ACTA MYCOLOGICA
Vol. 34 (1): 55–64
1999

Zoosporic fungi in springs in the vicinity of Białystok

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Czeczuga B., Kiziewicz B., Wykowska E.: *Zoosporic fungi in springs in the vicinity of Białystok.* Acta Mycol. 34 (1): 55-64, 1999.

Zoosporic fungi and environmental factors in 5 springs were analysed at monthly intervals for one year. A total of 83 zoosporic fungus species were noted. 13 species are new to the hydromycoflora of Poland.

Key words: zoosporic fungi, aquatic fungi, springs, hydrochemical study.

INTRODUCTION

Our studies of aquatic fungi in north-eastern Poland in relation to environmental hydrochemistry have referred to such water bodies as ponds, lakes and rivers (Czeczuga et al. 1997). Investigations of conidial fungi in the spring waters of the Knyszyńska-Białostocka Forest revealed a number of rare species (Czeczuga and Orłowska 1996). Preliminary studies of zoosporic fungi in several springs demonstrated the occurrence of interesting taxa (Czeczuga et al. 1989).

Investigated springs at Table 1 and 2.

Table 1. Characteristics of the springs investigated outside Białystok

Spring	Location in Białystok	Surroundings	Type of spring	Width (m)	Depth (m)	Discharge (l/sek)
Cypisek	N	single pine trees	limnokrenic	0.41	0.17	0.6
Dojlidy Górne	SE	Forests	rheokrenic	0.15	0.08	0.9
Dolistówka	E	withast trees	limnokrenic	0.35	0.15	0.3
Jaroszówka	N	withast trees	limnokrenic	0.65	0.12	2.4
Zwierzyniec	SW	Forests	limnokrenic	0.25	0.06	0.1

Tab
Chemical properties of waters of

Properties	Cypisek				Dojlidy Górne			
	s	sr	a	w	s	sr	a	w
Temperature °C	9.2	12.5	11.2	2.4	8.7	12.5	12.0	3.5
pH	6.85	6.63	7.02	7.38	6.41	7.82	7.07	7.22
COD (Oxydability)	2.8	2.2	4.6	3.0	2.3	7.3	7.4	6.7
CO_2	8.8	15.5	24.2	11.4	11.0	6.6	19.8	13.2
Alkalinity*	5.1	5.8	5.7	5.2	5.1	3.5	5.2	4.8
$N\text{-}NH_3$	0.022	0.122	0.051	0.065	0.072	0.281	0.442	0.425
$N\text{-}NO_2$	0.008	0.008	0.006	0.013	0.006	0.035	0.040	0.030
$N\text{-}NO_3$	0.236	4.700	1.484	0.082	3.550	1.952	0.644	0.396
$P\text{-}PO_4$	1.000	0.850	0.134	1.208	1.008	0.334	0.356	3.332
Cl	20.0	24.5	30.2	20.4	22.4	28.0	28.6	28.4
Total hardness in Ca	121.7	125.3	131.1	44.6	123.8	78.5	110.9	97.2
Total hardness in Mg	18.9	20.2	26.7	18.9	20.2	12.9	22.4	17.2
SO_4	58.8	57.4	63.8	65.2	65.8	64.2	75.3	74.1
Fe	0.52	0.36	0.0	0.64	0.50	0.45	0.34	0.52
Dry residue	525	572	520	620	553	375	477	667
Dissolved solids	505	532	479	405	522	313	254	407
Suspended solids	20	40	41	215	31	62	223	260

* in $CaCO_3$ mval l^{-1}; s – spring, sr – summer, a – autumn, w – winter

The results of the above studies encouraged us to undertake more detailed investigations of zoosporic fungi in springs with regard to seasonal changes.

MATERIAL AND METHODS

Five springs were investigated in the vicinity of Białystok (Table 1). The water of the springs examined had different content of biogenes. The water of Cypisek was the least abundant, while that of Zwierzyniec the most abundant in biogenes. Three water samples from each spring were collected at monthly intervals (January, May, August, October) in 1997 for hydrochemical analysis and determination of zoosporic fungi. For the determination of chemical properties of water the methods recommended by Standard Methods (Golterman and Clymo 1969) were employed.

In the water zoosporic fungi were studied by direct microscopic examination of water samples collected from materials in the water as well as by bait method (buckwheat-seeds, hemp-seeds, cellophane and snake-exuviae). For the identification of species some keys were used (Skirgiełło 1954; Johnson 1956; Sparrow 1960; Seymour 1970; Batko 1975; Karling 1977; Dick 1990).

le 2
particular springs (in mg l^{-1})

Dolistówka				Jaroszówka				Zwierzyniec			
s	sr	a	w	s	sr	a	w	s	sr	a	w
9.5	12.0	13.5	3.5	8.7	12.5	12.8	3.0	8.5	12.0	11.5	2.8
6.42	7.49	7.08	6.89	7.00	7.86	7.02	7.64	6.55	7.63	7.03	7.25
4.5	5.4	6.7	7.6	4.4	10.6	4.2	6.7	7.0	13.6	10.6	8.2
33.0	41.8	26.4	33.0	4.6	2.2	17.6	6.6	13.2	28.6	15.4	28.6
6.5	7.1	4.6	6.9	4.3	4.9	5.3	4.7	5.9	7.3	6.8	8.0
0.293	0.355	0.205	2.545	0.145	1.292	1.370	0.112	0.475	0.762	0.194	0.305
0.015	0.024	0.029	0.047	0.025	0.126	0.044	0.026	0.022	0.325	0.638	0.128
4.348	2.540	2.052	1.364	0.160	0.102	2.212	0.054	0.316	1.672	2.866	0.112
2.742	2.348	0.255	5.112	1.908	3.704	0.128	1.814	1.345	9.082	1.241	4.825
30.8	35.6	40.4	39.2	20.4	15.6	24.4	16.2	63.2	60.4	33.5	31.8
182.2	179.3	108.0	172.8	115.2	38.2	97.9	102.4	162.7	122.3	128.2	162.4
34.8	30.5	18.5	28.4	19.4	5.2	28.4	16.3	27.1	17.1	27.1	41.7
66.2	78.6	84.8	86.4	59.2	19.3	80.6	59.7	113.1	70.4	88.9	115.6
0.62	0.18	0.20	0.52	0.73	1.505	0.32	0.73	0.68	0.75	0.45	0.66
1286	1415	432	1097	451	465	591	450	787	602	552	1030
1260	1414	353	1067	414	254	506	225	760	587	535	941
26	1	79	30	37	211	85	225	27	15	17	89

RESULTS

The morphological features of the springs and their limnological classification according to T h i e n e m a n n (1926) are presented in Table 1. The springs are mostly of limnokrenic type and vary in the rate of discharge from less than 0.1 (Zwierzyniec) to 2.4 l/s (Jaroszówka). The results of chemical analysis of water are presented in Table 2. In the case of ammonia, nitrite nitrogen and phosphorus the minimum mean values were noted in spring Cypisek, whereas for nitrate nitrogen in spring Jaroszówka. The maximum mean values of ammonia and nitrate nitrogen were noted in spring Dolistówka and these of nitrite nitrogen and phosphorus in spring Zwierzyniec.

Altogether 83 species of zoosporic fungi were found in the waters of 5 springs in the vicinity of Białystok (Table 3). Most of thus have been encountered in, of other types of bodies of water in north-eastern Poland. However, such species as *Aphanomyces apophysci*, *Aphanomyces coniger*, *Aphanomyces phycophilus*, *Chytridium lagenula*, *Olpidiopsis achlyae*, *Olpidiopsis aphanomycis*, *Olpidiopsis varians*, *Phytophthora cryptogea*, *Protoachlya polyspora*, *Pythiopsis humphreyana*, *Pythium gracile*, *Pythium pythioides* and *Rozella monoblepharidis-polymorphae* are new to the hydromycoflora of Poland. The highest number of species was found in Jaroszówka (65), whereas the lowest number in Zwierzyniec (34).

Table 3
Aquatic fungi found in particular springs

Taxa	Spring				
	Cypisek	Dojlidy Górne	Dolistówka	Jaroszówka	Zwierzyniec
Chytridiomycetes					
Olpidiales					
Rozella monoblepharidis-polymorphae Cornu			sr		
Chytridiales					
Chytridium lagenula Braun				a	
Chytridium xylophilum Cornu				a	
Karlingia rosea (de Bary et Wor.) Johanson	w				
Nowakowskiella elegans (Nowak.) Schroeter	w				
Phlyctochytrium aureliae Ajello	sr,a		sr,a,w	w	a
Rhizophydium globosum (Braun) Rabenh.			a		
Rhizophydium keratinophilum Karling	sr,a,w	s	a	sr,a	a
Blastocladiales					
Blastocladiopsis parva (Whiffen) Sparrow	s,a,w	w	sr,a,w	s,sr	a,w
Catenaria anguillulae Sorokin			s		
Catenaria verrucosa Karling			w		
Catenophlycis variabilis (Karling) Karling	s,sr,a,w	sr,a,w	s,sr,a,w	s,sr,a,w	s,sr,a,w
Plasmodiophoromycetes					
Plasmodiophorales					
Woronina polycystis Cornu	a	sr	a	sr,a,w	
Oomycetes					
Lagenidales					
Lagenidium destruens Sparrow				sr	
Olpidiopsis achlyae McLarty	s,sr		a,w	s,sr,a	
Olpidiopsis aphanomycis Cornu			sr,a	a	

Olpidiopsis saprolegniae (Braun) Cornu	sr,w	sr,a	s,sr,a	s,a	
Olpidiopsis varians Shanor		a	sr	w	
Olpidiopsis vexans Barret				s	
Saprolegniales					
Achlya americana Humphrey	s,sr,a,w	w	s,a,w	s,sr,a,w	s,a,w
Achlya apiculata de Bary	s,a,w		s,a,w	s,sr,a,w	s,a
Achlya caroliniana Coker	s	sr	s,a	s,a,w	
Achlya colorata Pringsh.	s	s		s	
Achlya debaryana Humphrey	s		sr,a		
Achlya diffusa Harvey ex Johnson				s	
Achlya flagellata Coker	a	a	sr	sr,w	
Achlya klebsiana Pieters	s,w	s,a	s,sr,a,w	s,sr,a,w	s,sr,a,w
Achlya oligacantha de Bary				s	
Achlya orion Coker et Couch	s,a	s,sr	sr,w	s,sr,a,w	s,sr
Achlya polyandra Hildebrand	a	s,w	sr,a	s,sr,a,w	s,a
Achlya prolifera Coker	s,a,w		s,w		sr
Achlya racemosa Hildebrand					s
Achlya treleaseana (Humphrey) Kauffman	s,w	a	s,a,w	w	
Aplanes androgynus (Archer) Humphrey	w	s	s,sr,a	a	
Aphanomyces apophysci Lacy		a		w	
Aphanomyces coniger Petersen				a	a
Aphanomyces irregularis Scott	s,sr,a,w	w	s,sr,a,w	s,sr,w	s,sr,a,w
Aphanomyces laevis de Bary	s,sr,a	s,s	s,sr,a,w	s,sr,a,w	s,a
Aphanomyces parasiticus Coker	a				
Aphanomyces phycophilus de Bary	a			a	s,w
Aphanomyces stellatus de Bary	s,sr,a,w	w	sr,w	sr,w	a,w
Brevilegnia diclina Harvey			s	s	s
Brevilegnia unisperma (Coker et Braxt.) Coker ex Braxt.	w		sr	s,sr,w	w
Calyptralegnia achlyoides (Coker et Couch) Coker				a	
Cladolegnia unispora (Coker et Couch) Johannes	a,w	a	sr,a,w	s,w	s

cont. Tab. 3

Taxa	Spring				
	Cypisek	Dojlidy Górne	Dolistówka	Jaroszówka	Zwierzyniec
Dictyuchus monosporus Leitgeb	sr,a	a	sr,a	s,sr,w	s
Dictyuchus sterilis Coker	a			a	
Isoachlya monilifera (de Bary) Kauffman	a,w	sr,w	s,a	a,w	a
Leptolegnia caudata de Bary	sr		sr,a,w	s	
Protoachlya polyspora (Lindstedt) Apinis	s		s	sr	
Pythiopsis cymosa de Bary	sr,a,w	w	sr,a,w	s,sr,a,w	a
Pythiopsis humphreyana Coker	s,w	w	s	s	s,w
Saprolegnia anisospora de Bary	s,sr,a	sr	s,sr,w	s,sr,a,w	s,sr,w
Saprolegnia delica Coker		s,a		sr	
Saprolegnia diclina Humphrey	s,sr		sr,w	s,sr	sr
Saprolegnia ferax (Gruith) Thuret	s,sr,a,w	s,sr,a,w	s,sr,a,w	s,sr,a,w	s,sr,a,w
Saprolegnia furcata Maurizio	a	s			
Saprolegnia hypogyna (Pringsh.) de Bary			sr		
Saprolegnia megasperma Coker			s,a,w	s,w	
Saprolegnia monoica Pringsh.	a		a	a,w	
Saprolegnia papillosa (Humphrey) Apinis		w		s	
Saprolegnia parasitica Coker	s,sr,a,w	s,sr,a,w	s,sr,a,w	s,sr,a,w	s,sr,a,w
Saprolegnia terrestris Cookson ex Seymour			sr		
Saprolegnia unispora Coker et Couch	a,w	a	sr,a,w	s,w	s
Thraustotheca clavata (de Bary) Humphrey	a,w			s	s,sr,a
Leptomitales					
Apodachlya pyrifera Zopf	sr		sr	sr	
Leptomitus lacteus (Roth) Agardh	sr	s	s,sr,w	sr	s,sr
Peronosporales					
Pythiogeton utriforme Minden	sr,a,w	sr,w	sr	w	

Pythium aristosporum Vanterpool			a		
Pythium artotrogus de Bary			a		
Pythium butleri Subramaniam	w	sr		sr	
Pythium catenulatum Matthews	s,a		w		
Pythium debaryanum Hesse	s,sr,w	sr	sr,w	sr,a,w	w
Pythium dissotocum Drechsler			w		
Pythium gracile Schenk	a		a	a,w	s
Pythium imperfecti Cornu		a	s	s,w	
Pythium inflatum Matthews	s,w	a	sr,w	sr,a,w	s,a
Pythium middletonii Sparrow			sr		
Pythium pythioides (Roze et Cornu) Ramsb.		s	w	w	
Pythium rostratum Butler	s,sr,a,w	s,sr,w	a,w	sr,a,w	s,sr,a,w
Phytophthora gonapodyoides (H.E. Petersen) Buisman		s			
Phytophtora cryptogea Pethybr. et Lafferty	a,w		sr,a,w	a,w	sr
Zoophagus insidians Sommerstorff	w		sr,w	w	
Total	**54:** **s – 25** **sr – 21** **a – 33** **w – 30**	**41:** **s – 15** **sr – 13** **a – 16** **w – 14**	**60:** **s – 21** **sr – 36** **a – 34** **w – 32**	**65:** **s – 33** **sr – 30** **a – 31** **w – 36**	**34:** **s – 24** **sr – 13** **a – 19** **w – 14**

s – spring, sr – summer, a – autumn, w – winter

DISCUSSION

The present study revealed an abundance of zoosporic fungi in springs in the vicinity of Białystok. New species were noted, including three species of the genus *Aphanomyces*. *Aphanomyces apophysci* was first described as a parasite conjugating *Spirogyra* threads (L a c y 1949) while studying the hydromycetes of India. We found it in the waters of Dojlidy Górne in autumn and Jaroszówka in winter. *Aphanomyces coniger* was first described as a saprotroph in waters of Denmark by P e t e r s e n (1910). We found it in the waters of the springs Jaroszówka and Zwierzyniec in autumn. *Aphanomyces phycophilus* had been recognized as a parasite of thready *Chlorophyta* (de B a r y 1858) in the 19th century. In our study *Aphanomyces phycophilus* was present in the springs Cypisek and Jaroszówka (in autumn) and Zwierzyniec (in spring and winter). *Chytridium lagenula* has been known to be a parasite of alga since the 19th century (B r a u n 1851). We found it in the waters of Jaroszówka in autumn.

Three species of the genus *Olpidiopsis* are also new to the Polish hydromycoflora. *Olpidiopsis aphanomycis* was first described by C o r n u (1872) as a parasite of another species of the genus *Aphanomyces*. *Olpidiopsis achlyae* and *Olpidiopsis varians* have been recognized as parasites of fungi of the genera *Aphanomyces* and *Achlya*. The former was first described by Mc L a r t y (1941) and the latter by S h a n o r (1939). In our study all three species were present in all the springs, except Zwierzyniec.

Phytophthora cryptogea, a water and soil plant saprotroph (B a t k o 1975), first described by P e t h y b r i d g e and L a f f e r t y (1919) as a tomato parasite, has been recognized as a parasite of the species of *Solanaceae* and other plants (W a t e r h o u s e 1956). *Phytophthora cryptogea* was present in all the springs, except Dojlidy Górne. Thus, this is the first record of the species in the waters of Poland. *Protoachlya polyspora*, described for the first time by L i n d s t e d t (1972), is regarded as a plant saprophyte inhabiting forest ditches, mosses and moist meadow soil (B a t k o 1975). We found the fungus in the springs Cypisek and Dolistówka (spring) and Jaroszówka (summer).

Pythiopsis humphreyana, reported for the first time by C o k e r (C o k e r and L e i t n e r 1938), is found to grow as an aquatic phytosaprophyte in early spring or winter. In our study thus fungus was present only in spring and winter. Two species of the genus *Pythium* are also new to Poland. *Pythium gracile*, described by S c h e n k (1859) has been reported to be a parasite of algae, particularly of thread green algae. It has been encountered in mountain streams of Crimea (S e r b i n o v 1905) and in lowland rivers like the Wołga (M i l k o and B e l a j e v a 1968). We found *Pythium gracile* in all the springs, except Dojlidy Górne. *Pythium pythioides*

was first described as a parasite of aquatic and semi-aquatic plants by Roze and Cornu (1869) who called it *Cystosiphon pythioides*. Lindstedt (1872) included the species in the genus *Pythium* as *Pythium cytosiphon*, while Ramsbottom (1916) introduced the term *Pythium pythioides*. Paul and Beghadi (1985) found the species to develop as a saprotroph in a pond near Oran in Algeria. In our study, *Pythium pythioides* grew as a saprotroph in the springs Cypisek and Jaroszówka. *Rozella monoblepharidis-polymorphae* was first described by Cornu (1872) as a parasite of the genus *Monoblepharis*. We found it in the waters of Cypisek.

The present study revealed that the largest number of aquatic fungus species was found in Jaroszówka spring, whereas the lowest number of species was noted in Zwierzyniec. The waters of the spring Jaroszówka had a comparatively low concentration of nitrate nitrogen, chloride, calcium and magnesium and a high concentration of iron. In this spring the discharge was the highest. However the waters of Zwierzyniec were characterized by the highest value of oxydability, and alkalinity and nitrite nitrogen, phosphorus, chloride and sulphuride concentrations. The discharge of this spring was the lowest. As regards the seasonal occurrence of aquatic fungi the lowest number of species was noted in summer in all the springs except for Dolistówka.

The present study demonstrated that springs were not only rich in *Hyphomycetes* species, but also provided favourable conditions for the growth of numerous zoosporic fungi which had never been encountered in other types of water bodies in north-eastern Poland.

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Grzyby pływkowe źródeł okolic Białegostoku

Streszczenie

Autorzy w 1997 roku co kwartał badali na tle chemizmu środowiska występowanie grzybów pływkowych w pięciu źródłach okolic Białegostoku. Jako przynęty używano ziaren gryki i konopi, celofanu oraz wylinki węża. Na wymienionych substratach obserwowano rozwój 83 gatunków grzybów pływkowych. Najwięcej gatunków występowało w wodzie źródła Jaroszówka, najmniej zaś w wodzie źródła Zwierzyniec.

W próbach stwierdzono obecność gatunków notowanych w Polsce po raz pierwszy: *Aphanomyces apophysci, A. coniger, A. phycophilus, Chytridium lagenula, Olpidiopsis achlyae, O. aphanomycis, O. varians, Phytophthora cryptogea, Protoachlya polyspora, Pythiopsis humphreyana, Pythium gracile, P. pythioides* a także *Rozella monoblepharis-polymorpha.*