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Fungal parasites of algae in the waters of North-Eastern Poland with reference to the enviroment[1]

BAZYLI CZECZUGA and LUCYNA WORONOWICZ

Department of General Biology, Medical Academy, Kilińskiego 1,
15-230 Białystok, Poland

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In the present work the results of investigations of the fungal parasites of algae in various types of water bodies (slough, ponds, lakes and river) in North-Eastern Poland with reference to the chemical environment are presented.

INTRODUCTION

Among the numerous ecological groups of aquatic fungi, an important place is occupied by those which are parasites of algae (M a s t e r s, 1976). In the studies carried out up to the present, attention was mainly paid to describing new parasitic species, their life cycle and new hosts. In these studies no account whatever was taken of the characteristics of the chemism try of the water in which a given fungus grew.

During the mycological investigations of waters in North-Eastern Poland with respect to the chemistry of these water bodies the relationship between certain species of fungal parasites of algae and chemistry of water was determined.

MATERIAL AND METHODS

Various of water reservoirs differing in size, and trophicity (such as pools, springs, water flows and rivers of various size, ponds and lakes) were investigated in the North-Eastern part of Poland (C z e c z u g a, 1993). Phytoplankton and water for chemical analysis were collected simultaneously from the same sites; chemical

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parameters were determined by means of methods recommended by Standard Methods (Golterman, Clymo, 1971).

In order to determine the occurrence of parasitic aquatic fungi in the cells of algae in a given water body, several plankton net hauls were done with mill gauze no 25 to obtain higher concentration of phytoplankton. Subsequently cells of respective phytoplankton species were examined under the microscope. Skirgiełło (1954), Sparrow (1960) and Batko (1975) keys were employed identification of fungi species.

RESULTS AND DISCUSSION

Results of chemical studies of water at the sites where phytoplankton samples were collected are presented in Table 1 (only data for the water reservoirs not yet published are included in the Table). The data reveal wide range of trophicity in the definied reservoirs, definied by the content of phosphorus and various forms of nitrogen.

In the waters of North-Eastern Poland, the presence of 27 aquatic fungus species which are parasites of phytoplankton was established.

Most of the species identified belong to *Chytridiomyces* (22 species) whereas only a few (4) were representatives of the *Oomycetes* and 1 species belonged to *Hyphochytriomycetes*. (Table 2). The following species were noted:

Achlyogeton entophytum. It has been found in the cells of the genus *Cladophora*. We observed the growth of the fungus in the cells of *Cladophora glomerata* (L.) Kütz. in a river in spring of 1988 and in a river in autumns of 1987.

Aphanomyces scaber. It is known tobe an aquatic and soil saprophyte but has rarely been found to be a parasite of algae. We found individuals of this species in the cells of *Pediastrum duplex* Meyen in the littoral zone of the eastern area of lake Ełk.

Blastocladiella anabaenae. It is known to be parasite of the cells of species of the genus *Anabaena* (Canter, Willoughby, 1964). We found this fungus in the cells of *Anabaena flos-aquae* Brèb.

Chytriomyces cosmarii. It has been found tobe a parasite of various alga species of genus *Cosmarium*. We observed it in the cells of *Cosmarium contracum* Kirch.

Dangeardia laevis. According to Batko (1975) it is a parasite of algae of the genus *Glenodinium*. We observed its growth in the cells of *Cladophora glomerata* (L.) Kütz. in rivers in spring 1985.

Hapalopera fragilariae. This fungus was described by Canter (1950) in the cells of *Diatoma* genus such *Fragilaria* as *Rhizopodium fragilariae*. Batko (1975) reclassified it as belonging to the genus *Hapalopera*. We observed its growth on *Diatoma* cells of *Fragilaria krotonensis* Kitton in the water of the river Węgorapa in spring 1988.

Table 1

Chemical composition of water in particular water bodies (mg l^{-1})*

Specification	River					Lake					
	Czaplinianka	Ełk	Lega	Netta	Strabelka	Ełk	Hołny	Komosa	Krzywe	Niciecz	Przepiórki
Temperature °C	12.4	10.5	11.0	6.8	12.4	12.5	18.5	20.4	12.0	11.6	11.5
pH	8.12	8.04	7.4	7.3	7.95	7.19	7.07	8.2	7.35	7.81	7.51
Oxidiability	8.9	9.8	14.48	8.2	5.8	8.3	8.7	7.8	10.9	312.5	9.0
CO_2	30.8	8.8	39.6	14.3	15.4	17.6	15.4	6.6	15.4	23.1	0.5
Alkalinity in $CaCO_3$ (in mvall^{-1})	3.8	3.6	4.4	3.7	4.4	3.4	3.1	3.0	3.6	4.5	4.0
$N(NH_3)$	0.385	0.06	0.350	0.105	0.175	0.225	0.13	0.445	0.25	0.42	0.274
$N(NO_2)$	0.029	0.016	0.032	0.006	0.021	0.004	0.006	0.01	0.006	0.006	0.01
$N(NO_3)$	0.642	0.095	0.245	0.0	0.08	0.025	0.112	3.305	0.145	0.075	0.145
PO_4	0.180	0.06	3.482	0.24	0.515	3.84	2.024	0.87	1.64	0.002	1.73
Cl	47.0	46.0	42.0	37.0	14.0	40.0	9.0	50.5	43.0	30.0	44.0
Total hardness in Ca	95.76	36.0	90.0	57.6	82.8	47.52	27.36	69.84	46.08	63.36	18.72
Total hardness in Mg	16.34	30.96	21.5	14.62	19.78	20.64	31.02	12.9	24.94	24.08	55.04
SO_4	75.29	0.41	32.1	29.64	67.86	28.39	30.44	40.73	30.44	4.94	29.21
Fe	1.55	0.30	1.6	3.65	0.45	1.58	0.98	1.18	1.4	0.35	1.73
Mn	0.06	0.05	0.05	–	0.04	0.02	–	–	0.01	–	0.02
Dry residue	340.0	398.0	477.0	281.0	463.0	333.5	274.0	187.0	309.0	1219.0	433.0
Dissolved solids	324.0	278.0	422.5	278.0	440.0	307.0	272.0	171.0	302.0	306.0	338.0
Suspended solids	16.0	120.0	54.5	3.0	23.0	26.5	2.0	16.0	7.0	913.0	85.0

*The chemical analysis of water from: lakes Bezimienne, Guber, Ławki, Pogubie Wielkie, Ryńskie, Tałtowisko and Tałty see Czeczuga (1991 a, 1993); river Biała, lake Necko and pond of Branicki palace see Czeczuga and Muszyńska 1994; river Biebrza see Czeczuga et al. (1990 a); river Czrna Hańcza see Czeczuga et al. (1990 b); river Horodnianka and river Narew see Czeczuga and Próba (1987); pond Grażyna see Czeczuga et al. (1988); river Pisa and river Skroda see Czeczuga (1991 b); river Rudawka see Czeczuga and Muszyńska (1993); river Węgorapa see Czeczuga (1991 c).

Table 2

Fungal parasites of algae

Family and species	Water of bodies	Season and date
Chytridiomycetes		
Achlyogeton entophytum Schenk	rivers Rudawka, Netta	spring 1988, autumn 1987
Blastocladiella anabaenae Canter et Willog.	river Biała	autumn 1992
Chytriomycetes cosmarii Karling	lake Necko	winter 1985
Dangeardia laevis Sparrow et Barr	rivers Ełk, Narew	spring 1985, autumn 1992
Hapalopera fragilariae (Canter) Batko	river Węgorapa	spring 1988
Hyphochytrium catenoides Karling	lake Krzywy	autumn 1990
Micromyces zygogonii Dangeard	lake Holny	summer 1992
Olpidium endogenum (Braun) Schroeter	lake Bezimienny	summer 1988
O. entophytum (Braun) Robenh.	lakes Rynski; Tałty	spirng, summer 1988
Phlyctidium apophysatum Canter	lake Rajgród (Przepiórki)	autumn 1990
Phlyctochytrium biporosum Couch	pond of Branicki Palace	spring 1992
P. laterale Sparrow	lake Komosa	summer 1992
Podochytrium clavatum Pfitzer	river Skroda	spring, autumn 1985
Polyphagus euglenae Nowakowski	rivers Narew, Ełk	spring, autumn 1990
Rhizophydium contractophilum Canter	river Czaplinianka	autumn 1992
R. globosum (Braun) Rabenh.	river Węgorapa	autumn 1988
R. laterale (Braun) Fischer	river Laga	autumn 1987
R. planktonicum Canter	lake Ławki	autumn 1988
R. subangulosum (Braun) Robenh.	river Czaplinianka	spring 1992
Septolpidium lineare Sparrow	lake Nieciecz	spring 1992
Zygorhizidium melosirae Canter	lake Tałtowisko	winter, spring 1988
Z. willei Loenthal	pond of Branicki Palace	spring 1992
Hyphochytriomyces		
Rhizidiomyces apophysatus Zopf	pond of Branicki Palace	spring 1992
Oomycetes		
Aphanomyces scaber de Bary	lake Ełk	autumn 1990
Lagenidium marchalianum de Wildeman	pond Grażyna, river Biebrza	spring 1984, autumn 1985
L. rabenhorstii Zopf	lake Guber, river Strabelka	spring 1986, autumn 1986
Myzocytium proliferum Schenk	lake PogubieWielkie, rivers Pisa, Czarna Hańcza, Narew	spring 1986, summer 1986, autumn 1987

Hypochytrium catenoides. It has been found to be a "weak" parasite of cells of algae of the genera *Nitella* (Czeczuga, Muszyńska, 1994 and *Chara*. We found it growing on the thalli of *Chara vulgaris* L. a lake near Rajgród.

Lagenidium marchalianum. A parasite found to date in the *Oedognium* cells. We noted it in the *Oedognium acrosporum* de Bary in rivers (Czeczuga, Woronowicz, Brzozowska, 1990) in 1984, in the pond in spring and autumn.

Lagenidium rabenhorstii. It is known tobe a parasite of the cells of algae of the genera *Spirogyra, Zygnema* and *Oedognium* (S p a r r o w, 1968). It was found growing in the cells *Zygonema insigne* (Hass.) Kütz. in a lake in the Masurian Lake District and in the river Strabelka in spring 1985.

Micromyces zygogonii. It has so far been found in the cells of genera *Zygogonium, Spirogyra, Mougeotia* and *Netrium* it was observed in the cells of *Spirogyra longata* (Vauch.) Kütz. in a lake in the Suwałki Lake District.

Myzocytium proliferum. Considered to be the commonest fungus parasite of the cells of fresh-water algae (B a t k o, 1975) particularly *Chlorophyceae.* We noted it in the cellsof *Cladophora glomerata* (L.) Kütz. and *Spirogyra varians* (Hass.) Kütz. in rivers in a lake in the Masurian Lake District in the rivers Narew and Czarna Hańcza (C z e c z u g a, P r ó b a, 1987).

Olpidium endogenum. It has been found on the cells of *Chlorophyceae* of the genus *Spirogyra* and in representatives of the *Desmidiaceae* family (L i t v i n o v, 1953). It was found in a lake in the Masurian Lake District in the cells of *Closterium moniliferum* (Bory) Ehr.

Olpidium entophytum. It is known tobe a parasite of the cells of species of the genera *Vaucheria, Cladophora, Aegagropila, Oedogonium, Bulbochaete, Spirogyra, Desmidium, Closterium* and *Gloeocystis.* We found this fungus in a lake Rynski in the cells of the algae *Cladophora glomerata* (L.) Kütz. and in lake Tałty – in the cells of *Spirogyra longata* (Vauch.) Kütz.

Phlyctidium apophysatum. It has previously been described as a parasite of the algae of the genus *Mougeotia.* We observed the growth of this fungus in the cells of *Mougeotia* sp. in the deep waters of lake Rajgród.

Phlyctochytrium biporosum. It has been found in the cells of the genera *Spirogyra, Oedogonium* and *Vaucheria.* In Poland it was observed in the cells of *Spirogyra longata* (Vauch.) Kütz. in a ponds.

Phlyctochytrium laterale. A parasite of numerous *Spirogyra* species. We found it in the cells of *Spirogyra varians* (Hass.) Kütz. in lake Komosa.

Podochytrium clavatum. A parasite of numerous *Diatoma* species including the cells of the genus *Pinnularia.* We found it in the cells of *Pinnularia nobilis* Ehr. in the river Skroda, a tributary of the river Pisa (C z e c z u g a, 1991 b).

Polyphagus euglenae. It has been noted in the cells of such *Flagellata algae* as *Euglena* and *Chlamydomonas.* We found it in the river Narew on *Euglena viridis* Ehr. and in the river Ełk at the village of Nowa Wieś Ełcka in April 1990.

Rhizidiomyces apophysatus. It has been found to be a parasite of various alga species of the genus *Vaucheria.* We observed it in cells of *Vaucheria hamata* Walz. in a pond.

Rhizophydium contractophilum. According to C a n t e r (1959) it is a parasite of algae of the genus *Eudorina.* We observed its growth in the cells of *Eudorina elegans* Ehr. in a river Czaplinianka.

Rhizophydium globosum. A parasite of numerous species of *Diatoma, Conjugatae* and *Chlorophyta* (C o u c h, 1932; L i t v i n o w, 1953). This fungus was found in the cells of *Asterionella formosa* Hass. in a river near Węgorzewo.

Rhizophydium laterale. A parasite of various filiform algae (S k i r g i e ł ł o, 1954). We found it in *Cladophora glomerata* (L.) Kütz. cells in autumn 1987 in a river.

Rhizophydium planktonicum. It has been noted in the cells of alga species of the genus *Asterionella*. During our investigations it occurred in the cells of *Navicula radiosa* Kütz. a lake Ławki in the Masurian Lake District.

Rhizophydium subangulosum. It is known to be parasite of the cells of species of the genera *Aphanizomenon* and *Oscillatoria* genera. We found this fungus in the spring of 1992 in the river Czaplinianka in the cells of *Oscillatoria limosa* Ag.

Septolpidium lineare. It is known as a parasite of cells of species of the *Synedra* genus. In our investigations it occurred in a lake on the alga *Synedra acus* Kütz. in April 1990.

Zygorhizidium melosirae. This fungus is a parasite of *Diatoma* of the genus *Melosira*. We noted this species in the cells of *Melosira granulata* (Ehr.) Raifs in a lake in the Mazurian Lake District.

Zygorhizidium willei. It is known as a parasite of cells of species of the genera *Mougeotia*, *Spirogyra* and *Zygnema*. It occurred on *Mougeotia parvula* Hass. pond of Branicki Palace alga *Mougeotia parvula* Hass.

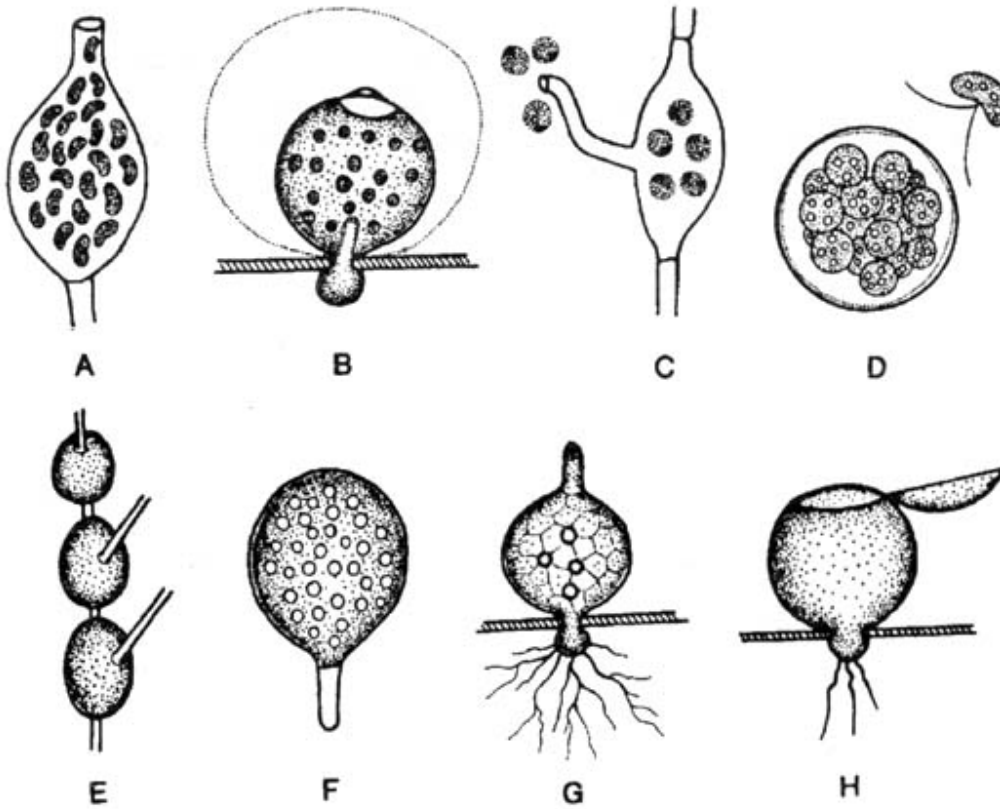

Fig. 1. Some fungal parasites of algae

A — *Blastocladiella anabaenae* – sporagnium from zoospore (8.4 x 5.2 μm); B —*Chytriomyces cosmarii* – thallus; C — *Hyphochytrium catenoides* – part of thallus with the sporangium; D — *Lagenidium rabenhorstii* – sporagnium from zoospore (2 x 7.5 μm); E — *Myzocytium profilerum* – sporangium (22.4 x 14.2 μm); F —*Podochytrium clavatum* – sporangium (14.5 x 7.6 μm); G — *Rhizydiomyces apophysatus* – sporangium (16.5 x 42.0 μm); H — *Zygorhizidium willei* – sporangium (3.5 x 14.0 μm)

The fungal parasites of algae often limit the development of this plankton by exerting a marked influence on the dynamics of phytoplankton and on the development of the various species occuring in a water body (Lund, 1957). This effect was observed in a population of *Diatoma* (Canter, Lund, 1948, 1953; Sparrow, 1951; Sen, 1988 a), *Thallophyta* (Canter, 1968b), in many *Chlorophyceae* species (Sen, 1988 c) and even *Cyanophyceae* (Sen, 1988 b). Such observations have also been made in aquarium cultures of algae (Fott, 1967; Soeder, Maiweg, 1969; Schnepf et al., 1971). Sometimes the infection of the alga cells is extensive. Kobb (1966) noted that in Lake Upper Twain in Colorado every other cell of the *Asterionella formosa* Hass. was infected by *Rhizophydium planktonicum*. In particular, such extensive growth of this fungus was found to occur in August 1958. Many enviromental factors have a significant effect on the intensity of ifection of phytoplankton population by various species of fungi, such as the season, temperature of the water, sun rays and above all the presence and density of the cells of a given alga which is the host of a given fungus (Paterson, 1960; Barr, Hickman, 1967 b; Canter, 1968 a; Canter, Lund, 1969; Masters, 1971; Muller, Sengbusch, 1983; Sen, 1987). The type of host of which a given fungus is a parasite often affects the morphology of this parasite (Barr, Hickman, 1967 a).

As regards the chemical factors in a given body of water, probably their influence on the occurrence of parasitic fungi is of a twofold character. On the one hand the direct effect of the various chemical agents on the development of a given fungus is observed and on the other hand the effect of the chemistry water on the presence of the alga species which are hosts of certain species of fungus is marhed.

The type of water body is not without significance as regards the occurrence of the various fungus species. The type of water body, however, does not appear to have any great effect on some of the species studied. In the investigated area *Olpidium endogenum* and *O. entophytum*, for example, were found only in lakes whereas Litvinov (1953) noted both these species in rivers in Lithuania. In the studies carried out by Litvinov and in the present investigations, on the other hand, *Rhizophydium globosum* and *R. laterale* were found only in rivers and Sparrow (1968) found the *Micromyces zygogonii* in a sphagnum peatbog whereas Johnson (1968) encountered it in volcanic soil in Iceland. We found this fungus growing in the river Węgorapa which flows from a large lake, Mamry Północne, the water of which is similar to the oligotrophic type. Similarly *Lagenidium rabenhorstii* was found by Sparrow (1968) to be a parasite of *Spirogyra* sp. in a puddle in spring whereas we observed this species to be growing in a small river, the Strabelka in spring and in lake Guber in the Mazurian Lake District in autumn. It is also worthy of note that *Zygorhizidium melosirae* has to date been found only in lakes even though the diatom which is the host of this fungus is to be encountered in other types of water bodies. Both Paterson (1958) and Canter (1967) found this fungus only in the water of lakes just as we did in the present studies.

It was interesting to note the occurrence of *Lagenidium marchalianum* in water bodies of different chemistry. The Grażyna pond is characterized by water of a eutrophic type whereas the water of the river Biebrza in which we observed the development of this fungus contains far less biogenetic elements. This also applies to *Myzocytium proliferum*. The water of the river Czarna Hańcza is poor in biogenetic salts whereas the water of the river Pisa is richer in nutrients. The chemical analysis of the water of lake Pogubie Wielkie revealed that its chemical composition differed from the other sites on rivers where we found *Myzocytium proliferum*.

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