ACTA MYCOLOGICA
Vol. 30 (2): 181-191
1995

Mycoflora of the Narew River and its tributaries in the stretch between Tykocin and Ostrołęka

BAZYLI CZECZUGA

Department of General Biology, Medical Academy,
Kilińskiego 1, 15-230 Białystok 8, Poland

C z e c z u g a B.: *Mycoflora of the Narew River and its tributaries in the stretch between Tykocin and Ostrołęka.* Acta Mycol. 30 (2): 181-191, 1995.

In the years (1987-1989) the author investigated of the mycoflora and the effect of environmental factors in the Narew River and its tributaries on the occurrence of various aquatic fungi. At the sites investigated the presence of 89 aquatic fungi species was noted. In total 10 fungi new to mycoflora of Poland were found at the investigated sites. The presence of *Tripospermum gardneri*, in the Olszanka River is worthy of notice.

Key words: hydromycoflora

INTRODUCTION

The Narew River is one of the largest rivers in the north-eastern region of Poland. It is characterized by an abundance of different ecological niches and numerous tributaries. For this reason in the studies of the hydromycoflora in the north--eastern region of Poland we first turned our attention to the water of this river. In the first stage of these studies, we investigated the hydromycoflora in the stretch between Suraż and Tykocin, which is known to abound in meanders and old river beds (C z e c z u g a et al., 1984; C z e c z u g a, P r ó b a, 1987; C z e c z u g a, 1990).

Some years later, similar investigations were carried out in the upper part of the Narew together with its tributaries in the stretch between the Polish border (Siemianówka) and Doktorce (C z e c z u g a, 1995). The present paper is a continuation of the studies of the Narew River hydromycoflora. This time the stretch between Tykocin and Ostrołęka was investigated together with its 9 main tributaries with the exception of the Pisa River, the hydromycoflora of which had been investigated and the results published (C z e c z u g a, 1991). The preliminary results of the studies on the hydromycoflora of the Biebrza River were also published (C z e c z u g a et al., 1990).

MATERIAL AND METHODS

For the purpose of our studies 17 different sites were chosen on the lowland Narew River (Table 1); the sites were located in the section of the river betweeen Tykocin and Ostrołęka (Sites 1-5) and on 12 of its tributaries (Sites 6-17). Samples of water were collected in spring and autumn (3 samples from each site) over the years 1987-1989 for hydrochemical analysis and for studies of the various species of aquatic fungi in the water.

For determinations of different chemical properties of water, the methods recommended by Standard Methods (G o l t e r m a n, C l y m o, 1971) were employed.

Aquatic zoosporic fungi were analysed by district microsporic examination of the water as well as from materials collected in the water and by means of the bait method (onion skin, hemp-seeds, clover-seeds, hairs and fillings of horn) applied in environmental studies and in the laboratory (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 (A r n o l d, 1968). The samples were fixed in formalin-acetic-alcohol immediately after collection and brought to the laboratory.

The keys used for identification of fungi species were as follows: S k i r g i e ł ł o, 1954; J o h n s o n, 1956; S p a r r o w, 1960; S e y m o u r, 1970; B a t k o, 1975; I n g o l d, 1975; K a r l i n g, 1977; D u d k a, 1974, 1975; D i c k, 1990.

RESULTS

The data (Table 2) revealed a wide range of trophicity in the water reservoirs studied, defined by the content of phosphorus and various forms nitrogen. The values of these and other parameters were within the range of variability of polytrophic (Narew, Gać and Jabłonka Rivers) and eutrophic waters (in others rivers).

In the waters of the Narew River and its 9 tributaries between Tykocin and Ostrołęka, the presence of 89 aquatic fungi species was established, of which twenty seven belonged to the *Chytridiomycetes*, 2 – to the *Hyphochytriomycetes*, 40 – to the *Oomycetes*, 4 – to the *Endomycetes* and 16 species to the *Hyphomycetes* (Table 3). The highest number in the Slina River. It is worthy of notice that a number of rare fungi species and some new species were found. In the Nereśl River these were: *Rhizophydium nodulosum, R. piligenum, Rhizidium verrucosum, Diplophlyctis complicata, Karlingia chitinophila, Catenaria anguillulae, Leptolegniella keratinophila, Rhizidiomyces apophysatus, R. bivelatus, Apanodictyon papilatum, Achlya dubia* and *Calyptralegnia achlyoides*.

On the other hand, in the Biebrza River the following fungi belonged to this group: *Achlya klebsiana, A. prolifera. Mitochytridium regale* and *Tripospermum gardneri* (the Olszanka River, a tributary of the Biebrza). In the Narew River, however, only one species i.e. *Obelidium mucronatum* can be included in this group.

Table 1

Characteristics of the investigated rivers

River and No of Site	Length (km)	Catchment area (km²)	Slope m/km	Mean (m)	
				Width	Depth
NAREW	484.0*	75155.2**	0.33		
Site 1 – Tykocin				37.0	2.0
Site 2 – Wizna				43.1	2.0
S ite 3 – Łomża				52.0	2.0
Site 4 – Nowogród				72.0	1.5
Site 5 – Ostrołęka				73.0	2.0
NEREŚL	37.1	283.1	1.43		
Site 6 – Dudki				4.2	0.3
Site 7 – pond Czechowizna					1.0
Site 8 – Wyszowate				5.5	0.5
SLINA	35.0	359.7	1.29		
Site 9 – Zawady				5.0	0.6
BIEBRZA	164.0	7067.0	3.92		
Site 10 – Sztabin				4.5	1.2
Site 11 – Osowiec				7.4	1.5
NETTA	102.5	1336.1	2.80		
Site 12 – Białobrzegi				4.2	1.2
OLSZANKA	8.3	0.9	0.64		
Site 13 – Suchowola				4.5	0.5
ŁOJEWEK	23.2	150.0	0.12		
Site 14 – Bożejewo				2.1	0.4
GAĆ	21.0	445.9	1.91		
Site 15 – village Gać				2.0	0.3
JABŁONKA	27.0	162.5	0.41		
Site 16 – Poryte Jabłoń				2.5	0.3
OMULEW	114.0	2052.8	0.65		
Site 17 – Podrężewo				15.1	1.0

* – in Polish border 448.1 km; ** – in Polish border 53787 km²

Table 2

Chemical properties of waters in the rivers studies
(mg l^{-1})

Specification	Site (see Table 1)							
	1	2	3	4	5	6	7	8
Temperature °C	21.0	18.2	18.4	18.8	16.2	14.8	16.1	15.2
pH	7.4	7.8	7.7	7.8	7.6	7.8	7.3	7.6
O_2	14.0	14.8	16.0	15.6	8.0	14.2	5.6	11.4
Oxydability	12.4	8.2	8.3	8.1	8.1	4.4	27.4	5.4
CO_2	9.9	11.0	11.0	13.2	13.2	7.7	12.1	11.0
Alkalinity in $CaCO_3$ (in mval l^{-1})	4.1	4.4	4.2	4.3	4.2	5.1	2.7	5.2
N-NH_3	1.81	0.42	0.53	0.40	0.60	0.07	0.47	1.68
N-NO_2	1.42	0.02	0.03	0.03	0.04	0.03	0.02	0.10
N-NO_3	0.34	0.0	0.03	0.04	0.16	0.03	0.07	0.05
PO_4	0.27	3.55	2.34	3.61	2.52	0.77	0.12	0.27
Cl	26	32	33	34	35	22	40	24
Total hardness in Ca	59.1	62.6	63.4	64.1	68.4	76.5	31.7	74.9
Total hardness in Mg	15.5	18.1	19.5	20.2	15.9	23.7	29.2	19.4
SO_4	28.8	26.7	22.2	22.6	28.0	18.1	6.2	19.3
Fe	0.45	0.20	0.20	0.00	0.25	0.50	0.35	0.58
Mn	–	–	–	–	0.10	–	–	0.05
Dry residue	297	345	417	243	321	486	301	478
Dissolved solids	268	318	348	227	304	450	231	361
Suspended solids	29	27	69	16	17	36	70	117

Specification	Site (see Table 1)								
	9	10	11	12	13	14	15	16	17
Temperature °C	17.0	16.4	16.2	16.5	15.8	14.2	16.0	18.5	15.8
pH	7.6	8.0	8.1	8.1	7.4	7.8	7.7	7.3	7.6
O_2	8.8	5.6	–	10.2	8.2	11.4	20.1	0.0	12.4
Oxydability	5.1	6.4	6.7	6.9	9.4	3.5	5.0	12.8	6.2
CO_2	15.4	41.8	29.7	4.4	17.6	13.2	6.6	17.6	11.8
Alkalinity in $CaCO_3$ (in mval l^{-1})	5.8	4.6	4.6	3.5	4.8	4.1	3.0	5.7	4.2
N-NH_3	0.08	0.30	0.50	0.12	0.22	0.0	0.0	0.0	0.0
N-NO_2	0.01	0.01	0.02	0.00	0.01	0.01	0.01	0.02	0.02
N-NO_3	0.03	0.00	0.18	0.02	0.00	0.07	0.44	17.3	0.09
PO_4	0.82	0.24	0.13	0.26	0.17	0.86	1.38	28.1	0.94
Cl	23	39	36	21	39	20	13	42	21
Total hardness in Ca	86.4	50.4	67.0	22.3	80.6	67.7	43.9	72.0	60.4
Total hardness in Mg	20.6	36.6	24.5	28.8	21.9	13.3	11.6	28.8	16.8
SO_4	28.4	12.3	29.2	20.2	29.2	28.8	17.7	72.1	26.4
Fe	0.32	0.10	1.82	0.0	4.02	0.25	0.0	0.43	0.28
Mn	–	–	–	0.10	–	–	–	–	0.08
Dry residue	358	357	352	312	336	335	219	539	346
Dissolved solids	356	352	347	238	304	298	150	409	304
Suspended solids	140	5	5	74	32	37	69	130	42

Table 3

Aquatic fungi found, particular rivers (s – spring, a – autumn)

Fungi	Rivers (see Table 1)
Chytridiomycetes	
Olpidium gregarium (Nowakow.) Schroeter	15a
Olpidium macrosporum (Nowakow.) Schroeter	8a
Rhizophydium carpophilum (Zopf) Fischer	11a
Rhizophydium keratinophilum Karling	12a
Rhizophydium nodulosum Karling	8s
Rhizophydium piligenum Ookubo et Kobayashi	8s
Rhizophydium pollinis-pini (Braun)Zopf	7s, 8s
Obelidium mucronatum Nowak.	2a
Rhizidium chitinophilum Sparrow	5a
Rhizidium verrucosum Karling	8s
Diplophlyctis complicata (Willeng.) Batko	8s
Chytridium xylophilum Cornu	1sa, 2sa, 3sa, 4sa, 13a, 15sa, 16sa, 17a
Karlingia chitinophila Karling	8s
Karlingia polonica Hassan	11s
Karlingia rosea (de Barry et Woronin) Johanson	2a, 10sa, 11a
Polychytrium agregatum Ajelo	1a, 2s, 14s, 16sa
Polyphagus euglenae Nowakow.	5a
Nowakowskiella elegans (Nowakow.) Schroeter	2a, 3a, 10s
Nowakowskiella macrospora Karling	1sa, 2s, 3s, 9a
Mitochytridium regale Hassan	10s
Blastocladia globosa Kanouse	11a
Blastocladia ramosa Thaxter	11sa
Blastocladiella britanica Horen et Cantino	11s
Blastocladiopsis parva (Whiffen) Sparrow	11a
Catenaria anguillulae Sorokin	8s
Leptolegniella keratinophila Huneycutt	8s
Monoblepharis macranda (Lagerh.) Woronin	7s, 8s
Hyphochytriomycetes	
Rhizidiomyces apophysatus Zopf	8s, 15s
Rhizidiomyces bivelatus Nabel	8s
Oomycetes	
Olpidiopsis saprolegniae (Braun) Cornu	1a, 6s, 8s, 11s, 15sa
Aphanomyces irregularis Scott	1s, 2s
Aphanomyces laevis de Barry	14sa
Aphanomyces parasiticus Coker	11a
Aphanodictyon papillatum Huneycutt	8s
Leptolegnia caudata de Barry	1s
Achlya apiculata de Barry	7s
Achlya colorata Prings.	3a
Achlya debaryana Humphery	8sa
Achlya dubia Coker	8sa
Achlya flagellata Coker	10a
Achlya hypogyna Coker et Pemberton	3a, 6s, 8s
Achlya klebsiana Pieters	11a

Achlya megasperma Humphrey	10a
Achlya oligacantha de Barry	8a
Achlya papillosa Humphrey	10s, 11sa
Achlya piculata de Barry	1s
Achlya polyandra Hildebr.	2s, 11a
Achlya prolifera Nees	10a
Achlya radiosa Maurizio	11a, 14s
Cladolegnia eccentrica (Coker) Johannes	11s
Isoachlya anisospora (de Barry) Coker	1sa, 2a, 4sa, 9a, 10sa, 11a, 12a, 13s, 14sa, 15a, 16sa, 17a
Isoachlya toruloides Kauffman et Coker	8sa
Saprolegnia ferax (Gruifh) Thurnet	1sa, 2sa, 3sa, 4sa, 5sa, 6s, 10sa, 11sa, 12sa, 13sa, 14sa, 15sa, 16sa
Saprolegnia hypogyna (Prings.) de Barry	2a, 16a
Saprolegnia monoica Prings.	7s, 8a
Saprolegnia parasitica Coker	7s
Dictyuchus monosporus Leitgeb.	1sa, 2a, 3sa, 4a, 10sa, 11sa, 12a, 13s, 14sa
Calyptralegnia achlyoides (Coker et Couch) Coker	8s
Leptomitus lacteus (Roth) Agardh	1s, 7s, 11s, 14s, 17s
Pythiogeton nigricans Batko	1sa, 2a, 3a, 5a, 6s, 7a, 8s, 10s, 11sa
Pythiogeton uniforme Lund	15sa, 17sa
Pythium artotrogus de Barry	1a, 2s, 3s, 11a
Pythium hydnosporum (Mont. ap. Berk.) Schroeter	10sa
Pythium debaryanum Hesse	11a, 15a, 16sa
Pythium middletonii Sparrow	10s, 17sa
Pythium rostratum Butler	11a
Pythium ultimum Trow	6s, 10sa
Pythium undulatum Petersen	15a
Zoophagus insidians Sommerstorff	1sa, 2s, 3a, 10a, 12a, 13a, 16sa, 17a
Endomycetes	
Candida albicans (Robin) Berkhout	10s
Candida aquatica Jones et Sloof	11a
Candida tropicalis (Castellania) Berkhout	15s
Trichosporon cutaneum (de Beur. et al) Ota	11s, 13a, 14a, 15s, 16s, 17a
Hyphomycetes	
Anguillospora longissima (Sacc. et Sydow) Ingold	2a, 3a, 15a, 16a
Arthrobotrys oligospora Fres.	3a, 7s, 11a, 17a
Bacillispora aquatica Nilsson	10s
Centrospora filiformis (Greath.) Petersen	10s
Flagellospora curvula Ingold	11s
Fusarium aqaeductum (Radlk. et Rabenh.) Lagerh.	7s, 14s, 17a
Geniculospora inflata (Ingold) Nilsson	11a
Lemonniera aquatica de Wildeman	2sa, 14s, 15a, 16sa, 17a
Robillarda phragmitis Cunnel	12a, 13s
Rozellopsis inflata (Butler) Karling	13a, 15a, 16a, 17s
Tetracladium marchalianum de Wildeman	11a, 15s
Tetracladium setigerum (Grove) Ingold	9a, 16sa
Tricladium anomalum Ingold	10s
Tripospermum gardneri Hughes	13a
Triscelophorus monosporus Ingold	12a
Vargamyces aquaticus (Dudka)Toth	9a, 14a, 15s

DISCUSSION

The results obtained indicated that the investigated stretch of the Narew River its tributaries had a profusion of aquatic fungi species. A great majority of these species had frequently been found in the waters of north-eastern Poland. Nevertheless a number of species, particularly those of the *Chytridiomycetes* and *Hyphochytriomycetes*, were found to be new to the hydromycoflora of Poland. Furthermore, some of the species can be classified as rare species in our waters since they were sporadically encountered, in various types of waters in the north-east of Poland, during several years of mycological studies.

As regards the fungi new to the hydromycoflora of Poland, studies *Rhizophydium nodulosum*, which is a keratinophilic fungus reported so far from was usually found to develop on hairs, loam and inland bodies of water. *Rhizophydium piligenum*, which grows on hair and human finger-nails, also belongs to the group of keratinophilic fungi. Both *R. nodulosum* and *R. piligenum* are new to Polish hydromycoflora. *Obelidium mucronatum* belongs to the group of fungi which undergo extensive morphological changes (K a r l i n g, 1968; S p a r r o w, 1937) observed the development of this fungus on insect exuviae and we now know that it grow on substrates containing chitin. *Rhizidium verrucosum* also develops on substrates containing chitin, thought it is to be found on grass blades. *Diplophlyctis complicata* also grows on chitin in the bed sediment of lakes. This species was first described by W i l l o u g h b y (1961) as *Nephrochytium complicatum* in the lakes of England. An interesting finding was that of the fungus *Karlingia chitinophila* growing on chitinous substrates (Fig. 1). It has been found to date in water and in soil. Another fungus which can develop on substrates containing chitin is *Catenaria anguillulae*, which has been observed on dead crustaceans of the *Cladocera* and has been isolated from both water and soil. *Catenaria anguillulae* is, however, known foremost as one of the most common endozoic nematodocial fungi (B u r c h f i e l d, 1960). It was interesting to note the presence of a keratinophilic fungus, *Leptolegniella keratinophila*, in the water of the Nareśl River since this fungus has only been found to date in soil (B a t k o, 1975). The occurrence of *Mitochytridium regale* is also noteworthy. In the present study it was reported from the Biebrza River, which is the third site at which it was found in Poland. It was previously found in the pools of the Łazienkowski Park in Warsaw (H a s s a n, 1986) and in Lake Necko (C z e c z u g a, 1994).

In the investigated waters, the presence of two representatives of the *Hyphochytriomycetes* was established which were also found to be new to the hydromycoflora of Poland. *Rhizidiomycetes apophysatus* is a parasite of the oogonium of other fungus usually of the genera *Saprolegnia* and *Achlya* and even of algae of the *Vaucheria* (C z e c z u g a, W o r o n o w i c z, 1994). It is also a parasite of pine pollen. On the other hand, *Rhizidiomyces bivelatus* is classified as a chitinophilic fungus and occurrs on the remains and exuviae of insects (C z e c z u g a, G o d l e w s k a, 1994).

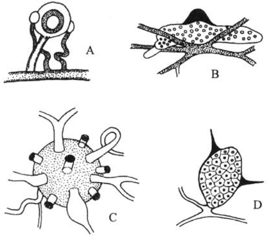

Fig. 1. Some aquatic zoosporic fungi

A — *Calyptralegnia achlyoides* – gametangium, B — *Diplophlyctis complicata*, C — *Karlingia chitinophila* – thallus, D — *Obelidium mucronatum* – thallus from sporangium (36-14 μm)

Of the *Oomycetes* representatives, *Achlya dubia, A. prolifera* and *Calyptralegnia achlyoides* were new to hydromycoflora of Poland. *Achlya dubia* belongs to the group of aquatic phytozoosaprophytes and more rarely among zoosaprophytes sometimes being found as a facultative parasite of crabs and fish. On the other hand, *Calyptralegnia achlyoides* in an aquatic and soil saprophyte.

A few species of the *Oomycetes* were found to be rare ones in Polish waters. These are: *Aphanodictyon papillatum* – a keratinolytic species found to date in the Masurian Lake District – the Mamry complex (C z e c z u g a, W o r o n o w i c z, 1992), and *Achlya klebsiana* – a soil or aquatic saprophyte also occurring on dead insects (S p a r r o w, 1960). We also observed the development of this fungus in the waters of some of the Augustów Lakes (C z e c z u g a, 1994).

As regards the representatives of the *Hyphomycetes*, it was particularly interesting to note the presence of *Tripospermum gardneri* in the water of the Olszanka River, a tributary of the Biebrza River. It is a fungus new to the Polish hydromycoflora. It is classified as a genus *Tripospermum* belong to the terrestial group *Hyphomycetes* which grow as epiphytes on the leaves of trees and are also found in water when the leaves fall in autumn. Other authors are of the opinion that water assists them only in dissemination (M a r v a n o v a, 1973). The presence of conidia of this fungus in the water of the River Olszanka was noted in late autumn at a site where the banks were covered with trees (willo, and alder). In comparison with the other rivers from this group, the waters of River Olszanka had at that time the highest concentration of carbon dixide (17.6 mg l^{-1}) and total content of iron (4.02 mg l^{-1}). In our case, such an amount of nitrites dissolved in the water was not noted in the River Olszanka. Species of the genus *Tripospermum* are often described in monographs dealing with aquatic *Hyphomycetes* (C a r m i c h a e l et al., 1980; D u d k a, 1985) since according to T u b a k i et al. (1985) a drop of rain, mist or dew-drops are sufficient enough to provide an aquatic habitat on the ground for fungi of the genus *Tripospermum.*

The results of the present study indicated that the waters of the Nereśl River were most abundant in rare or new to the Polish hydromycoflora fungi species. The hydrochemical parameters which were thoroughly analysed did not differ in their range from the values noted at other sites investigated in the present survey. The Nereśl River flows through the pond Czechowizna in which intensive carp breeding is carried out. It is possible that this factor was responsible for the variety of aquatic fungi species and, above all for the abundance of keratinophilic species.

During the period of sampling the carp were fed with various types of food, slaughterhouse offal which contained large amounts of keratin.

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