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Further Studies on Aquatic Fungi in the River Biebrza within Biebrza National Park

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Abstract

Zoosporic and conidial fungi species and environmental factors in 12 various sites of the River Biebrza in Biebrza National Park were studied. Samples of water were collected in autumn 1999 and spring 2000 for hydrochemical analysis in order to determine the number of fungal species. Buckwheat-seeds, hemp-seeds, cellophane and snake exuviae were used as bait during exposure in a laboratory. 199 lower aquatic fungus species were found in various sites of the River Biebrza. 16 species were recorded for the first time from Poland.

Keywords: aquatic fungi, hydrochemistry, river, Biebrza National Park

Introduction

The River Biebrza as a right tributary of the River Narew flows in the peaty valley and within Biebrza National Park forms diverse meanders and flooding, thus providing a wide environmental variety for flora and fauna. No wonder that the river valley is a habitat of rare plants and animal species. Preliminary investigations [1-4] have shown the presence of a number of aquatic fungus species in the waters of the park, which are new to Polish waters and rare in general. Therefore, we have decided to carry out a more detailed study of this water area, including different aquatic environments created by the River Biebrza within the Park.

Area of Study

For the purpose of our studies 12 different sites were chosen on the river Biebrza:

Site I - Dolistowo, river Biebrza in localities Dolistowo, round rivers stretch meadows, bank grown *Phragmites australis* (Cav.) Trien. ex Steudel and here and there steps out *Schoenoplectus lacustris* (L.) Pala.

Site II - Dolistowo, old river closed, stagnant water and covered *Lemna minor* L. here and there steps out *Phragmites australis* (Cav.) Trien. ex Steudel and *Nuphar lutea* (L.) Sibth. et Sm.

Site III - Goniądz, river at bridge, not near rivers of building, at bank grows *Phragmites australis* (Cav.) Trien. ex Steudel and *Sagittaria sagittifolia* L.

Site IV - Osowiec, river at bridge, slowly flows, muddy bottom, at bank grows *Phragmites australis* (Cav.) Trien. ex Steudel.

Site V - Osowiec moat, stagnant water, covered *Lemna minor* L., here and there steps out *Phragmites australis* (Cav.) Trien. ex Steudel and *Nuphar lutea* (L.) Sibth. et Sm.

Site VI - Kanał Rudzki, very quick water flows, stony bottom.

Site VII - Olszowe Pole, river Biebrza in localities Olszowe Pole, muddy bottom, at bank grows *Phragmites australis* (Cav.) Trien. ex Steudel and *Hydrocharis morsus-ranae* L.

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Table 1. Chemical composition (in mg l^{-1}) of water from the different sites (n=3) (autumn 1999).

XIISpecification	Sites											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XI
Temperature, ^{o}C	12.3	10.5	12.5	13.0	12.7	12.5	13.0	12.5	12.5	13.0	12.7	11.5
pH	7.46	7.64	7.66	7.81	7.61	7.95	7.72	7.72	7.61	7.92	7.92	8.00
COD (Chemical Oxygen Demand)	6.47	21.56	7.45	9.40	10.58	7.45	7.84	8.43	8.23	9.02	11.17	6.20
CO_2	11.0	17.6	11.0	8.8	13.2	11.0	8.8	11.0	11.0	11.0	15.4	13.2
Alkalinity in $CaCO_3$ (mval l^{-1})	4.6	6.2	4.5	4.5	5.5	4.2	4.2	4.3	4.0	4.4	5.9	5.1
$N\text{-}NH_3$	0.200	0.685	0.365	0.230	0.460	0.350	0.220	0.365	0.180	0.310	0.720	0.145
$N\text{-}NO_2$	0.014	0.012	0.145	0.013	0.006	0.016	0.015	0.015	0.002	0.015	0.007	0.014
$N\text{-}NO_3$	0.020	0.070	0.030	0.150	0.034	0.160	0.210	0.002	0.010	0.020	0.050	0.430
$P\text{-}PO_4$	1.290	0.800	0.900	1.450	1.000	2.600	1.245	1.100	1.900	1.305	0.400	1.450
Sulphates	25.50	11.93	26.33	18.92	11.93	23.64	19.75	24.27	8.64	22.63	7.40	13.16
Chlorides	22.0	28.0	26.0	32.0	32.0	22.0	30.0	21.0	30.0	27.0	21.0	22.0
Total hardness in Ca	72.00	88.56	70.56	72.00	84.96	70.56	66.96	69.84	61.20	70.56	88.56	79.92
Total hardness in Mg	20.64	22.36	19.35	19.78	21.07	17.63	20.21	20.64	18.49	26.66	33.97	23.95
Fe (total)	0.60	1.33	0.45	0.45	0.73	0.45	0.40	0.45	0.20	0.45	1.33	0.48
Dry residue	298	429	279	273	342	266	291	263	232	273	372	287
Dissolved solids	296	389	241	266	342	264	264	258	229	251	370	266
Suspended solids	2	44	38	7	0	2	27	5	3	22	2	21

Site VIII - Olszowe Pole, old river joint with river Biebrza, steps out *Phragmites australis* (Cav.) Trien. ex Steudel, *Nuphar lutea* (L.) Sibth. et Sm. and *Nymphaea alba* L.

Site IX - Olszowe Pole, old river closed, stagnant water steps out *Phragmites australis* (Cav.) Trien. ex Steudel, *Nuphar lutea* (L.) Sibth. et Sm., *Nuphar pumila* (Timm) DC and *Nymphaea alba* L.

Site X - Biały Grąd - river Biebrza, muddy bottom, banks grown *Phragmites australis* (Cav.) Trien. ex Steudel and here and there steps out *Lemna trisulca* L.

Site XI - Biały Grąd, old river joint with river Biebrza, steps out *Phragmites austalis* (Cav.) Trien. ex Steudel and *Nuphar lutea* (L.) Sibth. et Sm.

Site XII - Burzyn, dike on river Biebrza - in place of conscription of tests sampling banks concreted.

Materials and Methods

Samples of water were collected in autumn (October) 1999 and spring (May) 2000 for hydrochemical analysis and the order to determine the number of fungal species. From site IV Osowiec and site VI Kanał Rudzki samples of water to determine zoosporic fungi species were collected every month from October 1999 to May 2000 and in autumn 2002. Nineteen parameters were determined in each water (Table 1) according to the generally accepted methods [5].

The water for analysis was coured into 3 containers for each sites. Water from each site was transferred to three 1.0 litre vessel and added of the baits and placed in the laboratory at ambient temperature. Buckwheat-seeds, hemp-seeds, cellophane and snake exuviae were used as bait during exposure in the laboratory.

The following procedures for the determination of the presence of fungus species on the fragments of baits were employed: during one month of exposure the fragments of baits were examined under a light microscope (once or twice a week) and mycelium of aquatic fungi growing on the baits was recorded. Identification of respective species was based on morphology and biometric data of antheridia and oogonia of the zoosporic fungi and conidiophores and conidia of the hyphomycetes. The following keys were used for zoosporic fungi - Johnson [6],

Table 2. Chemical composition (in mg l-1) of water from the different sites (n=3) (spring 2000).

Specification	Sites											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XI
Temperature,°C	19.0	23.0	17.0	18.0	16.5	16.5	19.0	21.0	21.0	19.8	18.5	17.0
pH	7.45	7.82	8.08	8.01	7.70	8.38	7.76	7.89	7.77	8.14	8.23	8.24
COD (Chemical Oxygen Demand)	9.11	23.76	10.30	9.50	12.28	8.71	9.70	11.88	12.67	14.62	26.14	13.07
CO_2	13.2	11.0	4.4	6.6	13.2	4.4	8.8	11.0	11.0	10.5	6.6	8.8
Alkalinity in $CaCO_3$ (mval l^{-1})	5.5	7.0	4.5	4.5	5.0	4.2	4.2	4.4	4.7	5.2	5.4	4.8
$N\text{-}NH_3$	0.610	1.050	0.400	0.400	0.370	0.280	0.310	0.500	0.570	0.840	0.970	0.530
$N\text{-}NO_2$	0.005	0.011	0.016	0.010	0.003	0.015	0.015	0.013	0.003	0.008	0.006	0.010
$N\text{-}NO_3$	0.050	0.160	0.100	0.240	0.100	0.260	0.262	0.221	0.042	0.125	0.150	0.132
$P\text{-}PO_4$	1.850	0.650	0.310	0.310	0.470	0.751	0.530	0.605	0.530	0.740	0.650	1.094
Sulphates	51.84	11.93	16.87	9.87	13.99	14.81	21.80	14.81	16.46	10.82	5.35	9.05
Chlorides	27.0	37.0	26.0	15.0	19.0	19.0	21.0	34.0	19.0	21.5	48.0	20.0
Total hardness in Ca	63.36	141.58	61.92	60.48	90.00	64.08	66.96	64.80	76.32	80.62	83.52	68.40
Total hardness in Mg	29.24	20.64	28.81	19.35	12.90	17.20	16.77	17.20	12.04	13.02	15.05	12.47
Fe (total)	1.00	2.15	0.50	1.20	0.45	0.30	0.50	0.70	0.70	0.70	1.00	0.85
Dry residue	252	453	252	314	359	235	340	315	317	320	336	272
Dissolved solids	226	437	215	294	318	211	237	308	301	298	326	268
Suspended solids	26	16	37	20	41	14	103	7	16	22	10	4

Sparrow [7], Waterhouse [8, 9], Seymour [10], Bedenek [11], Batko [12], Karling [13],Dick [14], Pystina [15] and for Hyphomycetes - Nilsson [16], Dudka [17, 18], Ingold [19], Carmichael et al. [20], Bräthen [21], Matsushima [22], and works of the authors who were the first to describe the respective species.

The investigate parameter data of water and fungal flora for these investigations were processed by cluster analysis [23].

Results

The physico-chemical properties of water at particular sites in the study period are presented in Tables 1, 2. Substantial differences were revealed in such water trophicity indices as oxidability and nutrients content (nitrogen, phosphates). In October oxidability was lowest at site XII Burzyn and in May at site VI Kanał Rudzki. Its maximum values in October were observed at site II Dolistowo, and in May at site X Biały Grąd and site II Dolistowo. The lowest ammonium nitrogen content in October was revealed at site XII Burzyn, in May at site VI Kanał Rudzki. Its highest content in October was noted at site XI Biały Grąd, in May at site II Dolistowo. The content of nitrates in October was the lowest at site VIII Olszowe Pole, in May at site IX Olszowe Pole, and the highest in October at site XII Burzyn and in May in sites IV Osowiec and VI Kanał Rudzki. The lowest concentrations of phosphates were noted in October at site XI Biały Grąd and in May at sites III Goniądz and the IV Osowiec. The maximum values of phosphates in October were observed at site VI Kanał Rudzki, while in May at site I Dolistowo. In general, in the autumn the water at the sites examined showed higher oxidability and higher content of ammonium nitrate and phosphates, compared to the spring.

At 12 sites in Biebrza National Park 199 lower aquatic fungus species were found, including 108 zoosporic and 91 conidial belonging to Hyphomycetes (Table 3,4, Fig. 1). Most zoosporic fungus species were found to grow in water at sites IV Osowiec and VI Kanał Rudzki, fewest at site II Dolistowo. Most Hyphomycetes species were found at site I Dolistowo and site VIII Olszowe Pole (30 at each), fewest at site III Goniądz [18]. Some of the zoosporic and conidial fungi found in the present study are new to the waters of northeastern Poland. The group

Table 3. Zoosporic fungi found in water of particular sites of Biebrza National Park (a-autumn, s-spring, w-winter).

Species of fungi	Site											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XI
Chytridiomycetes												
Olpidiales												
Rozella septigena Cornu				w		a						
Chytridiales												
Chytriomyces poculatus Willoughby et Townley						w						
Endochytrium ramosum Sparrow	s	s										
Karlingia hyalina Karling						w						
Nowakowskiella elegans (Nowak.) Schr.						w						
Phlyctochytrium aureliae Ajello				w								
Phlyctochytrium parasitans Sparrow						w						
Phlyctochytrium reinboldtae Persiel				w								
Polyphagus euglenae Nowakowski						a,w						
Rhizidium richmondense Willoughby						w						
Rhizophydium ampullaceum (Braun) Fischer						a,w			s			
Rhizophydium apicculatum Karling		s										
Rhizophydium carpophilum (Zopf) Fischer	s		s	s			s	s	s	s		
Rhizophydium coronum Hanson				w								
Rhizophydium elyensis Sparrow				s								
Rhizophydium globosum (Braun) Rabenhorst	s		s	s	s		s		s	s	s	
Rhizophydium keratinophilum Karling						w						
Septochytrium variabile Berdan			s								s	
Blastocladiales												
Allomyces moniliformis Coker et Braxton						a						
Blastocladiopsis parva (Whiffen) Sparrow	s		s	s,a,w	s	a,w						s
Catenaria anguillulae Sorokin	s	s	s	s,a		a						
Catenaria verrucosa Karling	s	s		w		a						
Catenomyces persicinus Hanson						a						
Catenophlyctis variabilis (Karling) Karling	s	s		s,w	s	s,a,w		s		s	s	s
Plasmodiophoromycetes												
Plasmodiophorales												
Woronina polycystis Cornu						a,w						
Oomycetes												
Saprolegniales												
Achlya americana Humphrey			s	a,w		a,w		s		s	s	s
Achlya debaryana Humphrey	s					w						s
Achlya diffusa Harvey ex Johnson				a								
Achlya dubia Coker						w						

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Achlya flagellata Coker						a						
Achlya glomerata Coker				a		a,w						
Achlya hypogyna Coker et Pemberton				w		w						
Achlya klebsiana Pieters						a,w						
Achlya megasperma Humphrey				w								
Achlya orion Coker et Couch				w								
Achlya polyandra Hildebrand				s,w		w		s		s		
Achlya prolifera Coker				s								
Achlya proliferoides Coker				w		w						
Achlya racemosa Hildebrand	s			w		w			s			
Achlya treleaseana (Humphr.) Kauffman				w		s,w						
Aphanodictyon papillatum Huneycutt		s	s			s		s	s	s		
Aphanomyces amphigynus Cutter								s				
Aphanomyces irregularis Scott	s	s	s	s,w	s	w						s
Aphanomyces laevis de Bary	s	s	s	s,a,w	s	s,a,w	s	s		s	s	s
Aphanomyces ovidestruens Gickelh				w		w						
Aphanomyces parasiticus Coker		s		a,w		w						
Aphanomyces stellatus de Bary				a	s	s,a,w			s	s	s	
Brevilegnia unisperma (Coker et Braxton) Coker et Braxton	s			w		a,w		s	s	s	s	
Calyptralegnia achlyoides (Coker et Couch) Coker						w						
Cladolegnia unispora (Coker et Couch) Johannes				w		w						
Dictyuchus monosporus Leitgeb				a,w		a,w			s	s	a	s
Isoachlya anisospora (de Bary) Coker				s,w								
Isoachlya monilifera (de Bary) Kauffman						s						s
Isoachlya toruloides Kauffman et Coker				w								
Leptolegnia caudata de Bary	s				s							s
Leptolegniella keratinophila Huneycutt	s			a,w	s	s,a,w	s	s	s	s	s	s
Protoachlya paradoxa (Coker) Coker				w								
Protoachlya polyspora (Lindst.) Apinis		s		s,w		s,w						
Pythiopsis cymosa de Bary				w	s	a,w						
Saprolegnia anisospora de Bary				w		s,a,w	s		s			
Saprolegnia asterophora de Bary				w								
Saprolegnia diclina Humphrey				w		w						
Saprolegnia ferax (Gruith.) Thuret		s	s	s,a,w		a,w		a			s	
Saprolegnia furcata Maurizio				w		w						
Saprolegnia glomerata (Tiesenh.) Lund	s			s,w	s	w	s	s	s	s		
Saprolegnia hypogyna (Pringhs.) de Bary				w								
Saprolegnia litoralis Coker				w	s	w						
Saprolegnia megasperma Coker				w								

Table 3 continues on next page...

Saprolegnia mixta de Bary				w		a,w						
Saprolegnia monoica Pringsh.				w		w						
Saprolegnia parasitica Coker	s			a,w	s	s,a,w	s		s	s		
Saprolegnia semihypogyna S. Inaba et Tokumasu				a								
Saprolegnia torulosa de Bary						a						
Traustotheca clavata (de Bary) Humph.			s			s,w					s	s
Leptomitales												
Apodachlya brachynema (Hildebr.) Pring.				W								
Leptomitus lacteus (Roth) Agardh						w						
Lagenidiales												
Lagenidium destruens Sparrow									s		s	
Lagenidium humanum Karling				w								
Olpidiopsis saprolegnia (Braun) Cornu						a				a		
Peronosporales												
Phytophthora cactorum (Leb. et Cohn) Schröter						a						
Pythiogeton autossytum Drechsler							s					
Pythiogeton nigricans Batko				a								
Pythiogeton ramosum Minden								s			s	
Pythiogeton uniforme Lund				a			s	s		s		
Pythium afertile Kanouse et Humphrey				w								
Pythium aquatile Höhnk									s			
Pythium artotrogus Sideris				w		w						
Pythium butleri Subram.				a,w		a,w				a	a	
Pythium carolinianum Matthews				w								
Pythium catenulatum Matthews				w			s					
Pythium debaryanum Hesse				a,w		w					a	
Pythium dissotocum Drechsler				w		a,w						
Pythium echinulatum Matthews						a						
Pythium helicandrum Drechsler				w								
Pythium imperfectum Höhnk				a,w		a,w						
Pythium inflatum Matthews						s,w		s		s		
Pythium intermedium de Bary				w								
Pythium multisporum Poitras									s		s	
Pythium myriotylum Drechsler									s	s		
Pythium palingenes Drechsler	s		s		s							s
Pythium perniciosum A.A. Yachevskij et P.A. Yachevskij						w						
Pythium proliferum Schenk		s	s	w	s		s	s			s	
Pythium rostratum Butler				s,w		a,w	s			s	a	
Pythium tenue Gobi				w								
Pythium torulosum Coker et Patterson	s			w								

Table 3 continues on next page...

Pythium undulatum Petersen				w								
Pythium vanterpoolii V. Kouyeas et H. Kouyeas						w						
Zygomycetes												
Zoopagales												
Zoophagus insidians Sommerstorff				a,w		s,a,w	s			a		
Total number	18	12	13	69	14	66	13	15	16	20	18	12

Table 4. Hyphomycetes species found in water of particular sites of Biebrza National Park (a-autumn, s-spring).

Species of fungi	Site											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XI
Acrodictys bambusicola M. B. Ellis	a	a	a	s,a	a	a	a	a	s,a	a	s,a	a
Acrodictys elaeidicola M. B. Ellis	a			a	a	s				a		
Acrodictys martinii Crane et Dumont		s		a	s,a	a				a		
Alatospora acuminata Ing.					s						a	
Anguillospora longissima (Sacc. et Syd.) Ing.	s,a	s	s,a	s,a	a	s,a	s,a		s,a		s	a
Angulospora aquatica S. Nilss.	s,a	s,a	s,a	s,a	s,a	s,a	s,a	s,a	s,a	s,a	s,a	s,a
Arborispora palma Ando	a											s
Arbusculina fragmentans Marvanová et Marvan	a	s,a			s	a				a	a	s
Arthrobotrys silbacea Fres.					a		a					
Bacillispora aquatica S. Nilss.				s								
Beverwykella pulmonaria (v. Beverw.) Tubaki						s				a		
Bidenticula cannae Deighton				s	s							
Blongettia indica Subramanian				a	a	s		a	a	a	a	
Calcarispora hiemalis Marvanová et Marvan	s,a		a	s	s	s			a	a	s	
Canalisporium caribense (Hol.-Jech. et Merc.) Naw. et Kath.				a	s			a	s,a	a	a	
Centrospora aquatica Iqbal	a	a		s,a	a		s,a		a			s
Centrospora filiformis (Greath.) Petersen	s,a	s	s,a	s	s,a	s	s	s,a	s,a	s,a	s,a	s,a
Cladosporium peruamazonicum Matsushima							a					
Clavatospora longibrachiata (Ing.) S. Nilss.	s											
Clavatospora tentacula (Umph.) S. Nills.												a
Colispora elongata Marvanová							a					
Condylospora gigantea Nawawi et Kuth.						s						
Condylospora spumigena Nawawi		s,a				s		s				s
Corynespora cubensis Hol.-Jech.			s,a	s	a		a					
Cylindrocarpon aequatoriale Matsushima							s					
Cylindrocarpon aquaticum Matsushima												s
Dactylaria candidula (v. Höhnel) Bhatt et Kendrick												a
Dactylaria gracilis Duddington									a			

Table 4 continues on next page...

Dactylaria inaequilatera Matsushima	a											
Dactylella submersa (Ing.) S. Nilss.	a		a					a	s		a	
Didymobotrym verrucosum Hino et Katum				a								
Filosporella exilis Gulis et Marvanová		s					s	s				
Flagellospora stricta S. Nilss.	s											
Gyoerffyella myrmecophagiformis Mielnik et Dudka								s	s			
Heliscus lugdunensis Sacc. et Therry	s	a					a			a	a	a
Heliscus submersus Hudson	s,a	s	s,a		s,a	s,a	a	s,a	a		s	s,a
Helminthosporium bigenum Matsushima							s		a	a		
Hyalobelemnospora amazonica Matsushima							a					
Ingoldiella hamata Shaw									s			
Kontospora halophila Roldan et Honr.	s	s,a	s	s	a	s,a	s,a	s,a	a			
Kylindria keitae Ramb. et Onofri					a				s		s	
Kylindria peruamazonensis Matsushima										a		
Lemonniera aquatica de Wild.	s,a	s	s		s,a	s,a	s,a	a		a		s,a
Lemonniera filiforme Petersen			a									
Leuliisinea amazonensis Matsushima			s			a						
Lunulospora curvula Ing.	s,a	s,a	s,a			a	s,a	s,a	a	a	s,a	a
Margaritispora aquatica Ing.			a									
Melanocephala manuensis Matsushima										a		
Malanocepha sp.								a				
Mirandina corticola G. Arnaud	s,a	s,a	s	s,a	s,a	s	a	s	a	a	a	a
Monodictys peruviana Matsushima		a				a		a	s	a	s	
Monodisma fragilis Alcorn									a			
Paraarthrocladium amazonense Matsushima				s,a	s		s	s			s	
Paracryptophiale kamarudolinii Kuth. et Nawawi					s				s			
Paradactylella peruviana Matsushima	s											
Paraepicoccum amazonense Matsushima							a					
Phaedactylium acutisporum Matsushima	s											
Phialogeniculata multiseptata Matsushima						s					s,a	
Piricauda cubensis Hol.-Jech. et Merc.											a	
Pithomyces obscuriseptatus Matsushima											s	
Pleiochaeta amazonensis Matsushima												a
Polycladium equiseti Ing.			a	a								
Polystratorictus fusarioideus Matsushima	a					a	s	a	a			
Pseudaegerita corticalis (Peck.) Crane et Schok.			a			a						
Pseudoanguillospora gracilis Sincl. et Morgan-Jones		s		s								
Pseudohansfordia dimorpha Matsushima				a								
Pseudospiropes lotorus Morgan-Jones								s,a				s,a
Ramichloridium clavulisporum Matsushima							a					

Table 4 continues on next page...

Scolecobasidium lanceolatum Matsushima	s	s										a
Sigmoidea prolifera (Peter.) Crane	a	s,a			s,a			s	s			
Sporidesmium acutifusiforme Matsushima								a	a	a		s
Sporidesmium inflatum (Berk. et Br.) M.B. Ellis						s						
Sporidesmium moniliforme Matsushima				a	a			a	s			
Stachybotrys theobromae Hansf.							a			a		
Stagonospora macropycnidia Cunnell								a			s	
Sterigmatobotrys uniseptata Chang											a	a
Tetracladium marchalianum de Wild.	a	s	s,a	s,a	s,a	a	s,a	a	s	a	s,a	s,a
Tetracladium maxilliformis (Rostr.) Ing.					s							
Titaea clarkeae Ellis et Everh.												s
Tricellula aquatica Webster	s,a	s		s		s		a	s			s
Tricladium angulatum Ing.		a				s						
Tricladium attenautum Iqbal	s			s				s			s	
Tricladium marylandicum Crane		a			a							
Tricladium patulum Marvanová et Marvan	s							s				s
Trinacrium subtile Riess ap. Fres.		s						s			s	s,a
Tripospermum camelopardus Ing. et al.					a		s				s	s
Tripospermum prolongatum Sincl. et Morgan-Jones										a		
Triscelophorus monosporus Ing.	a			s		a						s
Varicosporium delicatum Iqbal	a			a			a				a	
Veronea bothryosa Cif. et Montem.						a						
Volucrispora graminea Ing. et al.								a				a
Total number	30: s-18 a-21	25: s-19 a-13	18: s-11 a-14	26: s-17 a-15	29: s-17 a-20	28: s-17 a-16	27: s-14 a-20	30: s-15 a-21	27: s-15 a-17	22: s-0 a-22	27: s-18 a-16	28: s-17 a-18

of zoosporic fungi new to Polish waters contains *Phlyctochytrium parasitans, Rhizophydium coronum, Rhizidium richmondense, Phytophthora cactorum, Endochytrium ramosum, Karlingia hyalina, Saprolegnia semihypogyna* and *Lagenidium destruens*. The Hyphomycetes, also new to Polish waters, include *Bidenticula cannae, Dactylaria gracilis, Dactylaria candidula, Filosporella exilis, Hyalobelemnospora amazonica, Monodisma fragilis, Pseudoanguillospora gracilis* and *Ramichloridium clavulisporum*.

The cluster analysis of the investigate parameters carried out in water of the River Biebrza during investigations of fungus species has revealed that in spring and autumn is different (Fig. 2,3).

Discussion

The present study has revealed that two sites - the River Biebrza in Osowiec (site IV) and Kanał Rudzki (site VI) are the most abundant in zoosporic fungus species. It does not indicate, however, that there exist the optimum environmental conditions, but may be due to the fact that water samples from these sites were additionally collected. The most common zoosporic fungi at most sites were *Aphanomyces irregularis, Aphanomyces laevis, Catenophlyctis variabilis* and *Leptolegniella keratinophilla*. These species have been quite frequently encountered in our studies on keratin-containing substrates in different limnological types. The conidial fungus species common in that region and found in the water at all sites included *Acrodictis bambusicola, Angulospora aquatica, Centrospora filiformis, Mirandina corticola* and *Tetracladium marchalianum*. They are commonly encountered in our waters, the first two can be even found during heavy cyanobacterial blooming [24].

Most fungus species revealed in the water of Biebrza National Park had already been found in other rivers of northeastern Poland [25-39].

Eight zoosporic species and nine conidial species found in the present study are new to Polish waters. *Endochy-*

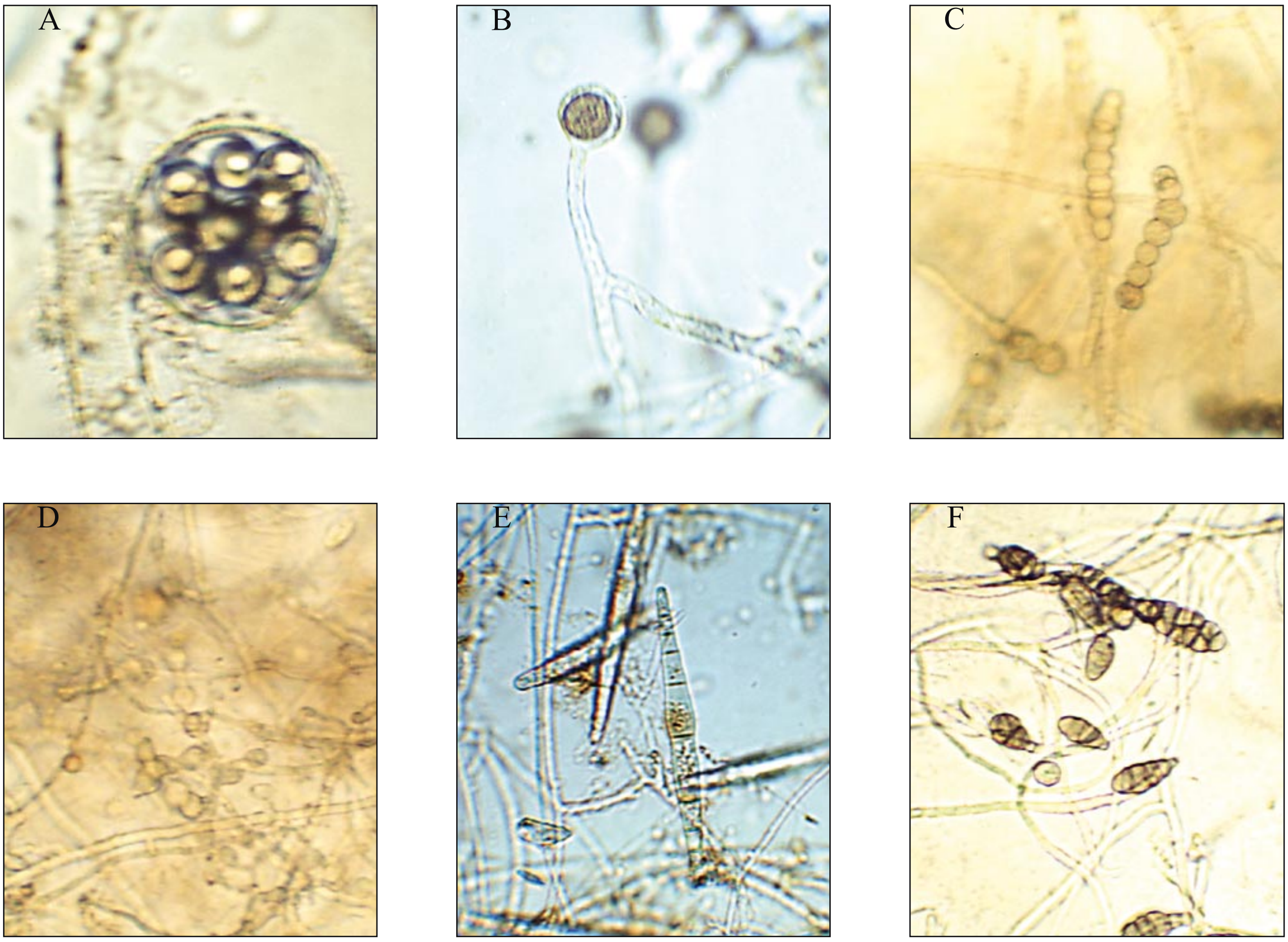

Fig. 1. Some zoosporic (A-D) and conidial (E,F) fungus species from river Biebrza (x 200).
A - *Achlya klebsiana*- oogonia (25-85 µm) with oospores (15-50 µm); B - *Aphanomyces stellatus* -hyphae from oogonia (25-30 µm); C - *Pythium echinulatum* - sporangia (10-30 µm); D - *Pythium vanterpoolii* - sporangia; E - *Paradactylella peruviana* - conidium (37-67 x 3.5-5.5 µm); F - *Pithomyces obscuriseptatus* - conidium (16-22.5 x 11-15.5 µm)

trium ramosum, a zoosporic species, was found to grow in the water collected at site I Dolistowo. This fungus was first described by Sparrow [40] in North America from dead aquatic green algae. *Karlingia hyalina*, known as an aquatic plant saprophyte, was first described by Karling [41] from Brazilian waters. We observed this fungus at site VI Kanał Rudzki in the winter.

Phlyctochytrium parasitans was found to grow on Achlya dubia specimens in water samples collected at site VI Kanał Rudzki in December. It was first described by Sparrow and Dogma [42] from soil samples in the Dominican Republic, where it was isolated from the oogonia of *Achlya flagellata*. This would be the first report on the occurrence of *Phlyctochytrium parasitans* in the aquatic environment. The growth of *Phlyctochytrium reinboldtae* was noted in December in the River Biebrza at the site by the road, being the first aquatic site of that fungus. It was isolated from soil samples by Persiel [43] and later also from soil [44-45]. *Rhizidium richmondense*, another new species to Polish waters, was found in December on cellophane at site VI Kanał Rudzki. This fungus was first described by Willoughby [46] also from soil, with cellophane as bait. It also grows well on onion skin [47]. *Rhizophydium ampullaceum*, never before encountered in Polish waters, was found in site VI Kanał Rudzki in December. In literature it is described as a parasite of filiform green algae [12]. *Rhizophydium coronum* is a plant saprophyte first described from grass leaves [48]. In Biebrza National Park we found this fungus in site VI Kanał Rudzki. *Saprolegnia semihypogyna*, another species new to Polish waters, was found in September 2002 at site IV Osowiec (in bottom of shore). This fungus was first described by Inaba and Tokumasu [49] from soil in Japan. *Lagenidium destruens* is a parasite of other aquatic fungi, particularly those belonging to the genus Achlya, and was first described by Sparrow [7]. In the River Biebrza valley it was observed at site IX Olszowe Pole - the old river-bed. And finally, *Phytophthora cactorum*, also new to Polish waters, was found in October at site VI Kanał Rudzki.

Among the conidial fungus species which appear new to Polish waters *Dactylaria gracilis* and *Dactylaria candidula* are predacious species catching nematodes.

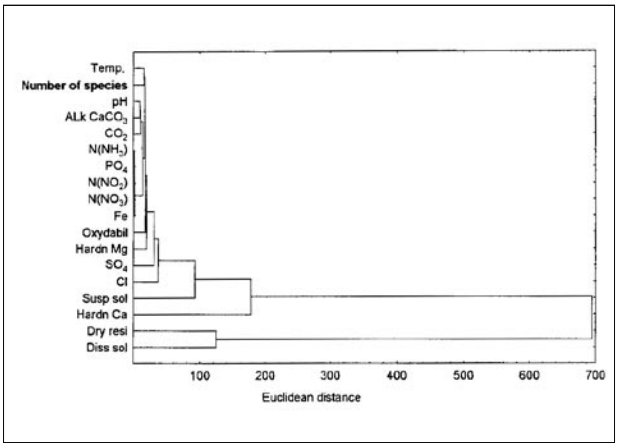

Fig. 2. Clustering of river Biebrza according of water chemistry data and to number fungus species (autumn 1999).

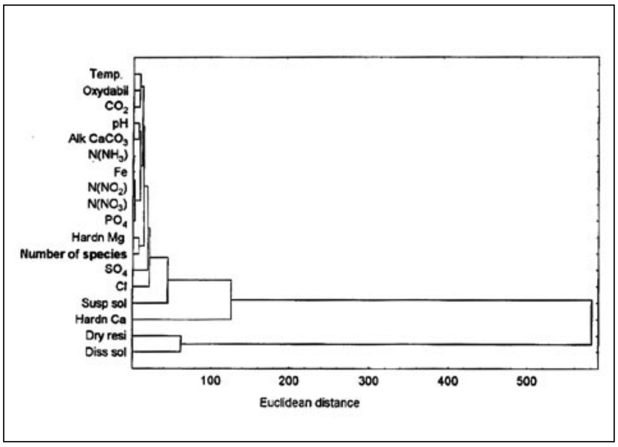

Fig. 3. Clustering of river Biebrza according of water chemistry data and to number fungus species (spring 2000).

The former was first reported from soil by Duddington [50], the latter by Bhatt and Kendrick [51]. In the present study they were both found in the autumn; *Dactylaria gracilis* at site VI Kanał Rudzki and *Dactylaria candidula* at site XII Burzyn. *Bidenticula cannae* was found to grow only in the spring months in the River Biebrza in Osowiec (site IV) and in the water of moat Osowiec (site V). It was observed in land conditions in Africa by Deighton [52] and reported from Rio Itaya, an Amazon tributary [22]. *Filosporella exilis* was first described from the fragments of horsetail *Equisetum fluviatilis* submerged in the water of Busianka stream in Belarus [53]. We found it in the old river-bed closed in the vicinity of Dolistowo (site II) and site IX Olszowe Pole (the old river-bed connected with the River Biebrza), and in the site VII River Biebrza at the site of Olszowe Pole. Species new to Polish waters, such as *Hyalobelemnospora amazonica* and *Ramichloridium clavulisporum* were first described and known from the Amazon Basin. In the present study *Hyalobelemnospora amazonica* was found to grow in the spring and autumn at site VII (Olszowe Pole), while the other species at the site also in the autumn. It was described by Alcorn [54] and encountered in the Amazon tributaries [22]. And finally, *Pseudoanguillospora gracilis* was reported from the State of Alabama in the United States from *Platanus occidentalis* leaves fallen to water [55]. We found this fungus in site IV River Biebrza at the site of Osowiec in the spring and in the old river-bed closed at the site I Dolistowo.

Like in the cases of the National Park [56] and Narew National Park [57], the waters of Biebrza National Park provide a favourable habitat for numerous groups of conidial fungus species belonging to the so called "Amazon fungi", first described at the beginning of the 1990s in South America in the Amazon Basin by Japanese mycologist Matsushima [22]. Twenty three conidial species found in the present study belong to this group. This is a relatively large group of conidial fungus species of which some inhabit springs in Knyszyn Forest [58] or certain lakes in the Suwałki District [38]. This would suggest that Podlasie waters still create favourable conditions for conidial fungus species variety.

There are no geographic barriers for aquatic fungi and therefore the same species can be encountered under different climatic conditions. The group of conidial fungus species described from the Amazon and its tributaries, and recently detected in the waters of northeastern Poland seems to confirm this phenomenon. Winds, air currents and migratory birds are all involved in the intercontinental dissemination of aquatic fungi. Physicochemical factors of a particular water reservoir determine the occurrence of a particular species in the aquatic environment. With a few exceptions, both zoosporic and conidial aero-aquatic and aquatic fungi belong to the group of cosmpolitan organisms [59,60].

The cluster analysis of the respective parameters carried out in water of river Biebrza during study on fungi species has revealed that in spring the number of fungi species is associated with hardness in Mg of water and in autumn with temperature of water. According to literature data an increase in water hardness in certain water-courses leads to a decrease in the number of zoosporic fungi [61] and conidial species [62]. It is generally accepted that the zoosporic and conidial fungi prefer low water temperature [32, 57, 63].

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