	+	.	.	+	.
Viburnum opulus	c	.	.	+	.	.	+
ChCl. *Trifolio-Geranietea*							
Origanum vulgare		+	+	+.2	.	+.2	+.2
Galium mollugo		+.2	+.2	+.2	+	.	.
Agrimonia eupatoria		+	+	+	.	+.2	.
Coronilla varia		+.2	+.2	.	1.2	.	.
Trifolium medium		.	.	.	+	+.2	1.2
Peucedanum oreoselinum		.	.	.	2.2	+.2	+.2
Galium verum		.	1.2	.	+.2	.	.
Vicia sepium		.	+	+.2	.	.	.
Astragalus glycyphyllos		.	+.2	.	.	.	.
Vicia cassubica		.	+.2	.	.	.	.
Geranium sanguineum		.	.	.	2.2	.	.
Trifolium alpestre		.	.	.	1.2	.	.
ChCl. *Festuco-Brometea*							
Ajuga genevevsis		.	.	.	+.2	.	.
Dianthus carthusianorum		.	+	.	.	.	.
Euphorbia cyparissias		+	.	+	+	+	.
Helianthemum nummularium subsp. *obscurum*		+	1.2	+.2	.	.	.
Plantago media		+	.	.	.	.	.
Poa compressa		+	.	.	.	.	.
Taraxacum laevigatum s.l.		.	.	.	+.2	.	.
Others							
Betula pendula	b	+	.	+	.	+	+.2
Frangula alnus	b	.	+	+	1.1	+	.
Frangula alnus	c	.	.	.	.	.	+
Juniperus communis	b	1.1	1.1	1.1	1.1	1.1	+.2
Juniperus communis	c	+	.	.	.	.	.

Populus tremula	b	+	.	+	.	1.1	+
Pyrus communis	b	+	.	.	.	.	.
Pyrus communis	c	.	+	+	.	.	.
Quercus petraea	b	1.1	1.1	1.1	.	.	.
Quercus petraea	c	+	.	+	.	.	.
Quercus petraea x *robur*	b	+	.	.	.	.	.
Quercus robur	b	.	.	.	+.2	1.1	+
Rubus sp.	b	.	.	+	.	.	.
Sorbus aucuparia	b	+	.	.	.	.	.
Sorbus aucuparia	c	.	.	.	+	+	+
Fragaria vesca		1.2	2.3	1.2	3.3	2.3	2.3
Hieracium pilosella		1.2	1.2	+.2	+.2	1.2	+.2
Solidago virgaurea		+	+	+	+.2	+.2	+
Luzula pilosa		+	+	+	+.2	+.2	1.1
Plantago lanceolata		+	+	+	+	1.1	+.2
Taraxacum officinale		+	+.2	.	+.2	1.1	+.2
Agrostis capillaris		+	+	+	1.2	.	+.2
Hieracium lachenalii		+	+	+	.	+.2	+.2
*Veronica officinalis**		1.1	+	1.1	.	+.2	+.2
Festuca ovina		+.2	.	.	3.4	3.4	3.4
Cerastium holosteoides		+	+	.	.	+.2	+.2
Vicia cracca		+	.	+	.	+.2	+.2
Chamaecystisus ratisbonensis		.	2.3	.	2.3	2.2	3.3
Knautia arvensis		+	+	.	+	+	.
Polygala vulgaris		+	.	+	1.2	1.2	.
Poa angustifolia *		.	+	+	1.2	+.2	.
Achillea millefolium		.	.	.	+	+	+.2
Hypericum perforatum		.	+	+	.	+.2	.
Maianthemum bifolium		+.2	+.2	.	+.2	.	.
Thymus serpyllum		1.2	1.2	1.2	.	.	.
Anthoxanthum odoratum		+			+.2	.	+.2
Veronica chamaedrys		.	1.2	.	1.2	.	+.2
Prunella vulgaris		+	+	+	.	.	.
Festuca rubra		3.3	2.2	3.3	.	.	.
Medicago lupulina		+	+	+	.	.	.
Viscaria vulgaris		1.2	+.2	.	+	.	.
Pteridium aquilinum		.	.	.	2.2	+	.
Trifolium repens		.	+	+	.	.	.
Dactylis glomerata		+	.	.	.	+.2	.
Trifolium pratense		+	.	+	.	.	.
Platanthera bifolia		+	.	1.1	.	.	.
Ranunculus bulbosus		+	+	.	.	.	.
Viola collina		.	+.2	+	.	.	.
Vicia hirsuta		.	+	+	.	.	.
Rumex acetosella		.	.	+	.	+	.
Galium vernum		.	.	.	+.2	.	1.2
Ranunculus sardous		.	.	.	+.2	+	.
Pulsatilla pratensis		.	.	.	+	+	.
Potentilla erecta		.	.	.	+	.	+

Tab. 11 cont.

Thymus pulegioides		.	.	.	.	2.3	+.2
Hypochoeris radicata		.	.	.	.	+.2	+
Calamagrostis epigejos		+	.	.	.	.	.
Anthyllis vulneraria		+	.	.	.	.	.
Dianthus deltoides		+	.	.	.	.	.
Festuca amethystina		+	.	.	.	.	.
*Hieracium umbellatum**		+	.	.	.	.	.
Viola odorata		.	1.2	.	.	.	.
Convallaria majalis		.	+.2	.	.	.	.
Poa pratensis		.	+.2	.	.	.	.
Luzula campestris		.	+	.	.	.	.
Rubus plicatilis		.	.	.	.	1.2	.
Carex ericetorum		.	.	.	.	+.2	.
Torylis japonica		.	.	.	.	+	.
Polygonatum verticillatum		.	.	.	.	+	.
Silene vulgaris		.	.	.	.	+	.
Calluna vulgaris		.	.	.	.	.	1.2
Botrichium lunaria		.	.	.	.	.	+.2
Lotus corniculatus		.	.	.	.	.	+.2
Plagiomnium affine	d	1.2	.	.	1.2	1.2	1.2
Hypnum cupressiforme	d	1.2	.	.	.	+.2	.
Brachythecium sp.	d	.	.	+.2	.	.	.
Dicranum scoparium	d	.	.	+.2	.	.	.
Plagiothecium sp.	d	.	.	+.2	.	.	.
Bryum sp.	d	.	.	+	.	.	.
Abietinella abietina	d	.	.	.	.	2.2	2.3
Brachythecium albicans	d	.	.	.	.	+.2	.
Ceratodon purpureus	d	.	.	.	.	+.2	.

Table 12
Fungi in *Serratulo-Pinetum*

Number of the plot		1	2	5	10	11	12	Frequency
Localities		Milechowy reserve			Kielce			
Density of tree layer	a in %	70	70	65	70	70	60	
Density of shrub layer	b in %	5	30	15	10	10	5	
Cover of herb layer	c in %	40	70	50	95	100	90	
Cover of moss layer	d in %	95	95	95	80	80	80	
Exposure		SW	SW	SW	S	S	-	
Inclination in degrees		3	5	3	5	5	0	
Surface of investigated plots in m^2		400						
Number of observations		30	30	30	38	38	38	
Number of plant species		65	67	58	51	59	45	
Number of fungi species		64	67	57	48	50	47	
Fungi on soil								
Suillus granulatus		6n	6r-n	4n	6n	6n	7r-n	6
Lycoperdon perlatum		4a	4a	4a	1r	4r-n	2r	6

Tab. 12 cont.

Ramaria abietina	.	2a	2n-a	4n	4n	4r	5
Cantharellus cibarius	4r	4r-n	3n	3r	4n	.	5
Lactarius deliciosus	3r	3n	3n	.	2r	3n	5
Suillus luteus	1r	1n	.	1r	1r	1r	5
Inocybe lacera	2n	2n	.	1n	1n	2n	5
Cystoderma amianthinum	3n	1n	3n	4n	.	6n	5
Lepista nuda	4n	.	1n	6n	2r	.	4
Hygrophoropsis aurantiaca	2n	2n	.	3n	.	2n	4
Macrolepiota procera	4r	2r	4r-n	.	3n	.	4
Psilocybe inuncta	1r	.	1r	.	1r	1r	4
Cystodermella cinnabarinum	1n	2n	.	.	.	4n-a	4
Hygrocybe conica	.	1r	.	3n	4n	2n	4
Chroogomphus rutilus	3r	5r	3r	.	.	3r	4
Cortinarius elegantior	2n	2n	2n	.	.	.	3
Inocybe fuscidula	3n	2n	3n	.	.	.	3
Russula fragilis	3r	3r	3r	.	.	.	3
Russula sanguinea	2r	3r	3r	.	.	.	3
Ramaria eumorpha	4n	2n	.	.	2r	.	3
Melanoleuca amica	1n	2n	1r	.	.	.	3
Calvatia excipuliformis	4n	6n	6n	.	.	.	3
Cystodermella granulosum	2n	3r-n	2n	.	.	.	3
Agaricus silvicola	2r	.	2r	.	1r	.	3
Marasmius oreades	3n	.	2n	.	.	4n	3
Calocybe gambosa	.	2n	.	3a	.	2a	3
Hebeloma crustuliniforme	.	4a	.	4r	.	5r	3
Amanita citrina	.	2r	.	2r	.	2r	3
Hebeloma mesophaeum	.	1a	.	.	2n	2r	3
Inocybe abjecta	.	.	.	1r	1n	2n	3
Melanoleuca melaleuca	.	.	.	1r	1r	1n	3
Melanoleuca microcephala	.	.	.	1r	1n	2r	3
Thelephora caryophyllea	.	.	.	4r-n	4r-n	4r-n	3
Russula turci	2r	2r	.	.	.	.	2
Inocybe praetervisa	2r-n	.	2r-n	.	.	.	2
Tricholoma terreum	.	3n	.	4r	.	.	2
Hebeloma hiemale	.	3a	.	.	.	3n	2
Coltricia perennis	.	.	.	4r	4n	.	2
Lepiota cristata	.	1n	.	.	1r	.	2
Lycoperdon lividum	.	4n	3n	.	.	.	2
Cystoderma carcharias	.	.	2r	.	.	2n	2
Lycoperdon umbrinum	.	.	2n	3n	.	.	2
Inocybe pseudodestricta	.	.	.	.	1r	2r-n	2
Conocybe tenera	1r	.	.	.	.	.	1
Inocybe geophylla var. *lilacina*	1n	.	.	.	.	.	1
Inocybe mixtilis	1r	.	.	.	.	.	1
Melanoleuca grammopodia	1n	.	.	.	.	.	1
Russula badia	1r	.	.	.	.	.	1

Tab. 12 cont.

Russula rosea	.	1r	1r	.	.	.	2
Amanita eliae	.	2r	.	.	.	.	1
Cortinarius glacopus	.	1n	.	.	.	.	1
Inocybe bongardii	.	1r	.	.	.	.	1
Inocybe cervicolor	.	1n	.	.	.	.	1
Inocybe fastigiata	.	3r-n	.	.	.	.	1
Tricholoma inamoenum	.	1n	.	.	.	.	1
Camarophyllus pratensis	.	.	2r	.	.	.	1
Cortinarius decipiens	.	.	1r	.	.	.	1
Cortinarius multiformis	.	.	1r	.	.	.	1
Inocybe hirtella	.	.	1n	.	.	.	1
Lactarius rufus	.	.	1r	.	.	.	1
Russula aeruginea	.	.	2r-n	.	.	.	1
Russula cyanoxantha	.	.	2r	.	.	.	1
Melanoleuca graminicola	.	.	.	1r	.	.	1
Russula emetica	.	.	.	2r	.	.	1
Inocybe inconcinna	.	.	.	.	1n	.	1
Inocybe inodora	.	.	.	.	1r	.	1
Inocybe sindonia	.	.	.	.	1r	.	1
Inocybe subnudipes	.	.	.	.	1r	.	1
Psilocybe albonitens	.	.	.	.	1r	.	1
Thelephora palmata	.	.	.	.	1n	.	1
Hebeloma pumilum	.	.	.	.	.	1n	1
Hebeloma truncatum	.	.	.	.	.	1r	1
Fungi on wood							
Galerina marginata	3r-n	2n	2r-n	4n	4n	3n	6
Crucibulum laeve	2n-a	.	.	3n	4a	4n-a	4
Trichaptum fuscoviolaceum	.	xa	.	xa	xa	xa	4
Psilocybe fascicularis	4a	.	.	5n-a	5n	.	3
Trichaptum abietinum	.	xa	xa	.	xr	.	3
Pluteus pouzarianus	1r	.	.	1r	.	.	2
Psilocybe capnoides	1n	.	.	.	.	1n	2
Gymnopilus hybridus	.	2n-a	.	.	3n	.	2
Tricholomopsis rutilans	.	.	.	2r	.	2r	2
Tricholomopsis decora	.	.	.	2n	1r	.	2
Galerina triscopa	1r	.	.	.	.	.	1
Stereum sanguinolentum	.	.	xn	.	.	.	1
Heterobasidion annosum s.l.	.	.	.	xn	.	.	1
Gymnopilus sapineus	.	.	.	.	1r	.	1
Fungi on litter							
Auriscalpium vulgare	xr-a	xr-a	xr-a	xr-a	xn	xr-a	6
Mycena epipterygia	8n-a	9n-a	9n-a	10r-a	12n	12n-a	6
Mycena galopus	3r	3n	3n	4n	3n	5n	6
Mycena metata	2r	2n	3n	4n	5n-a	4n-a	6

Tab. 12 cont.

Mycena zephirus	2r	2n	4n	4n-a	4n-a	4n-a	6
Psilocybe aeruginosa	5r-n	3r-n	3n	4r-n	5r-n	2r	6
Setulipes androsaceus	10a	10n-a	9n-a	12a	10a	10a	6
Strobilurus stephanocystis	6a	6a	6a	8a	8a	8a	6
Strobilurus tenacellus	6n-a	6n-a	6n-a	8a	8a	8a	6
Galerina mniophila	3a	5n-a	3a	4n	2r	.	5
Mycena aetites	3r	3n	2n	2r	.	3r	5
Mycena leptocephala	8n	6n	7n	9n	.	8n	5
Clitocybe metachroa	1n	2n	.	.	4n	2n	4
Mycena citrinomarginata	.	1r	2n	1r	2n	.	4
Mycena flavoalba	2n	2r	3n	.	.	4n	4
Mycena pura	10n	5n	5n	.	2r	.	4
Clitocybe gibba	2n	.	1r	2n	.	.	3
Mycena rubromarginata	2r	3n	2n	.	.	.	3
Clitocybe candicans	.	2n	2n	.	.	.	2
Clitocybe fragrans	.	.	+	n	.	.	2
Clitocybe subalutacea	.	.	.	1r	.	2n	2
Clitocybe vibecina	2r	.	1r	.	.	.	2
Galerina vittiformis	2n	1r	.	.	.	.	2
Geastrum quadrifidum	.	1r	.	1n	.	.	2
Clitocybe agrestis	1r	.	.	.	.	.	1
Clitocybe amarescens	.	1n	.	.	.	.	1
Clitocybe ditopa	.	1r	.	.	.	.	1
Clitocybe hydrogramma	2r	.	.	.	.	.	1
Clitocybe squamulosa	1n	.	.	.	.	.	1
Clitocybe strigosa	.	.	1n	.	.	.	1
Clitocybe tornata	.	.	.	.	3n	.	1
Galerina clavus	.	.	.	.	1r	.	1
Geastrum rufescens	.	.	2n	.	.	.	1
Mycena adonis	2n	.	.	.	.	.	1
Mycena arcangeliana	.	.	.	.	.	2n	1
Mycena atroalba	.	1r	.	.	.	.	1
Mycena capillaris	.	2r	.	.	.	.	1
Mycena rosea	.	2r	.	.	.	.	1
Mycena vitilis	2r	.	.	.	.	.	1
Psathyrella spadiceogrisea	1r	.	.	.	.	.	1

to the species of the genera *Cortinarius* and *Inocybe* given above: *Cortinarius elegantior, C. glacopus, C. multiformis, Inocybe inodora* and *I. mixtilis*. Due to the slightly broader ecological scale, other fungi also occur outside the community in various plant communities, and are sporadic species and accompanying species.

The greatest resemblance of terrestrial *Basidiomycetes* in *Serratulo-Pinetum* is observed in relation to fungi of *Peucedano-Pinetum* – 41.7% species in common and *Tilio-Carpinetum* – 33.3% (Fig. 10). It shares 11 species with the mesic subcontinental coniferous forest of which *Hebeloma mesophaeum, H. truncatum, Inocybe inconcinna, Lactarius deliciosus, Suillus luteus* and *Thelephora caryophyllea* are species typical of coniferous habitats, associated with pine mycorrhizae, while *Calocybe gambosa* and *Melanoleuca microcephala* prefer calcareous soils as well as xerophilous and warm sites. Five species in common with of the oak-linden-hornbeam forest were recorded: *Hebeloma crustuliniforme, Inocybe cervicolor, I. fuscidula, I. hirtella* and *Russula sanguinea*. As a result of mycorrhizal relationships with numerous deciduous tree species, for instance *Carpinus, Fagus* or *Quercus*, these fungi migrate with them to the subboreal mixed forest. As a pine mycosymbiont, *Russula sanguinea* is an exception from this rule and it follows it to, among others, pinetised forms of oak-hornbeam forests. *Inocybe cervicolor*, a fungus of coniferous forests that occurs on soils rich in calcium carbonate and that differentiates the biocoenosis of fungi in the *Serratulo-Pinetum* well, is especially noteworthy.

Only seven species were characterised by the highest frequency, that is in all six or five permanent plots, in the community. Of them, the abundance of fruitbody production was the highest in the case of *Cystoderma amianthinum, Lycoperdon perlatum* and *Suillus granulatus*.

Of the 42 species of fungi growing on litter, seven species were exclusive: *Clitocybe agrestis, C. strigosa, Galerina clavus, Geastrum rufescens, Marasmius oreades, Psathyrella spadiceogrisea* and *Psilocybe albonitens*. Their importance for the mixed forest varies greatly. It seems that the greatest diagnostic value should be assigned to *Clitocybe concava* and *Galerina clavus*. The former is a rare species typical of coniferous forests, observed only in mixed and pine forests so far (Wojewoda 2003). The latter is known only from the Góry Świętokrzyskie Mts. and was not recorded outside the plant community discussed here. The value of *Geastrum rufescens* is possibly smaller. Although it was observed in the Góry Świętokrzyskie Mts. exclusively in the biocoenosis in question, it had been collected both in deciduous and coniferous forests in Poland. The fungus is associated with habitats that are warmer and richer in $CaCO_3$. These requirements stress typical features of the *Serratulo-Pinetum* ecosystem and differentiate it from other pine and mixed forests at the same time. The presence of *Marasmius oreades*, associated with open, thermophilous non-forest communities, often xerothermic, is also quite interesting. Other fungal species seem to be random and therefore will not be discussed here.

The biota of fungi growing on litter in the *Serratulo-Pinetum* resembles litter-inhabiting saprobionts in deciduous forests, especially *Potentillo-Quercetum*, with which it shares 23 species, that is 53.5% of this fungal group, *Tilio-Carpinetum* – 20 species, and the *Peucedano-Pinetum* coniferous forest – 18 species in common (Fig. 11). These are mostly ubiquitous species, observed not only in these communities but also in others. *Clitocybe squamulosa* as well as bryophilous *Galerina mniophila* and *Mycena capillaris* are the only exclusive species that *Serratulo-Pinetum* and *Tilio-Carpinetum* have in common. They are rare and fairly rare fungi that occur in deciduous and coniferous forests.

Given the richness of the ecological groups discussed above, lignicolous *Basidiomycetes* do not appear impressive. Only 14 species were recorded in this association. The diversified dendroflora seems to provide conditions favourable for the development of xylobionts. However, the young age of the stands and the managed type of the forest where little dead wood can be found while ill or weakened individuals are removed are likely to be responsible for this.

A great majority of lignicolous fungi are common species that grow in various forest communities. The following are exclusive species: *Galerina triscopa* and *Tricholomopsis decora,* which grow only in this community, and, furthermore, *Gymnopilus sapineus*, which was also recorded only in *Leucobryo-Pinetum* and *Pluteus pouzarianus*, observed also in *Tilio-*

Carpinetum. These xylobionts are interesting and fairly rare; however, it is difficult to give them a special diagnostic value. *Gymnopilus sapineus*, associated with coniferous wood (*Picea, Pinus*), seems to exhibit the greatest fidelity to the community, at least locally in the Góry Świętokrzyskie Mts. Its optimum growth conditions can be found in coniferous forest communities of the *Peucedano-Pinetum* type (recorded outside research plots) and the *Serratulo-Pinetum* type. It was recorded in various coniferous forest communities outside the study area (DOMAŃSKI Z. 1999, 2001), in *Abieti-Piceetum montanae* (BUJAKIEWICZ 1979), *Leucobryo-Pinetum* (HOŁOWNIA 1968), and *Vaccinio uliginosi-Pinetum* (DYLĄG & GUMIŃSKA 1997).

Pluteus pouzarianus and *Tricholomopsis decora*, rare fungi that grow on coniferous wood, mostly on *Abies* and *Pinus*, follow a similar pattern. In the Góry Świętokrzyskie Mts., they were also recorded in *Abietetum polonicum* outside the community discussed here. Additionally, *Pluteus pouzarianus* was also recorded in *Peucedano-Pinetum, Querco-Pinetum* and *Tilio-Carpinetum*. The fungus may not be differentiated from *P. atricapillus*, similar to it, and thus overlooked or mistaken. The ecological range of *Galerina triscopa* is even broader. It is associated both with deciduous and coniferous species, and was thus observed in many communities of both types.

Galerina marginata, recorded in all research plots, was the most common species of lignicolous fungi.

Vaccinio uliginosi-Pinetum

Habitat and phytosociological description. Plots of the boggy coniferous forest were established in the southern part of the Białe Ługi reserve on the side of Kamień. Phytocoenoses in this community develop between mesic fresh coniferous forests and peat-bog communities. Patches of *Vaccinio uliginosi-Pinetum* cover peat gleysols that develop on the mineral substrate formed by loose sands (ŻUREK 1999). A thick layer (up to 30 cm) of poorly decomposed sphagnum peat lies in the upper horizons of the soil profile. The groundwater stagnates at a depth of 15 cm and its levels fluctuate characteristically in spring and autumn. The peat layer is strongly permeated with water due to the high water level. The pH of water is 4.5.

The tree stand consists of *Pinus sylvestris* with single trees of *Betula pubescens* and *B. pendula* present. Crown trees form a sparse layer whose density ranges between 50 and 80%. The shrub layer is very poorly developed (5-15% cover) and comprises saplings of the above trees and shrub forms of *Quercus petraea* and *Fagus sylvatica*. The ground cover consists of two layers; it is developed well and its density ranges from 90 to 95% (Tab. 13). *Ledum palustre* and *Vaccinium uliginosum*, characteristic of the community, occur in masses in the higher layer. They are accompanied by *V. myrtillus, V. vitis-idaea* and *Calluna vulgaris*, although their intensity varies. Infrequent herbaceous plants grow in the lower layer: *Eriophorum vaginatum, Carex nigra, Molinia caerulea* and *Oxycoccus palustris*. Species belonging to the class *Oxycocco-Sphagnetea* are of particular importance as they are differential species. The moss layer is very abundant; its density ranges from 80 to 100%, although it is in places outnumbered by highly developed tufts of undershrubs. *Sphagnum fallax, S. capillifolium, Dicranum undulatum* and *Pleurozium schreberi*, for instance, dominate here.

Mycological description. Mycological studies were conducted at three plots in *Vaccinio uliginosi-Pinetum*, and 90 observations were carried out. A total of 64 species, including

Table 13
Vaccinio uliginosi-Pinetum

Successive number		1	2	3
Number of plot		13	14	15
Date		25.05.2001		
Locality		Białe Ługi reserve		
Density of tree layer	a in %	70	80	50
Density of shrub layer	b in %	<5	15	15
Cover of herb layer	c in %	95	90	95
Cover of moss layer	d in %	100	80	100
Number of plant species		22	20	15
Surface of investigated plots in m^2		400		
ChAss., DAss*. *Vaccinio uliginosi-Pinetum*				
Ledum palustre		1.2	+.2	3.3
Vaccinium uliginosum		2.2	2.2	4.4
**Eriophorum vaginatum*		1.2	+	1.2
**Aulacomnium palustre*	d	+.2	+.2	+.2
**Oxycoccus palustris*		+.2	.	+.2
ChO. *Cladonio-Vaccinietalia,* ChCl. *Vaccinio-Piceetea*				
Pinus sylvestris	a	4.4	5.4	3.4
Pinus sylvestris	b	.	.	1.1
Pinus sylvestris	c	.	+	.
Vaccinium myrtillus		5.4	4.4	1.2
Vaccinium vitis-idaea		1.2	1.2	1.2
Melampyrum pratense		+.2	+	+
Pleurozium schreberi	d	3.4	4.4	3.3
Hylocomium splendens	d	.	.	2.3
Others				
Betula pubescens	a	2.1	.	1.2
Betula pubescens	b	1.1	1.2	1.1
Quercus petraea	b	1.1	1.1	.
Quercus petraea	c	1.2	.	.
Betula pendula	b	+	1.1	.
Fagus sylvatica	b	+	+.2	.
Calluna vulgaris	c	1.2	+	1.2
Carex nigra		+.2	+	.
Festuca ovina		+.2	.	.
Molinia caerulea		.	.	1.2
Polytrichum commune	d	.	.	1.2
Sphagnum fallax	d	3.4	1.2	.
Sphagnum squarrosum	d	+.2	+.2	.
Sphagnum capillifolium	d	1.2	1.2	3.3
Leucobryum glaucum	d	1.2	1.2	.
Dicranum undulatum	d	3.3	1.2	.

Table 14
Fungi in *Vaccinio uliginosi-Pinetum*

Number of plot		13	14	15	Frequency
Locality		Białe Ługi reserve			
Density of tree layer	a in %	70	80	50	
Density of shrub layer	b in %	<5	15	15	
Cover of herb layer	c in %	95	90	95	
Cover of moss layer	d in %	100	80	100	
Surface of investigated plots in m^2			400		
Number of observations		30	30	30	
Number of plant species		22	20	15	
Number of fungi species		32	26	29	
Fungi on soil					
Paxillus involutus		3r	3r	3n	3
Russula paludosa		3n-a	4n	3n	3
Cantharellus cibarius		4n	.	3n	2
Russula badia		3r	.	3r	2
Russula emetica		3a	.	4n-a	2
Lactarius vietus		1r	.	1r	2
Laccaria amethystea		5a	5a	.	2
Rhodocollybia maculata		4a	3n-a	.	2
Russula foetens		2n	2n-a	.	2
Rozites caperatus		2n	2n	.	2
Russula decolorans		1r	1r	.	2
Lactarius helvus		.	7n	5n	2
Amanita citrina		.	4r	5r	2
Amanita vaginata		.	4r	3r	2
Amanita fulva		.	3r	2r	2
Russula xerampelina		.	2r	2r	2
Cortinarius armillatus		2r	.	.	1
Cortinarius brunneus		1r	.	.	1
Cortinarius cinnamomeus		4a	.	.	1
Cortinarius semisanguineus		5a	.	.	1
Hygrophorus hypothejus		2n	.	.	1
Inocybe lanuginosa		2r	.	.	1
Lactarius volemus		1r	.	.	1
Leccinum scabrum		3r	.	.	1
Russula claroflava		2n	.	.	1
Russula vinosa		1r	.	.	1
Thelephora terrestris		3r	.	.	1
Tricholoma gausapatum		1r	.	.	1
Xerocomus badius		1r	.	.	1
Boletus reticulatus		.	1r	.	1
Cortinarius alboviolaceus		.	3a	.	1
Cortinarius uraceus		.	1r	.	1
Lactarius vellereus		.	3r	.	1
Psilocybe aeruginosa		.	2r	.	1

Tab. 14 cont.

Russula integra	.	1r	.	1
Russula vesca	.	2r	.	1
Amanita porphyria	.	.	2r	1
Boletus pinophilus	.	.	2r	1
Cortinarius anthracinus	.	.	1n	1
Cystoderma amianthinum	.	.	1r	1
Ramaria eumorpha	.	.	3a	1
Russula risigallina	.	.	1r	1
Russula virescens	.	.	1r	1
Scleroderma citrinum	.		2n	1
Xerocomus pascuus	.	.	1n	1
Fungi on wood				
Tricholomopsis rutilans	1r	1r	1r	3
Trametes versicolor	xr	.	.	1
Armillaria ostoyae	6a	.	.	1
Psilocybe fascicularis	4a	.	.	1
Polyporus brumalis	1n	.	.	1
Pluteus atromarginatus	1n	.	.	1
Trametes hirsuta		xr	.	1
Stereum hirsutum	.	xr	.	1
Pseudohydnum gelatinosum	.	1n	.	1
Daedalea quercina	.	.	xr	1
Heterobasidion annosum	.	.	xn	1
Bjerkandera adusta	.	.	xa	1
Gymnopilus hybridus	.	.	4a	1
Panellus stypticus	.	.	3a	1
Fungi on litter				
Gymnopus dryophilus	3n	3n	2n	3
Rhodocollybia butyracea	.	.	6a	1
Marasmius bulliardii	.	.	4a	1
Fungi among mosses				
Tephrocybe palustris	3n-a	4n	.	2
Galerina paludosa	.	5n-a	.	1

44 terrestrial, 6 litter-inhabiting or bryophilous and 14 lignicolous fungi, were recorded (Tab. 14). The constant number of *Basidiomycetes* at individual plots ranged between 26 and 32 species.

The mycobiota of the boggy coniferous forest resembles that in *Leucobryo-Pinetum*, *Dentario glandulosae-Fagetum* and *Abietetum polonicum* the most, sharing 59.4%, 45.3% and 39.1% species, respectively (Fig. 8). Its low similarity to the fungi of *Peucedano-Pinetum* (only 12.5% species in common) and *Fraxino-Alnetum* (14.1%) was surprising. *Basidiomycetes* in this community differ from those in other communities studied in this project by having seven exclusive species. These are mycorrhizal fungi that will be discussed in the section devoted to terrestrial fungi.

The ratio between *Basidiomycetes* and vascular plants highlights the importance of fungi for the biocoenosis of this community: four times as many *Basidiomycetes* were recorded.

Terrestrial *Basidiomycetes* constitute 68.7% of fungi recorded in the boggy coniferous forest. Mycorrhizal fungi constitute 95.4% of them (Fig. 7a). A considerable majority of terrestrial fungi was also recorded in other coniferous forest communities. They exhibit the greatest similarity to the mesic coniferous forest, *Leucobryo-Pinetum,* with which they share 61.4% species, including 8 species growing exclusively in both communities; it shares 45.4% species with *Abietetum polonicum* (Fig. 10). Species exclusive to the boggy coniferous forest community constitute 15.9%. Of them, the *Vaccinio uliginosi-Pinetum* differentiates the best fungi associated with moist, boggy, acid soils and related to mycorrhizae formed with dominant tree species, pines and birches. Those criteria are most fully met by *Cortinarius anthracinus, C. armillatus, C. brunneus, Lactarius vietus, Russula decolorans, R. paludosa* and *R. vinosa*; however, these species can be ascribed only local importance of indicator species of the boggy coniferous forest. Considered more broadly, above the regional level, these fungi are observed in boggy and humid coniferous forests as well as in mesic coniferous forests and mixed forests belonging to the class *Vaccinio-Piceetea*, and therefore their syntaxonomic value is applicable only to higher syntaxa.

In her studies on the fungi of the boggy coniferous forest in the Góry Świętokrzyskie Mts., Lisiewska (1979) reported *Lactarius helvus, Russula claroflava, R. emetica* and *Hygrophoropsis aurantiaca* var. *pallida* as species exclusive to this community. These species, however, were also recorded in other coniferous forest communities and in the Carpathian beech forest during the present project.

Amanita citrina, Lactarius helvus, Laccaria amethystea, Paxillus involutus, Russula emetica and *R. paludosa* produced fruitbodies most abundantly and were recorded most frequently.

Litter-inhabiting and bryophilous fungi in the boggy coniferous forest are the least numerous group of all the communities and do not exceed 9.4% of the basidiomycete biota in this community (Fig. 7b). No exclusive species were recorded while litter-inhibiting saprobionts observed here grow in various forest communities. The ecological scale of these fungi is broad, and it is difficult to assess the relationships they form. Bryophilous fungi such as *Galerina paludosa* and *Tephrocybe palustris* are interesting. They belong to fungi growing in moss patches belonging to *Sphagnum* where they occur quite numerously and frequently. The presence of this bryophilous species establishes a connection with boggy biocoenoses: the *Abies alba-Sphagnum girgensohnii* and humid forms of *Leucobryo-Pinetum*.

Xylobionts in *Vaccinio uliginosi-Pinetum* constitute 21.8% of all basidiomycete species in the community (Fig. 7c). They do not have exclusive species and mostly represent the biota typical of coniferous forests. The greatest resemblance is observed in the case of xylobionts in *Leucobryo-Pinetum*, with which they share as many as 78.6% species (Fig. 12). *Gymnopilus hybridus, Heterobasidion annosum* s.l., *Pseudohydnum gelatinosum, Tricholomopsis rutilans* are typical coniferous forest species. It is interesting that a high degree of resemblance, 78.6%, is achieved between lignicolous fungi of the boggy coniferous forest and xylobionts of the Carpathian beech forest. This results from the presence of *Betula, Fagus* and *Quercus* in the dendroflora of the boggy coniferous forest. These tree species are also recorded in beech forests, and certain fungal species are associated with them regardless of habitat conditions. *Bjerkandera adusta, Panellus stypticus, Stereum hirsutum, Trametes hirsuta* and *T. versicolor* are ubiquitous xylobionts that both forest biocoenoses have in common.

Abietetum polonicum

Habitat and phytosociological description. Permanent plots in the *Abietetum polonicum* were established in the Pasmo Klonowskie Ridge in the areas recently incorporated into the Świętokrzyski National Park in sections 262 and 263 within Klonów. The community develops on leached brown soils and acid cambisols lying on quartzites and on acid gleyic cambisols. These soils were formed by silty dusts, clayey dusts and sandy clays. They are deep, contain numerous matrix elements, such as quartzite rocks, and are characterised by high moisture stability (Głazek & Wolak 1991).

Abietetum polonicum contains multiple layers which owe their characteristic physiognomy to *Abies alba* (Tab. 15). The species occurs in all the layers and is a dominant one. Single trees of *Alnus glutinosa* and *Picea abies* grow in the gaps of the fir stand. The crown density ranges from 50 to 60%. Saplings of *Abies alba, Picea abies, Quercus petraea* and *Q. robur, Carpinus betulus* as well as undershrubs *Corylus avellana, Sambucus racemosa* and *Sorbus aucuparia* develop under the crown canopy. Their density ranges from 20 to 50%. The ground cover usually creates a mosaic and covers 60 to 70% of the surface. It is formed by mesophilic plants belonging to various syntaxa. The quantity of *Athyrium filix-femina, Galeobdolon luteum, Maianthemum bifolium* and *Oxalis acetosella* is the highest. Tree-stand thinning and felling encourages an increased development of *Calamagrostis villosa* and *Rubus hirtus*. The forest floor is uneven, moist, with numerous rocky chips on the surface. Mosses form a broken layer with a relatively small density, 10 to 30%. *Polytrichastrum formosum* and *Mnium hornum* play the greatest role in their group.

A substantial amount of lying branches and individual dead, standing fir trees was observed in the plots.

Mycological description. *Basidiomycetes* in the *Abietetum polonicum* were examined at two permanent plots where 108 species, including 58 terrestrial species, 30 litter-inhabiting and bryophilous species and 20 lignicolous species, were collected over three years (Tab. 16). Between 71 and 72 species were recorded at individual plots. A total of 16 exclusive species, that is 14.8% of the entire mycobiota, were observed. Fungi of the fir forest resemble the Carpathian beech forest with which they share 53.7% species, the oak-linden-hornbeam forest– 42.59%, the suboceanic mesic coniferous forest and mixed pine forest – 36.5% each. The quantity of *Basidiomycetes* in the *Abietetum polonicum* biocoenosis outnumbers that of vascular plants in a ratio of 3.6:1.

Terrestrial species in the fir forest constitute 53.7% of the biota, being second only to those in *Tilio-Carpinetum*. Mycorrhizal fungi that constitute 81% of this ecological group dominate. Eleven exclusive species, that is 18.9%, were recorded. The habitat and flora types make the *Abietetum polonicum* similar to *Dentario glandulosae-Fagetum*, with which it shares 33 species, that is 56.9%, and *Leucobryo-Pinetum* – 29 species, that is 50% (Fig. 10). The great resemblance to the biota in other forest communities makes it is difficult to name the community's characteristic species despite a fairly numerous exclusive group. Undoubtedly, there are some species that could be treated as differential and locally characteristic. These are as follows: *Cortinarius malachius, C. saniosus, Inocybe boltonii* and *Lactarius hepaticus*. *Lactarius hepaticus*, a very rare fungus in Poland, so far known only from the Góry Świętokrzyskie Mts. (Lisiewska 1979; Wojewoda 2003), is especially noteworthy. The exclusive occurrence of the species *Abietetum polonicum* makes it particularly valuable and the fungus can be treated as characteristic above the regional level. The other fungi are rare, recorded in the community discussed here only in *Abietetum polonicum*

Table 15

Abietetum polonicum

Successive number		1	2
Number of plot		1	5
Date		18.07.2000	
Locality		Klonów	
Density of tree layer	a in %	50	60
Density of shrub layer	b in %	50	20
Cover of herb layer	c in %	70	60
Cover of moss layer	d in %	30	10
Number of plant species		30	24
Surface of investigated plots in m²		400	
Ch.et D. Ass. *Abietetum polonicum*			
Abies alba	a_1	3.3	3.2
Abies alba	a_2	1.1	1.1
Abies alba	b	1.1	2.1
Abies alba	c	+	1.1
Rubus hirtus		+.2	2.2
Dryopteris dilatata		1.2	1.2
Thuidium tamariscinum	d	.	+.2
Others			
Alnus glutinosa	a_1	1.1	2.2
Picea abies	a_2	.	1.1
Picea abies	b	1.1	1.1
Picea abies	c	+	+
Corylus avellana	b	3.2	1.2
Sorbus aucuparia	b	+	+
Carpinus betulus	b	1.1	.
Quercus robur	b	+.2	.
Quercus petraea	c	+	.
Sambucus racemosa	b	+	.
Viburnum opulus	b	.	+
Anemone nemorosa		+	+
Athyrium filix-femina		2.2	1.2
Calamagrostis villosa		+.2	3.3
Galeobdolon luteum		1.1	+.2
Luzula pilosa		+	+
Lysimachia vulgaris		+	+
Maianthenum bifolium		1.2	1.2
Oxalis acetosella		3.3	2.2
Phegopteris dryopteris		+.2	+.2
Phegopteris polypodioides		1.2	+.2
Rubus idaeus		+	+
Ajuga reptans		1.2	.
Carex remota		+.2	.

Tab. 15 cont.

Ciracea lutetiana		+.2	.
Equisetum sylvaticum		+	.
Festuca gigantea		+	.
Paris quadrifolia		1.1	.
Dryopteris filix-mas		.	1.2
Mnium hornum	d	1.2	1.2
Polytrichastrum formosum	d	2.2	1.2
Polytrichum juniperinum	d	.	+.2

Table 16
Fungi in *Abietetum polonicum*

Number of plot		1	5
Locality		Klonów	
Density of tree layer	a in %	50	60
Density of shrub layer	b in %	50	20
Cover of herb layer	c in %	70	60
Cover of moss layer	d in %	30	10
Surface of investigated plots in m^2		400	
Number of observations		27	27
Number of plant species		30	24
Number of fungi species		72	71
Fungi on soil			
Laccaria laccata		9a	8n-a
Laccaria amethystea		8n-a	9n-a
Lactarius mitissimus		9r-n	9n
Lactarius lignyotus		3r	4r
Lactarius necator		4r	4r
Gymnopus peronatus		4a	6a
Cystodermella granulosum		2r	1r
Hygrophoropsis aurantiaca		3a	2n
Russula ochroleuca		.	4r
Lactarius vellereus		3r	5r
Russula turci		2r	3r
Scleroderma verrucosum		2r	2r
Cortinarius sanguineus		8a	9a
Inocybe napipes		2r	2r
Inocybe umbrina		1r	1r
Clavulina cinerea		2r	1r
Lepista nuda		2n	2n
Lycoperdon molle		1r	1r
Lycoperdon perlatum		2n	2n
Lycoperdon umbrinum		1r	1r
Cystoderma amianthinum		2r	.
Cortinarius decipiens		3a	.

Tab. 16 cont.

Cortinarius cinnamomeus	2r	.
Hygrophorus pustulatus	1r	.
Russula alutacea	1r	.
Russula integra	4r	.
Xerocomus badius	2r	.
Lactarius thejogalus	.	3r
Russula consobrina	.	2r
Russula meirei	.	3r
Russula nigricans	.	3r
Russula fragilis	.	1r
Russula cyanoxantha	2r	.
Paxillus involutus	3n	.
Lactarius ichoratus	2r	.
Russula lutea	1r	.
Russula xerampelina	2r	.
Russula badia	3r	.
Russula risigallina	1r	.
Russula chloroides	1r	.
Russula puellaris	3r	.
Russula albonigra	1r	.
Cortinarius anomalus	2r	.
Cortinarius semisanguineus	6n	.
Cortinarius malachius	2a	.
Entoloma papillatum	1r	.
Entoloma turci	1r	.
Lactarius blennius	5r	.
Lactarius hepaticus	3r	.
Boletus reticulatus	.	1r
Cortinarius saniosus	.	1r
Inocybe boltonii	.	2r
Lactarius piperatus	.	2r
Russula adusta	.	2r
Russula fellea	.	2r
Lepiota ochraceofulva	.	1n
Clavulina coralloides	.	2r
Russula liliacea	.	1n
Fungi on wood		
Calocera viscosa	4r	4n
Megacollybia platyphylla	5n	2n
Fomitopsis pinicola	xr	.
Psilocybe capnoides	3a	.
Xeromphalia campanella	2a	.
Crepidotus variabilis	3n	.
Delicatula integrella	1a	.

Marasmiellus ramealis	2a	.
Phellinus hartigii	xn	.
Pholiota flammans	2a	.
Ramaria stricta	2n	.
Gymnopilus hybridus	.	3a
Psilocybe fascicularis	.	9a
Psilocybe lateritia	.	4n
Mycena galericulata	.	3a
Mycena stipata	.	2n
Pholiota astragalina	.	2a
Polyporus ciliatus	.	2n
Stereum gausapatum	.	xn
Tricholomopsis rutilans	.	3n
Fungi on litter and among mosses		
Clitocybe clavipes	3n	1r
Mycena epipterygia	4a	4a
Mycena galopus	5a	4a
Mycena metata	4a	3n
Mycena pura	4a	4a
Mycena sanguinolenta	6n	5n
Setulipes quercophilus	4a	3a
Strobilurus stephanocystis	4a	4a
Gymnopus confluens	2a	2n
Gymnopus dryophilus	4a	4a
Collybia tuberosa	3a	4a
Mycena vitilis	4r	4r
Strobilurus esculentus	5a	7a
Mycena stylobates	4n	.
Galerina pumila	1n	.
Roridella rorida	5a	.
Clitocybe dealbata	.	2a
Clitocybe ditopa	.	2r
Clitocybe metachroa	.	2r
Collybia cirrhata	.	3a
Collybia cookei	.	2a
Rhodocollybia prolixa var. *distorta*	.	2a
Galerina josserandii	.	1r
Marasmius saccharinus	.	3a
Mycena aetites	.	5a
Mycena filopes	.	3n
Mycena rubromarginata	.	1n
Clitocybe langei	.	2r
Mycena zephirus	.	2a
Galerina vittiformis	.	2n

and can be assigned the value of diagnostic species, however, only on the narrow, regional level.

Terrestrial fungi that grow both in *Abietetum polonicum* and *Abies alba-Sphagnum girgensohnii*, and are exclusive to both syntaxa, should be discussed separately. *Hygrophorus pustulatus, Lactarius thejogalus* and *Russula consobrina* are particularly interesting. They are associated with humid patches of *Abietetum polonicum*, where local peat formations with *Sphagnum* synusiae are observed. *Hygrophorus pustulatus* is a rare species, associated with *Abies, Picea* and *Pinus*, recorded more often in mountain fir and spruce forests than in lowlands; it demonstrates the upland and mountain type of the community. This profile of the plant community is also stressed by *Russula consobrina*, known, for instance, from the Tuchola Forests (Hołownia 1967), Kórnik (Lisiewska & Nowicka 1979) and the Karkonosze Mts. (Nespiak 1971). It is associated with mountain spruce forests (Skirgiełło 1991, 1998a), and, according to Moser (1983), it is believed to be a boreal-montane element. Associated with boggy deciduous and coniferous forests, *Lactarius thejogalus* serves to differentiate this community from floristically related ones. This is true of different types of fir communities where this tree is present.

A very high participation of taxa belonging to the genera *Russula* (19 species), *Lactarius* (9 species) and *Cortinarius* (7 species) in the terrestrial biota is also quite interesting. *Cortinarius sanguineus, Cystodermella granulosum, Gymnopus peronatus, Hygrophoropsis aurantiaca, Laccaria amethystea, L. laccata, Lactarius lignyotus, L. mitissimus* and *L. necator* are some of the most common terrestrial fungi in the *Abietetum polonicum*.

Litter-inhabiting and bryophilous fungi constitute 28.7% of *Basidiomycetes* in the patches of *Abietetum polonicum* examined in the project. The biota does not seem to be distinguished by having specific species, and a great majority of saprobionts occurs in other forest communities. It mostly resembles that in *Dentario glandulosae-Fagetum*, with which it shares 58.1% species, as well as in *Potentillo-Quercetum* and *Tilio-Carpinetum* – 48.4% (Fig. 11). Four exclusive species were recorded but they are not greatly specific to the community. Two saprobionts, *Collybia cookei* and *C. tuberosa*, decompose old and dead fruitbodies of *Psilocybe fascicularis* and *Russula* sp. Fruitbodies of *Roridella rorida*, a species of little specific value that occurs in other forest communities, grew on fallen needles. Attention should be paid to *Galerina josserandii*, a fungus that grows on mossy *Abies* bark, a very rare saprobiont known from Babia Góra Mt (Bujakiewicz 1979), where it was recorded in the *Galio-Abietetum*. Due to a greatly similar nature of both forest communities, *Galerina josserandii* can be considered to be a species characteristic of *Abietetum polonicum*, at least in local conditions.

Fungi of the genus *Mycena* (13 species) and *Clitocybe* (6 species) play a dominant and particularly important role in the species structure of saprobionts growing on litter.

Clitocybe clavipes, Mycena epipterygia, M. galopus, M. metata, M. pura, M. sanguinolenta, Strobilurus esculentus and *S. stephanocystis* are the most common litter-inhabiting species.

Lignicolous fungi constitute 17.6% of the basidiomycete biota in the examined patches of *Abietetum polonicum* (Tab. 16). While deciduous wood is available, although in smaller amounts, fungi related to coniferous wood, mostly *Abies alba* and *Picea abies,* dominate. Thus, fungi in this group are of little specific value. They show the greatest affinity with the beech forest (63.1%), the oak-hornbeam forest (57.9%) as well as the mixed pine forest and the suboceanic mesic coniferous forest (52.6% of species in common). Only three exclusive species were recorded: *Marasmiellus ramealis, Mycena stipata* and *Stereum gausapatum*. Despite their exclusive status in the research plots, they are not species characteristic of this forest biocoenosis. The first two grow commonly in various forest communities. *Stereum gausapatum* is recorded more often on *Quercus* and less frequently on other species of deciduous trees and shrubs; although it is not common, the fungus does not represent any syntaxonomic value. *Phellinus hartigii* is an *Abies* parasite and is therefore very closely connected with this tree. However, firs are quite expansive in the Góry Świętokrzyskie Mts. and occur in various forest communities, for instance in *Querco-Pinetum* and *Tilio-Carpinetum*, where the parasite is found together with its host. A parallel pattern of occurrence is observed in the case of *Ganoderma carnosum*, which was recorded in similar forest communities. Another saprobe, *Pholiota astragalina*, which grows on dead *Abies* wood, is also interesting. Its syntaxonomic value, however, is challenged by the fact that, although it was observed on *Abies* more often, it was also recorded on *Pinus* in the beech forest and in the fresh coniferous forest.

Abies alba-Sphagnum girgensohnii community

Habitat and phytosociological description. A research plot in the *Abies alba-Sphagnum girgensohnii* community was established in the Pasmo Klonowskie Ridge, in section 263 within the Klonów area. The syntaxonomic position of this community is not clearly defined, and its physiognomy differs from other forest types. It develops on gleyic peat soils where the groundwater level is very high or complete flooding occurs periodically. The soils were formed from sands and clayey sands on lying slates and greywackes characterised by low permeability. Upper soil horizons are acidic and their pH is 3.9-4.4.

Abies alba and *Picea abies*, up to 30 m high and with a density of 70%, dominate the stand (Tab. 17). *Fagus sylvatica* and *Betula pendula*, whose density is only 10%, occur sporadically as an admixture in the gaps where the tree stand is thin. The ground cover is floristically very poor, relatively weakly developed, and covers the area up to 50%. Only the quantity of *Calamagrostis villosa, Maianthemum bifolium* and *Vaccinium myrtillus* is higher. Other species occur infrequently. The moss layer is very well developed and covers the surface in 80%. The forest floor is uneven with numerous bumps. Dense patches of peat mosses develop in depressions where *Sphagnum girgensohnii* dominates. Other mosses, *Dicranum scoparium, Plagiomnium cuspidatum, Polytrichastrum formosum*, are only admixtures. A dynamic rejuvenation process of the spruce is observed. Large amounts of broken branches and lying logs are observed on the soil surface.

Mycological description. *Basidiomycetes* in the *Abies alba-Sphagnum girgensohnii* community were examined at one research plot. A total of 27 mycological observations were conducted over three years and 75 species were collected (Tab. 18). Terrestrial fungi dominated (43 species), followed by lignicolous fungi (12 species), fungi growing on litter (12 species) and bryophilous fungi (8 species). *Basidiomycetes* in this community constitute a mixed group and both fungi typical of coniferous forest communities and mesophilic deciduous forests occur. Their composition is similar to that in *Leucobryo-Pinetum*, with which they share 48% species, *Dentario glandulosae-Fagetum* – 45.3% and *Abietetum polonicum* – 44% (Fig. 8). The biocoenosis is differentiated by having 12 exclusive species, that is 15.6% of the total biota. Some of them appear to be good characteristic species of this fir community whose phytosociological profile is insufficiently defined and must be further documented. The role of fungi in comparison with that of the vascular flora is

Table 17
Community *Abies alba-Sphagnum girgensohnii*

Number of plot		2
Date		18.07.2000
Locality		Klonów
Density of tree layer	a in %	70
Density of shrub layer	b in %	10
Cover of herb layer	c in %	50
Cover of moss layer	d in %	80
Number of plant species		22
Surface of investigated plot in m²		400
Ch., *D. *Vaccinio-Piceion, Vaccinio-Abietion*		
**Abies alba*	a_1	3.3
**Abies alba*	a_2	2.2
**Abies alba*	b	1.1
**Abies alba*	c	+
**Fagus sylvatica*	c	1.1
Sphagnum girgensohnii	d	5.4
Ch. *Vaccinio-Piceetalia*		
Picea abies	a_1	1.2
Picea abies	a_2	1.2
Picea abies	b	1.1
Picea abies	c	2.2
Bazzania trilobata	d	1.2
Ch. *Vaccinio-Piceetea*		
Vaccinium myrtillus		2.2
Pleurozium schreberi	d	1.2
Dicranum scoparium	d	+.2
Hylocomium splendens	d	1.2
Others		
Betula pendula	b	+
Quercus robur	c	+
Sorbus aucuparia	c	+
Maianthenum bifolium		2.2
Calamagrostis villosa		1.2
Carex stellulata		+
Dryopteris dilatata		+
Luzula pilosa		+
Oxalis acetosella		+
Tetraphis pellucida	d	+
Lepidozia reptans	d	1.2
Plagiomnium cuspidatum	d	1.2
Polytrichastrum formosum	d	1.2

Table 18

Fungi in community *Abies alba-Sphagnum girgensohnii*

Locality		Klonów
Density of tree layer	a in %	70
Density of shrub layer	b in %	10
Cover of herb layer	c in %	50
Cover of moss layer	d in %	80
Surface of investigated plot in m^2		400
Number of observations		27
Number of plant species		22
Number of fungi species		75
Fungi on soil		
Amanita citrina		3r
Amanita fulva		2r
Amanita rubescens		3n
Amanita virosa		1r
Boletus edulis		1r
Cantharellus cibarius		2n
Cantharellus cinereus		2n-a
Cantharellus tubaeformis		4a
Cortinarius cinnamomeus		1n
Cortinarius decipiens		4a
Cortinarius hemitrichus		4a
Cystoderma amianthinum		1r
Cystodermella granulosum		1r
Gymnopus peronatus		6a
Hygrophoropsis aurantiaca		2n
Hygrophorus olivaceoalbus		1r
Hygrophorus pustulatus		1r
Laccaria amethystea		8n-a
Laccaria laccata		9n-a
Lactarius badiosanguineus		1r
Lactarius camphoratus		2n
Lactarius helvus		3n
Lactarius lignyotus		4r
Lactarius mitissimus		9r-n
Lactarius necator		3n
Lactarius rufus		2r
Lactarius thejogalus		3r
Lactarius volemus		2r
Leccinum scabrum		4n
Leccinum variicolor		2r
Russula alutacea		2r
Russula amethystina		1r
Russula consobrina		3r
Russula emetica		2r
Russula fragilis		1r

Tab. 18 cont.

Russula integra	3r
Russula meirei	3r
Russula nigricans	3r
Russula ochroleuca	2r
Russula vinosa	1r
Thelephora caryophyllea	3a
Tylopilus felleus	3r
Xerocomus badius	2r
Fungi on wood	
Fomitopsis pinicola	xn
Gloeophyllum sepiarium	xn
Stereum sanguinolentum	xn
Bjerkandera adusta	xa
Trichaptum fuscoviolaceum	xa
Pholiota mutabilis	5a
Calocera viscosa	4n
Armillaria ostoyae	4a
Setulipes quercophilus	4a
Psilocybe capnoides	3a
Oligoporus caesius	2r
Xeromphalia campanella	2a
Fungi on litter	
Setulipes androsaceus	10a
Marasmius scorodonius	8a
Mycena galopus	5a
Mycena metata	4r
Mycena stylobates	4n
Strobilurus stephanocystis	4a
Mycena pura	4a
Mycena epipterygia	4a
Rhodocollybia butyracea var. *butyracea*	3r-n
Mycena sanguinolenta	3n
Gymnopus confluens	2n
Clitocybe clavipes	2n
Fungi among mosses	
Galerina atkinsoniana	2n
Galerina clavata	2n
Galerina fennica	1n
Galerina hypnorum	4n
Galerina paludosa	4n-a
Psilocybe elongata	4a
Psilocybe uda	4a
Rickenella fibula	3n

significant, the ratio between the two being 5.8:1. It is the highest coefficient between fungi and vascular plants in all the biocoenoses studied in this project.

Terrestrial fungi make up 57.3% of the biota of *Basidiomycetes*, 90.9% of which is constituted by mycorrhizal fungi (Fig. 7a). Only four exclusive species were recorded: *Cortinarius hemitrichus*, *Hygrophorus olivaceoalbus*, *Lactarius badiosanguineus* and *Leccinum variicolor*. The first is quite rare; it is associated with birches and grows on moist soils in various boggy and carr communities (Flisińska 1995; Bujakiewicz 1997a, b). The other are either rare or very rare in Poland, and can be treated as differential species. As a spruce mycobiont, *Hygrophorus olivaceoalbus* is associated with mountain spruce forests and boreal forests where this tree is present (Bujakiewicz 1979, 1997b; Lisiewska 1991(1992), 1992a; Wojewoda 2000a). *Lactarius badiosanguineus* is also associated with *Picea* and had been recorded only in the subboreal Augustów Forest (Anonymous 1968). *Leccinum variicolor* is a *Betula* mycosymbiont and was reported by Flisińska (1988, 2000a, b) and Sałata (1991) from the Jezioro Czarne Sosnowickie reserve, Bachus reserve and the vicinity of Chełm. In the Góry Świętokrzyskie Mts., these species were recorded only in humid and peated patches of fir forests with spruces and birches also present. Given a narrow group of symbionts and the habitat type of the phytocoenosis, these mycorrhizal fungi appear to be differential species of the *Abies alba-Sphagnum girgensohnii* community.

A particularly numerous occurrence of *Lactarius* (9 species) and *Russula* (10 species) was observed. The following terrestrial fungi were recorded in greatest numbers and most frequently: *Cantharellus tubaeformis v. lutescens, Cortinarius decipiens, C. hemitrichius, Gymnopus peronatus, Laccaria amethystea, L. laccata, Lactarius lignyotus, L. mitissimus* and *Leccinum scabrum*.

Litter-inhabiting and bryophilous fungi comprise 20 species, that is 25.3% of the total number (Fig. 7b). Saprobionts on litter (12 species) do not have exclusive species and can be found in various forest communities. The greatest number of species in common was observed between the community discussed here and deciduous forests: *Potentillo-Quercetum* (11 species), *Dentario glandulosae-Fagetum* and *Abietetum polonicum* (10 species). These fungi are common, their ecological scales are broad, and they are not specific to any of these forest communities.

Bryophilous fungi (8 species), however, which are associated with mosses, mostly of the genus *Sphagnum*, should be mentioned. They may be of significant diagnostic value due to high specialisation and a narrow ecological scale. Species of the genera *Galerina* and *Psilocybe* dominate: *Galerina atkinsoniana, G. clavata, G. fennica, G. hypnorum, G. paludosa, Psilocybe elongata* and *P. uda*. However, *Galerina atkinsoniana, G. clavata* and *G. fennica* can be considered to be differential species. They were recorded only in this community type in the study area. Generally speaking, they are bryophiles that grow in humid, fertile carrs, alder swamp forests and damp oak-hornbeam forests, boggy forests, on raised bogs, even in non-forest communities, always, however, among mosses, mostly *Sphagnum* (Wojewoda 1974; Flisińska 1988; Bujakiewicz 1992; Friedrich 1994; Wojewoda *et al.* 1999). Therefore, due to their possible occurrence in different plant communities, the diagnostic value of these fungi must be limited to the level of syntaxa differentiating *Abies alba-Sphagnum girgensohnii*.

Fruitbodies were produced by *Marasmius scorodonius, Mycena galopus*, and *Setulipes androsaceus* most frequently and most abundantly.

Xylobionts constitute the smallest ecological group in this community and their specificity is low (Fig. 7c). They are common, usually associated with wood of *Abies* and *Picea*;

however, species growing on deciduous wood also occur, resulting in a mixed type of lignicolous fungi. They exhibit the greatest similarity to fungi in the mesic coniferous forest with which they share 69.3% species, beech forests – 61.5% and oak-hornbeam forests – 53.8%.

Setulipes quercophilus is one of the most interesting fungi in this group. It is fairly rare in Poland and develops on fallen twigs and leaves lying in the litter in various forest communities. Outside the community discussed here, it was collected in *Abietetum polonicum, Dentario glandulosae-Fagetum*, and *Potentillo-Quercetum* in the Góry Świętokrzyskie Mts.

Fungi growing throughout the whole year dominate, for instance *Bjerkandera adusta, Fomitopsis pinicola, Gloeophyllum sepiarium, Stereum sanguinolentum* and *Trichaptum fuscoviolaceum*.

Potentillo albae-Quercetum

Habitat and phytosociological description. Study patches of *Potentillo-Quercetum* were established in the Grzywy Korzeckowskie Crest in the Chęciny Region, in section 189 of the Podzamcze forest district. Phytocoenoses of the thermophilous oak forest develop on southern hill slopes on rendzic leptosols formed from Jurassic limestones; their flatrocks occur on the surfaces. The soil pH ranged from 4.4 to 6.4 in the upper horizons. Pine trees which increase acidity cause soil acidification in the area.

The stand in *Potentillo-Quercetum* is mostly formed by 90 to 110-year-old *Quercus petraea* trees, developed from sprouts, reaching 15 m, with single *Pinus sylvestris* trees present. The crown density is small and fluctuates between 50 and 70%, admitting light onto the lower layers of plants (Tab. 19). The floristic diversity of the shrub layer is very high but the layer is not dense, ranging from 5 to 30%. *Crataegus monogyna, Cornus sanguinea, Frangula alnus* and *Juniperus communis* are dominant species. The development of the shrub layer is controlled by periodic cutting. The ground cover develops abundantly; it is floristically rich and covers the research plots from 90 to 95%. Unique light and soil conditions in this community influence the development of thermophilous, heliophilous and calcicolous species which constitute the core of the flora in the community. The following species characteristic of *Potentillo-Quercetum* should be mentioned: *Potentilla alba, Ranunculus polyanthemos* and *Vicia cassubica*. Thermophilous species of the class *Trifolio-Geranietea* and xerothermic species of the class *Festuco-Brometea* play an important role in the syntaxonomic description of the community. Dominant species in the ground cover, *Anthericum ramosum, Clinopodium vulgare, Euphorbia cyparissias, Galium mollugo, Poa compressa* and *Trifolium alpestre*, represent these syntaxa. They are accompanied by *Carex montana, Festuca ovina, Fragaria vesca, Melampyrum nemorosum, M. pratense* and *Viola collina*, which occur with a significant intensity. Due to the abundance of the ground cover, substrate dryness and its high temperature, the moss layer develops poorly or does not develop at all. Single oak and pine logs as well as single thicker branches at various stages of decomposition lie on the forest floor.

Abies alba and *Picea abies* are noticeable in the floristic composition in the shrub layer. They are genetically alien elements that were introduced artificially as plantings, causing a degeneration of phytocoenoses in the thermophilous oak forest. From the mycological point of view, these species are important elements of this biocoenosis as they introduce dependant fungi that accompany them.

Mycological description. The biota of *Basidiomycetes* in *Potentillo-Quercetum* was examined at five permanent plots. A total of 150 mycological observations were conducted over three years and 179 species, including 74 terrestrial species, 45 species on litter and 60 lignicolous species, were collected (Tab. 20). The number of fungal species at individual plots ranged between 73 and 93. The character of fungi in *Potentillo-Quercetum* is greatly individualised, and 55 exclusive species, that is 30.7% of the total number of fungi, were collected. A greater quantity of exclusive species was collected only in *Tilio-Carpinetum*. The similarity of *Basidiomycetes* in the discussed community to those in deciduous forest communities with which it shares the greatest number of species defines the mycobiota type in this community. Its fungi exhibit the greatest similarity to those in oak-hornbeam forests – 40.4% and fertile beech forests – 33.7% (Fig. 8). *Pinus sylvestris* present in the stand brings fungi typical of coniferous forests, causing the association's significant resemblance to *Querco-Pinetum* – 29.2% species in common. The role of *Basidiomycetes* in the *Potentillo-Quercetum* is significant as the number of fungi exceeds that of vascular plants in a ratio of 1.4:1.

Terrestrial fungi dominate and constitute 41.3% of the association's mycobiota (Fig. 7a). Mycorrhizal fungi prevail in this ecological group, constituting 76.1% of it. The species composition of the dendroflora, calcareous substrate and southern exposition significantly influence the biota in the community. Exclusive species, and in particular thermophilous and calcicolous mycobionts of oak, beech and dogwood, are of the greatest diagnostic value. Of 23 exclusive species, such features characterise the following fungi: *Boletus queletii, Entoloma incarnatofuscescens, E. nefrens, Inocybe calida, Lactarius chrysorrheus, Russula aurea* and *Xerula pudens*. They can be treated as locally characteristic species in *Potentillo-Quercetum*. *Boletus queletii, Lactarius chrysorrheus* and *Xerula pudens* are also reported by other authors (Dörfelt & Knapp 1974; Krieglsteiner 1999) as differential species or even as characteristic species. Thermophilous, mycorrhizal and non-mycorrhizal pedobionts, associated with soils rich in $CaCO_3$ but characterised by somewhat broader ecological ranges should also be mentioned. They were observed in thermophilous grasslands outside the Góry Świętokrzyskie Mts. *Bovista dermoxantha, Clavaria fumosa, Entoloma rusticoides, Geastrum minimum, Lycoperdon mammiforme* can be treated as differential in *Potentillo-Quercetum* in relation to similar biocoenoses, especially to warm forms of beech forests and oak-hornbeam forests.

Oak is a dominant species in this community. A few mycobionts are associated with it; *Hygrophorus eburneus*, *Lactarius quietus* and *L. uvidus*, recorded in the five research plots, as well as *Boletus reticulatus* and *Lactarius chrysorrheus*, observed at four plots, were characterised by the greatest frequency. The occurrence of pine trees also results in the presence of its symbionts. The most interesting species include *Tricholoma atrosquamosum*, a very rare thermophilous species, known only from the Tatra Mts. outside the Góry Świętokrzyskie Mts. (Anonymus 1968), *Russula sardonia*, slightly more frequent than the latter, occurring in coniferous forests and oak-hornbeam forests with pine trees also present. *Russula livescens*, another very rare fungus, known from *Tilio-Carpinetum* and *Querco-Pinetum* in the Jodły Łaskie reserve (Kałucka 1995), from Warsaw (Skirgiełło 1991) and from Kwidzyn (Neuhoff 1925), are associated with both tree species.

Fungi on litter constitute 25.2% of the biota in the thermophilous oak forest (Fig. 7b). Their species composition shows the greatest affinity with *Tilio-Carpinetum*, with which they share 52% species, and *Dentario glandulosae-Fagetum* – 50% species in common. Attention should also be paid to a great similarity between the community considered here

Table 19
Potentillo albae-Quercetum

Number of plots		1	2	3	4	5
Date				08.1996		
Locality				Grzywy Korzeckowskie Hills		
Density of tree layer	a in %	50	70	60	60	60
Density of shrub layer	b in %	5	5	20	20	30
Cover of herb layer	c in %	95	95	90	90	90
Cover of moss layer	d in %	+	+	+	-	+
Number of plant species		80	89	96	86	80
Exposure		S	S	S	S	S
Inclination in degrees		15	15	15	15	15
Surface of investigated plots in m^2				400		
Ch. *Potentillo albae-Quercetum petraeae*						
Potentilla alba		.	.	+	.	.
Ranunculus polyanthemos		.	+	+	+	+
Vicia cassubica		2.2	3.3	1.2	2.3	1.2
Ch. *Quercetalia pubescentis*						
Melittis melissophyllum		1.1	1.1	1.1	1.1	1.1
Lathyrus niger		1.2	1.2	1.2	1.2	+.2
Digitalis grandiflora		.	+	+	1.1	1.1
Campanula persicifolia		1.1	+	+	+	1.1
Hypericum montanum		+	+	+	+	.
Cephalanthera alba		.	.	.	+	.
Primula veris		.	.	.	.	+
Ch. *Querco-Fagetea*						
Euonynus verrucosa	b	.	.	.	.	+
Euonynus verrucosa	c	+	+	+	+	1.1
Corylus avellana	c	.	+	.	.	.
Lonicera xylosteum	b	.	.	+	.	.
Melica nutans		2.2	2.2	2.2	2.2	2.3
Hepatica nobilis		2.2	1.2	1.2	1.2	1.2
Carex digitata		1.2	1.2	1.2	+.2	1.2
Sanicula europaea		+.2	1.1	+	1.1	1.1
Lathyrus vernus		.	+	+	1.2	+
Anemone nemorosa		.	.	+.2	+	.
Brachypodium sylvestris		.	.	+.2	.	.
Poa nemoralis		.	.	+.2	.	.
Epipactis helleborine		.	+	.	.	.
Astrantia maior		.	.	.	+	.

Tab. 19 cont.

Ch. *Trifolio-Geranietea*					
Clinopodium vulgare	2.2	2.2	2.2	2.2	2.2
Anthericum ramosum	2.2	1.2	2.2	1.2	2.2
Galium mollugo	2.2	1.2	1.2	2.2	1.2
Trifolium alpestre	1.2	1.2	1.2	1.2	1.2
Silene nutans	1.1	1.1	+	1.1	1.1
Origanum vulgare	+	1.2	2.2	1.2	2.2
Trifolium rubens	+	+.2	+.2	1.2	+.2
Polygonatum odoratum	1.1	+	+	1.1	+
Coronilla varia	.	+	+.2	.	+
Agrimonia eupatoria	+	+	+	.	+
Peucedanum cervaria	.	+.2	1.2	+	.
Agrimonia procera	+	.	.	.	.
Ch. *Festuco-Brometea*					
Euphorbia cyparissias	1.2	1.2	2.2	1.2	1.2
Vincetoxicum hirundinaria	1.2	1.2	+.2	1.2	1.2
Poa compressa	1.2	1.2	1.2	1.2	1.2
Veronica spicata	+	+	+.2	+.2	+.2
Allium montanum	+.2	.	+.2	+.2	+.2
Seseli annuum	.	+	+	+	+
Pimpinella saxifraga	+	+	+	+	.
Achillea collina	+	.	+	.	+
Brachypodium pinnatum	.	.	+	+	.
Stachys recta	.	+	+	.	.
Avenula pratensis	.	.	.	+	.
Plantago media	.	.	+	.	.
Campanula glomerata	.	+	.	.	.
Ch. *Molinio-Arrhenatheretea*					
Festuca rubra	1.2	1.2	1.2	2.3	2.3
Taraxacum officinale	+	1.1	1.1	1.1	1.1
Achillea milefolium	+	1.1	+	+	+
Galium boreale	2.2	+.2	.	+.2	+.2
Deschampsia caespitosa	+	.	+	+	.
Plantago lanceolata	.	.	+	.	.
Cerastium fontanum ssp. *triviale*	.	+	.	.	+
Avenula pubescens	.	.	.	.	+
Trifolium montanum	+	.	.	.	.
Ch. *Festuco-Koelerietea*					
Festuca ovina	2.2	2.2	2.2	2.2	2.2
Sedum maximum	+	+	+	+	+
Rumex acetosella	.	+	.	.	.

Tab. 19 cont.

Others						
Quercus petraea	a	3.3	4.4	3.3	3.3	3.3
Quercus petraea	b	.	.	+.2	+.2	1.1
Quercus petraea	c	1.1	+	1.1	1.1	1.1
Pinus sylvestris	a	.	1.1	2.2	1.2	2.2
Pinus sylvestris	c	.	+	+	+	.
Crataegus monogyna	b	1.2	1.2	1.2	1.2	1.2
Crataegus monogyna	c	+	+	+	+	1.2
Juniperus communis	b	+.2	+.2	+.2	1.2	+.2
Juniperus communis	c	+.2	1.2	+.2	+.2	1.1
Frangula alnus	b	+	+	1.1	1.1	1.1
Frangula alnus	c	+	+	+	+	+
Cornus sanguinea	b	+	+	1.2	1.2	1.2
Cornus sanguinea	c	+	1.2	1.2	+	+
Pyrus communis	b	+	.	+	+	1.2
Pyrus communis	c	1.1	+	+	+	+
Rosa canina	b	+	.	+	+	.
Rosa canina	c	+	.	+	+	+
Rubus spp.	c	+	+	+	+	1.2
Prunus spinosa	b	.	.	.	.	1.2
Prunus spinosa	c	1.2	+	1.2	+	1.1
Prunus cerasus	b	.	.	1.1	+	1.1
Prunus cerasus	c	.	+	+	+	+
Rhamnus catharticus	b	+	.	+	1.1	.
Rhamnus catharticus	c	+	.	.	+	.
Sorbus aucuparia	b	+	.	+	+	+
Sorbus aucuparia	c	.	+	.	.	.
Quercus rubra	b	.	.	.	+	.
Quercus rubra	c	.	.	+	+	.
Abies alba	b	.	.	.	+	.
Abies alba	c	.	.	+	.	.
Berberis vulgaris	b	+	.	.	.	.
Rosa sp.	c	.	.	.	+	+
Picea abies	c	.	.	+	.	.
Fragaria vesca		3.3	3.3	2.2	2.2	3.3
Viola collina		2.2	2.2	1.2	1.2	1.2
Agrostis capillaris		1.2	1.2	1.2	1.2	1.2
Solidago virgaurea		+	+	+	1.1	1.1
Veronica officinalis		1.2	+.2	+.2	+.2	+.2
Cruciata glabra		2.2	1.2	1.2	1.2	1.2
Melampyrum pratense		1.1	1.1	1.2	2.2	1.1
Melampyrum nemorosum		3.2	2.2	1.2	2.2	2.3
Peucedanum oreoselinum		1.1	1.1	1.1	1.1	3.2

Tab. 19 cont.

Hieracium murorum		1.1	1.1	+	1.1	1.1
Viola riviniana		+	1.2	1.2	1.2	+
Ajuga reptans		1.2	1.2	+.2	+.2	+.2
Hypericum perforatum		+	+	2.1	1.1	+
Galium verum		+	+	+	+	+
Viscaria vulgaris		+	+	+	+	.
Veronica chamaedrys		+	+	+	+	.
Poa angustifolia		+.2	.	+.2	+.2	+.2
Carex montana		2.2	+.2	.	+.2	1.2
Calamagrostis epigejos		1.2	+	+	.	1.2
Thuidium recognitum var. *delicatulum*	d	+.2	+.2	+.2	.	+.2
Anthoxanthum odoratum		+	.	+	+	1.2
Moehringia trinervia		.	+	+	+	.
Platanthera bifolia		1.1	+	+	.	.
Chamaecytisus ruthenicus		+	.	+	.	+
Chamaecytisus ratisbonesis		.	+	+	.	+
Prunella vulgaris		.	.	+	+	+
Danthonia decumbens		.	.	+	.	+
Carex pilulifera		+	+	.	.	+
Silene vulgaris		+	+	.	+	.
Geum urbanum		.	.	+	+	.
Plantago maior		.	.	+	+	.
Luzula multiflora		+	.	.	.	+
Plagiomnium affine	d	.	.	+	.	+
Potentilla rupestris		.	.	+	.	+
Senecio jacobea		.	+	.	+	.
Carex pallescens		.	+	.	+	.
Luzula pilosa		.	.	.	+	.
Pleurozium schreberi	d	.	+	.	.	+
Thalictrum minus		+	.	.	+	.
Conyza canadensis		.	.	+	.	.
Hieracium vulgatum		+	.	.	.	.
Polytrichastrum formosum	d	+	.	.	.	.
Dianthus deltoides		.	.	+	.	.
Maianthemum bifolium		.	.	.	.	+
Viola rupestris		.	.	.	+	.
Mnium stellare	d	.	.	.	.	+
Senecio sylvaticus		.	.	+	.	.
Vaccinium myrtillus		.	.	+	.	.
Galeopsis bifida		.	+	.	.	.
Torylis japonica		+	.	.	.	.
Pohlia nutans	d	+	.	.	.	.
Brachytheciastrum velutinum	d	+	.	.	.	.
Leucobryum glaucum	d	+	.	.	.	.

Table 20
Fungi in *Potentillo albae-Quercetum*

Number of plot		1	2	3	4	5	Frequency
Locality		Grzywy Korzeckowskie Hills					
Density of tree layer	a in %	50	70	60	60	60	
Density of shrub layer	b in %	5	5	20	20	30	
Cover of herb layer	c in %	95	95	90	90	90	
Cover of moss layer	d in %	+	+	+	-	+	
Exposure		S	S	S	S	S	
Inclination in degrees		15	15	15	15	15	
Surface of investigated plots in m^2				400			
Number of observations		30	30	30	30	30	
Number of plant species		80	81	97	86	85	
Number of fungi species		92	82	70	73	73	
Fungi on soil							
Lactarius quietus		12r-n	10r-n	9r-a	10n	10r-n	5
Lactarius uvidus		4r-n	2r	2n	4n	2r	5
Hygrophorus eburneus		6a	6a	6a	6a	6a	5
Hygrocybe conica		3r-n	2n	2n	3n	2	5
Ramaria eumorpha		3r-n	1r	3n	1n	2n	5
Lactarius chrysorrheus		4r	3r	1r	.	1r	4
Xerocomus subtomentosus		1r	1r	1r	.	1r	4
Laccaria laccata		1r	2r	2r	.	1r	4
Entoloma nefrens		4r	.	2r	1r	1r	4
Clavulina cinerea		3r	2n	2n	.	2r	4
Clavulina coralloides		2r	.	3r	2r	2r	4
Lycoperdon lividum		3n	2n	.	3n	3r-n	4
Boletus reticulatus		1r	.	3r	1r	1r	4
Amanita phalloides		1r	1r	3r	.	.	3
Tubaria pellucida		.	5r	.	5r	5r	3
Amanita rubescens		.	2r	.	2r-n	3r	3
Tricholoma sulphureum		1r	3r	.	1r	.	3
Russula cyanoxantha		1r	.	1r	1r	.	3
Boletus edulis		1r	.	1r	.	.	2
Russula delica		1r	.	1r	.	.	2
Entoloma rhodopolium f. *nidorosum*		1r	.	.	2r-n	.	2
Agaricus silvaticus		2r	.	2r	.	.	2
Psilocybe aeruginosa		2r	.	2r	.	.	2
Lycoperdon mammiforme		3r	3r	.	.	.	2
Lepiota ochraceofulva		1r	1r	.	.	.	2
Lycoperdon perlatum		1r	1r	.	.	.	2
Inocybe calida		.	1r	.	1r	.	2
Geastrum quadrifidum		.	3r	.	.	3r	2
Hebeloma hiemale		.	2r	.	.	2r	2
Xerocomus badius		.	1r	.	.	1r	2
Tricholoma atrosquamosum		.	.	1n	.	1r	2

Tab. 20 cont.

Clavaria fumosa	.	.	2n-a	.	2r-a	2
Entoloma incarnatofuscescens	.	.	1r	.	1r	2
Inocybe pseudodestricta	2r	.	.	.	2r	2
Inocybe petiginosa	3r	.	.	.	.	1
Inocybe flocculosa	2r	.	.	.	.	1
Boletus queletii	1r	.	.	.	.	1
Inocybe sindonia	1r	.	.	.	.	1
Lactarius zonarius	1r	.	.	.	.	1
Russula livescens	1r	.	.	.	.	1
Galerina unicolor	2r	.	.	.	.	1
Tricholoma albobrunneum	1r	.	.	.	.	1
Entoloma rusticoides	3r	3r	.	.	.	2
Amanita citrina	.	5r	.	.	.	1
Russula xerampelina	.	3r	.	.	.	1
Tylopilus felleus	.	2r	.	.	.	1
Inocybe auricoma	.	1r	.	.	.	1
Laccaria amethystea	.	1r	.	.	.	1
Russula sardonia	.	1r	.	.	.	1
Russula versicolor	.	1r	.	.	.	1
Agaricus silvicola		3r	.	.	.	1
Tricholoma lascivum	.	1r	.	.	.	1
Entoloma percandidum	.	1n	.	.	.	1
Craterellus cornucopioides	.	1n	1n	.	.	2
Russula risigallina	.	1r	1r	.	.	2
Clavulina amethystina	.	.	1a	.	.	1
Pseudocraterellus undulatus	.	.	1a	.	.	1
Russula nigricans	.	.	2n	1n	.	2
Russula alutacea	.	.	1r	1r	.	2
Russula foetens	.	.	1n	1r	.	2
Cantharellus cibarius	.	.	.	1r	.	1
Cortinarius sp.	.	.	.	1r	.	1
Xerocomus rubellus	.	.	.	1r	.	1
Entoloma asprellum	.	.	.	1n	1n	2
Russula vesca	.	.	.	.	3r	1
Amanita fulva	.	.	.	.	2r	1
Chroogomphus rutilus	.	.	.	.	2r	1
Russula aurea	.	.	.	.	2r	1
Amanita excelsa	.	.	.	.	1r	1
Entoloma turci	.	.	.	.	1r	1
Camarophyllus pratensis	.	.	.	.	2r	1
Bovista dermoxantha	.	.	.	.	4r	1
Geastrum minimum	.	.	.	1r	.	1
Fungi on wood						
Psathyrella pygmaea	6n	6n	4n	3n	4n	5
Vuilleminia comedens	xn	xn	xn	xn	xn	5

Tab. 20 cont.

Fistulina hepatica	4n	4r	5r	4r	4r	5
Mycena polygramma	2n	2n	2n	2n	2n	5
Mycena inclinata	1n	2n-a	1n	3n	2n-a	5
Crepidotus lundellii	4a	1n	4a	4a	.	4
Pluteus cinereofuscus	3n	4n	.	2n	2n	4
Radulomyces molaris	xr	xr	.	xr	xr	4
Stereum rugosum	xr	xr	.	xr	xr	4
Peniophora quercina	xn	xn	.	xn	xn	4
Stereum hirsutum	xn	.	xn	xn	xn	4
Dacryomyces minor	xa	.	xa	xa	xa	4
Phellinus robustus	xr	.	xn	xr	xr	4
Rickenella fibula	2r	.	2r	.	2r	3
Sphaerobolus stellatus	2a	.	1a	.	1n	3
Exidia glandulosa	.	xa	xa	xa	xa	4
Dacryomyces stillatus	.	xa	xa	xa	.	3
Pluteus atricapillus	.	1r	1r	.	.	2
Pluteus depauperatus	2r	.	.	2r	.	2
Xerula radicata	.	1r	.	1r	.	2
Pluteus exiguus	1r	.	1r	.	.	2
Hymenochaete rubiginosa	xn	.	xa	.	.	2
Botryobasidium laeve	xn	.	xn	.	.	2
Peniophora nuda	xn	.	.	.	.	1
Phaeomarasmius erinaceus	2r	.	.	.	.	1
Tulasnella thelephorea	1r	.	.	.	.	1
Tulasnella pallida	1n	.	.	.	.	1
Phanerochaete sordida	xn	.	.	.	.	1
Pluteus atromarginatus	3r	.	.	.	.	1
Tricholomopsis rutilans	1r	.	.	.	.	1
Polyporus arcularius	1r	.	.	.	.	1
Hapalopilus nidulans	5n	4n	.	.	.	2
Panellus stypticus	2n	1n	.	.	.	2
Pluteus podospileus	1r	2r	.	.	.	2
Phanerochaete tuberculata	xn	xn	.	.	.	2
Dichomitus campestris	.	xr	.	.	.	1
Hyphoderma puberum	.	xr	.	.	.	1
Hyphodontia subalutacea	.	xr	.	.	.	1
Gloeoporus taxicola	.	12r	.	.	.	1
Crucibulum laeve	.	4n	.	.	4n	2
Lycoperdon pyriforme	.	.	6n-a	.	6n-a	2
Galerina marginata	.	.	1r	.	.	1
Bjerkandera adusta	.	.	xa	.	.	1
Psilocybe lateritia	.	.	xn	.	.	1
Gymnopus fusipes	.	.	6a	6a	.	2
Crepidotus variabilis	.	.	2r	2r	.	2
Psilocybe fascicularis	.	.	2r-a	2r-a	.	2
Radulomyces confluens	.	.	.	xr	.	1

Daedalea quercina	.	.	.	xr	.	1
Hyphoderma setigerum	.	.	.	3r	.	1
Phellinus contiguus	.	.	.	xn	.	1
Pluteus salicinus	.	.	.	1r	.	1
Sistotrema brinkmannii	.	.	.	xr	.	1
Trametes hirsuta	.	.	.	xn	.	1
Trechispora farinacea	.	.	.	4r	.	1
Mycena galericulata	.	.	.	4r	.	1
Gymnopus peronatus	.	.	.	1r	.	1
Schizophyllum commune	.	.	.	.	xa	1
Basidioradulum radula	.	.	.	.	xa	1
Armillaria ostoyae	.	.	.	.	1n	1
Fungi on litter						
Mycena pura	9n-a	10n-a	9n-a	10n-a	9n-a	5
Mycena aetites	4r-n	4r-n	4r-n	4r-n	4r-n	5
Mycena vitilis	4r-n	4n	4r-n	4r-n	4r	5
Mycena rosea	4n	4r-n	4r-n	4r-n	4r-n	5
Mycena epipterygia	2n-a	2n-a	2n-a	2n-a	2n-a	5
Mycena flavoalba	2n	2n	2n	2n	2n	5
Mycena arcangeliana	2a	2a	2a	2a	2a	5
Clavariadelphus junceus	1a	1a	1a	1a	1a	5
Clitocybe odora	.	6r-n	6r	4r-n	4n	4
Mycena stylobates	.	2n-a	2n	3n-a	2r-n	4
Clitocybe dealbata	3r	3r	.	3r	3r	4
Auriscalpium vulgare	4r-n	.	.	4r	2r	3
Mycena galopus	3r-a	.	.	3r-a	3r-a	3
Mycena flavescens	.	2n	2n	1n	.	3
Mycena atroalba	4n	.	.	4n	4n	3
Mycena leptocephala	3n	3n	3n	.	.	3
Clitocybe gibba	1r	2r	1r	.	.	3
Marasmius bulliardii	9n-a	11n-a	.	8n-a	.	3
Mycena metata	5n	4n	.	4n	.	3
Mycena citrinomarginata	2n	.	.	2n	.	2
Rhodocollybia butyracea var. *butyracea*	4r-n	.	.	.	.	1
Clitocybe hydrogramma	2r	.	.	.	.	1
Clitocybe candicans	1r	.	.	.	.	1
Clitocybe fuligineipes	1r	.	.	.	.	1
Clitocybe subalutacea	1r	.	.	.	.	1
Conocybe brunnea	1r	.	.	.	.	1
Setulipes quercophilus	1r	.	.	.	.	1
Mycena pelianthina	1r	.	.	.	.	1
Mycena sanguinolenta	3r	2r	.	.	.	2
Rhodocollybia butyracea var. *asema*	2n-a	2n	.	.	.	2
Strobilurus tenacellus	.	5n-a	.	.	.	1

Tab. 20 cont.

Coprinus xanthothrix	.	4r	.	.	.	1
Clitocybe fragrans	.	2r	.	.	.	1
Clitocybe umbilicata	.	1r	.	.	.	1
Mycena acicula	.	1r	1r	.	.	2
Gymnopus dryophilus	.	.	1r	.	1r	2
Mycena galopus var. *nigra*	.	.	1r	.	1r	2
Clitocybe metachroa	.	.	1n	.	.	1
Mycena erubescens	.	.	1n	.	.	1
Strobilurus stephanocystis	.	4n	.	4n	.	2
Mycena rosella	.	.	.	2r	.	1
Setulipes androsaceus	.	.	.	.	3r-a	1
Clitocybe ericetorum	.	.	.	.	1r	1
Conocybe semiglobata	.	.	.	.	1r	1
Mycena filopes	.	.	.	.	1n	1

and *Serratulo-Pinetum,* with which it shares 46% species. Fungi characterised by a broad ecological scale which therefore occur in various deciduous forests constitute the main body within litter-inhabiting saprobionts. The ecological range of only few exclusive species is narrower, which strengthens idiosyncratic features of the mycobiota in this community. The most interesting ones include: *Clitocybe ericetorum, C. fuligineipes, C. umbilicata, Mycena flavescens*, and *Tulasnella pallida*. *Clitocybe ericetorum* and *C. fuligineipes* can be assigned the greatest differential value. The former occurs in warm and open substitutional communities in habitats of coniferous forests as well as on the edges of pine forests. It is a rare species, known from the Wielkopolska National Park, the Jelonka reserve near Kleszczele and Międzyrzec (Eichler 1904; S. Domański 1955; Barkman & de Vries 1993; Wojewoda 2003). The latter has so far been known only from the Grzywy Korzeckowskie Crest in the Góry Świętokrzyskie Mts., where it was recorded only in *Potentillo-Quercetum*. Its requirements resemble those of calcicolous and thermophilous species, characteristic of this community. *Mycena flavescens* and *Tulasnella pallida* are rare saprobionts, and were also recorded in *Tilio-Carpinetum* phytocoenoses outside the thermophilous oak forest.

The greatest frequency was observed for the following fungi: *Clavariadelphus junceus, Mycena aetites, M. arcangeliana, M. epipterygia, M. flavoalba, M. pura* and *M. rosea*, which were recorded in all the plots. The greatest fruitbody productivity was also noticed in their case as well as in the case of *Clitocybe odora* and *Marasmius bulliardii*.

Lignicolous fungi constitute 33.5% of the biota in the community (Fig. 7c). *Quercus*-related xylobionts make its profile quite characteristic, although, predictably, not all xylobionts connected with this tree will be of special diagnostic value. Due to the presence of *Quercus* as well as *Pinus*, a number of other communities share a high number of species within this ecological group. Xylobionts in this association exhibit the greatest similarity to *Tilio-Carpinetum* – 40.7%, *Dentario glandulosae-Fagetum* – 31.5% and *Leucobryo-Pinetum* – 27.8% (Fig. 12). There were 21 exclusive species, that is 37.5% of the total number of xylobionts. The following fungi should be mentioned: *Dichomitus campestris, Peniophora nuda, Phanerochaete tuberculata* and *Pluteus exiguus*. These xylobionts are rare in Poland. Their exclusive occurrence in the xerophilous oak community suggests that they are characteristic species. Xylobionts closely associated with oak wood, such as *Daedalea quercina, Exidia glandulosa, Fistulina hepatica, Gymnopus fusipes, Hymenochaete rubiginosa, Mycena* *inclinata* and *Phellinus robustus,* also occur in the area. However, they follow the vegetation as it migrates to other forest communities or even occur outside forests, and therefore cannot be treated as characteristic despite their high frequency and fruitbody productivity in the thermophilous oak community. Rare lignicolous species associated with other tree species are also noteworthy. *Pinus sylvestris*, which significantly enriches the mycobiota of the community, plays a major role in this respect. The occurrence of *Gloeoporus taxicola* and *Hyphodontia subalutacea* was recorded on its wood.

The quantitative importance of oak parasites was not high; they were, however, characterised by high frequency and fruitbody productivity. The most important role was played by *Fistulina hepatica, Gymnopus fusipes* and *Phellinus robustus*.

The highest frequency in the patches of the thermophilous oak forest was recorded in the case of the following species: *Psathyrella pygmaea, Fistulina hepatica, Mycena polygramma, M. inclinata* and *Vuilleminia comedens*.

Fraxino-Alnetum

Habitat and phytosociological description. Three research plots, two in the peat-forest Białe Ługi complex along the Trupień River and one along the stream dividing the Pasmo Posłowickie Ridge from the Pasmo Dymińskie Ridge, were established in the ash-alder carr.

These carr phytocoenoses develop on mineral gleysols and gleyic peat soils formed on loose sand (Przemyski & Polinowska 2001). The habitats colonised by the forest are strongly eutrophied, moist, sometimes with stagnant waters, especially during spring thaws and after continuing rainfalls. The water level usually decreases in the summer period. The soil reaction is acidic and slightly acidic with pH 5.6-6.2.

The tree stand consists of *Alnus glutinosa* with an admixture of *Ulmus glabra*; it is not dense, between 60 and 70% (Tab. 21). The shrub layer whose density ranges from 40 to 50% is formed by various shrub species, mostly, however, of the class *Querco-Fagetea*: *Corylus avellana, Euonymus europaea, Frangula alnus, Fraxinus excelsior* and the association's differential species: *Padus avium* and *Ribes spicatum*. The ground cover develops homogenously and covers the surface from 70 to 90%. It is floristically fairly rich. As its characteristic species, *Circaea alpina*, is absent, the association's differential species are as follows: *Galium palustre, Lycopus europaeus, Lysimachia vulgaris* and *Scutellaria galericulata*. The syntaxonomic value is reinforced by *Alno-Ulmion* characteristic species: *Carex remota, Circaea lutetiana* and *Ficaria verna*. The moss layer is very poorly developed, and only *Plagiomnium affine* occurs more intensively. The litter is quickly decomposed. Significant amounts of dead wood, mostly of *Alnus glutinosa*, lie on the soil surface.

Mycological description. Fungi in *Fraxino-Alnetum* were examined at three research plots over 3 and 4 years and 105 mycological observations were performed. A total of 66 species of *Basidiomycetes* were collected (Tab. 22). The number of species at individual plots ranged between 17 and 45. The individual character of the mycobiota is emphasised by the presence of 23 exclusive species, that is 34.8% of the total fungal biota (Fig. 9). As regards the percentage participation of exclusive species, fungi in *Fraxino-Alnetum* are outnumbered only by those in *Tilio-Carpinetum*. Apart from exclusive species, the composition of *Basidiomycetes* resembles the most that in *Leucobryo-Pinetum* – 40.9% and *Dentario glandulosae-Fagetum* – 39.4% species in common.

Table 21
Fraxino-Alnetum

Successive number		1	2	3
Number of plot		9	10	15
Date		03.06.1997		20.06.1991
Localities		Białe Ługi		Kielce
Density of tree layer	a in %	60	60	70
Density of shrub layer	b in %	50	40	40
Cover of herb layer	c in %	90	70	80
Cover of moss layer	d in %	-	-	10
Number of plant species		36	30	33
Surface of investigated plots in m²			400	
ChAll. *Alno-Ulmion*				
Padus avium	b	1.2	1.2	1.2
Ribes spicatum	b	.	+	.
Carex remota		.	1.2	+.2
Circaea lutetiana		2.2	.	.
Ficaria verna		+.2	.	.
DAss. *Circaeo-Alnetum*				
Frangula alnus	b	1.1	2.1	2.2
Lysimachia vulgaris		+	1.1	1.1
Galium palustre		.	+.2	1.2
Solanum dulcamara		.	1.2	2.2
Lycopus europaeus		.	.	1.1
Scutelaria galericulata		.	.	+.2
Ch. *Fagetalia sylvaticae,Querco-Fagetea*				
Ulmus glabra	a	4.4	+	.
Ulmus glabra	b	1.1	.	.
Acer platanoides	b	.	.	+.2
Corylus avellana	b	2.2	.	.
Euonymus europaea	b	1.2	.	.
Fraxinus excelsior	b	.	1.1	+.2
Anemone nemorosa	c	2.3	+	.
Melica nutans		+	.	+.2
Ranunculus lanuginosus		.	+.2	+.2
Asarum europaeum		1.2	.	.
Galeobdolon luteum		+.2	.	.
Ranunculus auricomus		2.2	.	.
Paris quadrifolia		1.1	.	.
Milium effusum		+.2	.	.
Polygonatum multiflorum		+	.	.
Aegopodium podagraria		.	.	+.2
Others				
Alnus glutinosa	a	1.1	4.5	4.4
Betula pubescens	b	.	+.2	.

Tab. 21 cont.

Picea abies	b	1.2	+	.
Populus tremula	b	.	.	1.1
Sorbus aucuparia	b	1.2	+	1.2
Salix caprea	b	.	.	1.2
Viburnum opulus	b	.	.	1.2
Rubus idaeus		+.2	1.1	+.2
Filipendula ulmaria		3.3	+.2	3.3
Athyrium filix-femina		1.2	2.2	1.2
Caltha palustris		1.2	1.2	1.2
Scirpus sylvaticus		+.2	2.2	2.3
Carex sp.		+.2	2.2	.
Crepis paludosa		+.2	2.2	1.2
Calla palustris		+	2.2	.
Dryopteris carthusiana		+.2	+.2	.
Oxalis acetosella		+.2	+.2	.
Equisetum sylvaticum		2.2	.	3.3
Isopyrum thalictroides		1.2	.	.
Geum rivale		+.2	.	.
Maianthemum bifolium		+.2	.	.
Vaccinium myrtillus		+	.	.
Valeriana simplicifolia		+	.	.
Mentha aquatica		.	.	+.2
Ribes uva-crispa	c	.	.	+.2
Thalictrum flavum		.	.	+
Valeriana dioica		.	.	2.2
Angelica sylvestris		.	.	1.2
Peucedanum palustre		.	1.2	1.1
Stellaria uliginosa		.	+.2	.
Carex canescens		.	+	.
Equisetum palustre		.	+	1.2
Myosotis palustris		.	+	+.2
Viola palustris		.	+	.
Brachythecium rutabulum	d	.	.	+.2
Climacium dendroides	d	.	.	+.2
Plagiomnium affine	d	.	.	2.3

Table 22
Fungi in *Fraxino-Alnetum*

Number of plot		9	10	15	Frequency
Localities		Białe Ługi		Kielce	
Density of tree layer	a in %	60	60	70	
Density of shrub layer	b in %	50	40	40	
Cover of herb layer	c in %	90	70	80	
Cover of moss layer	d in %	-	-	10	
Surface of investigated plots in m^2			400		
Number of observations		32	32	41	
Number of plant species		36	30	33	
Number of fungi species		45	42	17	

Fungi on soil				
Lactarius obscuratus	6r	5n	8n	3
Naucoria scolecina	3n	4n	4n	3
Entoloma speculum	1r	1r	.	2
Naucoria escharoides	.	3n	2n	2
Paxillus involutus	4r	2r	.	2
Laccaria laccata	7n	8n	.	2
Laccaria amethystea	4n	5r	.	2
Naucoria celluloderma	2n	.	.	1
Naucoria cephalescens	1r	.	.	1
Naucoria permixta	1n	.	.	1
Entoloma euchroum	1r	.	.	1
Lactarius lilacinus	3r	.	.	1
Russula alnetorum	1r	.	.	1
Lycoperdon echinatum	2r	.	.	1
Lycoperdon perlatum	4r	.	.	1
Naucoria striatula	.	1r	.	1
Lactarius lacunorum	.	1r	.	1
Fungi on wood				
Mycena speirea	4n	3n	3r	3
Bjerkandera adusta	xn	xr	xn	3
Delicatula integrella	2n	1n	2n	3
Inonotus radiatus	xn	xn	xa	3
Phellinus igniarius	xr	.	xr	2
Psathyrella candolleana	2r	.	1n	2
Fomes fomentarius	xr	xr	.	2
Psilocybe subviridis	1n	1n	.	2
Mycena inclinata	3n	2n	.	2
Mycena megaspora	2n	2r	.	2
Lentinus torulosus	1r	1r	.	2
Polyporus brumalis	1r	2r	.	2
Schizophyllum commune	xn	xn	.	2
Stereum hirsutum	xa	xn	.	2
Trametes versicolor	xa	xn	.	2
Mycena galericulata	2n	1r	.	2
Pholiota aurivella	2r	.	.	1
Pholiota alnicola	1r	.	.	1
Pluteus atricapillus	2r	.	.	1
Psathyrella cotonea	1r	.	.	1
Stereum subtomentosum	xn	.	.	1
Trametes hirsuta	xn	.	.	1
Trametes ochracea	xn	.	.	1
Ganoderma applanatum	xr	.	.	1
Gymnopilus penetrans	n	.	.	1
Exidia glandulosa	n	.	.	1
Datronia mollis	.	1r	.	1
Psilocybe lateritia	.	2r	.	1

Tab. 22 cont.

Merulius tremellosus	.	2r	.	1
Mycena stipata	.	2n	.	1
Mycena tintinnabulum	.	3n	.	1
Panellus stypticus	.	2n	.	1
Stereum rugosum	.	xn	.	1
Psilocybe capnoides	.	5n	.	1
Pseudohydnum gelatinosum	.	.	6n	1
Trametes suaveolens	.	.	xr	1
Fungi on litter and among mosses				
Mycena pura	9n	9a	11n	3
Mycena acicula	2r	3r	2r	3
Mycena galopus	3n	3r	2r	3
Mycena leptocephala	2r	2r	.	2
Rickenella setipes	1r	1r	.	2
Coprinus plicatilis	.	.	2r	1
Psathyrella canoceps	.	.	2n	1
Psathyrella subnuda	.	1r	.	1
Tubaria minutalis		1r	.	1
Mycena aetites	.	3n	.	1
Rickenella fibula	.	4n	.	1
Psilocybe elongata	.	4n	.	1
Galerina hypnorum	.	5n	.	1

The quantity of *Basidiomycetes* in the ash-alder carr exceeds that of vascular plants in a ratio of 1.1:1. The relatively small number of fungi can be attributed to the fact that the carr communities are highly deformed. The absence of major rivers and the presence of settlements in river valleys result in a poor development and significant degeneration of narrow strips of the floodplain forest.

A group of 17 species, that is 25.7% of the mycobiota, is formed by terrestrial species (Fig. 7a). *Alnus glutinosa* mycosymbionts are particularly important within this group which consists of 10 species: *Lactarius lacunorum, L. lilacinus, L. obscuratus, Naucoria celluloderma, N. cephalescens, N. escharoides, N. permixta, N. scolecina* and *N. striatula* as well *Russula alnetorum*. The rarest fungi, such as *Lactarius lacunorum, Naucoria celluloderma, N. cephalescens, N. permixta* and *N. striatula*, which have so far been recorded only in alder-ash carrs, are of the greatest diagnostic value. Being alder symbionts, the other species were recorded together with this tree in various forest communities, mostly in *Alnetum incanae, Fraxino-Alnetum, Ribeso nigri-Alnetum,* oak-hornbeam forests of the *Galio-Carpinetum* and *Tilio-Carpinetum* types (Ławrynowicz 1973; Wojewoda 1974; Friedrich 1994; Bujakiewicz 1997a; Skirgiełło 1997; Lisiewska & Połczyńska 1998). Other pedobionts do not seem to be attached to either the alder habitat or the plants of the community, and are recorded across different communities of deciduous and mixed forests. Mycorrhizal fungi are characterised by the highest frequency and fruitbody productivity. These were, in particular, *Lactarius obscuratus* and *Naucoria scolecina*, at the research plots.

Fungi on litter are the smallest group in the community and comprise 13 species of saprobionts (Fig. 7b). This small number of species can be attributed to the fact that the area is often covered by water throughout the long vegetative period, especially after thaws and during persistent precipitation, and to the small amount of the litter that mostly comes the ongoing biomass production. *Psathyrella subnuda* and *Tubaria minutalis* were the only exclusive species recorded in the community. These fungi are indicator species of very fertile deciduous forest such as *Mercuriali-Fagetum* (Lisiewska 1963) and *Violo odoratae-Ulmetum minoris* (Bujakiewicz 1997b). Therefore, they can be treated as *Fraxino-Alnetum* differential species in the Góry Świętokrzyskie Mts.

Bryophilous fungi, such as *Galerina hypnorum* and *Psilocybe elongata*, that grow in moss tufts, mostly *Plagiomnium affine*, are also noteworthy. Other species of saprobionts are ubiquitous and are recorded in different plant communities.

Lignicolous fungi are the most numerous group – 36 species, that is 54.5% of the mycobiota recorded in the ash-alder carr (Fig. 7c). There are 8 exclusive species; of them, only *Mycena speirea* and *Stereum subtomentosum* indicate a significant attachment to carr communities, especially to alders. *Mycena speirea* was also considered by Lisiewska (1979) to be a differential species in the case of the alder-ash carr in the Czarny Las reserve. Due to the small differentiation of carr communities in the Góry Świętokrzyskie Mts., they can be considered characteristic of *Fraxino-Alnetum*. Above the regional level, however, both species were observed in various communities where *Alnus* was present and can therefore be treated as *Alno-Ulmion* characteristic species. Other species, for instance *Inonotus radiatus, Psathyrella cotonea, Trametes sauveolens*, can be considered characteristic at this stage of research on the local mycobiota. As their potential to colonise other tree and shrub species shows, these xylobionts can occur in communities outside the *Alno-Ulmion* alliance, for instance in *Dentario glandulosae-Fagetum, Querco-Pinetum, Tilio-Carpinetum* (Ławrynowicz 1973; Bujakiewicz 1979; Gumińska 1994; Skirgiełło 1997), which significantly decreases their diagnostic value.

Other lignicolous fungi observed in the research plots are similar to the adjacent forest communities because of the penetration of tree species (Fig. 12). The greatest number of shared species was recorded in the case of *Leucobryo-Pinetum* – 51.4% and *Dentario glandulosae-Fagetum* – 45.7%. The following xylobionts are in common with the former: *Datronia mollis, Mycena tintinnabulum* and *Stereum subtomentosum*, and the following with the latter: *Ganoderma applanatum, Lentinus torulosus, Mycena inclinata* and *Pholiota aurivella*.

Bjerkandera adusta, Delicatula integrella, Inonotus radiatus and *Mycena speirea*, which were recorded in all the plots, were characterised by the highest frequency in the patches of the community.

Tilio cordatae-Carpinetum betuli

Habitat and phytosociological description. Mycological studies in *Tilio-Carpinetum* were conducted at 17 plots situated on Mt Biesak and Mt Kolejowa (Pasmo Posłowickie Ridge), Mt Brusznia (Pasmo Kadzielniańskie Ridge), Mt Buk (Pasmo Masłowskie Ridge), Mt Malik (Pasmo Bolechowickie Ridge), Mt Milechowska (Grząby Bolmińskie Ridge), on Mt Święty Krzyż (Pasmo Łysogórskie Ridge) and Mt Telegraf (Pasmo Dymińskie Ridge). Phytocoenoses of the subcontinental oak-hornbeam forest are floristically differentiated, and two subassociations can be distinguished: a typical and with *Abies alba*.

Patches of *T.-C. typicum* cover flat habitats, slightly inclined, where leached brown soils have developed, medium deep, mesic, formed from sand and boulder clays lying on different parent rocks (Devonian and Jurassic limestones). These soils are slightly acid and neutral, pH 6.4 -7, or even alkaline, pH 7-7.6 (Świercz 1997). Both the parent rock and the high rate of cement dust emissions from the "Nowiny" Cement and Limestone Works which have a high alkalising effect on the surface soil horizons influence the soil pH. The stand is composed of many species and multiple layers, fairly sparse, and its density is from 40 to 90% (Tab. 23). Beech, pine and oak and single hornbeam trees dominate the highest layer; they are accompanied by sycamore maples in the lower layer. The low crown density encourages an abundant development of many species in the shrub layer whose cover ranges from 40 to 80%. The field layer is particularly strongly developed in the degenerated forms of the community where pine trees dominate the stand. *Cornus sanguinea*, *Corylus avellana, Euonymus verrucosa* oraz *Lonicera xylosteum* and *Sorbus aucuparia* occur here, as well as saplings of deciduous species. The ground cover is not fully dense, and its development depends on the composition of the tree stand, slope direction and substrate type. *Galium schultesii,* a characteristic species, grows in the ground cover, together with plants such as *Actaea spicata, Euphorbia amygdaloides, Hepatica nobilis, Galeobdolon luteum, Pulmonaria obscura* and *Phyteuma spicatum*. The thermophilous character of the oak-hornbeam forest is stressed by the presence of, for instance, *Cimicifuga europaea, Fragaria viridis, Galium vernum, Lathyrus niger, Melittis melissophyllum, Origanum vulgare* and *Vincetoxicum hirundinaria*. The moss layer is usually poorly developed and it is of any importance only exceptionally.

Tilio-Carpinetum abietetosum covers slightly inclined and fairly steep slopes of hills directed northwards or eastwards where mesic, leached cambisols, arenic brown stagnic gleysols, formed by different deposits of Pleistocene genesis lying on various parent rocks. These soils are acid and the pH is 4.7-4.9 in the surface horizons. A layer of mull-moder humus is present (Kowalkowski *et al.* 1992).

The tree stand comprises species of beeches, firs and hornbeams, with *Acer pseudoplatanus*, *Quercus petraea, Q. robur* and *Pinus sylvestris* as admixtures. It is usually quite dense, between 80 to 90%. Pine trees growing in the stand developed from artificial plantings. The field layer is usually not dense and its cover ranges from 15 to 40%, or, when particularly high, 70%. Its main components include tree saplings as well as *Sambucus racemosa* and *Sorbus aucuparia*. The density of the ground cover is not full and fluctuates from 20 to 85%. Species characteristic of the community and of the *Carpinion betuli* alliance as well as the subassociation's differential species occur here: *Athyrium filix-femina, Dentaria glandulosa, Dryopteris dilatata, D. filix-mas, Mycelis muralis, Polygonatum verticillatum, Senecio fuchsii* and *Solidago virgaurea* (Głazek & Wolak 1991). The moss layer is very poorly developed or is not present at all.

Mycological description. Fungi in *Tilio-Carpinetum* were examined at 17 plots over 3 and 4 years, and 503 mycological observations were conducted. A total of 244 species, including 105 terrestrial fungi, 57 litter-inhabiting and 82 lignicolous fungi, were collected (Tab. 24). The number of basidiomycete species at individual plots ranged between 20 and 42. The association's special features are emphasised by the presence of as many as 93 exclusive species, that is 38.1% of the total biota. This is also the most numerous group in the all the plant associations examined in the project (Fig. 9). Other fungi mostly resemble those growing in deciduous forests: *Dentario glandulosae-Fagetum*, with which it shares 33.6% species, *Potentillo-Quercetum* – 29.1% and *Querco-Pinetum* – 25.5% (Fig. 8).

The quantity of *Basidiomycetes* in the *Tilio-Carpinetum* biocoenosis exceeds that of vascular plants in a ratio of 1.9:1.

Table 23
Tilio-Carpinetum

Successive number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Constancy
Number of plot		1	2	3	4	5	3	4	3	4	5	1	2	1	2	3	4	5	
Date		27.05.2001					15.06.2000		16.06.1992					25.05.2002					
Localities		Góra Malik Mt					Milechowy Mt		Kielce					Święty Krzyż Mt					
Density of tree layer	a in %	40	60	80	50	90	40	50	60	60	90	80	90	80	80	80	80	80	
Density of shrub layer	b in %	80	60	40	60	40	80	80	70	80	40	30	40	15	70	10	20	20	
Cover of herb layer	c in %	80	40	50	60	60-70	50	50	80	70	80	80	85	30	20	70	80	80	
Cover of moss layer	d in %	< 5	< 5	+	+	+	+	+	10	60	0	+	+	10	<5	5	<5	-	
Number of plant species		45	32	30	35	34	33	45	35	44	36	42	29	43	23	30	31	24	
Exposure		N	SW	SE	E	N	S	S	S	S	SW	N	E	N	N	N	N	N	
Inclination in degrees		15	3	5	15	3	20	15	5	5	10	30	20	3	5	3	3	3	
Surface of investigated plots in m^2		400																	
		Tilio-Carpinetum typicum										*Tilio-Carpinetum abietetosum*							
Ch. *Carpinion betuli*																			
Carpinus betulus	a	.	.	1.1	.	.	.	1.2	.	.	1.1	.	.	1.1	.	3.3	1.2	2.2	II
Carpinus betulus	b	.	.	+.2	1.1	.	2.2	4.4	.	+	.	.	.	1.1	1.2	+.2	1.1	1.2	III
Carpinus betulus	c	+	.	.	.	+	.	.	.	.	.	.	.	+	+.2	+	+	.	II
Corylus avellana	b	2.2	2.2	2.2	2.2	1.2	4.4	1.2	3.3	4.4	2.2	+.2	.	+.2	.	.	.	.	IV
Corylus avellana	c	.	+	.	+.2	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Galium schultesii		.	.	.	.	.	.	1.2	.	+.2	+.2	.	.	+.2	.	+.2	3.3	1.2	II
Stellaria holostea		+.2	.	.	.	.	.	.	.	.	.	.	.	1.2	.	.	1.2	1.2	II
Ch. *Fagetalia sylvaticae*																			
Fagus sylvatica	a	1.2	2.2	2.2	4.4	3.3	.	.	2.2	1.2	3.3	3.2	2.2	2.2	3.3	3.3	4.4	3.3	V
Fagus sylvatica	b	1.1	1.2	+.2	.	.	.	.	2.2	1.2	1.1	+	.	1.2	3.2	.	1.2	1.2	IV
Fagus sylvatica	c	.	.	.	+	.	.	.	.	.	.	.	.	1.2	+	+	.	.	II
Acer pseudoplatanus	a	.	1.2	.	.	.	.	.	.	.	.	.	.	.	3.3	1.1	1.2	1.2	II
Acer pseudoplatanus	b	+	.	.	.	+	.	+	.	.	.	.	.	1.1	1.1	.	+.2	1.2	II
Acer pseudoplatanus	c	+	1.2	+	.	+	.	+	.	.	.	.	.	1.2	+.2	2.2	2.2	1.2	III
Daphne mezereum	b	+	+	.	+	+	.	+	1.1	.	+.2	.	.	.	.	.	.	.	II

Tab. 23 cont.

Ribes spicatum	b	+	+	.	+	+.2	.	.	.	.	.	.	.	.	.	.	.	.	II
Asarum europaeum		2.2	.	1.2	2.2	1.2	.	.	1.2	.	1.2	1.2	.	1.2	.	.	1.2	.	III
Pulmonaria obscura		1.2	+	+.2	+.2	+.2	2.2	1.2	.	.	+.2	.	.	.	.	.	+.2	.	III
Viola reichenbachiana		1.1	1.2	.	+.2	1.2	.	+	.	1.2	.	1.2	1.1	1.2	.	.	+.2	.	III
Sanicula europaea		+	+.2	+.2	.	.	1.2	+.2	3.3	.	+	.	+.2	.	.	.	.	.	III
Galeobdolon luteum		.	.	1.2	1.2	.	.	.	.	.	2.3	3.4	3.4	+.2	+.2	1.2	1.2	2.3	III
Atrichum undulatum	d	1.2	.	.	.	.	.	.	+.2	.	.	.	.	+.2	.	1.2	.	.	II
Mercurialis perennis		+.2	.	1.2	3.4	1.2	.	.	.	.	.	2.2	2.2	.	.	.	.	.	II
Cephalanthera alba		1.2	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Euphorbia amygdaloides		+.2	.	.	.	.	.	.	.	2.3	1.2	+	.	.	.	.	.	.	I
Euphorbia dulcis		+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	I
Lathyrus vernus		.	+.2	.	.	.	1.2	1.2	+	1.2	+.2	+.2	.	.	.	.	.	.	II
Lilium martagon		.	.	.	.	.	.	.	1.1	1.1	.	+	+	.	.	+.2	.	.	II
Polygonatum multiflorum		.	.	.	.	.	.	.	.	+	+.2	+	+	.	.	.	.	.	II
Neottia nidus-avis		.	.	.	.	.	.	.	1.1	.	+.2	.	.	.	.	.	.	.	I
Primula elatior		.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	I
Actaea spicata		.	.	.	.	.	.	.	.	.	+.2	+	.	.	.	.	.	.	I
Dryopteris filix-mas		.	.	.	.	.	.	.	.	.	.	1.1	+.2	+.2	+.2	1.2	.	1.1	II
Galium odoratum		.	.	.	.	.	.	.	.	.	.	3.3	+.2	.	.	.	.	.	I
Impatiens noli-tangere		.	.	.	.	.	.	.	.	.	.	1.2	.	+	.	.	+.2	.	I
Stachys sylvatica		.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	I
Chrysosplenium alternifolium		.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	I
Dentaria glandulosa		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I
Milium effusum		.	.	.	.	.	.	.	.	.	.	.	.	1.2	+.2	.	3.3	.	I
Festuca gigantea		.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	+.2	.	.	I
Festuca sylvatica		.	.	.	.	.	.	.	.	.	.	.	.	+	.	+.2	.	+.2	I
Phyteuma spicatum		.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	I
Paris quadrifolia		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	+.2	I
Ch. *Querco-Fagetea*																			
Euonymus verrucosa	b	1.2	+.2	+.2	1.1	1.2	1.2	1.2	2.3	+.2	1.2	1.1	.	.	.	.	.	.	IV
Euonymus verrucosa	c	+	.	.	.	1.2	.	.	.	.	+.2	.	.	.	.	.	.	.	I
Lonicera xylosteum	b	+.2	1.2	1.2	+.2	+.2	1.2	1.2	.	.	1.2	+	.	.	.	.	.	.	III

Lonicera xylosteum	c	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
Acer platanoides	b	.	.	+.2	.	.			.	.	.	.	.	.	.	.	.	.	I
Padus avium	b	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	I
Anemone nemorosa		2.2	.	1.2	.	+.2	+.2	+.2	+.2	1.3	3.3	2.2	2.3	2.2	+.2	3.3	1.2	3.3	V
Hepatica nobilis		2.3	1.2	2.2	2.2	3.3	1.2	2.2	3.3	3.3	2.2	1.2	.	.	.	.	.	.	IV
Melica nutans		+	+.2	.	1.2	+.2	1.2	1.2	1.2	1.2	1.2	+.2	.	+.2	.	.	.	.	IV
Aegopodium podagraria		.	.	.	+.2	.	.	.	.	+.2	.	.	.	+	.	.	+.2	+	II
Carex digitata		+.2	.	1.2	+.2	1.2	.	.	+.2	+.2	+.2	.	.	.	.	.	.	.	II
Melittis melissophyllum		+	.	.	.	.	+	+	1.1	+	+	.	.	.	.	.	.	.	II
Lathyrus niger		.	.	.	.	.	+.2	+	.	.	.	.	.	.	.	.	.	.	I
Epipactis helleborine		.	.	.	.	1.1	.	+	.	.	.	.	.	.	.	.	.	.	I
Brachypodium sylvaticum		.	.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	I
Poa nemoralis		.	.	.	.	.	.	.	+.2	.	.	.	.	1.2	.	+.2	.	.	I
Ch. *Trifolio-Geranietea*																			
Galium verum		+	1.2	.	1.2	+.2	1.2	.	+.2	+.2	.	.	.	.	.	.	.	.	II
Fragaria viridis		+	+.2	+	+.2	+.2	.	.	.	.	+.2	.	.	.	.	.	.	.	II
Polygonatum odoratum		+	.	+	.	.	.	+	.	.	.	.	.	+	+	+	+	.	II
Origanum vulgare		.	+	.	.	+.2	+	.	.	+.2	.	.	.	.	.	.	.	.	II
Vicia cassubica		.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I
Viola hirta		.	.	.	.	+.2	1.2	+.2	.	.	.	.	.	.	.	.	.	.	I
Agrimonia eupatoria		.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	I
Peucedanum cervaria		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I
Thalictrum minus		.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	I
Ch. *Rhamno-Prunetea*																			
Cornus sanguinea	b	2.2	1.2	1.2	2.2	2.2	1.2	1.2	.	.	+	.	.	.	.	.	.	.	III
Cornus sanguinea	c	.	.	.	1.2	.	.	.	+	.	.	.	.	.	.	.	.	.	I
Crataegus monogyna	b	1.2	+	.	+	+	+.2	.	.	.	.	.	.	.	.	.	.	.	II
Crataegus monogyna	c	.	.	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	I
Viburnum opulus	b	.	.	.	.	+	.	+	.	+.2	.	.	.	.	.	.	.	.	I
Viburnum opulus	c	+	.	+.2	+	+	.	.	.	.	1.1	.	.	.	.	.	.	.	II
Rosa canina	b	.	+.2	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
Rosa canina	c	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Tab. 23 cont.

Others																			
Pinus sylvestris	a	3.3	4.4	4.4	4.4	3.3	1.2	2.2	1.1	4.4	4.4	.	2.3	.	.	.	.	.	IV
Pinus sylvestris	c	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Abies alba	a	.	.	.	.	.	.	.	.	.	1.1	3.3	3.3	3.3	1.2	1.2	2.2	3.2	II
Abies alba	b	2.1	2.2	2.2	+.2	2.2	.	.	1.1	+.2	.	+	2.2	+	3.3	2.2	2.2	2.2	V
Abies alba	c	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1.1	+	+.2	II
Quercus petraea	a	.	2.2	.	1.1	.	3.2	2.3	3.3	.	.	.	1.1	.	.	.	.	.	II
Quercus petraea	b	.	.	.	.	1.1	.	.	1.1	+	.	.	.	.	.	.	.	.	I
Quercus petraea	c	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	I
Quercus robur	a	1.2	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	I
Quercus robur	c	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Populus tremula	a	.	.	.	.	.	.	.	+.2	.	.	.	+.2	.	.	.	.	.	I
Populus tremula	b	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I
Populus tremula	c	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+.2	I
Betula pendula	a	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sorbus aucuparia	b	.	.	.	.	.	.	.	.	.	.	1.1	1.1	+	1.1	.	.	.	II
Sorbus aucuparia	c	+	+	+	+	+	.	.	.	.	.	.	.	+	1.1	+	+	+	III
Salix caprea	b	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	I
Frangula alnus	b	1.2	.	.	.	.	.	+	.	+.2	.	.	.	.	.	.	.	.	I
Frangula alnus	c	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pyrus communis	b	.	.	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.	I
Pyrus communis	c	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
Ulmus scabra	b	.	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sambucus nigra	b	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1.2	.	I
Sambucus nigra	c	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	I
Prunus padus	b	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I
Prunus padus	c	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I
Aesculus hippocastanum	c	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Padus serotina	c	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	II
Sambucus racemosa	b	.	.	.	.	.	.	.	.	.	.	2.2	1.2	.	+.2	.	.	.	I
Sambucus racemosa	c	.	.	.	.	.	.	.	.	.	.	+	+	.	+	+	.	.	II
Maianthemum bifolium		+	+	.	+.2	.	.	+	.	.	1.2	1.1	+.2	+	2.2	3.3	1.2	1.2	IV

Ajuga reptans		+	.	+.2	+	.	+	.	+	+.2	.	.	.	+	.	+	+.2	+	III
Rubus hirtus		+	.	.	.	.	+	+	+.2	+.2	.	.	+.2	+	2.2	+.2	.	1.2	III
Oxalis acetosella		.	.	1.2	+.2	.	.	.	+	.	3.3	2.3	3.4	2.2	1.2	.	1.2	1.2	III
Viola mirabilis		1.2	+.2	+	+.2	+.2	.	.	.	.	.	.	.	.	.	.	.	.	II
Vaccinium myrtillus		+.2	.	+.2	.	.	.	+	+.2	.	.	.	+.2	.	+.2	.	.	.	II
Luzula pilosa		+	.	.	.	.	.	+	+.2	.	+	.	+	.	.	.	.	.	II
Plagiomnium affine	d	.	+.2	.	+.2	+.2	.	.	1.2	3.2	.	.	+.2	.	.	.	.	.	II
Geum urbanum		.	.	+	+	+	.	+	.	1.2	+	.	.	.	.	.	.	.	II
Convallaria maialis		+	.	.	.	.	.	+.2	.	+.2	.	.	.	.	.	.	.	.	I
Taraxacum officinale		.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
Cimicifuga europaea		.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Monotropa hypopitys		.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Fragaria vesca		.	.	.	.	.	1.2	.	+	2.2	.	.	.	.	.	.	.	.	I
Hieracium murorum		.	.	.	.	.	.	.	+	+	.	.	.	+	.	+	.	.	II
Anthriscus sylvestris		.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	I
Dryopteris dilatata		.	.	.	.	.	.	.	.	.	.	+.2	+.2	+	1.2	+.2	1.2	+.2	II
Athyrium filix-femina		.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	1.2	+.2	.	I
Mycelis muralis		.	.	.	.	.	.	.	.	.	.	+	.	+.2	.	+	+	+	II
Polygonatum verticillatum		.	.	.	.	.	.	.	.	.	.	.	+.2	+	+	.	+	.	II
Senecio fuchsii		.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	1.1	1.1	II
Solidago virgaurea		.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	II
Viola odorata		.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	.	I
Carex spicata		.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
Euphorbia angulata		.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
Vincetoxicum hirundinaria		.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	I
Cephalanthera rubra		.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	I
Campanula glomerata		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I
Digitalis grandiflora		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I
Hieracium lachenalii		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I
Hypochoeris maculata		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I
Pteridium aquilinum		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I
Rubus caesius		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I
Vicia sylvatica		.	.	.	.	.	.	.	+.2	1.2	.	+.2	.	.	.	.	.	.	I

Tab. 23 cont.

Veronica chamaedrys		.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	I
Viola collina		.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	I
Euphorbia cyparissias		.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	.	.	I
Betonica officinalis		.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	I
Ribes uva-crispa		.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	I
Peucedanum oreoselinum		.	.	.	.	.	.	.		+.2	.	.	.	.	.	.	.	.	I
Moehringia trinervia		.	.	.	.	.	.	.	.	.	1.2	.	.	+	.	.	+.2	.	I
Viola riviniana		.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	.	I
Galeopsis tetrahit		.	.	.	.	.	.	.	.	.	+.2	+	.	.	.	.	.	.	I
Geranium robertianum		.	.	.	.	.	.	.	.	.	+	+.2	+	.	.	.	.	.	I
Gymnocarpium dryopteris		.	.	.	.	.	.	.	.	.	.	1.2	.	.	+.2	.	.	.	I
Rubus idaeus		.	.	.	.	.	.	.	.	.	.	+.2	+.2	.	.	.	.	.	I
Chelidonium majus		.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	I
Stellaria nemorum		.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	.	+.2	.	I
Polypodium vulgare		.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	I
Aruncus sylvestris		.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Lysimachia vulgaris		.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	.	I
Melandrium rubrum		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I
Lamium purpureum		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	I
Brachythecium sp.	d	+.2	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Hylocomium splendens	d	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I
Euhrynchium angustirete	d	.	.	.	.	.	.	.	1.2	.	.	+.2	.	.	.	.	.	.	I
Oxyrrhynchium hians	d	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	.	.	.	I
Pleurozium schreberi	d	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	.	.	I
Hypnum cupressiforme	d	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	.	.	I
Brachythecium velutinum	d	.	.	.	.	.	.	.	.	.	.	+.2	+.2	.	.	.	.	.	I
Brachythecium salebrosum	d	.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	I
Dicranella heteromalla	d	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	+.2	.	I
Lophocolea heterophylla	d	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I
Herzogiella seligeri	d	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I

Table 24
Fungi in *Tilio-Carpinetum*

Number of plot		3	4	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Constancy
Localities		Milechowy		Kielce					Góra Malik Mt					Święty Krzyż Mt					
Density of tree layer	a in %	40	50	80	90	60	60	90	40	60	80	50	90	80	80	80	80	80	
Density of shrub layer	b in %	80	80	30	40	70	80	40	80	60	40	60	40	15	70	10	20	20	
Cover of herb layer	c in %	50	50	80	85	80	70	80	80	40	50	60	60-70	30	20	70	80	80	
Cover of moss layer	d in %	+	+	+	+	10	60	0	< 5	< 5	+	+	+	10	<5	5	<5	-	
Exposure		S	S	N	E	S	S	SW	N	SW	SE	E	N	N	N	N	N	N	
Inclination in degrees		20	15	30	20	5	5	10	15	3	5	15	3	3	5	3	3	3	
Surface of investigated plots in m^2										400									
Number of observations		24	24	36	36	36	36	36	27	27	27	27	27	28	28	28	28	28	
Number of plant species		33	45	42	29	35	44	36	45	32	30	35	34	43	23	30	31	24	
Number of fungi species		33	34	42	35	24	35	22	42	31	32	22	35	25	20	24	21	24	
Fungi on soil																			
Lycoperdon perlatum		2n	.	.	2r	.	.	.	4n	.	3a	.	5a	.	.	1r	3n	2r	III
Inocybe fastigiata		4n	4n	.	.	.	.	.	2n	.	2a	.	3n	.	.	.	.	.	II
Inocybe geophylla var. *geophylla*		1r	.	4n	5n	4r-n	7n-a	2r	.	.	.	.	.	.	.	.	.	.	II
Psilocybe aeruginosa		3r	3r	.	2r	.	4r-n	.	.	.	.	.	.	.	.	.	1n	.	II
Laccaria amethystea		.	.	7n	5r	9n	.	.	.	.	.	.	.	.	1n	1r	.	1n	II
Scleroderma verrucosum		.	.	2r	1r	1r	.	.	.	.	.	.	.	.	.	.	1r	.	II
Phallus impudicus		.	.	1r	.	1r	.	.	.	.	.	.	.	.	.	3r	1r	.	II
Xerocomus pascuus		.	.	3r	6a	.	.	.	.	.	.	.	.	.	+	.	.	1r	II
Russula nigricans		.	.	.	.	.	2r	.	.	.	.	.	.	7a	1r	.	3n	2r	II
Geastrum fimbriatum		.	.	.	.	.	3r-n	.	4r	.	.	3r-n	5r	.	.	.	.	.	II
Amanita rubescens		.	.	.	.	.	.	.	.	.	.	.	.	1r	2r	1r	1r	.	II
Lepiota castanea		.	.	.	.	.	.	.	2n	1r	2n-a	3n	.	.	.	.	.	.	II
Ramaria flaccida		.	.	.	.	.	.	.	3a	3n	.	4a	2a	.	.	.	.	.	II
Lycoperdon molle		.	.	.	.	.	.	.	4r	.	2r	.	.	3n	.	1r	.	1r	II
Suillus granulatus		6r	.	.	.	.	5r-n	.	.	2r	.	.	.	.	.	.	.	.	I
Tricholoma terreum		1r	2r	.	.	.	2r	.	.	.	.	.	.	.	.	.	.	.	I
Lepiota cristata		.	.	2n-a	.	.	2n-r	3r-n	.	.	.	.	.	.	.	.	.	.	I

Tab. 24 cont.

Inocybe splendens	.	.	2a	.	.	.	.	1r	.	.	1r	.	.	.	.	.	.	I
Lepiota aspera	.	.	1r	.	.	1r	.	.	.	.	1r	.	.	.	.	.	.	I
Laccaria laccata	.	.	.	8n-a	9n-a	.	.	.	.	8a	.	.	.	.	.	.	.	I
Inocybe flocculosa	1r	.	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	I
Inocybe fuscidula var. *fuscidula*	1r	.	.	.	.	.	.	.	.	.	.	2r	.	.	.	.	.	I
Cortinarius orellanus	.	1r	.	.	.	.	.	2r	.	.	.	.	.	.	.	.	.	I
Inocybe abjecta	.	1r	.	.	.	2r	.	.	.	.	.	.	.	.	.	.	.	I
Inocybe posterula	.	.	1r	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	I
Ramaria abietina	.	.	1r	.	.	.	2r	.	.	.	.	.	.	.	.	.	.	I
Lepista nebularis	.	.	.	2n	.	4r-n	.	.	.	.	.	.	.	.	.	.	.	I
Inocybe fuscidula	.	.	.	.	.	2r	.	.	.	.	.	2r	.	.	.	.	.	I
Chroogomphus rutilus	.	.	.	.	.	1r	.	.	.	1r	.	.	.	.	.	.	.	I
Ramaria eumorpha	.	.	.	.	.	1n	1n	.	.	.	.	.	.	.	.	.	.	I
Cortinarius incisus	.	.	.	.	.	.	.	1r	.	.	.	.	.	1n	.	.	.	I
Galerina unicolor	.	.	.	.	2r	.	.	.	.	.	1r	1r	.	.	.	.	.	I
Amanita excelsa	.	.	.	.	.	.	.	.	.	.	.	.	1r	2r	.	.	.	I
Russula delica	.	.	.	.	.	.	.	.	.	.	.	.	2r	.	1r	.	1r	I
Xerocomus subtomentosus	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	1r	I
Lactarius decipiens	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	2r	.	.	I
Lactarius pallidus	.	.	.	.	.	.	.	.	.	.	.	.	.	2r	2r			I
Russula ochroleuca	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	1r	I
Russula violeipes	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2n	2n	I
Paxillus involutus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	2n	I
Porphyrellus porphyrosporus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	2n	I
Hebeloma crustuliniforme	4r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Hebeloma hiemale	3r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Hygrophorus eburneus	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Inocybe erubescens	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula sanguinea	.	2r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cortinarius argutus	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cortinarius gracilior	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cortinarius venetus	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Hebeloma danicum	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Lactarius vellereus	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula lutea	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Tricholoma fulvum	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cortinarius cf. *multiformis*	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Melanoleuca cognata	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Entoloma byssisedum	.	.	2n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Hebeloma pumilum	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Inocybe pseudodestricta	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Clavulina rugosa	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Conocybe subpallida	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Tricholoma sulphureum	.	.	.	3r	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lepiota ventriosospora	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Conocybe sulcatipes	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Gyroporus castaneus	.	.	.	.	2n	.	.	.	.	.	.	.	.	.	.	.	.	I
Amanita vaginata	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	I
Inocybe calida	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	I
Tricholoma saponaceum	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	I
Entoloma rhodopolium var. *nidorosum*	.	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	I
Clavulina coralloides	.	.	.	.	.	3r-n	.	.	.	.	.	.	.	.	.	.	.	I
Inocybe auricoma	.	.	.	.	.	3r	.	.	.	.	.	.	.	.	.	.	.	I
Geastrum quadrifidum	.	.	.	.	.	2r-n	.	.	.	.	.	.	.	.	.	.	.	I
Inocybe geophylla var. *lilacina*	.	.	.	.	.	2n-a	.	.	.	.	.	.	.	.	.	.	.	I
Ramaria stricta	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	I
Melanoleuca melaleuca	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	I
Lyophyllum connatum	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.			I
Lycoperdon mammiforme	.	.	.	.	.	.	.	4r	.	.	.	.	.	.	.	.	.	I
Inocybe cookei	.	.	.	.	.	.	.	3n-a	.	.	.	.	.	.	.	.	.	I
Amanita strobiliformis	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	I
Hebeloma edurum	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	I
Hebeloma leucosarx	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	I
Inocybe dulcamara	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	I
Inocybe griseolilacina	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	I
Tricholoma apium	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	I
Entoloma hebes			.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	I

Tab. 24 cont.

Lyophyllum loricatum	.	.	.	.	.	.	.	.	1a	.	.	.	.	.	.	.	.	I
Lycoperdon umbrinum	.	.	.	.	.	.	.	.	.	3n-a	.	.	.	.	.	.	.	I
Inocybe rimosa	.	.	.	.	.	.	.	.	.	2r	.	.	.	.	.	.	.	I
Lepiota clypeolaria	.	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	.	I
Lepiota ochraceofulva	.		.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	I
Inocybe hirtella	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	I
Entoloma venosum	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	I
Inocybe cervicolor	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	I
Amanita pantherina	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	I
Amanita virosa	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	I
Russula amoenicolor	.	.	.	.	.	.	.	.	.	.	.	.	2n	.	.	.	.	I
Cortinarius trivialis	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	I
Russula badia	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	I
Russula mairei	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	I
Hebeloma versipelle	.	.	.	.	.	.	.	.	.	.	.	.	1n	.	.	.	.	I
Lactarius picinus	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	I
Hygrophoropsis aurantiaca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2r	.	.	I
Russula consobrina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	I
Boletus pulverulentus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	I
Russula virescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	I
Bovista nigrescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	I
Fungi on wood																		
Psilocybe fascicularis	.	.	4r-a	4n-a	.	2n-a	1n	8a	7n-a	9a	.	2n-a	.	.	1a	.	.	III
Polyporus varius	.	.	2r	.	.	.	1r	3r	2r	1r	.	3r	.	.	.	.	.	II
Xerula radicata	.	.	.	.	.	.	1r	1r	1r	1r	.	1r	.	.	.	.	.	II
Armillaria ostoyae	.	.	3n-a	5n	.	4n	4n	.	.	.	.	.	.	.	1a	.	.	II
Fomitopsis pinicola	.	.	.	.	.	.	.	.	.	.	.	.	xr	xn	.	xr	xr	II
Galerina marginata	.	2r	.	.	.	2r-n	.	2r	.	.	.	2r	.	.	.	.	.	II
Gymnopilus penetrans	.	.	.	1n	.	.	.	.	.	.	.	.	.	1a	2a	.	1n	II
Pluteus atricapillus	.	.	.	.	.	.	.	.	.	1r	.	1r	.	.	.	2r	1r	II
Stereum hirsutum	xn	.	.	.	.	.	xn	xn	.	xn	.	.	.	.	.	.	.	II
Crucibulum laeve	2n	.	.	.	2a	.	1a	.	.	.	.	.	.	.	.	.	.	I

Ganoderma carnosum	.	.	.	.	.	.	.	.	.	.	.	.	xr	xr	xr	.	.	I
Hericium coralloides	.	.	.	.	.	.	.	.	.	.	.	.	1r	2r	.	2r	.	I
Heterobasidion annosum s.l.	.	.	.	xr	.	.	.	.	.	xn	.	xn	.		.	.		I
Mycena vitilis	2r	2r	.	.	2r	.	.	.	.	.	.	.	.	.	.	.	.	I
Phylloporia ribis	4r	.	4r	.	3n	.	.	.	.	.	.	.	.	.	.	.	.	I
Pluteus pouzarianus	.	.	1r	.	.	.	.	.	.	.	.	.	1r	.	.	.	1r	I
Stereum rugosum	xn	.	.	.	xn	.	xn	.	.	.	.	.	.	.	.	.	.	I
Tricholomopsis rutilans	.	.	.	1n	1r	.	.	.	.	.	1r	.	.	.	.	.	.	I
Vuilleminia comedens	xn	xn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Paxillus atrotomentosus	1r	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	I
Pluteus plautus	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	I
Irpex ochraceus	.	1r	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	I
Phellinus hartigii	.	.	xr	.	.	.	.	.	.	.	.	.	xr	.	.	.	.	I
Daedaleopsis confragosa	.	.	xn	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	I
Gymnopilus hybridus	.	.	3n-a	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Coprinus micaceus	.	.	1a	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	I
Oligoporus caesius	.	.	1n	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	I
Psilocybe capnoides	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	1n	.	.	I
Crepidotus cesatii	.	.	.	.	.	.	.	.	2n	.	.	1a	.	.	.	.	.	I
Mycena alba	.	.	.	.	.	.	.	.	1r	.	.	1r	.	.	.	.	.	I
Pluteus atromarginatus	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	1r	.	I
Calocera viscosa	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	+	.	.	I
Psilocybe lateritia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	1n	I
Coprinus xanthothrix	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Phellinus robustus	xr	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Galerina stylifera	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Radulomyces molaris	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena galericulata	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Crepidotus mollis	.	3a	.	.	.		.	.	.	.	.	.	.	.	.	.	.	I
Crepidotus mollis var. *calolepis*	.	3a	.	.	.		.	.	.	.	.	.	.	.	.	.	.	I
Pluteus salicinus	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Tubaria furfuracea	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Daedalea quercina	.	.	xr	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Chondrostereum purpureum	.	.	2n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Tab. 24 cont.

Auricularia auricula-judae	.	.	2n	.	.	.	.	.	.	.	.	.	.		.	.	.	I
Pluteus chrysophaeus	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pluteus depauperatus	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Oligoporus alni	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Basidioradulum radula	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pleurotus ostreatus	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lycoperdon pyriforme	.	.	1a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Tubaria pellucida	.	.	1a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Amylostereum chailletii	.	.	.	xn-a	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Hyphodontia sambuci	.	.	.	2n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pseudohydnum gelatinosum	.	.	.	2n	.	.	.	.	.	.	.	.	.	.	.		.	I
Panellus mitis	.	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Exidiopsis grisea	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Hyphoderma praetermissum	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pholiota flammans	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Trichaptum fuscoviolaceum	.	.	.	.	.	xa	.	.	.	.	.	.	.	.	.	.	.	I
Antrodiella hoehnelii	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	I
Pluteus romelii	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	I
Armillaria lutea	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	I
Coprinus truncorum	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	I
Hyphodontia radula	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	I
Piptoporus betulinus	.	.	.	.	.	.	.	4r	.	.	.	.	.	.	.	.	.	I
Trametes versicolor	.	.	.	.	.	.	.	.	xa	.	.	.	.	.	.	.	.	I
Pholiota mutabilis	.	.	.	.	.	.	.	.	4a	.	.	.	.	.	.	.	.	I
Gymnopus fusipes	.	.	.	.	.	.	.	.	2r	.	.	.	.	.	.	.	.	I
Pholiota tuberculosa	.	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	.	.	I
Galerina nana	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	I
Phellinus pini	.	.	.	.	.	.	.	.	.	.	xr	.	.	.	.	.	.	I
Galerina subbadipes	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	I
Crepidotus cesatii var. *subsphaerosporus*	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	I
Polyporus ciliatus	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	I
Fomes fomentarius	.	.	.	.	.	.	.	.	.	.	.	.	xr	.	.	.	.	I
Trametes hirsuta	.	.	.	.	.	.	.	.	.	.	.	.	xn	.	.	.	.	I

Bondarzewia mesenterica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2r	.	.	I
Lentinellus cochleatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	I
Megacollybia platyphylla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	I
Pholiota mixta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	I
Ramaria rubella	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	I
Fungi on litter and among mosses																		
Mycena pura	4n	4n	8n	10n-a	8n	7n-a	9r-n	7n	5a	6n-a	5n	8n	.	.	.	1r	.	IV
Auriscalpium vulgare	4r	.	2r	4n	2r	1n	.	3n	.	4n	3n	.	.	.	.	.	.	III
Mycena flavoalba	.	2r	.	.	.	1r	1r	3r	3n-a	4n	3n	4n	.	.	.	.	.	III
Gymnopus dryophilus	3r	2r	.	.	.	.	.	4a	.	.	.	.	2n	.	3n	1r	1r	III
Mycena aetites	2r	.	.	.	.	.	.	3r	2r	2r	1r	3r	.	.	.	.	.	II
Strobilurus tenacellus	.	2r	.	4n	.	4n	4n	.	.	4n	4n	.	.	.	.	.	.	II
Mycena acicula	.	.	4n-a	.	1r	1n	3r-n	.	1r	2r	.	.	.	.	.	.	.	II
Mycena capillaris	.	.	.	.	.	.	.	2n	2n-a	3n	2n	2n	.	.	.	.	.	II
Mycena sanguinolenta	.	1r	1n	2r-a	.	.	.	.	.	.	.	1r	.	.	.	.	.	II
Mycena polygramma	.	1n	.	.	1n	.	.	4r	3r-a	.	.	.	.	.	.	.	.	II
Clavulina cinerea	.	.	.	2n	.	1n	.	1n	.	.	1r	.	.	.	.	.	.	II
Clitocybe gibba	.	.	.	.	.	3n	.	.	4n	.	.	.	2n	.	1r	.	.	II
Mycena zephirus	.	.	.	.	.	.	.	4n	.	4r-a	5n	.	2n	.	.	.	.	II
Mycena flavescens	.	.	.	.	.	.	.	3r	4r	3r	.	.	.	.	.	.	.	II
Mycena metata	.	.	.	.	.	.	.	3r	2r	3r	2r	.	.	.	.	.	.	II
Strobilurus esculentus	.	.	.	.	.	.	.	.	4n	4n	4n	4n	.	.	.	.	.	II
Gymnopus confluens	.	.	.	.	.	.	.	.	.	.	4a	.	.	3a	4a	3a	.	II
Gymnopus peronatus	.	.	.	.	.	.	.	.	.	.	.	6a	.	4n	3n	1r	3n	II
Rhodocollybia butyracea var. *asema*	.	.	.	.	.	.	.	.	.	.	.	.	1r	2n	2n	.	1r	II
Mycena rosea	2r	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena galopus	.	2r	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Strobilurus stephanocystis	.	1r	.	.	.	4n	.	.	.	.	.	.	.	.	.	.	.	I
Clitocybe odora	.	.	.	1r	.	.	2r-n	.	.	.	.	.	.	.	.	.	.	I
Marasmius saccharinus	.	.	.	.	.	.	.	1r	2n	.	.	.	.	.	.	.	.	I
Mycena excisa	.	.	.	.	.	.	.	1r	.	1r	.	.	.	.	.	.	.	I
Mycena amicta	.	.	.	.	.	.	.	1r	.	.	.	1r	.	.	.	.	.	I
Mycena smithiana	.	.	.	.	.	.	.	.	2r	2r	.	.	.	.	.	.	.	I

Tab. 24 cont.

Gymnopus hariolorus	.	.	.	.	.	.	.	.	2a	.	.	1a	.	.	.	.	.	I
Mycena leptocephala	4r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena citrinomarginata	2r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Marasmius scorodonius	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Galerina mniophila	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Conocybe hexagonospora	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Conocybe brunnea	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Conocybe macrocephala	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Conocybe brachypodii	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Malanophyllum hematospermum	.	.	.	2n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Galerina fallax	.	.	.	1n	1r	.	.	.	.	.	.	.	.	.	.	.	.	I
Conocybe cf. *moseri*	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	I
Hemimycena delectabilis	.	.	.	.	1a	.	.	.	.	.	.	.	.	.	.	.	.	I
Clitocybe brumalis	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	I
Clitocybe metachroa	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	I
Marasmius epiphyllus	.	.	.	.	.	.	.	3a	.	.	.	.	.	.	.	.	.	I
Clitocybe diatreta	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	I
Clitocybe squamulosa	.	.	.	.	.	.	.	.	3a	.	.	.	.	.	.	.	.	I
Mycena stylobates	.	.	.	.	.	.	.	.	2r	.	.	.	.	.	.	.	.	I
Mycena cyanorrhiza	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	I
Mycena purpureofusca	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	I
Rhodocollybia butyracea var. *butyracea*	.	.	.	.	.	.	.	.	.	.	.	3r	.	.	.	.	.	I
Clitocybe obsoleta	.	.	.	.	.	.	.	.	.	.	.	3n	.	.	.	.	.	I
Gymnopus ocior	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	I
Volvariella murinella	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	I
Clitocybe candicans	.	.	.	.	.	.	.	.	.	.	.	1a	.	.	.	.	.	I
Mycena laevigata	.	.	.	.	.	.	.	.	.	.	.	.	.	1a	.	.	.	I
Clitocybe dealbata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	I
Pseudoclitocybe cyathiformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1a	.	I

Terrestrial fungi constitute 42.2% of all *Basidiomycetes* in the community (Fig. 7a). A great number of pedobionts, dominated by mycorrhizal fungi (80 species), results from factors such as the diversity of tree species that encourage the development of a significant group of mycorrhizal fungi. *Abies alba, Fagus sylvatica, Pinus sylvestris, Quercus petraea* and *Q. robur* as well as numerous mycorrhiza-forming shrubs are of particular importance in this respect. A total number of 43 exclusive species classified in the first degree of constancy was recorded. Locally differential species include the following exclusive species: *Amanita strobiliformis, Boletus pulverulentus, Conocybe macrocephala, C. subpallida, Cortinarius gracilior, C. venetus, Inocybe griseolilacina, I. splendens, Lepiota clypeolaria, Lyophyllum loricatum* and *Melanoleuca cognata*. *Lepiota clypeolaria* was also considered by Lisiewska (1979) to be a differential species in the oak-lime-hornbeam forest. The occurrence range of other *Basidiomycetes* is broader, and although they were exclusive species at these research plots, they were also recorded outside them in other communities, for instance in *Dentario glandulosae-Fagetum* and *Querco-Pinetum*. Thus their diagnostic value can only be applicable to higher syntaxa. The choice of fungi characteristic of *Tilio-Carpinetum* in the Góry Świętokrzyskie Mts. is made particularly difficult as patches of the community are characterised by a fairly high variability of the dendroflora, a factor of certain importance for fungi. Therefore, a great similarity and a number of shared species are observed between this community and other forest groups, for instance *Dentario glandulosae-Fagetum* – 26 species, *Serratulo-Pinetum* – 24 species, *Querco-Pinetum* – 23 species and *Potentillo-Quercetum* – 22 species. The presence of *Fagus sylvatica* in the *Tilio-Carpinetum* stand encourages the development of fungi typical of beech forests, for example *Entoloma rhodopolium* var. *nidorosum, Lactarius pallidus, Russula amoenicolor, R. mairei* and *R. violeipes*. Except *Russula amoenicolor* and *R. violeipes*, these species were also recorded by Lisiewska (1978a, 1979) in the Carpathian beech forest. *Inocybe cervicolor, I. fuscidula, Ramaria abietina* and *Russula sanguinea*, which accompany *Pinus sylvestris*, serve to connect the oak-hornbeam forest and *Serratulo-Pinetum*. Both communities also share other species, for instance *Hebeloma crustuliniforme* and *Inocybe hirtella*, which are associated with *Quercus*, among others, and can develop in the community with this tree species. Furthermore, numerous ubiquitous species that grow in the majority of the associations examined in the project occur in the area.

The degree of constancy is low in the case of terrestrial fungi in *Tilio-Carpinetum*. It exceeded 2 only for eight ubiquitous species while that of others, that is 92.4%, equalled only 1. Litter-inhabiting and bryophilous fungi constitute 24.8% of the basidiomycete biota in the oak-hornbeam forest (Fig. 7b). There were only 18 exclusive species. Only the following fungi appear to be locally characteristic: *Clitocybe brumalis, C. obsoleta, Conocybe brachypodii, C. hexagonospora, Gymnopus hariolorum, Hemimycena delectabilis, Melanophyllum hematospermum, Mycena cyanorrhiza* and *M. excisa*. *Conocybe brachypodii* and *C. hexagonospora* are species new to Poland; the others, on the other hand, are rare and are associated with fertile deciduous forests. Fungi growing on litter in the oak-hornbeam forest are particularly conspicuously similar to those in the thermophilous oak forests with which they share 42.6% species, the Carpathian beech forest – 39.3%, and the subboreal mixed forest where the resemblance is 32.8%. *Mycena flavescens* and *Geastrum quadrifidum* are exclusive to the oak-hornbeam forest and thermophilous oak forest. The latter was also recorded in the subboreal mixed forest. *Clitocybe odora, Coprinus truncorum* and *Pseudoclitocybe cyathiformis* as well as *Coprinus xanthothrix,* which was also recorded in the thermophilous oak forest, are connective species of the oak-hornbeam forest and the beech forest. *Clitocybe squamulosa*, *Galerina mniophila* and *Mycena capillaris* were exclusive common species in the case of the oak-hornbeam forest and the subboreal mixed forest. A great majority of litter-inhabiting saprobionts recorded in *Tilio-Carpinetum* was also recorded in other forest communities and is of little selective value. The following species were characterised by the greatest constancy: *Mycena pura* (IV degree of constancy), *Auriscalpium vulgare, Gymnopus dryophilus*, and *Mycena flavoalba* (III degree). 67.8% of species half of which were recorded only once was classed in the first degree of constancy.

Lignicolous fungi constitute 33.3% of all *Basidiomycetes* recorded in the community (Fig. 7c). A high species diversity of xylobionts arises from a great number of ligneous plant species. The presence of a varied dendroflora makes xylobionts in the oak-hornbeam forest greatly similar to lignicolous species in *Dentario glandulosae-Fagetum*, 28 species, that is 35% of this mycobiota, then *Leucobryo-Pinetum* and *Potentillo-Quercetum*, 22 species, that is 27.5%, and *Querco-Pinetum* – 20 species, that is 25% (Fig. 12). Species exclusive to *Tilio-Carpinetum* constitute a significant group – 30 species, that is 37%, and determine the special nature of this association. Only some of them can be considered to be regionally characteristic. Those include *Crepidotus mollis* var. *calolepis, Galerina fallax, G. subbadipes, Pholiota mixta, Ph. tuberculosa, Phylloporia ribis, Pluteus chrysophaeus, P. plautus* and *P. romellii*. Special attention should be paid to *Galerina fallax* and *Phylloporia ribis*, fungi usually recorded almost exclusively in *Tilio-Carpinetum* in other parts of Poland; thus, their diagnostic value is above the regional level (Ławrynowicz 1973; Wojewoda 1974; Łuszczyński 1999b; Wojewoda *et al.* 1999). The presence of a few very rare species, for instance *Ramaria rubella*, was recorded within this ecological group and in the group of exclusive species (Łuszczyński 2007a, b). The fungus is known only from the Góry Świętokrzyskie Mts. and is closely associated with fir wood. A fir saprophyte, it was also observed in *Abietetum polonicum* and *Dentario glandulosae-Fagetum* outside the study area. This stresses a close and direct relationship between the fungus and the substrate (*Abies* wood), and not between the fungus and the phytocoenosis type. Similar correlations and relationships between the fungus and the substrate were observed in the case of *Amylostereum chailletii, Bondarzewia mesenterica, Exidiopsis grisea* and *Ganoderma carnosum*.

Similarly to pedobionts, xylobionts emphasise the complex biocoenotic relationships within *Tilio-Carpinetum* in the Góry Świętokrzyskie Mts. The presence of beech, fir and pine in the phytocoenoses in this community encourages the migration of fungi associated with them to the oak-hornbeam forests and the disappearance of genetic differences between various communities.

The constancy degree of lignicolous species is on the whole low in the association. The highest, third degree was recorded in the case of *Psilocybe fascicularis*, and the second degree in the case of *Armillaria ostoyae, Fomitopsis pinicola, Galerina marginata, Gymnopilus penetrans, Pluteus atricapillus, Polyporus varius, Stereum hirsutum* and *Xerula radicata*. The degree of constancy of other species, that is 89% of xylobionts, equalled one.

Luzulo pilosae-Fagetum

Habitat and phytosociological description. Plots in *Luzulo-Fagetum* were established on Chełmowa Góra Mt in the Świętokrzyski National Park. Phytocoenoses in this community cover areas that are flat or slightly inclined, from 3° to 5°, towards SSW. This type of the beech forest develops on luvisols, formed from decalcified loess, with acid pH from 4.7 to

4.8 and moder humus. According to Głazek (1985a), these soils are of low humic quality, poor in phosphorus, potassium and total nitrogen.

The stand is composed of many generations of beech trees with *Quercus petraea* and *Q. robur* admixtures, reaching the density between 80 and 95% (Tab. 25). Due to the high shading caused by the tree crowns, the field layer is usually poorly developed, from 10 to 25%, or does not develop at all. It consists of tree saplings, firs and hornbeams as well as single *Corylus avellana, Euonymus europaea, Frangula alnus* and *Sambucus nigra* shrubs. Floristically deficient, the shrub layer covers from 30 to 80% of the surface. Among it, the greatest quantitative presence is observed for *Anemone nemorosa* and *Maianthemum bifolium*. Other species occur infrequently. These are: *Asarum europaeum*, *Athyrium filix-femina, Galeobdolon luteum, Galium odoratum, Luzula pilosa, Milium effusum, Oxalis acetosella, Stellaria holostea* and *Vaccinium myrtillus*. Mosses occur only in very small quantities, in places exposed by the litter. *Atrichum undulatum*, *Brachythecium salebrosum* and *Polytrichastrum formosum* occur sporadically.

A deposit of thick layers of the litter composed mostly of beech leaves that have not been decomposed was observed in all the research plots.

Mycological description. Fungi in the *Luzulo pilosae-Fagetum* were examined at four plots where 112 mycological observations were conducted and 98 species of *Basidiomycetes* were collected (Tab. 26). There were 52 species of terrestrial fungi, 23 species of saprobionts on litter and 23 species of xylobionts (Fig. 7a-c). The number of basidiomycete taxa at individual plots ranged from 27 to 49. The mycobiota of the beech forest was similar to *Dentario glandulosae-Fagetum*, with which it shared 56.1% species, to *Querco-Pinetum* and *Tilio-Carpinetum* – 41.8% each, *Potentillo-Quercetum* – 40.8% and *Abietetum polonicum* – 32.6% (Fig. 8). The individual character of the acid beech forest biocoenosis is strengthened by exclusive fungi, 16 species of which were recorded in the entire mycobiota of this community. The role of *Basidiomycetes* in the floristically poor *Luzulo-Fagetum* biocoenosis is significant and exceeds vascular plants in a ratio of 3.9:1.

Terrestrial fungi constitute 53.1% of the mycobiota in the community. Nine terrestrial species (17.3%) are exclusive taxa. Mycorrhizal fungi constitute over 82% of pedobionts. *Cortinarius bicolor, C. nemorensis, Lactarius fuliginosus* and *Russula aquosa* are of the greatest diagnostic value for *Luzulo-Fagetum* in the Góry Świętokrzyskie Mts. The first three are beech symbionts while the latter is a pine and spruce symbiont. According to Lisiewska (1974), *Cortinarius nemorensis* is characteristic of the *Fagion sylvaticae* alliance and prefers fertile mountain beech forests. Despite their exclusive status, the other species were also recorded outside the research plots in other forest communities and cannot be treated as the syntaxon's characteristic species.

Fagus sylvatica is a phytobiont that brings together some mycorrhizal fungi growing in *Luzulo-Fagetum* and *Dentario glandulosae-Fagetum*. *Cortinarius cinnabarinus, C. trivialis* and *Lactarius subdulcis* are such connective species. Fungi growing with this tree species in *Abietetum polonicum*, for instance *Cortinarius anomalus, Lactarius piperatus* and *Russula albonigra*, occur with this fungus, while *Russula adusta* and *R. rosea* occurred in all the three communities listed above. *Lactarius piperatus* and *L. subdulcis* are believed to be characteristic species of the order *Fagetalia* (Lisiewska 1974).

As regards terrestrial fungi, *Luzulo-Fagetum* shows the greatest affinity with pedobionts in *Dentario glandulosae-Fagetum* – 50%, and *Abietetum polonicum* – 38.5% (Fig. 10).

Table 25
Luzulo pilosae-Fagetum

Successive number		1	2	3	4
Number of plot		2	3	4	5
Date		19.05.2001			
Locality		Chełmowa Góra Mt			
Density of tree layer	a in %	80	85	90	95
Density of shrub layer	b in %	20	25	10	0
Cover of herb layer	c in %	80	80	40	30
Cover of moss layer	d in %	+	+	+	+
Number of plant species		19	13	11	10
Exposure		SSW	SSW	SSW	-
Inclination in degrees		3	5	3	0
Surface of investigated plots in m^2		400			
ChAll. *Fagion sylvaticae*					
Fagus sylvatica	a	3.3	2.3	2.1	2.1
Fagus sylvatica	b	2.2	2.3	2.2	.
Fagus sylvatica	c	+	+	1.1	1.1
DAss. *Luzulo pilosae-Fagetum*					
Luzula pilosa		+	.	+.2	+.2
Trientalis europaea		.	.	+	.
ChO. *Fagetalia sylvaticae*					
Carpinus betulus	b	+.2	.	.	.
Padus avium	b	+.2	.	.	.
Galeobdolon luteum		+	.	.	1.1
Viola reichenbachiana		.	.	+	+
Asarum europaeum		1.2	.	.	.
Milium effusum		+.2	.	.	.
Stellaria holostea		+.2	.	.	.
Galium odoratum		.	.	1.2	.
ChCl. *Querco-Fagetea*					
Euonymus europaea	b	+	.	.	.
Euonymus europaea	c	.	+	.	.
Anemone nemorosa		4.4	4.4	2.2	2.2
Others					
Abies alba	b	1.2	+	.	.
Quercus robur	a	1.2	4.3	4.4	.
Quercus robur	b	1.2	.	.	.
Quercus robur	c	.	+	.	.
Quercus petraea	a	.	.	.	4.4
Frangula alnus	b	.	+	.	.
Sambucus nigra	b	+	.	.	.

Tab. 25 cont.

Sambucus nigra	c	.	.	+	.
Maianthemum bifolium		.	1.2	2.3	1.2
Oxalis acetosella		+.2	.	.	+.2
Athyrium filix-femina		+.2	+	.	.
Vaccinium myrtillus		+.2	1.2	.	.
Rubus hirtus		+	+	.	.
Galium vernum		.	+	.	.
Rubus idaeus		.	.	+	.
Brachythecium salebrosum	d	+.2	+.2	+.2	+.2
Polytrichastrum formosum	d	+.2	.	.	+.2
Atrichum undulatum	d	.	+.2	.	.

Table 26

Fungi in *Luzulo pilosae-Fagetum*

Number of plot		2	3	4	5	Frequency
Locality		Chełmowa Góra Mt				
Density of tree layer	a in %	80	85	90	95	
Density of shrub layer	b in %	20	25	10	0	
Cover of herb layer	c in %	80	80	40	30	
Cover of moss layer	d in %	+	+	+	+	
Exposure		SSW	SSW	SSW	-	
Inclination in degrees		3	5	3	0	
Surface of investigated plots in m²		400				
Number of observations		28	28	28	28	
Number of plant species		19	13	11	10	
Number of fungi species		27	49	47	41	
Fungi on soil						
Laccaria amethystea		6n	6n	6n	6n	4
Lycoperdon perlatum		4n-a	3n-a	.	4n	3
Russula vesca		3r	.	4r	2r	3
Macrolepiota rhacodes		2n	2r	.	3n	3
Amanita citrina		.	5r	3r	3r	3
Lactarius quietus		.	3n	5r	3n	3
Russula aeruginea		.	3r	2r	2r	3
Suillus grevillei		4n	.	.	4n	2
Lycoperdon molle		3n-a	3n-a	.	.	2
Amanita vaginata		2r	.	3r	.	2
Lactarius fulvissimus		2r	2r	.	.	2
Macrolepiota procera		2r	2r	.	.	2
Xerocomus badius		2r	.	1r	.	2
Amanita excelsa		.	3r	3r	.	2
Cortinarius trivialis		.	3r	.	3r	2
Lactarius vellereus		.	3r	4n	.	2
Lepista flaccida		.	.	3n	3n	2
Lepista nuda		.	1n	1n	.	2

Tab. 26 cont.

Russula adusta	.	1r	1r	.	2
Russula cyanoxantha	.	.	3n	3n	2
Russula undulata	.	2r	1r	.	2
Cortinarius nemorensis	3r	.	.	.	1
Lactarius decipiens	3r	.	.	.	1
Xerocomus subtomentosus	2r	.	.	.	1
Tricholoma album	2n	.	.	.	1
Laccaria laccata	.	4n	.	.	1
Psilocybe aeruginosa	.	3n-a	.	.	1
Cortinarius cinnabarinus	.	2r	.	.	1
Lactarius piperatus	.	2r	.	.	1
Russula nigricans	.	2r	.	.	1
Cortinarius bicolor	.	1r	.	.	1
Inocybe sindonia	.	1r	.	.	1
Lactarius ichoratus	.	1r	.	.	1
Russula albonigra	.	1r	.	.	1
Amanita eliae	.	.	2r	.	1
Amanita porphyria	.	.	2r	.	1
Lepista gilva	.	.	2n	.	1
Amanita pantherina	.	.	1r	.	1
Cortinarius anomalus	.	.	1r	.	1
Lactarius blennius	.	.	1r	.	1
Russula alutacea	.	.	1r	.	1
Russula fragilis	.	.	1r	.	1
Russula xerampelina	.	.	1r	.	1
Agaricus silvicola	.	.	.	2r	1
Inocybe fastigiata	.	.	.	3r-n	1
Inocybe geophylla	.	.	.	2r	1
Lactarius chrysorrheus	.	.	.	2n	1
Lactarius subdulcis	.	.	.	1n	1
Russula aquosa	.	.	.	1r	1
Russula ochroleuca	.	.	.	2n	1
Russula risigallina	.	.	.	1r	1
Russula rosea	.	.	.	2r	1
Fungi on wood					
Crepidotus variabilis	5n-a	4n-a	5n-a	5n-a	4
Stereum hirsutum	xn	xn	xn	.	3
Lycoperdon pyriforme	.	3a	4a	3a	3
Phellinus robustus	.	xn	xn	xn	3
Psilocybe fascicularis	.	8a	6a	9a	3
Irpex ochraceus	.	xn	xn	.	2
Pluteus atricapillus	.	.	3r	2r	2
Tremella mesenterica	.	.	2n	1n	2
Xerula radicata	.	.	2r	2r	2
Heterobasidion annosum	xr	.	.	.	1

Tab. 26 cont.

Tricholomopsis rutilans	1n	.	.	.	1
Mycena galericulata	.	3n	.	.	1
Pholiota spumosa	.	2r-n	.	.	1
Crepidotus cesatii var. *subsphaerosporus*	.	2a	.	.	1
Lentinus lepideus	.	1n	.	.	1
Gymnopilus junonius	.	1a	.	.	1
Phellinus igniarius	.	.	xr	.	1
Paxillus atrotomentosus	.	.	2r	.	1
Armillaria ostoyae	.	.	2n	.	1
Fomes fomentarius	.	.	.	xn	1
Fomitopsis pinicola	.	.	.	xn	1
Trametes ochracea	.	.	.	xn	1
Fungi on litter					
Clitocybe gibba	3n-a	3n	4n	3n-a	4
Mycena pura	6n	5n	5n	6n	4
Rhodocollybia butyracea var. *asema*	4n-a	4r	4n	4n	4
Gymnopus dryophilus	5r	3r	3r	.	3
Clitocybe dealbata	.	2n	3n	2n	3
Mycena aetites	.	4n	4n	4n	3
Mycena maculata	4n	.	4n	.	2
Coprinus leiocephalus	2n-a	.	2a	.	2
Clitocybe candicans	1n	.	.	+	2
Rhodocollybia butyracea var. *butyracea*	.	4n-a	.	2a	2
Clitocybe clavipes	.	3n	3n	.	2
Clitocybe phyllophila	.	3n	3n	.	2
Clitocybe odora	.	.	5n	3n	2
Strobilurus tenacellus	4a	.	.	.	1
Clitocybe vibecina	1r	.	.	.	1
Strobilurus stephanocystis	.	4a	.	.	1
Calvatia excipuliformis	.	2n	.	.	1
Mycena metata	.	2n	.	.	1
Mycena epipterygia	.	2a	.	.	1
Clitocybe geotropa	.	1r	.	.	1
Clitocybe inornata	.	.	.	1n	1
Gymnopus peronatus	.	.	.	4n-a	1
Rhodocybe popinalis	.	.	.	2a	1

The frequency of ubiquitous species was the greatest; only 7 species were recorded at three and four plots while over 60% were recorded only once.

Litter-inhabiting fungi in *Luzulo-Fagetum* constitute 24.5% (24 species) of the mycobiota in the community. Four exclusive species were recorded: *Clitocybe geotropa, C. inornata, C. phyllophila* and *Rhodocybe popinalis*, of which only *Clitocybe inornata* and *C. phyllophila* can be considered to be locally characteristic. *Rhodocybe popinalis* was recorded outside permanent plots in *Dentario glandulosae-Fagetum*. *Coprinus leiocephalus, Mycena maculata* and *M. fagetorum* were also recorded in this community. The latter is considered to be characteristic of the *Fagion sylvaticae* alliance and is significantly attached to mountain beech forests. The greatest similarity is observed with the Carpathian beech forest community, reaching 60.9% of shared species.

The greatest frequency and, at the same time, the greatest fruitbody productivity in the patches were observed in the case of fungi of little selective value, such as *Clitocybe gibba, Mycena pura, Gymnopus dryophilus* and *Rhodocollybia butyracea* var. *asema*.

Xylobionts constitute 22.5% (22 species) of the association's mycobiota. Apart from *Gymnopilus junonius*, exclusive species are of little specific value and do not represent much diagnostic value. *Gymnopilus junonius* is associated with, among others, *Fagus* and *Quercus* wood as well as with *Betula* and *Pinus* wood in its broader range (Lisiewska 1978a, 1979; Bujakiewicz & Lisiewska 1983; Flisińska 2000a, b; Ławrynowicz & Stasińska 2000); therefore, its diagnostic value is only local. Lignicolous fungi in the association show the greatest similarity with those in *Tilio-Carpinetum* – 60.9%, *Dentario glandulosae-Fagetum* – 52.2%, as well as *Leucobryo-Pinetum* and *Potentillo-Quercetum* – 43.5% each (Fig. 12). *Crepidotus cesatii* var. *subsphaerosporus*, *Tremella mesenterica* and *Xerula radicata,* whose fruitbodies develop on the wood of fallen *Fagus* twigs and, in the case of the latter, on *Fagus* roots, also grow in these communities.

The ecological scale of a great majority of xylobionts is broad and these fungi grow in most communities examined in this project. The following species are most numerous and are recorded most frequently: *Crepidotus variabilis, Phellinus robustus, Lycoperdon pyriforme, Psilocybe fascicularis, Stereum hirsutum*. Tree parasites (seven species) do not pose a major threat to the tree stand in *Luzulo-Fagetum*.

Dentario glandulosae-Fagetum

Habitat and phytosociological description. Plots in *Dentario glandulosae-Fagetum* were established for mycological studies in the Cisów and Zamczysko reserves and on Mt Wysokówka (Pasmo Orłowińskie Ridge), on Chełmowa Góra Mt and in the Klonów protection zone in the Świętokrzyski National Park. Phytocoenoses of the Carpathian beech forest develop on luvisols and mesic cambisols of the following subtypes: grey-brown soils, brown leached soils, gleysols, acid cambisols. These soils were formed from silty dusts and dusty sands lying on various formations such as clays, clayey sands and loose sands. These soils are rich in mull humus and moder humus. The acidity of accumulation horizons ranges from pH 4.7 to 6.1.

The phytocoenoses examined here represent a beech-fir forest composed of many species with a varying degree of admixture by *Acer platanoides, A. pseudoplatanus* and single trees of *Betula pendula*, *Carpinus betulus, Larix decidua* ssp. *polonica, Pinus sylvestris, Quercus petraea* and *Q. robur* (Tab. 27). The crown density is usually high and ranges from 70 to 90%. The shrub layer is moderately developed and its cover is between 20 and 50%. It is mostly formed by saplings of deciduous species. Species of *Corylus avellana, Euonymus europaea, Sambucus nigra* and *S. racemosa* are also present. Despite significant shading, the field layer is usually developed well and covers the surface from 60 to 80%, infrequently less extensively. *Dentaria glandulosa* (V degree of constancy) and *D. bulbifera* (IV degree) are *Dentario glandulosae-Fagetum* characteristic species that grow in the area. The greatest constancy was achieved by the following species of the order *Fagetalia*: *Galeobdolon* *luteum* (V degree), *Galium schultesii* and *Paris quadrifolia* (III degree) as well as *Allium ursinum, Dryopteris filix-mas* and *Viola reichenbachiana* (II degree).

The occurrence of *Allium ursinum* was recorded in the Zamczysko reserve and on Mt Wysokówka, at five plots. Therefore, a variant with this species present can be distinguished. Phytocoenoses of this type develop on habitats that are more fertile than in the typical variant, on slopes directed northwards but also towards SE, E, and inclined from 15 to 25°.

The moss layer is usually poorly developed or not developed at all. High amounts of dead wood, mostly beech and fir, which occurs in the developmental stages, up to the end phase in the Zamczysko reserve, as well as trunks and logs undergoing successive phases of decomposition lie on the forest floor.

The beech tree stand on Wysokówka was rejuvenated following forest thinning, and the remaining stumps provide sites for xylobiont development.

Mycological description. *Basidiomycetes* in the Carpathian beech forest were observed at 17 permanent plots where 530 mycological observations were conducted and 186 species were collected (Tab. 28). Those include 75 species of terrestrial fungi, 51 fungi on litter and 60 lignicolous species. The number of taxa at individual plots ranged between 14 and 48. As regards the species type, the mycobiota in *Dentario glandulosae-Fagetum* resembles the most that in *Tilio-Carpinetum*, with which it shares 44.8% species, *Potentillo-Quercetum* – 32.3%, *Abietetum polonicum* – 31.3% and *Querco-Pinetum* – 30.8% (Fig. 8). Thirty-nine exclusive species were recorded, that is 21.1% of all *Basidiomycetes*. The role of fungi in the *Dentario glandulosae-Fagetum* biocoenosis and their number exceed those of vascular plants in a ratio of 2.5:1.

Pedobionts constitute 40.3% (75 species) of *Basidiomycetes* at the research plots and are the most numerous ecological group in the Carpathian beech forest. Of them, 57 species, that is 76%, are mycorrhizal fungi (Fig. 7a). There were 15 exclusive species; the following fungi are of the highest diagnostic value: *Agaricus comtulus*, *Cortinarius coerulescens, C. torvus, C. viscidulus, Lyophyllum gangraenosum, Russula brunneoviolacea, R. cuprea* and *R. zonatula*. These fungi are mostly of local value but *Cortinarius coerulescens* and *C. torvus* may be assigned the value of species characteristic of *Dentario glandulosae-Fagetum* above the regional level (Lisiewska 1974; Wojewoda 2003).

Lisiewska (1979) reports species such as *Lactarius glyciosmus,* characteristic of the community, from the Świętokrzyski National Park. The species was found in *Tilio-Carpinetum* patches in this project.

As a result of the presence of major forest-forming species in the beech forest, *Abies alba* and *Fagus sylvatica*, in various forest communities, mycobionts of these trees are recorded not only in beech forests but also in other communities. Terrestrial fungi mostly resemble those in *Abietetum polonicum*, with which they share 33 species, that is 44% pedobionts, *Luzulo-Fagetum* and *Tilio-Carpinetum* – 26 species each, that is 34.7% (Fig. 10). Species exclusive of the beech forest and the fir forest are *Lactarius ichoratus* and *L. lignyotus* (also only in the *Abies alba-Sphagnum girgensohnii* community), and for the latter pair – species listed in the description of *Luzulo-Fagetum*. *Leccinum pseudoscabrum* and *Phallus impudicus* turned out to be exclusive species in the case of the Carpathian beech forest and the oak-hornbeam forest.

Xerocomus pascuus (IV degree of constancy), *Lactarius subdulcis, Lycoperdon perlatum, Macrolepiota rhacodes* and *Ramaria eumorpha* (III degree of constancy) had the highest

Table 27
Dentario glandulosae-Fagetum

Successive number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Constancy
Number of plot		4	5	1	6	7	2	3	8	9	10	1	5	2	3	1	3	4	
Date		19.05.2003				20.05.	19.05.2003		20.05.2003			19.05	16.06.2002				18.06.2000		
Localities		Wysokówka Mt				Zamcz	Wysokówka		Zamczysko res.			Ch.G.	Cisów res.				Klonów		
Density of tree layer	a in %	90	70	85	80	95	85	85	85	80	90	70	70	70	70	80	90	90	
Density of shrub layer	b in %	20	50	20	40	30	25	40	40	25	30	40	40	40	30	20	25	30	
Cover of herb layer	c in %	70	70	70	70	70	70	60	70	70	60	80	80	70	30	10	40	40	
Cover of moss layer	d in %	-	-	+	-	-	+	-	-	-	-	+	5	5	+	+	+	+	
Number of plant species		28	17	19	36	30	29	30	20	19	17	21	19	18	14	12	15	13	
Exposure		N	N	SE	N	E	SE	N	E	S	S	SSW	W	S	E	S	SW	SW	
Inclination in degrees		25	15	25	15	15	25	20	10	30	30	3	35	10	20	5	3	3	
Surface of investigated plots in m²		400																	
		variant with *Allium ursinum*					typical												
ChAss. *Dentario glandulosae-Fagetum*, ChAll. *Fagion sylvaticae*																			
Fagus sylvatica	a	3.3	4.3	2.2	4.4	4.4	2.2	4.4	4.4	3.3	4.4	3.2	4.4	2.3	4.4	4.4	4.4	4.3	V
Fagus sylvatica	b	1.1	1.1	1.1	1.1	2.2	1.2	1.2	1.2	1.2	1.1	2.2	3.3	3.3	4.4	2.3	2.2	2.1	V
Fagus sylvatica	c	.	.	+	.	.	.	.	.	.	+	.	1.1	1.1	+	1.1	+	1.2	III
Dentaria glandulosa		3.3	3.3	+.2	3.3	3.3	2.2	3.3	3.3	3.3	1.2	.	1.1	1.2	+	+	.	.	V
Dentaria bulbifera		2.3	1.2	1.2	1.2	3.3	1.2	.	3.3	3.3	3.3	.	1.2	2.3	.	1.1	1.2	.	IV
ChO. *Fagetalia sylvaticae*																			
Acer pseudoplatanus	a	2.2	1.1	4.3	.	3.3	4.4	.	3.3	2.3	1.2	.	.	.	.	.	+	.	III
Acer pseudoplatanus	b	.	1.1	+		.	.	1.2	.	1.1	.	.	.	.	.	.	.	+	II
Acer pseudoplatanus	c	1.1	1.1	+		+	.	+	+	.	.	.	.	.	.	.	.	.	II
Carpinus betulus	a	1.1	.	.	.	.	.	.	.	1.2	.	1.2	.	.	.1.1	.	2.2	1.2	II
Carpinus betulus	b	+	.	.	1.1	.	.	.	+.2	.	.	+	.	.	.	.	1.1	.	II
Carpinus betulus	c	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	1.2	2.2	II
Padus avium	b	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I

Ribes spicatum	b	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	I
Galeobdolon luteum		1.2	2.2	1.2	2.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	2.2	2.2	2.2	+.2	.	.	V
Galium schultesii		1.2	.	+.2	.	1.2	1.2	.	1.2	+.2	1.2	.	.	.	.	.	.	.	III
Paris quadrifolia		.	.	1.1	1.2	1.2	1.2	1.2	.	1.2	.	.	+	.	.	.	.	.	III
Allium ursinum		1.2	2.2	1.2	2.3	+.2	.	.	.	.	.	.	.	.	.	.	.	.	II
Mercurialis perennis		1.2	.	.	.	.	.	+.2	.	.	.	.	.	.	.	.	.	.	I
Isopyrum thalictroides		+.2	.				.		.	.		.	.	.	.	.	.	.	I
Polygonatum mutiflorum		+.2	.	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	.	I
Viola reichenbachiana		.	.	.	.	.	.	.	.	+	+	.	+	+.2	.	+.2	.	.	II
Dryopteris filix-mas		.	+.2				.		.	.		.	+.2	.	+.2	+.2	.	+	II
Asarum europaeum		.	.	.	.	.	.	.	.	.	.	2.2	.	.	.	.	.	.	I
Milium effusum		.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	+	I
Stellaria holostea		.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	I
Lathyrus vernus		.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Pulmonaria obscura		.	.	.	.	.	.	.	.	.	.	+	1.2	.	.	.	.	.	I
Ranunculus lanuginosus		.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Sanicula europaea		.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Carex remota		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I
Actaea spicata		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I
Adoxa moschatellina		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I
Veronica montana		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I
Galium odoratum		.	.	.	.	.	.	.	.	.	.	.	3.3	.	+.2	.	.	.	I
Impatiens noli-tangere		.	.	.	.	.	.	.	.	.	.	.	1.2	.	+.2	.	.	.	I
Atrichum undulatum	d	.	.	.	.	.	.	.	.	.	.	.	.	+.2	+.2	+.2	.	.	I
ChCl. *Querco-Fagetea*																			
Acer platanoides	a	.		2.2	.	1.2	2.2	.	.	.	2.3	.	.	.	.	.	.	.	II
Acer platanoides	b	.	1.1	.	1.1	+	.	1.2	1.1	1.1	.	.	.	.	.	.	.	.	II
Acer platanoides	c	.		+	.	1.2	+	.	1.2	.	1.2	.	.	.	.	.	.	.	II
Lonicera xylosteum	b	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	I
Corylus avellana	b	.	.	.	.	.	.	.	.	.	.	1.2	+.2	.	.	.	.	.	I
Euonymus europaea	c	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I

Tab. 27 cont.

Anemone nemorosa		+.2	1.2	1.1	2.2	.	1.2	2.3	.	.	.	3.3	+.2	1.2	1.2	.	.	.	III
Melica nutans		.	.	.	.	.	.	.	.	.	.	1.2	+.2	.	.	.	.	.	I
Hepatica nobilis		.	.	.	.	.	.	.	.	.	.	+	+.2	.	.	.	.	.	I
Aegopodium podagraria		.	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	I
Carex digitata		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+.2	I
Others																			
Abies alba	a	3.4	.	1.2	2.2	1.2	.	2.2	1.2	2.3	1.2	.	3.3	3.3	4.4	3.3	.	2.2	IV
Abies alba	b	2.1	3.3	2.2	3.3	2.3	3.3	3.3	3.3	1.2	2.2	1.2	.	1.2	.	.	1.1	1.1	V
Abies alba	c	+	.	+	+	.	+.2	+.2	.	.	+	.	+	+	+	+	+	+	IV
Quercus petraea	a	.	.	.	.	.	.	.	.	.	.	.	1.1	.	1.1	1.1	.	.	I
Quercus robur	a	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	I
Quercus robur	b	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Quercus robur	c	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Larix decidua ssp. *polonica*	a	.	.	.	.	.	.	.	.	.	.	1.2	1.2	.	.	.	.	.	I
Betula pendula	a	.	.	1.1	.	.	1.1	.	.		.	.	.	.	.	.	.	1.2	I
Pinus sylvestris	a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	I
Sambucus racemosa	b	+.2	+.2	.	.	+.2	.	.	1.2	.	.	.	+.2	.	.	+.2	.	.	II
Sambucus racemosa	c	.	.	.	+.2	.	+	.	.	+	.	.	.	.	.	+	.	+	II
Sorbus aucuparia	b			.	.	.		1.2			.	+	.	+	.	.	1.1	.	II
Sorbus aucuparia	c	+.2	.	+	.	.	+	+	.	.	.	.	.	+	.	.	+	+	III
Sambucus nigra	b	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	+.2	.	.	I
Sambucus nigra	c	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	.	II
Frangula alnus	b	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	I
Maianthemum bifolium		1.2	1.2	3.4	1.2	.	2.3	1.2	.	1.2	1.2	+	+	2.2	1.2	+	2.2	1.2	V
Rubus hirtus		2.2	1.2	+.2	1.2	+	+.2	1.2	+	.	+	1.2	1.2	3.3	+	+	.	.	V
Dryopteris carthusiana		.	1.2	+.2	.	1.2	1.2	+.2	.	+.2	1.2	+	+.2	1.2	1.2	+.2	+	+	V
Oxalis acetosella		+	+.2	1.2	+.2	.	1.2	.	.	.	.	1.2	1.2	2.2	2.2	1.2	+	1.2	IV
Athyrium filix-femina		1.2	1.2	.	1.2	+	.	2.2	1.2	1.2	.	.	2.2	1.2	1.2	+.2	+	+	IV
Dryopteris dilatata		1.2	.	1.2	+.2	.	1.2	+.2	.	.	.	.	.	+.2	+.2	+.2	.	.	III
Galeopsis pubescens		.	.	.	.	.	.	.	.	.	.	.	1.1	1.1	+	+	.	.	II

Rubus idaeus		.	.	.	.	.	.	.	.	.	.	+	.	+.2	.	+.2	.	.	I
Polygonatum odoratum		.	+.2	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	.	I
Galanthus nivalis		.	1.2	.	1.2	.	.	1.2	.	.	.	.	.	.	.	.	.	.	I
Gymnocarpium dryopteris		1.2	.	.	.	.	.	1.2	.	.	+.2	+.2	.	.	.	.	.	.	I
Urtica dioica		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Luzula pilosa		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+.2	I
Populus tremula	c	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	I
Rubus sp.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	+	I
Hedera helix		.	.	.	.	.	.	.	.	.	.	.	.	1.2	+	+.2	.	.	I
Moehringia trinervia		.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I
Geranium robertianum		.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I
Hieracium lachenalii		.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I
Vaccinium myrtillus		.	.	.	.	.	.	.	.	.	.	.	.	+.2	+.2	+.2	.	.	I
Pteridium aquilinum		.	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	I
Ajuga reptans		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I
Aruncus sylvestris		.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I
Calamagrostis villosa		.	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	I
Mycelis muralis		.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	I
Rhizomnium punctatum	d	.	.	+	.	.	.	.	.	.	.	+	.	+	+	+	.	.	II
Dicranella heteromalla	d	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	I
Polytrichastrum formosum	d	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	1.2	1.2	I
Brachythecium velutinum	d	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I
Herzogiella seligeri	d	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	I
Plagiothecium curvifolium	d	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	I
Pohlia nutans	d	.	.	.	+	.	.	.	.	.	.	.	.	+	.	+	.	.	I
Isothecium alopecuroides	d	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	I
Hypnum cupressiforme	d	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	I
Calypogeia trichomanes	d	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I
Plagiochila asplenioides	d	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	I

Ch.G. - Chełmowa Góra Mt; Zamcz - Zamczysko reserve

Table 28
Fungi in *Dentario glandulosae-Fagetum*

Number of plot		1	3	4	5	2	3	1	1	2	3	4	5	6	7	8	9	10	Constancy
Localities		Ch.G.	Klonów		Cisów				Wysokówka Mt						Zamczysko reserve				
Density of tree layer	a in %	70	90	90	70	70	70	80	85	85	85	90	70	80	95	85	80	90	
Density of shrub layer	b in %	40	25	30	40	40	30	20	20	25	40	20	50	40	30	40	25	30	
Cover of herb layer	c in %	80	40	40	80	70	30	10	70	70	60	70	70	70	70	70	70	60	
Cover of moss layer	d in %	+	+	+	5	5	+	+	+	-	-	-	-	+	-	-	-	-	
Exposure		SSW	SW	SW	W	S	E	S	SE	SE	N	N	N	N	E	E	S	S	
Inclination in degrees		3	3	3	35	10	20	5	25	25	20	25	15	15	15	10	30	30	
Surface of investigated plots in m²		400																	
Number of observations		32	33	33	28	28	28	28	32	32	32	32	32	32	32	32	32	32	
Number of plant species		28	17	19	36	30	29	30	20	19	17	21	19	18	14	12	15	13	
Number of fungi species		44	39	24	48	38	26	32	25	20	24	28	28	31	20	24	26	14	
Fungi on soil																			
Xerocomus pascuus		2r	.	2r	3r	.	3r	.	.	3r	1r	3n	1r	1r	.	1r	2r	.	IV
Ramaria eumorpha		.	.	.	.	4n	4n	4n	5n	1r	1r	3r	.	3r	.	.	3r	.	III
Lactarius subdulcis		.	.		6n	1n	1n	4n	3r	.	.	.	.	3n	.	.	.	3r	III
Lycoperdon perlatum		8n	.	.	5r	9n	3n	12n	.	.	.	.	2r	.	.	2r	3r	2r	III
Macrolepiota rhacodes		.	.	.	5r	.	.	.	3r	.	.	.	.	2r	1r	1r	3n	3n	III
Laccaria amethystea		3n	2r	3n	2r		.	3n	.	1r	.	.	.	.	.	.	.	.	II
Amanita rubescens		.	2r	2r	2r	1r	1r	.	.	.	.	.	.	2r	.	.	.	.	II
Laccaria laccata		.	6n	5r	3n	3n	.	3n	.	.	.	.	.	.	.	.	.	.	II
Phallus impudicus		1r	.	1r	.	2r	6r	.	.	.	.	.	.	.	.	3r	.	.	II
Russula ochroleuca		.	.	.	2r	.	6n	.	.	2r	1r	.	.	.	.	2r	.	.	II
Russula cyanoxantha		.	.	8r	.	.	.	9r	.	.	.	.	.	2r	3r	.	.	.	II
Lycoperdon molle		1r	.	.	.	.	.	.	.	.	1r	2n	1r	.	.	1r	1r	1r	II
Lepista nuda		1r	.	.	1r	.	.	.	2n	.	.	.	.	2n	.	.	.	.	II
Russula fellea		3r	.	.	.	3r	.	3r	.	.	.	.	.	.	.	.	.	.	I
Amanita excelsa		2r	.	.	.	.	.	.						.	.	.	.	.	I
Lactarius ichoratus		1r	2r	2r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lycoperdon umbrinum		1r	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cortinarius coerulenscens		1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Cortinarius cinnabarinus	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cortinarius viscidulus	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cortinarius trivialis	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula fragilis	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Tricholoma album	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Hygrophoropsis aurantiaca	1r	.	.	.	.	.	.	.	3r	.	.	.	.	2r	.	.	.	I
Rhodocybe popinalis	1a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula adusta	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Clavulina coralloides	.	9n	10r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lactarius camphoratus	.	6r	4r	.	.	.	2n	.	.	.	.	.	.	.	.	.	.	I
Lactarius blennius	.	4r	3r	.	.	.	.	.	.	.	.	.	.	.	.	.	1n	I
Russula emetica	.	3r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula turci	.	3r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Scleroderma verrucosum	.	3r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Clavulina cinerea	.	3n	4n	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula rosea	.	2r	3r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula claroflava	.	2r	2r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula mairei	.	1r	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lactarius piperatus	.	1r	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Amanita fulva	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula brunneoviolacea	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula lepida	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Russula zonatula	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cystoderma amianthinum	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Craterellus cornucopioides	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Amanita vaginata	.	.	2r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Leccinum pseudoscabrum	.	.	2r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Hebeloma versipelle	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Inocybe napipes	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lactarius lignyotus	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lepista flaccida	.	.	.	1n	1n	.	.	.	.	.	.	.	.	.	.	.	.	I
Lyophyllum gangraenosum	.	.	.	4n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Agaricus silvicola	.	.	.	1r	1r	2n	3r	.	.	.	.	.	.	.	.	.	.	I
Russula claroflava	.	.	.	1r	.	.		.	.	.	.	.	.	.	.	.	.	I
Lyophyllum connatum	.	.	.	1n	.	.	.	1n	.	.	.	.	1n	.	.	.	.	I

Tab. 28 cont.

Clitopilus prunulus	.	.	.	.	.	3n	2n	.	.	.	.	.	.	.	.	.	.	I
Paxillus involutus	.	.	.	.	.	2r	2n	.	.	.	.	.	.	.	.	.	.	I
Inocybe geophylla var. *lilacina*	.	.	.	.	.	2r	.	.	.	.	.	.	.	.	.	.	.	I
Agaricus comtulus	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	I
Lactarius aurantiacus	.	.	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	I
Entoloma juncinum	.	.	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	I
Tricholoma lascivum	.	.	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	I
Ripartites tricholoma	.	.	.		.	1n	.	.	.	.	.	.	.	.	.	.	.	I
Xerocomus badius	.	.	.	.	.	.	2r	.	.	.	.	.	.	.	.	.	.	I
Russula heterophylla	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	I
Psilocybe aeruginosa	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	I
Lactarius volemus	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	I
Galerina unicolor	.	.	.	.	.	.	.	1r	.	.	.	.	1r	.	.	.	.	I
Russula nigricans	.	.	.	.	.	.	.	.	2r	3n	.	.	.	.	.	.	.	I
Russula lutea	.	.	.	.	.	.	.		1r	.	.	1r	.	.	.	.	.	I
Russula aeruginea	.	.	.	.	.	.	.	.	.	2r	.	2r	.	.	2r	.	.	I
Cortinarius cf. *obtusus*	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	I
Cortinarius torvus	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	I
Clitocybe nebularis	.	.	.	.	.	.	.	.	.	.	.	1n						I
Russula cuprea	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	I
Lactarius vellereus	.	.	.	.	.	.	.	.	.	.	.	.	1n	.	.	.	.	I
Amanita citrina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2n	.	I
Fungi on wood																		
Stereum hirsutum	xa	xn	.	xn	xn	xn	xn	.	.	.	xa	xn	xn	.	.	xn	.	III
Xerula radicata	2n	.	.	5r	2r	.	24	5r	.	.	3r	3r	1r	.	.	3r	3r	III
Lycoperdon pyriforme	.	.	.	.	.	.	2r	.	.	1a	3a	1n	1n	1n	2n	.	.	III
Crepidotus variabilis	2n	.	.	5n	2n	.	2a	1a	.	.	1n	.	.	.	.	.	.	II
Pluteus atricapillus	1r	1r	.	1r	.	.	.	.	1r	.	.	1r	.	.	.	1r	.	II
Armillaria ostoyae	.	2n	.	3n	3a	1n	2n	.	.	.	.	.	.	.	.	.	.	II
Fomes fomentarius	.	.	.	xn			xr				xn	xr	.	.	.	xr	.	II
Polyporus varius	.	.	.	.	.	.	.	1r	.	1r	.	1r	1r	.	3r	.	.	II
Psilocybe fascicularis	.	.	.	3n	.	.	3a	.	.	.	.	3a	.	.	1a	.	.	II
Megacollybia platyphylla	.	1n	.	.	.	.	.	.	.	.	.	3a	1n	.	.	3n	.	II

Bjerkandera adusta	.	.	.	.	.	.	.	xa	.	.	.	.	xa	xa	.	.	.	I
Calocera viscosa	.	.	.	.	1n	.	2n	.	.	.	.	.	1n	.	.	.	.	I
Ganoderma applanatum	.	xr	.	3n	.	.	.	.	.	.	xn	.	.	.	.	.	.	I
Hericium coralloides	.	.	.	.	5r	.	.	.	.	.	1n	.	.	.	.	1n	.	I
Heterobasidion annosum	.	.	.	.	xr	.	xn	xr	.	.	.	.	.	.	.	.	.	I
Mycena inclinata	.	.	.	.	.	.	.	.	1n	1n	.	.	1n	.	.	.	.	I
Trametes hirsuta	.	.	.	.	.	.	.	.	.	xn	.	.	.	xn	xa	.	.	I
Trichaptum fuscoviolaceum	xn	.	xn				xn	.	.	.	.	.	.	.	.	.	.	I
Fomitopsis pinicola	xr	.	.	xn	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Laetiporus sulphureus	1n	.	.	.	.	.	2n	.	.	.	.	.	.	.	.	.	.	I
Pseudohydnum gelatinosum	.	3n	3r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Psilocybe lateritia	.	2n	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	I
Gymnopilus penetrans	.	.	.	3r	2r	.	.	.	.	.	.	.	.	.	.	.	.	I
Panellus mitis	.	.	.	1n	2a	.	.	.	.	.	.	.	.	.	.	.	.	I
Ramaria stricta	.	.	.	2n	2n	.	.	.	.	.	.	.	.	.	.	.	.	I
Tricholomopsis rutilans	.	.	.	1r	.	1r	.	.	.	.	.	.	.	.	.	.	.	I
Xeromphalia campanella	.	.	.	.	2a	.	3a	.	.	.	.	.	.	.	.	.	.	I
Piptoporus betulinus	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	1r	.	I
Trametes versicolor	.	.	.	.	.	.	.	.	xa	.	.	.	xn	.	.	.	.	I
Crepidotus cesatii	.	.	.	.	.	.	.	.	.	1r	.	.	.	1r	.	.	.	I
Grifola frondosa	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	1r	.	I
Pholiota squarrosa	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	1r	.	I
Cyathus striatus	.	.	.	.	.	.	.	.	.	.	.	3a	.	.	.	.	1a	I
Phaeolus schweinitzii	xr	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sparassis crispa	2r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Dacryomyces minor	.	xa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Exidia glandulosa	.	xn	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pholiota astragalina	.	2r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Tyromyces chioneus	.	1r	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	I
Flammulina velutipes	.	.	.	2n		.	.	.	.	.	.	.	.	.	.	.	.	I
Gymnopilus hybridus	.	.	.	2n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lentinus adhaerens	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Panellus stypticus	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lentinus torulosus	.	.	.	3a	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Phellinus robustus	.	.	.	xr	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Tab. 28 cont.

Gymnopus fusipes	.	.	.	3n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena galericulata	.	.	.	.	2n	.	.	.	.	.	.	.	.	.	.	.	.	I
Pholiota mutabilis	.	.	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	I
Hyphodontia paradoxa	.	.	.	.	.	1a	.	.	.	.	.	.	.	.	.	.	.	I
Pholiota aurivella	.	.	.	.	.	.	2n	.	.	.	.	.	.	.	.	.	.	I
Trichaptum abietinum	.	.	.	.	.	.	xn	.	.	.	.	.	.	.	.	.	.	I
Lenzites betulinus	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	I
Pleurotus pulmonarius	.	.	.	.	.	.	.	1n	.	.	.	.	.	.	.	.	.	I
Crepidotus amygdalosporus	.	.	.	.	.	.	.	.	.	.	1n	.	.	.	.	.	.	I
Psilocybe capnoides	.	.	.	.	.	.	.	.	.	.	1n	.	.	.	.	.	.	I
Pluteus ephebeus	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	I
Trametes pubescens	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	I
Coprinus truncorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	I
Lentinellus ursinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	I
Fungi on litter and among mosses																		
Mycena pura	7n	.	.	.	2n	.	.	2n	6n	3a	4a	3n	2n	6a	3n	5n	3n	IV
Gymnopus confluens	.	.	.	5a	.	2n	.	2n	5n	6n	6n	6n	3n	4n	8n	6n	5n	IV
Gymnopus peronatus	.	6n	.	.	2r	.	.	8n	5a	8a	5n	3n	8n	6n	9a	11a	9a	IV
Marasmius bulliardii	.	.	.	.	.	.	.	6a	2a	2a	1n	3n	6n	3a	3n	8a	5a	III
Mycena stylobates	.	.	3r	.	2a	.	.	3r	3n	.	1r	1r	1r	1r	.	1r	1r	III
Marasmius alliaceus	.	.	.	.	.	.	.	2n	2n	2n	6a	2n	.	1n	1n	3n	2n	III
Clitocybe gibba	4n	.	.	1r	4r	.	.	.	.	2n	1r		2r	.	2r	5a	.	III
Coprinus xanthothrix	.	.	.	.	.	.	.	3r	.	1r	1r	1r	1r	.	1r	3r	.	III
Marasmius rotula	.	.	.	.	.	.	.		2a		6a	4a	.	n	2a	3a	.	II
Mycena sanguinolenta	.	.	.	.	1r	.	.	.	1n	2a	.	.	2n	1n	2n	.	.	II
Mycena vitilis	.	.	.	3n	.	.	.	.	.	1r	.	1r	1r	.	1r	.	.	II
Clitocybe odora	.	.	.	.	6r	.	.	1r	.	.	.	3r	.	.	.	2r	1r	II
Rhodocollybia butyracea var. *butyracea*	.	6n	3n	.	.	.	.	.	2n	.	.	.	.	2n	2n	.	.	II
Gymnopus dryophilus	4r	.	.	1r	2r	1n	2n	.	.	.	.	.	.	.	.	.	.	II
Clitocybe dealbata	3r	.	.	.	.	.	.	.	.	.	.	3r	1r	.	3r	.	.	II
Clitocybe tornata	.	.	.	.	.	.	.	.	.	1r	.	1r	1r	1r	.	.	.	II
Rhodocollybia butyracea var. *asema*	2r	3r	.	.	.	.	2n	.	.	.	.	.	.	.	.	.	.	I
Clitocybe vibecina	.	.	.	1r	2n	2n	.	.	.	.	.		.	.	.	.	.	I

Mycena polygramma	.	.	.	.	1n	.	.	1r	.	.	.	.	2r	.	.	.	.	I
Mycena metata	2r	6n	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Clitocybe clavipes	2r	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Galerina hypnorum	.	.	.	1r	1n	.	.	.	.	.	.	.	.	.	.	.	.	I
Macrocystidia cucumis	.	.	.	2a	1n	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena zephirus	.	.	.	1r	1r	.	.	.	.	.	.	.	.	.	.	.	.	I
Flammulaster carpophilus	.	.	.	.	5n	2n	.	.	.	.	.	.	.	.	.	.	.	I
Pseudoclitocybe cyathiformis	.	1r	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	I
Galerina triscopa	.	.	.	.	.	.	.	.	1r	.	.	.	.	1r	.	.	.	I
Galerina laevis	.	.	.	.	.	.	.	.	.	.	1r	.	.	1r	.	.	.	I
Gymnopus erythropus	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Coprinus leiocephalus	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena aetites	2r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena arcangeliana	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena flavoalba	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena haematopus	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena leptophylla	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena maculata	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena fagetorum	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Strobilurus staphanocystis	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Collybia cirrhata	.	.	1r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Clitocybe hydrogramma	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena filopes	.	.	.	3n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mycena crocata	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Clitocybe fragrans	.	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	.	I
Psilocybe semiglobata	.	.	.	.	2r	.	.	.	.	.	.	.	.	.	.	.	.	I
Clitocybe metachroa	.	.	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	.	I
Coprinus plicatilis	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	.	.	.	I
Marasmiellus ramealis	.	.	.	.	.	.	1n	.	.	.	.	.	.	.	.	.	.	I
Setulipes quercophilus	.	.	.	.	.	.	.	.	1n	.	.	.	.	.	.	.	.	I
Coprinus domesticus	.	.	.	.	.	.	.	.	.	1r	.	.	.	.	.	.	.	I
Marasmius epiphyllus	.	.	.	.	.	.	.	.	.	1n	.	.	.	.	.	.	.	I
Clitocybe amarescens	.	.	.	.	.	.	.	.	.	.	.	.	.	1r	.	.	.	I

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frequency. A relatively high degree of constancy was achieved by *Lactarius subdulcis*, which is attached to beech forests the most of the group of species listed above.

Fungi on litter comprise 51 species, that is 27.4% of the total number of *Basidiomycetes* (Fig. 7b). Twelve exclusive species are of little selective value except for *Marasmius alliaceus* var. *alliaceus*, which is a good characteristic species of *Dentario glandulosae-Fagetum* not only in the Góry Świętokrzyskie Mts. but also more broadly within the entire distribution area of the species. Others, such as *Flammulaster carpophilus, Gymnopus erythropus, Mycena crocata* and *M. haematopus*, are characterised by a fairly high preference for small-sized remains of *Fagus sylvatica*; however, due to their occurrence in other communities where beech trees were present, no diagnostic value can be ascribed to them.

Saprobionts on litter exhibit a great similarity to fungi in *Potentillo-Quercetum*, with which they share 47.2% species, *Tilio-Carpinetum* – 45.3% and *Abietetum polonicum* – 34% (Fig. 11). Despite their resemblance, no species that would be in common between the beech forest and thermophilous oak forest were recorded. *Clitocybe odora, Coprinus truncorum, Macrocystidia cucumis, Marasmiellus ramealis* and *Pseudoclitocybe cyathiformis* were observed exclusively in the oak-hornbeam forest and the beech forest. The low similarity to litter-inhabiting fungi in *Luzulo-Fagetum,* with which only 14 species were recorded, is surprisingly low. *Clitocybe vibecina, Coprinus leiocephalus, Mycena fagetorum, M. maculata* and *Rhodocybe popinalis* are species exclusive to both beech forests. *Mycena fagetorum*, a species characteristic of the *Fagion sylvaticae* alliance (Lisiewska 1974; Friedrich 1994), is particularly noteworthy. The rare *Rhodocybe popinalis*, a species recorded in the vicinity of Janów Lubelski (Flisińska & Sałata 1998; Flisińska 2000a) and Międzyrzec Podlaski (Eichler 1907), is also interesting.

The highest frequency was recorded for the following species: *Gymnopus confluens, Gymnopus peronatus* and *Mycena pura* (IV constancy degree), *Clitocybe gibba, Coprinus xanthothrix, Marasmius alliaceus* v. *alliaceus, M. bulliardii* and *Mycena stylobates* (III constancy degree).

Lignicolous fungi constitute 60 species, that is 32.2% of all *Basidiomycetes* recorded at permanent plots (Fig. 7c). Species exclusive to this community form a group of 14 species. These fungi are not selective in relation to the syntaxon examined here. Due to the frequent occurrence on *Fagus*, some xylobionts, such as *Grifola frondosa, Hyphodontia paradoxa* s.str., *Lentinellus ursinus* and *Pluteus ephebeus*, can be considered to be of differential value. The first species is a frequent facultative parasite on *Fagus* and *Quercus*. It was found in *Querco-Pinetum* outside the examined patches. The second, a very rare xylobiont recorded on *Fagus*, was also collected in *Tilio-Carpinetum*. The very rare *Pluteus ephebeus* was recorded only in the Carpathian beech forest in the Góry Świętokrzyskie Mts.; however, it also occurs outside forests, for instance on roadside trees – on *Aesculus*. Other xylobionts in the group of exclusive species were recorded across various forest communities in the study area. *Hericium coralloides* can be treated as characteristic of the *Fagion sylvaticae* alliance, and *Mycena crocata*, *Oudemansiella mucida* and *Polyporus tuberaster* can be treated as characteristic outside the plots (Lisiewska 1974).

Due to floristic relationships with other forests of the class *Querco-Fagetea*, lignicolous fungi in *Dentario glandulosae-Fagetum* show the greatest resemblance to xylobionts in *Tilio-Carpinetum*, with which they share 49.1% species, and, among coniferous species, to those in *Leucobryo-Pinetum* – 40.3 and *Querco-Pinetum* – 36.8% species in common (Fig. 12). *Crepidotus cesatii, Hericium coralloides* and *Polyporus varius* were recorded only in the Carpathian beech forest and the oak-hornbeam forest. The latter species reached the second degree of constancy in both comunities, which stresses the close relationships between forest biocoenoses in the Góry Świętokrzyskie Mts. and respective submontane and subapline forests.

Only *Lycoperdon pyriforme, Stereum hirsutum* and *Xerula radicata* var. *radicata* achieved the highest frequency (III degree of constancy), and seven species were recorded in the second degree of constancy, that is 12%, while 82.7% are sporadic species.

5.4. Relationships between plants and *Basidiomycetes*

As organisms dependent on organic sources of carbon, *Basidiomycetes* form more or less close relationships with certain plant species at different trophic levels and on different surfaces of the biological space in each biocoenosis. Three basic trophic groups can be distinguished according to the type of nutrient absorption of fungi: saprobionts, parasites and mycorrhizal fungi. Furthermore, a number of ecological fungal groups can be distinguished depending on their development within a biocoenosis. For instance, Orłoś (1966) differentiates five basic categories: cormobionts, xylobionts, pedobionts, rhizobionts and allobionts. The practical application of this ostensibly simple and convenient division, however, seems to be somewhat problematic as fungi can simultaneously colonise and explore different spaces and habitats. Therefore, it may be difficult to identify the dividing lines among individual ecological groups while the classification of fungi is becomes somewhat inaccurate. This is the case of, for instance, facultative mycorrhizal fungi and facultative parasites. Additionally, fidelity to plants is also a feature of *Basidiomycetes*. Consequently, both fungi strongly associated with a certain species or genus of plants and fungi characterised by a broad ecological scale and concurrent multiple relationships with various plants can co-occur. Correlations between the biota of *Basidiomycetes* examined in this project and 34 genera of flower plants and 11 genera of mosses were recorded in the present study (Tab. 29).

The mycobiota of ***Pinus sylvestris,*** one of the most common forest-forming species, is the most numerous. Pine can be a dominant, co-dominant or admixture species in the stands. This plant is accompanied by a numerous group of highly faithful and specialised *Basidiomycetes,* and has developed its “own” fungi on all the trophic levels. The presence of pine trees in any plant community invariably results in the occurrence of fungi associated with them. If the tree is of anthropogenic origin, accompanying fungi both enrich and upset the characteristic fungal composition in a given phytocoenosis. This phenomenon can be observed in degenerated forms of forests belonging to the class *Querco-Fagetea* in which differences between the mycobiota of deciduous forests and that of mixed forests of the class *Vaccinio-Piceetea* disappear.

Both factors such as climatic conditions and the geographical plant range exert an important influence on the geographical type of the mycobiota. Due to the presence of *Pinus sylvestris*, which belongs to the Eurasian subelement (Pawłowska 1977), rare species of continental xylobionts, such as *Diplomitoporus flavescens,* or boreal xylobionts, for example *Ceraceomyces sublaevis, Phlebia lilascens* and *Phlebiella allantospora*, reach the study area. The distribution of *Dacryomyces ovisporus* is boreal and Central European (Wojewoda 2002). Common *Auriscalpium vulgare, Strobilurus stephanocystis* and *S. tenacellus* are some

Table 29
Vascular plants, mosses and fungi: relationships

Genera of vascular plants	Number of fungal species	Genera of vascular plants	Number of fungal species	Genera of mosses	Number of fungal species
Pinus	114	*Prunus*	6	*Sphagnum*	48
Fagus	105	*Robinia*	6	*Pleurozium*	6
Abies	102	*Fraxinus*	4	*Hypnum*	4
Quercus	100	*Ligustrum*	4	*Hylocomium*	3
Betula	55	*Sambucus*	4	*Niphotrichum*	3
Alnus	54	*Ulmus*	4	*Plagiomnium*	3
Populus	34	*Frangula*	2	*Ceratodon*	2
Picea	29	*Agropyron*	1	*Polytrichum*	2
Larix	20	*Agrostis*	1	*Syntrichia*	2
Salix	18	*Brachypodium*	1	*Atrichum*	1
Carpinus	16	*Corynephorus*	1	*Aulacomium*	1
Acer	15	*Crataegus*	1		
Corylus	13	*Euonymus*	1		
Sorbus	13	*Poa*	1		
Tilia	7	*Pteridium*	1		
Aesculus	6	*Ribes*	1		
Cerasus	6	*Spirea*	1		

of litter-inhabiting fungi associated with pine trees that develop on fallen cones buried in the litter.

Fruitbodies of parasite *Sparassis crispa* grow on roots and trunk bases. *Phellinus pini* develops fruitbodies on living trunks. This fungus, characterised by the Holarctic range, grows exclusively on species of the genus *Pinus* in Europe while it also develops on other types of coniferous trees in North America (Kotlaba 1984; Ryvarden & Gilbertson 1994). Pine-wood decomposition determines the succession of *Basidiomycetes* (Jahn 1968). Species such as *Gloeophyllum sepiarium, Hyphodontia crustosa, Phanerochaete gigantea, Stereum sanguinolentum, Trichaptum abietinum, T. fuscoviolaceum* grow on wood in the initial phase. The optimal phase is distinguished by the presence of *Gymnopilus hybridus, Heterobasidion annosum, Oligoporus caesius, Psilocybe capnoides, P. fascicularis, P. lateritia* and *Tricholomopsis rutilans* while wood in the end phase is colonised by the following fungi: *Antrodia serialis, Calocera viscosa, Phlebia lilascens* and *Pseudohydnum gelatinosum*.

Different relationships between symbionts are observed in the case of mycorrhizal fungi, ranging from obligatory mycorrhizae to facultative mycorrhizae. The knowledge on mycorrhizae has been expanding, and many fungal species earlier considered to be saprobes are now classified as mycorrhizae. *Ramaria abietina* is a pine symbiont (Mleczko 2004). Obligatory ectomycorrhizae with *Pinaceae* are formed by fungi of the families *Gomphidiaceae* and *Suillaceae* (Singer 1986; Besl & Bresinsky 1997; Fischer *et al.* 1997). The rare *Suillus collinitus,* which grows in habitats that are warm and rich in carbonates, is particularly interesting. *S. granulatus* is another calcicolous species. *S. flavidus* grows among *Sphagnum* mosses on oligotrophic raised bogs. Other mycorrhizal fungi very often form mycorrhizae with *Pinus* as well as with other trees.

Some species of parasitic fungi are only seemingly associated with pine. Their fruitbodies develop on pinophilous fungi and not on pine wood; for instance *Tremella encephala* fruitbodies are produced on the mycelium and fruitbodies of *Stereum sanguinolentum*. The mycelium of *Tremella obscura* develops in fruitbodies of *Dacryomyces stillatus* for which *Pinus* branches and logs provide the substrate. Some other species of the genus *Tremella*, for instance *T. cladoniae* and *T. hypogymniae*, are parasites of lichens and not of pine trees. Therefore, the role of the pine is that of the habitat and not the substrate.

A total of 114 species of *Basidiomycetes* that are characterised by different degrees of fidelity to pine trees were recorded in the study area (Tab. 30).

Fagus sylvatica is one of those trees that dominate the plant cover of the Góry Świętokrzyskie Mts. and has a numerous group of basidiomycete species that are associated with it. Beeches are on the northern and north-eastern limit of their natural range along the borders of the study area. Due to the Western European distribution of the tree, many interesting species reach the area of the Góry Świętokrzyskie Mts. Those include, for instance *Oudemansiella mucida* and *Xerula hygrophoroides*, whose development is influenced by the oceanic and suboceanic climate. The former is relatively frequent while the latter is very rare and has been observed at individual localities in Western Europe (France, Germany and Switzerland). *Phanerochaete ravenelii* is a species of Southern Europe (Domański S. 1991a). In Poland, it has been recorded only in the Góry Świętokrzyskie Mts. and the Carpathians (Domański S. *et al.* 1960, 1963; Domański S. 1961, 1962; Wojewoda 2003). *Phlebia cremeoochracea* is a very rare xylobiont that develops on fallen beech branches. *Marasmius alliaceus* grows on highly rotten beech twigs buried in the soil. *Mycena crocata* grows on logs and fallen twigs in the litter, *Gymnopus hariolorum, Marasmius cohaerens* and *Mycena pelianthina* develop on fallen beech leaves while *Flammulaster carpophilus* is found on lying fruit.

A numerous group of mycorrhizal fungi is associated with beech trees that are their obligatory or almost exclusive phytosymbionts. These are, among others, *Craterellus cornucopioides, Lactarius blennius, L. ichoratus* and *L. pallidus, Russula curtipes, R. mairei* as well as *Tricholoma ustale*.

Due to the forest-forming role of *Fagus sylvatica*, fungi associated with this tree species find conditions suitable for their development in various plant communities. They develop fruitbodies most frequently and abundantly in phytocoenoses of beech forests belonging to the *Fagion* alliance while their individuals also penetrate other related communities of the class *Querco-Fagetea* and mixed coniferous forests of the class *Vaccinio-Piceetea*.

A substantial inflow and penetration of the mycobiota accompanying beeches in lowland and mountain beech forests have been observed in the Góry Świętokrzyskie Mts. It is characteristic of the region, which is situated along the border of lowlands and upland-mountain areas. This group is formed by, for instance, *Cortinarius nemorensis, Hericium coralloides, Marasmius alliaceus, Mycena capillaris, M. crocata, M. fagetorum, Omphalina epichysium, Oudemansiella mucida* and *Setulipes quercophilus* as well as *Tubaria pellucida*.

Many more *Basidiomycetes* are associated with beech; their relationship with this tree species, however, is not close as they develop on wood and litter of other trees and shrubs equally well (Tab. 31).

As many as 102 fungal species co-occur with ***Abies alba*** in various ways (Tab. 32). It should be strongly emphasised that these fungi are not exclusive to this tree species; the high number of fir companions results from factors such as the role played by this species in the plant cover in the Góry Świętokrzyskie Mts. It occurs in nearly all forest communities

Table 30
Fungi associated with *Pinus sylvestris* in the Góry Świętokrzyskie Mts.

Amphinema byssoides	*Antrodia serialis*
Armillaria ostoyae	*Athelia arachnoidea*
Athelia decipiens	*Athelia epiphylla*
Auriscalpium vulgare*	*Basidiodendron caesiocinereum*
Botryobasidium subcoronatum	*Botryobasidium vagum*
Calocera furcata	*Calocera viscosa*
Calvatia excipuliformis	*Ceraceomyces sublaevis*
Ceratobasidium cornigerum	*Cerrena unicolor*
Clavicorona pyxidata	*Cortinarius delibutus*
Crepidotus versutus	*Crucibulum laeve*
Dacryomyces minor	***Dacryomyces ovisporus***
Dacryomyces stillatus	*Dichomitus squalens*
Diplomitoporus flavescens	*Entoloma speculum*
Fibulomyces mutabilis	*Fomitopsis pinicola*
Galerina clavus	*Galerina marginata*
Galerina pseudobadipes	*Galerina mniophila*
Galerina stylifera	*Galerina subbadipes*
Galerina triscopa	*Galerina unicolor*
Gloeocystidiellum porosum	*Gloeophyllum odoratum*
Gloeophyllum sepiarium	*Gloeoporus taxicola*
Gymnopilus hybridus	*Gymnopilus penetrans*
Gymnopilus picreus	*Gymnopilus sapineus*
Hebeloma radicosum	*Heterobasidion annosum*
Hyphoderma capitatum	*Hyphoderma praetermissum*
Hyphodontia alienata	*Hyphodontia crustosa*
Hyphodontia pallidula	*Hypochnicium bombycinum*
Hypochnicium geogonium	*Leccinum vulpinum*
Lindtneria trachyspora	*Lentinus lepideus*
Mycena atroalba	*Lycoperdon pyriforme*
Mycena purpureofusca	*Mycena galericulata*
Mycena smithiana	*Oligoporus caesius*
Oligoporus fragilis	*Panellus mitis*
Paxillus atrotomentosus	*Paxillus panuoides*
Phaeolus schweinitzii	*Phanerochaete gigantea*
Phanerochaete sanguinea	*Phanerochaete sordida*
Phellinus pini	***Phlebia lilascens***
Phlebiella allantospora	*Pholiota astragalina*
Pholiota flammans	*Pholiota mutabilis*
Pholiota squarrosa	*Pluteus atromarginatus*
Pluteus pouzarianus	*Pseudohydnum gelatinosum*
Psilocybe capnoides	*Psilocybe fascicularis*
Psilocybe lateritia	*Psilocybe subviridis*
Radulomyces confluens	***Ramaria abietina***
Resinicium bicolor	*Roridella rorida*
Skeletocutis amorpha	*Sistostrema brinkmannii*

Tab. 30 cont.

Sphaerobolus stellatus	***Sparassis crispa***
Strobilurus stephanocystis	***Stereum sanguinolentum***
Suillus bovinus	***Strobilurus tenacellus***
Suillus flavidus	***Suillus collinitus***
Suillus luteus	***Suillus granulatus***
Tremella cladoniae	***Suillus variegatus***
Tremella foliacea	*Tremella encephala*
Tremella obscura	*Tremella hypogymniae*
Trichaptum fuscoviolaceum	*Trichaptum abietinum*
Tricholomopsis decora	*Tricholoma orirubens*
Tricholomopsis rutilans	*Tricholomopsis ornata*
Tylopilus felleus	*Tubaria conspersa*
	Xeromphalia campanella

* taxa given in bold are closely associated with this tree species

Table 31
Fungi associated with *Fagus sylvatica* in the Góry Świętokrzyskie Mts.

Antrodiella hoehnelii	*Armillaria lutea*
Armillaria ostoyae	*Athelia arachnoidea*
Athelia fibulata	*Basidioradulum radula*
Bjerkandera adusta	*Bolbitius reticulatus*
Boletus calopus	*Botryobasidium aureum*
Chondrostereum purpureum	*Cortinarius mucifluus*
Craterellus cornucopioides*	*Crepidotus cesatii*
Dacryomyces minor	*Exidia plana*
Flammulaster carpophilus	*Fomes fomentarius*
Fomitopsis pinicola	*Galerina triscopa*
Galerina unicolor	*Ganoderma applanatum*
Ganoderma lucidum	*Grifola frondosa*
Gymnopus fusipes	***Gymnopus hariolorum***
Hebeloma edurum	*Hebeloma leucosarx*
Hebeloma versipelle	***Hericium coralloides***
Hyphoderma litschaueri	*Hyphodontia paradoxa*
Inocybe hirtella	*Irpex ochraceus*
Lactarius blennius	*Lactarius fluens*
Lactarius ichoratus	***Lactarius pallidus***
Lentinellus cochleatus	*Lentinellus ursinus*
Lindtneria trachyspora	*Lycoperdon pyriforme*
Marasmius alliaceus	*Marasmius epiphyllus*
Megacollybia platyphylla	*Meripilus giganteus*
Mycena capillaris	***Mycena crocata***
Mycena fagetorum	*Mycena galericulata*
Mycena inclinata	*Mycena polygramma*
Mycena stipata	*Ossicaulis lignatilis*
Oudemansiella mucida	*Panellus serotinus*

Tab. 31 cont.

Peniophora incarnata	*Phanerochaete laevis*
Phanerochaete ravenelii	*Phanerochaete velutina*
Phellinus nigricans	***Phlebia cremeoochracea***
Phlebia radiata	*Pholiota aurivella*
Pholiota mutabilis	*Phyllotopsis nidulans*
Pluteus chrysophaeus	*Pluteus depauperatus*
Pluteus ephebeus	*Pluteus godeyi*
Pluteus romellii	*Pleurotus ostreatus*
Pleurotus ostreatus f. *peregrinus*	*Pleurotus pulmonarius*
Pluteus atricapillus	*Pluteus pellitus*
Pluteus salicinus	*Polyporus brumalis*
Polyporus tuberaster	*Polyporus varius* var. *elegans*
Polyporus varius var. *nummularius*	*Polyporus varius*
Protomerulius caryae	*Psilocybe crobula*
Psilocybe lateritia	*Ramaria stricta*
Resupinatus unguicularis	***Russula curtipes***
Russula mairei	*Schizophyllum commune*
Setulipes quercophilus	*Stereum hirsutum*
Trametes hirsuta	*Trametes ochracea*
Trametes pubescens	*Trametes versicolor*
Tremella lichenicola	*Tremella lutescens*
Tremella mesenterica	***Tricholoma ustale***
Tubaria pellucida	*Volvariella bombycina*
Xerula hygrophoroides	*Xerula radicata*

* taxa given in bold are closely associated with this tree species

Table 32
Fungi associated with A*bies alba* in the Góry Świętokrzyskie Mts.

Aleurodiscus amorphus*	*Amphinema byssoides*
Amylostereum areolatum	***Amylostereum chailletii***
Antrodiella citrinella	*Athelia arachnoidea*
Basidiodendron caesiocinereum	*Basidioradulum radula*
Bondarzewia mesenterica	*Botryobasidium laeve*
Botryobasidium subcoronatum	*Botryohypochnus isabellinus*
Calocera furcata	*Calocera viscosa*
Ceriporiopsis mucida	***Clavulicium macounii***
Clitocybula lacerata	*Coniophora arida*
Coniophora puteana	***Cortinarius delibutus***
Creolophus cirrhatus	***Cystostereum murrayi***
Exidia saccharina	***Exidiopsis grisea***
Fomitopsis pinicola	*Galerina triscopa*
Galerina unicolor	*Ganoderma applanatum*
Ganoderma carnosum	*Gloeophyllum abietinum*
Gloeophyllum odoratum	*Gloeophyllum sepiarium*
Gloiothele citrina	*Gymnopilus hybridus*
Gymnopilus penetrans	*Hapalopilus salmonicolor*

Tab. 32 cont.

Hericium flagellum	***Heterobasidion abietinum***
Hydropus atramentosus	***Hydropus marginellus***
Hymenochaete cruenta	*Hyphoderma praetermissum*
Hyphoderma puberum	*Hyphodontia arguta*
Hyphodontia breviseta	*Hyphodontia nespori*
Hyphodontia pallidula	*Hyphodontia paradoxa*
Hyphodontia spathulata	*Irpex ochraceus*
Ischnoderma benzoinum	***Lactarius salmonicolor***
Lentinellus ursinus	*Lentinus adhaerens*
Lentinus lepideus	*Lentinus torulosus*
Litschauerella abietis	*Lobulicium occultum*
Lycoperdon pyriforme	*Marasmiellus perforans*
Megacollybia platyphylla	***Mycena aurantiomarginata***
Oligoporus caesius	*Oligoporus fragilis*
Oligoporus ptychogaster	*Oligoporus stypticus*
Panellus mitis	*Phaeomarasmius erinaceus*
Phellinus hartigii	*Pholiota astragalina*
Pholiota aurivella	*Pholiota flammans*
Pholiota mixta	*Pholiota mutabilis*
Physisporinus vitreus	*Pluteus pouzarianus*
Porphyrellus porphyrospous	*Pseudohydnum gelatinosum*
Psilocybe capnoides	*Psilocybe fascicularis*
Pycnoporellus fulgens	*Radulomyces confluens*
Ramaria polonica	***Ramaria rubella***
Resinicium bicolor	*Rigidoporus crocatus*
Schizophyllum commune	*Serpula himantioides*
Sistostrema brinkmannii	*Skeletocutis amorpha*
Skeletocutis lenis	*Skeletocutis odora*
Skeletocutis stellae	*Trechispora mollusca*
Tremella mycetophiloides	*Trichaptum abietinum*
Trichaptum fuscoviolaceum	*Tricholomopsis decora*
Tricholomopsis rutilans	*Tubaria pellucida*
Tyromyces chioneus	*Xeromphalia campanella*

* taxa given in bold are closely associated with this tree species

in the area. Lignicolous saprobionts constitute the most numerous ecological group. Fungi whose fruitbodies were recorded both on logs, dead standing trunks, stumps and dead braches as well as facultative parasites are included in this category.

Abies alba occurs in Central Europe in the lower subalpine forest and reaches its northern range limit in the Central Uplands Zone (Pawłowska 1977). The fir's significant contribution to the development of the mycobiota of the Góry Świętokrzyskie Mts. is impressive, and rare species, especially mountain ones (typical of the subalpine forest), species representing primeval relict species, typical of the geographical element growing in Central Europe and associated with the fir, as well as species associated with the tree reaching the northern range limit in the area, are particularly noteworthy. Species typical of the subalpine forest include *Amylostereum chailletii, Bondarzewia mesenterica, Hericium flagellum, Hymenochaete cruenta, Hydropus atramentosus, H. marginellus* and *Tricholomopsis decora*;

species growing in Central Europe consist of, for instance, *Ganoderma carnosum, Ramaria polonica* and *R. rubella*. The two latter are very rare xylobionts and are associated with the Góry Świętokrzyskie Mts. in a special way. Fruitbodies of the former come from Łysica and are the holotype of the species (Petersen 1975); the latter is known from Poland from the locality on Święty Krzyż (Łuszczyński 2007a, b, in print). Boreal-montane fungi, such as xylobionts *Clavulicium macounii, Pycnoporellus fulgens* and *Skeletocutis odora*, are rare and interesting, and can often be considered to represent relict, old-growth forest species. *Oligoporus ptychogaster*, which is believed to be a species endemic to Europe (Ryvarden & Gilbertson 1994), is of particular importance. The fungus is associated with many tree species of the genera *Larix, Picea* and *Pinus* outside the study area (Wojewoda 2003).

A mere group of seven species constitutes obligatory parasites. Only *Heterobasidion abietinum* and *Phellinus hartigii* are closely associated with fir trees. The former is differentiated from the collective species *H. annosum* by intersterile form F parasitizing on *Abies* and described by Korhonen (1978) as well as Niemelä & Korhonen (1998) as *H. abietinum* Korhonen. The species is not often identified and the literature on it is sparse. The latter is fairly frequent and is observed within the entire range of its host in Poland; more often, however, in mountain areas.

The biological and mechanical condition of fir wood significantly influences the development of xylobionts. Jahn (1968) distinguished four groups of xylobionts that find the best development conditions depending on the degree of wood decomposition. The first group comprises fungi occurring on living trunks within which he differentiates the same species as those occurring in the Góry Świętokrzyskie Mts.: *Bondarzewia mesenterica*, *Heterobasidion abietinum*, *Hymenochaete cruenta* and *Phellinus hartigii.* The second group comprises xylobionts that produce fruitbodies on dead lying logs: a. in the initial phase – *Aleurodiscus amorphus*, *Tremella mycetophiloides* parasitising on it, b. in the optimal phase – *Amylostereum chailletii*, *Cystostereum murrayi*, *Hericium flagellum,* and c. in the end phase – *Hydropus marginellus*.

Exidiopsis grisea and *Mycena aurantiomarginata* are litter-inhabiting saprobionts that are more closely related to fallen needles and small fir twigs.

Numerous mycorrhizal fungi accompany fir trees. It is practically impossible to determine in the field which terrestrial fungus forms mycorrhizal associations, especially in relation to facultative mycosymbionts. This group includes, for instance, species of the genera *Inocybe, Laccaria* and *Hebeloma*, as well as *Paxillus involutus*. The determination of potential mycosymbionts is based on the literature (Agerer 1987-2002; Michael *et al.* 1988; Münzenberger *et al.* 2004). *Cortinarius delibutus*, *Lactarius salmonicolor* and *Porphyrellus porphyrosporus* are mycorrizhal fungi of which fir trees are exclusive or very frequent symbionts.

Species of the genus ***Quercus*** form numerous and often very close relationships with *Basidiomycetes*. Similarly to the tree species described above, oaks have also developed their own group of *Basidiomycetes* through co-evolution. The relationship between fungi and oak trees has also been investigated within the framework of the international programme „Mycological monitoring in European oak forests" (Lisiewska & Połczyńska 1998; Łuszczyński 1998; Skirgiełło 1998b; Wojewoda *et al.* 1999; Ławrynowicz & Stasińska 2000; Ławrynowicz 2001; Ławrynowicz *et al.* 2001). Fungi dependent on oaks belong to different trophic groups of saprobionts, parasites and mycosymbionts. Apart from the species listed above, facultative oak-loving trees whose relationship with *Quercus* spp. trees is very strong but that also occur on other plants as well as ubiquitous fungi were also recorded (Tab. 33). The group of fungi exclusive to oaks includes: *Aleurocystidiellum*

Table 33
Fungi associated with *Quercus* spp. in the Góry Świętokrzyskie Mts.

Aleurocystidiellum disciforme*	*Antrodiella hoehnelii*
Armillaria ostoyae	***Armillaria tabescens***
Basidioradulum radula	*Bjerkandera adusta*
Botryobasidium laeve	***Buglossoporus quercinus***
Chondrostereum purpureum	*Coprinus disseminatus*
Cortinarius incisus	*Cortinarius orellanus*
Crepidotus cesatii	*Dacryomyces minor*
Daedalea quercina	*Datronia mollis*
Dendrothele commixta	*Dichomitus campestris*
Entoloma undatum	***Exidia glandulosa***
Exidia plana	***Fistulina hepatica***
Flammulina velutipes	*Ganoderma lucidum*
Grifola frondosa	*Gymnopilus junonius*
Gymnopus fusipes	*Hapalopilus nidulans*
Hymenochaete rubiginosa	*Hyphoderma praetermissum*
Hyphoderma puberum	*Hyphoderma setigerum*
Hyphodontia crustosa	*Hyphodontia subalutacea*
Inocybe dulcamara	*Inocybe hirtella*
Irpex nitidus	***Lactarius chrysorrheus***
Lactarius quietus	*Laetiporus sulphureus*
Leccinum quercinum	*Lentinellus cochleatus*
Lenzites betulinus	*Lycoperdon pyriforme*
Marasmiellus ramealis	*Marasmius epiphyllus*
Mycena atroalba	*Mycena crocata*
Mycena galericulata	***Mycena inclinata***
Mycena polyadelpha	*Mycena polygramma*
Panellus stypticus	*Peniophora nuda*
Peniophora quercina	*Perenniporia medulla-panis*
Phaeomarasmius erinaceus	*Phanerochaete sordida*
Phanerochaete tuberculata	*Phellinus contiguus*
Phellinus robustus	*Phlebia radiata*
Pholiota aurivella	*Pholiota mutabilis*
Pholiota squarrosa	*Pholiota tuberculosa*
Pleurotus dryinus	*Pluteus atricapillus*
Pluteus cinereofuscus	*Pluteus depauperatus*
Pluteus exiguus	*Pluteus godeyi*
Pluteus podospileus	*Pluteus salicinus*
Polyporus arcularius	*Polyporus ciliatus*
Polyporus umbellatus	*Psathyrella piluliformis*
Psathyrella sarcocephalla	*Psilocybe fascicularis*
Psilocybe lateritia	*Radulomyces molaris*
Russula livescens	*Schizophyllum commune*
Setulipes quercophilus	*Sistostrema brinkmannii*
Sparassis brevipes	*Stereum complicatum*
Stereum gausapatum	*Stereum hirsutum*

Tab. 33 cont.

Stereum ostrea	*Trametes hirsuta*
Trametes versicolor	*Trechispora farinacea*
Tremella hypogymniae	*Tremella mesenterica*
Tulasnella thelephorea	*Vuilleminia comedens*
Xerula pudens	*Xerocomus rubellus*

* taxa given in bold are closely associated with this tree species

disciforme, Buglossoporus quercinus, Daedalea quercina, Dendrothele commixta, Fistulina hepatica, Gymnopus fusipes, Hymenochaete rubiginosa, Lactarius chrysorrheus, Lactarius quietus, Leccinum quercinum, Peniophora quercina, Phellinus robustus and *Setulipes quercophilus*. Querophilous fungi that are not obligatory species are as follows: *Armillaria tabescens, Dichomitus campestris, Exidia glandulosa, Mycena inclinata, Pleurotus dryinus, Sparassis brevipes* and *Xerula pudens*.

Three very rare species, *Armillaria tabescens, Buglossoporus quercinus* and *Sparassis brevipes*, deserve special attention. *Armillaria tabescens* is a very rare species of the genus *Armillaria*, distributed in south-western Europe. It reaches the north-eastern and eastern range limit in Poland, and is also known only from the Bieszczady Mts. (Domański S. *et al.* 1967). *Buglossoporus quercinus* is a very rare parasite of very old oaks. It occurs in the boreomeridian Eurasian zone of the range of the genus *Quercus*. Outside Europe, its localities have been reported from, among others, Japan, the Caucasus and Turkey. Its distribution in Europe is subatlantic and submediterranean (Kotlaba 1984). It is very rare in Poland and is known only from the Puszcza Białowieska Forest and the Lasy Łochowskie Forests outside the Góry Świętokrzyskie Mts. (Domański S. *et al.* 1967; Domański Z. 1997). *Sparassis brevipes* is a European species. Despite being a parasite of old oaks, it has also been reported from under old beeches, firs and larches (Kreisel 1983); it is clearly associated with old-growth forests (Łuszczyński 2003).

Species of the genus ***Betula*** are components of nearly all of the forest communities. The common occurrence of these trees influenced a vast body of fungi that are associated with them (Tab. 34). Obligatory mycosymbionts that belong to the genera *Cortinarius, Lactarius, Leccinum* and *Russula* are particularly numerous. Some of them are rare and colonise highly limited and disappearing habitats, for instance boggy coniferous forests and midforest raised bogs. Those include *Leccinum niveum, L. roseofractum* and *L. variicolor*. *Inonotus obliquus*, whose conidial form was collected only, is an interesting species parasitising on *Betula*. Apart from the common *Fomes fomentarius*, parasites do not constitute a significant quantitative group nor is the damage caused by them particularly extensive. Lignicolous and mycorrhizal fungi are the most numerous groups. Among saprobionts, particular attention should be paid to *Lindtneria trachyspora*, which is not a birch-dependent fungus (it was also recorded on twigs and litter of *Fagus* and *Pinus*); it is, however, a species new to Poland and rare in Europe and North America. This xylobiont grows on highly decomposed wood, mostly deciduous wood (Domański S. 1991a). While soft wood is easily colonised by numerous common xylobionts, only *Piptoporus betulinus* forms an obligatory relationship with birch wood.

Alnus glutinosa plays a relatively small role in the plant cover of the Góry Świętokrzyskie Mts. and its range is mostly limited to boggy and carr communities. Fungi which accompany this plant comprise 54 species that develop on all of its organs (Tab. 35). Many of

Table 34
Fungi associated with *Betula* spp. in the Góry Świętokrzyskie Mts.

Basidioradulum radula	***Leccinum scabrum***
Bjerkandera adusta	*Leccinum thalassimum*
Boletus betulicola*	***Leccinum variicolor***
Climacodon septentrionalis	*Lenzites betulinus*
Cortinarius armillatus	*Lindtneria trachyspora*
Cortinarius balaustinus	*Mycena galericulata*
Cortinarius duracinus	*Panellus stypticus*
Cortinarius hemitrichus	*Paxillus involutus*
Cortinarius mucifluus	*Phanerochaete sordida*
Dacryomyces stillatus	*Phellinus nigricans*
Daedaleopsis confragosa	*Pholiota mutabilis*
Exidia plana	*Pholiota spumosa*
Fomes fomentarius	***Piptoporus betulinus***
Fomitopsis pinicola	*Pleurotus pulmonarius*
Ganoderma applanatum	*Pluteus pseudorobertii*
Hapalopilus nidulans	*Polyporus brumalis*
Inonotus hispidus	*Polyporus ciliatus*
Inonotus obliquus	*Polyporus varius*
Lactarius aurantiacus	*Psilocybe fascicularis*
Lactarius fluens	***Russula claroflava***
Lactarius piperatus	***Russula nitidia***
Lactarius pubescens	*Russula versicolor*
Lactarius torminosus	*Stereum hirsutum*
Lactarius trivialis	*Trametes hirsuta*
Lactarius vietus	*Trametes ochracea*
Leccinum niveum	*Trametes versicolor*
Leccinum roseofractum	*Tremella hypogymniae* (lichenicolous fungus)
Leccinum versipelle	

* taxa given in bold are closely associated with this tree species

them are obligatory mycobionts, parasites and saprobionts. Alder trees have developed a group of exclusive mycorrhizal fungi, represented most numerously by species of the genus *Naucoria*. *Naucoria permixta* and *N. striatula* are very rare species in Poland, and are known only from single localities outside the study area. *Lactarius lilacinus* and *L. obscuratus* also exhibit very close biotrophic relationships. These species migrate to different forest communities together with alder trees. Alder wood is the substrate for many xylobionts; it is, however, the exclusive or almost exclusive substrate for only few of them, such as *Mycena speirea, Phellinus alni* and *Stereum subtomentosum*. The latter is a lichenised basidiomycete. *Inonotus radiatus* is a frequent xylobiont recorded on *Alnus* (also reported on many other species outside the Góry Świętokrzyskie Mts.). *Basidiomycetes* observed on alder trees exhibit a broad ecological scale and are ubiquitous in the majority of cases.

The degree of development and preservation condition of alders significantly influence the richness and type of the *Basidiomycetes* biota associated with this tree. Apart from few examples of older and vaster alder phytocoenoses, for instance in the Białe Ługi reserve,

Table 35
Fungi associated with *Alnus glutinosa* in the Góry Świętokrzyskie Mts.

Athelia arachnoidea	*Panellus stypticus*
Bjerkandera adusta	*Paxillus involutus*
Chondrostereum purpureum	***Phellinus alni***
Entoloma euchroum	*Phlebia radiata*
Entoloma speculum	*Pholiota alnicola*
Exidia plana	*Pholiota mutabilis*
Fomes fomentarius	*Pluteus atricapillus*
Ganoderma applanatum	*Polyporus badius*
Ganoderma lucidum	*Polyporus brumalis*
Hyphodontia flavipora	*Polyporus varius*
Inonotus radiatus	*Psathyrella cotonea*
Lactarius lilacinus*	*Psathyrella spadiceogrisea*
Lactarius obscuratus	*Psilocybe capnoides*
Lactarius trivialis	*Psilocybe fascicularis*
Mycena galericulata	*Psilocybe lateritia*
Mycena galopus	*Psilocybe subviridis*
Mycena inclinata	*Stereum hirsutum*
Mycena speirea	*Stereum rugosum*
Mycena stipata	***Stereum subtomentosum***
Mycena tintinnabulum	*Trametes hirsuta*
Naucoria celluloderma	*Trametes ochracea*
Naucoria cephalescens	*Trametes versicolor*
Naucoria escharoides	*Tremella hypogymniae* (lichenicolous fugus)
Naucoria permixta	*Tremella lichenicola* (lichenicolous fugus)
Naucoria scolecina	*Tremella mesenterica*
Naucoria striatula	*Vuilleminia comedens*
Naucoria subconspersa	*Xerula radicata*

* taxa given in bold are closely associated with this tree species

Alnus glutinosa mostly develops in narrow belts along small streams. It very often occurs as young trees or sprout forms. Unfortunately, anthropogenic influences mostly negatively affect the development of the fungal biota of this tree species.

Mosses of the genus ***Sphagnum*** form very specific ecological niches that are accompanied by ca. 50 species, including a highly specialised group of sphagnophilous *Basidiomycetes* (Tab. 36). These fungi occur with *Sphagnum* mosses in various phytocoenoses, for instance in the *Abies alba-Sphagnum girgensohnii, Sphagnetum magellanici* and *Vaccinio uliginosi-Pinetum*. *Galerina atkinsoniana, G. paludosa, G. sphagnorum, Mycena megaspora, Omphalina sphagnicola* and *Tephrocybe palustris* are such exclusive sphagnophilous fungi. *Galerina atkinsoniana* is very rare, previously known from only two localities in the Puszcza Niepołomicka Forest (Wojewoda *et al.* 1999) and on Babia Góra Mt (Bujakiewicz 1979). The other species are more frequent than *Galerina atkinsoniana*; none of them, however, is common. Apart from sphagnophilous fungi, bryophilous species characterised by a broader ecological scale, for instance *Entoloma atromarginatum, E. xanthochroum, Galerina clavata, G. fennica, Hygrocybe lepida, Psilocybe elongata* and *P. uda*, also occur on *Sphagnum* mosses.

Table 36
Fungi associated with *Sphagnum* spp. in the Góry Świętokrzyskie Mts.

Amanita fulva	*Laccaria amethystea*
Amanita virosa	*Lactarius camphoratus*
Cantharellus tubaeformis	*Lactarius helvus*
Cortinarius armillatus	*Lactarius lignyotus*
Cortinarius balaustinus	*Lactarius mitissimus*
Cortinarius decipiens	*Lactarius sphagneti*
Cortinarius delibutus	*Lactarius thejogalus*
Cortinarius hemitrichus	*Lactarius volemus*
Cortinarius paleaceus	*Leccinum niveum*
Cortinarius paragaudis	*Leccinum variicolor*
Cortinarius pholideus	*Leccinum versipelle*
Cortinarius scaurus	***Mycena megaspora***
Entoloma atromarginatum	***Omphalina sphagnicola***
Entoloma cetratum	*Psilocybe elongata*
Entoloma griseorubidum	*Psilocybe uda*
Entoloma hirtipes	*Russula claroflava*
Entoloma xanthochroum	*Russula decolorans*
Galerina atkinsoniana*	*Russula emetica*
Galerina clavata	*Russula fragilis*
Galerina fennica	*Russula integra*
Galerina paludosa	*Russula vinosa*
Galerina sphagnorum	*Suillus flavidus*
Hygrocybe lepida	*Suillus variegatus*
Hygrophoropsis aurantiaca	***Tephrocybe palustris***

* taxa given in bold are closely associated with the plant species

Mycorrhizal fungi of trees, recorded exclusively or almost exclusively in boggy phytocoenoses, among *Sphagnum* mosses, are an interesting group of fungi. These include both random species and fungi exclusive to such biocoenoses, for example *Cortinarius armillatus, Cortinarius scaurus, Leccinum niveum, Russula vinosa* and *Suillus flavidus*. *Leccinum niveum* and *Suillus flavidus* are threatened fungi (Wojewoda & Ławrynowicz 2006). All sphagnophilous fungi are highly specialised and very sensitive to changes of water relations. When patches of *Sphagnum* dry out, these stenobiontic species die and regress.

Bryophilous species that do not exhibit obligatory relationships with a specific moss species or genus as is the case with *Sphagnum* are given in Table 37. These fungi always grow among moss stems and turfs.

Tree species of the genus ***Populus*** constitute the exclusive or almost exclusive substrate of a few specialised basidiomycete species or enable symbiosis formation. Among saprobionts, *Marasmius tremulae*, a rare European species, develops fruitbodies on fallen leaves in the litter. Small fruitbodies of this fungus are often similar to *M. epiphyllus*; however, they differ by having a divergent cystid structure and spore size. Fruitbodies of *Auricularioppsis ampla* and *Peniophora polygonia* were recorded on fallen branches. As reported in the literature, these fungi grow on *Populus* most frequently but they are also found

Table 37
Fungi associated with other mosses in the Góry Świętokrzyskie Mts.

Arrhenia glauca*	*Laccaria proxima*
Arrhenia retiruga	*Mycena capillaris*
Arrhenia spathulata	*Omphaliaster asterosporus*
Cantharellula umbonata	*Omphalina griseopallida*
Cortinarius malicorius	***Omphalina rustica***
Cortinarius semisanguineus	***Omphalina umbellifera***
Cortinarius traganus	***Psilocybe elongata***
Flammulaster ferrugineus	***Psilocybe montana***
Galerina fallax	***Psilocybe polytrichi***
Galerina hypnorum	***Psilocybe uda***
Galerina mniophila	*Ramaria gracilis*
Galerina pumila	***Rickenella fibula***
Galerina vittiformis	***Rickenella setipes***
Inocybe relicina	

* taxa given in bold are closely associated with mosses

on other deciduous species; however, they were collected only on *Populus* in the Góry Świętokrzyskie Mts.

Parasites of this tree genus, *Phellinus tremulae, Pholiota populnea, Pleurotus calyptratus*, are often obligatory. The latter species is particularly interesting. Rare, connected with warmer areas in central and southern Europe, this fungus usually occurs in natural tree stands. It was also recorded on poplars planted along streets in Kielce. *Phellinus tremulae*, a *Populus tremula* parasite, occurs in natural forests. The fungus is rare both in Poland and in the entire range of its host.

Mycorrhizal fungi form infrequent obligatory symbioses with *Populus*. *Leccinum aurantiacum* is an example of an exclusive *Populus tremula* mycosymbiont. *Inocybe squamata*, a very rare fungus in Poland was recorded not only under *Populus* but also under other trees. According to Horak (2005), this fungus is observed under *Betula* and *Populus* most frequently.

Apart from the above species, *Basidiomycetes* that form various trophic relationships with poplars are significantly more numerous (Tab. 38). *Populus* is a plant species only slightly specific to the majority of these fungi.

The presence of ***Picea abies*** in the plant cover in the Góry Świętokrzyskie Mts. is relatively small. It is an admixture species, and only single individuals are found in many forest communities. Twenty-nine species are associated with the tree (Tab. 39), and few species of *Basidiomycetes* are exclusive or almost exclusive to it in the study area. Spruce-dependant fungi include *Strobilurus esculentus*, which develops fruitbodies only on fallen *Picea* cones, and some obligatory mycosymbionts, such as *Cortinarius scaurus, Hygrophorus olivaceoalbus, Lactarius deterrimus* and *Sarcodon imbricatum* in the Góry Świętokrzyskie Mts. They are rare and very rare not only in the Góry Świętokrzyskie Mts. but also in Poland. *Cortinarius scaurus* has been recorded in Poland only three times (Schröter 1889; Dominik, Pachlewski 1956; Domański Z. 1997), and is a threatened species. It was recorded outside the study area 50 and over 100 years ago. This rare species is red-listed in some European countries, for instance the Netherlands, Switzerland and Great Britain. It is still

Table 38
Fungi associated with *Populus* spp. in the Góry Świętokrzyskie Mts.

Agaricus maleolens	*Lentinus torulosus*
Athelia arachnoidea	***Marasmius tremulae***
Auriculariopsis ampla*	*Paxillus involutus*
Bjerkandera adusta	*Peniophora cinerea*
Botryobasidium laeve	***Peniophora polygonia***
Byssomerulius corium	***Phellinus tremulae***
Chondrostereum purpureum	*Phlebia tremellosa*
Coprinus disseminatus	***Pholiota populnea***
Crepidotus mollis	***Pleurotus calyptratus***
Daedaleopsis confragosa	*Pleurotus ostreatus*
Datronia mollis	*Polyporus badius*
Flammulina velutipes	*Polyporus varius*
Fomes fomentarius	*Schizophyllum commune*
Hypsizygus ulmarius	*Stereum rugosum*
Inocybe squamata	*Trametes hirsuta*
Laetiporus sulphureus	*Trametes ochracea*
Leccinum aurantiacum	*Vuilleminia comedens*

* taxa given in bold are closely associated with the plant species

Table 39
Fungi associated with *Picea abies* in the Góry Świętokrzyskie Mts.

Antrodia crassa	*Marasmiellus perforans*
Antrodia serialis f. *resupinato-stratosus*	*Mycena cyanorrhiza*
Antrodia serialis	*Mycena galericulata*
Antrodia sinuosa	*Mycena galopus*
Armillaria ostoyae	*Mycena stipata*
Botryobasidium obtusisporum	*Mycena vulgaris*
Cortinarius balaustinus	*Phellinus nigrolimitatus*
Cortinarius delibutus	*Resinicium bicolour*
Cortinarius duracinus	***Sarcodon imbricatum***
Cortinarius erythrinus	*Skeletocutis odora*
Cortinarius scaurus*	*Stereum sanguinolentum*
Cystostereum murrayi	***Strobilurus esculentus***
Gloeophyllum odoratum	*Trichaptum abietinum*
Hygrophorus olivaceoalbus	*Trichaptum fuscoviolaceum*
Lactarius deterrimus	

* taxa given in bold are closely associated with this tree species

common in oligotrophic coniferous forests only in Scandinavia (http://hjem.get2net.dk/phlegmacium/Photosection/Gallery/scaurus1.html). *Hygrophorus olivaceoalbus* and *Sarcodon imbricatum* represent the rare boreal-montane element. As demonstrated by Johannesson *et al.* (1999), the latter is an obligatory symbiont of *Picea abies* and does not form mycorrhizae with *Pinus*. The twin-like *S. squamosum* is associated with pine trees.

The Góry Świętokrzyskie Mts. are an important centre of occurrence of larch trees, and especially ***Larix decidua*** ssp. ***polonica***, in Poland. Twenty species of *Basidiomycetes* are associated with it in the study area (Tab. 40) of which only seven species are exclusive. The majority of larch companions, given in Table 40, are rare fungi, apart from *Suillus grevillei,* which is common. *Oligoporus obductus* is a larch facultative parasite. It occurs in natural, old-growth forest stands where old larch trees are present. It is a threatened species and red-listed for instance in Germany, Norway and Switzerland. It is distributed in Central Europe in the Old World. *Fomitopsis officinalis* is an obligatory parasite of *Larix.* It is interesting that the species occurs only on *Larix decidua* ssp. *polonica* in Poland. The fungus is extremely threatened in Poland and many other European countries. The majority of the Polish population of the fungus is concentrated in the Góry Świętokrzyskie Mts. and areas directly adjacent to them (Łuszczyński 2000b, c, 2004a; Chlebicki & Łuszczyński 2002; Piętka & Szczepkowski 2004). The species' greatest subpopulation develops on Chełmowa Góra Mt in the Świętokrzyski National Park.

Larch trees are accompanied by a group of obligatory mycorrhizal fungi: *Boletinus cavipes, Gomphidius maculatus, Hygrophorus lucorum, Lactarius porninsis* and *Suillus grevillei*. Apart from the latter, all of them are rare and threatened in many countries, for example in Germany, Denmark and the Netherlands. They are recorded in the mountains more often than in lowlands in Poland.

Relationships between fungi and other plant species are given in Table 41. However, obligatory relationships between, among others, ***Acer pseudoplatanus*** and *Hymenochaete carpatica* deserve special attention. The fungus was not known from Poland until recently; it has lately been reported from very many natural and synanthropic sites within the range of *Acer pseudoplatanus* (Chlebicki 2003; Krieglsteiner & Ławrynowicz 2003; Wojewoda 2003). Its inconspicuous fruitbodies that develop mostly on the internal side of sycamore bark were overlooked and were not recorded. The fungus is definitely common in the Góry Świętokrzyskie Mts. and in Poland.

Leccinum pseudoscabrum forms an obligatory mycorrhiza with ***Carpinus betulus***. The fungus is not rare in the study area and is recorded together with its phytosymbiont in *Dentario glandulosae-Fagetum* and *Tilio-Carpinetum*.

Table 40
Fungi associated with *Larix decidua* ssp. *polonica* in the Góry Świętokrzyskie Mts.

Boletinus cavipes*	*Panellus mitis*
Cortinarius delibutus	*Paxillus involutus*
Fomitopsis officinalis	*Phaeolus schweinitzii*
Gomphidius maculatus	*Phanerochaete gigantea*
Hygrophorus lucorum	*Pseudohydnum gelatinosum*
Lactarius porninsis	*Psilocybe fascicularis*
Lentinus lepideus	***Suillus aeruginascens***
Mycena aurantiomarginata	***Suillus grevillei***
Mycena viridimarginata	*Tricholomopsis rutilans*
Oligoporus obductus	*Tremella hypogymniae* (lichenicolous fungus)
Omphaliaster asterosporus	

* taxa given in bold are closely associated with this tree species

Table 41
Fungi associated with other plants in the Góry Świętokrzyskie Mts.

Plants	Fungi
Trees	
Salix spp.	*Athelia arachnoidea, Auricularia auricula-judae, Bjerkandera adusta, B. fumosa, Exidia plana, Flammulina velutipes, Hebeloma crustuliniforme, H. hiemale, Laetiporus sulphureus, Lentinus tigrinus, Phellinus conchatus,* ***P. igniarius,*** *Pleurotus ostreatus, P. ostreatus* var. *salignus, Polyporus squamosus, Trametes gibbosa, T. suaveolens, Vuilleminia comedens*
Carpinus betulus	*Byssomerulius corium, Hapalopilus nidulans,* **Leccinum pseudoscabrum,** *Megacollybia platyphylla, Panellus serotinus,* ***Peniophora laeta,*** *P. nuda, Phlebia radiata, Pholiota mutabilis,Pluteus salicinus, Polyporus varius, Schizophyllum commune, Ramaria stricta, Stereum hirsutum, Trametes versicolor, Tremella mesenterica*
Acer spp.	*Auricularia auricula-judae, Cerrena unicolor, Coprinus disseminatus, Cylindrobasidium laeve, Flammulina velutipes, Fomes fomentarius,* **Hymenochaete carpatica**, *Inonotus cuticularis, Oxyporus populinus, Pholiota aurivella, Pluteus atricapillus, Polyporus alveolaris, P. squamosus, P. tuberaster, Tremella lichenicola* (lichenicolous fungus)
Sorbus aucuparia	*Byssomerulius corium, Daedaleopsis confragosa, Exidia plana, Hapalopilus nidulans, Marasmius epiphyllus, Oligoporus alni, Phlebia radiata, Pleurotus ostreatus, Pluteus salicinus,Protomerulius caryae, Stereum hirsutum, Tremella hypogymniae* and *T. lichenicola* (lichenicolous fungi)
Tilia cordata and *T. platyphyllos*	*Exidia villosa, Flammulina velutipes, Mycena tintinnabulum, Polyporus alveolaris, P. umbellatus, Schizophyllum commune, Scleroderma fuscum*
Aesculus hippocastanum	*Auricularia auricula-judae, Bjerkandera adusta, Flammulina velutipes, Meripilus giganteus, Pluteus ephebeus, Volvariella bombycina*
Robinia pseudacacia	*Armillaria ostoyae, Auricularia auricula-judae, Coprinus disseminatus, Laetiporus sulphureus, Pholiota squarrosa, Radulomyces confluens*
Cerasus spp.	*Laetiporus sulphureus, Lycoperdon pyriforme, Piptoporus betulinus, Stereum hirsutum, S. rugosum, Trametes hirsuta*
Prunus spp.	*Entoloma saundersii, Laccaria tortilis,* ***Phellinus pomaceus****, Schizophyllum commune, Stereum hirsutum, Trametes hirsuta*
Fraxinus excelsior	*Cerrena unicolor, Lycoperdon pyriforme, Phlebia radiata, Pluteus aurantiorugosus*
Ulmus spp.	*Flammulina velutipes, Ganoderma applanatum, Hypsizygus ulmarius, Pluteus atricapillus*
Shrubs	
Corylus avellana	*Byssomerulius corium, Datronia mollis, Mycena polygramma, Peniophora cinerea, P. incarnata, Pluteus plautus, P. romellii, Polyporus ciliatus, Stereum complicatum, S. gausapatum, S. hirsutum, Trametes hirsuta, Vuilleminia comedens*
Ligustrum vulgare	*Hebeloma crustuliniforme, H. hiemale, Pholiota squarrosa, Psathyrella candolleana*
Sambucus nigra	*Athelia neuhoffii, Auricularia auricula-judae, Hyphodontia sambuci, Pleurotus ostreatus*
Frangula alnus	*Datronia mollis, Pleurotus cornucopiae*
Crataegus spp.	*Flammulina velutipes*
Euonymus spp.	***Phylloporia ribis***
Ribes spp.	***Phylloporia ribis***
Spiraea spp.	*Inocybe squamata*

Basidiomycetes form obligatory biotrophic, mycorrhizal and parasitic relationships with some fruit trees and shrubs. *Phellinus pomaceus* parasitises on trees and shrubs of the genus ***Prunus***. It is a frequent fungus, especially in deserted or untended orchards and in blackthorn-bush communities. The occurrence of *Entoloma saundersii*, a fungus of the early spring period that had not been previously recorded in Poland, was observed under trees belonging to this genus. It was found at two mutally distant localities in the Góry Świętokrzyskie Mts.

Phylloporia ribis f. *ribis* parasitises on shrubs of the genus ***Ribes***. This form is very rare; another form of this parasite, *Phylloporia ribis* f. *evonymi*, occurs more often on ***Euonymus verrucosa*** shrubs. The fungus occurs exclusively in *Tilio-Carpinetum* phytocoenoses. As its host is a characteristic species in the *Tilio-Carpinetum*, *Phylloporia ribis* f. *evonymi* can be treated as a good characteristic species of this syntaxon.

The occurrence of *Crucibulum laeve* on petioles of ***Pteridium aquilinum*** in *Querco-Pinetum* patches should also be mentioned.

5.5. The role and position of *Basidiomycetes* in biocoenoses of selected ecosystems in the Góry Świętokrzyskie Mts.

Fungi are basic components of every natural ecosystem and their role in a biocoenosis is of fundamental importance for the development of certain plant species. Quantitative ratios describing a biocoenosis often demonstrate that they are the most numerous elements, while quantitative relationships between, for instance, fungi and plants range from 3.6:1 to 8.7:1 (Mułenko 1998; Grzywacz 1999).

Basidiomycetes emerge as integral and essential elements of each biocoenosis examined in this project. Their occurrence is expressed by a specific number of species that inhabit a certain space, occupy different habitats (microhabitats) and form trophic relationships with other organisms or their remains.

The quantitative presence of fungi belonging to *Basidiomycetes* in plant communities in the Góry Świętokrzyskie Mts. varies (Fig. 13; Tab. 42).

The greatest number of basidiomycete species, 393, was recorded in phytocoenoses belonging to the *Tilio-Carpinetum*. However, 246 fungal species were observed at selected permanent research plots in this community. The ratio between the richness of fungal species and the number of species of vascular plants only from those plots where fungi of this systematic group form the most numerous relationships and are of vital importance for them equals 1.87:1. The mixed coniferous forest, *Querco-Pinetum*, and the Carpathian beech forest, *Dentario glandulosae-Fagetum*, where 292 and 268 species were recorded, respectively, are equally rich communities. The proportions of the presence of *Basidiomycetes* and the number of vascular plants were similar in both, and were 2.63:1 and 2.52:1, respectively. However, the greatest relative richness was observed in the *Abies alba-Sphagnum girgensohnii* community, where the number of *Basidiomycetes* exceeded that of plants in a ratio of 5.71:1, in the mesic coniferous forest *Leucobryo-Pinetum* – 4.33, and in the boggy coniferous forest *Vaccinio uliginosi-Pinetum* – 4:1. It is interesting, and also confirmed by earlier observations by Mułenko (1998) and Grzywacz (1999), that the number of *Basidiomycetes* is greater than that of plants in all the biocoenoses studied. The number of both was the same only in the mesic coniferous forest *Peucedano-Pinetum* within the

Table 42
Number of basidiomycete species in plant communities in the Góry Świętokrzyskie Mts.

Plant community	Total number of *Basidiomycetes*	Number of species at research plots		Fungi/plants ratio
		Basidiomycetes	vascular plants	
Sphagnetum magellanici	60	59	17	3.47:1
Cladonio-Pinetum	53	53	20	2.65:1
Peucedano-Pinetum	199	78	78	1:1
Leucobryo-Pinetum	168	143	33	4.33:1
Querco-Pinetum	292	129	49	2.63:1
Serratulo-Pinetum	128	128	119	1.07:1
Vaccinio uliginosi-Pinetum	97	64	16	4:1
Abietetum polonicum	230	108	30	3.6:1
Abies alba-Sphagnum girgensohnii community	79	75	13	5.76:1
Potentillo-Quercetum	187	179	124	1.44:1
Fraxino-Alnetum	99	67	60	1.1:1
Tilio-Carpinetum	393	249	133	1.87:1
Luzulo pilosae-Fagetum	108	98	25	3.92:1
Dentario glandulosae-Fagetum	268	187	74	2.52:1

research plots and equalled 78. However, the total number of fungi recorded in all the phytocoenoses of this community was 199.

Basidiomycetes colonise almost all surfaces within the space of a biocoenosis (Orłoś 1966). Because of the distribution pattern, substrate dependence, and the influence of ecological factors that occur in individual plant communities, the mycobiota is not a seemingly

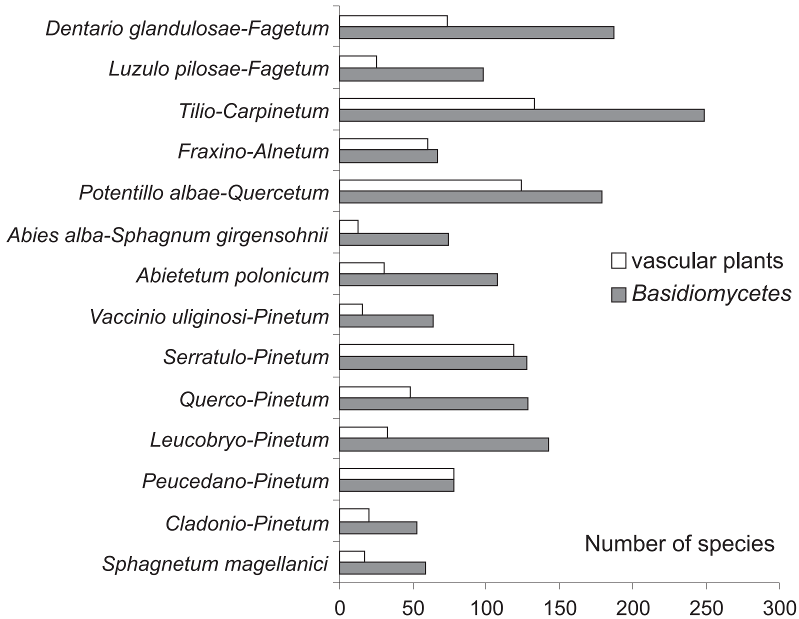

Fig. 13. Occurrence of vascular plants and *Basidiomycetes* in biocoenoses at the research plots

homogeneous and coherent mycocoenosis but forms a certain system of synusiae and smaller mycocoenoses that overlap and penetrate one another. Lignicolous fungi developing on different parts of logs, trunks or branches, for example, are by some authors treated as autonomous mycoassociations (Pirk & Tüxen 1957; Kreisel 1961; Jahn 1966; Darimont 1973; Runge 1980; Michael *et al.* 1985; Kreisel & Müller 1987; Fellner 1988a). A similar approach to terrestrial fungi is presented by, for instance, Šmarda (1973). Such a reductionistic understanding of a mycocoenosis has been criticised by some researchers, Dörfelt (1974), for instance. These groups of fungi develop on the substrate that belongs to a certain biocoenosis type, and their growth is influenced by and depends on ecological conditions that occur there. Therefore, they are part of a biocoenosis whose range is determined by the borders of its phytocoenosis. Fungi are treated holistically within the entire plant association as elements belonging to its complex biocoenosis.

The genetic layout and organisation of fungi associated with burnt-out sites and of coprophilous fungi differ from the above pattern. Fungi connected with these habitats, alien to the phytocoenosis studied, create autonomous synusiae that are independent mycoassociations (Pirk & Tüxen 1949; Ebert 1958; Darimont 1973; Wojewoda 1975; Lisiewska 1992b).

Saprobic fungi. Saprobionts constitute a very important group that participates in the decomposition of the dead organic matter, degeneration of plant, animal and fungal remains and matter circulation in the ecosystem. Pedobionts growing on humus whose mycelium develops in the fermentation and humus layer take part in litter decomposition and in soil-forming processes. Bacteria and fungi are the only organisms that can decompose cellulose and lignin. Wood decomposition and decay open up the way for other destruents. The species composition of xylobionts, especially those developing on trunks and logs, depends on the changes that take place in the wood structure and the degree of its decomposition. Therefore, three phases of wood decomposition can be distinguished: initial, optimal and end phase (Kreisel 1961; Jahn 1968). The initial phase belongs to pioneer species colonising wood that is not structurally changed while the end phase is conducted by species that prefer highly decomposed wood (cf. chapter 5.4). The rate of fungal succession and wood decomposition is modified by the microclimate identifiable in a given plant community.

Saprobionts are a dominant group in the mycobiota of the examined forest communities, comprising 593 species, that is 57% of the total number of species. Among them, 332 (32%) are saprobionts – pedobionts, species growing on litter and humus, 251 (24%) – xylobionts that decompose dead standing and lying trunks and logs, thick and small-sized branches, and 10 (0.9%) – allobionts, coprophilous species that occur on animal faeces (Fig. 14).

Pedobionts constitute the largest group. It is represented most numerously by fungi of the family *Tricholomataceae* – 148 species, belonging to 24 genera, and the family *Agaricaceae* – 28 species, belonging to 5 genera. The following genera are the most numerous in this trophic group: *Mycena* (55 species), *Clitocybe* (30) and *Entoloma* (24). Furthermore, *Mycena pura*, recorded at 97 localities (in 52 squares), *Lycoperdon perlatum* – 91 (51), *Marasmius oreades* – 87 (59), *Gymnopus peronatus* – 81 (42) and *Gymnopus dryophilus* – 80 (43), are the most common pedobionts.

Xylobionts are represented by fungi belonging to different systematic groups. *Polyporaceae* – 40, followed by *Cortinariaceae* – 19, *Pluteaceae* – 18, *Schizoporaceae* – 13 and *Stereaceae* – 12, have the greatest number of species. *Pluteus* – 18 species, *Hyphodontia* – 11

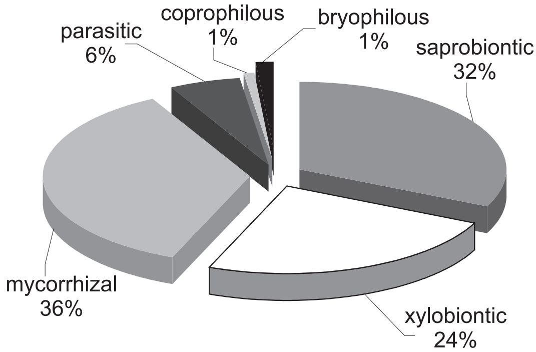

Fig. 14. Ecological groups within *Basidiomycetes* examined in the project

and *Polyporus* – 9, are the most numerous genera. The most common xylobionts are as follows: *Dacryomyces stillatus* – 122 localities (in 65 squares), *Stereum hirsutum* – 107 (54), *Trichaptum fuscoviolaceum* – 92 (51), *Trichaptum abietinum* – 91 (50), *Psilocybe fasciculare* – 90 (47), *Schizophyllum commune* – 89 (48), *Bjerkandera adusta* – 88 (42), *Athelia arachnoidea* – 85 (51), *Exidia plana* – 85 (45), *Strobilurus tenacellus* – 85 (44), *Trametes hirsuta* – 81 (46) and *Trametes versicolor* – 81 (46).

Coprophilous *Basidiomycetes* are extremely specialised organisms that develop on animal faeces. It is a relatively small group, and its representatives belong to four families: *Bolbitiaceae* – 8 species, *Coprinaceae* – two, *Pluteaceae* – one, and *Strophariaceae* – one. *Panaeolus*, with six species, is the most numerous genus, while other species belong to *Bolbitius* – two, *Coprinus* – two, *Psilocybe* – one and *Volvariella* – one species.

Parasitic fungi. The role of this fungi in biocoenoses and in their individual types is highly important. Monophagous parasites, associated with a defined host, as well as polyphagous parasites, feeding on many plant species, are present in this group. Different forms of parasitism can be identified: from obligatory, biotrophic, where a parasite lives only on living plant organs, to facultative, where a parasite can still develop on the host's dead tissues after its death. Parasites comprise 59 species of *Basidiomycetes* examined in this project, that is 6% of the total number of species. Fungi of the family *Hymenochaetaceae*, 14 species belonging to three genera: *Phellinus* – 10 species, *Inonotus* – three and *Phylloporia* – one, are the most numerous group. Monophagous parasites, for example *Buglossoporus quercinus* on *Quercus*, *Bondarzewia mesenterica* on *Abies alba* and *Fomitopsis officinalis* on *Larix decidua* ssp. *polonica* deserve special attention. A group of mycophages belonging to the genus *Tremella* and comprising 9 species is also noteworthy.

Armillaria ostoyae, recorded at 83 localities in 55 squares, *Fomes fomentarius* 64 (36), *Heterobasidium annosum* – 59 (34), *Phellinus igniarius* – 54 (37) and *Laetiporus sulphureus* 26 (21) are the most common basidiomycete parasites in the Góry Świętokrzyskie Mts.

Mycorrhizal fungi. The biocoenotic importance of mycorrhizal fungi changes as research into this ecological group of fungi progresses. Over 90% of plants are at present known to form mycorrhizal relationships. It is not possible to determine in the field whether a fungus forms symbioses with plant roots or whether it is a saprobiont. Mycorrhizal fungi were identified on the basis of the literature (Agerer 1987-2002; Michael *et al.* 1988; Münzenberger *et al.* 2004). Potentially mycorrhizal fungi were also analysed. The disappearance of mycorrhizal fungi results in a slow death of trees and other plants. Due to the role they play in biocoenoses, mycorrhizal fungi can be used as sensitive tools in bioindication (Fellner 1988b; Jansen 1990).

A total of 375 species were identified in the mycorrhizal biota of *Basidiomycetes*, that is 36% of all the fungi recorded in this mesoregion. The most numerous families are as follows: *Russulaceae* – 103, *Cortinariaceae* – 90, *Tricholomataceae* – 44, *Boletaceae* – 28 and *Bolbitiaceae* – 22. The greatest number of species belongs to the families *Russula* – 59, *Cortinarius* – 52, *Lactarius* – 44, *Inocybe* – 36, *Tricholoma* – 20, *Amanita* – 15 and *Hebeloma* – 15. *Laccaria laccata,* observed at 90 localities in 49 squares, *Laccaria amethystea* – 90 (49), *Amanita muscaria* – 81 (47), *Amanita citrina* – 81 (43), *Boletus edulis* – 69 (43), *Leccinum scabrum* – 69 (38), *Cantharellus cibarius* – 62 (37), *Paxillus involutus* – 58 (36), *Lactarius rufus* – 56 (31) and *Suillus luteus* – 53 (34), are the most common mycorrhizal species.

5. 6. Fungi in the Góry Świętokrzyskie Mts. against other regions in Poland

The current composition of *Basidiomycetes* in the Góry Świętokrzyskie Mts. has been influenced by the location of the area in relation to the adjacent geographical regions, climatic conditions, natural topography, geological structure and plant cover as well as human economy. The area is situated on the northern occurrence limit of *Abies alba, Acer pseudoplatanus, Fagus sylvatica, Larix decidua* ssp. *polonica* and *Picea abies.* The importance of these trees is emphasised by their geobotanic character. They are mountain plants (Zając M.1996) that descend to the upland area and have developed their own mycobiota. The presence of these tree species in the plant cover of the Góry Świętokrzyskie Mts. encourages the penetration of mountain fungi into the study area. A great similarity between the participation of mountain species in the Góry Świętokrzyskie Mts., the Carpathian Mts. and the Sudeten Mts. emerges from the analysis (Tab. 43). As many as 69 species that occur both in the study and in the Tatra Mts., 56 in the Beskid Żywiecki Mts., 49 in the Pieniny Mts. and 48 in the Beskid Sądecki Mts. are identified of the total number of 87 species of *Basidiomycetes* examined here that can be considered to be montane or boreal-montane. They include 11 typically mountain species: *Hygrophorus erubescens, Lactarius badiosanguineus, L. lignyotus, L. picinus, L. salmonicolor, L. scrobiculatus, Mycena laevigata, M. renati, M. viridimarginata, Porphyrellus porphyrosporus* and *Tricholomopsis decora*.

The species composition of *Basidiomycetes* in the Góry Świętokrzyskie Mts. is greatly dependent on the development of the plant cover. The local forest vegetation which is characterised by a vertical distribution of communities can be divided into two layers: upper and lower (Szafer 1977).

Fungi associated with *Abietetum polonicum* and *Dentario glandulosae-Fagetum* are characteristic elements of the mycobiota in the Góry Świętokrzyskie Mts. The presence of montane and boreal-montane species resembles that in similar biocoenoses in the Carpathians and the Sudeten Mts. However, due to the border range of these communities, the participation and species composition of *Basidiomycetes* are lower.

Fungi in the ***Dentario glandulosae-Fagetum*** in Poland were analysed in mycocoenological studies by many authors, for instance by Gumińska (1962a, b, 1992a), Wojewoda (1964, 1965, 1975, 1990, 1999b, 2000a), Nespiak (1968), Lisiewska (1972, 1974, 1979), Sałata (1972), Lisiewska *et al.* (1977), Bujakiewicz (1979, 1981, 1982, 1987) and Ronikier

Table 43
Mountain and boreal-mountain fungi in the Góry Świętokrzyskie Mts. and other mountain massifs in Poland and Europe

Mountain massifs	**GŚ**	TNP	BŻ	PNP	BS	S	B	G	BNP	SNP
Total species	**87**	69	56	49	48	40	33	29	36	30
Albatrellus confluens	+	+	.	+	+	+	.	+	.	.
Albatrellus cristatus	+	+	+	+	+	+	.	+	.	.
Albatrellus ovinus	+	+	+	.	+	+	.	+	.	.
Aleurodiscus amorphus	+	+	+	+	+	+	.	.	.	.
Amylostereum chailletii*	+	+	+	.	+	.	+	+	.	.
Bankera violascens	+	+	.	.	+	.	.	.	.	.
Boletinus cavipes	+	+	.	.	.	+	.	.	+	+
Boletus calopus	+	+	+	+	+	+	+	+	.	.
Boletus luridiformis	+	+	+	+	+	+	+	+	.	.
Boletus luridus	+	+	+	+	+	+	+	+	+	.
Bondarzewia mesenterica	+	+	.	+	+	+	+	+	.	.
Clavulicium macounii	+	.	.	.	+	.	+	.	.	.
Clitocybe fragrans	+	+	+	+	+	+	+	.	.	.
Clitocybe pruinosa	+	.	+	+	.	.	.	.	.	.
Cortinarius acutus	+	+	+	.	.	.	.	.	+	+
Cortinarius brunneus	+	+	+	.	.	+	.	.	+	+
Cortinarius elegantior	+	.	.	+	.	.	.	.	.	.
Cortinarius glaucopus	+	+	.	+	.	+	.	.	.	.
Cortinarius lividoochraceus	+	+	.	.	.	.	+	.	.	.
Cortinarius malicorius	+	.	+	.	+	.	.	+	.	.
Cortinarius sanguineus	+	+	+	+	.	.	+	+	+	+
Cortinarius scaurus	+	+	.	.	.	.	.	.	.	.
Cortinarius venetus	+	+	.	.	.	.	.	..		.
Crepidotus applanatus	+	+	+	.	.	.	+	.	+	+
Crepidotus caesatii var. *subsphaerosporus*	+	+	+	.	.	.	+	.	+	+
Cystoderma carcharias	+	+	+	+	+	.	+	+	+	+
Cystostereum murrayi	+	+	.	+	+	.	+	.	.	.
Entoloma hirtipes	+	+	+	+	+	.	.	.	+	+
Fomitopsis officinalis	+	.	.	.	.	.	.	.	.	.
Galerina atkinsoniana	+	+	.	.	.	.	.	.	.	.
Ganoderma carnosum	+	.	.	+	.	+	.	.	.	.
Gomphidius maculatus	+	+	+	+	+	+	.	.	.	.
Gomphus clavatus	+	+	.	.	+	+	+	+	.	.
Gymnopilus picreus	+	.	+	.	.	+	.	.	.	.
Gymnopus hariolorum	+	+	.	+	.	.	.	.	+	.
Hericium flagellum	+	.	+	+	+	.	+	.	.	.
Hydnellum aurantiacum	+	.	.	.	+	+	.	+	.	.
Hydropus atramentosus	+	.	.	.	+	.	.	.	.	.
Hydropus marginatus	+	.	+	+	+	.	.	.	.	.
Hygrocybe persistens	+	+	.	+	.	.	.	.	.	.
Hygrophorus erubescens	+	+	.	.	.	.	.	.	+	+
Hygrophorus hyacinthinus	+	+	.	+	.	.	.	.	.	.
Hygrophorus olivaceoalbus	+	+	+	.	+	+	+	+	+	+
Hygrophorus pudorinus	+	+	.	+	+	.	.	+	.	

Tab. 43 cont.

Hygrophorus pustulatus	+	+	+	+	.	+	.	.	+	+
Hygrophorus unicolor	+	+	+	.	.	.	.	.	+	.
Hymenochaete cruenta	+	+	+	+	+	+	+	.	.	.
Lactarius acris	+	+	+	+	+	+	+	.	+	.
Lactarius badiosanguineus	+	+	.	.	.	.	.	.	+	+
Lactarius lignyotus	+	+	+	.	+	+	+	+	+	+
Lactarius picinus	+	+	+	+	+	.	.	.	+	+
Lacatrius porninsis	+	+	+	+	+	.	.	.	+	+
Lacatrius salmonicolor	+	+	+	+	.	.	+	+	+	+
Lactarius scrobiculatus	+	+	+	+	+	+	.	.	+	+
Lentinus adhaerens	+	+	+	+	+	.	.	.	.	.
Leucocortinarius bulbiger	+	.	.	.	.	.	+	.	.	.
Limacella glioderma	+	+	.	+	.	.	.	.	+	+
Marasmius cohaerens	+	+	.	+	.	.	+	.	+	.
Mycena aurantiomarginata	+	+	+	+	+	+	+	.	+	+
Mycena citrinomarginata	+	+	+	.	.	.	+	.	+	+
Mycena laevigata	+	+	+	.	.	+	.	.	+	+
Mycena megaspora	+		+	.	.	.	.	.	.	.
Mycena renati	+	+	+	+	.	.	+	.	+	.
Mycena rosella	+	+	+	+	+	+	.	+	+	+
Mycena rubromarginata	+	+	+	+	+	+	.	.	+	+
Mycena viridimarginata	+	+	+	.	.	+	.	.	+	+
Omphalina epichysium	+	+	+	+	+	.	+	.	.	.
Panellus serotinus	+	.	+	+	.	.		+	.	.
Phellinus hartigii	+	+	+	.	+	+	+	+	.	.
Phellinus nigricans	+	+	.	.	.	.	+	+	.	.
Phellinus nigrolimitatus	+	.	+	.	.	.	.	.	.	.
Pholiota astragalina	+	.	+	+	+	.	.	+	.	.
Phyllotopsis nidulans	+	+	.	.	.	+	.	+	.	.
Porphyrellus porphyrosporus	+	+	+	+	+	+	+	+	.	+
Pycnoporellus fulgens	+	.	.	.	+	.	+	+	.	.
Ramaria botrytis	+	+	+	+	+	+	.	.		.
Ramaria flava	+	+	.	+	+	+	.	+	.	.
Russula consobrina	+	.	.	.	.	+	.	.	.	.
Russula integra	+	+	+	+	.	.	.	.	+	+
Russula mustelina	+	+	+	.	+	+	+	+	.	.
Russula queletii	+	+	+	+	+	+	+	.	+	+
Russula vinosa	+	+	+	.	.	.	.	.	+	+
Sarcodon imbricatum	+	+	+	+	+	+	.	.	.	.
Tremella mycetophilloides	+	+	+	+	+	.	.	+	.	.
Tricholoma vaccinum	+	+	+	+	+	+	.	+	+	+
Tricholomopsis decora	+	+	+	.	+	+	.	.	+	+
Xeromphalia campanella	+	+	+	+	+	+	+	.	+	+

GŚ – Góry Świętokrzyskie Mts.; TNP – Tatra National Park (Frejlak 1973; Wojewoda 1996b; Ronikier 2005c); BŻ – Beskid Żywiecki Mts., PNP – Pieniny National Park, BS – Beskid Sądecki Mts. (Gumińska 1962a, b, 1966; Lisiewska *et al*. 1977); S – Sudety Mts. (Domański S. 1963; Nespiak 1971; Narkiewicz 2001); B – Bieszczady Mts. (Domański S. *et al*. 1960, 1963, 1967, 1970); G – Gorce Mts. (Wojewoda 1964; Domański Z. 1965); BNP – Berchtesgaden National Park (Schmid-Heckel 1985); SNP – Swiss National Park (Favre 1960; Horak 1963, 1985); * – mountain element s.str.

(2005c). *Basidiomycetes* occurring in patches of *Dentario glandulosae-Fagetum* in the Góry Świętokrzyskie Mts. are on the whole similar to those in beech forests in the lower subalpine forest in the Carpathians. Quantitatively, 182 species were recorded on Babia Góra Mt (Bujakiewicz 1981), 81 in the Sarnia Skała massif in the Tatra Mts. (Ronikier 2005c) and 186 species in the Góry Świętokrzyskie Mts. The presence of species characteristic of beech forests (Lisiewska 1974) demonstrates that biocoenoses in the Góry Świętokrzyskie Mts. are intermediate forms between typical mountain or lowland beech forests and *Tilio-Carpinetum* with *Fagus sylvatica* also present. *Cortinarius nemorensis, C. torvus* and *Mycena fagetorum* are considered by Lisiewska (1974) to be fungi characteristic of beech forests in the study area while *Marasmius alliaceus, Mycena crocata, Oudemansiella mucida* and *Polyporus tuberaster* – to be connective species of mountain and lowland beech forests. These results confirm earlier conclusions by Lisiewska (1979) and Bujakiewicz (1981) on the profile of beech forests in the Góry Świętokrzyskie Mts.

The character of acid beech forests ***Luzulo pilosae-Fagetum*** is different. The body of information on fungi in this community is fairly good, and they have been examined by Adamczyk (1995), Friedrich (1986, 1994), Lisiewska & Marach (2002) and Stasińska (1999). The acid beech forest is mycologically poorer than the Carpathian beech forest. The lowland form of the acid beech forest is negatively differentiated by an infrequent participation or complete lack of mountain species. In *Luzulo-Fagetum* in the Góry Świętokrzyskie Mts., a sporadic presence of *Lactarius nemorensis* and *Mycena fagetorum*, which are believed to prefer fertile mountain beech forests according to Lisiewska (1979) was observed. This positions the *Luzulo-Fagetum* biocoenoses discussed here between typical acid beech forests and mountain beech forests. The species composition of fungi in *Luzulo-Fagetum* is significantly poorer in comparison with other regions, and in particular with biocoenoses in North-Western Poland, where it finds optimum development conditions (Matuszkiewicz 2006). Climatic and edaphic conditions, the tree age and the amount of dead wood are important factors that influence the species composition of *Basidiomycetes* in beech forests. Beeches represented the 4th age class in the phytocoenoses, which inhibits the occurrence of some xylobionts due to young age.

A great part of the mycobiota of *Basidiomycetes* in the ***Abietetum polonicum*** is similar to fungi growing in the *Dentario glandulosae-Fagetum*. This is a results from, among others, the presence of deciduous tree species, mostly *Fagus,* but also other trees, for example *Betula*, which bring many of its “own” species to the biocoenosis of the fir forest. The present author’s observations and the literature on the subject confirm this thesis (Sałata 1969, 1972, 1978; Lisiewska 1979; Kałucka 1995). Typical phytocoenoses of *Abietetum polonicum* in the Góry Świętokrzyskie Mts. are differentiated from the same community in other regions by a definite domination of *Abies alba* with only single *Fagus* and *Sorbus* individuals. Therefore, the participation of species typical of beech forests in the *Abietetum polonicum* phytocoenoses in the Góry Świętokrzyskie Mts. is significantly smaller than that in, for instance, Roztocze or the Beskid Sądecki Mts. (Gumińska 1966; Sałata 1969, 1972, 1978; Lisiewska 1974). A special feature of *Abietetum polonicum* in the Góry Świętokrzyskie Mts. is also the primeval character of many phytocoenoses in this community, including the presence of ample amounts of dead fir trees and fir logs. This positively influences the occurrence of rare *Basidiomycetes* typical of old-growth forests, for example *Bondarzewia mesenterica*, *Ganoderma carnosum*, *Pycnoporellus fulgens* and *Sparassis brevipes*. Apart from many common species, fir forests in the Góry Świętokrzyskie Mts. and in other regions are connected by some other rare species that accompany firs, for instance *Hericium flagellum* and *Hymenochaete cruenta*.

Apart from the species given above, fungi such as *Mycena aurantiomarginata, Lactarius lignyotus, Lentinus adhaerens, Russula mustelina* (not found in the present study) and *Galerina josserandii* connect lower subalpine coniferous forests and fir forests (*Abieti-Piceetum montanum* and *Galio-Abietetum*) in the Carpathians with the community discussed here. *Galerina josserandii* is known in Poland only from the Góry Świętokrzyskie Mts. and Babia Góra (Bujakiewicz 1979). Bujakiewicz (1981) believes that *Russula mustelina*, among others, is a species characteristic of lower alpine fir forests.

The mycobiota in the ***Abies alba-Sphagnum girgensohnii*** community is also clearly similar to lower subalpine mixed forests and fir forests in the Carpathians. The presence of fir in the community results in the occurrence of many interesting species that it has in common with forests in the Carpathians, for example *Hygrophorus olivaceoalbus, H. pustulatus* and *Lactarius lignyotus*, as well as *Cystoderma jasonis*, frequent in these biocoenoses (Bujakiewicz 1981). The resemblance to *Bazzanio-Piceetum* is also noticeable and is related to the participation of bryophilous species *Galerina paludosa, Psilocybe elongata, P. uda* as well as *Lactarius helvus, L. rufus* and *L. thejogalus*. *Cystoderma jasonis* and *Hygrophorus olivaceoalbus* were recorded in the mossy coniferous forest. No information on the boggy form of the fir forest is available in the Polish literature.

The mycobiota of mesic pine forests is discussed in numerous studies and the literature on it is ample (Hołownia 1959, 1967; Wojewoda 1961, 1964, 1973, 1974, 1976a, 1977c, 1979b, 1980, 1981a; Rudnicka-Jezierska 1963; Sałata 1968, 1978; Bujakiewicz 1975; Lisiewska 1978a, b, 1982, 1991(1992); Friedrich 1984, 1986, 1987(1985), 1994, 2002; Lisiewska & Wójcik 1984; Flisińska 1997a; Ławrynowicz & Szkodzik 1998, 2002). It was described as *Vaccinio myrtilli-Pinetum* in older studies; two geographically vicariant associations, *Leucobryo-Pinetum* and *Peucedano-Pinetum*, are distinguished in recent syntaxonomic studies concerning mesic coniferous forests.

Pine forests and mixed coniferous forests dominate in lower locations of the Góry Świętokrzyskie Mts. As a result of a great differentiation of the study area, different communities of coniferous forests occur next to each other or replace one another depending on local habitat, humidity and lithologial conditions.

Mycological studies in the ***Leucobryo-Pinetum*** in Poland were conducted by, for example, Lisiewska (1978a), Lisiewska & Wójcik (1984), Friedrich (1986, 1994) and Ławrynowicz & Szkodzik (1998). The composition of fungi in this community appears to be typical and comparable to that in other areas in Poland. Species richness is similar to that in, for example, the Puszcza Goleniowska Forest and the Bory Tucholskie Forests, and are less numerous than in the Cedyński Landscape Park, which results from a smaller number of examined plots (Friedrich 1994, 2001). The mycobiota in *Leucobryo-Pinetum* is not very specific. Some *Basidiomycetes,* for instance *Cortinarius mucosus*, can be considered to be differential due to the frequency of their records in this community. Apart from this species, a fairly numerous group of characteristic species that connects different communities of coniferous forests of the *Dicrano-Pinion* alliance is also noteworthy.

The preservation condition of coniferous forests which are particularly susceptible to negative anthropogenic influences has a particular impact on the qualitative and quantitative profile of the mycobiota. Older tree stands are recorded infrequently. The mycobiota in older phytocoesnoses significantly differs from that in young, managed pine forests. Rare, relict species, such as *Bankera fuligineoalba,* occur in those fragments of oligotrophic mesic coniferous forests that are preserved the best. *Leucobryo-Pinetum* forests are similar to those in the Bory Tucholskie Forests and coniferous forests in the Puszcza Knyszyńska Forest in this respect (Łuszczyński 2004b).

A relatively small resemblance between fungi in two vicariant associations, *Leucobryo-Pinetum* and *Peucedano-Pinetum*, is noteworthy. This has already been pointed out by Friedrich (1994). The differences in the mycobiota in the two associations also result from the floristic conditions in both and the influence of climatic and edaphic conditions.

The knowledge on *Basidiomycetes* in the ***Peucedano-Pinetum*** is relatively limited in comparison with that on *Leucobryo-Pinetum*, which is mostly attributable to a small number of mycosociological studies conducted in the community. Such investigations were carried out by Nespiak (1956, 1959), Rudnicka-Jezierska (1969), Lisiewska (1994, 1995), Bujakiewicz (1995, 1997b), Bujakiewicz *et al.* (1995) and Flisińska (1997a). As the results of these studies show, fungi in *Peucedano-Pinetum* in the Góry Świętokrzyskie Mts. are characterised first of all by the presence of species typical of coniferous forests, and, which should also be stressed, by the occurrence of calcicolous fungi and fungi preferring calcium in the substrate, such as *Calocybe gambosa, Lepiota ventriosospora, Hebeloma hiemale* and *Tricholoma terreum*. The correlation between their occurrence and the presence of calcium carbonate in the substrate is significant as these fungi were recorded only in areas rich in $CaCO_3$.

The knowledge on *Peucedano-Pinetum* phytocoenoses in the Puszcza Białowieska Forest is relatively extensive (Nespiak 1959; Bujakiewicz 1997b; Lisiewska 1997; Skirgiełło 1997). These phytocoenoses are characterised by the presence of, among others, boreal and boreal-montane, species rare in other parts of Poland, for instance *Climacocystis borealis, Cortinarius camphoratus, Pycnoporellus fulgens*. Other rare species that are observed there, for example *Albatrellus ovinus, Tyromyces chioneus*, occur in the Góry Świętokrzyskie Mts. in other forest communities.

In the Góry Świętokrzyskie Mts., fungi of *Peucedano-Pinetum* show a fairly high degree of resemblance to *Basidiomycetes* of the *Serratulo-Pinetum*. The degree of knowledge on the mycobiota in ***Serratulo-Pinetum*** in Poland is low, making a comparative analysis with other regions in Poland difficult or impossible. Fungi in the community were examined by Nespiak (1959, 1962) and Lisiewska (1991/1992). The results are given for the North-Eastern Poland, where the most typical, subboreal form of this community occurs (Matuszkiewicz 2006). The boreal spruce which introduces its own species, including some rare species, for instance *Climacocystis borealis, Hygrophorus olivaceoalbus*, as well as boreal species, for example *Albatrellus subrubescens*, grows in these phytocoenoses. The Sarmatian variant of this community develops in the Southern Poland, also in the Góry Świętokrzyskie Mts. Its mycological profile is differentiated by the absence of the rare species given above. Those that do occur in the Góry Świętokrzyskie Mts., such as *Hygrophorus olivaceoalbus*, are associated with other biocoenoses. The mycobiota of *Serratulo-Pinetum* in the Góry Świętokrzyskie Mts. is positively differentiated from northern forms of this forest by having a numerous group of calcicolous species, for instance *Calocybe gambosa, Cortinarius elegantior, C. glaucopus, C. multiformis, Geastrum rufescens, Inocybe bongardii, I. cervicolor* and *I. mixtilis*.

Due to the mesothermophilous character and the species composition of plants, the mycocoenosis of *Basidiomycetes* in *Serratulo-Pinetum* biocoenoses shows resemblance to thermophilous forms of *Tilio-Carpinetum* and *Potentillo-Quercetum*.

Because of the widespread community type, fungi of the mixed coniferous ***Querco-Pinetum*** have been investigated in different parts in Poland, and the literature on their subject is quite extensive (Lisiewska 1966b, 1974, 1978a, b, 1995, 1997; Wojewoda 1973, 1974, 1975, 1977c; Hołownia 1974; Bujakiewicz 1975, 1995, 1997b; Sałata 1978; Friedrich 1984, 1994; Lisiewska & Wójcik 1984; Flisińska 1988, 1999; Lisiewska & Płaczek 1993; Kałucka 1995; Skirgiełło & Lisiewska 1996). This community is on the whole characterised by a very rich composition of *Basidiomycetes* species and is one of the richest in this respect (Wojewoda 1975). However, the floristic composition, and especially the presence or absence of some trees, quite significantly influences regional differentiation of the mycobiota of this community within its range.

Biocoenoses growing in North-Eastern Poland are clearly continental and are characterised by the presence of spruce trees. Rare fungi whose distribution is boreal-montane and continental-montane are recorded in it, for instance *Climacocystis borealis*, *Fomitopsis rosea, Inocybe relicina* (Bujakiewicz 1997b; Skirgiełło 1997). A similar, although slightly poorer, composition where many rare species are absent is observed in the Pojezierze Łęczyńsko-Włodawskie Lake District (Flisińska 1988).

Querco-Pinetum biocoenoses in North-Western Poland are characterised by relatively low specificity (Friedrich 1994). Their species composition resembles that of fungi in mixed coniferous forests in the Central and South-Western Poland.

Mixed coniferous forests in the Wyżyna Krakowsko-Częstochowska Upland are characterised by the diversity of tree species and the development on calcareous substrate, which results in the development of a greatly individualised mycocoenosis (Wojewoda 1975). The richest forms of *Querco-Pinetum* resemble the variant with *Pinus sylvestris*, and the poorest resemble that with *Abies alba*. Biocoenoses in the latter variant also include rare species accompanying the fir, for instance *Aleurodiscus amorphus, Hericium flagellum, Hymenochaete cruenta* and *Ischnoderma trogii*.

In the Góry Świętokrzyskie Mts., *Querco-Pinetum* mixed forests, a variant with *Abies alba*, are some of the most important components of the plant cover in the region. The occurrence of firs in the community causes the presence of, for instance, species observed in the Ojców National Park, such as *Aleurodiscus amorphus* and *Hymenochaete cruenta*. The occurrence of fir-dependent fungi as well as fungi associated with oaks, for example *Hymenochaete rubiginosa, Lactarius chrysorrheus, L. quietus*, or with beeches, such as *Craterellus cornucopioides*, *Lactarius blennius* results in a great similarity between the compared mycocoenoses.

Species richness and the presence of some rare *Basidiomycetes* reveal a great similarity between *Querco-Pinetum* coniferous forests in the Góry Świętokrzyskie Mts. and those in the Puszcza Białowieska Forest. Species that connect these mycocoenoses include geomycologically interesting fungi: *Amylostereum areolatum, Hydropus marginellus, Marasmius cohaerens, Phellinus nigrolimitatus* and *Psilocybe subviridis*. Apart from these connective species, mixed pine and oak coniferous forests have species of *Basidiomycetes* that emphasise their special character, for instance *Bondarzewia mesenterica, Dacryomyces ovisporus* and *Pleurotus calyptratus*.

Mycocoenoses in ***Potentillo-Quercetum*** are underexplored in Poland and the literature on the subject is sparse (Ławrynowicz *et al.* 2004). There are even fewer studies on mycosociological investigations and the presence of *Basidiomycetes* in this community (Ławrynowicz 1973, 2001; Łuszczyński 1998). Examinations have so far been conducted in the Wysoczyzna Rawska Plateau in the Trębaczew reserve and in the Wyżyna Częstochowska Upland (Ławrynowicz 1973, 2001), in the Góry Świętokrzyskie Mts. (Łuszczyński 1998) and in the Wyżyna Lubelska Upland in the vicinity of Annopol (Sałata 1968). Mycocoenoses in the examined communities of thermophilous oak forests exhibited a high degree of similarity to fungi in other deciduous forests, and especially those resembling *Tilio-Carpinetum*. Species associated with oak play an important role here. This tree introduces a numerous group of its mycorrhizal, saprobic and parasitic fungi. Six shared species that are exclusive or almost exclusive to oaks were recorded in the examined biocoenoses: *Daedalea quercina, Exidia glandulosa, Gymnopus fusipes, Lactarius chrysorrheus, L. quietus* and *Peniophora quercina*. The presence of *Lactarius chrysorrheus* and *Xerula pudens*, believed to be characteristic of this community (Dörfelt & Knapp 1974), is a positive element. A high participation of mycorrhizal fungi is also interesting.

Floristic differences among the examined biocoenoses are reflected in the mycobiota composition. *Larix decidua* ssp. *polonica*, which introduces dependant species, such as *Boletinus cavipes, Gomphidius maculatus, Hygrophorus lucorum, Suillus aeruginascens* and *S. grevillei*, occurs in the Trębaczew reserve. The presence of pine trees enriches the mycocoenosis by further species characteristic of the tree, such as *Auriscalpium vulgare, Chroogomphus rutilus, Suillus luteus* (Ławrynowicz 1973). The origin of the biocoenosis of this community in the Wyżyna Częstochowska Upland, which developed from plantings of xerotherimc grasslands with oaks, is different. These are quantitatively rich communities where 190 species of macromycetes were collected (Ławrynowicz 2001). *Boletus radicans, Hohenbuehelia atrocoerulea* and *Resupinatus trichotis* were recorded among them. The thermophilous oak forest in the Góry Świętokrzyskie Mts. is natural but is characterised by the presence of *Pinus sylvestris* in the stand. Mary rare, thermophilous and calcicolous fungi, such as *Bovista dermoxantha, Geastrum minimum, Lycoperdon mammiforme* and *Russula aurea*, which emphasise its unique character, are present in it. The occurrence of oak-dependent species, for example *Fistulina hepatica, Hymenochaete rubiginosa, Phellinus robustus* and *Xerocomus rubellus*, is a positive differential feature of the thermophilous oak forest in comparison with other phytocoenoses.

Fungi dependent on *Quercus* are strong connective species with acid oak forests and oak-hornbeam forests (Lisiewska 1965a, b; Ławrynowicz 1973; Lisiewska & Bujakiewicz 1976; Lisiewska & Połczyńska 1998; Skirgiełło 1998b; Wojewoda *et al.* 1999; Ławrynowicz & Stasińska 2000; Ławrynowicz *et al.* 2001).

The mycobiota of ***Tilio-Carpinetum*** is one of the best researched components of this biocoenosis and has been examined in numerous studies (Nespiak 1956, 1959, 1960; Rudnicka-Jezierska 1963; Lisiewska 1972, 1974, 1978a, 1979, 1991(1992), 1994, 1995, 1997; Ławrynowicz 1973; Wojewoda 1973, 1974, 1975, 1977c, 1978, 1980, 1981a, 1991a, b, 1996a, 1998(1997-1998), 2000a; Hołownia 1974, 1977; Lisiewska *et al.* 1977; Sałata 1978; Flisińska 1988, 1997a, b; Lisiewska & Rybak 1990; Flisińska & Sałata 1991; Gumińska 1991(1992); Bujakiewicz 1995, 1997b, 2002; Wojewoda *et al.* 1999). The results of studies conducted so far demonstrate that mycocoenoses of this community share a large group of species that have a broad ecological scale and are recorded in biocoenoses in different deciduous forests belonging to the *Carpinion* alliance and the order *Fagetalia*, and even to the class *Querco-Fagetea* (Lisiewska 1974, 1992b). Apart from this broad group of fungi, species that significantly differentiate individual phytocoenoses of this community and can be treated as locally characteristic species also occur here (Ławrynowicz 1973). *Galerina fallax, Leccinum pseudoscabrum* and *Phylloporia ribis* appears to be characteristic above the regional level (Ławrynowicz 1973; Wojewoda 1974, 1975; Wojewoda *et al.* 1999). A group of differential species that are recorded in this biocoenosis more often than in others can be identified, for instance *Boletus pulverulentus* and *Psilocybe squamosa*.

The mycocoenosis in *Tilio-Carpinetum* in the Góry Świętokrzyskie Mts. is similar to the association's mycocoenoses in other regions in Poland as discussed above but it also has its own idiosyncratic features. Fungi associated with fir and beech give it a particular character and make is greatly similar to, for instance, *Dentario glandulosae-Fagetum* and other communities to which these species migrate (cf. chapter 5.2).

Basidiomycetes in biocoenoses of the *Fraxino-Alnetum* have been studied extensively and the relevant literature is quite abundant (Bujakiewicz 1967, 1968, 1970, 1973, 1994, 1995, 1997a, b; Lisiewska 1972, 1974, 1978a, 1979, 1994, 1995, 1997; Lisiewska & Bujakiewicz 1976; Wojewoda 1978; Bujakiewicz & Lisiewska 1983; Friedrich 1984, 1986, 1987(1985), 1994, 1997, 2002; Lisiewska & Rybak 1990; Bujakiewicz & Fiebich 1991 (1992); Łuszczyński 1997, 2000a, 2001).

As the literature data show, mycocoenoses in ***Fraxino-Alnetum*** are characterised by a great species richness which results from, among other factors, the richness of ecological niches that can be colonised by these fungi. Fungi associated with alders are the most important and differential group. They characterise biocoenoses of the *Alno-Ulmion* alliance well and differentiate it from other communities belonging to the order *Fagetalia*. Many species are saprobionts, parasites and mycorrhizal fungi associated with alder, for instance *Mycena speirea, Naucoria* spp., *Lactarius lacunorum, L. lilacinus, L. obscuratus* and *Russula alnetorum*. However, it is difficult to treat them as characteristic since they follow it to different communities as alder-dependent species. These fungi can be recognised as characteristic of *Alno-Ulmion*. According to Strid (1975, after Lisiewska 1992b), approximately 200 species are associated with *Alnus*; only two of them, however, *Stereum subtomentosum* and *Peniophora erikssonii*, can be considered exclusive. Numerous species that migrate to various community from the *Fagetalia* alliance are recorded in this community although they are observed in carrs more often. Only some of them can be considered characteristic and, furthermore, only on the local level.

Basidiomycetes of *Fraxino-Alnetum* in the Góry Świętokrzyskie Mts. show a very high degree of similarity to those occurring in the community in other parts of Poland. Numerous species accompanying alder trees are recorded here (cf. chapter 5.3); they were also observed in other parts of Poland. Some rare species and species that are known only from this region, for instance *Lactarius lacunorum, Naucoria celluloderma, N. cephalescens, N. permixta* and *N. striatula*, are a differential feature of this mycocoenosis in the area discussed here.

Fungi of the boggy coniferous forest ***Vaccinio uliginosi-Pinetum*** have been examined extensively and the body of literature on their subject is quite rich (Nespiak 1959, 1962; Rudnicka-Jezierska 1963; Fiklewicz-Sobstyl 1965; Wojewoda 1973, 1979b, 1980, 1981a; Bujakiewicz 1975, 1978, 1986, 1997b; Lisiewska 1978a, 1979; Flisińska 1982, 1988, 1997a; Bujakiewicz & Lisiewska 1983; Friedrich 1984, 1997; Kałucka 1995; Łuszczyński 2000a, 2001). Fungi of this community develop in special habitat conditions and do not have characteristic species. A different nature of basidiomycete mycobiota in this community, however, is quite conspicuous (Nespiak 1959; Lisiewska 1978a). It results from a high degree of presence of bryophilous fungi, especially those associated with *Sphagnum* mosses. However, it is difficult to assign a major diagnostic status other than differential to these highly specialised bryophiles. As dependant fungi, they occur in *Sphagnum* tufts in different boggy-forest and non-forest communities. Fungi associated with oligotrophic and acid boggy habitats characterise the type of mycocoenoses in this community the best. Apart from bryophiles, *Lactarius helvus, L. rufus, Russula claroflava, R. decolorans* and

R. emetica exhibit a high degree of constancy in the case of this community. These fungi, accompanying *Betula* and/or *Pinus*, stress the resemblance of fungi in this community to mycocoenoses in coniferous forest communities.

In comparison with other regions in Poland, the structure of ecological groups and species richness of *Basidiomycetes* of the boggy coniferous forest in the Góry Świętokrzyskie Mts. show a high degree of similarity to the classically developed biocoenoses in this community in northern, North-Eastern and Eastern Poland.

Basidiomycetes of the ***Sphagnetum magellanici*** have been examined in, for instance, the Białowieża National Park (Nespiak 1959), on the lower Odra River (Friedrich 1987, 1994, 1997), in northern Wielkopolska (Fiklewicz-Sobstyl 1965), in the Pojezierze Łęczyńsko-Włodawskie Lake District (Flisińska 1988, 1995), on Babia Góra (Bujakiewicz 1979, 1981, 1982) and in the Góry Świętokrzyskie Mts. (Łuszczyński 2000a, 2001). These peatbogs are characterised well by sphagnophilous fungi and, more broadly, bryophilous fungi, such as *Galerina paludosa, G. sphagnorum, Omphalina sphagnicola, Psilocybe elongata* and *Tephrocybe palustris*, as well as by some mycorrhizal fungi: *Lactarius helvus, L. rufus* and *Russula emetica*. Rare, sphagnophilous mycorrhizal fungi *Leccinum niveum* and *Suillus flavidus* bring together the peatbogs in Polesie and the Góry Świętokrzyskie Mts. Apart from the fungi given above, the occurrence of *Cortinarius brunneus* and *C. muscigenus*, typical of subalpine fir forests, shows a resemblance to raised bogs on Babia Góra. The latter species, recorded by Błoński (1890), was not observed in the present project. *Cortinarius brunneus*, however, was not recorded in the discussed community but in the adjacent *Vaccinio uliginosi-Pinetum* among *Sphagnum* patches. Biocoenoses of *Sphagnetum magellanici* in the Góry Świętokrzyskie Mts. are differentiated from similar ones by the presence of rare species known from the region, such as *Entoloma formosum* (also known only from the vicinity of Elbląg) and *E. xanthochroum*.

The mycobiota of *Sphagnetum magellanici* biocoenoses in the Góry Świętokrzyskie Mts. indicates an interesting composition of species typical of lowland peatbogs and some subalpine peatbogs as well as the presence of rare species that differentiate them from other regions in Poland.

Macromycetes in ***Cladonio-Pinetum*** have not been studied in great depth. Only a handful of studies have been published on the subject in Poland (Dominik & Pachlewski 1955; Sałata 1968; Rudnicka-Jezierska 1969; Lisiewska 1982, 1988; Łuszczyński 2001). The mycobiota of *Basidiomycetes* in this community is poor. A total of 59 species were recorded in the Puszcza Kampinoska Forest (Rudnicka-Jezierska 1969), where the most extensive studies were carried out and where the largest patches of this community grow. Fungi typical of coniferous forests, associated with sandy, oligotrophic and dry habitats, dominate. The presence of pine-dependent fungi is significant. According to the cited author, a relative participation of xerophilous fungi is a feature characteristic of such biocoenoses. Given the results obtained in the Puszcza Kampinoska Forest, the mycocoenosis of *Basidiomycetes* in *Cladonio-Pinetum* in the Góry Świętokrzyskie Mts. is highly similar. Thirteen species in common were recorded in the examined patches, for instance *Coltricia perennis, Cortinarius cinnamomeus, Psilocybe montanum, Scleroderma citrinum, Setulipes androsaceus* and *Tricholoma equestre*. The majority of these species are also indicators of dry and oligotrophic forms of coniferous forests, for instance *Leucobryo-Pinetum*.

Some of the species observed in *Cladonio-Pinetum*, such as *Amanita muscaria, Cantharellus cibarius* and *Psilocybe montana*, were recorded in and are characteristic of succession phase 6/7 and 8 of *Peucedano-Pinetum* in the Jelonka reserve on the edges of the Puszcza

Bialowieska Forest (Kałucka & Sumorok 1996). A high degree of similarity between the floristic, spatial and developmental structure of these succession phases in *Peucedano-Pinetum* and those in *Cladonio-Pinetum* phytocoenoses and the presence of basidiomycete species that both have in common is quite interesting.

6. *BASIDIOMYCETES*: CHANGES AND THREAT

6.1. Changes of fungi in forest communities

Changes in the biota of *Basidiomycetes*, resulting from those of the local plant cover, have been observed over the 120 years of mycological studies conducted in the Góry Świętokrzyskie Mts. The size of areas occupied by forests where the majority of *Basidiomycetes* develop, the degree of their natural character and the species composition of tree stands have changed over the years while forests themselves have been significantly rejuvenated.

In the 1920s and 1930s, forests in the Góry Świętokrzyskie Mts. were badly affected by the abusive exploitation of wood resources, pest gradations, hurricanes and excessively cold weather which were later aggravated by tree felling and the emergence of patches of bare land and irregularly stocked open stands. The amount of large timber went down from 336 m^3/ha in 1925 to 130 m^3/ha in 1936 (Gądek 2000). Local forests had to endure further misery after World War II, which significantly influenced their species composition, age and surface area.

The surface participation of tree species in the Góry Świętokrzyskie Mts. has changed considerably over the last 50 years. The greatest surface area was covered by pine and larch – 59.4%, fir – 28.0%, beech – 3.5%, oak, hornbeam and other deciduous species – 8.4% as well as spruce – 0.7% in the early 1950s (Myczkowski 1969). In 1998, the tree percentage presence was as follows: pine – 69.34%, fir – 16.6%, oak – 7.45%, beech – 3.3% and other species 3.3%. The majority of stands, over 53%, are in the 3rd and 4th age classes, and approximately 20% is in the 2nd age class. Older stands that are over 100-year-old constitute only 13.9% (Jędrzejczyk 1998). The ratios of tree species and age classes are different in the national park. At present, fir covers 8.7% of the forest area, beech 29.7%, pine 22%, spruce 3.5%, oak 2.3%, alder 1.6% and larch 1.3%. Most tree stands are between 81 and 120-year old , and ca. 14% is in the age classes from 7 to 9 (Gądek 2000).

These changes are accompanied by other transformations connected with the impact of acid rains, soil alkalisation caused by the Kielce Region of Carbonate Material Mining (Kowalkowski *et al.* 1993), urbanisation processes, fires, leisure activities and mass mushroom-picking trips. They reached their peak in the late 1970s and the early 1980s. The dustfall in Kielce equalled 90 t/km^2 between 1975 and 1982 while the permissible amount for protected areas was 40 t (according to the data of the Voivodeship Sanitary and Epidemiological Station in Kielce). The content of sulphur, nitrogen, copper and manganese in needles of dying firs was higher than that in healthy trees (Grzywacz 1973; Kapuściński 1985). Based on the content of heavy metals in mosses, Grodzińska (1985) included the park in the group of highly and very highly threatened areas in Poland. Soil acidity increased to 4.2 and the water pH to 4.3-4.4 as a result of dust and gas retention by tree stands (Kozłowski 2002).

Sanitary and maintenance works in managed forests were important factors that interfered with the optimum development of fungi, at least until 1999 (Regulation no 11A of the Director General of State Forests of 11 May 1999). Such protective treatment inhibited the development of many species of xylobionts and saprobionts. The disappearance of and a decrease in the number of some fungal species in the study area are the effects of the cumulative impact of these changes.

Thirty species reported by Berdau (1876) and Błoński (1890), 19 of which are mycorrhizal fungi, have not been observed since the end of the 19th century. Fungi associated with firs and spruces have suffered the greatest damage. Spruce is either an important species or the only partner for the development of 9 species: ***Bankera violascens,*** *Cortinarius muscigenus, Gomphus clavatus, Hydnellum aurantiacum,* ***Hygrophorus erubescens, Lactarius scrobiculatus, Russula mustelina, Sarcodon imbricatum*** and ***Tricholoma vaccinum***. It is interesting that all these species belong to a group of fungi disappearing in Poland, including forests that are preserved better than those in the Góry Świętokrzyskie Mts. Hydnoidal fungi, *Bankera violascens, Hydnellum aurantiacum* and *Sarcodon imbricatum*, are particularly noteworthy. Two of the 30 forest species that have not been recorded, *Clavaria aculeata* and *Hygrocybe ceracea*, are believed to be extinct in entire Poland (Wojewoda & Ławrynowicz 1992, 2006; Wojewoda 2003).

Mycological data of the early 1950s (Domański S. 1962; Anonymous 1968) document and highlight the exacerbation of the already negative direction of changes taking place in the forests in the Góry Świętokrzyskie Mts. *Basidiomycetes* rare in Poland, such as *Antrodia crassa, A. sinuosa, Ceriporiopsis mucida, Clavulicium macounii, Creolophus cirrhatus, Hygrophorus hyacinthinus, Gloeocystidiellum luridum, Hapalopilus salmonicolor, Oligoporus ptychogaster, Phanerochaete ravenelii, Physisporinus vitreus, Protomerulius caryae, Rhigidoporus crocatus, Skeletocutis lenis, S. odora* and *S. stellae*, have not been recorded since then. Most of them are lignicolous fungi that require special conditions: large natural forest complexes, such as the Puszcza Białowieska Forest or the Bieszczady Old-Growth Forest, the microclimate typical of old-growth forests and big masses of dead wood that provide the substrate for fungal development. A great majority of them can be considered to be primeval relicts. In the Góry Świętokrzyskie Mts., they were recorded under Łysica and on Święty Krzyż, and in the forests in the Świętokrzyski National Park characterised by the highest degree of preservation. Processes of overall changes, and in particular gradations of fir stands, have caused such an impoverishment and decline of habitats that the regression of these fungi is very likely (Grzywacz & Grzesiak 1983).

Some of the species reported in the 1970s may also have disappeared. This may be the fate of fungi such as *Antrodiella citrinella, Hydropus atramentosus, Lactarius sphagneti* and *Phyllotopsis nidulans*. *Hysterangium hessei*, which was collected by Z. Domański (Lisiewska 1979) on Chełmowa Góra Mt, is believed to be extinct (Wojewoda & Ławrynowicz 1992, 2006). Its underground lifestyle and technical difficulties experienced during collection of hypogeic fruitbodies make one hope that the fungus has not disappeared completely from the Góry Świętokrzyskie Mts.

The greatest population of *Larix decidua* ssp. *polonica* develops on Chełmowa Góra Mt (Fig. 15). Greater complexes of old larch forests that occurred in the Serwis-Dąbrowa and Gawroniec nature reserves and on Mt Psarska Góra were destroyed during both world wars (Krysztofik 1959). Surface and age limitations of larches make Chełmowa Góra

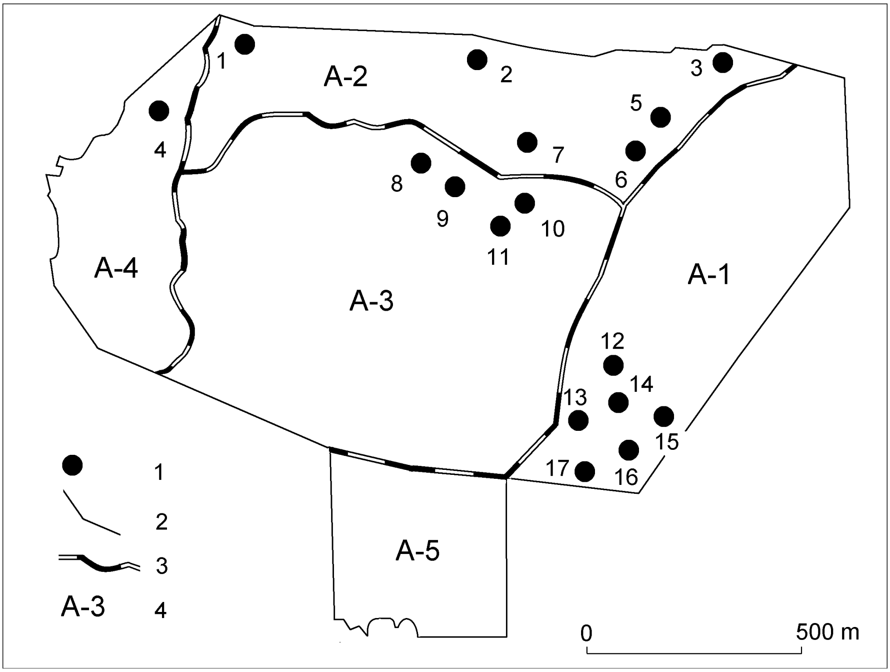

Fig. 15. Distribution of *Fomitopsis officinalis* localities on Chełmowa Góra Mt in the Świętokrzyski National Park
1 – trees with fungal fruitbodies; 2 – borders of the reserve; 3 – borders of the forest section; 4 – forest section number

Mt a refugium of many species associated with this tree in the Góry Świętokrzyskie Mts. *Fomitopsis officinalis* and *Oligoporus obductus* are particularly threatened. Young larch forests that were planted artificially in many sites in the Góry Świętokrzyskie Mts. create development conditions favourable for only few symbionts characterised by a broader ecological scale, such as *Suillus grevillei*, but are unable to provide a sufficient substrate for more demanding species, for instance *Boletinus cavipes, Hygrophorus lucorum* or *Lactarius porninsis* mentioned above.

Climatic changes are another important ecological factor that influences the species composition of *Basidiomycetes* in the Góry Świętokrzyskie Mts. A significant drop in precipitation, a phenomenon highly unfavourable for fungi of the mountain element, has been noticed over the last 50 years (cf. Fig. 4). The gradient of soil moisture and air humidity is of particular importance for mountain and boreal fungi whose requirements are greater. The disappearance of montane and boreal-montane fungi seems understandable in these conditions.

The disappearance of certain forest species of fungi has been triggered off by a combination of various adverse factors. Their effects are especially conspicuous in fir stands in the Góry Świętokrzyskie Mts. These forests develop in the northern belt of the fir range limit in the zone of the species' biological resistance. Some mountain *Basidiomycetes* associated with fir have turned out to be so sensitive to changes occurring in the ecosystems in these areas that they may be used for the purposes of bioindication of phytocoesnoses in the Góry Świętokrzyskie Mts.

6.1.1. Primeval relicts of *Basidiomycetes*

Highly divided forest complexes of different size, formation and tree-stand structure have survived of what used to be the Puszcza Świętokrzyska Forest (Fig. 5). Those fragments of it that are preserved the best, characterised by a high degree of its natural and old-growth condition, still provide a refugium for a group of fungi associated with old-growth forests that do not occur in managed forests.

Definitions of a primeval relict and indicators of old forests in relation to lichenised fungi (lichens) are given by, for instance, Cieśliński *et al.* (1996) and Czyżewska & Cieśliński (2003). High ecological specialisation and a narrow scale of tolerance to environmental factors are characteristic features of this element. They are stenotopic organisms, highly sensitive to anthropogenic factors, not expansive and characterised by a poor ability or the lack of the ability to enter synanthropic habitats. The occurrence of primeval relicts is connected first of all with a specific microclimate of old stands, presence of windfallen trees and the occurrence of natural processes of wood decomposition, including its complete mineralization. Fungi that meet the criteria of the definition of primeval relicts develop in old-growth biocoenoses or biocoenoses characterised by the highest degree of natural condition where buffering factors that limit synanthropisation processes and maintain the continuity of ecological processes sustaining stenotopic organisms are active.

The pattern of such habitat, climatic and vegetation conditions is preserved the best in the largest forest complexes, for instance in old-growth forests in North-Eastern Poland: Puszcza Bialowieska Forest, Puszcza Augustowska Forest, Puszcza Borecka Forest, Puszcza Knyszyńska Forest, in some fragments of the Carpathian Old-Growth Forest, especially in the Western Bieszczady Mts.

Special attention should be paid to species of macromycetes that could be part of the so-called primeval relict due to their ecological requirements and current distribution (Łuszczyński 2003). A body of 28 species has been designated for inclusion in this group (Tab. 44). These species are very rare or rare not only in the Góry Świętokrzyskie Mts. but also in Poland. For instance, *Albatrellus confluens, A. cristatus, A. ovinus, Bankera fuligineoalba, Gomphus clavatus* are endangered in entire Poland. They have not been collected for 50 years or more even in such sites as, for instance, the Polish Carpathians, where the conditions for their development are much better (Wojewoda 1991b). Old-growth forests in North-Eastern Poland, such as the Puszcza Białowieska Forest, offer a certain model of relict preservation and current distribution of some basidiomycete species. Many species that occur there do not find suitable development conditions in other districts in Poland or occur individually in forest complexes that are preserved better. *Auricularia mesenterica* and *Protomerulius caryae*, which are very rare in Poland outside the Puszcza Białowieska Forest, can be good examples of such a distribution (Wojewoda 1976b).

Boletinus cavipes and *Fomitopsis officinalis* (Fig. 16), fungi associated with *Larix*, are endangered species due to the disappearance of stands of old larches. The former is a mycorrhizal fungus, the latter is a parasite. *Fomitopsis officinalis* is a particular example of a disappearing relict associated exclusively with old larches (Łuszczyński 2000b; Chlebicki & Łuszczyński 2002; Piętka & Szczepkowski 2004). *Cortinarius violaceus* is known in Poland from between ten and twenty localities but most of them have already become historical and are 19th-century sites.

Table 44
Relict fungi of old-growth forest in the Góry Świętokrzyskie Mts.

Fungi	Number of localities	Trophic groups	Associated plants	Status of threat	
				in Góry Świętokrzyskie Mts.*	in Poland**
Albatrellus confluens	2	M	*Pinus sylvestris*	E	E
Albatrellus cristatus	3	M	*Quercus robur*	E	E
Albatrellus ovinus	4	M	*Picea abies*, *Pinus sylvestris*	E	E
Antrodia crassa	1	S	*Picea abies*	V	V
Bankera fuligineoalba	1	M	*Pinus sylvestris*	E	E
Boletinus cavipes	5	M	*Larix decidua* ssp. *polonica*	R	R
Bondarzewia mesenterica	5	S	*Abies alba*	E	V
Cortinarius violaceus	4	M	*Populus tremula*	E	V
Creolophus cirrhatus	1	S	*Fagus sylvatica*	E	V
Dichomitus campestris	2	S	*Quercus petraea*, *Fagus sylvatica*	V	V
Fomitopsis officinalis	2	P	*Larix decidua* ssp. *polonica*	E	E
Ganoderma carnosum	5	S	*Abies alba*	E	V
Gomphus clavatus	2	M	*Picea abies*	E	E
Hericium coralloides	3	S	*Fagus sylvatica*	V	V
Hericium flagellum	2	S	*Abies alba*	V	E
Hydropus marginellus	2	S	*Abies alba*	E	E
Hymenochaete cruenta	4	S	*Abies alba*	R	V
Ischnoderma resinosum	3	S	*Fagus sylvatica*	E	V
Mycena renati	2	S	*Fagus sylvatica*	E	V
Phellinus nigrolimitatus	3	S	*Picea abies, Pinus sylvestris*	R	E
Polyporus umbellatus	3	S	*Carpinus betulus, Fagus sylvatica, Quercus robur*	V	V
Protomerulius caryae	3	S	deciduous wood	V	E
Pycnoporellus fulgens	3	S	*Picea abies, Pinus sylvestris*	R	V
Ramaria botrytis	3	M	*Fagus sylvatica*	E	E
Skeletocutis odora	1	S	*Populus tremula, Picea abies*	V	V
Skeletocutis stellae	1	S	*Picea abies*	V	V
Sparassis brevipes	1	P	*Abies alba, Larix decidua* ssp. *polonica*, *Quercus robur*	E	V
Tricholomopsis decora	3	S	*Pinus sylvestris*	R	R

* acc. to Łuszczyński (2002); ** acc. to Wojewoda & Ławrynowicz (2006); M – mycorrhizal; P – parasitic; S – saprobic fungi; The Red Book Category: E – Endangered, V – Vulnerable, R – Rare.

Species whose main area of occurrence is situated in the Carpathians and which are associated with *Abies alba*, for instance *Hymenochaete cruenta, Ganoderma carnosum* (Sokół 2000; Fig. 17), *Bondarzewia mesenterica* (Wojewoda 2000b; Fig. 18), grow in the forests in the Góry Świętokrzyskie Mts. Lowland species, some boreal but mostly encountered in old-growth forests of northern Poland rather than in the mountains, such as *Antrodia crassa, Antrodiella citrinella* (Niemelä & Ryvarden 1983), *Skeletocutis odora, S. stellae*, have survived at single localities.

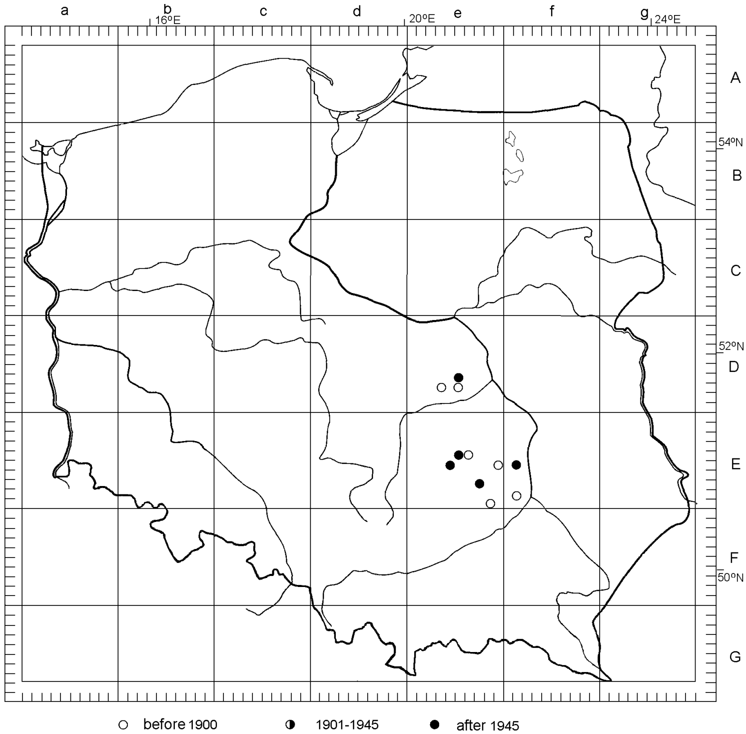

Fig. 16. Distribution of *Fomitopsis officinalis* in Poland

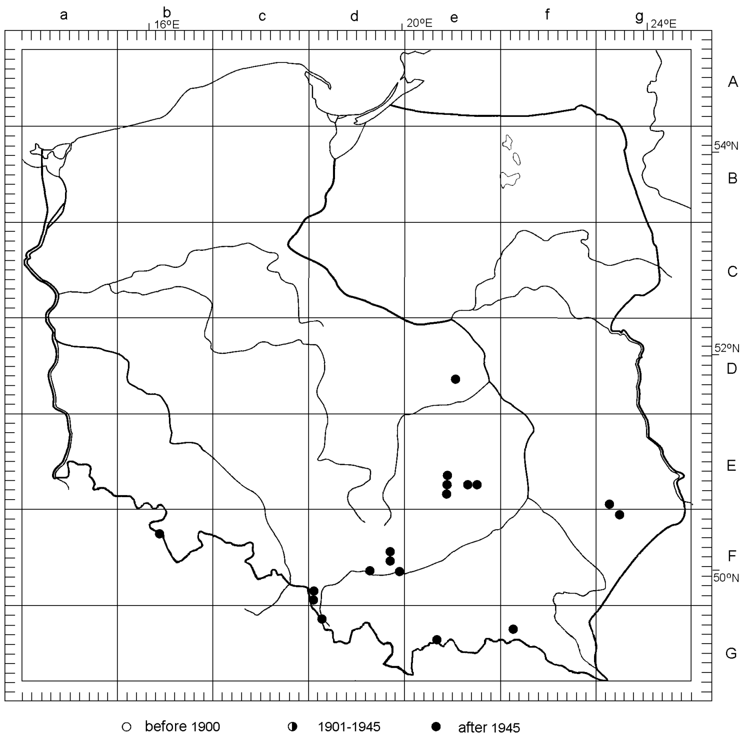

Fig. 17. Distribution of *Ganoderma carnosum* in Poland

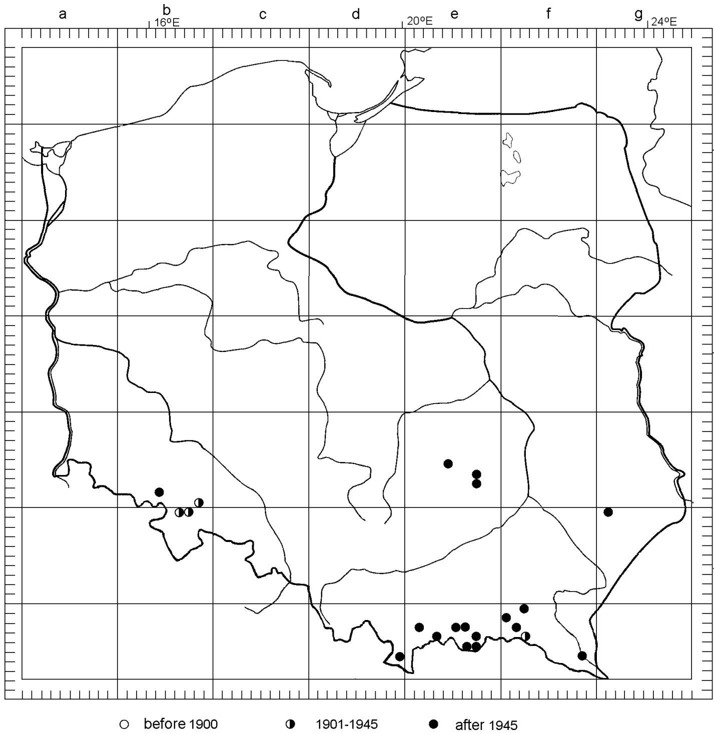

Fig. 18. Distribution of *Bondarzewia mesenterica* in Poland

The relict character of species such as *Bondarzewia mesenterica, Fomitopsis officinalis, Pycnoporellus fulgens, Skeletocutis nivea* or *S. odora* has also been emphasised by Ryvarden & Gilbertson (1993, 1994), outstanding researchers of polyporoid fungi.

Because of their narrow ecological scales on the one hand and progressive anthropopressure on the other, fungal species believed to be primeval relicts are highly vulnerable and are red-listed in Poland and in the region (Wojewoda & Ławrynowicz 1992, 2006; Łuszczyński 2002). It should also be noticed that almost 50% of the species given in Table 44 are polyporoid fungi, species closely related to dead wood or living trees.

The surviving remnants of the Puszcza Świętokrzyska Forest are still a refugium of the most demanding and specialised macromycetes. Forests characterised by the most natural features, including a range of characteristics of old-growth forests, constitute a small percentage of the forests in the Góry Świętokrzyskie Mts. Fungi that are identified as relicts were found in these habitats. The total number of 28 does not appear small given that the Góry Świętokrzyskie Mts. and their forests have been exposed to permanent human pressure in its most aggressive form. Currently, only extensive forest complexes, such as the Augustów, Białowieża, Borecka or Carpathian Forests, have preserved large fragments of old-growth forests, and, consequently, fungi typical of them have survived most effectively and in greatest numbers in these areas (Wojewoda 1976b).

Protection of primeval relicts of macromycetes is connected with biocoenotic protection, restitution of the natural condition of forest communities, enrichment of the nutrition base by leaving dead or dying trees in the area, raising the tree-cutting age and limiting the scope of necessary forest works. It should be noticed that nearly all relict species have survived only in protected areas, that is in the Świętokrzyski National Park and forest reserves. These species increase natural qualities of biocoenoses and contribute to the enrichment of the biodiversity of forest ecosystems. These sites are important for scientific, educational and formative reasons.

The Góry Świętokrzyskie Mts. and the surviving Puszcza Świętokrzyska Forest are of considerable biocoenotic importance because of their location in Central Poland and are a very important refugium of many rare and disappearing fungi. The presence of relict fungi makes the Góry Świętokrzyskie Mts. a bridge between some of the best preserved forests in Europe, that is old-growth forests of North-Eastern Poland, mainly the Puszcza Białowieska Forest, and the impressive, although also highly damaged, Carpathian Old-Growth Forest in the South Poland.

6.2. Changes of fungi in non-forest communities

While non-forest communities are less complex than forest biocenoses, very many interesting *Basidiomycetes* occur in them. Many species are threatened or endangered not only in the region but also in Poland or even in Europe. In the Góry Świętokrzyskie Mts., these fungi are associated with heaths, xerothermic and psammmophilous grasslands or meadows characterised by different moisture relationships. The development of non-forest communities has always taken place at the expense of forests and is invariably connected with the expansion of settlements, agriculture and industry. A negative direction of changes that also affect these habitats and fungi associated with them has been observed in the case of *Basidiomycetes* in the Góry Świętokrzyskie Mts. Transformations of the management pattern and usage type of non-forest areas are main factors that unfavourably influence the local mycobiota. Humid meadows, extensive in the past, have been reclaimed and transformed into hay meadows that are often fertilised with minerals to increase green mass production. As a result of agrotechnical changes of habitat types, many species of *Hygrophoraceae* have significantly changed their areas while species such as *Hygrocybe miniata, H. ovina* and *H. psittacina* have not been recorded again for the last 100 years. Fungi of this systematic group are organisms sensitive to changes occurring in semi-natural grassland communities (Griffith *et al.* 2002; Jelink & Nauta 2002; Jordal 2002; Kautmanova 2002). Many of these species are currently red-listed as threatened fungi in Europe (Arnolds 1989).

Coprinus digitalis and *Panaeolus fimiputris* are also some of the fungi that have not been recorded for over 100 years.

The history of research into fungi connected with xerothermic grasslands in the Góry Świętokrzyskie Mts. is not documented well. However, the current trend of transformations that have influenced this type of plant communities unambiguously indicates the scale of the problem and the scope of resulting threats. The discontinuation of former types of usage, pasturing and cutting is a major danger to and a limiting factor of the development of xerothermic and steppe fungi. Secondary succession and artificial forestation of grasslands have caused a transformation of plant communities from grasslands into shrubs, and upon further succession, into thermophilous oak-hornbeam forests and thermophilous oak forests or anthropogenic forest communities. Such profound changes influencing the vegetation can turn out to be critical for some *Basidiomycetes* causing their regression. Fungi thriving at high temperatures, especially *Conocybe sienophylla* and *Leucopaxillus lepistoides*, species of southern Europe, thermophilous and growing exclusively in open communities, are particularly vulnerable.

6.3. Threat to fungi

Threats posed to *Basidiomycetes* in the Góry Świętokrzyskie Mts. were examined during the preparation of a regional red list of fungi (Łuszczyński 2002). Species were selected and classified in individual categories on the basis of the data collected in the past and current findings, the assessment of species behaviour and the direction of changes affecting their habitats. A preliminary list comprised 313 species, including four extinct species (Ex), 67 endangered species (E), 44 vulnerable species (V), 194 rare species (R); the status of 4 species was indeterminate (I).

Extinct species. Significant changes of the plant cover, most importantly of the forests, that have taken place over the last 100-150 years have resulted in the disappearance of some fungi in the Góry Świętokrzyskie Mts., especially those last recorded by Berdau (1876) and Błoński (1890), that is over a century ago. These fungi should be considered extinct. This group comprises 32 species of *Basidiomycetes* which, apart from *Hysterangium hessei* and *Sarcodon imbricatum*, were recorded in the 19th century for the last time. Two species, *Hygrocybe ceracea* and *Hysterangium hessei*, are also believed to be extinct in Poland (Wojewoda & Ławrynowicz 2006). Two further species, *Clavaria aculeata* and *Thelephora mollissima*, are also likely to be extinct in Poland (Wojewoda 2003). The former, described by Błoński (1890), has never been collected again, and the latter was last reported by Błoński (1890) and by Bresadola (1903) from the Góry Świętokrzyskie Mts. and Międzyrzec Podlaski, respectively.

Entoloma formosum, Pholiota mixta and *Ramaria flaccida*, which were not formally red-listed as threatened fungi in Poland (Wojewoda & Ławrynowicz 2006) and which were proposed for inscription as potentially extinct (Ex) by Wojewoda (2003), were found in the study area. The occurrence of a few other fungi classed as extinct in the second edition of the red list (Wojewoda & Ławrynowicz 1992) was also observed in the study area. These are: *Amanita strobiliformis*, *Psilocybe luteonitens* and *Serpula himantioides*. No information on the threat category of *Hebeloma danicum*, which was also considered to be extinct, is provided on the new list of threatened fungi.

It is difficult to determine unequivocally whether these fungi were in fact extinct or whether they were overlooked because of the ephemeral occurrence of their fruitbodies, and then regenerated from spores carried over from the adjacent areas after the matrix mycelium had disappeared. Molecular studies of current populations and herbarium material could help answer this question.

Endangered species. A total of 313 species of *Basidiomycetes* are threatened in the Góry Świętokrzyskie Mts. The 67 species classified as endangered (E) seem to be threatened the most: the threat status of many of them is lower in red lists in Poland than that proposed for the region. The severity of the actual threat level observed in the Góry Świętokrzyskie Mts. arises from a combination of many complex factors. One of them, however, appears to be quite unique and is connected with the location of the area (cf. chapter 6.1). Some

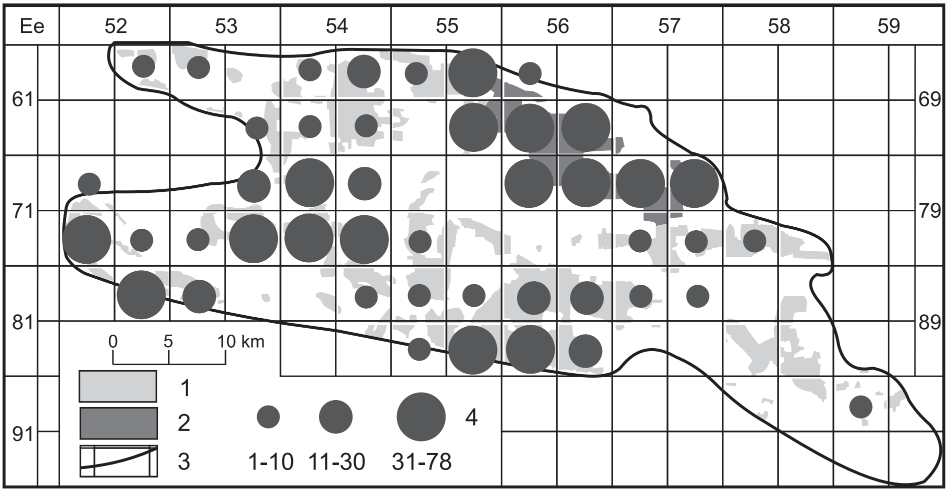

Fig. 19. Occurrence of threatened fungi in the Góry Świętokrzyskie Mts. in the ATPOL grid squares
1 – forests; 2 – forests in the Świętokrzyski National Park; 3 – borders of the study area; 4 – number of threatened species in a square

species of trees and fungi grow on their range limits where fluctuations of different abiotic and biotic factors trigger off acute stress and changes in marginal populations (Zarzycki 1976; Bhar & Fahrig 1998) while changes of the same scope taking place inside a species' range may not be as noticeable. Primeval, mountain and boreal species of fungi seem to be particularly threatened. Their specific climatic and habitat requirements are on the verge of resistance in the Góry Świętokrzyskie Mts. (Fig. 19).

Extremely specialised species, for instance those associated with old trees, are similarly threatened. This is noticed in the case of, for example, species associated with old oaks, *Aleurocystidiellum disciforme, Buglossoporus quercinus, Dendrothele commixta, Fistulina hepatica*, which can develop only on aged trees.

Threats posed to fungi in non-forest areas, such as meadow, xerothermic or psammophilous grasslands or peat bogs, are of different nature. Changes in usage methods of meadow and xerothermic communities cause natural secondary succession which completely changes living conditions of fungi, and species associated with these communities regress. The rarest habitats, for instance thermophilous xerothermic grasslands and peat bogs, are particularly threatened. Highly specialised organisms, unable to live in different conditions, occupy these areas (cf. chapter 6.2).

6.4. Expansive species

Migration of geographically alien species takes place in all groups of organisms, including fungi. Reasons for expansion are often highly complex and underexamined. The inflow and expansion of new species of *Basidiomycetes* have been observed in Poland for many years (Skirgiełło & Rudnicka-Jezierska 1963; Sałata 1977; Stengl-Rejthar & Wojewoda 1985; Sałata & Jakubowska 1987; Sokół & Szczepka 1987; Miądlikowska 1995;

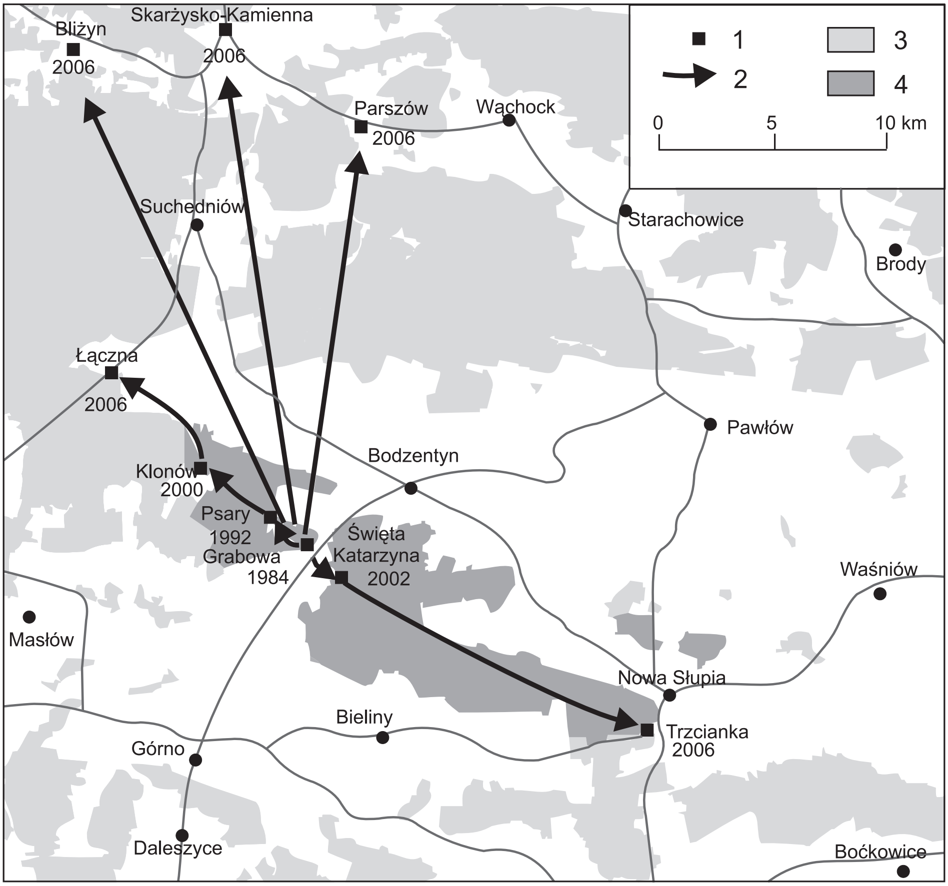

Fig. 20. Expansion of *Clathrus archeri* in the Góry Świętokrzyskie Mts.
1 – localities of the fungus; 2 – migration route of the fungus; 3 – forests; 4 – Świętokrzyski National Park

further literature – see Wojewoda 2003). Some of them, such as *Clathrus archeri, Mutinus caninus*, *M. ravenelii* and *Psilocybe rugosoannulata*, have also been reported from the Góry Świętokrzyskie Mts. and are expansive.

Clathrus archeri was recorded in Grabowa near Święta Katarzyna in the protection zone of the Świętokrzyski National Park in 1984 by Sałata & Jakubowska (1987). It has been spreading since then (Kierasiński 1992; Łuszczyński & Świercz 2004; Skarżyski Wortal 2006) and its localities were recorded in Psary, Budy near Klonów, in Święta Katarzyna and Trzcianka. In 2006, it was also observed on the borders of the study area, in Brzask near Bliżyn, Parszów, Skarżysko Kamienna and Zaskale near Łączna (Fig. 20). The fungus occurs in fertile habitats, rich in humus, on the edges of forests and meadows as well as pasture grasslands with *Nardus stricta*.

Mutinus caninus also seems to be expansive. It was first reported on the Grzywy Korzeckowskie Ridge near Chęciny (Łuszczyński 1998), and, later on, on the borders of the Góry Świętokrzyskie Mts., in the Lisiny Bodzechowskie reserve near Ostrowiec Świętokrzyski (Łuszczyński 1999b), Skarżysko Kamienna (Skarżyski Wortal 2006) and in Stąporków.

Its main habitats include fertile deciduous forests such as oak-hornbeam forests and carrs, and, less frequently, gardens.

Mutinus ravenelii has been less expansive than the above fungi. It was reported only once from Skarżysko Kamienna (Skarżyski Wortal 2006) and was found on the edge of compost in a garden in Wola Kopcowa near Kielce.

Psilocybe rugosoannulata, an edible fungus, was introduced for cultivation in Poland in 1970 (Gumińska & Wojewoda 1985). The cultivation technique is very simple: it was grown using the garden method in beds on straw in eastern lands in Germany (former East Germany). The straw with the mycelium was composted and scattered in fields as fertiliser. In 1986, its mass occurrence was observed in Tumlin on heaps of compost straw, and a cultivated mushroom made its way from culture into fields. In 2006, large quantities of it were recorded in field cereal crops outside the study area in Nowy Korczyn near the area where the Nida River flows into the Vistula.

The behaviour of some native species that colonise new synanthropic habitats quite dynamically is fairly interesting. *Langermannia gigantea, Meripilus giganteus* and *Phallus impudicus*, for instance, are noteworthy. A similar tendency was noticed in Kraków by Wojewoda (1991b, 1996a). The first is a synanthrope and occurs in anthropogenic habitats rich in nitrogen, in gardens and near village cottages. The second is definitely a forest species and penetrates substitutional habitats. It was recorded under *Aesculus hippocastanum* in the S. Staszic city park in Kielce; the species is frequent in Poland and has been observed in anthropogenic habitats more often than in natural ones over the last few decades. Distribution maps of its localities are given by Skirgiełło (1976) and Szczepka & Grzegorzek (1984) and supplemented by Wojewoda (2003). The third species is also a forest species but it penetrates reforested habitats, parks and cemeteries, and shrubs. It prefers fertile soils and habitats characterised by the presence of high amounts of fresh humus.

Changes in the occurrence ranges of fungi caused by climate warming has been observed across Europe. They are also visible in its central and northern parts, in Germany, Poland, Scandinavia, where more and more new sites of *Basidiomycetes*, considered to be thermophilous and known mostly from southern Europe so far, have been observed. Kreisel (2006) presented a list of species of *Basidiomycetes* that have significantly expanded their ranges northwards. Different ecological groups, for instance xylobionts, terrestrial and litter-inhabiting saprobionts or mycorrhizal fungi, have been undergoing these processes. Fungi typical of steppes and xerothermic grasslands are particularly interesting as their thermal and humidity requirements are especially high. Some *Basidiomycetes* began their journey fairly early on and have colonised new habitats to such an extent that are considered to be common and therefore native, for instance *Amanita phalloides, Auricularia auricula-judae* and *Schizophyllum commune*.

Studies conducted by Kreisel (2006) on the chorology of selected *Basidiomycetes* have greatly contributed to the knowledge on the origin, natural status and synanthropisation of fungi. In the Góry Świętokrzyskie Mts., there are 13 species of *Basidiomycetes* that he believes to be indicator species of current climate changes: *Agaricus xanthodermus*, *Amanita phalloides, A. solitaria, A. verna, Auricularia auricula-judae, Cortinarius orellanus, Clathrus archeri, Diplomitoporus flavescens, Mutinus caninus, M. ravenelii, Pluteus aurantiorugosus, Polyporus alveolarius* and *Schizophyllum commune*. These fungi occur in different ecosystems, both natural forest ecosystems and anthropogenic ones. *Amanita phalloides, A. solitaria, A. verna, Cortinarius orellanus, Diplomitoporus flavescens, Pluteus aurantiorugosus* and *Polyporus alveolarius* are recorded exclusively in natural forest communities and are not expansive. Their localities are most definitely natural and result from the changes of climatic conditions.

The occurrence of *Conocybe sienophylla* growing in Southern Europe (Łuszczyński 2007a) and a steppe fungus, *Leucopaxillus lepistoides*, (Łuszczyński 2006) can probably be attributed to general climate warming. They grow in xerothermic grasslands of the *Cirsio-Brachypodion* alliance. These records are the northernmost localities of these species in Europe at present. It is interesting that these fungi produced fruitbodies every year over the last three years of the project, which should be attributed to the presence of ecological conditions resembling the optimum ones.

Other species occur either exclusively in anthropogenic communities (*Agaricus xanthodermus*) or in anthropogenic and natural communities, more often, however, in substitutional communities, for instance *Auricularia auricula-judae, Clathrus archeri, Mutinus ravenelii* and *Schizophyllum commune*. Anthropogenic factors also greatly and positively influence the expansion of these species. Habitats rich in nitrogen compounds play an important role in the process of colonisation of new areas by *Clathrus archeri* and *Mutinus ravenelii*, while weakened and dying trees and shrubs in urbanised area are important for xylobionts. The types of habitats colonised by these species indicate significant synathropic features of these fungi.

6.5. Threat status of *Basidiomycetes* in comparison with other regions in Poland

Idiosyncratic features of nature and natural conditions make the Góry Świętokrzyskie Mts. a special place (cf. chapter 3 and 5). Threats to *Basidiomycetes* identifiable in the study area result from the confluence of local and global unfavourable factors. Local factors seem to determine the behaviour and survival of fungi as their intensity influences the degree of threat to these organisms. Regression of fir forests which used to play a dominant role in the history of the plant cover in the Góry Świętokrzyskie Mts. is one of the most important threat factors. Inadequate cultivation methods that either directly or indirectly exacerbate the process of fir disappearance and inhibit its rejuvenation significantly contribute to this unfavourable phenomenon (Falińska 2004). Demographic studies on fir populations in the Góry Świętokrzyskie Mts. show that, despite a high rate of rejuvenation, the growth index is 0.83, indicating a population decrease by 17% after its age structure becomes established. Therefore, if regression continues, fir forests will disappear and fir trees will only be an admixture in tree stands of other communities (Mazur 1985). A similar problem has been observed in the case of the thermophilous oak forest. When anthropogenic factors that establish this biocoenosis type regress, the thermophilous oak forest is subject to succession towards shady oak-hornbeam forests. Phytocoenotic changes are also accompanied by changes of abiotic conditions (Kwiatkowska 1994).

As many as 313 species of *Basidiomycetes* are classified as threatened in the Góry Świętokrzyskie Mts., that is 29.6% of the entire biota of *Basidiomycetes* in this region, on the regional red list (Łuszczyński 2002). The red list of fungi threatened in Poland (Wojewoda & Ławrynowicz 2006), on the other hand, specifies 262 species of *Basidiomycetes* growing in the Góry Świętokrzyskie Mts., that is 25% of the total number recorded in the study area.

Table 45
Threats to *Basidiomycetes* in selected regions in Poland

Region	Threat category					Total
	Ex	E	V	R	I	
Bielskie Voivodeship*	7	29	15	65	96	212
Częstochowskie Voivodeship*	12	20	7	30	38	107
Katowickie Voivodeship*	29	28	14	49	46	166
Opolskie Voivodeship*	117	6	3	11	8	145
Upper Silesia Voivodeship*	74	75	28	95	160	432
Góry Świętokrzyskie Mts.	**4**	**67**	**44**	**194**	**4**	**313**
Polish Carpathian Mts.**	6	77	9	128	20	240
Poland***	53	423	176	69	40	963

* Wojewoda (1999a); ** Wojewoda (1991a); *** Wojewoda & Ławrynowicz (2006)

A comparative analysis of the threats posed to fungi in the Góry Świętokrzyskie Mts. and in other regions can be conducted only for those areas that have regional lists of fungi. Such lists have been compiled only for the Polish Carpathians (Wojewoda 1991b), Upper Silesia (Wojewoda 1999a) and the Góry Świętokrzyskie Mts. (Łuszczyński 2002) (Tab. 45). A high degree of presence of rare and threatened *Basidiomycetes* differentiates the Góry Świętokrzyskie Mts. from the areas that have been studied relatively well, that is the Polish Carpathian Mts. It is noteworthy that interesting and rare fungi still occur in the Góry Świętokrzyskie Mts., whose natural qualities have been greatly damaged. However, a high number of species considered to be extinct is disconcerting; it exceeds areas that are preserved better in the Carpathians and makes the area similar to those destroyed the most, that is Upper Silesia. It is difficult to compare the values concerning extinct species in the Opole Region as mycological studies were not conducted after World War II, and the data mostly deal with studies by Schröter (1889). It is also difficult to compare the scale of the problem in other districts in Poland due to the lack of such studies.

The occurrence of species belonging to the family *Polyporaceae* is an interesting indicator of the degree of natural quality of the basidiomycete biota. Not only have these fungi been studied in greatest depth in Poland but they are very sensitive to anthropogenic changes taking place in forest biocoenoses (Wojewoda 1976b). A very interesting image of the preservation condition of polyporoid fungi in central Poland emerges from a modified version of Wojewoda's tabular list (Tab. 46).

Table 46 shows that a highly numerous group of *Polyporaceae* s.l. still occurs in well-preserved remnants of the former Puszcza Świętokrzyska Forest, mostly comprising the current Świętokrzyski National Park. The polyporoid biota of the study area lags behind the resources of the Białowieża National Forest, which is the model for all European forests in this respect. Its mycobiota has not changed or has changed only slightly (Wojewoda 1976b). However, the unique quality of fungi in the Góry Świętokrzyskie Mts. is still very high in comparison with other regions in Poland. This special value is stressed by the presence of rare and threatened fungi that have long regressed or have been disappearing in urbanised areas. Strong anthropopressure which causes the degradation of the mycobiota is reflected in the number of extinct species.

Table 46
Polyporaceae (s.l.) in selected regions in Poland (acc. to WOJEWODA 1976b, modified)

Regions	Puszcza Białowieska Forest	Ojców National Park	Kraków	Chrzanów and Jaworzno districts	Forest Inspectorate of Lubin	**Góry Świętokrzyskie Mts.**
Area in km^2	580	15	320	650	225	**1600**
Percent of *Polyporaceae* in Poland	80	43	35	35	23	**64**
Number of known species	115	63	50	50	35	**92**
Number of rare and very rare species in Poland	78	26	13	15	4	**49**
Number of common and very common species in Poland	37	37	37	35	30	**37**
Number of species known in Poland from this region only	19	.	.	.	.	**2?**
Number of species dead in last years in this region	.	6	1?	1?	1?	**3**
Number of threatened species	.	20	10	15	6	**44**

7. SUMMARY OF RESULTS AND CONCLUSIONS

- Mycological studies on *Basidiomycetes* were conducted in different ecosystems in the Góry Świętokrzyskie Mts. as defined by KONDRACKI (2000) between 1986 and 2006. The richness of the mycobiota was assessed using combined methods: the field cartogram method based on the ATPOL grid, the route method using a topogram, and the permanent research plot method. Permanent plots, 400 m^2, were established in 14 forest associations and communities representative of the mesoregion: *Abietetum polonicum, Cladonio-Pinetum, Dentario glandulosae-Fagetum, Fraxino-Alnetum, Leucobryo-Pinetum, Luzulo pilosae-Fagetum, Peucedano-Pinetum, Potentillo-Quercetum, Querco-Pinetum, Serratulo-Pinetum, Sphagnetum magellanici, Tilio-Carpinetum, Vaccinio uliginosi-Pinetum* and *Abies alba-Sphagnum girgensohnii* community. Moreover, the occurrence of *Basidiomycetes* in non-forest communities belonging to the classes *Koelerio glaucae-Corynephoretea canescentis, Molinio-Arrhenatheretea*, and *Festuco-Brometea* was also observed.
- A rich body of information was collected over a period of long-term, comprehensive observations. The mycological profile of the Góry Świętokrzyskie Mts. was investigated in depth, making the region one of the best-studied areas in Poland. Several interesting relationships and features that can be overlooked in small areas were noted. It should be stressed, however, that research work into *Basidiomycetes* has by no means been

completed. Because of the ephemeral nature of fruitbodies and the unique course of fungal development, new species that produce fruitbodies infrequently, for instance once every few years, and therefore may not have been found in this project, will be collected in the future.

- The following factors play an important role in the spatial distribution of fungi: the degree of natural character of the plant cover, lithological conditions, edaphic conditions, topoclimate, and anthropogenic elements. A close relationship between the distribution of calcicolous, psammophilous and acidophilous fungi and the geological structure of the Góry Świętokrzyskie Mts. was demonstrated. Calcicolous fungi found the best conditions for their development in the western parts of the Góry Świętokrzyskie Mts., in the Wzgórza Chęcińskie Hills, where species such as *Cortinarius elegantior, C. glaucopus, C. gracilior, Hygrocybe erubescens, Inocybe bongardii, Lepiota alba, Lycoperdon mammiforme* grow, as well as in the eastern and south-western part of the mesoregion, along the border with the Wyżyna Sandomierska Upland. A significant part of the mesoregion is covered by rocks poor in or devoid of calcium carbonate that are favourable for the development of acidophilous fungi. Psammophilous species developed in the valleys on sands. Sphagnophilous fungi, growing on raised bogs, constitute an interesting ecological group.
- Mycosociological studies on the role and presence of *Basidiomycetes* in the biocoenoses of forest communities were conducted at 77 permanent research plots in the main forest communities. These studies contribute to a greater knowledge of the mycobiota of some forest communities in the Góry Świętokrzyskie Mts., not examined formally before, for instance *Cladonio-Pinetum, Luzulo-Fagetum, Peucedano-Pinetum, Potentillo-Quercetum, Serratulo-Pinetum, Sphagnetum magellanici* and the *Abies alba-Sphagnum girgensohnii* community. Indicator species the majority of which function as locally characteristic species were identified. The indicator value of a fungal species is expressed by the degree of its fidelity to and exclusive occurrence in a specific community. Parameters such as the degree of constancy and abundance of fruitbodies that are particularly dependent on weather factors is of significantly lesser importance. The presence of indicator species whose value is recognisable above the regional level was also recorded for many communities. These species, however, are usually connected with syntaxa higher than an community.
- *Basidiomycetes* form trophic relationships with at least 34 species of vascular plants and 5 genera of mosses in the study area. The most numerous groups of fungi accompany trees, for instance pine – 114 species, beech – 105 species, fir – 102 species, oak – 100 species, birch – 55 species, alder – 54 species, and, among mosses, peat mosses – 48 species of *Basidiomycetes*. Despite highly numerous groups of fungi, only infrequent fungal species are strictly correlated with specific plant species. Factors resulting from the degree of flora preservation and its natural character as well as the preservation, complexity and maturity of entire phytocoenoses greatly influence the relationship between the mycobiota and plants. Saprobionts colonising different plant parts always constitute the most numerous group in the trophic structure; mycorrhizal fungi are a less numerous group, and parasites are the least numerous.
- The biota of *Basidiomycetes* plays a very important role in the examined forest biocoenoses. These fungi fill the entire space of the biocoenoses examined in this project. Their distribution, degree of substrate dependence and influence of ecological conditions occurring in specific plant communities show that the mycobiota only seemingly does not form a uniform and coherent mycocoenosis but constitutes a system of

overlapping and interpenetrating synusiae and smaller mycocoenoses. Fungi are treated as components of a complex biocoenosis that constitute a whole within the entire surface of a plant community. Quantitatively, the biota of *Basidiomycetes* in relation to vascular plants in the biocoenoses studied in the project is on the whole more numerous, and the ratio between the two groups ranges from 1:1 in *Peucedano-Pinetum* to 4.33:1 in *Leucobryo-Pinetum*.

- Saprobionts constitute a dominant group in the mycobiota of the forest communities studied, comprising 539 species, that is 57% of the total number of species. Of them, 332 species (32%) are pedobionts, species living on litter and humus, 251 (24%) – xylobionts, decomposing dead standing and lying trunks and logs, thick and smaller branches, and 10 (0.9%) – allobionts, coprophilous species, occurring on animal faeces. Three hundred and seventy five species of mycorrhizal fungi were recorded, that is 36% of all the recorded fungi while parasites constitute a group of 59 species, that is 6% of the total mycobiota.
- The current profile of *Basidiomycetes* in the Góry Świętokrzyskie Mts. results from the location of the region in relation to the surrounding geographical regions, climatic conditions, natural topography, geological structure and the development of the plant cover as well as anthropogenic influences. The area of the Góry Świętokrzyskie Mts. is located within the distribution range of important forest-forming tree species, such as *Abies alba, Acer pseudoplatanus, Fagus sylvatica, Larix decidua* ssp. *polonica* and *Picea abies,* which encourage the penetration of mountain fungi into the study area. The occurrence of 87 species of the mountain element sensu lato was recorded. The presence of mountain species of *Basidiomycetes* in the Góry Świętokrzyskie Mts. emphasises the similarity of the mycobiota in the study area to that of, for instance, Babia Góra, the Beskid Sądecki Mts., the Pieniny Mts. and the Tatra Mts. Biocoenoses of the *Abietetum polonicum* and *Dentario glandulosae-Fagetum*, which resemble forest communities of the lower subalpine forest in the Carpathians and similar communities in Roztocze, stand out in particular. The expansive penetration of fir into various forest communities significantly enriches the mycobiota of these biocoenoses thanks to the presence of fungi associated with this species.
- The forests of the former Puszcza Świętokrzyska Forest are a major refugium of fungal resources. Despite significant damages of the plant cover caused by different forms of persistent human economy, forest parts characterised by a high degree of their natural character have survived. They provide habitats for many rare species of *Basidiomycetes* characteristic of old-growth forests, such as *Albatrellus confluens, A. ovinus, Bankera fuligineoalba, Cortinarius violaceus, Fomitopsis officinalis, Hericium coralloides, H. flagellum, Polyporus umbellatus, Pycnoporellus fulgens, Skeletocutis odora*, and *S. stellae*.
- An influx of new species of *Basidiomycetes* that colonise forest and anthropogenic phytocoenoses has been observed in the Góry Świętokrzyskie Mts. Some of the newly arrived fungi seem expansive, for instance *Clathrus archeri, Mutinus caninus, M. ravenelii* and *Psilocybe rugosoannulata*. Species considered to be native, such as *Langermannia gigantea* and *Phallus impudicus*, have also been undergoing synanthropisation. Two main trends of fungal penetration into various types of habitats can be distinguished: synanthropisation of fungi, that is the expansion of native species into synanthropic habitats, and neofungisation, that is the penetration of synanthropic and alien species into natural communities. Therefore, an attempt was made to classify synanthropisation processes of *Basidiomycetes*.

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9. RÓŻNORODNOŚĆ *BASIDIOMYCETES* W EKOSYSTEMACH GÓR ŚWIĘTOKRZYSKICH (streszczenie)

Góry Świętokrzyskie ze względu na bogactwo form geologicznych odznaczają się dużą zmiennością siedlisk, które stwarzają warunki do rozwoju różnorodnych ekosystemów. W krajobrazach mezoregionu główną rolę odgrywają lasy. Lasy świętokrzyskie, opisywane jako Puszcza Świętokrzyska, przetrwały do dziś w różnym stopniu naturalności. Ważnym czynnikiem kształtującym biocenozy roślin i grzybów jest człowiek użytkujący zasoby przyrody nieożywionej i żywej.

W Górach Świętokrzyskich wykształcone są tylko dwa piętra roślinne. Piętrowość ta wynika bardziej z panujących warunków edaficznych niż z różnic klimatycznych. Piętro wyższe porastają bory jodłowe *Abietetum polonicum* oraz lasy bukowe i bukowo-jodłowe nawiązujące do lasów i borów występujących w reglu dolnym Karpat. W piętrze niższym rozwijają się grądy, bory sosnowe i bory mieszane, zbiorowiska podobne do rosnących na sąsiednich obszarach nizinnych. Świętokrzyskie lasy jodłowo-bukowe przedstawiają ubogi wariant buczyny karpackiej niższych położeń (Szafer 1977). Lasy bukowe pod względem fitosocjologicznym należą do różnych zespołów ze związku *Fagion sylvaticae*. Rozległe obszary zajmuje kwaśna buczyna niżowa *Luzulo pilosae-Fagetum*. Znacznie rzadsze są płaty żyznej buczyny *Dentario glandulosae-Fagetum*, które są utożsamiane z podgórską formą tego zespołu. Pod względem siedliskowym i florystycznym buczyna ta różnicuje się na dwa warianty: typowy (na siedliskach świeżych i średnio żyznych) oraz wariant z *Allium ursinum* (na siedliskach żyznych i wilgotnych usytuowanych w pobliżu strumieni). Interesujące florystycznie są buczyny z udziałem *Dentaria enneaphyllos*, które nawiązują do buczyny sudeckiej *Dentario enneaphylli-Fagetum* (Bróż 1992). Najlepiej wykształcone płaty lasów bukowych, poza Świętokrzyskim Parkiem Narodowym, zachowały się w Paśmie Cisowsko-Orłowińskim i Jeleniowskim. W Paśmie Zgórskim i fragmentarycznie w Paśmie Posłowickim występują drzewostany bukowe z runem grądowym.

W niższych położeniach przeważają zbiorowiska borów sosnowych, które w zależności od poziomu wód gruntowych dzielą się na bory suche, świeże, wilgotne i bagienne. Powierzchniowo dominują bory świeże, które pod względem siedliskowym, florystycznym i fitosocjologicznym różnicują się na dwa zespoły: *Leucobryo-Pinetum* i *Peucedano-Pinetum*. Bory wilgotne (*Molinio-Pinetum*) i bory bagienne (*Calamagrostio villosae-Pinetum* i *Vaccinio uliginosi-Pinetum*) zajmują znacznie mniejsze powierzchnie.

Bory mieszane *Querco-Pinetum* są pospolitymi zbiorowiskami na całym badanym terenie. W składzie florystycznym można wyróżnić charakterystyczne dla Gór Świętokrzyskich warianty z *Abies alba* i *Larix decidua* ssp. *polonica*. Pierwszy wariant jest szeroko rozpowszechnionym typem fitocenoz niemal w całym mezoregionie, natomiast drugi rośnie na Chełmowej Górze w Świętokrzyskim Parku Narodowym.

Lasy dębowo-grabowe występują dość rzadko. Fitocenozy *Tilio-Carpinetum* pod względem florystyczno-siedliskowym różnicują się na cztery podzespoły: *T.-C. corydaletosum*, *T.-C. stachyetosum*, *T.-C. typicum* i *T.-C. abietetosum* (Głazek & Wolak 1991).

W dolinach większych rzek i strumieni rozwinęły się lasy łęgowe *Fraxino-Alnetum*. Większość tych fitocenoz w wyniku gospodarki człowieka została silnie zniekształcona. Naturalne fragmenty tego zespołu zachowały się na obszarach chronionych, w Świętokrzyskim Parku Narodowym (w Dolinie Dębniańskiej i Wilkowskiej), w rezerwacie Białe Ługi, a poza tym w Paśmie Klonowskim. Ocalałe fitocenozy buduje głównie *Alnus glutinosa*.

W zachodniej części mezoregionu występują skały węglanowe (wapienie i częściowo dolomity) budujące niewysokie wzniesienia, na których wykształciły się ciepłe i węglanowe gleby. Siedliska te pokrywają ciepłolubne i kserotermiczne zbiorowiska roślinne. Większość wzgórz została całkowicie odlesiona. Lasy, głównie w postaci ciepłolubnych grądów, świetlistej dąbrowy, borów mieszanych i borów sosnowych zachowały się jedynie fragmentarycznie.

W dolinach, na glebach piaszczystych rosną głównie bory sosnowe typu *Peucedano-Pinetum*. Żyźniejsze siedliska podnóży wzniesień zajmują bogate florystycznie bory mieszane należące do zespołu *Serratulo-Pinetum*. W wyższych położeniach, na zboczach południowych rosną płaty świetlistej dąbrowy *Potentillo-Quercetum*. Północne zbocza zasiedla grąd *Tilio-Carpinetum melittetosum* i lasy zbliżone do *Aceri-Tilietum* (Bróż 1992). Na odlesionych pagórkach użytkowanych pastersko rozwinęły się murawy kserotermiczne z klasy *Festuco-Brometea* i zbiorowiska okrajkowe z klasy *Trifolio-Geranietea* z udziałem rzadkich gatunków roślin (Głazek 1987).

Przedmiotem badań są grzyby z klasy *Basidiomycetes* sensu Kirk *et al.* (2001) na obszarze mezoregionu Góry Świętokrzyskie (Kondracki 2000).

Celem pracy jest: poznanie różnorodności *Basidiomycetes*, ich zróżnicowania ekologicznego pod względem zajmowanych siedlisk, funkcji i znaczenia biocenotycznego grzybów na tle roślinności leśnej i nieleśnej tego obszaru; określenie wartości wskaźnikowej grzybów w ocenie przywiązania ich do zbiorowisk roślinnych i ich zachowania pod wpływem zróżnicowanego natężenia czynników antropogenicznych; rozpoznanie zagrożeń i ocena kierunków przemian, jakie dokonały się w minionym czasie pod względem jakościowym i ilościowym w biocie grzybów; przedstawienie podobieństw i różnic badanej mikobioty w stosunku do mezoregionów sąsiadujących z Górami Świętokrzyskimi.

Badania mikologiczne prowadzono w różnych typach ekosystemów naturalnych, półnaturalnych i antropogenicznych. Podstawą opracowania były badania terenowe prowadzone w ciągu 20 lat, tj. od roku 1986 do 2006 na obszarze całego mezoregionu. Badania mikocenologiczne prowadzono posługując się zmodyfikowaną metodą mikosocjologiczną. Powierzchnie stałe o wielkości 400 m^2, w liczbie 77, zostały założone w 14 przewodnich zbiorowiskach leśnych mezoregionu: *Abietetum polonicum, Cladonio-Pinetum, Dentario glandulosae-Fagetum, Fraxino-Alnetum, Leucobryo-Pinetum, Luzulo-Fagetum, Peucedano-Pinetum, Potentillo-Quercetum, Querco-Pinetum, Serratulo-Pinetum, Sphagnetum magellanici, Tilio-Carpinetum, Vaccinio uliginosi-Pinetum* i w zbiorowisku *Abies alba-Sphagnum girgensohnii*. Ponadto prowadzono obserwacje występowania *Basidiomycetes* w zbiorowiskach nieleśnych z klas: *Koelerio glaucae-Corynephoretea canescentis, Molinio-Arrhenatheretea* i *Festuco-Brometea*. Obserwacje mikosocjologiczne prowadzono od marca do lipca jeden raz w miesiącu, a od sierpnia do listopada – 2-3 razy w miesiącu, podczas których dokonywano spisu mikobioty z uwzględnieniem obfitości owocników według 3-stopniowej skali Jahna *et al*. (1967). Uwzględniono grzyby rosnące na wszystkich typach substratów. W niniejszej pracy przyjęto podział grzybów na naziemne, naściółkowe, briofilne oraz nadrzewne. Uzyskane zdjęcia mikosocjologiczne zestawiono w tabele zbiorcze (Tab. 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28), przedstawiające biotę *Basidiomycetes* w poszczególnych zespołach roślinnych. Dla każdego gatunku podano liczbę wystąpień na określonej powierzchni (cyfra pierwsza) oraz zakres i obfitość owocników. Dla gatunków o owocnikach trwałych użyto symbolu „X", który odpowiada sumie wszystkich obserwacji na danej powierzchni. Poza powierzchniami stałymi prowadzono obserwacje uzupełniające i zbiory grzybów stosując metodę kartogramu polowego. Obszar badań został pokryty siecią kwadratów wpisanych w siatkę ATPOL (Zając A. 1978), przy czym podstawowy kwadrat 10 km^2 został podzielony na cztery mniejsze, każdy o boku 5 km (Fig. 6). Cały badany mezoregion został pokryty 72 kwadratami o powierzchni 25 km^2, na których metodą marszrutową zbierano dalsze informacje o grzybach. Każdorazowo notowano stanowisko na podstawie topogramu (mapy drzewostanowe i topograficzne w skali 1:10 000), substrat na którym zbierano owocniki, zbiorowisko roślinne i datę zbioru.

Basidiomycetes we wszystkich biocenozach obserwujemy jako stałe ich składniki, które występują w określonej liczbie gatunków, zajmują określoną przestrzeń, różnorodne siedliska (mikrosiedliska), tworzą określone związki troficzne z roślinami i innymi organizmami.

Pod względem ilościowym udział grzybów z klasy *Basidiomycetes* w zbiorowiskach roślinnych Gór Świętokrzyskich jest zróżnicowany (Tab. 42). Największą liczbę gatunków grzybów z tej grupy – 393, zanotowano w fitocenozach należących do *Tilio-Carpinetum*. Oceniając bogactwo gatunkowe grzybów w stosunku do liczby gatunków roślin naczyniowych, relacje te układają się w proporcji 1.87:1. Podobnie, bardzo bogatymi fitocenozami są bór mieszany *Querco-Pinetum* (292 gatunki grzybów) i buczyna karpacka *Dentario glandulosae-Fagetum* (268). W obydwu przypadkach proporcje udziału *Basidiomycetes* do liczby gatunków roślin naczyniowych są podobne i wynoszą odpowiednio: 2.63:1 oraz 2.52:1. Najwyższe jednak relatywne, względne bogactwo zaobserwowano w bagiennym borze jodłowym, w zbiorowisku *Abies alba-Sphagnum girgensohnii*, w którym liczba *Basidiomycetes* była większa od liczby roślin w stosunku 5.71:1, w borze świeżym *Leucobryo-Pinetum* – 4.33:1 i borze bagiennym *Vaccinio uliginosi-Pinetum* – 4:1. Potwierdza to wcześniejsze obserwacje, m.in. Grzywacza (1999) i Mułenki (1998), że liczba grzybów *Basidiomycetes* jest większa od liczby roślin. Tylko w borze świeżym *Peucedano-Pinetum* liczba gatunków grzybów była równa liczbie gatunków roślin na badanych powierzchniach (po 78). Jednakże ogólna liczba grzybów zanotowanych we wszystkich fitocenozach tego zespołu wyniosła 199. W mikobiocie badanych zbiorowisk leśnych saprobionty stanowią dominującą grupę, obejmującą 593 gatunki, tj. 57% ogółu gatunków. Wśród nich, 332 gatunki (32% całości) to pedobionty, gatunki rozwijające się na ściółce i na humusie, 251 (24%) – ksylobionty, rozkładające martwe stojące i leżące pnie oraz kłody, grube i drobniejsze gałęzie, i 10 (0.9%) – to allobionty, gatunki koprofilne, występujące na ekskrementach zwierząt. Symbiontów mikoryzowych stwierdzono 375 gatunków, co stanowi 36% wszystkich odnotowanych grzybów, natomiast pasożyty stanowią grupę 59 gatunków, tj. 6% ogółu badanej mikobioty.

Grzyby *Basidiomycetes* zasiedlają niemal wszystkie obszary biologicznej przestrzeni biocenozy (Orłoś 1966). Sposób ich rozmieszczenia, stopień zależności od substratu, wpływ czynników ekologicznych jakie występują w określonych zbiorowiskach roślinnych powoduje, że całość mikobioty nie tworzy pozornie jednolitej i spójnej mikocenozy lecz pewien układ nakładających się i przenikających się synuzji i mniejszych mikocenoz. Grzyby nadrzewne rozwijające się na różnych częściach kłód, pni, gałęzi itd. przez niektórych autorów są traktowane jako autonomiczne mikoasocjacje (Pirk & Tüxen 1957; Kreisel 1961; Jahn 1966; Darimont 1973; Runge 1980; Michael *et al.* 1985; Kreisel & Müller 1987; Fellner 1988a). Podobne podejście w odniesieniu do grzybów naziemnych prezentuje m.in. Šmarda (1973). Taki sposób redukcjonistycznego pojmowania mikocenozy spotkał się z krytyką niektórych autorów, m.in. Dörfelta (1974). Wymienione grupy grzybów rozwijają się na podłożu, które należy do określonego typu biocenozy. Rozwój tych grzybów jest kształtowany i zależny od warunków ekologicznych jakie tam panują. Wobec powyższego są częścią określonej biocenozy, której zasięg wyznaczają najlepiej granice tej fitocenozy. Na całej powierzchni zespołu roślinnego grzyby traktowane są holistycznie, jako składowe jego skomplikowanej biocenozy.

Odmienny charakter genetyczny i organizacyjny mają grzyby związane z wypaleniskami i grzyby koprofilne. Grzyby tych siedlisk, obce badanej fitocenozie, tworzą autonomiczne synuzje o charakterze niezależnych mikoasocjacji (Pirk & Tüxen 1949; Ebert 1958; Darimont 1973; Wojewoda 1975).

Współczesny obraz składu gatunkowego i rozmieszczenia *Basidiomycetes* w Górach Świętokrzyskich wynika z jego położenia w stosunku do otaczających go innych regionów geograficznych, warunków klimatycznych, rzeźby terenu, budowy geologicznej i rozwoju szaty roślinnej, a także wpływów antropogenicznych. Góry Świętokrzyskie są położone w zasięgu geograficznym ważnych drzew lasotwórczych, tj. *Abies alba, Fagus sylvatica, Acer pseudoplatanus, Larix decidua* ssp. *polonica* i *Picea abies,* które kształtują jego biotę i sprzyjają przenikaniu na badany teren grzybów o charakterze górskim. Stwierdzono występowanie 87 gatunków szeroko rozumianego elementu górskiego (Tab. 43). Udział górskich gatunków *Basidiomycetes* na obszarze Gór Świętokrzyskich podkreśla podobieństwo tego terenu do mikobioty znacznie wyższych pasm górskich, jak np. Babiej Góry, Beskidu Sądeckiego, Pienin i Tatr. Szczególnie wyróżniają się tu biocenozy *Abietetum polonicum* i *Dentario glandulosae-Fagetum*, które nawiązują do leśnych zbiorowisk dolnoreglowych w Karpatach oraz do podobnych zespołów na Roztoczu. Ekspansywne wnikanie jodły do różnych zbiorowisk leśnych wyraźnie wpływa na wzbogacenie bioty *Basidiomycetes* tych biocenoz. Wyróżniono gatunki wskaźnikowe, spośród których większość ma walor gatunków lokalnie charakterystycznych. Wartość wskaźnikowa gatunku grzyba wyraża się jego stopniem wierności i wyłączności dla danego zespołu. Znacznie mniejszą rolę odgrywają takie parametry jak stałość i obfitość owocników, które wybitnie zależne są od czynników pogodowych. Stwierdzono również obecność wielu gatunków wskaźnikowych o wartościach ponadregionalnych. Gatunki te jednak odnoszą się z reguły do wyższych syntaksonów.

Basidiomycetes na badanym terenie tworzą związki troficzne z co najmniej 34 gatunkami roślin naczyniowych i 11 rodzajami mchów. Najliczniejsze grupy grzybów towarzyszą drzewom, np. sośnie – 114 gatunków, bukowi – 105, jodle – 102, dębowi – 100, brzozie – 55 i olszy – 54, a także mchom torfowcom – 48 gatunków *Basidiomycetes*. Pomimo bardzo licznych grup grzybów, ścisły charakter zależności od określonego gatunku rośliny wykazują tylko nieliczne gatunki *macromycetes*. Na stosunki ilościowe powiązań mikobioty z roślinami ogromny wpływ mają czynniki wynikające ze stopnia zachowania i naturalności flory, a także z zachowania, złożoności i dojrzałości całych fitocenoz. W strukturze troficznej najliczniejsze grupy stanowią zawsze saprobionty zasiedlające różne części roślin, mniej liczną grupę tworzą grzyby mikoryzowe, a najmniej liczną pasożyty.

Lasy dawnej Puszczy Świętokrzyskiej mimo dużych zniszczeń wskutek różnorodnej i długotrwałej działalności gospodarczej człowieka zachowały nadal fragmenty o wysokim stopniu naturalności, które są siedliskiem i ostoją wielu rzadkich, puszczańskich gatunków *Basidiomycetes*. Do grupy tej należą m.in. *Albatrellus confluens, A. ovinus, Bankera fuligineoalba, Cortinarius violaceus, Fomitopsis officinalis, Hericium coralloides, H. flagellum, Polyporus umbellatus, Pycnoporellus fulgens, Skeletocutis odora* i *S. stellae*.

Zagrożenie *Basidiomycetes* Gór Świętokrzyskich w świetle ogólnopolskiej czerwonej listy grzybów zagrożonych dotyczy 262 gatunków. Jednakże zjawisko to w warunkach lokalnych dotyczy znacznie szerszej grupy grzybów, co wynika z uwarunkowań regionalnych przyrody. Czerwona lista *Basidiomycetes* dla Gór Świętokrzyskich zawiera 313 gatunków, tj. 29.6% bioty *Basidiomycetes* mezoregionu. Do kategorii Ex należą 4 gatunki, E – 67, V – 44, R – 194 i do kategorii I – 4 gatunki. Na obszarze tym odnaleziono cztery gatunki grzybów, *Hebeloma danicum*, *Entoloma formosum, Pholiota mixta* i *Ramaria flaccida*, co do których były podejrzenia o wymarciu ich na terenie kraju.

Przemiany bioty grzybów, jakie obserwowane są na obszarze Gór Świętokrzyskich dokonują się pod wpływem czynników naturalnych i antropogenicznych. Grzyby związane z pierwszą grupą czynników, wynikających m.in. z ocieplania się klimatu, są stwierdzane wyłącznie w zbiorowiskach naturalnych. Drugą grupę grzybów stanowią *Basidiomycetes*, które wskutek zmian klimatycznych napłynęły na badany teren, ale zadomowiły się w ekosystemach o różnym stopniu naturalności. Niektóre z tych grzybów wykazują znamiona ekspansji. Problem ten dotyczy synantropów, np. *Clathrus archeri, Mutinus caninus, M. revenelii* i *Psilocybe rugosoannulata*. Synantropizacji ulegają również gatunki uważane za rodzime, np. *Langermannia gigantea* lub *Phallus impudicus*.

W ogólnym zjawisku przenikania grzybów do różnych typów siedlisk można wyróżnić dwa zasadnicze procesy: synantropizacji grzybów, tj. wnikania gatunków rodzimych na siedliska synantropijne i neofungizacji, tj. wnikania synantropów i obcych gatunków grzybów do zbiorowisk naturalnych.

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INDEX OF FUNGAL NAMES

Chroogomphus rutilus
Clathrus archeri
Clavaria aculeata
Clavaria fragilis
Clavaria fumosa
Clavariadelphus junceus
Clavicorona pyxidata
Clavulicium macounii
Clavulina amethystina
Clavulina cinerea
Clavulina coralloides
Climacocystis borealis
Climacodon septentrionalis
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Clitocybe dealbata
Clitocybe ditopa
Clitocybe ericetorum
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Clitocybe geotropa
Clitocybe gibba
Clitocybe hydrogramma
Clitocybe inornata
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Clitocybe metachroa
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Clitocybe obsoleta
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Clitocybe phyllophila
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Clitocybe strigosa
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Clitocybe tornata
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Mycena polyadelpha
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Mycena smithiana
Mycena speirea
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Mycena tintinnabulum
Mycena viridimarginata
Mycena vitilis
Mycena vulgaris
Mycena zephirus
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Naucoria escharoides
Naucoria permixta
Naucoria scolecina
Naucoria striatula
Naucoria subconspersa
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Omphalina sphagnicola
Omphalina umbellifera
Ossicaulis lignatilis
Oudemansiella mucida
Oxyporus populinus
Panaeolus acuminatus
Panaeolus fimiputris
Panaeolus foenisecii
Panaeolus leucophanes
Panaeolus sphinctrinus
Panellus mitis
Panellus serotinus
Panellus stypticus
Paxillus atrotomentosus
Paxillus involutus
Paxillus panuoides
Peniophora cinerea
Peniophora erikssonii
Peniophora incarnata
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Peniophora nuda
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Peniophora quercina
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Phaeomarasmius erinaceus
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Pholiota alnicola
Pholiota astragalina
Pholiota aurivella
Pholiota flammans
Pholiota mixta
Pholiota mutabilis
Pholiota populnea
Pholiota spumosa
Pholiota squarrosa
Pholiota tuberculosa
Phylloporia ribis
Phyllotopsis nidulans
Physisporinus vitreus
Piptoporus betulinus
Pleurotus calyptratus
Pleurotus cornucopiae
Pleurotus dryinus
Pleurotus ostreatus
Pleurotus ostreatus f. *peregrinus*
Pleurotus ostreatus var. *salignus*
Pleurotus pulmonarius
Pluteus atricapillus
Pluteus atromarginatus
Pluteus aurantiorugosus
Pluteus chrysophaeus
Pluteus cinereofuscus
Pluteus depauperatus
Pluteus ephebeus
Pluteus exiguus
Pluteus godeyi
Pluteus leoninus
Pluteus pellitus
Pluteus plautus
Pluteus podospileus
Pluteus pouzarianus
Pluteus pseudorobertii
Pluteus romellii
Pluteus salicinus
Pluteus umbrosus
Polyporus alveolaris
Polyporus arcularius
Polyporus badius
Polyporus brumalis
Polyporus ciliatus
Polyporus squamosus
Polyporus tuberaster
Polyporus umbellatus
Polyporus varius
Polyporus varius var. *elegans*
Polyporus varius var. *nummularius*
Porphyrellus porphyrosporus
Porpoloma spinulosum
Protomerulius caryae
Psathyrella candolleana
Psathyrella canoceps
Psathyrella cotonea
Psathyrella piluliformis
Psathyrella pygmaea
Psathyrella rugosoannulata
Psathyrella sarcocephala
Psathyrella spadicea

Psathyrella spadiceogrisea
Psathyrella subnuda
Pseudoclitocybe cyathiformis
Pseudocraterellus undulatus
Pseudohydnum gelatinosum
Psilocybe aeruginosa
Psilocybe albonitens
Psilocybe capnoides
Psilocybe coronilla
Psilocybe crobula
Psilocybe elongata
Psilocybe ericaea
Psilocybe fascicularis
Psilocybe inuncta
Psilocybe lateritia
Psilocybe luteonitens
Psilocybe merdaria
Psilocybe montana
Psilocybe phyllogena
Psilocybe polytrichi
Psilocybe rugosoannulata
Psilocybe semiglobata
Psilocybe squamosa
Psilocybe subericaea
Psilocybe subviridis
Psilocybe uda
Pycnoporellus fulgens
Radulomyces confluens
Radulomyces molaris
Ramaria abietina
Ramaria botrytis
Ramaria corrugata
Ramaria eumorpha
Ramaria flaccida
Ramaria flava
Ramaria gracilis
Ramaria polonica
Ramaria rubella
Ramaria stricta
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Resupinatus trichotis
Resupinatus unguicularis
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Rhodocollybia butyracea var. *asema*
Rhodocollybia butyracea var. *butyracea*
Rhodocollybia maculata
Rhodocollybia prolixa
Rhodocollybia prolixa var. *distorta*
Rhodocybe popinalis
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Rickenella setipes
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Rozites caperatus
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Russula albonigra
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Russula brunneoviolacea
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Russula cuprea
Russula curtipes
Russula cyanoxantha
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Russula delica
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Russula liliacea
Russula livescens
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Russula mairei
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Russula olivacea
Russula paludosa
Russula piceetorum
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Russula pungens
Russula queletii
Russula risigallina
Russula rosea
Russula sanguinea
Russula sardonia
Russula turci
Russula undulata
Russula versicolor
Russula vesca
Russula vinosa
Russula violacea
Russula violeipes
Russula virescens
Russula xerampelina
Russula zonatula
Sarcodon imbricatum
Schizophyllum commune

Scleroderma citrinum
Scleroderma fuscum
Scleroderma verrucosum
Serpula himantioides
Setulipes androsaceus
Setulipes quercophilus
Sistotrema brinkmannii
Skeletocutis amorpha
Skeletocutis lenis
Skeletocutis nivea
Skeletocutis odora
Skeletocutis stellae
Sparassis brevipes
Sparassis crispa
Sphaerobolus stellatus
Stereum complicatum
Stereum gausapatum
Stereum hirsutum
Stereum ostrea
Stereum rugosum
Stereum sanguinolentum
Stereum subtomentosum
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Tricholoma myomyces
Tricholoma orirubens
Tricholoma pessundatum
Tricholoma sulphureum
Tricholoma terreum
Tricholoma ustale
Tricholoma vaccinum
Tricholoma virgatum
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Tricholomopsis ornata
Tricholomopsis rutilans
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Tulasnella thelephorea
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Vascellum pratense
Volvariella bombycina
Volvariella gloiocephala
Volvariella murinella
Volvariella pusilla
Vuilleminia comedens
Xerocomus badius
Xerocomus parasiticus
Xerocomus pascuus
Xerocomus rubellus
Xerocomus subtomentosus
Xeromphalia campanella
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