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Studies of Aquatic Fungi. XXIV. Aquatic Fungi in the Water of Melting Snow

BAZYLI CZECZUGA

Department og General Bioligy, Medical Academy, Kilińskiego 1,
15-230 Białystok, Poland

C z e c z u g a B.: *Studies of aquatic fungi. XXIV. Aquatic fungi in the water of melting snow.* Acta Mycol. XXVII (2): 257-265, 1991-1992.

The work was undertaken to investigate the mycoflora in the water of melting snow. Samples of water were collected in March 1987-1988 for hydrochemical analysis (3 sites) and studies of the fungus content (9 sites). Forty-nine species of fungi were found in this waters. The following fungi unknown from Poland were found: *Skirgiella septigena, Monoblepharis macrandra, M. polymorpha, M. fasciculata, M. insignis, Achlya apiculata, Apodachlya punctata, Pythium dissotocum, Hansenula holstii, H. saturnus, Actinospora megalospora* and *Heliscus lugdunensis*.

INTRODUCTION

For many years now we have been carrying out investigation of the presence of various fungus species in different types of bodies of water in the north-eastern region of Poland. These studies included running and stagnant water. In the studies of running water, the species composition of hydromycoflora was analysed reference to the chemism of the environment in rivers varying from one of the largest in this region, the River Narew (C z e c z u g a, P r ó b a, 1987), smaller rivers such as the Czarna Hańcza and Marycha, woodland streams (C z e c z u g a, W o r o n o w i c z, B r z o z o w s k a, 1986; C z e c z u g a, B r z o z o w s k a, W o r o n o w i c z, 1990) to different types of springs (C z e c z u g a et al., 1989). The studies of stagnant water included shaft wells and fish ponds (C z e c z u g a, W o r o n o w i c z, B r z o z o w s k a, 1987, 1988); park ponds (C z e c z u g a, B r z o z o w s k a, W o r o n o w i c z, 1987) and lakes of various types of trophicity (C z e c z u g a, 1991). In these studies we established the presence in this region of several scores of species new to Polish hydromycoflora and from ten to twenty very rare species which have

to date benn noted in only a very few places throughout the world (Czeczuga, Orłowska, Woronowicz, 1989; Czeczuga, 1992).

A very specific environment for fungi is provided by the small pools formed by melted snow. For this reason we felt that it would be of interest to investigate the hydromycoflora of such specific waters. The date obtained has provided new information in the field of hydromycoflora.

MATERIALS AND METHODS

The investigations were carried out in the month of March in 1987 and 1989. These were "pools" approximately 40 cm x 40 cm and 5-8 cm in depth formed by melting snow round a certain species of tree, the ice on a pond, on a meadow and cultivated soil. The following 9 sites were chosen:

Site I – on an ice
Site II – on a soil substrate
Site III – near a lindens
Site IV – on a meadow
Site V – near a pines
Site VI – near an alders
Site VII – near a poplars
Site VIII – near an elms
Site IX – in a mixed forest

The samples of water for the study of the presence of aquatic fungi were cellected at least two days after the formation of such a pool. The water from there selected sites vere also hydrochemically analysed. In the water, the temperature was measured and folowind determined: the pH, CO_2, the oxydability of the water and its alkanility, the hardness of the water calculated in Ca and Mg, amonium, organic nitrogen, nitrates, phosphates, chlorides, iron, manganese, sulphates, dry residue, substances dissolved in the water and the suspension in the water. For determinations of the different chemical elements in the water the methods recommended by Standard Methods (Golterman, Clymo, 1971) were employed; the details of these methods were described in a previous paper (Czeczuga, Próba, 1980).

The zoosporic fungi in the water were studied by a method by Fuller and Jaworski (1986) described based on direct microscopic examination of the water and of materials collected from the water as well as the bait methods (onion skin, hemp-seeds, clover-seeds, snake skin, hairs and filings of horn) applied in environmental studies and in the laboratory. In addition (for *Hyphomycetes*), the water collected from the surface of sites was examined directly under a microscope (Casper, 1965; Arnold, 1968). The samples were fixed in formalin-acetic-alcohol immediately after collection and brought to the laboratory.

For determinations of the fungi were used different keys and papers: Skirgiełło, 1954; Batko, 1975; Sparrow, 1960; Dudka, 1974 and Ingold, 1975.

RESULTS

The chemical analysis of the water from melting snow from ice, a soil substrate and near the lindens-trees differed in all the parameters studied (Table 1). As regards the water from snow melting on a soil substrate and near lindens-trees, it was found to have higher values of pH, oxydability, carbon dioxide content, overall alkalinity, all three forms of nitrogen, phosphates, iron, manganese, and suspended matter. On the other hand, the water from snow melting on ice contained more chlorides, calcium, magnesium and sulphates. The highest values of dry residue, substances dissolved in the water, and suspended matter were noted in the water frommelting snow at Site III (under a linden-tree).

Table 1

Chemical composition (mean from 3) of the water at particular sites (in mg l^{-1})

Specification	Sites		
	I	II	III
Temperature °C	2.50	2.60	2.80
pH	7.59	7.99	8.00
Oxydability	2.11	13.46	9.28
CO_2	6.60	11.00	8.20
Alkalinity in $CaCO_3$*	1.10	1.30	1.30
$N(NH_3)$	0.16	0.32	0.38
$N(NO_2)$	0.01	0.01	0.04
$N(NO_3)$	0.00	0.03	0.04
PO_4	0.00	2.82	1.06
Cl	47.00	29.00	30.40
Total hardness in Ca	22.32	11.52	14.64
Total hardness in Mg	7.74	3.01	4.12
SO_4	30.85	11.52	12.04
Fe	0.10	0.35	0.35
Mn	0.00	0.05	0.05
Dry residue	128.00	104.00	224.00
Dissolved solids	127.00	88.00	182.00
Suspended solids	1.00	21.00	42.00

* – in mval l^{-1}

In 1987-1988, 49 species of aquatic fungi were determined in the water of melting snow (Table 2): 11 belonged to the *Chytridiomycetes*, 19 to the *Oomycetes*, 3 to the *Endomycetes* and 16 to the *Hyphomycetes*. Some of the species had already been found in other bodies of water in Poland but a number of species are new to the hydromycoflora of Poland (Fig. 1). These newspecies included the following representatives of the *Chytridiomycetes*, *Skirgiella septigena*, *Monoblepharis macrandra*, *M. polymorpha*, *M. fasciculata and M. insignis species*. The species of the *Oomycetes* new to Polish hydromycoflora were *Achlya apiculata*, *Apodachlya punctata* and *Pythium dissotocum*. As regard the representatives of the *Endomycetes* of the three species found two were new to Polish water: *Hansenula saturnus* and *Hansenula holstii*. Two species of the *Hyphomycetes* were also new to our water: *Actinospora megalospora* and *Heliscus lugdunensis*. In addition, a noteworthy finding was that of the presence of *Flagellodpora stricta* in the water of melting snow since Poland in now the third country in the world where this representative of the *Hyphomycetes* has been found. Two rare species are the *Polycladium equiseti* and the *Speiropsis irregularis*. This is the second site at which these fungi have been found in Polish waters.

DISCUSSION

Of the 49 species found during three years' study, as was mentioned above, as many as 12 were new to Polish hydromycoflora (5 belonged to the *Chytridiomycetes*, 3 to the *Oomycetes*, 2 to the *Endomycetes*, 2 to the *Hyphomycetes*).

One of the representatives of the *Oomycetes* new to Polish hydromycoflora, the *Skirgiella septigena*, is a parasite of other fungi, above all of species of the *Achlya* and *Saprolegnia*. The presence of this fungus was noted in the water of melting snow at a site localized in a mixed forest. Two of the 4 species of the *Monoblepharis* genus are also new Polish mycoflora. As B a t k o (1975) reported all the species of this genus are aquatic saprophytes frequently occurring on tree branches in melting water, with the approach of spring. They are usually found in cold water (H a r d e r, 1954). The new species of the *Monoblepharis* genus were *M. asciculata* (at a site in a meadow) and *M. insignia* (at a site near alders).

A representative of the *Oomycetes* new to Polish fungi is the *Achlya apiculata*, the grow of which was observed in melting snow collected from ice and near alders. It is aquatic saprophyte to be found on branches, usually in spring or in winter. It has also been isolated from soil. Another new species is the *Apodachlya punctata*, the growth of which was observed in water collected from a meadow and near alders. It in an aquatic saprophyte encountered on branches immersed in water. To the ground of new species of the *Oomycetes*, the *Pythium dissotocum* also belongs. This in an aquatic and soil saprophyte. In our studies it was found in the water of melting snow on a soil substrate near lindens and alders.

Table 2

Aquatic fungi found in particular sites

Class and species	Sites								
	I	II	III	IV	V	VI	VII	VIII	IX
CHYTRIDIOMYCETES									
Olpidium allomycetes Karling			x	+					
Olpidium macrosporum (Nowak.) Schroeter		x		+					
Skirgiellia septigena (Cornu) Batko									x
Rhizidium chitinophilum Sparrow							x		
Polyphagus euglenae Nowakowski		x	x						
Nowakowskiella elegans (Nowak.) Schroeter		x	x				x		x
Nowakowskiella macrospora Karling			x						
Monoblepharis fasciculata Thaxter		x							
Monoblepharis insignis Thaxter						x			
Monoblepharis macrandra (Jagerh.) Woronin	x	x	x		x				
Monoblepharis polymorpha Cornu		x			x				
OOMYCETES									
Olpidiopsis aphanomycis Cornu			x						
Olpidiopsis vexans Barret		x							
Aphanomyces irregularis Scott			x			x	x	x	
Aphanomyces parasiticus Coker						x			
Achlya apiculata de Bary			x			x			
Achlya megasperma Humphrey			x			x			x
Achlya polyandra Hildebrandt								x	
Achlya prolifera Nees						x			
Achlya racemosa Hildebrandt		x							
Isoachlya anisospora (de Bary) Coker			x			x			
Isoachlya toruloides Kauffman et Coker		x	x			x			
Saprolegnia ferax (Gruith) Thurnet			x		x	x			x
Saprolegnia hypogyna (Pringsheim) de Bary			x						
Saprolegnia monoica Pringsheim			x						
Dictyuchus monosporus Leitgeb		x	x						
Apodachlya punctata Minden		x				x			
Pythiogeton nigricans Batko			x						
Zoophagus insidians Sommerstorff	x	x	x		x	x			x
Pythium dissotocum Drechsler	x			x		x			
Pythium sp.					x	x			x
Phytophtora sp.			x						
ENDOMYCETES									
Hansenula holstii Wickerham					x				
Hansenula saturnus (Klocker) H. et H. Sydov		x			x				
Trichosporon cutaneum (de Beur et al.) Ota			x				x		
HYPHOMYCETES									
Actinospora megalospora Ingold			x						x
Anguillospora crassa Ingold		x							x
Anguillospora longissima (Saccardo et Sydov) Ingold		x	x						
Anguillospora pseudolongissima Ranzoni							x		
Bacillispora aquatica Nelson		x		x					
Dactylella aquatica (Ingold) Ranzoni			x						
Dactylella submersa (Ingold) Nilsson		x	x					x	
Flagellospora stricta Nilsson					x				
Heliscus lugdunensis Saccardo et Therry								x	
Lemonniera aquatica de Wildeman		x	x					x	
Polycladium equiseti Ingold							x	x	
Speiropsis irregularis Petersen		x					x		
Tetrachaetum elegans Ingold				x					
Tetracladium marchalianum de Wildeman			x						
Tricladium anomalum Ingold								x	
Tricladium gracile Ingold								x	
Number of species	3	19	25	3	8	13	7	8	8

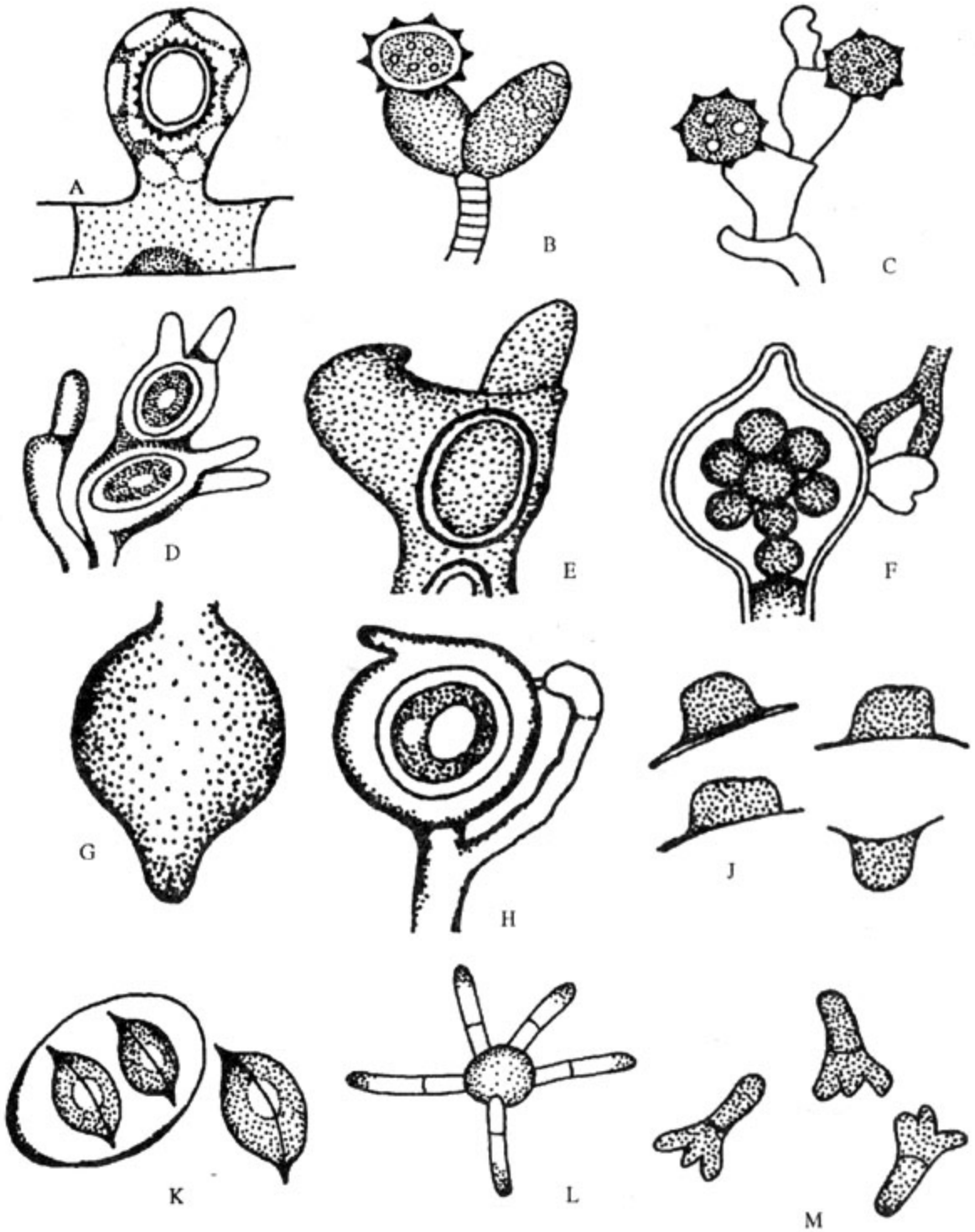

Fig. 1. Aquatic fungi

A — *Skirgiella septigena* – spore (16-22 μm) in hypha; B — *Monoblepharis macrandra* – thallus from oospore (12-24 μm); C — *Monoblepharis polymorpha* – thallus from oospores (13-25 μm); D — *Monoblepharis fasciculata* – thallus from oospores (12-28 x 16-32 μm); E — *Monoblepharis insignis* – thallus from oospore (10-32 x 18--46 μm); F — *Achlya apiculata* – – gametangium (58-82 x 46-62 μm); G — *Apodachlya punctata* – sporangium (42 x 58 μm); H — *Pythium dissotocum* – – gametangium (14-30 μm); I — *Hansenula holstii* – hat-like ascospore; K — *Hansenula saturnus* – saturne-like ascospore; L — *Actinospora megalospora* – conidium (arms 100-176 x 4-8 μm); M — *Heliscus lugdunensis* – conidia (24-38 x 4.5 μm)

Of the three species of the *Endomycetes*, two were new to Polish mycoflora, that is *Hansenula saturnus* and *H. holstii*. Acording to B a t k o (1975), the *H. holstii* occurs in the water of lakes and streams in forests, on the wood of conifers whereas *H. saturnus* is found in the water of springs, streams, ponds and bogs and is quite often found in the soil. In our case *Hansenula holstii* was found in the water of snow melting round a pine-tree and *H. saturnus* in the water of melting snow in a meadow and, *H. holstii*, near a pine-tree.

The representative of the *Hyphomycetes*, *Heliscus lugdunensis*, is a saprophyte widely distributed throughout the world. In our investigations it was found in the water of snow near elms. In addition, some rare representatives of the *Hyphomycetes*, the *Flagellospora stricta*, *Polycaldium equiseti* and *Speiropsis irregularis*, were noted in the water of melting snow. The *Flagellospora stricta* has been found previously in a stream in Sweden (N i l s s o n, 1962), in a river in Armenia (O s i p j a n, A j r a p e t i j a n, 1979) and in two sites in Poland. It was first noted in Poland in a fish-pond (C z e c z u g a, W o r o n o w i c z, B r z o z o w s k a, 1988) and then in the River Supraśl (C z e c z u g a, O r ł o w s k a, W o r o n o w i c z, 1989 a). This species was found in the present studies, in the water of melting snow beside a pine-tree. *Polycladium equiseti* has to date been found in the waters of Great Britain (I n g o l d, 1959; J o n e s, 1965), in Sweden (N i l s s o n, 1964) and in USSR (A r n o l d, 1969). We observed the growth of this fungus in the water of the River Supraśl in August and September. In the water of that same river, the third of the rare representatives of the *Hyphomycetes*, the *Speiropsis irregularis*, was noted in September and December. It has been found previously only in the USA (P e t e r s e n, 1963) and the Ukraine (D u d k a, 1970). In the water of melting snow, it was noted at a site in a meadow and near some poplars.

Furthermore, in the water of melting snow three fungus species rare to Polish hydromycoflora were found. These are *Polyphagus euglenae* (*Chytridiomycetes*) and *Olpidiopsis vexans* and *Achlya megasperma* (*Oomycetes*). *Polyphagus euglenae* was noted in the water of the River Gołdapa and Węgorapa, whereas *Olpidiopsis vexans* was noted in the River Węgorapa (C z e c z u g a, 1991 c), and *Achlya megasperma* in the waters of Lake Roś in the Masurian Lake District (C z e c z u g a, 1991 b). The number of aquatic fungus species found at the various sites differed. The most abundant in aquatic fungus species were found to be the water of melting snow at Site III (under a linden-tree) and at Site II (on soil), whereas the lowest species were noted in the water of Site I (water on ice) and Site IV (in a meadow).

It should be remembered that were differences in the chemism of the water formed snow melting on ice, soil, and in the pool under the linden-tree. Our previous investigations of the relation between the number of aquatic fungus species and the concentration of the various chemical components of the water revealed a negative correlation between the concentration of calcium and sulphates and the number of aquatic fungus species (C z e c z u g a, P r ó b a, 1987). It is noteworthy that the

water from the snow melting on ice contained more calcium and sulphates than the water in pools on soil or under the linden-tree.

As the present studies show, in the water of melted snow, the presence of representatives of four families of fungi was noted as early as two days after the formation of such small pools at all the sites under study. It can be assumed that in the substrate on which these pools formed, there werew pieces of fungus spawn or forms of spores which enabled the fungus to withstand unfavourable conditions. This supposition is substantiated by the data obtained in recent years by Sridhar and Kaveriappa (1988) and by Hood and Robinson (1989). In the studies of the former workers (1988), it was found that aquatic fungi growing on *Coffea arabica* and *Hevea brasiliensis* leaves collected from the water of a small stream and then kept in the laboratory under dry conditions for 360 days, continued to grow on being returned to a watery environment. These were aquatic fungi of the *Hyphomycetes* genus. Furthermore, Hood and Robinson (1989) noted that in the commonest representative of the *Oomycetes* occurring in water, the *Saprolegnia ferax*, on a hard substrate aerial hyphae formed in this fungus. The data of these two papers provide evidence of the mechanisms of adaptation of aquatic fungi to their existence in waters which during the year periodically dry up. In such cases as soon as the water returnus, the fungi begin to develop.

As regards the fungi of the *Hyphomycetes* taxon, the spores of some of them have been previously found in snow or in pools of a seasonal character (Nilsson, 1964). Of the *Hyphomycetes* species which we found in the pools of melting snow, the spores of such species as *Anguillospora crassa, A. longissima, Lemonniera aquatica* and *Tetrachaetum elegans* have been noted to date in snow. On the other hand, according to Nilsson (1964) in seasonal pools including those of melting snow *Anguillospora longissima, Bacillispora aquatica, Dactylella submersa, Heliscus lugdunensis* and *Lemonniera aquatica* have been found. It would therefore appear that such species of *Hyphomycetes* as *Actinospora megalospora, Anguillospora pseudolongissima, Dactylella aquatica, Flagellospora stricta, Polycladium equiseti, Speiropsis irregularis, Tetracladium marchalianym, Tricladium anomalum* and *Tricladium gracile* are species new to such a type of aquatic environment as pools formed by melting snow. Of this group of new fungi of the *Hyphomycetes*. The presente of *Tricladium anomalum* in a pool of melting snow (Site VIII) is worthy of note since according to Nilsson (1964) it has been found to date in lakes only.

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