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Macromycetes of the Kręgi Kamienne nature-archaeological reserve in the Bory Tucholskie (NW Poland)

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In the years 1994–1995 mycocoenological investigations in the *Leucobryo-Pinetum* and *Calluno-Genistetum* associations on permanent plots were carried out. The survey of macrofungal species and discussion of results are given in the paper.

Key words: macromycetes, pine forest, nature-archaeological reserve, *Leucobryo-Pinetum*, *Calluno-Genistetum*.

INTRODUCTION

The Kręgi Kamienne reserve is one of the most mycologically interesting objects within the Bory Tucholskie forest complex (Ł a w r y n o w i c z, D z i e d z i ń s k i, S z k o d z i k and S z o s t e k 1995; Ł a w r y n o w i c z 1997).

Two plant associations are distinguished there: *Leucobryo-Pinetum* Mat. (1962) 1973 – a Scots pine forest association, the most typical for this region, and *Calluno-Genistetum* Tx. 1937 – an anthropogenic association on the area changed during archaeological excavations. The *Leucobryo-Pinetum* association, covering ca 75% of the reserve, has been studied mycocoenologically in several places in Poland. The survey of the results is given by F r i e d r i c h (1994). The *Calluno-Genistetum* was never before investigated by mycocoenologists.

So far lichens in the reserve are relatively well described. The recent lichenological investigations reveal the occurrence of 86 epilithic lichens with some montaneous species rare in Poland.

Before the present studies, macromycetes of the reserve were poorly recognized. Several collections were made mostly in 1973 and 1974 (Ł a w r y n o w i c z 1997). Among 65 species collected in the reserve some appeared interesting enough to be published (W o j e w o d a 1976; S k i r g i e ł ł o 1984; Ł a w r y n o w i c z 1989).

STUDY AREA

The nature-archaeological reserve Kręgi Kamienne (the stone circles), of 16.9 ha, is situated at the northern limit of the Bory Tucholskie forest complex, on the south bank of the Wda River (Fig. 1). It was established in 1958 to protect: 1) the monument of religious cult from the Neolithic Age, a group of erratic blocks arranged into 10 circles; 2) communities of lichens and mosses occurring on the blocks characteristic of primary morains.

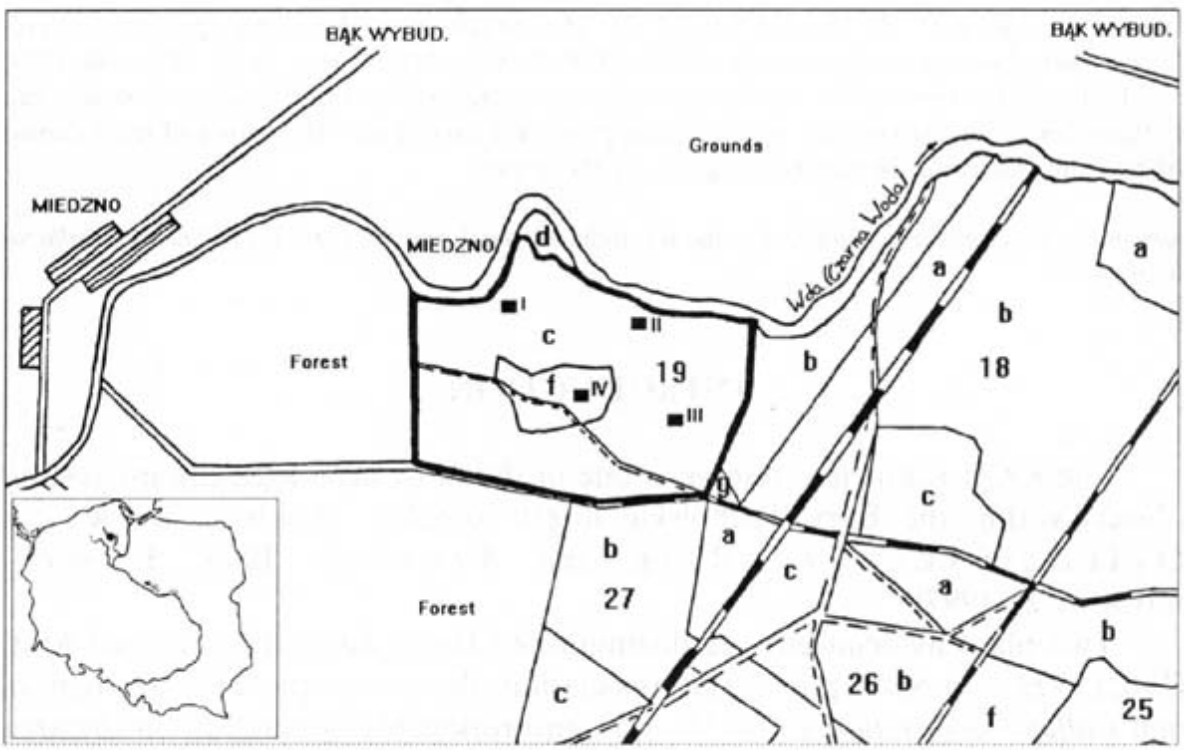

Fig. 1. Distribution of permanent plots: I, II, III, IV in the Kręgi Kamienne nature-archaeological reserve

The landscape of the reserve is slightly hilly, with depressions reaching several meters. To the north, the terrain declines to the river bed along a steep slope, of about 40°. In 19. century the reserve became a subject of archeological investigations. The excavations are continued also nowadays.

According to the recent data the stone circles are ca 2 thousand years old. At present the most important feature of the reserve is an aggregation of 10 stone circles 15–33 m in diameter, constructed of huge erratic blocks, 30 grave--mounds, numerous steles and grave-stones (K m i e c i ń s k i 1968; W a l e n t a 1981).

The whole area of the Bory Tucholskie is dominated by sand formations. Loose postglacial sands (outwash sands) cover the reserve with a very thick layer, frequently with a considerable contribution of skeletal parts (K o m e n d a r c z y k 1989a).

The mean annual precipitation of the area is 580 mm, the heaviest rain periods occurring in summer (87 mm) and the lightest in February and March (29 mm). Meteorological data on the study period were obtained from a meteorological station at the town Chojnice, located about 40 km from the study area (Fig. 2 and 3). They indicate that the distribution of precipitation was untypical.

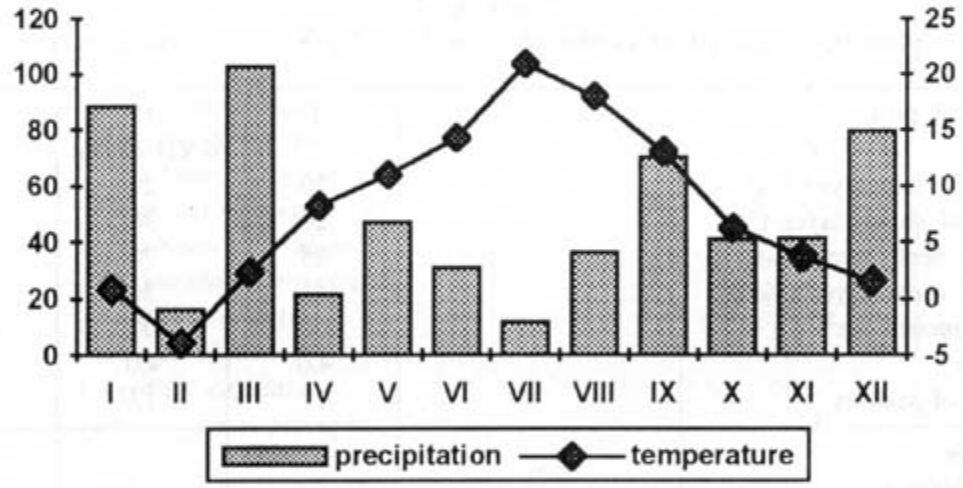

Fig. 2. Mean monthly air temperatures and precipitation totals at the meteorological station at Chojnice in 1994

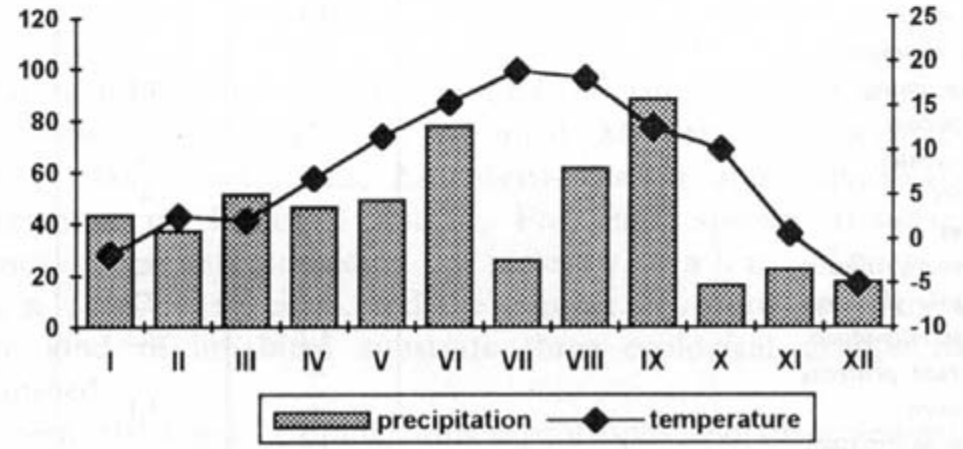

Fig. 3. Mean monthly air temperatures and precipitation totals at the meteorological station at Chojnice in 1995

The beginning of the vegetation season usually occurs in early April, the end in early November. Late spring ground frost occurs quite frequently, in May and even in June. Long periods of draught in July and August in the both years of investigations, stopped the production of fruit-bodies in these months.

MATERIAL AND METHODS

Four permanent plots of 400 sq. m each were established in the reserve. On each plot 14 mycological surveys were carried out from May to November during the years 1994 and 1995. Descriptions of the plots including vascular plants were made in full vegetation season, in July 1998 (Tab. 1 and 2). Lichens and bryophytes were not included in the project.

Table 1
Floristical description of the plots in *Leucobryo-Pinetum* association

Number of plot	I	II	III
Date		6 VII 1998 r.	
Density of tree layer (%)	20	20	30
Density of shrub layer (%)	20	30	20
Cover of herb layer (%)	85	70	70
Cover of moss layer (%)	15	30	30
Area of record (m^2)	400	400	400
pH value	4.0	4.0	4.0
Number of species	17	13	11
Tree layer			
Pinus sylvestris	2.2	2.2	3.3
Shrub layer			
Betula pendula	+	1.1	1.1
Quercus robur	1.1	+	1.1
Frangula alnus	1.1	1.1	
Juniperus communis	+	.	1.1
Sorbus aucuparia	+	1.1	.
Quercus petrea	+	.	.
Populus tremula	.	+	.
Picea abies	.	+	.
Herb layer			
Vaccinium myrtillus	4.4	3.3	3.3
Deschampsia flexuosa	2.2	2.2	2.2
Vaccinium vitis-idaea	1.1	2.2	2.2
Melampyrum pratense	+	.	1.1
Luzula pilosa	+	1.1	.
Vaccinium uliginosum	1.1	.	.
Chimaphila umbellata	+	.	.
Calluna vulgaris	+	.	.

Table 2
Floristical description of the plot in *Calluno-Genistetum* association

Number of plot	IV
Date	6 VII 1998r.
Density of tree layer (%)	0
Density of shrub layer (%)	15
Cover of herb layer (%)	70
Cover of moss and lichen layer (%)	15
Area of record (m^2)	400
pH value	4.5
Number of species	25
Shrub layer	
Betula pendula	2.2
Juniperus communis	1.1
Pinus sylvestris	1.1
Quercus robur	+
Frangula alnus	+
Herb layer	
Calluna vulgaris	4.4
Deschampsia flexuosa	2.2
Arctostaphylos uva-ursi	1.1
Vaccinium myrtillus	1.1
Calamagrostis epigeios	1.1
Vaccinium vitis-idaea	1.1
Corynephorus canescens	1.1
Rumex acetosella	1.1
Festuca ovina	1.1
Agrostis capillaris	1.1
Melampyrum pratense	+.2
Teesdalea nudicaulis	+
Chamenarion angustifolium	+
Veronica officinalis	+
Astragalus danicus	+

During the observations the number of fruit-bodies of each species as well as inhabited substrate were recorded. Macromycetes occurring in the respective plant associations, *Leucobryo-Pinetum* and *Calluno-Genistetum*, are presented in Tables 3 and 4. For each species abundance (rare, numerous, abundant) according to scale by Jahn, Nespiak and Tüxen (1967) is specified, and the number of records is given. Considering the kind of inhabited substrate three ecological groups have been distinguished:

1) terrestial fungi – humicolous saprotrophs and suspected mycorrhizal fungi; 2) litter saprotrophs – on fallen leaves, twigs, cones and dead parts of bryophytes; 3) lignicolous saprotrophs – on stumps.

The nomenclature of fungi is used according to Dennis (1978), Jülich (1984) and Moser (1984).

The collection of macrofungi was deposited in the Herbarium Universitatis Lodziensis (LOD).

Description of the studied forest

The Kręgi Kamienne reserve is located in the area where the occurrence ranges of two vicariating forest associations, the suboceanic *Leucobryo-Pinetum* and subcontinental *Peucedano-Pinetum*, meet with each other.

Phytosociological investigations of the reserve were carried out by Komendarczyk (1989b). In the whole forested area, he distinguished the association of *Peucedano-Pinetum*. However, the latest ecological and chorological synthesis of forest associations in Poland (Matuszkiewicz and Matuszkiewicz 1996) unequivocally indicates that a subatlantic association of the pine forest *Leucobryo-Pinetum* occurs in the investigated reserve. Plots I–III were established in the vegetation representing this association (Tab. 1).

In deforested, archaeologically exploited plots, an anthropogenic association of *Calluno-Genistetum* (Komendarczyk 1989b) develops. In this association plot IV was established (Tab. 2).

As a nature-archaeological object the reserve fulfils the function of a whole year's open-air exposition. Forest constitutes its natural protection border, which is cultivated by the immediate removing of dead tree trunks and branches. All the year round the reserve is accessible to tourists, hundreds of whom visit it both collectively and individually.

The reserve area is fenced round. Lanes lead from the gate to archaeological objects, which are systematically cleared. Besides, the forest is cut through with a huge number of spontaneously created paths that appeared as a result of penetrating the area by humans. The reserve is very attractive not only archaeologically but also due to the Wda River and its meander limiting the northern side of the terrain. The area is also abundant with edible mushrooms.

Plot I (Fig. 1; Tab. 1). *Leucobryo-Pinetum*. The terrain is slightly slanting to the north, close to the river. Several pine stumps, litter of conifer needles, dead remnants of vascular plants, undergrowth and mosses occur there.

Plot II (Fig. 1, 4; Tab. 1). *Leucobryo-Pinetum*. Located in a shallow depression of the terrain, with recolonizing pines. Plentiful substrate for fungi: pine stumps, fallen branches, litter of conifer needles.

Fig. 4. Plot II. The area covered with old and young Scots pine trees and *Deschampsia flexuosa* dominating in herb layer (Phot. J. Szkodzik)

Fig. 5. Plot III. *Leucobryo-Pinetum* penetrated with sunshine; dense moss layer dominated by *Pleurozium schreberi* (Phot. T. Dziedziński)

Fig. 6. Plot IV. *Calluno-Genistetum* covering places of archaeological excavations (Phot. J. Szkodzik)

Fig. 7. *Tremella encephala* parasiting on fruit-bodies of *Stereum sanquinolentum* growing on dead branches of *Pinus sylvestris* (Phot. W. Mułenko)

Plot III (Fig. 1, 5; Tab. 1). *Leucobryo-Pinetum.* Exposed to the north, no brushwood and undergrowth. Infrequent stumps and fallen branches. The moss layer seems to play an important role in fungal development.

Plot IV (Fig. 1, 6; Tab. 2). *Calluno-Genistetum.* Located in the excavated terrain, deforested. Numerous stumps after incessantly recolonizing pine and birch. Bare soil patches and patches of fire-places are visible.

RESULTS

A total of 130 macromycetes species were recorded in the Kręgi Kamienne reserve.

As regards abundance and frequency a group of species that dominate in all the plots of *Leucobryo-Pinetum* can be distinguished: *Russula decolorans*, *Russula paludosa*, *Hygrophoropsis aurantiaca*, *Amanita citrina* and others (Tab. 3). These species form large populations producing fruit-bodies of bright and saturated colours, frequently of huge dimensions. This makes the fungi most pronouncedly manifesting their presence as compared with all the other herb layer components. Terrestrial fungi are most abundantly represented by mycorrhizal species associated with pine. This phenomenon can be observed both in plot II, which is being intensively recolonized by pines, and in the other plots, overgrown by 120 year old pine trees.

A group of species that form mycorrhiza with birch can be also distinguished in plot II. Its contribution is low but noticeable due to the appearance of *Cortinarius armillatus*, *Russula flava*, *Leccinum scabrum*, *Lactarius torminosus*, *L. vietus* and others. On the other hand, the occurrence of *Lactarius quietus* is connected with the presence of oak trees in the plot. In plot III a group inhabiting sandy areas, e.g. *Tricholoma flavovirens* and *Suillus bovinus* (Tab. 3), can be noticed.

In the *Leucobryo-Pinetum*, conditions occurring in the moss layer are of much significance for development of fungi. The litter of conifer needles, leaves, cones and other dead parts of vascular plants also aggregate there, while favourable humidity conditions facilitate their decomposition by fungi. Litter-decomposing as well as bryophilous species simultaneously occur there, hence in this study the moss layer with everything that may be found in it was considered a unity. Although the list of species in this layer is not long (Tab. 3), they are characterized with high abundances of, usually, tiny fruit-bodies. The dominants of the group in all the plots are: *Xeromphalina cornui*, *Marasmius androsaceus*, *Strobilurus stephanocystis*, *Galerina hypnorum* and others (Tab. 3).

Table 3

Macromycetes in *Leucobryo-Pinetum* plant association in the Kręgi Kamienne reserve

Number of plot	I	II	III
Area of plot in sq. m	400	400	400
Number of observations	14	14	14
Number of species	45	37	38
I. Terrestrial fungi			
Russula decolorans Fr.	a^5	a^7	a^7
Russula paludosa Britz.	a^2	a^4	a^4
Hygrophoropsis aurantiaca (Wulf.: Fr.) Mre.	n^3	n^5	a^6
Amanita citrina (Schaeff.) Pers.	n^3	a^4	n^2
Amanita porphyria (A. et S.: Fr.) Mlady	n^2	n^5	n^6
Xerocomus badius (Fr.) Kühn. ex Gilb.	n^2	n^2	n^2
Lactarius rufus (Scop.: Fr.) Fr.	.	a^2	a^6
Dermocybe semisanguinea (Fr.) Mos.	.	a^3	n^3
Clitocybe clavipes (Pers.: Fr.) Kumm.	a^3	n^2	.
Russula emetica (Schaeff.: Fr.) Pers.	n^2	.	a^3
Dermocybe cinnamomea (L.: Fr.) Wünsche	n^1	.	a^3
Laccaria laccata (Scop.: Fr.) Bk. et Br.	n^1	n^1	.
Cantharellus cibarius Fr.	r^1	.	r^4
Russula vesca Fr.	r^1	r^2	.
Clitocybe gibba (Pers.: Fr.) Kumm.	n^4	.	.
Psathyrella candolleana (Fr.: Fr.) Mre.	n^2	.	.
Russula fragilis (Pers.: Fr.) Fr.	n^2	.	.
Paxillus involutus (Batsch: Fr.) Fr.	r^7	.	.
Tylopilus felleus (Bull.: Fr.) O. Kuntze	r^2	.	.
Russula vinosa Lindbl.	r^2	.	.
Lycoperdon perlatum Pers.: Pers.	r^1	.	.
Lepista inversa (Scop.: Fr.) Pat.	r^1	.	.
Lactarius quietus (Fr.) Fr.	r^1	.	.
Cortinarius armillatus (Fr.) Fr.	.	n^3	.
Russula flava (Rom.) Rom. ap. Lindbl.	.	n^1	.
Leccinum scabrum (Bull.: Fr.) S. F. Gray	.	r^4	.
Amanita muscaria (L.: Fr.) Hook	.	r^2	.
Lactarius torminosus (Schaeff.: Fr.) S. F. Gray	.	r^1	.
Lactarius vietus (Fr.) Fr.	.	r^1	.
Rozites caperata (Pers.: Fr.) P. Karst.	.	.	a^5
Chroogomphus rutilus (Schaeff.: Fr.) O. K. Miller	.	.	a^2
Amanita rubescens (Pers.: Fr.) S. F. Gray	.	.	n^4
Cortinarius mucosus (Bull.: Fr.) Fr.	.	.	n^3
Tricholoma flavovirens (Pers.: Fr.) Lund et Nannf.	.	.	n^2
Boletus pinicola Vitt.	.	.	n^2
Suillus bovinus (L.: Fr.) O. Kuntze	.	.	n^1
Amanita gemmata (Fr.) Bertill.	.	.	r^3
Thelephora terrestris Pers.: Fr.	.	.	r^2
Suillus variegatus (Swartz.: Fr.) O. Kuntze	.	.	r^2

Tab. 3 cont.

II. Litter-decomposing fungi			
Xeromphalina cornui (Quél.) Favre	a^9	a^7	a^7
Marasmius androsaceus (L.: Fr.) Fr.	a^7	a^7	a^3
Mycena sanguinolenta (A. et S.: Fr.) Kumm	a^2	a^3	a^4
Galerina hypnorum (Schrank: Fr.) Kühn.	a^2	a^1	a^1
Mycena galopus (Pers.: Fr.) Kumm.	a^3	a^4	n^1
Strobilurus stephanocystis (Hora) Sing.	a^2	n^1	n^1
Mycena epipterygia (Scop.: Fr.) S. F. Gray	a^5	a^1	.
Clitocybe dealbata (Sow.: Fr.) Kumm.	n^2	.	r^1
Mycena tenella (Fr.) Quél.	n^1	r^1	.
Mycena zephirus (Fr.: Fr.) Kumm.	n^3	.	.
Mycena pura (Pers.: Fr.) Kumm.	n^1	.	.
Collybia dryophila (Bull.: Fr.) Kumm.	n^1	.	.
Galerina pumila (Pers.: Fr.) M. Lge.	n^1	.	.
Cystoderma granulosum (Batsch: Fr.) Fay.	r^4	.	.
Rickenella fibula (Bull.: Fr.) Raith.	r^2	.	.
Rhodophyllus nigrellus (Pers.) Quél. ss. Lge.	r^1	.	.
Cystoderma carcharias (Pers.) Fay.	r^1	.	.
Mycena chlorinella (Lge.) Sing.	r^1	.	.
Collybia butyracea (Bull.: Fr.) Quél.	.	n^3	.
Collybia tuberosa (Bull.: Fr.) Kumm.	.	n^2	.
Entoloma cetratum Fr.	.	.	n^1
Collybia asema (Fr.: Fr.) Kumm.	.	.	r^2
Clitocybe vibecina (Fr.) Quél.	.	.	r^1
III. Lignicolous fungi			
Calocera viscosa (Pers.: Fr.) Fr.	.	n^3	n^5
Hypholoma capnoides (Fr.: Fr.) Kumm.	.	n^4	r^2
Tricholomopsis rutilans (Schaeff.: Fr.) Sing.	r^1	r^2	.
Collybia maculata (A. et S.: Fr.) Kumm.	n^5	.	.
Hypholoma fasciculare (Huds.: Fr.) Kumm.	r^4	.	.
Pluteus atricapillus (Batsch) Fay.	r^3.	.	.
Onnia triqueter (Fr.) Imaz.	r^2	.	.
Hypholoma sublateritium (Fr.) Quél.	r^2	.	.
Pholiota astragalina (Fr.) Sing.	.	n^4	.
Xeromphalina campanella (Batsch: Fr.) R. Mre.	.	n^1	.
Paxillus atrotomentosus (Batsch: Fr.) Fr.	.	r^3	.
Pluteus atromarginatus (Konr.) Kühn.	.	r^2	.
Armillaria mellea (Vahl.: Fr.) Kumm.	.	r^2	.
Crepidotus mollis (Schaeff.: Fr.) Kumm.	.	r^2	.
Dacrymyces stillatus Nees: Fr.	.	r^2	.
Sparassis crispa (Wulf. in Jacq.) Fr.	.	r^1	.
Gymnopilus penetrans (Fr.: Fr.) Murr.	.	.	n^3
Dacrymyces capitata Raitv.	.	.	n^1
Trichaptum abietinum (Pers.: Fr.) Ryv.	.	.	x^1

There are only few lignicolous fungi, which is a result of the removal of dead trees or their parts. Only fungi inhabiting pine stumps have a chance to develop there, which is reflected in Table 3.

The *Calluno-Genistetum* association, mycologically investigated in one plot, comprises a mosaic of various fungi. Among terrestrial fungi there occur species that form mycorrhizal association with pine and birch, including those typical of sandy habitats, such as *Tricholoma portentosum* and *Suillus luteus*. The habitat of lignicolous fungi are pine and birch stumps, originating from self-sowing and systematically cut-out and burned. A specific group of species is formed there by anthracophilous fungi, e.g. *Tephrocybe atrata* and *Pholiota carbonaria* (Tab. 4). On the remaining twigs of Scots pine, *Tremella encephala* (Fig. 7) is to be found.

Table 4

Macromycetes in *Calluno-Genistetum* association in the Kręgi Kamienne reserve

Number of plot	IV		
Area of plot in sq. m	400		
Number of observations	14		
Number of species	34		
I. Terrestrial fungi			
Russula paludosa Britz.	a^1	*Lycoperdon perlatum* Pers.: Pers.	r^4
Thelephora terrestris Pers.: Fr.	n^6	*Suillus luteus* (L.: Fr.) S. F. Gray	r^4
Laccaria laccata (Scop.: Fr.) Bk. et Br.	n^4	*Amanita rubescens* (Pers.: Fr.) S. F. Gray	r^3
Suillus bovinus (L.: Fr.) O. Kuntze	n^4	*Coltricia perennis* (L.: Fr.) Murr.	r^2
Russula aeruginea Lindl. in Fr.	n^3	*Xerocomus badius* (Fr.) Kühn. ex Gilb.	r^2
Clitocybe clavipes (Pers.: Fr.) Kumm.	n^2	*Dermocybe semisanguinea* (Fr.) Mos.	r^1
Tricholoma imbricatum (Fr.: Fr.) Kumm.	n^1	*Boletus pinicola* Vitt.	r^1
Inocybe lacera (Fr.: Fr.) Kumm.	n^1	*Xerocomus subtomentosus* (L.: Fr.) Quél.	r^1
Dermocybe cinnamomea (L.: Fr.) Wünsche	n^1	*Lycoperdon marginatum* Vitt.: Moris et De Not.	r^1
Suillus variegatus (Swartz.: Fr.) O. Kuntze	r^4	*Tricholoma portentosum* (Fr.) Quél.	r^1
II. Litter-decomposing fungi			
Cantharellula umbonata (Gmel.: Fr.) Sing.	a^4	*Clitocybe dealbata* (Sow.: Fr.) Kumm.	n^3
Galerina hypnorum (Schrank: Fr.) Kühn.	a^3	*Collybia tuberosa* (Bull.: Fr.) Kumm.	n^2
Mycena sanguinolenta (A. et S.: Fr.) Kumm.	a^2	*Marasmius androsaceus* (L.: Fr.) Fr.	r^1
III. Lignicolous fungi			
Armillaria mellea (Vahl.: Fr.) Kumm.	r^4	*Chondrostereum purpureum* (Pers.: Fr.) Pouz.	x^1
Trametes versicolor (L.: Fr.) Pil.	r^4	*Skeletocutis amorpha* (Fr.: Fr.) Kotl. et Pouz.	x^1
Crepidotus mollis (Schaeff.: Fr.) Kumm.	r^1	*Polyporus ciliatus* Fr.	x^1
Tremella encephala Pers.: Pers.	r^1	*Merulius tremellosus* Fr.	x^1

Table 5
Species collected outside of plots

Terrestrial fungi	
Albatrellus ovinus (Schaeff.: Fr.) Kotl. et Pouz.	*Gyromitra esculenta* (Pers.) Fr.
Amanita spissa (Fr.) Kumm.	*Hebeloma testaceum* (Batsch: Fr.) Quél.
Cantharellus tubaeformis Fr.	*Hydnum repandum* L.: Fr.
Clavariadelphus ligula (Schaeff.: Fr.) Donk	*Inocybe dulcamara* (A. et S.: Pers.) Kumm.
Cortinarius alboviolaceus (Pers.: Fr.) Fr.	*Lactarius deliciosus* Fr.
Cortinarius collinitus Fr.	*Lactarius turpis* (Weinm.) Fr.
Cortinarius hemitrichus Fr.	*Macrolepiota procera* (Scop.: Fr.) Sing.
Cortinarius pholideus (Fr.: Fr.) Fr.	*Russula albonigra* Krbh.
Cortinarius subtortus (Pers.: Fr.) Fr.	*Russula heterophylla* (Fr.) Fr.
Dermocybe sanguinea (Wulf.: Fr.) Wünsche	*Tricholoma saponaceum* (Fr.) Kumm.
Gomphidius roseus (L.) Fr.	*Xerocomus chrysenteron* (Bull. ex St. Am.) Quél.
Litter-decomposing fungi	
Baeospora myosura (Fr.) Sing.	*Collybia peronata* (Bolt.: Fr.) Sing.
Ciboria amentacea (Balbis: Fr.) Fuck.	*Mycena vitilis* (Fr.) Quél.
Clitocybe dicolor (Pers.) Lge.	*Naucoria escharoides* (Fr.: Fr.) Kumm.
Clitocybe obsoleta (Batsch: Fr.) Quél.	*Rhodophyllus juncinus* Kühn. et Romagn.
Collybia cirrhata (Schum.: Fr.) Kumm.	*Stropharia aeruginosa* (Curt.: Fr.) Quél.
Lignicolous fungi	
Ascocoryne cylichnium (Tul.) Korf	*Peniophora incarnata* (Pers.: Fr.) P. Karst.
Cylindrobasidium evolvens (Fr.: Fr.) Jülich	*Peniophora pini* (Schleicher: Fr.) Boidin
Daedaleopsis confragosa (Bolt.: Fr.) Schroet.	*Pycnoporus cinnabarinus* (Jacq.: Fr.) P. Karst.
Heterobasidion annosum (Fr.) Bref.	*Stereum hirsutum* (Willd.: Fr.) S. F. Gray
Inonotus radiatus (Sow.: Fr.) P. Karst.	*Stereum sanguinolentum* (A. et S.: Fr.) Fr.
Mycena galericulata (Scop.: Fr.) S. F. Gray	*Trametes hirsuta* (Wulf.: Fr.) Pilát
Paxillus panuoides Fr.	

Table 5 presents fungi collected outside the plots, thus complementing the macromycetes picture of the reserve.

DISCUSSION

The area of the reserve, where archaeological excavations have been carried on for years, constitutes of good testing ground for investigating changes in a phytocoenosis and mycocoenosis caused by the disturbing of their given state.

As a result of the phytosociological investigations a separate, anthropogenic association of *Calluno-Genistetum*, which occurs in the excavation sites, was distinguished beside the overwhelming *Leucobryo-Pinetum*. In this way, a side by side existence of two associations that are distant in terms of phytosociological systematics, structure and species compositions, was determined.

Investigations carried on in these two communities prove that mycocoenoses, in contrast to phytocoenoses, display slight differences. This refers to all fungal groups, but is most important in the case of mycorrhizal fungi. They can condition the return of surrounding pine stand onto the excavation terrain in the course of secondary succession. Fungi developing on wood and other dead organic remnants are first of all connected with the substrate and occur in both associations. This makes it possible to conclude that fungi possess a wide ecological range, exceeding the limits of phytocoenoses.

Similarly, fungi display wider geographical scale than plants, hence mycological research data are of very limited importance in determining the geographical differentiation of an association, e.g. *Leucobryo-Pinetum* and *Peucedano-Pinetum*. The species composition and abundance proportions in ecological groups of fungi in the Kręgi Kamienne reserve are similar to those recorded by F r i e d r i c h (1994) in *Leucobryo-Pinetum* of the Cedynia Landscape Park, although the latter is much richer in fungi.

A comparison of fungi proved that the number of macromycetes species collected in the Kręgi Kamienne reserve is lower than in the simultaneously investigated reserves of Ustronie and Dolina Rzeki Brdy in the Bory Tucholskie. This refers to all groups of fungi, and most clearly to the lignicolous ones (Fig. 8).

The developmental possibilities of numerous fungi typical of the association of *Leucobryo-Pinetum* in the Kręgi Kamienne reserve are limited by the cultivation/maintenance measures of removed litter and dead wood. Separate research is necessary to estimate the impact of archaeological and touristic exploitation of the area on fungi. A respective investigation is the subject of a next project.

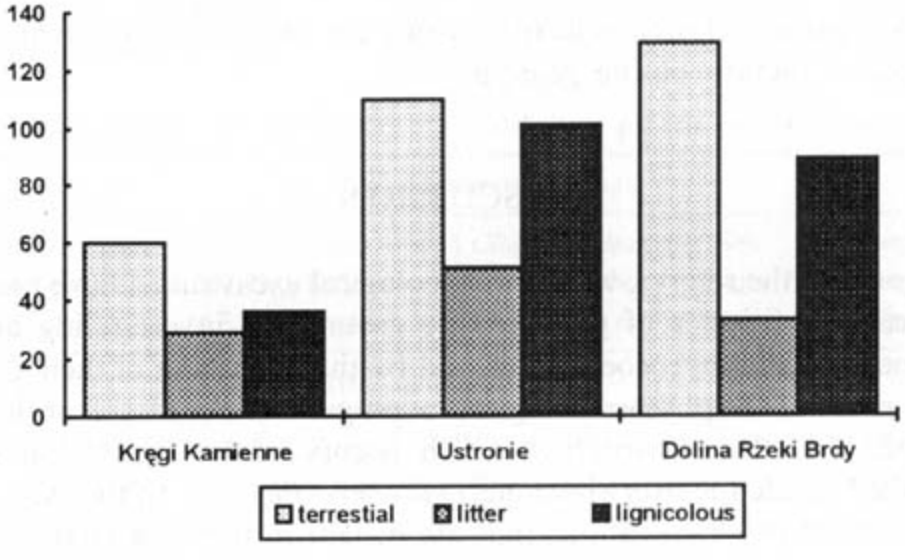

Fig. 8. Proportions of ecological groups in the three simultaneously investigated reserves

However, protecting of the area against accidental intrusion, and maintenance management contribute to sustaining the sites of several rare species, such as *Dacrymyces estonicus* Raitv. (W o j e w o d a 1976), hypogeous fungus of *Elaphomyces asperulus* Vitt. (Ł a w r y n o w i c z 1989), which is common in the reserve, or *Sparassis crispa*, which is protected by law, and several threatened species in Poland.

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Macromycetes rezerwatu przyrodniczo-archeologicznego Kręgi Kamienne w Borach Tucholskich

Streszczenie

W latach 1994 i 1995 przeprowadzono badania mikosocjologiczne na 4 stałych powierzchniach w rezerwacie obejmującym 16,9 ha. Teren rezerwatu pokrywa bór świeży *Leucobryo-Pinetum*. W części, gdzie prowadzone były wykopaliska wykształcił się antropogeniczny zespół *Calluno-Genistetum*. Z uwagi na turystyczne użytkowanie obiektu oraz prowadzone prace porządkowe zauważa się ograniczenie występowania niektórych grzybów, zwłaszcza gatunków nadrzewnych.

Występujące w rezerwacie gatunki naziemne stanowią żywą ekspozycję grzybów, które są często przedmiotem zainteresowania osób zwiedzających wykopaliska. Stwarza to dogodną sytuację do wykorzystania rezerwatu dla upowszechniania wiedzy o grzybach, czemu może służyć niniejsze opracowanie.