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The presence of predatory fungi in the waters of north-eastern Poland

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The work was undertaken to investigate the predatory fungi in the waters of north-eastern Poland. The following predatory fungi were found: *Sommerstorffia spinosa, Zoophagus insidians, Z. pectosporus, Z. tentaculum, Zoopage phanera, Arthrobotrys oligospora* and *Dactylaria brochopaga.*

INTRODUCTION

There is a huge variety of substrates on which aquatic fungi live. They are most frequently found on dead substrate though there are several species which are parasites of other fungus species, algae and aquatic organisms both invertebrates and vertebrates (N o r t o, 1962; B a r r o n, S z i j a r t o, 1982). A separate group of aquatic fungi is that of predatory species which grow freely in an aquatic environment and catch invertebrate animals in their surroundings as their prey (S p a r r o w, 1960; D u d d i n g t o n, 1973).

While conducting studies on aquatic fungi in various types of water bodies with reference to the chemical composition of the water we turned our attention this time to the predatory fungi. It is possible that the occurrence of some of them is related to a given type of water, its trophicity or an appropriate concentration of a different chemical component.

MATERIALS AND METHODS

Samples of water were collected in the years 1980-1992 for hydrochemical analysis and for studies on the various species of aquatic fungi. The water was

collected in a 5-litre Ruttner bucket from the depth at which the bucket was immersed. In the water, the temperature was measured and the following were determined: the pH, CO_2, dissolved oxygen, the oxydability of the water and its alkalinity, the hardness of the water calculated in Ca and Mg, ammonium, organic nitrogen, nitrates, phosphates, chlorides, iron, manganese, sulphate concentrations, dry residue, substances dissolved in the water and the suspension in the water. For determination of the different chemical elements in the water the methods recommended by Standard Methods (G o l t e r m a n, C l y m o, 1971) were employed (details see: C z e c z u g a, P r ó b a, 1980).

The zoosporic fungi in the water were studied by a method based on direct microscopic examination of the water and of materials collected from the water as well as by the bait method (onion skin, hemp-seeds, clover-seeds, snake-skin, hairs and fillings of horn) applied in environmental studies and in the laboratory. The methods were described in detail in a paper by F u l l e r, J a w o r s k i (1986). In addition (for *Hyphomycetes*), the foam collected from the surface of eddies in running water or at the edges of stagnant water was examined directly under a microscope (D u d k a, 1974). The samples were fixed in formalin-acetic-alcohol immedietly after collection and broth to the laboratory.

For determination of the fungi the following keys were used: for *Sommerstorffia spinosa* – S p a r r o w (1960); for all *Zoophagus* species – D i c k (1990); for *Zoopage phanera* – D r e c h s l e r (1935); for two species of *Hyphomycetes* – D u d k a (1974) and I n g o l d (1975).

RESULTS

During the many years' studies of aquatic fungi in the water of north-eastern Poland, the presence of several species of predatory fungi was established (Table 1). These are *Sommerstorffia spinosa* (r)[1], *Zoophagus insidians* (r), *Z. pectosporus* (r), *Z. tentaculum* (r), *Zoopage phanera* (a), *Arthrobotrys oligospora* (n) and *Dactylaria brochopaga* (n). The commonest of these was found to be *Zoophagus insidians*, the presence of which was noted in a spring, the water of melting snow, in a marsh, ponds and in numerous lakes of varying size and trophicity as well as in rivers. On the other hand, during the many years of study the *Zoophagus pectosporus* was encountered in Lake Rospuda (December, 1990) and in a pond by Branicki Palace (December, 1992), where as *Z. tentaculum* only in the river Rudawka (July, 1988).

The data of the hydrochemical analysis of the water bodies studied are presented in Table 2 (in the case of such species as *Zoophagus insidians*, *Arthrobotrys oligospora* and *Dactylaria brochopaga*, data on the lowest and highest values of the hydrochemical parameters of the water bodies are given). As these data show, the chemical composition of the water bodies in which the various species were found varies greatly.

[1] a – cath amoebae, n – catch nemathodes, r – catch rotifers

Table 1

Predatory fungi in the waters of north-eastern Poland

Class and species	Reservoir
Oomycetes	
Sommerstorffia spinosa Arnaudow	**Lake:** Talty **River:** Turośłanka
Zoophagus insidians Sommerstorff	**Spring:** Ribnik **Melting snow:** on ice, on soil substrate, near lindens, near pines and near alders **Marsh:** by Branicki Palace **Pond:** Poryta Jabłoń **Lakes:** Białe Rajgrodzkie, Białe Wigierskie, Ełk, Hańcza, Jaczno, Jagodne, Jędzielewo, Kamenduł, Klusy, Krejwel, Leszczówek, Łuknajno, Necko, Ołów, Rajgrodzkie, Regielskie, Rekielt, Roś, Ryńskie, Śniardwy, Suchar II, Sunowo, Selmęt Wielki, Szelment, Tajno, Wigry and Wiłkokuk **Rivers:** Awissa, Biała, Biebrza, Czarna Hańcza, Ełk, Gołdapa, Horodnianka, Jarka, Kurówka, Liza, Narew, Pisa, Rudawka, Supraśl, Szeszupa, Turośłanka and Węgorapa
Zoophagus pectosporus (Drechsler) Dick	**Pond:** by Branicki Palace **Lake:** Rospuda
Zoophagus tentaculum Karling	**River:** Rudawka
Zygomycetes	
Zoopage phanera Drechsler	**Marsh:** by Branicki Palace **Lake:** Wigry
Hyphomycetes	
Arthrobotrys oligospora Fresenius	**Marsh:** by Branicki Palace **Pond:** Poryta Jabłoń **Lakes:** Boczniel, Dargin, Dobskie, Ełk, Hołny, Kolesne, Leśmiady, Łuknajno, Mierucie, Roś, Selmęt Wielki, Śniardwy, Tajno, Tałty, Widmińskie, Wigry, Wiłkokuk and Woszczelskie **Rivers:** Awissa, Czarna Hańcza, Golubica, Horodnianka, Jarka, Kurówka, Narew, Olszanka, Pisa, Rudawka, Supraśl, Turośłanka and Węgorapa
Dactylaria brochopaga Drechsler	**Lake:** Brzozolasek **Rivers:** Awissa, Horodnianka, Jarka, Kurówka, Liza, Narew, Supraśl and Turośłanka

Table 2

Chemical composition of the water at particular sites (in mg l^{-1})

Specyfication	*S. spinosa*		*Z. insidians*			*Z. pectosporus*		*Z. tentaculum*	*Z. phanera*		*A. oligospora*		*D. brochopaga*	
	Turośląnka river	Tałty lake	ice	Hańcza lake	Biała river	pond	Rospuda lake	Rudawka river	Wigry lake	marsh	Hańcza river	Awissa river	Narew river	Awissa river
Temperature °C	12.4	10.2	2.5	12.0	18.2	1.8	1.6	18.6	14.1	4.2	11.5	18.6	16.2	14.0
pH	8.1	8.0	7.6	8.1	7.4	7.7	7.2	7.4	7.6	7.8	8.3	7.2	7.0	7.6
O_2	7.2	15.6	–	18.3	12.6	7.6	16.4	12.8	14.3	8.5	18.4	0.8	16.2	0.7
Oxidability	6.5	8.2	2.1	5.4	12.2	9.9	8.9	9.1	3.0	5.4	5.6	12.4	1.2	14.8
CO_2	16.6	6.8	6.6	4.4	16.5	63.8	28.6	7.2	1.6	6.2	4.4	18.2	8.8	23.4
Alkalinity in $CaCO_3$*	5.2	3.0	1.1	2.6	4.0	5.4	3.9	2.6	2.5	4.8	3.5	6.4	0.5	7.1
$N\text{-}NH_3$	0.32	0.35	0.16	0.1	3.36	0.82	0.31	0.061	0.005	0.0	0.0	2.8	0.3	3.9
$N\text{-}NO_2$	0.05	0.006	0.01	0.0	2.62	0.009	0.0	0.004	0.003	0.005	0.003	2.0	0.021	3.04
$N\text{-}NO_3$	0.33	0.04	0.0	0.004	0.34	0.06	0.0	0.035	0.018	0.028	0.07	1.4	0.05	1.9
PO_4	0.01	0.99	0.0	0.032	1.18	0.26	0.06	0.312	0.07	0.524	0.09	1.8	0.05	2.1
Cl	49.2	29.0	47.0	15.5	62.5	60.0	50.0	44.5	37.4	52.5	18.0	124.6	37.0	558.0
Total hardness in Ca	31.8	44.0	22.3	35.3	58.3	89.3	63.4	40.8	41.3	110.2	46.8	94.2	14.4	111.2
Total hardness in Mg	6.5	15.2	7.7	9.5	20.0	22.4	14.6	16.8	12.8	17.6	13.8	57.3	2.6	61.2
SO_4	48.6	32.0	30.8	15.2	30.0	52.3	25.9	15.6	20.6	52.7	18.1	50.8	20.4	64.2
Fe	0.0	0.12	0.05	0.0	0.25	0.15	3.7	0.45	0.09	0.1	0.15	1.8	0.05	2.0
Mn	–	0.01	0.0	0.0	–	–	–	–	0.04	–	0.05	–	–	–
Dry residue	477.2	303.5	128.0	172.0	386.0	394.0	301.0	274.0	208.0	498.0	252.0	1020.0	149.0	1398.0
Dissolved solids	365.0	258.3	127.0	164.0	326.0	345.0	191.0	268.0	194.0	483.0	249.0	840.0	130.5	1053.0
Suspended solids	112.2	45.2	1.0	8.0	60.0	49.0	10.0	6.0	34.0	15.0	3.0	180.0	18.5	345.0

* in mval/l

DISCUSSION

Among the seven species of predatory fungi encountered in the waters of north-eastern Poland, the representatives of the *Hyphomycetes* have so far been comparatively most frequently found and at various latitudes (Drechsler, 1935; Peach, 1950; Carmichael et al., 1980). The representatives of the *Oomycetes* and *Zygomycetes* have been so often encountered so far. As regards *Sommerstorffia spinosa* this is a predatory fungus which catches rotifers and lives in soil but above all lives epiphytically on thread-lake algae in water. It is comparatively rare having been found so far in only 6 places. It was first described by Arnaudow (1923) in rotifer cultures in Bulgaria. It was next found in North America (Sparrow, 1929; Karling, 1952), Great Britain (Prowse, 1954) and in Japan (Saikawa, 1986). In the waters of north-eastern Poland, it was first observed in the water of the river Turośląnka (Czeczuga, Próba, 1980, 1987; Czeczuga, Próba, Brzozowska, 1984). In recent years we found this fungus in littoral part of Lake Tałty in the Masurian Lake District. This is the first time this fungus has been found in a lake. It was previously found in soil or in small bodies of water or small rivers. In our case, both the water of the river Turośląnka and of Lake Tałty had a basic character (pH 8.0-8.1) and similar values of such parameter as oxidability, alkalinity, $N\text{-}NH_3$ and $N\text{-}NO_2$. The water of the river and lake, however, different in their content of such components as O_2, CO_2, $N\text{-}NO_3$, $P\text{-}PO_4$, Cl and Fe.

Zoophagus insidians Sommerstoff, 1911. The biology and morphology of this fungus in the waters of France were studied by Mirande (1920) and, in the waters of Bulgaria, by Arnaudow (1921, 1925). The mechanism of catching rotifers by this fungus is described by Whistler and Travland (1974); the niches in which they are usually found are given in Dodge's paper (1983) and the structure of the forms of reproduction were described by Powell, Hayburn, Toadvine (1990). The systematic characteristics of this fungus are presented by Dick (1990). In the north-eastern region of Poland we have found this species in widely varied types of water bodies from puddles of melting snow (Czeczuga, 1992), to river Czarna Hańcza (Czeczuga, Brzozowska, Woronowicz, 1990) and the largest lake in Poland, Śniardwy 10524.5 ha (Czeczuga, 1991 a). These waters present a wide range of variations in hydrochemical parameters.

Zoophagus pectosporus Drechsler described in 1962 as *Acaulopage pectospora* but was latter reclassified by Dick (1990) as belonging to the *Zoophagus* genus. The occurrence of this fungus in Indian soils was reported by Das-Gupta and Shome (1965) and in the waters of Japan by Miura (1967). By means of an electron microscope Saikawa and Morikawa (1985) and Saikawa et al. (1988) demonstrated the common and differentiating features of the structure of the mycelium of this species as compared with the *Zoophagus insidians*. In our study, we found *Zoophagus pectosporus* in the littoral part of Lake Rospuda and pond by Branicki Palace in December. At the time when this fungus occurred, the water at

the site the lake was characterized by an increase concentrations of CO_2, Cl, Ca and Fe but with minimal (0.06) P-PO_4 concentrations. Furthermore at that time there was no N-NO_2 or N-NO_3 in the water. However the water of pond by Branicki Palace in December 1992 is characterized by a comparatively highest concentrations of all parameters except only of oxygen and iron.

Zoophagus tentaculum K a r l i n g, 1936. After revising the taxonomy of species belonging to the *Zoopagales*, D i c k (1990) confirmed the significant features characterizing this species. In north-eastern Poland, we observed the growth of *Zoophagus tentaculum* in a small river, Rudawka, flowing from a peatbog, Rudawe, not far from the village of Plutycze in July 1988. The water of the river Rudawka at the time had an increased phosphorus concentration and neglible ammonia concentration.

Zoopage phanera D r e c h s l e r, 1935 described as a predatory fungus which caught amoebae. We observed the growth of this fungus in the autumn months (VIII--IX) both in respect of size and the content of some hydrochemical parameters of water bodies (at two entirely different places). These were a marsh (0.5 x 1 m) and one of the largest lakes (2170 ha) in Poland, Lake Wigry (C z e c z u g a, 1991 b). The water in the sampling sites of this two bodies of water differed first and foremost in the P-PO_4, calcium and sulphate concentrations.

The water bodies in which the representatives of the *Hyphomycetes* occurred were found to have particularly wide range of variations of the hydrochemical parameters. This applies above all to forms of nitrogen, phosphorus, chloride, calcium, magnesium, sulphate, iron, dry residue, substances dissolved and substances suspended in water. In addition, while *Arthrobotrys oligospora* was found in marshes, ponds, lakes and rivers, *Dactylaria brochopaga* was usually encountered in rivers and, of the several score lakes studied; this fungus occurred only in the littoral area of a dystrophic lake, Brzozolasek (159.4 ha and maximum depth 18.0 m) (C z e c z u g a, 1991 a).

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