The diversity of aquatic fungi and fungus-like organisms in the Biała River in Białystok, Poland

Bożena Kiziewicz

Department of General Biology, Medical University, Białystok, Kilińskiego 1, 15-089 Białystok, Poland
(e-mail: bkizbiol@amb.edu.pl)

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Abstract. During studies concerning the occurrence of some fungi and fungus-like organisms in the Biała River in Bialystok, forty-three species were established. Among 34 straminipilous fungi, the most common species were *Achlya americana, A. debaryana, A. polyandra, Aphanomyces laevis, Dictyuchus monosporus, Pythium debaryanum, Saprolegnia ferax,* and *S. parasitica.* New for the Polish fungal biota were *Achlya ambisexualis, Calyptralegnia basraensis,* and *Achlya papillosa*. *Achlya crenulata, A. diffusa, A. flagellata, Aphanomyces stellatus,* and *Pythium afertile* were considered rare. Physical and chemical analysis showed that the water of Biała River in Białystok had a high content of ammonium nitrogen and phosphate, reflecting poor cleanliness.

Key words: aquatic fungi, fungus-like organisms, hydrochemistry, Poland, river

Introduction

Fungi are universally present in all types of natural waters and, as decomposers, form one of the most important components of ecosystems. Fungi decompose organic compounds and metal ions in the natural environment. Pollution of local shores is common; therefore, the role of fungi in such situations is important. At the same time, fungi are very sensitive to the action of toxic substances, and consequently can be used as water pollution indicators (Batko 1975; Rheinheimer 1987; Podbielkowski & Tomaszewicz 1996; Dick 2001). Water bodies provide an environment where fungi can be particularly diverse. Mainly, the number of fungal species depends on the amount of organic matter, oxygen concentration, temperature, acidity, and water irradiation. Aquatic fungi mineralize organic matter, helping in the natural purification of water (Podbielkowski & Tomaszewicz 1996; Dick 2001). Studies on water fungi of running waters in Poland (Czeczuga *et al.* 2002a, b; 2005; Kiziewicz 2004a) and in different geographical latitudes (Dick 2001) have shown that although there is a huge number of cosmopolitan fungal species, there are also species peculiar to different running waters. For this reason, studies on running waters contribute, among other things, to our knowledge on the geographical distribution of various fungal species. The Biała River, a small river in Podlasie Province, is characterized by a large number of specific ecological niches. The Biała River flows through Białystok and forms a fairly large pond in the middle of the town (Kędzierzawski 2002).

Whilst carrying out mycological studies on various types of water bodies in north-eastern Poland, we became interested in the fungal species diversity of the Biała River. This study provided the opportunity to determine which particular species take part in the process of natural purification.

Materials and Methods

The study was carried out in 2006-2007. Water used in the experiments was collected from the Biała River, which flows through Białystok and the Knyszyńska Forest and represents a left-bank tributary of the Supraśl River with length of 29.9

km. This river is located in the north-eastern part of Poland. Samples were collected from the site in Białystok, in the upper course of the river (53°21' N, 22°43' E).

Baits of onion skin (*Allium cepa*), hemp-seeds (*Cannabis sativa*), crucian carp eggs (*Carassius carassius*), and snake skin (*Natrix natrix*), were applied to isolate fungi from the water as described by Seymur & Fuller (1987). The baits were transferred to one-liter vessels and poured with water from the respective river site and placed in the laboratory at room temperature. Microscopically determined mycelia were removed from the baits and transferred to sterilized Petri dishes containing sterile water with 200 units of antibiotic (crystal penicillin). The microscopic examinations of the mycelia were repeated every few days. The duration of the experiments was four weeks. The identification of the aquatic fungi and fungus-like organisms was based on morphological characters of the vegetative organs – shape and size of the hyphae; asexual reproductive organs – shape of sporangium and spores; generative organs – structure of the oogonium, oosporangium, and antheridium; and conidiophores and conidia of the anamorphic fungi. Fungi were identified according to the works of Batko (1975), Fassatiová (1983), and Dick (1990a, 2001).

Water samples for physical and chemical, and mycological analyses were collected at the same time. Samples of water were collected from the river with a 1 litre Ruttner sampler (capacity of 2.0 dm^3), approximately 2 m from the shore and 50 cm under the surface. Physical and chemical analyses performed in laboratory conditions measured temperature, pH, O_2, CO_2, alkalinity in $CaCO_3$, ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, phosphates, chlorides, total hardness in Ca, total hardness in Mg, sulphates, Fe, dry residue, dissolved solids, and suspended solids. Physical and chemical parameters were measured using standard methods and followed Dojlido (1995).

Results

The physical and chemical analyses revealed that the water of Biała River in Białystok had a high content of ammonium nitrogen and phosphate, refleelcting poor cleanliness (Table 1). The content of nitrogen forms in the studied water demonstrated second and third class degree of phosphate cleanliness. The oxygen consumption and phosphorus content indicated, in particular, that the water of Biała River was eutrophic and polluted. Analysis of the number of fungi species found in the water of the River Biała examined indicates, that in the river, the number of zoosporic fungus species decreases with the increasing chemical loading (more eutrophic water).

In total, 43 fungi belonging to *Chytridiomycetes, Zygomycetes,* straminipilous and anamorphic fungi were identified (Appendix 1, Figs 1-2). The genera *Achlya* (14 species), *Pythium* (5 species), and *Saprolegnia* (4 species) were most prevalent and were represented in 32.56 %, 11.63 % and 9.30 % of total samples, respectively. The most common species in the Biała River were *Achlya americana, A. debaryana, A. polyandra, Aphanomyces laevis, Dictyuchus monosporus, Pythium debaryanum, Saprolegnia ferax,* and *S. parasitica.* New for the Polish fungal biota were *Achlya ambisexualis, Calyptralegnia basraensis* and *Achlya papillosa. Achlya crenulata, A. diffusa, A. flagellata, Aphanomyces stellatus,* and *Pythium afertile* were rarely obtained in the Biała River.

Table 1. Physical and chemical characteristic (in mg l^{-1}) of water from the Biała River (n = 3)

Specification	
Temperature (°C)	6.7
pH	7.49
O_2	10.36
CO_2	52.48
Alkalinity in $CaCO_3$(mval/l)	4.50
N-NH_4	2.24
N-NO_2	0.031
N-NO_2	0.27
P-PO_4	1.22
Chlorides	78.94
Total hardness in Ca	105.10
Total hardness in Mg	20.65
Sulphates	54.20
Fe	0.56
Dry residue	470
Dissolved solids	451
Suspended solids	19
N-NH_4	6.7
N-NO_2	7.49

Discussion

The waters of the Biała River are eutrophic and quite polluted (Kędzierzawski 2002).

Forty-three species of fungi were encountered in the Biała River. The most common species were straminipilous fungi or fungus-like organisms (*Oomycetes*) *Achlya americana, A. debaryana, A. polyandra, Aphanomyces laevis, Dictyuchus monosporus, Pythium debaryanum, Saprolegnia ferax,* and *Saprolegnia parasitica* (see the list of fungi). Most of the species were previously isolated from Polish water areas (Czeczuga & Kiziewicz 1999; Czeczuga *et al.* 2002c; Kiziewicz 2004a) and from water areas in the world (Dick 2001). Fungi living in water environment represent more than one thousand species (Batko 1975; Dick 2001). In rivers and streams, many representatives of straminipilous fungi (*Oomycetes)* occur.

Saprolegnia ferax and *S. parasitica* belong to the group of fungi, most frequently reported in waters of north-eastern Poland. They have been encountered in a number of places, including springs (Czeczuga *et al.* 1989), melting snow pools

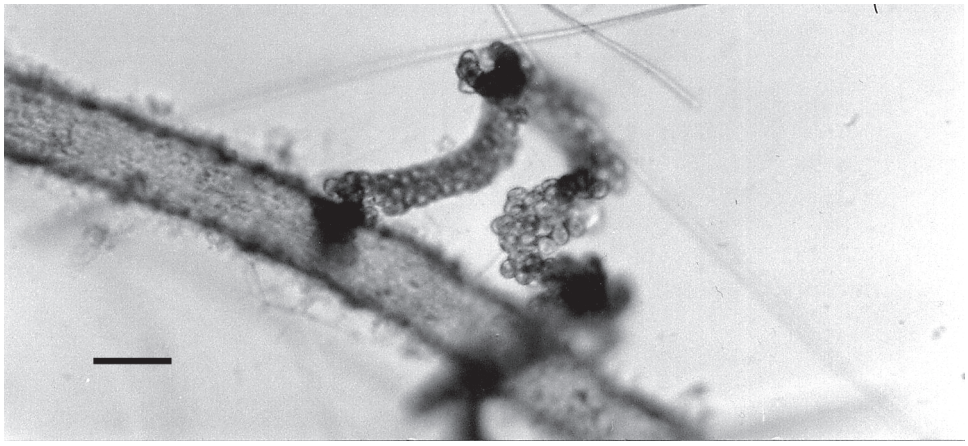

Fig. 1. *Achlya dubia* – a hypha with zoospores. Bar = 20 µm

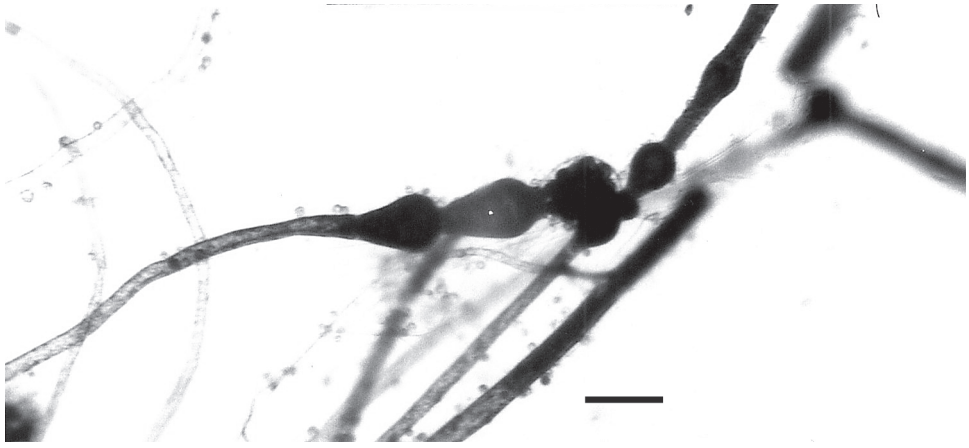

Fig. 2. *Isoachlya monilifera* – oogonia with oospores. Bar = 100 µm

(Czeczuga 1992), sunken well water (Czeczuga *et. al.* 1987), forest streams (Czeczuga *et al.* 1986), the biggest rivers of the region – the Narew, Biebrza, Pisa, Gołdapa, Czarna Hańcza (Czeczuga & Próba 1987; Czeczuga *et al.* 1990; Czeczuga 1991a, c), and lakes such as Wigry, Mikołajskie, Wdzydze, Mamry Lake complex as well as the largest lake Śniardwy (Czeczuga 1991b, d; Czeczuga & Woronowicz 1992, Czeczuga *et al.* 2004b).

The genera *Achlya* (14 species), *Pythium* (5 species), and *Saprolegnia* (4 species) were the most prevalent, representing 32.56 %, 11.63 %, and 9.30 % of the total samples, respectively. At present, about one hundred species from genus *Pythium* are known and half of them live in water (Dick 1990a). These species were considered soil saprotrophs or parasites on plants (Kiziewicz 2005). Our research proved that fungi from genus *Pythium* also grow in different water bodies as phytosaprotrophs and most of them are zoosaprotrophs and fish parasites (Czeczuga *et al.* 1995; Czeczuga 1996b; Czeczuga & Snarska 2001).

Some fungi can change their ecological role as saprobionts into parasites or predators. These fungi use living animals as a source of nitrogen (Czeczuga & Próba 1980; Dick 1990b; Barron 2003). Fungi obtained from chitinous baits in Biala River were: *Euryancale sacciospora, Zoophagus insidians,* and *Zoophagus tentaclum,* which can grow predaciously on protozoas, rotifers, nematodes, and other animals (Kiziewicz & Kurzątkowska 2004). The above mentioned representatives of fungi were frequently found at various latitudes (Saikawa 1986; Powell *et al.* 1990; Czeczuga 1993; Czygier & Boguś 2001; Kiziewicz & Czeczuga 2003; Kiziewicz 2004b). *Catenaria anguillulae,* known as a phyto- and zoosaprotroph, was previously isolated from chitin and keratin-containing substrates (Paterson 1967), from feather of bird, crayfish and fish in surface water in Poland (Czeczuga & Godlewska 1994, 1998; Czeczuga *et al.* 2002b, 2004a). In Biała River *Catenaria anguillulae* was obtained on snake skin. This would indicate that snake skin, which contains keratin, constitute a favourable substratum for the growth of these fungi.

During our studies, the nitrophilic fungus *Leptomitus lacteus* was found in the water of Biała River. According to literature, it is a typical representative of the mycobiota of waters heavy polluted by nitrogen – rich municipal sewage (Dick 2001). Therefore, it occurs in water flows or rivers beneath villages or towns, as it was in the case of the Narew River (Czeczuga *et. al.* 1984; Czeczuga & Próba 1987) the Czarna Hańcza (Czeczuga *et al.* 1990), or Pisa (Czeczuga 1991a). The studied water of Biała River was also quite polluted (Table 1) (Kędzierzawski 2002). *Leptomitus lacteus* also lives as a parasite and necrotroph on fishes (Willoughby & Roberts 1991; Czeczuga *et al.* 1995, 2002a).

The zoosporic species, *Achlya crenulata, A. diffusa, A. flagellata, Aphanomyces stellatus,* and *Pythium afertile,* were

found in the present study in the Biała River and are considered rare to Polish waters. *Achlya flagellata* was isolated for the first time in Poland from peat bog by Zaborowska (1965) and was also found on croak of frogs, eggs of fish, and adult crayfish by Czeczuga & Muszyńska (1997), Czeczuga *et al.* (1998a, b). *Achlya flagellata* caused death to eggs of the fish *Tor tor* during incubation in a hatchery in India (Sati & Khulbe 1981).

These species of fungi and fungus-like organisms supplemented the list of fungi, already found in Bug River, Narew River, and Supraśl River, the biggest rivers in the north-eastern part of Poland (Czeczuga 1995, 1996a; Czeczuga *et al.* 2002b, c).

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Appendix 1. List of aquatic fungi and fungus-like organisms found in the Biała River

Fungi

Chytridiomycetes

Blastocladiales

Blastocladiopsis parva (Whiffen) Sparrow
Catenaria anguillulae Sorokin
C. verrucosa Karling
Catenophlyctis variabilis (Karling) Karling

Chytridiales

Nowakowskiella elegans (Nowak.) J. Schröt.
Phlyctochytrium aureliae Ajello

Zygomycetes

Zoopagales

Euryancale sacciospora Drechsler
Zoophagus insidians Sommerst.
Z. tentaculum Karling

Straminipilous fungi (Oomycetes)

Saprolegniales

Achlya ambisexualis Raper
A. americana Humphrey
A. apiculata de Bary
A. colorata Pringsh.
A. crenulata Ziegler
A. debaryana Humphrey
A. diffusa J.V. Harv. et T.W. Johnson
A. dubia Coker
A. flagellata Coker
A. klebsiana Pieters
A. orion Coker et Couch
A. papillosa Humphrey
A. polyandra Hildebr.
A. proliferoides Coker
Aphanomyces irregularis W.W. Scott
A. laevis de Bary
A. stellatus de Bary
Aplanes androgynus (W. Archer) Humphrey
Calyptralegnia basraensis Muhsin
Dictyuchus monosporus Leitg.
Isoachlya monilifera (de Bary) Kauffman
Leptolegnia caudata de Bary
Saprolegnia anisospora de Bary
S. diclina Humphrey
S. ferax (Gruith.) Thur.
S. parasitica Coker

Leptomitales

Apodachlya pyrifera Zopf
Leptomitus lacteus (Roth) C. Agardh

Pythiales

Pythiogeton utriforme Minden
Pythium afertile Kanouse et T. Humphrey
P. aquatile Höhnk
P. butleri Subraman.
P. debaryanum R. Hesse
P. rostratum E.J. Butler

Number of species: 43