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Macromycetes of oak-hornbeam forests in the Białowieża National Park – monitoring studies

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Mycosociological observations were carried out between 1994 – 1996 on permanent plots within a *Tilio-Carpinetum* association in the Białowieża National Park. The project was carried out with international cooperation within the "Mycological monitoring in European oak forests" programme which was a result of multiple signals concerning the disappearance of oaks in our continent. Almost 40 years before mycosociological research in the same plant association and at the same plots were carried out. Studies were mainly concerned with analysing the terrestrial macromycetes, predominantly *Boletales* and *Agaricales*. They analysed the occurrence of saprotrophic and mycorrhizal fungi. Totaly 215 species from the above listed ecological groups, but there were only 34 species common to both studies. Dominating species within the mycorrhizal group were found.

Key words: mycological monitoring, disappearance of oaks, *Boletales*, *Agaricales*.

INTRODUCTION

In 1992, during a meeting of mycologists, a project was conceived to carry out a monitoring programme for some groups of fungi in Europe. The idea emerged during a discussion concerning the disappearance of oak trees in various countries, including Poland. Reasons for this decline were sought for among environmental conditions, amongst others the negative influence of parasitic fungi. Interference by so-called "terrestrial fungi" was also suggested, since their fruit-bodies are found near trees which constitute their mycorrhizal partners. And there are difficulty in carrying out respective studies. Trees take many years to grow, whereas fruit-bodies appear sporadically, although their mycelium develops and lives in the soil. The disappearance of oak trees has been observed for many years, but nothing indicated any association of this phenomenon with the species of macromycetes fruit-bodies found. Among them a group of fungi stands out, consisting of species that only attack weakened parts of plants and develop only on dead parts (twigs, leaves). This group includes some endophytic fungi, the presence of which cannot be detected in the infected over-ground organs that do not show any pathological changes (P r z y b y ł 1995). Hence the question emerged as to whether the perceived appearance of macromycetes fruit-bodies near oak trees can to some extent reflect the state of health of those economically important trees, or not.

Poland was among those countries that undertook the three-year long fungi monitoring programme. Our country, situated in the central part of Europe and covered in forests where *Quercus robur* is one of the most common forest tree species, was established as the north-eastern border of the study area. The Białowieża Forest, being the largest (62 500 ha) continuous forest complex with variously distributed mosaic of plant associations in Central Europe, was considered to be one of the most suitable study objects. Within the complex, which constitutes a relatively well-preserved monument of natural plant communities, a large fragment (5 346 ha) was established as a National Park with the characteristics of a nature reserve in 1921. The Park's value was recognised by the World Health Organisation which included it in the clean biosphere zone in 1977.

Several researchers penetrated the Park's area before it was established, studying its mycogeography by walking through it (B ł o ń s k i et al. 1888; B ł o ń s k i and D r y m m e r 1889). Between 1959 and 1978 more regular studies were carried out by Dominik, Domański (see S k i r g i e ł ł o 1988). The latter study was dominated by taxonomic issues. A new direction in mycology, fungi sociology, was reflected in by studies N e s p i a k studies (1955, 1959), who was the first to publish an extensive report of the results of his research in several plant associations within the Park.

Nespiak's study was, to a certain extent, continued by the CRYPTO programme, initiated by Faliński and carried out by a group of specialists. The aim of this undertaking was to survey cryptogamous plant communities in six main forest associations of the National Park, in the area of approximately 144 ha (F a l i ń s k i and M u ł e n k o 1992). Almost simultaneously, scientists undertook international cooperation within the mycological monitoring programme, in oak forests in several regions of Poland.

The monitoring programme required its participants to carry out stationary studies on permanent study plots within one association. In the face of reports coming from all over Europe, concerning the disappearance of oak trees, *Tilio-Carpinetum* Tracz. 1962 was selected since both those trees and mycorrhizal fungi can be found there. Polish mycologists designed the study in several forest complexes situated at distances from each other where this type of forest prevails. The Białowieża National Park, a large area, the most north-easterly situated of those in our country, was selected as one of them. Nespiak's first mycosociological observations were carried out there 40 years ago, which was another argument for such a choice. It should be expected that changes may have happened in the macromycetes community during such a long period.

METHODS

The study methods were very similar to those of Nespiak, which ensured the possibility of making comparisons. I was interested in observing changes that may have occurred in the macromycetes community in 40 years, in a forest where the oak had a large share, while Nespiak intended to investigate the diversity of fungi in various communities. Nespiak established his study plots (usually two) in each plant association. I established my study plots in two neighbouring forest divisions, at a distance of about 1.5 km apart. One of the plots was located in a subassociation *Tilio-Carpinetum typicum* (I) and the other in *Tilio-Carpinetum stachyetosum* (II). Collected specimens are preserved in the Herbarium of the University of Warsaw (WA).

I carried out my studies between 1994 and 1996 in divisions 370 and 399, which were the same ones that Nespiak penetrated. With difficulty I managed to find his old study plots (100 m^2). I established two (I and II) new, ten times larger (1000 m^2) plots there. I divided each plot into ten 100 m squares and I drew sketches of the location of trees and fallen logs (Fig. 1). Observations and material collecting were carried out 6 times during the vegetation period (May – October). Notes concerned the number of fruit-bodies in each square, the number of denoting each species and all comments concerning the ground. The fruit-bodies had to be big enough to be detected by the unaided eye (i.e. more than 1 mm). Therefore they included not only *Basidiomycetes*, but also some *Ascomycetes*. Nespiak, who was mainly interested in macromycetes carried out his observations in much the same way.

STUDY AREA

A comparison of the general picture of the plots from the old study and the present one doesn't show many differences. All plots are characterised by flat, even areas, they are dry and easily accessible throughout the vegetation period. Their soils can be described as brown forest soil on a bed of sand or boulder clay, with a pH of 4.59 (I) and 5.76 (II). Both plots differ slightly in their pH level; the former one being more acidic, with a lower

Table 1

Trees and shrubs on permanent plots (Jakubowska-Gabara 1996, part of Tab. 6)

Locality			Białowieża forest																					
Association			*Tilio Carpinetum* Tracz. 1962																					
Subassociation			*Tilio-Carpinetum typicum*							*Tilio-Carpinetum stachyetosum*														
Successive number			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	C		
Number of plot			I	I	I	I	I	I	I	I	I	I	II	II	II	II	II	II	II	II	II	II	o		
Number of releve			4	5	6	7	8	9	10	1	2	3	1	2	3	4	5	6	7	8	9	10	n		
Area of releve		m^2	100																				s		
Data			July 1996																				t		
Density of trees canopy	a_1	%	50	30	30	60	50	30	70	30	60	70	30	40	90	20	50	60	80	60	90	80	a		
	a_2	%	90	70	40	70	70	90	90	40	60	50	80	70	20	90	–	–	60	80	–	40	n		
Density of shrubs	b	%	20	–	10	20	40	30	–	10	30	30	10	5	10	5	50	60	20	–	10	5	c		
Cover of herb layer	c	%	40	80	80	70	60	50	40	90	80	70	80	90	80	80	90	80	80	80	90	90	y		
Cover of mosses	d	%	–	5	<5	<5	–	–	–	<5	5	–	–	<5	<5	5	5	<5	5	–	–	–			
																							1–7	8–20	1–20
Carpinus betulus	a_1		·	·	·	·	·	·	·	·	·	3	1	3	2	·	·	·	4	4	·	4	–	III	II
	a_2		5	4	3	3	4	5	5	·	3	3	4	·	2	5	·	·	2	·	·	·	V	III	IV
	b		2	·	2	·	3	3	·	1	3	2	·	·	·	·	·	·	·	·	·	·	III	II	II
	c		·	+	+	·	+	+	+	1	1	1	+	+	+	+	+	·	+	+	+	·	IV	IV	IV
Tilia cordata	a_1		·	·	·	·	·	·	·	·	2	2	·	1	4	·	·	·	·	·	5	·	–	II	II
	a_2		·	1	·	2	·	·	·	·	2	·	1	4	·	·	·	·	3	5	·	3	II	III	II
	b		·	·	·	·	2	+	·	1	·	·	2	+	1	1	3	3	2	·	1	1	II	IV	III
	c		·	·	·	·	+	+	·	+	+	·	1	+	·	+	+	+	+	+	+	+	II	V	IV

Quercus robur	a_1	3	2	1	3	2	1	3	·	·	2	2	·	·	·	·	·	·	·	·	2	V	I	III
	c	+	+	·	+	+	·	+	·	+	+	+	·	·	·	·	·	·	·	·	·	IV	I	II
Picea abies	a_1	·	·	2	·	·	1	2	2	·	·	·	·	·	·	·	·	·	·	·	·	III	I	I
	a	1	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I	–	I
	b	·	·	·	·	·	·	·	·	·	·	·	·	1	·	·	·	·	·	·	·	–	I	I
	c	+	+	+	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	III	I	II
Ulmus scabra	a_1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	3	3	·	·	·	·	–	I	I
	a_2	·	·	·	·	·	·	·	3	·	·	·	·	·	·	·	·	·	·	·	·	–	I	I
	b	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2	·	·	·	·	–	I	I
	c	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	+	+	+	+	–	III	II
Populus tremula	a_1	1	2	·	·	·	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	III	–	I
	c	+	1	+	+	+	+	+	·	·	·	·	·	·	·	·	·	·	·	·	+	V	–	I
Acer platanoides	a_1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2	·	·	–	I	I
	b	·	·	·	·	·	·	·	·	·	·	·	+	·	1	·	·	·	·	·	·	–	I	I
	c	·	·	·	·	·	·	·	+	+	+	1	·	+	·	+	+	+	1	1	1	–	V	III
Fraxinus excelsior	a_1	·	·	·	·	·	·	·	·	3	·	·	·	·	·	·	·	·	·	·	·	–	I	I
	c	·	·	·	·	·	·	·	+	·	·	·	·	+	+	·	·	+	·	:	·	–	II	I
Betula pendula	a_1	·	·	·	·	·	·	·	·	·	·	·	·	·	2	·	·	·	·	·	·	–	I	I
Sorbus aucuparia	c	+	+	+	+	+	+	+	+	+	+	·	·	·	·	·	·	·	·	·	·	V	II	III
Sambucus nigra	c	+	·	·	+	+	+	·	·	·	+	·	·	·	·	·	+	·	·	·	·	III	I	II
Rubus idaeus	c	·	+	+	+	+	1	·	1	1	+	·	·	·	·	·	·	·	·	·	·	IV	II	II
Rubus sp. div.	c	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	I	–	I
Viburnum opulus	c	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	–	I	I

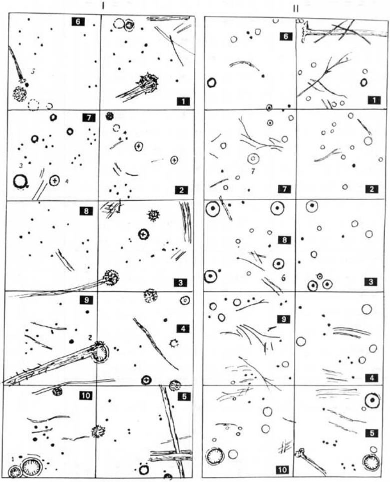

Fig. 1. Living and dead trees on the plots I and II: 1. *Quercus robur*, 2. *Picea abies*, 3. *Ulmus scabra*, 4. *Carpinus betulus*, 5. *Sorbus aucuparia*, 6. *Tilia cordata*, 7. *Acer platanoides*

pH than the latter. In his studies, Nespiak found a slightly wider range of pH values, i.e. from 4.8 to 6.5, which is slightly closer to the neutral level. The forest floor is covered by a thick layer of leaf litter. It is relatively thin under old oak trees and it is not covered by herbaceous vegetation or mosses. All types of dry-ground forests are dominated by hornbeam accompanied by oak, linden and spruce (Tab. 1). In this case the spruce doesn't enter the association.

Plot I

The relatively shady plot I includes 4 large oaks. Two of them are situated deep in its central part and the other, older (more than 200 years) two are on a bank of a small forest marsh which is partially situated within the plot (Fig. 1). During drier years its water table decreases and the surface is covered in duckweed, while rushes develop at its edge. The fifth oak tree, which is not considered here, is located just outside the plot. It is periodically flooded and infected with *Fomes fomentarius*.

The density of the canopy of oaks and young, although tall hornbeams, as well as the bushy undergrowth cause relatively high shading of the ground (30 – 70%). Oak seedlings are not numerous there. Herbaceous plants are mainly represented by *Anemone nemorosa*, *Oxalis acetosella* and *Maianthemum bifolium*. Several slightly decomposed logs and branches, as well as three humified spruce trunks, a decaying birch log and a fallen mountain ash, mouldy near its roots, complete the picture of the plot's arborescent vegetation.

Plot II

Plot II is more intensively green than plot I. It has a younger tree stand, more undergrowth, less thick, decaying logs, but more thin branches, more air current and light, as well as denser ground flora providing better conditions for fungi to thrive. The a1 layer contains less young, as well as old oak and hornbeam trees. The canopy is not so dense, which gives light more access to the ground than on plot I. The plot's location also has an influence on the light penetration. The plot is situated on the edge of the Białowieża Primeval Forest, close to an agricultural field which is not extensively used. Sun rays penetrate the trunk wall from this direction and the winds coming from the open area have an influence on drying the forest litter. Several mature maple and elm trees are situated right outside the plot. The a_2 layer includes quite a lot of young and little-branched lindens, particularly in the northern part of the square. The forest ground is much more densely covered by herbaceous vegetation than within plot I. *Impatiens nolitangere*, *Paris quadrifolia* and *Ranunculus lanuginosa* can be found there, while *Stellaria holostea*, *Galium odoratum*, *Oxalis acetosella* and *Urtica dioica* are everywhere. Forest animals, such as roe and red deer, as well as wild bores disturb the plots by turning over fallen branches and destroying the forest floor.

RESULTS AND DISCUSSION

Comparison of the collections

While working on the mycosociology of the Białowieża National Park Nespiak (1959) concentrated his studies on analysing species that have short-lived, fleshy fruit-bodies, mainly of the orders *Boletales* and *Agaricales*, since he was afraid of making mistakes resulting from repeating the collection. Therefore, there is no proper reference material concerning *Aphyllophorales* with perennial fruit-bodies which remain in the forest for a long time or the small *Discomycetes* and *Pyrenomycetes*.

Our comparisons of the species composition indicate that almost 3/4 of *Ascomycetes* found in the previous study occurred on plots I and II. All of them are saprotrophes. *Bisporella citrina* (abundance 5/frequency V) whose fruit-bodies locally occur in large numbers is worth noting, as well as *Xylaria longipes* (ab 4/fr III), frequently referred to as *X. polymorpha*. The former dominated in plot II (700 individuals in June) and the latter in May (113 individuals). Both these fungi had seasonal fruit-bodies that occurred in clusters. The randomly occurring *Laccaria laccata* and *Lactarius quietus* were also among dominating species in 1996.

Amongst the 29 representatives of *Aphyllophorales* there were four well known tree parasites – *Fomitopsis pinicola* that grows on spruce trees, as well as *Fomes fomentarius*, *Ganoderma lipsiense* and *Polyporus squamosus* which grow on deciduous trees. Other species, whose fruit-bodies were smaller and which occurred individually thrived on small, fallen and partially decayed twig fragments. Only *Schizopora paradoxa* occurred numerously on the moist twigs laying on the forest floor in 1995 when it stopped its competitors from developing. It was almost gone by the following year.

Within both of the studied divisions Nespiak found 109 species of fungi, while I found twice as many, i.e. 215 species (Tab. 2). I shortened my collection list largely by reducing the species which were not included in his analysis. The eventual list contained 175 names. This revealed a 5:1 ratio in favour of the years 1994–1996, since 34 species were considered common, i.e. found in Nespiak's studies as well as in the current one, 40 years later.

Table 2

Collected species with number of fruit-bodies found during the three-year researches (1994 – 1996)

Species	Number of fruit-bodies
1	2
Bisporella citrina (Batsch: Fr.) Korf et Carp.	2225
Stereum hirutum (Wilb.: Fr.) S. F. Gray	732
Mollisia cinerea (Batsch ex Mérat) Karst.	686
Dasyscyphus virgineus S. F. Gray	650
Xylaria longipes Nitschke	650
Armillaria mellea Fr. s.l.	478
Xylaria hypoxylon (L.: Fr.) S. F. Gray	289
Lactarius quietus Fr.	238
Collybia butyracea (Bull.: Fr.) Quél.	219
Crepidotus variabilis (Pers.: Fr.) Quél.	216
Kuehneromyces mutabilis (Schaeff.: Fr.) Sing. et Smith	200
Inonotus rheades (Pers.) Bond. et Sing.	186
Collybia peronata (Bolt.: Fr.) Sing.	168
Lycoperdon pyriforme Schaeff.: Pers.	157
Lycoperdon perlatum Pers.: Pers.	156
Paxillus involutus (Batsch) Fr.	151
Hypoxylon fragiforme (Pers.: Fr.) Kickx	139
Fomes fomentarius (L.: Fr.) Kickx	135
Schizopora paradoxa (Schrad.: Fr.) Donk	124
Hypholoma sublateritium (Pers.) Quél.	123
Dacrymyces stillatus Nees.: Fr.	111
Coprinus desseminatus (Pers.) S. F. Gray	110
Hypholoma subviride (Berk. et Curt.) Dennis	98
Fomitopsis pinicola (Sw.: Fr.) P. Karst.	94
Mycena filopes (Bull.) Kummer non ss. Ricken	94
Clitocybe clavipes (Pers.: Fr.) Kummer	86
Ganoderma lipsiense (Batsch) Atk.	85
Rickenella fibula (Fr.) Raith.	84
Laccaria laccata (Scop.: Fr.) Berk. et Br.	78
Lactarius mitissimus (Fr.) Fr.	76
Bjerkandera adusta (Willd.: Fr.) Karst.	75
Exidia plana (Wigg. ex Schlecht.) Donk	75
Mycena maculata Karst.	71
Mycena tintinnabulum (Fr.) Quél.	70
Rusula ochroleuca (Pers.) Fr.	67
Collybia confluens (Pers.: Fr.) Kummer	64
Lepista nuda (Bull.: Fr.) Cook	61
Mycena polygramma (Bull.: Fr.) S. F. Gray	58
Strobilurus esculentus (Wulf.: Fr.) Sing.	58
Mycena vitilis (Fr.) Quél.	56
Mollisia discolor (Mont.) Le Gal	55
Pluteus cervinus (Schaeff.: Fr.) Kummer	52
Lasiosphaeria ovina (Fr.) Ces. et de Not.	50
Mycena epipterygia (Scop.) S. F. Gray	46
Ascocoryne sarcoides (Jacq. ex S. F. Gray) Tul.	46

Tab. 2 cont.

1	2
Mycena praecox Vel.	40
Scleroderma verrucosum Pers.	40
Scleroderma citrinum Pers.	30
Leptoglossum acerosum (Fr.) Moser	30
Pluteus romellii (Britz.) Sacc.	26
Marasmius rotula (Scop.: Fr.) Fr.	25
Coprinus patouillardii Quél.	23
Mycena pura (Pers.) Kummer	21
Antrodia malicola (Bark. et Curt.) Donk	21
Hymenoscyphus fructigenus (Bull. ex Mérat) S. F. Gray	21
Creopus gelatinosus (Tode: Fr.) Link (= *Hypocrea*)	21
Calocera viscosa (Pers.: Fr.) Fr.	20
Tubaria pellucida (Bull.: Fr.) Gillet	19
Trichaptum abietinum (Pers.: Fr.) Ryv.	19
Clitopilus prunulus (Scop.: Fr.) Kummer	18
Xerocomus chrysenteron (Bull. ex St.-Amans) Quél.	18
Mycena polygramma (Bull.: Fr.) S. F. Gray	18
Clitocybe gibba (Pers.: Fr.) Kummer	18
Cystolepiota sistrata (Fr.) Sing. (= *Lepiota semniuda*)	18
Ustulina deusta (Fr.) Petrak	18
Merulius tremellosus Fr.	17
Mollisia melaleuca (Fr.) Sacc.	15
Calocera viscosa (Pers.: Fr.) Fr.	15
Collybia dryophila (Pers.: Fr.) Kummer	15
Lactarius flexuosus (Pers.: Fr.) Fr.	15
Mycena galericula (Scop.: Fr.) S. F. Gray	15
Leptoglossum acerosum (Fr.) Moser	14
Clitocybe fragrans (Sow.: Fr.) Kummer	14
Inocybe auricoma (Batsch) Fr.	14
Oudemansiella platyphylla (Pers.: Fr.) Moser	13
Mycena alcalina (Fr.) Kummer	13
Hygrophoropsis auriantiaca (Wulf.: Fr.) Maire	13
Mycena parabolica Fr.	13
Inocybe geophylla (Sow.: Fr.) Kummer	13
Hygrophorus camarophyllus (Alb. et Schw.: Fr.) Fr.	12
Psathyrella atomata (Fr.) Quél.	10
Psathyrella obtusata (Fr.) A. H. Smith	10
Cystoderma amianthinum (Scop.: Fr.) Fayod	10
Delicatula integrella (Pers.: Fr.) Fayod	10
Pluteus romellii (Britz.) Sacc.	10
Macrolepiota rachodes (Vill.) Sing.	9
Lactarius glyciosmus Fr.	9
Postia caesia (Schaeff.: Fr.) Karst.	9
Mycena zephirus (Fr.: Fr.) Kummer	9
Pluteus salicinus (Pers.: Fr.) Kummer	9
Lepista nebuularis (Fr.) Harmaja	9
Hemimycena cucullata (Pers.: Fr.) Sing.	8

Tab. 2 cont.

1	2
Coprinus patouillardii Quél.	7
Pholiota gummosa (Lasch) Sign.	7
Trametes pubescens (Schum.: Fr.) Pilát	7
Inocybe asterospora Quél.	7
Coprinus atramentarius (Bull.: Fr.) Fr.	7
Pluteus phlebophorus (Dittmar.: Fr.) Kummer	7
Mycena hiemalis (Osbeck.: Fr.) Quél.	7
Clavulina cristata (Fr.) Schroeter	6
Amanita citrina (Schaeff.) S. F. Gray	6
Laccaria amethystina (Bolt. ex Hooker) Murr.	6
Mycena aurantiomarginata (Fr.) Quél.	6
Tremella mesenterica Retz ex Hook	6
Phellinus igniarius (L.: Fr.) Quél.	6
Hymenochaete rubiginosa (Dickson: Fr.) Lév.	6
Entoloma sericeum (Bull. ex Mérat) Quél.	5
Macrolepiota procera (Scop.: Fr.) Sing.	5
Hypholoma fasciculare (Huds.: Fr.) Kummer	5
Cortinarius saniosus (Fr.) Fr.	5
Humaria hemisphaerica (Wiggers: Fr.) Fuckel	5
Pholiota squarrosa (Pers.: Fr.) Kummer	5
Coprinus lagopus Fr.	4
Psathyrella eonopilea (Fr.) Pears. ex Dennis	4
Stropharia albo-cyanea (Desm.) Quél. Fr.	4
Hebeloma sinapizans (Paulet: Fr.) Gillet	4
Paxillus panuoides Fr.	4
Hygrophorus pustulatus (Pers.: Fr.) Fr.	4
Conocybe tenera (Schaeff.: Fr.) Kummer	3
Mycena flavoalba (Fr.) Quél.	3
Pseudoclitocybe cyathiformis (Bull.: Fr.) Sing.	3
Russula fragilis (Pers.: Fr.) Fr. ss. Schaeff.	3
Scutellinia scutellata (L.: Fr.) Gillet	3
Psilocybe inquilina (Fr.: Fr.) Bres.	3
Xeromphalina campanella (Batsch: Fr.) Maire	3
Pholiota dealbata (Scop.: Fr.) Kummer	3
Conocybe cryptocystis (Atk.) Sing.	3
Coprinus stercoreus (Bull.) Fr. ss. K. et R.	3
Cortinarius delibutus Fr.	3
Mycena erubescens Hoehnel	3
Russula heterophylla (Fr.) Fr.	3
Tubaria furfuracea (Pers.: Fr.) Gillet	3
Psathyrella gracilis (Fr.) Quél.	3
Crepidotus sphaerosporus (Pat.) Lge	3
Galerina triscopa (Fr.) Kühn.	3
Russula versicolor Schaeff.	3
Conocybe tenera (Schaeff.: Fr.) Kummer	3
Mycena flavoalba (Fr.) Quél.	3
Pluteus pellitus (Pers.: Fr.) Kummer	3

Tab. 2 cont.

1	2
Hebeloma crustuliniformis (Bull. ex St.-Amans) Quél.	2
Psathyrella orbitarum (Romagn.) Moser	2
Xylobolus frustulatus (Pers.: Fr.) Boidin	2
Mycena viridimarginata (Karst.)	2
Mycena mucor (Batsch: Fr.) Gillet	2
Pholiotina aporos (K. v. W.) Clç. (= *togularis* ss. Lge.)	2
Pholiota tuberculosa (Schaeff.: Fr.) Kummer	2
Tricholoma populinum Lge.	2
Polyporus ciliatus Fr.: Fr.	2
Polyporus squamosus Huds.: Fr.	2
Polyporus varius Pers.: Fr.	2
Agrocybe praecox (Pers.: Fr.) Fayod	2
Clitopilus prunulus (Scop.: Fr.) Kummer	2
Coprinus ephemerus (Bull.: Fr.) Fr.	2
Entoloma nidorosum (Fr.) Quél.	2
Gyroporus castaneus (Bull.: Fr.) Quél.	2
Hemimycena cucullata (Pers.: Fr.) Sing.	2
Hypholoma capnoides (Fr.) Kummer	2
Mycena stylobates (Pers.: Fr.) Kummer	2
Panellus stypticus (Bull.: Fr.) Kummer	2
Rickenella setipes (Fr.) Raith.	2
Stropharia semiglobata (Batsch.: Fr.) Quél.	2
Amanita phalloides (Vaill.: Fr.) Secr.	2
Amanita vaginata (Bull.: Fr.) Quél.	2
Tricholomopsis rutilans (Schaeff.: Fr.) Sing.	2
Entoloma sericellum (Bull.: Fr.) Kummer	2
Pholiotina filaris (Fr.) Sing.	2
Mycena vitilis (Fr.) Quél.	2
Galerina badipes (Fr.) Kühn.	2
Marasmiellus vaillantii (Pers.: Fr.) Sing.	2
Boletus edulis Fr.	1
Clitocybe cerussata (Fr.) Kummer	1
Entoloma clypeatum (L.: Fr.) Kummer	1
Entoloma mougeotii (Quél.) Hesler	1
Entoloma sinuatum (Bull.: Fr.) Kummer	1
Entoloma subradiatum Kühn. et Romagn.	1
Entoloma rhodocylix (Lasch.: Fr.) Moser	1
Hebeloma pumilum Lge	1
Hyphoderma puberum (Fr.) Wallr. (= *Peniophora*)	1
Cystoderma carcharias (Pers.: Secr.) Fayod	1
Cystoderma granulosum (Batsch: Fr.) Kummer	1
Oudemansiella radicata (Relh.: Fr.) Sing.	1
Leptopodia atra (König: Fr.) Boud.	1
Coprinus micaceus (Bull.: Fr.) Fr.	1
Amanita fulva Schaeff.: Pers.	1
Galerina laevis (Pers.) Sing.	1
Galerina unicolor (Fr.) Sing.	1

Tab. 2 cont.

1	2
Mycena corticola (Pers.: Fr.) Quél.	1
Hyphoderma radula (Fr.: Fr.) Donk	1
Lactarius blennius Fr.	1
Peziza varia (Hedw.) Fr.	1
Pholiota destruens (Brond.) Quél.	1
Pluteus atrotomentosus (Konr.) Kühn.	1
Russula alutacea (Pers.: Fr.) Fr.	1
Russula pectinata Fr.	1
Russula vitellina (Pers.) Fr.	1
Simocybe centunculus (Fr.) Sign.	1
Steccherinum ochraceum (Pers.: Fr.) S. F. Gray	1
Mycena speira (Fr.: Fr.) Gillet	1
Cortinarius privignus Fr.	1
Lactarius piperatus (L.: Fr.) S. F. Gray	1
Tricholoma sulphureum (Bull.: Fr.) Kummer	1
Mycena amygdalina (Pers.) Sign. (=*filopes*)	1
Pholiota lucifera (Lasch) Quél.	1
Inocybe asterophora Quél.	1
Mycena pelianthina (Fr.) Quél.	1
Tyromyces lowei (Pilát) Jülich	1
Tyromyces kymatodes (Rost. s. Bourd. et G.) Donk	1
Mycena rubromarginata (Fr.) Kummer	1
Pleurotellus chioneus (Pers.: Fr.) Kühn.	1
Pluteus ephebeus (Pers.: Fr.) Quél.	1
Russula delica Fr.	1
Russula emetica Fr.	1
Pycnoporellus fulgens (Fr.) Donk	1
Polyporus badius (Pers.: S. F. Gray) Schw.	1
Entomola juncinum (Kühn. et Romagn.) Noord.	1

Colonisation

The tree stand on both plots, I and II, was rather healthy, judging by the state of the trees which were in a good condition. Therefore it is not surprising that there were not many fallen branches, although there were some fallen trees, logs and trunks of different ages. However, the fully mature mountain ash tree which fell in summer of 1996 on plot I displayed its illness. Its smooth trunk showed brown rot near its roots. Old spruces, broken half way through their height or lower, were infested by *Fomitopsis pinicola.* Its fruit-bodies were formed quite high and the fungus grew through old logs that lay on the forest floor up to half of their height in a long, horizontal band. The close contact with the ground, mosses which colonised the logs rapidly, as well as shade (the bands occurred on the northern face) assured a moisture level suitable for the mycelium. An association of mosses emerged there which provided an ecological niche for the development of small, saprotrophic fruit-bodies of *Agaricales* (e.g. *Mycena*).

Two fungi with well-formed fruit-bodies, *Fomes fomentarius* and *Ganoderma applanatum*, thrived on similar substrates, i.e. deciduous tree wood in an advanced stage of decay. These two parasites, which cause rapid decomposition of wood, are largely responsible for fallen and broken trees and branches and they live as saprotrophes for a long time after the host is dead. *Pycnoporus fulgens* and *Inonotus rheades* appeared in spring and summer for a one-year period. Other *Aphyllophorales* species with small fruit-bodies occurring individually or in small, overlapping clutches, as well as some sac fungi, such as *Xylaria longipes* thrived on thin, but still firm twigs or humifying logs.

One of *Agaricales*, *Armillaria mellea*, a well-known forest parasitic fungus which qualifies here as a saprotroph, was found only twice in rather small quantities (less than 15 individuals) and always on the ground.

Multifructificating fungi with fleshy fruit-bodies, including *Armillaria mellea* are so-called terrestrial species. However, they can find suitable substrates on decaying timber found in the forest. Since the partially rotten wood is usually covered by ground flora or is shaded, it provides good conditions for the fungi to thrive. Amongst those species the cold-resistant *Kuehneromyces mutabilis* can always be found in autumn, while *Hypholoma fasciculare* is considered a dominating species in early and full autumn (Lisiewska and Celka 1995). They were both not found by Nespiak. Both in his studies and on plots I and II *Pluteus romellii* and *P. cervinus* were commonly found. Also *Strobilurus esculentus* was found everywhere on spruce cones buried in the ground in both of our studies.

The actual terrestrial macromycetes are found on the ground, but their mycelia develop in deeper layers of soil, where its moisture is high enough to allow for the production of large fruit-bodies. Mycelia forming fruit-bodies develop less deeply, closer to the surface of the ground which is frequently covered by fallen leaves. In order for the fruit-bodies to develop, the moisture (sufficient rainfall) of the soil and air is not the only necessary factor. The process also requires suitable temperature and proper light, which, however, cannot be full sunlight. Some such fungi produce rhizomorphic strands or rhizomorphs (e.g. *Marasmius rotula* or *Lycoperdon pyriforme*) which penetrate the substrate and are found on all plots. Also a small group of coprophilous fungi can be found. Since they depend on a quickly drying substrate (roe deer and wild boar droppings) they do not last for long and hence they can be called ephemerids.

The occurrence of other coprophilous fungi of the *Coprinus* genus could be expected due to the proximity of the agricultural field. However, the dense protection zone of the Park doesn't let their spores spread. Also worth noting is the lack of species that prefer open areas and cope with direct sunlight or shading by small herbs (e.g. of the genus *Hygrocybe*). Also other species that could have got here from other divisions where various associations of vascular plants dominate are not found here.

Mycelia of species that form larger fruit-bodies spread in the humus-rich soil easily and widely. Hyphae of some fungi penetrate the substrate and establish symbiotic contacts mainly with roots of trees. These are the so-called mycorrhizal fungi. In numerous papers they are described as summer and autumn terrestrial fungi which produce large fruit-bodies sought for by mycophages. They live together with coniferous and deciduous trees alike.

Mycorrhizal species

While analysing the collection list it appeared that there were 39 species in common. They occur on plots I and II and they were also recorded earlier by Nespiak. The list includes all common mycorrhizal species. Only at this stage apparent differences between our collections were revealed. Nespiak found 16 species of those listed in Table 3, of which only 6 were found again. Almost 40 years later there were twice as many of those species found on plots I and II, including the 6 that were found again. The proportion 2:1 was sustained, similarly as in the case of the general number of all fungi listed.

Table 3
Comparison of numbers of species within ecological groups

Groups \ Plots	1994 (I + II)	1995 I	1995 II	1996 I	1996 II
Mycorrhizal	16	14	20	14	12
Saprotrophes	66	83	70	58	56
Parasites	4	3	3	4	6
Total	86	100	93	76	74

Table 4
Differences between the previous and current collections

	1994 – 1996 collection	Common	Nespiak (1959) collection
Boletales	5	1	1
Russulales	17	1	4
Sclerodermatales	2	–	–
Agaricales	23	4	11
Total	37	6	16

As it can be seen, in this case general ecological factors influence both saprotrophs and mycorrizal fungi in the same degree. K a l a m e e s (1980) gives similar results from Estonia. He states that mycobionts are the group of *Agaricales* that is the richest in trophic species, including as many as 39% of all the groups found in that country.

Mycobionts react to water shortages much less than common saprotrophs. Having established connections with the roots of their co-symbionts they obtain the moisture necessary to survive. Their fruit-bodies reduce their growth rate, their hyphae loose their elasticity, their caps wind up and present the hymenophores. However, as soon as rains start the fungi quickly return to their previous shape. The smaller the fruit-bodies the sooner they regain their normal shape (e.g. *Laccaria laccata*). An important part is played by the surroundings, which are small ground plants. They also encounter potential competitors for symbiotic partners of the same type. They can also differ in the period of forming fruit-bodies during a season or during vegetation periods.

The differences in the rhythm of fructification of some species of terrestrial fungi observed (G u m i ń s k a 1991/1992). The pic fructification occurred in the second part of September 1996 year or in the first part of October.

Within the mycorrhizal fungi group on my both plots three species are worth noting, which occur most often and for longest periods. These species are:
Lactarius quietus (fr. 14/2),
Laccaria laccata (fr. 15/2)
as well as one that gives the studied area a real character
Paxillus involutus (fr. 8/2).

Xerocomus chrysenteron (fr. 13/2), which forms symbiotic links with deciduous trees, mainly not very old hornbeam, is represented less richly. All of them were found near oaks. K a l a m e e s ' e s (1980) opinion is also worth mentioning. He considers *Laccaria laccata* a facultatively mycorrhizal species.

Fruiting intensity and weather conditions

The influence of periodic moisture conditions on the fruiting of the fungi found also has to be discussed. *Lactarius quietus* and *Laccaria laccata* were the mycorrhizal dominants in 1996. Amongst saprotrophic species *Bisporella citrina* dominated. It occurred in large numbers and in clusters (503 individuals on plot I and 138 individuals on plot II). During the first period of my studies there was a long drought in Poland during summer months. It stopped the development of macromycetes almost completely. They started appearing in the eastern part of the country after small rains (on August 30th I only found 15 species). Despite some rains in September, the forest floor was not water soaked properly and it remained dry. In October, the just starting development of fruit-bodies was halted by frost that arrived too early ($-3°C$ on October 19th). The second study period was characterised by a long and cold spring and the fruit-bodies appeared rapidly after a warm storm in May. The situation was similar in 1996, but drought and rain periods were spread differently, which influenced the timing of fungi appearance.

SUMMARY AND CONCLUSIONS

1. The fungi of the Białowieża Forest, the National Park in particular, have not been analysed in terms of their trophy so far. Only Nespiak (1959) carried out a large-scale study concerning fungi on 100 m^2 plots in six different plant associations.
2. During the 40 years the composition of vascular plants did not change significantly.
3. This work's aim was to compare possible changes in macromycetes occurring in the forest in the same plant associations in which Nespiak worked, as well as to carry out a similar study but on larger plots (1000 m^2) and only in one association, *Tilio-Carpinetum*.
4. Altogether, Nespiak found 109 species on his plots (here treated as one), while I found 215, i.e. almost twice as many. Such big a difference may be a result of climatic conditions in the seasons that the fungi were collected, the size of the plots and the mycelium's adjustment to the fruiting time.
5. Due to the way Nespiak treated the subject, who mainly concentrated on *Agaricales* producing large fruit-bodies, I also limited my collection list and analysis to the representatives of this order, in order to make comparisons easier. Nespiak's list "adjusted" in such way included 175 species. It revealed a 5 : 1 ratio in favour of the present time, since 34 species were common for Nespiak and for me. This fact suggested that there is certain stability in the macromycetes group in *Tilio-Carpinetum* in the Białowieża National Park.
6. Saprotrophs occurred evenly. In all the plots (Nespiak's, I and II) they included *Pluteus cervinus*, *P. romellii* and *Strobilurus esculentus* (due to the presence of buried spruce cones), *Marasmius rotula*, *Lycoperdon pyriforme*. There were almost none coprophilous, ephemeric *Coprinus* species. Also species that prefer open areas did not occur.
7. Each plot revealed the presence of the same 4 parasites.
8. Thirty two species of mycorrhizal fungi were found on each plot (I and II), which, in comparison to saprotrophs, amounted 21.1% (I) and 20.4% (II).

9. The new study plots were 10 times larger and relatively more fungi were collected there.
10. The September – October period was the richest in terms of species diversity, since the forest provided enough warmth then. During all the visits *Lactarius quietus* and *Paxillus involutus* were found. These fungi, as well as *Laccaria laccata* appeared the earliest and lasted the longest. It seems strange that Nespiak did not ever encounter the strongly oak-connected *Lactarius quietus*, which he did find in other divisions.
11. Most saprotrophes on I and II plots are not, as it seems, connected with herbaceous plants that grow there. They were found in different periods as single, dispersed individuals. Only the occurrence of *Strobilurus esculentus* depended on fallen cones of an old spruce.
12. Most unfavourable conditions that halted the development of mycelia of small saprotrophs were created by a long-lasting drought. Mycorrhizobionts with large fruit-bodies managed to adjust to it properly by benefiting from their symbiotic partners.
13. Due to the high diversity of species that require different conditions we still have certain doubts. Finding five times more species, including only 34 common species out of 131, after 40 years indicates the necessity of further penetration of *Tilio-Carpinetum* patches in the Białowieża National Park.
14. The three-year study period is too short for monitoring fungi due to, for example, changing climatic conditions.

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Macromycetes Białowieskiego Parku Narodowego – studia monitoringowe

S t r e s z c z e n i e

Obserwacje mikologiczne prowadzono w latach 1994–1996 na dwóch stałych powierzchniach w *Tilio-Carpinetum* na terenie Białowieskiego Parku Narodowego. Projekt realizowany był przy międzynarodowej współpracy w ramach programu „Mycological monitoring in European oak forests" w odpowiedzi na sygnały o zagrożeniu dębów na naszym kontynencie. Blisko 40 lat temu Andrzej Nespiak prowadził mikosocjologiczne badania w tym samym zespole, na tych samych powierzchniach. Badania koncentrowały się na grzybach naziemnych, głównie *Boletales* i *Agaricales*, gatunkach mikoryzowych i saprotroficznych. Zebrano łącznie 215 gatunków, ale tylko 34 były wspólne w badaniach obojga autorów. Wykazano gatunki dominujące w grupie grzybów mikoryzowych.