ACTA SOCIETATIS
BOTANICORUM POLONIAE
vol. XXXVI — nr 3
1967

Further investigations on the relationship between soil fungi and the macroflora

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INTRODUCTION

Numerous investigations prove unequivocally that there exists a positive correlation between the number of fungi occurring in the given habitat and the ecological conditions. According to W.G.E. Eggleton (1934), M. Witkamp and J. van der Drift (1961) and A. Burges and D. P. Nichelson (1962) mycological associations and their activities are controlled by the temperature and moisture of the soil as well as by the amount of available organic matter. There exists also a negative correlation between the number of isolated fungi and the depth of the soil sampled for mycological analysis (M. J. Timonin 1935; H. Krzemieniewska and L. Badura 1954; L. Badura 1960).

In so far as the relationship between ecological conditions and the number of fungi is concerned, the controlling effect of ecological conditions can be shown, but the dependence of myco-associations on the associations of higher plants is very little known. This problem has been dealt with by B. Peyronel and G. dal Vesco (1955) and by A. E. Apinis (1960, 1964). The former authors investigated the occurrence of soil fungi in cultivated soils in order to find a relationship between the mycoflora and cultivated plants. The latter attempted to establish a relation between the soil fungi and the associations of higher plants on various alluvial soils. The above investigations permitted to state that a relationship does exist. The question arises, however, whether the occurrence of soil fungi is conditioned by the ecological factors of the habitat, or by the organic substrate derived from the associations of higher plants. This problem has attracted the attention of L. Badura (1964) who by means of diagrams made according to B. Peyronel's method (1955, 1956) showed that there exists an analogy in the percentage of individual fungal groups occurring in beech forests, differing with the ecological conditions. In view of the above results L. Badura (1964) assumed that the dominance of strictly determined groups of fungi is conditioned by the litter because of its trophic character. Since the chemical composition varies with the litter, different groups of fungi will be more or less priviledged.

The purpose of the present paper was to obtain further information on the relations between the mycoflora and the vegetal cover.

DESCRIPTION OF TERRAIN

Mycological research was conducted in the reserve „Kamień Śląski", district Krapkowice, province Opole. The reserve measuring 10.7 ha was set up in 1958 because of the specimens of *Sorbus torminalis* (L.) Krantz growing within that region. The floristic community of that species has been qualified as the *Melico-Fagetum* association (A. Krawiecowa and L. Kuczyńska 1968). This classification was based upon ligneous and herbaceous plants constituting the vegetal cover, Of the ligneous plants the most common are: *Fagus silvatica* L. and *Carpinus betulus* L. There are, moreover, the following

Ligneous plants	Herbaceous plants
Quercus sessilis Ehr.	*Melica uniflora* Retz.
Quercus robur L.	*Dentaria bulbifera* L.
Picea excelsa Link	*Festuca silvatica* Vill.
Pinus silvestris L.	*Elymus europaeus* L.
Acer pseudoplatanus L.	*Neottia nidusavis* L.
Sorbus aucuparia L.	*Asarum europaeum* L.
Larix decidua Müll.	*Galeobdolon luteum* Huds.
	Sanicula europaea L.

This community situated on the ridge of triassic limestone is characterized (Greszta and Kwiatkowska 1962) by very bad water conditions. The waters coming from precipitation (average annual precipitation for Opole and Prószków, according to the data obtained from the nearest meteorological stations, amount to 671 mm and 637 mm, respectively) run off quickly down the crevices. Consequently, the soils (group of fairly deep or deep alikaline marly soils) are dry. The climate of the reserve can be classed to the climatic region of submontane lowlands and basins. More detailed ecological data can be found in the paper by Wachowska-Serwatka (1968).

METHODS

In the reserve "Kamień Śląski" the sampling site was chosen so that the litter consisted chiefly of beech leaves, but the leaves and needles of other trees could also be found. Consequently, besides beech leaves, the layer L contained also oak and service leaves and the pine and spruce needles. Samples for mycological research were taken from three layers. The first layer (F, I) consisted of the decaying organic matter with a slight addition of humus (dry leaves being first removed). The second dark-stained layer ($H+A_1$, II) was defined as humus layer, while the third one (A_2, III) was a mineral horizon. The samples were taken four times, i.e. in autumn, winter, spring and summer in the years 1965 and 1966.

Data concerning the temperature, soil moisture, organic matter content and pH on the days of sampling are given in Table 1.

Table 1

Data on moitsure, organic matter, pH and temperature on day of sampling

Season	Layer	Moisture %	Org. matter %	pH	Air temp. at 1 m altitude	Soil temp. at 10 cm depth
Autumn	F (I)	54.97	61.46	7.3	18°C	14°C
	$H+A_1$ (II)	27.07	15.96	7.4		
	A_2 (III)	5.70	1.87	6.9		
Winter	F (I)	50.57	72.28	6.8	2°C	3°C
	$H+A_1$ (II)	27.49	16.72	6.8		
	A_2 (III)	12.73	4.87	5.8		
Spring	F (I)	66.51	69.10	6.5	13°C	9°C
	$H+A_1$ (II)	27.49	21.16	7.2		
	A_2 (III)	11.96	2.20	7.1		
Summer	F (I)	55.96	71.31	5.8	16°C	13°C
	$H+A_1$ (II)	38.72	28.12	6.0		
	A_2 (III)	9.88	4.90	6.8		

The soil samples were plated (in five replications) by Winogradsky's method on Petri dishes containing Czapek's, Waksman's and cellulose media. The authors used also the method described by H. Krzemieniewska and L. Badura (1954). The plating done by the latter method was repeated only twice. The appearing species were identified, either immediately or (if this was impossible) after obtaining pure cultures, on the basis of the monographs quoted in the References. The obtained results are given in Table 2.

RESULTS

The number of species isolated from all soil samples amounted to 162. The isolated fungi belonged to different systematic groups. The representatives found within separate classes are given in the decreasing order of their incidence:

I. *Fungi Imperfecti* — 64 species
   Moniliaceae — 37 species
   Dematiaceae — 20
   Stilbaceae and *Tuberculariaceae* — 6 species
   Sphaeropsidales — 1 species.

II. *Phycomycetes* — 55 species
   Mucor gen. — 18 species
   Mortierella gen. — 14 species
   The remaining genera were represented by a very small number of species.

III. *Ascomycetes* — 43 species
   To this class the authors have included such genera as *Penicillium* and *Aspergillus* which, according to other authors, belong to *Fungi Imperfecti*. Within this

Table 2

Seasonal occurernce of microfungi and their distribution in the soil profiles in the *Melico-Fagetum* from "Kamień Śląski" reserve

Seasons	autumn			winter			spring			summer		
Layer / Fungi recorded	I	II	III	I	II	III	I	II	III	I	II	III
1	2	3	4	5	6	7	8	9	10	11	12	13
PHYCOMYCETES *MUCORALES*												
Absidia glauca Hag.	+	+	+	+	+	+	+	+	+	+	+	+
A. lichtheimii (Luc. et Cost.) Lend.	—	—	—	—	—	—	—	—	—	+	—	—
A. spinosa Lend.	+	+	+	—	+	+	+	+	+	+	+	+
Actinomucor repens Schost.	+	—	—	—	—	—	—	—	—	—	—	—
Basidiobolus ranarum Eidam	—	—	—	—	—	—	+	+	+	—	—	—
Coemanisa erecta Bain.	+	+	+	—	+	+	—	+	+	—	+	+
C. pectinata (Coem.) Bain.	+	+	—	+	+	+	+	+	+	+	+	+
Cunninghamella albida (Sacc.) Matr.	—	—	—	—	—	—	—	—	—	—	+	—
C. elegans Lend.	+	+	—	—	—	—	—	—	—	—	—	—
Haplosporangium decipiens Thaxt.	—	—	—	—	—	—	—	+	+	—	—	—
Mortierella alpina Peyronel	+	—	—	—	—	—	—	—	+	—	—	—
M. bainieri Cost.	+	+	+	+	+	+	+	+	+	+	+	+
M. candelabrum v. Tiegh. et Le Mon.	—	—	—	+	+	—	—	+	—	—	—	—
M. canina Dauph.	—	—	—	—	—	—	—	—	—	+	+	—
M. elongata Linnm.	—	—	—	—	—	—	+	—	+	—	+	—
M. exigua Linnm.	+	—	—	—	—	—	+	—	+	—	—	—
M. gracilis Linnm.	—	—	—	—	—	—	—	—	+	—	—	—
M. isabellina (Oudem.) Zycha	—	—	—	—	—	—	+	—	—	—	—	—
M. polycephala Coem.	+	—	—	—	+	—	—	—	—	—	+	—
M. pusilla Oudem.	+	—	—	—	—	—	+	+	—	+	—	—
M. ramanniana (Moeller) Linnm.	+	—	—	+	—	+	+	+	—	+	+	—
M. stylospora Dix.-St.	—	—	—	—	—	—	—	+	+	—	—	+
M. vinacea Dix.-St.	+	—	+	—	—	—	—	—	—	—	—	—
Mortierella sp.	—	—	—	—	—	—	+	—	—	—	—	—
Mucor adventitius Oudem	—	—	—	—	—	—	—	—	—	+	—	—
M. albo-ater Naum.	—	—	—	+	—	—	—	—	—	—	—	—
M. corticolus Hag.	—	+	+	+	—	—	+	+	+	+	+	—
M. fragilis Bain.	+	+	+	—	—	—	—	—	—	+	—	—
M. griseo-cyanus Hag.	—	+	—	—	—	—	+	—	—	—	—	—
M. griseo-lilacinus Pov.	—	—	—	—	—	—	—	—	—	—	+	—
M. griseo-ochraceus Naum.	—	—	—	—	—	—	—	—	—	—	+	—
M. hiemalis Wehm.	+	++		+	+	+	+	+	+	+	+	+
M. lamprosporus Lend.	—	—	—	—	+	—	—	—	—	—	—	—
M. microsporus Naum.	—	—	—	+	+	—	—	—	—	—	—	—
M. mucedo (L.) Fres.	—	—	—	+	—	—	—	—	—	—	—	—
M. piriformis Fischer	—	—	—	+	—	—	—	—	—	—	+	—
M. racemosus Fres.	—	—	+	—	—	—	—	+	—	—	—	—
M. silvaticus Hag.	—	+	—	+	—	—	+	—	—	+	+	—
M. spinosus v. Tiegh.	+	+	—	+	+	—	+	—	—	+	+	+
M. strictus Hag.	+	—	—	+	—	+	+	+	—	+	+	—
M. subtilissimus Oudem.	—	—	—	—	—	—	+	—	—	—	—	—

1	2	3	4	5	6	7	8	9	10	11	12	13
M. varians Pov.	—	+	—	—	—	—	—	—	—	+	—	—
Piptocephalis cylindrospora Bain.	+	+	—	+	+	—	+	+	+	+	+	—
P. dichotomica Krzem. et Bad.	—	—	—	—	—	—	—	+	—	—	—	—
P. fusispora v. Tiegh.	+	+	—	—	—	—	+	+	—	+	+	—
Rhizopus nigricans Ehrenb.	—	—	—	—	—	—	+	—	—	+	—	—
Rh. nigricans Ehrenb. var. *minor*	—	—	—	—	—	+	—	—	—	—	—	—
Rhopalomyces coronata Krzem. et Bad.	+	—	—	+	+	—	+	+	—	+	+	—
Syncephalis cordata v. Tiegh. et Le Mon.	+	—	—	—	—	—	—	+	—	—	—	—
S. depressa v. Tiegh. et Le Mon.	+	+	—	—	+	+	+	+	—	+	+	+
S. sphaerica v. Tiegh.	+	—	—	—	—	—	+	+	+	+	+	+
S. tenuis Thaxt.	—	—	—	+	+	—	+	+	+	—	—	+
Zygorhynchus moelleri Vuill.	—	—	+	—	—	+	—	—	+	—	—	—
Z. vuilleminii Namysl.	—	—	—	—	—	—	—	+	+	—	—	+
Thamniduim sp.	+	+	—	+	+	—	+	+	+	+	+	+
ASCOMYCETES												
PLECTASCALES												
Gymnoascaceae												
Arachniotus aureus (Eidam) Schröt.	+	—	—	—	—	—	—	—	—	—	—	—
Eidamella sp.	—	—	—	—	—	—	—	+	—	—	—	—
Gymnoascus reesii Baranetzky	—	+	+	—	—	—	—	—	—	—	+	—
Microascus sordidus Zukal	+	—	—	—	—	—	—	—	—	—	—	—
Perisporiaceae												
Preussia funiculata (Preuss) Fckl.	+	—	—	+	—	—	+	—	—	—	—	—
Aspergillaceae	—	—	+	—	—	—	—	—	—	—	—	—
Aspergillus fumigatus Fres.												
A. versicolor (Vuill.) Tiraboschi	—	—	+	—	—	—	—	—	—	—	—	—
Penicilliaceae												
Penicillium brevi-compactum Dierckx	—	—	—	+	—	—	—	+	—	—	—	—
P. citrinum Thom	—	—	—	—	—	—	—	—	+	—	—	—
P. cyclopium West.	—	—	—	—	+	—	—	—	—	—	—	—
P. daleae Zaleski	—	—	—	—	—	—	—	+	—	—	—	—
P. frequentans West.	—	—	+	+	—	—	+	—	+	—	—	—
P. godlewskii Zaleski	—	—	+	—	—	—	—	—	—	—	—	—
P. lanosum West.	—	—	+	—	—	—	—	—	—	—	—	—
P. nigricans (Bain.) Thom	+	+	+	+	+	+	+	+	+	+	+	+
P. notatum West.	—	—	+	+	—	—	—	+	—	—	—	—
P. purpurogenum Stoll	—	—	—	—	—	—	—	+	—	—	—	—
P. rubrum Stoll	+	—	—	—	—	—	—	—	—	—	—	—
P. verruculosum Peyronel	+	—	—	—	—	—	—	—	—	—	—	—
SPHAERIALES												
Chaetoceratostoma hispidum Turconi et Maffei	—	+	—	—	+	—	—	+	+	—	+	+
Ch. longicolleum (Krzem. et Bad.) Bad.	—	+	—	—	+	+	—	—	—	—	—	—

1	2	3	4	5	6	7	8	9	10	11	12	13
Chaetomium bostrychodes Zopf	+	—	—	—	—	—	—	—	—	—	—	—
Ch. crispatum Fuckel	+	+	—	+	+	+	+	+	+	+	+	+
Ch. elatum Kunze	—	—	—	—	—	—	—	—	—	—	+	—
Ch. globosum Kunze	—	—	+	—	—	—	—	—	—	—	+	—
Ch. homopilatum Omvik	—	+	—	—	—	—	—	—	—	—	—	—
Ch. seminudum Ames	+	+	+	—	+	+	+	+	+		—	—
Ch. sphaerale Chivers	+	+	+	—	—	—	—	—	—	—	—	—
Ch. spirale Zopf	+	—	—	—	—	—	—	+	—	+	—	—
Ch. torulosum Bain.	—	—	—	—	—	—	—	—	—	—	+	—
Pleurage curvicolla (Win.) Kuntze	—	+	—	—	—	—	—	+	—	—	—	—
P. curvula (de Bary) Kuntze	—	—	—	—	—	—	+	—	—	—	—	—
P. minuta (Fuck.) Kuntze for. *tetraspora*	+	—	—	+	+	—	+	—	—	+	—	—
P. neglecta (Hansen) Moreau	—	—	—	—	—	—	+	—	—	—	—	—
P. setosa (Win.) Kuntze	+	+	—	—	—	+	+	—	—	+	+	—
Sordaria fimicola (Rob.) Ces. et de Not.	+	+	—	+	—	+	+	+	—	+	+	—
Sporormia ambiqua Niessl	—	—	—	—	—	—	+	—	+	—	—	—
S. intermedia Auersw.	—	—	—	+	+	+	—	—	—	—	—	—
S. minima Auersw.	—	—	—	—	+	—	—	—	—	+	+	—
HYPOCREALES												
Melanspora fimicola Hansen	+	—	+	—	+	+	—	+	+	—	+	+
M. leucotricha Corda	—	+	—	—	—	—	—	—	—	+	+	+
M. zamiae Corda	+	—	—	—	—	—	—	—	—	—	—	—
PEZIZALES												
Lachnum sp.	—	—	—	—	—	—	—	—	—	+	—	—
FUNGI IMPERFECTI *SPHAEROPSIDALES*												
Phoma sp.	+	—	—	+	+	—	+	+	—	+	—	—
MONILIALES *Moniliaceae*												
Acrostalagmus cinnabarinus Corda	—	—	—	—	—	—	+	—	+	+	+	—
Artrobotrys superba Corda	+	—	—	+	+	—	—	—	—	—	—	—
Arthrobotrys sp.	+	+	—	—	—	+	—	+	+	+	+	+
Botrytis cinerea Pers.	+	—	—	—	—	—	+	—	—	—	—	—
Calcarisporium arbuscula Preuss	+	—	—	—	—	—	+	—	—	—	—	—
Cephalosporium acremonium Corda	+	+	+	+	—	+	+	—	+	—	+	—
C. asperum March.	+	—	—	—	—	—	—	—	—	—	—	—
C. coremioides Raillo	+	+	+	—	—	—	—	—	—	—	—	—
C. roseo-griseum Saksena	+	—	—	—	—	—	—	—	+	—	—	—
Clonostachys araucaria Corda	—	—	—	—	—	—	—	—	—	+	—	—
Dactylella ellipsospora (Preuss) Sacc.	+	+	+	+	+	—	+	+	+	+	+	—
Gliocladiopsis sagariensis Saksena	—	—	—	—	+	—	—	—	—	—	—	—
Gliocladium sp. (seria *catenulatum*)	—	—	—	—	—	—	+	—	—	—	—	—
Hyalopus ater Corda	+	+	+	+	+	—	+	+	+	—	+	+

1	2	3	4	5	6	7	8	9	10	11	12	13
Moeszia? *sp.*	+	+	+	+	+	+	+	+	+	+	+	+
Monacrosporium sarcopodioides (Harz) Berl. et Vogl.	—	—	—	—	—	—	+	—	—	—	—	—
Monopodium uredopsis Delacr.	+	—	—	—	—	—	—	—	—	—	—	—
Mycogone nigra (Morgan) Jensen	+	+	+	+	+	+	+	+	+	+	+	+
Oospora sulphurella Sacc. et Roum.	+	+	+	+	+	+	+	+	+	+	+	+
O. variabilis (Lindn.) Lindau	+	+	—	+	+	—	+	+	+	+	+	—
Pachybasium hamatum (Bon.) Sacc.	+	—	+	+	+	—	+	—	+	—	+	—
Paecilomyces sp.	—	—	—	—	—	—	—	—	+	—	—	+
Physospora albida v. Höhn.	—	—	+	—	—	—	—	—	—	—	—	—
Pseudobotrys terrestris (Krzem. et Bad.) Subr.	—	—	—	+	—	—	+	—	—	—	—	—
Spicaria elegans (Corda) Harz	—	—	—	—	+	—	+	+	+	—	—	—
S. griseola Sacc.	—	—	+	+	+	—	+	—	—	+	+	+
S. simplicissima Oudem.	—	—	—	—	—	—	+	—	—	—	—	—
Sporotrichum epigaeum Brun. var. *terrestre* Daszewska	+	—	—	—	—	—	—	—	—	+	—	—
S. olivaceum (Link) Fries												
S. roseolum Oudem. et Beijerinck	—	+	+	—	—	—	+	—	—	—	—	+
Trichoderma album Preuss	+	—	—	—	+	—	—	—	—	—	—	—
T. glaucum Abbott	+	+	+	+	+	—	+	+	+	+	+	—
T. koningi Oudem.	—	+	+	+	+	+	+	+	+	—	+	+
T. lignorum (Tode) Harz	+	—	+	+	+	+	+	—	+	+	+	—
Trichoderma Sp.	—	—	—	+	+	+	+	—	+	—	—	—
Trichothecium roseum (Pers.) Link	—	—	—	—	—	—	+	—	—	—	—	—
Verticillium candidulum Sacc.	—	—		—	—	—	+	—	—	—	+	—
Dematiaceae												
Acremoniella fusca Kunze	—	—	—	—	—	—	—	—	—	+	—	—
Alternaria tenuis Nees	—	—	+	—	+	—	—	—	—	—	+	—
Bisporomyces chlamydosporis v. Beyma	+	—	+	+	+	—	+	—	—	+	—	—
Cercospora sp.	—	—	—	+	—	—	—	—	—	—	—	—
Chaetopsis stachyobola Corda	—	—	—	+	+	—	—	—	—	—	—	—
Chalara aeruginosa v. Höhn.	—	—	—	+	—	—	—	—	—	—	—	—
Cladosporium herbarum (Pers.) Link	—	—	+	+	—	—	—	—	—	—	—	—
Cordana pauciseptata Preuss	—	—	+	—	—	—	+	—	—	—	—	—
Dicoccum asperum Corda	+	+	+	+	+	+	+	+	+	+	+	+
Echinobotryum atrum Corda	—	—	—	—	—	—	—	+	—	—	+	—
Gliobotrys albo-viridis v. Höhn.	—	—	—	—	—	—	—	—	—	—	+	—
Hormodendrum cladosporioides (Fres.) Sacc.	—	—	—	—	—	+	—	—	—	—	—	—
Stachybotrys cyindrospora Jensen	+	—	—	—	—	—	—	—	—	—	—	—
S. lobulata Berk.	+	+	—	—	—	—	—	—	—	—	—	—
Staphylotrichum coccosporum Meyer et Nicot	—	—	—	—	—	—	—	—	+	—	—	—
Stemphylium macrosporoideum (Berk. et Broom.) Sacc.	+	—	+	—	—	+	+	—	—	+	—	—
Torula herbarum (Pers.) Link	—	—	—	+	—	—	—	—	—	—	—	—
Torula sp.	—	—	+	+	—	—	+	—	—	—	—	—
Wardomyces papillata Dickinson	—	—	+	—	—	—	—	—	+	—	—	—
Zygodesmus fuscus Corda	—	—	—	—	—	+	—	+	+	—	+	—

1	2 3 4	5 6 7	8 9 10	11 12 13
Stiblacae				
Stysanus stemonitis (Pers.) Corda	+ + +	— — —	+ + —	— + —
Tuberculariaceae				
Cylindrocarpon didymum (Hart.) Woll.	— — —	— — —	+ + —	+ — —
C. heteronemum (Berk. et Broom.) Woll.	+ + +	— + +	+ — +	— + +
C. radicicola Woll.	— + +	+ + +	+ + +	— + +
Fusarium sp.	— + —	— + +	— + +	+ + —
Volutella ciliata (Alb. et Schw.) Fries	+ + —	+ + +	+ + —	+ — —

group the following families prevailed:
Aspergillaceae — 14 species
Chaetomiaceae — 10 species
Sordariaceae — 9 species.
The remaining families or genera were very scarce.

Among the isolates some species occurred in great numbers being present in samples taken from each level and each season. This group (18,5% of the total number of isolated species) comprised the following species: *Absidia glauca*, *A. spinosa*, *Coemansia pectinata*, *C. erecta*, *Mortierella bainieri*, *Mucor hiemalis*, *M. spinosus*, *Piptocephalis cylindrospora*, *Rhopalomyces coronata*, *Thamnidium sp.*, *Penicillium nigricans*, *Chaetomium crispatum*, *Sordaria fimicola*, *Chaetoceratostoma hispidum*, *Melanospora fimicola*, *Cephalosporium acremonium*, *Dactylella ellipsospora*, *Hyalopus ater*, *Moeszia? sp.*, *Oospora sulphurella*, *O. variabilis*, *Trichoderma glacum*, *T. koningi*, *T. lignorum*, *Dicoccum asperum*, *Mycogone nigra*, *Cylindrocarpon heteroneum*, *C. radicicola*, *Fusarium sp.*, *Volutella ciliata*.

The second very numerous group consisted of fungi isolated from only one sample. The total number of these species amounted to 52 (32,1%). The remaining species (49,4%) appeared more frequently and occurred at various depths and in different seasons.

Table 3

Number of species found in the particular seasons

Class	Season			
	autumn	winter	spring	summer
Phycomycetes	38	34	32	36
Ascomycetes	21	15	29	16
Fungi Imperfecti	53	33	41	37

Since the quantitative distribution of species within the particular seasons was not uniform, a correlation between the number of species and the season could be found. This is illustrated by Fig. 1. It follows from the graph that the maximum number of fungi was found in soil samples taken in autumn and spring, the minimum being found in samples taken in winter and summer. The authors did

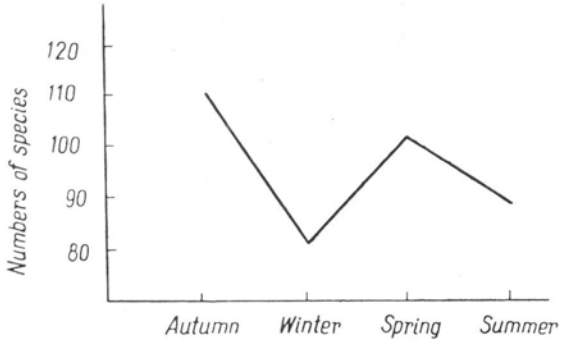

Fig. 1. Number of the species found in all three layers with respect to season of the year.

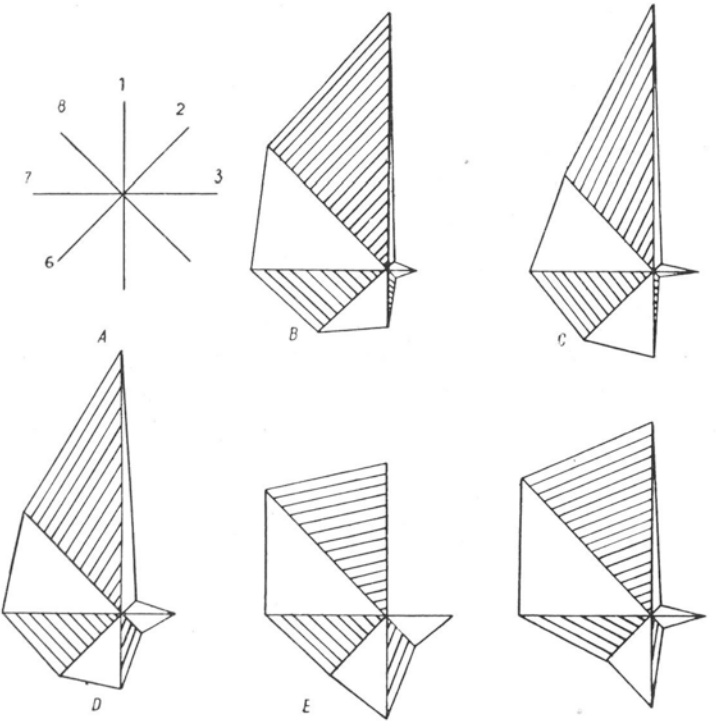

Fig. 2. Diagrams are drawn accordingly to the method proposed by B. Peyronel Jr. A — The lengths of axes represent per cent of fungi in the following groups: 1-*Phycomycetes*, 2-*Sphaeropsidales*, 3-*Stilbaceae* and *Tuberculariaceae*, 4-*Aspergillus*, 5-*Penicillium*, 6-*Dematiaceae*, 7-*Ascomycetes*, 8-*Moniliaceae*; B — mycoflora from the investigated *Melico-Fagetum* association; C — mycoflora from the *Melico-Fagetum* association at Leśna Woda; D — mycoflora from the *Alno-Padion* association at Łęższak; E — mycoflora from the beech community at the Botanical Garden of Turin (Italy); F — mycoflora from the beech community at Lubsza.

not find species distinctly related to the definite season of the year. They, however, observed some changes in the number of species depending on the season (Table 3).

The greatest seasonal changes in the number of species were observed within the class of *Fungi Imperfecti*, the *Phycomycetes* appeared to be the most stable in this respect.

Table 4

Number of species in separate layers

Class	Layer		
	F (I)	H+A_1 (II)	A_2 (III)
Phycomycetes	43	39	25
Ascomycetes	25	27	20
Fungi Imperfecti	53	38	38
Total number of species	121	104	83

Table 4 illustrates the changes in the number of species within separate classes of fungi in samples taken from different layers.

From this table it unequivocally follows that the number of species decreases with depth. This drop in the number of species is distinctly seen within the *Phycomycetes*, in *Ascomycetes* no differences are observed. This phenomenon becomes clear if we consider the physiology of these fungal groups. The *Phycomycetes* constitute the majority of species. The fungi belonging to this group are able to utilize only relatively simple sources of carbon, such as sugars and proteins. On the other hand, the isolated *Ascomycetes*, and first of all the three most numerous genera: *Penicillium*, *Chaetomium* and *Sordaria* are characterized by an intensive decomposition of cellulose. In the layer F, the species belonging to the group of *Fungi Imperfecti* were also very numerous. This group of fungi is not uniform with resepct to its nutritive demands, it comprises species able to utilize only simple carbon compounds like sugars, proteins and fats, as well as species capable to oxidize cellulose and even lignins. Hence, the observed high frequency of these species in the layer F is quite clear, if we bear in mind that of all layers the layer F is richest in the above named substances.

The myco-association studied characterized by B. Peyronel's (1955,1956) method deserves a special discussion. This method consists in assigning the percentual frequencies of separate groups of fungi to the axes 1—8. The above groups have been arranged in the order given in Table 5.

From the percentual distribution of the particular groups of fungi as well as from the diagram based on the data obtained it follows, that the species belonging to *Phycomycetes* were in the investigated community a dominant group.

Moniliaceae and the *Ascomycetes* were less numerous. Attention should be called to the fact that the diagram obtained from this community (Fig. 2) is almost analogical to that obtained from the reserve "Leśna Woda" (M. Badurowa — unpublished

Table 5

Number and percentage of species in the given group of fungi

No	Name of group	Number of species in the given group	Frequency of the given group %
1	*Phycomycetes*	55	34,00
2	*Sphaeropsidales*	1	0,62
3	*Stilbaceae* and *Tuberculariaceae*	6	3,72
4	*Aspergillus*	2	1,23
5	*Penicillium*	12	7.40
6	*Dematiaceae*	20	12,34
7	*Ascomycetes*	29	17,87
8	*Moniliaceae*	37	22,82

paper) which phytosociologically also belongs to the *Melico-Fagetum* association On the other hand, both diagrams differ from those obtained from other beech community. (L. Badura 1963, L. Badura and M. Badurowa 1964) in which the litter was uniform consisting exclusively of beech leaves.

DISCUSSION

It follows from phytociological studies that the type of vegetal cover is conditioned by a number of external factors such as: climate, soil (type of soil, the content of mineral salts, sorptive properties, etc.) and water conditions. The vegetal cover, in turn, is strongly related to the type of litter, the latter being the energy source for the soil fungi. The question whether there exists a relationship between the vegetal cover and the mycoflora can be answered in positive. The diagrams obtained from the association studied (belonging to the *Melico-Fagetum* association) are very similar to those obtained from an analogical (*Melico-Fagetum*) association in the reserve 'Leśna Woda" (Fig. 2). Those diagrams, in turn, are closely similar to the diagrams obtained from another community (*Alno-Padion*). The three communities being characterized by the same species of trees, the litters consisted of the same organic substances. On the other hand, the diagrams differed somewhat from those obtained from other beech forests which included also a small number of other species like *Quercus robur* L., *Carpinus betulus* L., *Ulmus campestris* L., *Picea excelsa* Link, *Pinus silvestris* L., *Larix decidua* Müll., etc. Consequently, the litter in those forests consisted of beech leaves, exclusively (L. Badura and M. Badurowa 1964). On this ground we may infer that the character of the mycoflora is closely related to the vegetal cover, being eventually determined not by ecological conditions (which in those associations are different) but by the litter by which the nutritive substances are supplied. The above conclusion has been confirmed by M. Wit-

kamp (1966) who studied the differences in the number of bacteria and fungi and measured gas exchange in litters composed of needles and leaves of different species of trees. The results obtained showed significant differences both in the number of species and in their activity.

The present investigations have also confirmed the relationship between the number of fungi and the season. These problems are topical in the literature because of the different opinions on this subject. Fom the investigations of H. Krzemieniewska and L. Badura (1954) it follows that there exists a distinct maximum and minimum in the number of fungi in autumn and spring, respectively. From the investigations of M. Witkamp and J. van der Drift (1961) it follows that the maximum is found in winter, while O. Fasstiova (1966) claims that it occurs in April. In the present paper two maxima (in spring and autumn) and two minima (in winter and summer) vere observed. It seems, however, that the above mentioned problems cannot be considered in absolute categories. The amount of fungi in the soil (Webley, Eastwood and Gimingham 1952; Brown 1958; Burges and Nichelson 1962; Witkamp and van der Drift 1961, and others) is chiefly controlled by three factors: the temperature, the moisture and the amount of available nutritive components. The autumnal maximum observed in the former studies is understandable, since the leaves fall from September until November, and the nutritive substances are constituted by the fallen leaves. In this season characterized by rainy weather the soil is supplied with the desirable moisture, and maintains a suitable temperature being due to the summer warmth. The optimum temperature for the fungi ranges within 16—21°C. (Jensen 1934). The fungi dominant in the autumn are *Phycomycetes* and *Fungi Imperfecti*. During the winter the general conditions are entirely changed. The fungi become fragmentarized, their development being inhibited owing to the decreased temperature of the soil. (Aristovskaja 1962). A mild or late winter prolonges the autumnal period of rich development of fungi and leads to depletion of easily available organic compounds. Under the above circumstances a spring minimum in the number of fungi should be expected. If, however, the winter is early and severe and the spring is warm, the fungi may attain their maximum number in the latter season. In our climate the summer is rather warm the amount of precipitation is relatively small, and the investigated area, because of its situation, is exceptionally dry. In this case the depletion of easily available organic compounds and the moisture of the soil may be considered as chief controlling factors. Therefore the *Ascomycetes* and the groups of fungi able to decompose cellulose and lignins were most intensively developed in autumn.

The decrease in the number of fungi with the increasing depth of the soil may be explained by the decreasing amount of organic matter (Table 1). The results obtained are consistent with the latest investigations of the authors quoted in the present paper.

SUMMARY

The purpose of the present paper was to obtain further information on the dependence of the mycoflora on the vegetal cover. Mycological research was conducted in the reserve "Kamień Śląski", phytosociologically qualified as the *Melico-Fagetum* association. One sampling site was chosen. The samples were taken from three layers (I-F, II-H+A_1, III-A_2) during the autumn, winter, spring and summer. The samples were plated on Czapek's, Waksman's and cellulose mineral media in five replications, and on rabbit dung medium (H. Krzemieniewska and L. Badura 1954) in two replications. The isolated species are presented in Table 2.

In the investigated community distinct differences in the number of isolates in respect, to season and to the depth of the soil were observed. The fungi attained their maximum number in autumn and spring, and their minimum in summer and winter (Fig. 1.). The number of fungi decreased with the increasing depth (Table 4).

Considering the diagrams obtained one may infer that the percentual composition of the mycoflora of the investigated community is almost analogical to that of a similar forest association ("Leśna Woda"), being somewhat different from other beech community (Table 5, Fig. 2). These results can be only explained by the fact that the composition of the litter is the factor decisive in the occurrence of definite groups of fungi.

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REFERENCES

Apinis A. E., 1960, Über das Vorkommen niederer Pilze in alluvialen Böden bestimmter Pflanzengesellschaften, Mitteil. d. Flor.-soziologischen Arbeitsgemeinschaft, Stolzenau[Wesser] 8: 110—117.

Apinis A. E., 1964, Concerning occurrence of *Phycomycetes* in Alluvial soils of certain pastures, marshes and swamps, Nova Hedwigia 8: 103—126.

Aristowskaja T. W., 1962, O principach ekologiczeskogo analiza w poczwiennoj mikrobiolcii, Poczwowedenie 1 : 1—16.

Badura L., 1960, Some observations on the mycoflora from the litter ans soil in the pine forest in the Radunia (Sępia Góra) region, (English summ.) Acta Microbiol. Polon. 9: 33—58.

Badura L., 1963, Ricerche sulla micoflora del suolo sotto i faggi dell'Orto Botanico dell'Universita di Torino, Allionia 9: 65—74.

Badura L., 1964, Próby uchwycenia zależności mikroflory od szaty roślinnej, Wiadomości Botaniczne 7 (3—4): 195—204.

Badura L., Badurowa M., 1964, Some observations on the mycoflora in the litter and soil of the beech forest in Lubsza region, (English summ.) Acta Soc. Botan. Polon. 33: 507—525.

Benjamin R. K., 1959, The merosporangiferous *Mucorales*, Aliso 4: 321—433.

Benjamin R. K., 1966, The merosporangium, Mycologia 58: 1—42.

Brown J. C. 1958, Soil fungi of some British sand dunes in relation to soil type and succession, J. Ecology 46: 641—664.

Burges N. A., Nichelson D. P., 1962, Use of soil sections in studing amount of fungal hyphae in soil, Soil Sci. 92: 25—29.

Doguet G., 1955, Le Genere "*Melanospora*", Im E. Droullard, Bordeaux.
Eggleton W. G. E., 1934, Studies on the microbiology of Grassland soil, J. Agric. Sci. 24: 416—434.
Ellis J. J., Hesseltine C. W., 1965, The genus *Absidia*: globose-spored species, Mycologia 57: 222—235.
Fassatiova O., 1966, Bodenmikromyceten am Hügel Doutnač im Böhmischen Karst, Preslia (Praha) 38: 1—14.
Gilman J. C., 1959, A manual of soil fungi, The Iowa St. Coll. Press. Iowa.
Greszta J., Kwiatkowska A. 1962, "*Kamień Śląski*" rezerwat brzęku *Sorbus torminalis* w woj. opolskim, Chrońmy Przyr. Ojczystą 182: 3—15.
Hennebert G. L., 1962, *Wardomyces* and *Asteromyces*, Canad. J. Botan. 40: 1203—1216.
Hesseltine C. W., Ellis J. J., 1964, The genus *Absidia*: *Gongronella* and cylindrical-spored species of *Absidia*, Mycologia 54: 568—601.
Hughes S. J., 1958, Revisions Hyphomycetum aliquot cum appendice de nominibus rejiciendis, Canad. J. Botan. 36: 727—836.
Jensen H .L., 1934, Contribution to the microbiology soils, Linn. Soc. N.S. Wales Proc. 59: 101—117.
Krawiecowa A., Kuczyńska L., 1968, Roślinność rezerwatu "Kamień Śląski", Acta Univer. Wrat. Prace Bot. (w druku).
Krzemieniewska H., Badura L., 1954, Some observations on the mycoflora of beech woods, (English summ.) Acta Soc. Botan Polon. 23: 545—587.
Migula W., 1913, Krypt.-Flora, III, Pilze, 3-Teil, 1—2 Abt., Fr. v. Zeschwitz, Gera R.
Migula W., 1921, Krypt.-Flora, III, Pilze, 4-Teil, 1 Abt., Bermller, Berlin.
Migula W., 1934, Krypt.-Flora, III, Pilze, 4-Teil, 2 Abt., Ac. Ver. M.B.H., Leipzig.
Moreau C., 1953, Les Generes *Sordaria* et *Pleurage*, Ed. P. Lechexvalier, Paris.
Munk A., 1957, Danish *Pyrenomycetes*, Dansk Botan. Arckiv 17: 1—491.
Peyronel B. (Jr.), 1956, Considerazioni sulle micocenosi del suolo e sui metodi per studiarle, Allionia 3: 85—109.
Peyronel B., Dal Vesco G., 1955, Ricerche sulla micoflora di un terreno agrario presso Torino, Allionia 2: 357—417.
Timonin M. J. T., 1935, The microorganisms in profils of certain virgin soils in Manitoba, Canad. J. Res. C 13: 32—46.
Wachowska-Serwatka K., 1968, Warunki ekologiczne rezerwatu "Kamień Śląski" Acta Univer. Wrat. Prace Bot. (w druku).
Webley D. M., Eastwood D. J., Gimingham C., 1952, Development of soil micoflora in relation to plant successsion and sand dunes, including the rihsosphaere flora associated with colonizing species, J. Ecology 40: 168—178.
Winogradsky S., 1925, Études sur la microbiologie du sol, Ann. Inst. Pasteur 39: 299—354.
Witkamp M., 1966, Decomposition of leaf litter in relation to environnment micoflora, and microbial respiration, Ecology 47: 194—201.
Witkamp M., van der Drift J. 1961, Breakdown of forest litter in relation to environmental factors, Plant and Soil 15: 295—311.
Zycha H., 1935, Krypt.-Flora Mark Brand., Pilze II, *Mucorineae*, Geb. Bornträger, Leipzig.

Dalsze badania nad związkiem pomiędzy grzybami glebowymi, a makroflorą

Streszczenie

Celem pracy było zebranie dalszych informacji o zależnościach micro. — od makroflory. Poszukiwania mikologiczne prowadzono w rezerwacie "Kamień Śląski" zaliczony pod względem fitosocjologicznym do zespołu *Melico-Fagetum* (A. Krawiecowa i I. Kuczyńska 1968). Do badań wybrano jedno miejsce z którego pobierano próbki z ściółki i gleby w okresie jesiennym, zimowym,

wiosennym i letnim. Próbki pobierano z trzech warstw: F (I), H+A_1 (II), A_2 (III). Materiał wysiewano na pożywki mineralne: Czapka, Waksmana i celulozową w 5 powtórzeniach oraz na pożywkę nawozową (wg. H. Krzemieniewskiej i L. Badury 1954) w 2 powtórzeniach. Wyizolowane gatunki zestawiono w tabeli 2.

W badanym zespole wyraźnie zaznaczały się różnice w ilości wyizolowanych gatunków, a porą roku oraz głębokością. Ilość grzybów miała dwa maksima: jesienią i wiosną oraz dwa minima: latem i zimą. Ilość gatunków malała wraz ze wzrostem głębokości.

Na podstawie układów diagramów można sądzić, że skład mikroflory w badanym zespole jest prawie analogiczny ze składem flory z podobnego zespołu leśnego *Melico-Fagetum* w rezerwacie „Leśna Woda", a nie co inny z innych bukowych zbiorowisk. Ponieważ w obu zespołach *Melico Fagetum* ściółkę budowały liście różnych gatunków drzew, a w innych zbiorowiskach bukowych na ściółkę składały się wyłącznie liście bukowe to wydaje się, że otrzymane wyniki wskazują, że decydującym czynnikiem w ukształtowywaniu się mikoflory jest ściółka stanowiąca w ostatecznym rozrachunku substrat pokarmowy.

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