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Changes in species composition and physiological activity of fungi associations in two lakes, differing in trophicity

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K o r n i ł ł o w i c z T.: *Changes in species composition and physiological activity of fungi associations in two lakes, differing in trophicity*. Acta Mycol. 30 (2): 233-253, 1995.

The results of the present study indicated differences in species composition and physiological activity of saprophytic mycoflora between two lakes: mesotrophic lake with accelerated eutrophication and an eutrophic one. In waters of the lake with lower trophicity the most frequently occurring species were *Hyalodendron* sp. and *Verticilliun lecani*. These fungi prevailed in the total mycoflora and mycoflora decomposing proteins. The waters of the lake with higher trophicity are dominated by the population of *V. lecani*, which was proteolitically and pectinolytically active. In bottom sediments the following ubiquistic species were most common: *Cladosporium herbarum* (mesotrophic lake) and *Cephalosporium roseum* (eutrophic lake).

Key words: fungi associations

INTRODUCTION

Previous works on ecology and physiology of saprophytic non-aquatic mycoflora in water environment dealt mainly with yeast and yeast-like fungi (C o o k e et. al., 1960; C o o k e, 1961, 1965; M e y e r s, A h e a r n, C o o k, 1970; S i m a r d, B l a c k w o o d, 1971 a, b; W o l l e t t, H e d r i c k, 1978; Q u i n n, 1984; H i n z e l i n, B l o c k, 1985; S l á v i k o v á, G r a b i ń s k a - Ł o n i e w s k a, 1987 (1990), 1988 (1989); G r a b i ń s k a - Ł o n i e w s k a, S l á v i k o v á, 1990; G r a b i ń s k a - - Ł o n i e w s k a, 1991; G r a b i ń s k a - Ł o n i e w s k a et al., 1993; D y n o w s k a, 1993, 1995). These microorganisms play an essential role in the eutrophication of natural water reservoirs, indicating the degree of the fertility and pollution (C o o k e et al., 1960; C o o k e, 1961, 1965; M e y e r s, A h e a r n, C o o k, 1970; S i m a r d, B l a c k w o o d, 1971 a, b; H i n z e l i n, B l o c k, 1985; D y n o w s k a, 1993, 1995). Some authors (K o r n i ł ł o w i c z, S z e m b e r, 1991; K o r n i ł ł o w i c z, 1994 a, b) have also indicated that lakes with different trophicity and basin utilization also vary in number and distribution of saprophytic mycoflora. The dynamic of changes in the number of those fungi has revealed the growth of a number of yeasts in the plankton of mesotrophic lake changing towards eutrophy (Korniłłowicz, Szember, 1991; Korniłłowicz, 1994 b).

Much more attention has been paid to yeasts and yeasts-like than filamentous non-aquatic fungi in water environment (Collins, Willoughby, 1962; Meyers, Ahearn, Cook, 1970; Park, 1972 a, b, 1974; Mishra, Tiwari, 1983). According to Cooke (1961), however, these fungi could also play an essential role in the decomposition of organic matter and in eutrophication of water. These issues had been the subject of previous studies (Korniłłowicz, Szember, 1991; Korniłłowicz, 1991; Korniłłowicz, 1993 c, d; Korniłłowicz, 1994 a, b, c). The results of taxonomic research on some physiological associations of non-aquatic moulds in two lakes, i.e. mesotrophic lake with accelerated eutrophication and an eutrophic one, were presented.

MATERIAL AND METHODS

Two lakes located in the Łęczyńsko-Włodawskie Lake District were investigated: mesotrophic Lake Piaseczno with progressive eutrophication caused by the development of agriculture and recreation, and eutrophic Lake Głębokie situated in the agricultural area. The discription of the area studied, including basic physical and chemical features of the lakes and catchment were given in earlier papers (Korniłłowicz, Szember, 1991; Korniłłowicz, 1993 b, 1994 a).

Mycological research was done in 1990. Water and bottom sediment samples were taken on the following dates: 26.04; 30.05; 3.07; 25.09 according to the method described in earlier papers (Korniłłowicz, 1993 b, 1994 a). The total population of fungi including those decomposing proteins, pectin, starch, and cellulose were estimated using methods described in the paper of Korniłłowicz, 1994 a, c). For isolation of particular strains, one of the five plate repetitions was chosen randomly. Subsequently all grown mould colonies were separated and put in the medium with the same composition as the isolating medium. Tests checking the fungi ability to decompose particular substrata were performed according to the methods described by Korniłłowicz (1994 c).

Genera and species of filamentous fungi were identified on the basis of observations made in micro cultures and on plates using standard growth medium: Czapek, Sabouraud's and PDA (potato-glucose agar). Taxonomic classification was done according to the following keys and taxonomic works: Gilman (1945), Barnett (1960), Litwinow (1967), Messiaen, Cassini (1968), Ellis (1971), Kirylenko (1972), Skirgiełło, Zadara (1979), Domsch, Gams, Anderson (1989), Onions, Brady (1987), Ellis, Ellis (1988).

Species with frequency of occurrence of at least 50 % considered dominant within a particular physiological group. Taxa with 25-50 % isolation frequency were considered co-dominant.

RESULTS

In total 3051 isolates of filamentous fungi from 37 genera representing 81 species were found in the water and bottom sediments of Lake Piaseczno and Głębokie. One isolate was identified as an aquatic fungus (*Achlya* sp.). The remaining isoaltes represented the so-called non-aquatic fungi. Most populations (98 %) of those micromycetes constituted imperfect fungi (*Deuteromycetes*). The other 2 % consisted of 78 isolates belonging to the *Zygomycetes* or *Ascomycetes*. Most of the imperfect fungi were classified as *Moniliales*, including 2381 isolates as *Moniliaceae*, 426 – *Dematiaceae*, 19 – *Tuberculinariaceae*, and 1 – *Stilbaceae*. On hundred and five isolates were classified as *Coelomycetes*.

Planktonic mycoflora of the investigated lakes consisted of 40 species and was more opulent in Lake Piaseczno (33 species) than in Głębokie Lake (23 species). The greatest taxonomic differentiation was noted in the so-called total mycoflora (Martin's medium) which assimilated simple organic linkages, like glucose and peptone, as well as in the mycoflora decomposing proteins. The smallest differentiation was observed among amylolytic fungi (Tables 1-2).

The mycoflora of bottom sediments contained more species (65) than the communities of planktonic fungi. In this environment a greater number of cellulolytic fungi was found (Tables 3-4). However in relation to the degree of trophicity of the lake, communities of benthonic fungi showed a reserved tendency as compared with those of planktonic fungi. This was manifested by a greater number of species in the lake higher trophicity (50) than in the lake with lower trophicity (36).

The present study revealed that physiologically differentiated fungi communities of both lakes were characterized by a greater number of populations (1-3 more) as compared to other fungi (Figs. 1-4).

The mycoplankton of Lake Piaseczno consisted chiefly of fungi representing *Hyalodendron* sp. (Table 1, Fig. 1). The population of the species showed proteolytic activity and utilizing less complex bonds of organic C and N. In some habitats *Hyalodendron* sp. was co-dominant or was replaced by *Verticillium lecani* (Fig. 1 a). Both species also occurred in the pectinolytic mycoflora. Most of all, however, pectinolytic properties were detected in *Paecilomyces lilacinus* (Table 1, Fig. 1 b). Among fungi decomposing starch, mainly *Penicillium* spp. and sometimes *Cladosporium herbarum* and *Phoma humicola* were found (Fig. 1 b). The genus *Penicillium* was also noted among cellulolytic mycoflora. It was mainly represented by *Gliocladium roseum* (Table 1, Fig. 1 c).

The distribution of species dominating in the waters of Lake Piaseczno was not uniform. It was manifested by the accumulation of *Hyalodendron* sp. propagules in surface waters and methalimnion while the accumulation of *V. lecani* propagules was observed in waters of the hypolimnion. Dark-pigmenting species, namely, *C. herbarum* and *P. humicola* were more frequently found in surface waters, than in deep waters while *G. roseum* was more abundant in mid-lake waters than near the lake shore. Only *Penicillium* spp. did not show clear relationship with horizontal and vertical stratification of the lake. Among distinct seasonal changes observed in the number of dominating populations were: the higher occurrence of *Hyalodendron* sp. and *Cladosporium* spp. in summer and early fall, and of *Penicillium* spp. and *V. lecani* in spring (Fig. 1).

Table 1

List of species of fungi isolated from water of Piaseczno lake

Genus or species	I			II			III			IV			V		
	L	S	P	L	S	P	L	S	P	L	S	P	L	S	P
Alternaria alternata (Fr.) Keissl.	–	–	–	–	–	–	–	–	1	–	–	1	2	–	–
Aspergillus versicolor (Vuill.) Tiraboschi	–	–	2*	–	–	–	6	3	2	1	–	1	–	–	–
Aureobasidium pullulans (de Bary) Arnaud	–	–	–	3	2	1	–	–	–	–	–	–	–	–	–
Cephalosporium curticeps Sacc.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Cladosporium (Fres.) de Vries	4	2	–	–	–	2	–	–	2	3	–	1	–	–	–
– *herbarum* (Pers.) Link ex S. F. Gray	9	38	6	6	9	16	4	7	5	5	5	2	1	12	4
– *macrocarpum* Preuss	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–
Chrysosporium pannorum (Link) Hughes	–	–	–	–	1	–	–	–	–	–	–	2	–	–	2
– *pruinosum* (Gilman et Abb.) Carm.	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
Geotrichum candidum Link ex Leman	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–
Gliocladium roseum Bain.	–	18	20	–	2	–	–	4	3	–	–	–	6	15	21
Gliomastix murorum (Corda) Hughes	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
Hyalodendron sp.	1	30	46	175	94	72	25	10	3	–	–	–	–	–	–
Mucor ramonissimus Samutsevitsch	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
– *saturninus* Hagem	–	–	–	–	2	4	–	–	–	–	–	–	–	–	–
– *strictus* Hagem	–	–	–	1	2	1	–	–	1	–	–	–	–	–	–
Paecilomyces farinosus (Holm ex S. F. Gray) A. H. S. Brown et W. G. Smith	2	–	–	3	–	–	5	7	2	–	–	–	–	–	–
– *lilacinus* (Thom) Samson	–	–	–	–	11	15	–	37	69	–	2	–	–	–	1
Penicillium spp.	5	5	18	3	–	20	1	2	18	3	9	31	40	5	25
– *frequentans* Westl.	6	13	7	–	9	6	7	–	7	5	–	–	–	–	–
– *purpureum* Stoll	–	–	11	–	–	–	–	–	–	–	–	–	2	–	–
Phoma sp.	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
– *herbarum* Westend.	–	–	–	–	9	12	–	2	1	–	1	–	–	–	–
– *humicola* Gilman et Abb.	–	1	–	–	1	4	–	4	5	2	24	20	9	8	7
Rhizopus nigricans Ehrenb.	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–
Scopulariopsis brevicaulis (Sacc.) Bain.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
– *brumptii* Salvanet-Duval	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
– *chartarum* (wg Sm.) Morton et W. G. Smith	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–
Sclerotium sp.	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1
Stachybotrys chartarum (Ehrenb. ex Link) Hughes	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–
Trichoderma viride Pers. ex S. F. Gray	–	–	–	–	–	2	2	–	1	–	–	–	2	6	1
Verticillium lecanii (Zimm.) Viegas	–	85	30	–	11	68	–	–	21	–	–	–	–	–	1
– *nigricens* Pethybr.	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
– *psalliotae* Treschow	–	–	–	–	1	1	–	2	–	–	–	–	–	–	–
Total	30	192	143	191	157	224	52	78	145	19	41	59	62	46	73

Explanations: I – "total" of fungi, II – protein decomposing fungi, III – pectin decomposing fungi, IV – starch decomposing fungi, V – cellulose decomposing fungi;
L – littoral, S – sublittoral, P – pelagial, * – number of fungi

Table 2

List of species of fungi isolated from water of Głębokie lake

Genus or species	I		II		III		IV		V	
	L	S	L	S	L	S	L	S	L	S
Alternaria alternata (Fr.) Keissl.	–	–	–	–	–	–	–	–	–	1
– tenussima (Kunze ex Pers.) Wilts	–	–	–	–	–	–	–	–	–	1
Aspergillus versicolor (Vuill.) Tiraboschi	–	–	–	2*	–	–	1	–	–	–
Aureobasidium pullulans (de Bary) Arnoud	–	–	5	3	–	1	2	1	–	–
Cephalosporium roseum Oudem	6	12	1	17	5	5	10	36	2	11
Cladosporium cladosporioides (Fres.) de Vries	–	–	1	–	–	4	–	–	–	–
– *herbarum* (Pers.) Link ex S. F. Gray	–	1	4	–	3	–	1	1	4	2
Chrysosporium pannorum (Link) Hughes	–	–	–	–	–	–	–	–	–	1
– *pruinosum* (Gilman et Abb.) Carm.	–	–	1	–	–	–	–	–	–	–
Cylindrocarpon heteronemum (Berk.) Broome) Wellonw.	–	–	–	–	–	–	–	1	–	–
Emericellopsis terricola van Beyma	–	–	–	–	–	–	–	–	–	1
Fusarium culmorum (W. G. Smith) Sacc.	–	–	–	–	–	–	–	–	–	1
Gonatobotrys simplex Corda	–	–	–	–	1	–	–	–	–	–
Mucor racemosus Samutschevitsch	–	–	1	–	–	1	–	–	–	–
Paecilomyces farinosus (Holm ex S. F. Gray) A. H. S. Brown et W. G. Smith	7	–	–	–	–	–	–	–	–	–
Penicillium sp.	1	12	–	10	–	22	14	28	2	–
– *frequentans* Westl.	3	–	–	4	–	–	–	5	–	–
– *purpurogenum* Stoll	–	–	–	–	–	–	–	–	18	20
Phoma herbarum Westend.	3	–	–	–	–	1	1	1	–	–
– *humicola* Gilman et Abb.	–	–	–	–	1	–	–	–	–	–
Scopulariopsis chartarum (W. G. Smith) Morton et W. G. Smith	–	–	–	–	–	–	–	1	–	–
Trichoderma viride Pers. ex S. F. Gray	–	–	–	–	–	–	–	5	6	7
Verticillium lecani (Zimm.) Viegas	76	116	93	127	37	42	–	1	–	–
Total	96	141	106	163	47	76	29	80	32	46

Explanations: see Table 1

Table 3

List of species of fungi isolated from sediment of Piaseczno lake

Genus or species	I			II			III			IV			V		
	L	S	P	L	S	P	L	S	P	L	S	P	L	S	P
Alternaria alternata (Fr.) Keissl.	1*	–	–	–	–	–	2	–	–	–	–	–	1	–	–
– *tenussima* (Kunze ex Pers.) Wilts.	–	–	–	–	–	–	1	–	–	1	–	–	2	–	–
Anixiopsis stercoraria (Hansen) Hansen	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–
Aspergillus clavatus Desm.	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
– *fumigatus* Fres.	1	2	1	–	–	–	1	–	–	–	–	–	–	–	–
– *niger* van Tieghem	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–
– *versicolor* (Vuill.) Tiraboschi	–	–	–	–	–	1	–	1	–	–	–	–	1	–	1
Aureobasidium pullulans (de Bary) Arnaud	2	–	–	–	–	–	–	–	2	1	–	–	–	–	–
Botrytis cinerea Pers. ex Nocca, Bald.	1	–	2	–	–	–	3	–	–	–	–	–	2	–	–
Chaetomium globosum Kunze	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
– *funiculosum* Cooke	–	–	–	–	–	–	–	1	–	–	–	–	1	1	–
Cladosporium cladosporioides (Fres.) de Vries	3	3	1	–	–	–	4	–	2	1	2	2	3	2	–
– *herbarum* (Pers.) Link ex Gray	9	11	1	22	6	1	9	6	6	6	5	9	9	1	7
– *macrocarpum* Preuss	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chrysosporium medarium (Link ex Grev.) Carm.	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Cylindrocarpon heteronemum (Berk. et Br.) Wollenw.	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Drechslera dematioidea (Bubak et Wróbl.) Subram.	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Emericellopsis terricola van Beyma	–	1	13	–	4	6	–	–	–	1	–	1	1	–	–
Fusarium arthosporioides Shreb.	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
– *oxysporum* (Schlecht.) Snyder et Hans.	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–
Gliocladium catenulatum Gllman et Abb.	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–
– *fimbriatum* Gilman et Abb.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
– *roseum* Bain.	–	–	–	9	6	2	–	–	–	–	–	–	–	–	–
Gliomastix murorum (Corda) Hughes	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
Gonatobotryum fuscum (Sacc.) Sacc.	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–
Monocillium indicum Saksena	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–

cont. Tab. 3

Mucor ramonissimus Samutschevitsch	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–
– *saturninus* Hagem	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–
– *strictus* Hagem	–	–	1	1	–	–	2	–	–	–	–	–	–	–	–
Paecilomyces carneus (Duche et Heim) A. H. S. Brown et W. G. Smith	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
– *lilacinus* (Thom) Samson	–	1	–	–	–	–	–	3	–	–	–	–	–	–	–
Penicillium sp.	–	1	4	–	2	4	1	2	4	8	4	5	3	5	3
– *expansum* Link ex F. S. Gray	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
– *frequentas* Westl.	–	–	–	–	1	–	–	1	1	–	–	–	–	–	–
– *purpurogenum* Stoll	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
– *thomii* Maire	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1
– *vinaceum* Gilman et Abb.	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Pestalotia truncata Lev.	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Phialophora fastigiata (Lagerb. et Melin.) Contant	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Phoma herbarum Westend.	9	1	1	–	–	–	2	1	1	–	–	–	–	–	–
– *humicola* Gilman et Abb.	6	1	1	–	–	–	1	–	–	–	–	–	–	–	–
– *leveillei* Boerema et Bollen	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Pseudourotium sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Sclerotium sp.	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Scopulariopsis communis Bain.	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
– *chartarum* (W. G. Smith) Morton et W. G. Smith	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–
Septonema chaetospira Grove) Hughes	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–
Stysanus stemonites (Pers. ex Steud.) Corda	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Trichoderma viride Pers. ex S. F. Gray	1	–	1	–	–	–	1	–	–	–	–	–	6	2	–
Trichothecium roseum (Pers.) Link ex S. F. Gray	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Verticillim lecani (Zimm.) Viegas	–	–	–	–	–	–	–	1	–	–	–	–	–	–	2
Total	40	22	27	34	23	18	34	21	16	20	11	17	34	12	20

Explanations: see Table 1

Table 4

List of species of fungi isolated from sediment of Głębokie lake

Genus or species	I		II		III		IV		V	
	L	S	L	S	L	S	L	S	L	S
Achlya sp.	–	1*	–	–	–	–	–	–	–	–
Alternaria alternata (Fr.) Keiss.	1	–	–	–	–	–	–	–	–	–
– *radicina* Meier Drechsler et Eddy	–	–	–	–	–	–	–	–	1	–
Aspergillus flavus Link ex Gray	–	–	–	–	–	–	1	–	1	–
– *fumigatus* Fres.	–	1	–	4	–	1	–	1	2	–
– *niger* van Tieghem	1	–	–	–	1	–	–	–	–	–
– *versicolor* (Vuill.) Tiraboschi	–	–	–	–	–	–	1	–	1	–
Aureobasidium pullulans (de Bary) Arnaud	–	–	1	1	–	–	–	–	–	–
Botrytis cinerea Pers ex Nocca. Balb.	–	–	–	–	–	–	–	–	3	–
Chaetomium bostrychodes Zopf	–	–	–	–	–	–	–	–	1	–
– *spirale* Zopf	–	–	–	–	–	–	–	–	1	–
Cephalosporium acremonium Corda	1	–	–	–	–	–	–	–	–	–
– *roseum* Oudem	28	8	21	15	20	17	–	5	–	3
Cladosporium cladosporioides (Fres.) de Vries	–	–	–	–	1	1	–	–	–	–
– *herbarum* (Pers.) Link ex Gray	–	–	2	2	4	2	1	1	2	1
– *macrocarpum* Preuss	–	–	–	–	–	1	–	–	–	–
Emericellopsis terricola van Beyma	9	–	2	–	–	1	–	–	–	–
Fusarium arthrosporoides Sherb.	–	–	–	–	–	–	–	–	1	2
– *oxysporum* (Schlecht.) Snyder et Hans.	1	1	–	–	–	–	–	–	1	–
– *solani* (Mart.) (Appel. et Wr.) Sn. et Hans.	1	–	1	1	–	–	–	–	–	–
– *sporotrichoides* Sherb.	1	–	1	–	–	–	–	–	–	–
– *tricinctum* (Corda) Sacc.	–	–	1	–	1	–	–	–	–	–
Gliocladium fimbriatum Gilman et Abb.	6	3	–	–	4	10	–	–	8	4
– *roseum* Bain.	1	–	–	–	–	–	–	–	–	–
Humicola grisea Traaen	–	2	–	–	–	–	–	–	–	–
Monicillium indicum Saksena	–	–	–	–	–	–	–	2	–	–
Mucor racemosus Samutschevitsch	–	–	–	2	2	–	–	–	–	–
Paecilomyces marquandii (Masse) Hughes	–	–	–	–	–	–	–	–	2	–
Penicillium sp.	7	3	–	–	2	2	74	9	–	3
– *luteum* Zukal	2	–	–	–	–	–	–	–	–	–
Scopulariopsis chartarum (G. Sm.) Morton et G. Sm.	–	–	–	–	–	–	–	–	1	–
Trichoderma glaucum Abbot	–	–	–	–	–	–	–	–	2	2
– *viride* Pers. ex Gray	6	4	–	1	5	–	–	–	4	12
Verticillium lecani (Zimm.) Viegas	–	–	3	–	–	–	–	–	–	–
– *lateritium* Berkeley	–	1	–	–	–	–	–	–	1	–
Total	63	23	31	26	40	35	77	18	32	27

Explanations: see Table 1

Communities of planktonic fungi in Lake Głębokie were characterized, above all, by the accumulation of propagules of *V. lecani* (Fig. 2) . Physiological activity of the previously mentioned population was higher than the activity of *V. lecani* population in Lake Piaseczno. It was manifested by higher density of fungus propagula within the mycoflora utilizing simple organic linkages of C and N, as well as within the mycoflora which hydrolized proteins and pectin (Tab. 2, Fig. 2 a-b). Amylolyctic and cellulolytic properties were mainly exhibited by the *Cephalosporium roseum* and *Penicillium* spp. among the mycoplankton of Lake Głębokie.

The distribution of relevant populations of fungi in the plankton of the investigated lake was usually uniform and there were hardly any seasonal fluctuations observed (Fig. 2), because of counter balanced nutrition and thermal conditions of eutrophic lakes (D o n d e r s k i, 1983).

The results obtained indicated significant differences in floristic composition of mycoplankton and mycobenthos of both lakes.

In mesotrophic lake, benthonic fungi communities were chiefly represented by *Cladosporium herbarum* (Fig. 3). Physiological activity of this species was noted within a wide range of substrata, including cellulose. The greatest contribution of *C. herbarum*, until the growth in the form of monoculture, was observed within the so-called total mycoflora and mycoflora which utilized proteins and pectin. Occasionally *Gliocladium roseum* and *Emericellopsis terricola* were noted as co-dominants among proteolytic forms while *Penicillium* spp. and *P. lilacinus* co-dominated within pectinolytic mycoflora (Fig. 3 a-b). Analogically to the planctonic mycoflora, amylolytic activity was chiefly exhibited by *Penicillium* spp. and *Cladosporium herbarum* among the benthonic mycoflora at Lake Piaseczno. Cellulolytic fungi also contained relevant amounts of *Trichoderma viride* propagules. Generally, however, the lowest species domination was marked within the fungi decomposing cellulose.

It was pointed out that the frequency of occurrence of particular species dominating in the benthonic mycoflora of Lake Piaseczno was dependent upon the depth at which bottom sediments occurred and on the season of the year. In shallow sediments, mainly *Cladosporium* species were found (especially in July). In deep sediments, hyaline fungi such as *Penicillium* spp., *Emericellopsis terricola, Trichoderma viride* were often found (Fig. 3).

Mycoflora colonizing the bottom sediments of Lake Głębokie consisted mostly of *Cephalosporium roseum* (Fig. 4). The range of physiological abilities of *C. roseum* in Lake Głębokie was lower than that of *C. herbarum* in Lake Piaseczno as no fungi of that species had been found among cellulolytic forms. These were mainly represented by *Gliocladium fimbriatum* and *T. viride*. *C. roseum* occurred less frequently among amylolytic forms which were chiefly represented by *Penicillium* spp.

The present observations revealed a small influence of the lake's depth and of the sampling period on the occurrence and distribution of particular micromycetes in the bottom sediments of the lake investigated (Fig. 4).

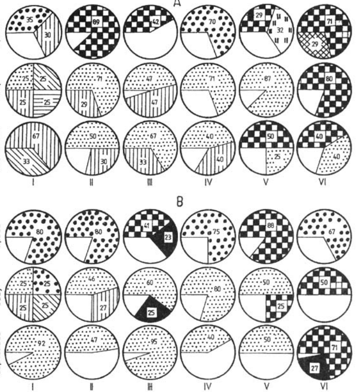
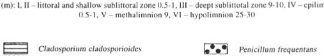


Fig. 1 a. The frequency of occurrence of some fungi species in the plankton on Piaseczno lake (in %):
A – assimilated glucose and pepton fungi, B – proteolytic fungi;
depth (m): I, II – littoral and shallow sublittoral zone 0.5-1, III – deept sublittotal zone 9-10, IV – epilimnion 0.5-1, V – methalimnion 9, VI – hypolimnion 25-30



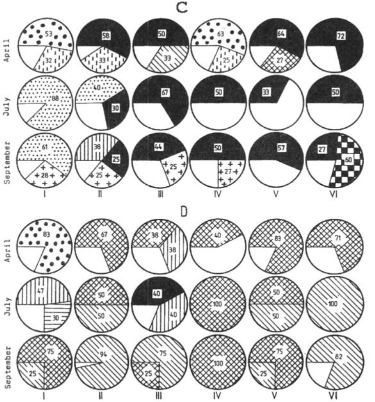


Fig. 1 b. The frequency of occurrence of some fungi species in the plankton on Piaseczno lake (in %): C – pectinolytic fungi, D – amylolytic fungi

Aspergillus versicolor

Paecilomyces farinosus

other explanations: see Fig. 1 a

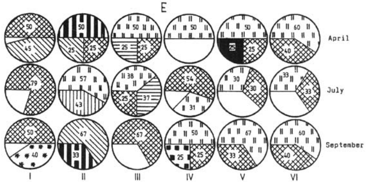


Fig. 1 c. The frequency of occurrence of some fungi species in the plankton on Piaseczno lake (in %):
E – cellulolytic fungi

Gliomastix murorum
Phoma sp.
Trichoderma viride

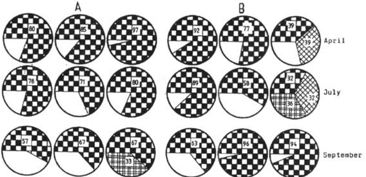


Fig. 2 a. The frequency of occurrence of some fungi species in the plankton on Głębokie lake (in %):
A – assimilated glucose and pepton fungi, B – proteolytic fungi;
depth (m): I, II – littoral and shallow sublittoral zone 0.5-1, III – deept sublittotal zone 4.5

Cephalosporium roseum
Penicillium sp.
Verticillium lecani
other

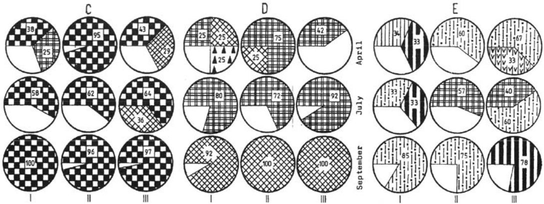


Fig. 2 b. The frequency of occurrence of some fungi species in the plankton on Głębokie lake (in %):
C – pectinolytic fungi, D – amylolytic fungi, E – cellulolytic fungi

Alternaria alternata
Aureobasidium pullulans
Cladosporium herbarum
Penicillium purpurogenum
Trichoderma viride

other explanations: see Fig. 2 a

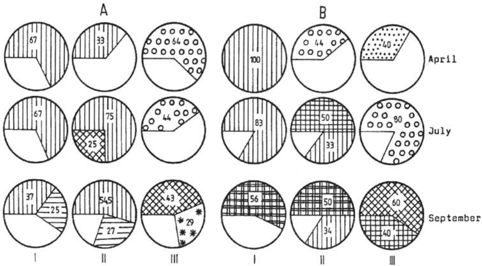


Fig. 3 a. The frequency of occurrence of some fungi species in the bottom sediments of Piaseczno lake (in %):

A – assimilated glucose and pepton fungi, B – proteolytic fungi;
depth (m): I – littoral zone, II– sublitoral zone 10, III – pelagial 30

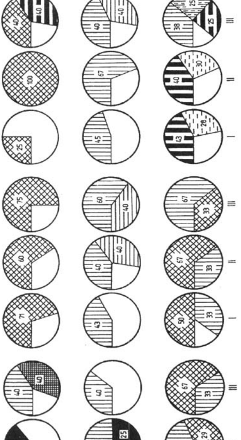


Fig. 3 b. The frequency of occurrence of some fungi species in the plankton on Piaseczno lake (in %):
C – pectinolytic fungi, D – amylolytic fungi, E – cellulolytic fungi

Chaetomium funiculosum
Gliocladium fimbriatum
Paecilomyces lilacinus

Trichoderma viride
Trichosporon sp.
Verticilium lateritium

other explanations: see Fig. 3 a

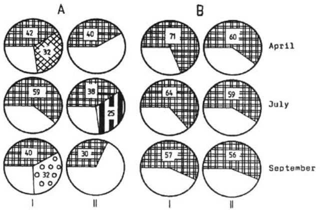
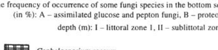


Fig. 4 a. The frequency of occurrence of some fungi species in the bottom sediments of Głębokie Lake (in %): A – assimilated glucose and pepton fungi, B – proteolytic fungi;
depth (m): I – littoral zone 1, II – sublittotal zone 5



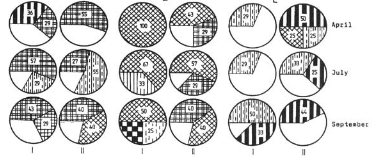


Fig. 4 a. The frequency of occurrence of some fungi species in the bottom sediments of Głębokie lake (in %): C – pectinolytic fungi, D – amylolytic fungi, E – cellulolytic fungi

other explanations: see Fig 4 a

DISCUSSION

In previous papers (Korniłłowicz, Szember, 1991; Korniłłowicz, 1993 c, d, 1994 a, b, c) it was pointed out that saprophytic mycoflora of water and bottom sediments of lakes with different trophicity had also differed in the number and range of physiological abilities. In the present study it was revealed that some physiological groups had 1 or 2 populations of non-aquatic fungi more. Species composition of the micromycetes in question was associated with the type of lake, catchment basin and habit. The medium used and the time of sampling (related to the seasons of the year) were also relevant.

It was found that the growth of fungi decomposing proteins and simple peptide bonds in the water of Lake Piaseczno (Korniłłowicz, 1994 c) was concomitant with the accumulation of *Hyalodendron* sp. propagules in profundal zone, which were replaced by *Verticillium lecani*. In addition, the monoculture of *V. lecani* dominated among proteolytic and pectinolytic plankton of the eutrophic lake. It should be emphasized that in the mesotrophic lake, pectinolytic micromycetes were mainly represented by the *Paecilomyces lilacinus* population. It was noteworth that saprophytic forms of this fungi isolated from soil have strong proteolytic abilities (Domsch, Gams, Anderson, 1980), which has often been stated by the author of this paper (Korniłłowicz, 1991-1992, 1993 a, b). It seems that the alternation of the physiological abilities of some fungi – "aliens" towards less favourable substrates could have been caused by the competition of species which are better adapted to water conditions, for richer source of food i.e. proteins and aminoacids. *Hyalodendron* sp., which can exist in yeast-like forms may serve as an illustration (Meyers, Ahearn, Cook, 1970). Hence, water may constitute the living environmental of the fungus and its source of food (soluble substances). By contrast, *P. lilacinus*, a typical filamentous fungus for which migrating in water is difficult (because of dry spores), probably settles on detritus particles or plankton. Contrary to the populations dominating in water, species with wider substratum spectrum containing, among others, cellulose – a substratum rarely used by planktonic mycoflora (Korniłłowicz, 1994 c) prevailed in bottom sediments of the mesotrophic lake colonized chiefly by *Cladosporium herbarum*. In the muddy bottom sediments of the eutrophic lake *Cephalosporium roseum* was most frequetnly noted.

The results obbtained confirmed the earlier observations of Korniłłowicz (1991) indicating that in the mesotrophic lake fungi which had colonized of plants surface i.e. *Hyalodendron* sp., *Verticillium lecani*, *Cladosporium* spp., *Phoma* spp., *Emericellopsis terricola* occurred most frequently. In the eutrophic lake, however, fungi associated with soil or, its organic matter were most abundant i.e. *Celphalosporium* sp., *Gliocladium* spp., *Trichoderma* spp., *Penicillium* spp. Altough the species isolated are mainly known as saprophytes, some of them, like *Hyalodendron* sp. (conidial *Ceratocystis* stadium) or *Phoma* spp. were mostly represented by fungi potentially pathogenic to higher plants, fungi and insects as in the case of *V. lecani* and *P. lilacinus*.

The results obtained indicated that at least dominant species (*Hyalodendron* sp., *Verticillium lecani, Cladosporium herbarum* and *Cephalosporium roseum*) were metabolically active. This was manifested by the massive occurrence of those fungi and by the range of their physiological abilities matching the physiological activity of particular communities of fungi (K o r n i ł ł o w i c z, 1994 c). The activity of some non-aquatic fungi mentioned above in aquatic environment has also been pointed out by P a r k (1972 a).

In an earlier paper (K o r n i ł ł o w i c z, 1991) the author stressed that factors determining the adaption of non-aquatic fungi to water environment are such propeties as the production of moisturized, spores covered with slime (e.g. *Cephalosporium*) or, as in the case of "areo-water" species (*Cladosporium*) of dry spores, the production of conidiosphores – similar in shape to the spores of aquatic *Hyphomycetes*. In the water environment distribution of other species of geophilic fungi with hydrophobic spores, like *Penicillium* or *Paecilomyces* can be accelerated by forming clusters and by sporulating inside the substratum (P a r k, 1972 a). On the basis of observations presented in this paper we can assume that dimorphism is a possitive feature of filamentous fungi during the adaptation to aquatic environment (an example of which is provided by *Hyalodendron* sp.). This can be accompanied by changes in the catabolism of a fungus towards the domination of anaerobic processes (C o o l e, N a z a w a, 1981), which are relevant during the process of formation of bottom sediments, especially the muddy bottom sediments with wide anaerobic areas (R h e i n h e i m e r, 1977). The phenomenon described above might have accounted for the spreading of *Cephalosporium* in the bottom sediments of Lake Głębokie which was previously observed by the author (K o r n i ł ł o w i c z, 1991). The genus under discussion, like *Hyalodendron* sp., can grow in the yeast-like form (M e y e r s, A h e a r n, C o o k, 1970).

Morpholigical and physiological features of some geophilic fungi make it easier for them to adapt to aquatic environment. It seems, however that the basic factors in this matter are the nutrient requirement of the fungi. In most terrestrial environments e.g. in soil there is a deficiency of nutrients (M a r s h a l, 1980), while eutrophicated waters with a high rate of eutrophication are full of organic matter (K a j a k, 1979). This indicates that the changes of the environment – from land to water – may lead to the decrease in nutrition stress of fungi. This accounts for the great abundance of yeasts in water reservoirs with accelerated eutrophication (C o o k e, 1974).

It is an established fact that the accumulation of inorganic N in water is one the factors responsible for eutrophication of water reservoirs (K a j a k, 1979). In the latest paper (K o r n i ł ł o w i c z, 1994 c) the author stressed that a great number of proteolytic mycoplankton can enhance this process. Now has been show that the increase in the number of fungi decomposing proteins had been concomitant with the increase of two populations of non-aquatic fungi: *Hyalodendron* sp, and *V. lecani.* Therefore we may assume that the massive occurrence of both species of filamentous fungi, as well as stronger development of some species of yeast and yeast-like fungi (M e y e r s, A h e a r n, C o o k, 1970; S i m a r d, B l a c k w o o d, 1971 a, b; Q u i n n, 1984; K o r n i ł ł o w i c z, 1991) could indicate an increase in soil fertility.

Changes in the frequency of occurrence of *Hyalodendron* sp. and *V. lecani* in the mesotrophic lake becoming eutrophic, can also point to the source of organic matter. An increase in the number of *Hyalodendron* sp. was marked during the intesified transport of soil organic matter during the summer stagnation (G ó r n i a k, M i s z t a l, 1991). Additionally the density of *V. lecani* population increased during the period of water blooms in spring and was evident in the area of increased development of phytoplankton and in the area of accumulation of native organic matter e.i. in metha- and hypolimnion (C z e r n a ś, K r u p a, W o j c i e c h o w s k i, 1992, 1993). Those observations allow us to assume that some species of non-aquatic moulds, anallogically to yeast-like fungi – such as *Rhodotorula* spp. and *Cryptococcus* spp. (Q u i n n, 1984; K o r n i ł ł o w i c z, 1991) may not only be indicative of the amount, but also of the type inflowing organic matter.

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Zmiany w składzie gatunków i fizjologiczna aktywność grzybów w dwóch jeziorach różniących się troficznością

Streszczenie

Zbadano skład gatunkowy fizjologicznie zróżnicowanych zespołów grzybów zasiedlających wody i osady denne jezior różniących się stopniem troficzności oraz sposobem użytkowania zlewni. Wykazano, że wszystkie (jeden wyjątek) wyodrębnione grzyby (3051 izolatów) reprezentowały tzw. grzyby nie-wodne. Poszczególne zbiorowiska grzybów charakteryzowały się dominacją odmiennych gatunków. W toni wodnej jez. mezotroficznego o postępującej eutrofizacji ilościowo przeważały populacje *Hyalodendron* sp. i *Verticillium lecani* asymilujące głównie prostsze połączenia C i N-organicznego oraz rozkładające białko. Mikoplankton jeziora eutroficznego zdominowała populacja *V. lecani*. Wyróżniała się ona nie tylko rozpowszechnieniem uzdolnień proteolitycznych lecz również właściwości pektynolitycznych.

W zbiorowiskach grzybów bentosowych największą liczebnością odznaczały się *Cladosporium herbarum* (piaszczyste osady jez. mezotrificznego) i *Cephalosporium roseum* (osady muliste jez. eutroficznego). Wymienione gatunki charakteryzowały się szerszym spektrum substratowym niż odmiany planktonowe.

Częstość pojawów poszczególnych dominantów gatunkowych w jeziorze przechodzącym do eutrofii była uwarunkowana stanowiskiem oraz terminem badań. W bardziej ustabilizowanym troficznie jeziorze eutroficznym rozmieszczenie grzybów było równomierne.