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New aquatic sites of the fungus *Sommerstorffia spinosa*

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When studying zoosporic fungi in the waters of northeastern Poland the authors found new sites of a rare fungus – *Sommerstorffia spinosa* Arnaudow. Its growth was observed in water samples collected from limnologically different reservoirs, from the spring Jaroszówka, the oligotrophic type (Lake Białe), through mesotrophic (Lake Wigry) to the polytrophic type (pond Fosa with high content of hydrogen sulphide under ice cover). This fungus was also found in the river Biała, which flowing through Białystok gets polluted by municipal wastes. Moreover, the successive stages of S. spinosa development in the aquatic environment are described.

Key words: *Sommerstorffia spinosa*, zoosporic fungi, hydrochemistry.

INTRODUCTION

Aquatic mycoflora contains species, which can be found in any type of water reservoir irrespective of its size or water chemism, as well as rare species. *Saprolegnia ferax* is a species commonly encountered in open waters. Rare species observed in inland waters include *Sommerstorffia spinosa* which since 1923 when it was described by Arnaudow (1923a, b), has been observed only in a few countries. In the studies on the occurrence of aquatic fungi with regard to water chemism in different water basins of northeastern Poland from springs (Czeczuga et al. 1989, 1999b), rivers (Czeczuga 1991a, b; Czeczuga et al. 1990) to lakes of various types in the Suwalsko-Mazurski Lake District (Czeczuga 1991c, 1995, 1996) we found *S. spinosa* in environmental conditions new to this fungus. Therefore, we believe that the publication will enrich the knowledge of this species ecology.

MATERIAL AND METHODS

The presence of *Sommerstorffia spinosa* were recorded in water of the following water bodies:

(I) Lake Białe, area 100.2 ha, max. depth of 34.0 m. The lake Białe and next lake Wigry are situated in Wigierski National Park in northeastern Poland. The samples of water were collected at distance of 50 m from the lake coastline of north part of this lake, it is typical of oligotrophic lake (Czeczuga 1991c).

(II) Lake Wigry, are 2.118 ha, max. depth of 73 m, the samples of water were collected at distance of 100 m from the lake coastline of Słupiańska Bay. Lake Wigry is a mesotrophic lake (Czeczuga et al. 2000).

(III) Pond Fosa, 2.5 ha, max. depth of 1.75 m, in which swans are breeding and wild ducks also come. In addition, crucian carp and tench are bred for anglers (Czeczuga et al. 1999a).

(IV) Spring Jaroszówka, located in north part of the Białystok city; limnokrenic type, width 0.65 m, depth 0.12 m, discharge 2.4 l/sec. (Czeczuga et al. 1999b).

(V) River Biała, length 9.8 km, left-bank tributary of Supraśl River flowing through Białystok City. The river Biała waters carry large amounts of municipal pollutans (Czeczuga and Orłowska 2000).

The water for analysis was poured into 2 containers (one for hydrochemical analysis, the other for mycological analysis) for each water body. Eighteen parameters were determined in each water (Table 1) according to the generally accepted methods (Greenberg et al. 1992). Temperature of the water in the laboratory was maintained at 12–16°C. Samples for mycological analysis were transported in sterile glass containers of 1.5 l capacity. Subsequently, in the mycological laboratory, they were placed in sterilized beakers (capacity of 0.6 l), to which the appropriate baits (cellophane, snake exuviae) were added in accordance with the general principles of culture setting (Fuller and Jaworski 1986). The cellophane and snake exuviae were previously cut into small pices, washed carefully and then boiled in a weak seap solution. Subsequently, they were rinsed throughly and boiled several times. The samples were kept in the laboratory for 3 months and precautions of ensuring that the thermo--lighting conditions were as close as possible to those prevalent outside the laboratory were taken. Peces of various baits were observed under a microscope once a week. The hyphae of *S. spinosa* were distinguished by their morphological features, measurements being made of the mycelium (zoosporic, oogonia and antheridium). To identify the hyphae it was necessary to tint the samples with a 0.01% solution of a neutral red. For identification *S. spinosa* keys by Sparrow (1960) and Jones (1976) were used.

Table 1
Chemical composition (in mg l^{-1}) of water from the sampling sites (n = 3)

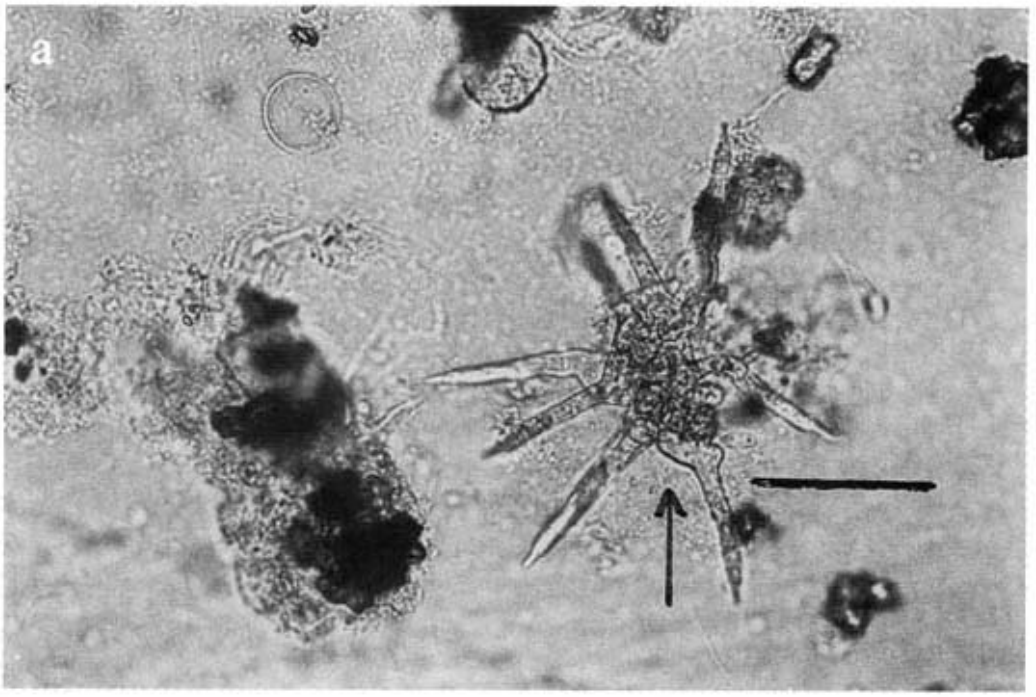
Parameters	Lake Białe August '98	Lake Wigry August '98	Pond Fosa				Spring Jaroszówka October '00	River Biała January '96
			September '95	September '96	March '97	September '97		
Temperature °C	21.0	21.5	19.7	20.0	0.5	20.4	6.2	2.0
Transparency (m)	7.15	3.95						
pH	7.95	8.26	6.96	7.64	7.02	7.04	7.45	7.21
$O_2$2	12.15	10.18	4.25	5.12	0.50	5.50	8.42	6.42
BOD_5	1.82	3.10	2.65	8.15	9.22	7.04	2.20	4.82
COD	5.10	5.82	13.52	11.78	20.15	19.06	7.30	14.25
CO_2	2.2	1.8	22.0	17.2	18.8	13.4	17.6	37.4
Alkalinity in $CaCO_3$ (mval l^{-1})	2.1	2.9	4.4	7.0	4.8	4.1	4.4	5.1
N-NH_3	0.140	0.350	0.440	0.550	0.950	0.650	0.612	1.482
N-NO_2	0.002	0.008	0.0	0.008	0.008	0.005	0.012	0.065
N-NO_3	0.025	0.045	0.008	0.075	0.025	0.082	0.083	1.012
P-PO_4	0.120	0.445	1.950	9.015	3.125	2.850	3.505	3.500
Sulphates	7.41	25.01	28.38	49.36	26.85	24.27	70.76	48.13
Chlorides	16.0	21.0	70.2	42.0	64.1	45.2	33.5	82.0
Total hardness in Ca	41.76	40.70	88.56	102.96	62.56	74.20	90.08	123.12
Total hardness in Mg	6.02	13.30	40.85	27.52	74.20	52.56	15.34	26.66
Fe	0.01	0.01	0.50	0.45	0.45	0.50	0.35	0.18
Manganese	0.0	0.05	0.20	0.24	0.30	0.20	0.08	0.0
Dry residue	124	294	358	460	320	356	398	1650
Dissolved solids	35	260	282	442	305	325	396	1230
Suspended solids	89	34	76	18	15	31	2	420

RESULTS

In the years 1995–2000 during mycological studies of water reservoirs in northeastern Poland 5 new aquatic localities where *Sommerstorffia spinosa* occurs were found: the spring Jaroszówka, the river Biała, pond Fosa, lake Białe Wigierskie and Słupiańska Bay of lake Wigry. These new sites show diverse environmental conditions different morphology and water chemism (Table 1). The lake Białe is an oligotrophic reservoir, while the lake Wigry is mesotrophic, the pond Fosa is a typical polytrophic water bodies with sulphur hydrogen, which appears immediately under ice cover. The water of spring Jaroszówka is characterized by comparatively high content of sulphates. The river Biała waters carry large amounts of municipal pollutants. The growth of *S. spinosa* was observed (Fig. 1) in water samples collected from the spring Jaroszówka in October 2000, from the river Biała in January 1996, from lake Białe and Wigry in August 1998, while from pond Fosa in August 1996, March and September 1997. It appeared on the samples 70–80 days after water had been collected from the reservoirs.

DISCUSSION

Sommerstorffia spinosa was described by Arnaudov (1923a, b) in Bulgaria as a predacious fungi catching rotifers from the aquarium where rotifers were bred. Then it was observed in surface layers of soil in five States of North America. Sparrow (1929) reported its presence in Cambridge, Massachusetts, while Karling (1952) in New Jersey (1936), Virginia (1939), Louisiana (1947) and Alaska (1950). Prowse (1954) found this fungus in soil samples from the British Islands, while Karling (1966) observed the fungus in India and a few years later in soil samples from New Zealand (Karling 1968). In Poland this fungus was found for the first time in the river Turośląnka, the right tributary of the Narew, in the study on aquatic fungi and water chemism of the middle part of the river Narew (Czeczuga and Próba 1980, 1987; Czeczuga et al. 1984/85). It was the first locality of *S. spinosa* in central Europe, being characterized by sandy substratum, depth 0.10 m, clean water poor in biogenes and organic matter. Afew years further on the presence of this fungus was established for the first time in lake – in coastal parts of lake Bełdany in Mazury, the area of which is 793.6 ha and the maximum depth 46.0 m (Czeczuga 1991d, 1993). From the limnological point of view lake Bełdany is of mesotrophic type. Saikawa (1986) found this fungus on the Japanese Islands and described morphological electron microscopic data. *S. spinosa* was obtained in January 1983 from littoral detritus, which had been floating on the surface of a tiny fire-pool (ca. 5×5 m) in Tokyo Gakugei University.



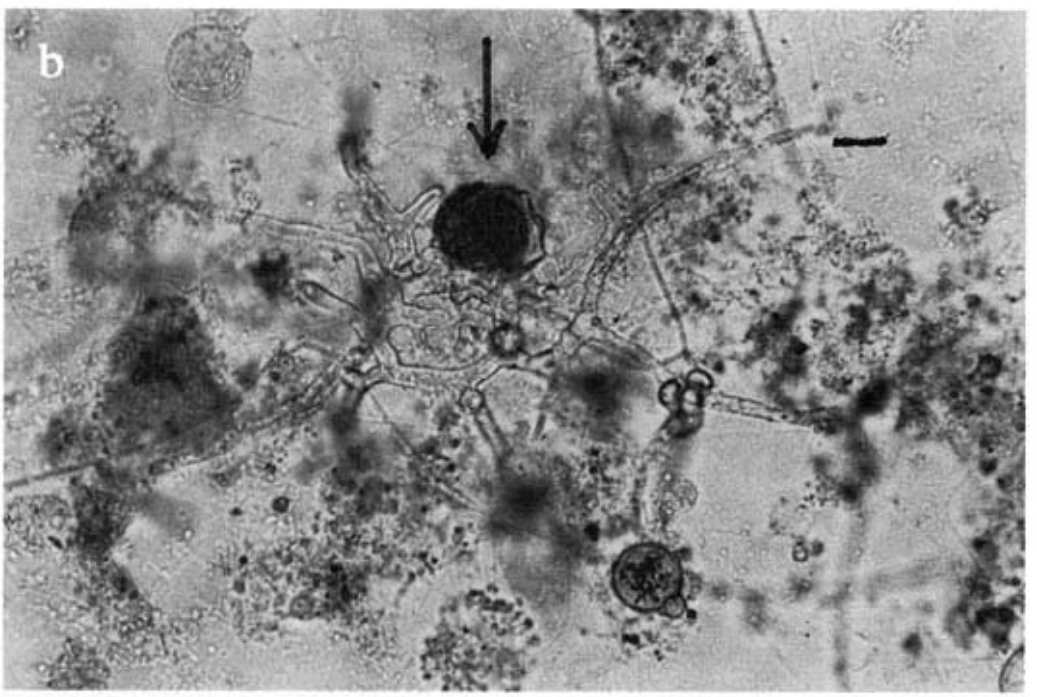


Fig. 1. *Sommerstorffia spinosa*: a – Hyphae; b – Oogonium; bare – 10 μm

As it has been reported in the monographs on the aquatic zoosporic fungi (Sparrow 1968; Batko 1975) *S. spinosa* leads an epiphytic mode of life on thread algae in water and soil, and is a predacious species catching rotifers. In our study *S. spinosa* was found in pond Fosa on avian excrements as a bait for coprophylic fungi (Czeczuga and Mazalska 2000), while in the river Biała, lake Białe and Wigry it was observed on baits for imperfect *Hyphomycetes*, such as cellophane and snake exuviae used in our studies for years. Also Karling (1968) isolated this fungus from soil in New Zealand using snake exuviae. After many years of observation it can be noted that water reservoirs, where *S. spinosa* has been found, differ in size irrespective of their nature (stagnant waters – ponds and lakes, running waters – rivers). The water in these reservoirs differs considerably in the content of biogenes, organic matter and other hydrochemical parameters. Worth special noting is pond Fosa with its great amount of sulphur hydrogen under ice cover. The water collected at the time of ice cover is devoid of living spores of zoosporic fungi (Czeczuga et al. 1999c) and *Hyphomycetes* (Czeczuga and Orłowska 1999). However, the water collected in March 1997 during ice melting contained living cytospores of *S. spinosa* – after some time the fungus mycelia appeared in the samples. It seems quite unlikely to interpret this phenomenon by resistense of cytospores to sulphur hydrogen, as they possess no protection e.g. thick sheet. In the light of our previous studies it appears that more aquatic fungus species are present in the water from melting ice collected from limnologically different water reservoirs than in the water collected at the same time and site from under ice. Such extraordinary accumulation of aquatic fungus spores in ice may be associated with surface tension, which is the highest when water changes into ice. It appears as if spores were pulled to the surface from the bottom layer. This refers not only to aquatic fungus spores but also to other microorganis, called neuston by Naumann (1917). According to Babenzien and Schwarz (1970) neuston composition is varied, consisting of algae, bacteria as well as conidial and zoosporic aquatic fungi.

This could explain the presence of living cytospores of *S. spinosa* in the water during ice melting in pond Fosa. After many years' our observation of the biology of *S. spinosa* in aquatic environment, the development of this fungus was presented of Figure 2.

In our laboratory, antheridia were recorded in *S. spinosa* for the first time (Próba 1980). Antheridia have not been reported in the monographs on the aquatic zoosporic fungi, as they have not observed (Sparrow 1960; Batko 1975).

S. spinosa preys on rotifers of the genus *Monostyla*, *Distyla* and *Colurus* (Arnaudow 1923b; Karling 1952; Batko 1975; Saikawa 1986). In our investigations *S. spinosa* was found to prey on the species of the genus *Lepadella* – in the river Biała and pond Fosa it was observed

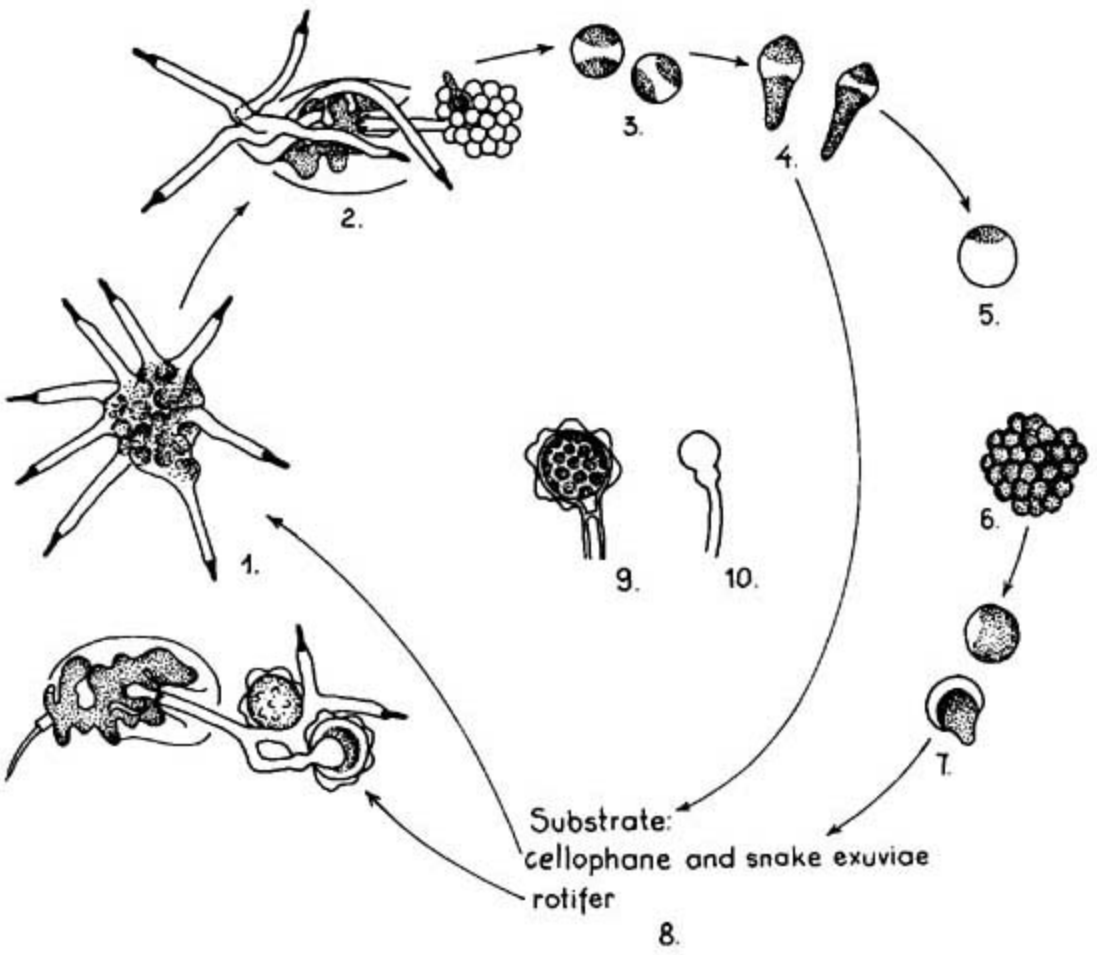


Fig. 2. Development of *Sommerstorffia spinosa*: 1 – Hyphae (5.8–8.2 μm in diameter and about 10–200 μm long) on the celophane; 2 – Sporangium – boaring hyphae in the body of *Lepadella elliptica*, hypha protruding outside; it ends with thinner, grasping filaments or tentacles, group of empty envelopes forming as a result of zoospore encystation at mouth of sporangium; 3 – Spores (6.5–8.5 μm), protoplasm separated into apical and basal parts; 4 – Germinating spores; 5 – Empty envelope of cystospores (7–9 μm); 6 – Group of cystospores; 7 – Germinating cystospores; 8 – Hyphae growing into the substrate; 9a – Oogonium with characteristic verrucose incrustation, oogonium with one oospore and antheridium; 9 – Oogonium (24–26 μm, containing 1 to 11 oospores of 7.5–9.5 in diameter); 10 – Antheridium (5–7 μm)

on *Lepadella elliptica* Wulfert and in lake Białe and Wigry on *L. patella* (O.F. Müller). These species of rotifers are typical of this type of waters in Central Europe (V o i g t 1957). However, it is still not clear why it takes tens of days for its mycelia to appear in water samples kept in a laboratory, whereas the mycelia of other representatives of *Saprolegniales* and *Hyphomycetes* are found to be fully grown already after a few days.

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Nowe wodne stanowiska grzyba *Sommerstorffia spinosa*

Streszczenie

Badając wodne grzyby zoosporowe wód północno-wschodniej Polski autorzy stwierdzili nowe stanowiska rzadkiego grzyba – *Sommerstorfia spinosa* Arnaudow. Rozwój tego gatunku obserwowano w próbach wody pobranych z różnych pod względem limnologicznym zbiorników poczynając od typu oligotroficznego (jezioro Białe) poprzez jezioro typu mezotroficznego (jezioro Wigry) a kończąc na politroficznym zbiorniku, w którym tuż po pokryciu się lodem w wodzie pojawia się siarkowodór (staw Fosa). Ponadto grzyb ten rozwijał się w wodzie rzeki Białej Wody, zanieczyszczonej odchodami komunalnymi. Przy tym autorzy opisują poszczególne stadia rozwojowe *S. spinosa* w środowisku wodnym.