ZOOSPORIC FUNGI IN THE ICE OF SOME WATER RESERVOIRS

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ABSTRACT

The presence of 65 zoosporic fungi species was noted in the water obtained from melting ice from five water (3 ponds and 2 rivers). In the water of the all basins the number of zoosporic fungus species decreases along with the increasing chemical loading (more eutrophic water). Out of these 65 species, 18 are known as necrotrophs of fish. The following fungi were recorded for the first time from Poland: *Achlya conspicua*, *Apodachlyella completa*, *Pythiomorpha undulata*, *Pythium butleri*, *Pythium carolinianum*, *Pythium gracile*, *Pythium imperfectum*, *Pythium indicum*, *Pythium irregulare*, *Pythium myriotylum*, *Pythium papillatum*, *Pythium pyrilobum* and *Pythium rostratum*.

KEY WORDS: zoosporic fungi, ice, ponds, rivers.

INTRODUCTION

Our investigations of aquatic fungi in trophically diverse water basins revealed sulphur hydrogen-induced death of all spore forms of fungi in over-fertile basins in winter period. However, in the water found in the hollows of melting ice we observed atypical mycelia of aquatic zoosporic fungus species (Czczuga et al. 1986a). Thus, it was assumed that the spore forms of these fungi released during ice melting developed in the water that accumulated in the hollows.

To confirm that assumption we determined to analyse the water obtained from melting ice in laboratory conditions for the presence or absence of various forms of zoosporic fungi. The results obtained were so suprising that we decided to publish them.

MATERIAL AND METHODS

The study investigated the ice of stagnant water basins (ponds) and running bodies (rivers) in the vicinity of Białystok (22°43' E long. and 53°21' N lat.). The altitude of this place is 150 m above sea level. Average annual: rainfall 600 mm and insolation 22.4 kJ cm². Mean annual temperature 6.4°C (maximum 18.4°C in July and minimum minus 4.3°C in January). In January 1998, ice blocks (about 25x25 cm thick) were collected from water basins to sterile containers. Then, in the laboratory they were rinsed with distilled water three times and transferred to sterile dishes to melt. The water formed from the ice collected from each type of water reservoirs was distributed to 6 one-litre beakers. Eighteen parameters of this water were determined (Table 1) according to the generally accepted methods (Golterman and Clymo 1969). Temperature in the laboratory was maintained at 1-2°C.

For the determinations of the presence of zoosporic fungi species in the ice water, the following procedure was employed: a part each water poured into previously sterilized 0.5 L beakers, 300 ml each and was added buckwheat-seeds, hemp-seeds, cellophane and snake exuviae as bait. The cellophane and exuviae were cut into small pieces and boiled several times with the water being changed each time. The were placed as bait in the containers with ice water from the various reservoirs. During a 1-mo-period, any kind of cluster from a beaker bottom, side walls and the surface film of water was examined under a light microscope. Identification of respective species was based on morphology and biometric data of zoosporic, antheridia and oogonia, contained in the keys Skirgiełło (1954), Johnson (1956), Sparrow (1960), Seymour (1970), Batko (1975), Karling (1977) and Dick (1990) and in the works of the authors who were the first to describe a respective species.

RESULTS

The results of hydrochemical analysis of water are presented in Table 1. In the case of ammonia, nitrate nitrogen and phosphorus the minimum values were noted in the pond Dojlidy, whereas for nitrite nitrogen in the pond Fosa. The maximum values ammonia, nitrate and nitrite nitrogen and phosphorus were noted in pond the Akcent. During a 1-mo-period sixty-five zoosporic fungus species of the Chytridiomycetes (2) and Oomycetes (63) were found in the water from ice of water basins investigated (Table 2). The were antheridia, oogonia, zoospores and spores of the particular species. The largest numbers of Oomycetes represented the order of Saprolegniales (37 species), Peronosporales (22 species) and Leptomitales (4 species). Most of the fungi

TABLE 1. Chemical properties of water in particular water bodies (in mg l⁻¹).

Specyfification	Pond			River	
	Akcent	Fosa	Dojlidy	Biała	Supraśl
Temperature °C	3.0	1.0	0.0	2.0	0.5
pH	7.48	7.00	7.50	7.31	7.36
O ₂	0.05	1.82	13.60	11.04	11.88
COD (Oxydability)	29.78	15.09	9.38	9.02	8.80
CO ₂	37.4	22.0	4.4	15.4	6.6
Alkalinity in CaCO ₃ *	6.8	5.5	3.0	4.7	4.0
N-NH ₃	1.470	0.854	0.280	0.642	0.324
N-NO ₂	0.292	0.008	0.014	0.011	0.012
N-NO ₃	1.04	0.05	0.03	0.05	0.06
PO ₄	7.182	3.590	0.007	1.504	1.108
Cl	43.0	44.0	26.0	40.0	18.0
Total hardness in Ca	128.16	79.20	56.88	92.16	68.42
Total hardness in Mg	28.80	26.23	13.76	22.34	14.19
SO ₄	90.50	23.04	38.26	68.70	30.85
Fe	1.95	1.05	0.72	0.90	1.02
Dry residue	604.0	429.0	224.0	532.0	236.0
Dissolved solids	593.0	370.0	117.0	496.0	199.0
Suspended solids	11.0	59.0	107.0	36.0	37.0

*in mval l⁻¹

species found in ice have been already encountered in the waters of northeastern Poland, while such species as *Achlya conspicua*, *Apodachlyella completa*, *Pythiomorpha undulata*, *Pythium butleri*, *Pythium carolinianum*, *Pythium gracile*, *Pythium imperfectum*, *Pythium indicum*, *Pythium irregulare*, *Pythium myriotylum*, *Pythium papillatum*, *Pythium pyrilo-bum* and *Pythium rostratum* are new to the hydromycology of Poland. In the water of the all basins the number of zoosporic fungi species decreases along with the increasing chemical loading (more eutrophic water).

DISCUSSION

A number of new species, never encountered in Poland were found in the water from ice of water basins. The species include *Achlya conspicua*, observed in the water from ice of the river Biała. In the relevant literature it has been reported as an aquatic phytosaprophyte or sometimes encountered in sandy soil (Batko 1975). In our study, it was observed in the water from ice of the river Biała. It was first described by Coker in the United States (Coker and Leitner 1938). *Apodachlyella completa* was first reported as *Apodachlyella completa* also from the United States (Humphrey 1893). Then, Indoh (1939) observed its growth in the waters of Japan, describing it as a species of the genus *Apodachlyella*. It is an aquatic and soil saprophyte isolated mainly from flies and hemp seeds. We isolated that fungus from the water from ice collected from a pond Fosa in the palace park. *Pythiomorpha undulata* was found in the water from the ice collected from a bathing pond in Dojlidy. It was first reported by Petersen (1909) from Danish waters as *Pythium undulatum*. Then Apinis (1930), studying aquatic fungi of muddy areas of Latvia described a new species *Pythiomorpha undulata*, believing that it also included the Petersens *Pythium undulatum*. According to Lund (1934), this fungus occurs in Denmark in small basins overgrown with mosses of the genus *Sphagnum*. It should be noted here that our long studies of water of the basins from which ice was collected for the present analysis, conducted in various seasons of the year, never revealed the above zoosporic fungus species (Czeczuga 1996; Czeczuga and Godlewska 1998; Czeczuga and Woronowicz 1994; Czeczuga et al. 1986a, b). Moreover, worthy of notice is a relatively large

number of species of the genus *Pythium* found in the water. In earlier studies we found only a few species of the genus *Pythium* in each of the water basins examined, while the species of the genus *Achlya* and *Saprolegnia* were predominating.

Interesting is also the finding of such zoosporic fungus species as *Achlya papillosa*, *Aphanomyces phycophilus*, *Saprolegnia eccentrica*, *Saprolegnia furcata* and *Saprolegnia turfosa*, which were previously found in single cases on fish eggs as a bait (Czeczuga and Muszyńska 1998).

Among 19 species of the genus *Pythium* found in water from ice, 10 are new to the hydromycology of Poland. *Pythium butleri* was found in water from ice collected from stagnant waters (pond Fosa, bathing pond in Dojlidy) and in running waters (the river Biała and the river Supraśl). It was first described by Subramaniam (1919) in India as a parasite causing diseases in certain cultivated plants. *Pythium carolinianum* was found in the water from ice collected from the river Biała. It was first reported from North Caroliniana as an aquatic alga parasite of the genus *Spirogira* (Matthews 1931). Also *Pythium gracile* was first found on algae of the genus *Spirogira*, *Cladophora* and *Nitella* in the botanical garden in Würzburg (Schenk 1859). In our study it was observed in the water from ice collected from the pond Fosa. *Pythium imperfectum* was noted in the water from ice collected from the pond Akcent. It was first described at the end of the previous century by Cornu (1872). *Pythium indicum* was found to grow both in the water from ice collected from the pond Fosa and from the river Supraśl. It was first described by Balakrishnan (1948), who observed its growth on fruit *Hibiscus esculentus* in Coimatore, Podanur in South India. *Pythium irregulare* was first isolated from the roots of certain cultivated plants in Holland (Buisman 1927). We found it in the water from ice collected from the pond Fosa and the two rivers examined. *Pythium myriotylum*, first isolated from fallen fruits in South Carolina, Florida and in the State of Georgia (Drechsler 1930), is also a new species to the hydromycology of Poland. *Pythium papillatum*, also new to Poland, was found in the river Supraśl. It was first described as a soil saprophyte in North Carolina (Matthews 1928). *Pythium pyrilo-bum* were noted in the water from ice collected from the pond in Dojlidy. That fungus was first described in land conditions – from pine seedlings in Australia (Vaartaja 1965). *Pythium*

TABLE 2. Aquatic zoosporic fungi in ice of particular water bodies.

Taxa	Pond			River	
	Akcent	Fosa	Dojlidy	Biała	Supraśl
Chytridiomycetes					
Chytridiales					
<i>Chytridium xylophilum</i> Cornu		x			
Blastocladales					
<i>Blastocladiopsis parva</i> (Whiffen) Sparrow	x	x		x	x
Oomycetes					
Saprolegniales					
* <i>Achlya caroliniana</i> Coker		x			
<i>Achlya colorata</i> Pringsheim			x		x
<i>Achlya conspicua</i> Coker				x	
* <i>Achlya flagellata</i> Coker	x	x			x
<i>Achlya hypogyna</i> Coker et Pemberton	x				x
* <i>Achlya klebsiana</i> Pieters	x	x			
<i>Achlya megasperma</i> Humphrey			x	x	
<i>Achlya oligacantha</i> de Bary					x
* <i>Achlya orion</i> Coker et Couch					x
<i>Achlya papillosa</i> Humphrey				x	
* <i>Achlya polyandra</i> Hildebrand			x		
* <i>Achlya prolifera</i> Nees					x
<i>Achlya radiosa</i> Maurizio			x		
<i>Achlya treleaseana</i> (Humphrey) Kauffman			x		
<i>Cladolegnia eccentrica</i> (Coker) Johannes					x
<i>Cladolegnia unispora</i> (Coker et Couch) Johannes					x
* <i>Aphanomyces laevis</i> de Bary	x	x	x	x	
<i>Aphanomyces parasiticus</i> Coker			x		
<i>Aphanomyces phycophilus</i> de Bary			x		
* <i>Aphanomyces stellatus</i> de Bary	x	x			x
<i>Aplanes androgynus</i> (Archer) Humphrey	x	x	x	x	x
* <i>Dictyuchus sterilis</i> Coker	x		x	x	
* <i>Isoachlya anisospora</i> (de Bary) Coker				x	
<i>Pythiopsis humphreyana</i> Coker				x	
<i>Saprolegnia anisospora</i> de Bary			x		
* <i>Saprolegnia delicata</i> Coker			x		x
* <i>Saprolegnia diclina</i> Humphrey	x				
<i>Saprolegnia eccentrica</i> Coker		x			
* <i>Saprolegnia ferax</i> (Gruith) Thuret	x	x	x		x
<i>Saprolegnia furcata</i> Maurizio			x		x
<i>Saprolegnia glomerata</i> (Tiesenhausen) Lund			x		
<i>Saprolegnia latvica</i> Apinis			x		x
<i>Saprolegnia litoralis</i> Coker		x	x	x	
* <i>Saprolegnia mixta</i> de Bary			x	x	
* <i>Saprolegnia parasitica</i> Coker	x	x		x	
* <i>Saprolegnia subterranea</i> Dissmann					x
<i>Saprolegnia turfosa</i> (Minden) Gäumann		x	x		
Leptomitales					
<i>Apodachlya branchynema</i> (Hildebrand) Pringsheim			x		
<i>Apodachlya pyrifera</i> Zopf				x	
<i>Apodachlyella completa</i> (Humphrey) Indoh		x			
* <i>Leptomitax lacteus</i> (Roth) Agardh	x			x	
Peronosporales					
<i>Pythiomorpha undulata</i> (Petersen) Apinis			x		
* <i>Pythiopsis cymosa</i> de Bary	x		x		x
<i>Pythium aquatile</i> Höhnk				x	x
<i>Pythium butleri</i> Subramaniam	x	x	x	x	x
<i>Pythium carolinianum</i> Matthews				x	x
<i>Pythium catenulatum</i> Matthews	x	x			
<i>Pythium debaryanum</i> Hesse	x	x	x	x	x
<i>Pythium diacarpum</i> Butler	x	x			
<i>Pythium echinulatum</i> Matthews	x				
<i>Pythium gracile</i> Schenk		x			
<i>Pythium imperfectum</i> Cornu	x				
<i>Pythium indicum</i> Balakrishnan		x			x
<i>Pythium inflatum</i> Matthews	x	x	x	x	x
<i>Pythium intermedium</i> de Bary		x	x		
<i>Pythium irregulare</i> Buisman		x		x	x
<i>Pythium myriotylum</i> Drechsler				x	x
<i>Pythium papillatum</i> Matthews					x
<i>Pythium pyriforme</i> Vaartaja			x		
<i>Pythium rostratum</i> Butler	x	x	x	x	x
<i>Pythium torulosum</i> Coker et Patterson		x	x		x
<i>Pythium vanterpoolii</i> V. Kouyeas et H. Kouyeas		x			x
<i>Zoophagus insidians</i> Sommerstorff	x	x	x		x
Number of species	22	27	30	22	30

*species known in literature as necrotrophs of fish

rostratum, known in literature since the beginning of our century (Butler 1907), was first isolated in France from garden-mould near Antibes.

Chemical analysis of water collected from the basins examined reveals that water trophicity in ponds and rivers was different at that time. The pond Akcent water was trophically the richest, while pond Dojlidy – the poorest. Comparison of the results indicates that the river Biała water contains more biogenes and organic matter than the water of the river Supraśl. Analysis of the numbers of fungi species found in the water of the five basins examined suggests that both in the ponds and the rivers the number of zoosporic fungus species decreases along with the increasing chemical loading (more eutrophic water). We observed a similar phenomenon while studying conidial fungi (Czeczuga and Orłowska 1993).

The data concerning various forms of zoosporic fungi in water from ice obtained in the present study allow to understand to the phenomenon observed in water basins, where in winter periods oxygen is replaced by sulphur hydrogen. During many years studies of fungi in water containing sulphur hydrogen in winter no fungus was cultured with any bait, as sulphur hydrogen destroyed all forms. In the present study, a few days after ice melting, water samples showed the growth of zoosporic fungi. The data obtained allow a proper interpretation of this phenomenon. The spore and other forms of ice-bound zoosporic fungi are protected against sulphur hydrogen destructive effects, while similar forms in sulphur hydrogen-containing water become destroyed. During melting, the spore and other forms get released and develop, filling up free environmental niches. This is of great significance in the so-called fish kill lakes. Fish kills can bring total death of fish and other aquatic organisms, which after melting of ice form a favourable substrate for the fungi preserved in ice cover. This accelerates mineralization of dead organisms drifting on water surface and secreting an unpleasant smell around the basin. Table 2 presents a large group of zoosporic fungi growing on fish, including some of the genus *Achlya* and *Saprolegnia*.

At the present state of knowledge of biology of aquatic fungi the occurrence of certain rare fungi species in ice-melting water still remains unexplained. This refers not only to zoosporic, but also to aquatic conidial fungi (Czeczuga and Orłowska 1999). Our long-term studies on zoosporic and conidial fungi carried out in the same water basins from which ice was collected, as well as, in other reservoirs of northeastern Poland in different seasons of the year, using the same methods and baits, have not revealed the presence of these aquatic fungi species. They were found only in ice-melting water collected from these basins. Moreover, the number of species observed in the adequate volume of ice-melting water is significantly larger than in the same volume of water collected from the same basin not only in winter but in any other season of the year.

This may be associated with water properties during freezing and particularly with surface tension, being the highest at water temp. of 0°. According to Ruttner (1962), a specific biotop is formed in the zone of the highest surface tension, with a specific accumulation of organisms, called neuston. As water temperature decreases, the increasing surface tension of the upper layer seems to attract various forms of neuston-forming aquatic fungi from the lower layers. Thus, their highest condensation occurs in the layer of water which turns into ice. This assumption needs to be confirmed.

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GRZYBY PŁYWKOWE W ŁODZIE KILKU ZBIORNIKÓW WODNYCH

STRESZCZENIE

Autorzy zimą 1998 roku badali na tle chemizmu środowiska występowanie grzybów pływkowych w łodzie trzech stawów i dwóch rzek okolic Białegostoku. Stwierdzono występowanie 65 gatunków grzybów pływkowych, zarówno w obrębie stawów jak i rzek w miarę zwiększania się obciążenia chemicznego wody malała w niej liczba gatunków grzybów.

Achlya conspicua, *Apodachlyella completa*, *Pythiomorpha undulata*, *Pythium butleri*, *Pythium carolinianum*, *Pythium gracile*, *Pythium imperfectum*, *Pythium indicum*, *Pythium irregulare*, *Pythium myriotylum*, *Pythium papillatum*, *Pythium pyrilobum* a także *Pythium rostratum* są gatunkami zarejestrowanymi po raz pierwszy w Polsce.

SŁOWA KLUCZOWE: grzyby pływkowe, łód, stawy, rzeki.