Polish Journal of Environmental Studies Vol. 14, No. 2 (2005), 149-158

Original Research

Effect of Aquatic Plants on the Abundance of Aquatic Zoosporic Fungus Species

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Received: 5 April, 2004
Accepted: 4 August, 2004

Abstract

The authors investigated the influence of 9 species of aquatic plants (*Ceratophyllum demersum, Elodea canadensis, Hydrocharis morsus-ranae, Lemna minor, Nuphar luteum, Potamogeton natans, Sagittaria sagittifolia, Sparganium ramosum, Stratiotes aloides*) on the occurrence of aquatic zoosporic fungus species in the water of three water bodies of different trophy. The fewest fungi were noted in the containers with *Potamogeton natans* (9), *Elodea canadensis* (15) and *Hydrocharis morsus-ranae* (16), the most in containers with *Sparganium ramosum* (23), *Lemna minor* (24) and *Nuphar luteum* (25). More fungi were found to grow in the containers with 7 plants than in the controls (the mean ratio of Co/Pl ranged from 1.7/3.7 to 6.7/8.7). However, for *Potamogeton natans* and *Sparganium ramosum*, control samples contained more fungus species. The mean ratio for the samples with *Potamogeton natans* was 5.7/2.7 and with *Sparganium ramosum* – 6.3/5.4.

Keywords: aquatic plants, zoosporic fungus species, hydrochemical study

Introduction

Numerous interactions that occur between organisms in each water reservoir include the most common food interlinkage resulting in a number of trophic chains as well as interactions in which specimens of one species either stimulate or inhibit propagation and growth of another species. This usually happens as a result of excretion of certain organic substances to the environment [1]. Certain species of cyanobacteria may serve as an example of such an effect on other aquatic organisms [2,3]. During growth, cyanobacteria excrete toxic substances, which remain toxic even after cell death [4].

As shown in numerous studies, photosynthesizing bacteria [5-8], algae [1,9,10] and higher plants [11,12] found in water excrete some of the organic compounds produced in the process of photosynthesis to the aquatic environment. This is the so-called primary extracellular production [1,8].

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In aquatic reservoirs, reducers such as heterotrophic bacteria and fungi play a significant role in the matter and energy cycles. Up to now, our studies have shown that the substances excreted by cyanobacteria considerably inhibit the growth of bacteria [13], and aquatic conidial [14] and zoosporic [15] fungi. However, the substances excreted by aquatic plants may either stimulate or inhibit the growth of bacterioplankton [16].

In this context, we decided to focus on the interactions between certain species of aquatic plants and zoosporic fungi which have never before been discussed in literature.

Material and Methods

The experiments were conducted in September 2003 using 9 species of aquatic plants:

Ceratophyllum demersum L., *Elodea canadensis* Rich., *Hydrocharis morsus-ranae* L., *Lemna minor* L., *Nuphar luteum* (L.) Sm., *Potamogeton natans* L., *Sagittaria sagittifolia* L., *Sparganium ramosum* Huds. and *Stratiotes aloides*

L. Aquatic plants for experiments were collected from the Narew River in Narew National Park near Kurowo.

Water for analysis and experiments was collected from three water bodies:

I. Dojlidy Pond, located near Białystok: Area 34.2 ha, max. depth 2.85 m, its south shore borders with coniferous woods and its western part with the town of Białystok. The samples were collected from the western part of this pond, which has been used by the inhabitants of the town as a beach.

II. Fosa Pond, near Palace Park in Białystok: Area 2.5 ha, max. depth 1.75 m. Pond contains wild ducks and breeding swans as well as crucian carp and tench bred, used by anglers. The pond was surrounded by meadows with linden (*Tilia cordata* Mill.) and elm (*Ulnus carpinifolia* Gled.).

III. Supraśl River, right-bank tributary of the middle part of the Narew river flowing through Knyszyńska Forest. Length 106.6 km. The samples were collected from the site above the municipal swimming pool at the sluice of an arm of the Supraśl river flowing just through the town of Supraśl. The sampling site was surrounded by meadows and the bed was muddy.

Water samples for the experiments were collected from each reservoir at a depth of 15-30 cm at a distance of 0.5 m from the bank. The water was filtered through a gauze and then poured to containers. Nineteen parameters were determined for the water using standard methods [17].

Water samples, 800 ml each, were placed in 1000 ml containers. The aquatic plant species mentioned above (rewashed with distillated water) were added, 200g to each container. For each plant, there were two containers containing water from the particular water body used to obtain the plant. The third container served as control without aquatic plants (9 containers for each plant). All containers were enclosed in Petri dishes with the bed turned upside down to prevent possible airborne contamination in the containers by funga spores [18]. The containers were stored at 15±1°C, with access to daylight resembling natural conditions and following the recommended instructions [18]. The analyses were carried out in two parallel repetitions.

The grains of buckweat, hemp and clover served as bait and were added to all experimental (from plants and control) containers.

During one month of exposure, clusters from the container bottoms, side walls, and the surface of baits of control samples and with aquatic plants were examined under a microscope. The mycelium (zoospores, antheridia and oogonia) of aquatic fungi growing in particular containers was recorded. For determinations of the particular fungi species, the following keys were used: Johnson [19], Sparrow [20], Waterhouse [21], Seymour [22], Batko [23], Karling [24], Dick [25], Pystina [26], Watanabe [27] and in the works of the authors who were the first to describe the respective species.

The effect of aquatic plants on the number of aquatic zoosporic fungus species is presented as a ratio of Co/Pl – number of cases where a species were found in control culture (Co) to those in culture with water plants (Pl) [28].

The results were subjected to statistical analysis [28].

Results

Chemical analysis of water used for the experiment shows that the water was the most eutrophic in Pond Fosa, the least eutrophic in the river Supraśl, and in the middle in pond Dojlidy. This is expressed by such parameters of chemical analysis of water as dissolved oxygen content, BOD_5, COD of all three forms of nitrogen, sulphates, chlorides, dry residue and dissolved solids (Table 1).

In the present experiment, 103 types of zoosporic fungus species were found to grow, including 18 belonging to the Chytridiomycetes, 1 to Plasmodiophoromycetes, 82 to the Oomycetes and 2 species to the Zygomycetes (Table 2). In the waters of all three aquatic reservoirs a considerably larger number of fungi developed in containers with plants than in controls, 19 species were found to grow only in control containers, 45 species in containers with aquatic plants and 39 species were isolated both in controls and plant-containing containers (Table 3). The fewest fungi were noted in the containers with *Potamogeton natans* (9), *Elodea canadensis* (15) and *Hydrocharis morsus-ranae* (16), the most in the containers with *Nuphar luteum* (25), *Lemna minor* (24) and *Sparganium ramosum* (23) (Table 4). The number of fungi in containers with plants compared to control in general – (Table 3) and for particular aquatic plants – (Table 4) are important statistically.

As shown in Table 5, more fungi were found to grow in the containers with plants than in the control ones. However, for *Potamogeton natans* and *Sparganium ramosum*, control samples contained more fungus species. The mean ratio for the samples with *Potamogeton natans* was 5.7/2.7 and with *Sparganium ramosum* – 6.3/5.4.

Discussion

The number of zoosporic fungus species was higher in the containers with plants in comparison to the control in seven out of nine plant species examined. The mean ratio of Co/Pl ranged from 1.7/3.7 to 6.7/8.7. However, in the case of *Potamogeton natans* and *Sparganium ramosum*, more fungus species were found to grow in the control containers. The mean ratio of Co/Pl for *Potamogeton natans* was 5.7/2.7 and for *Sparganium ramosum* 6.3/5.3. It should be emphasized that we observed the inhibitory effect on the growth of bacteria in the case of other species of the genus *Potamogeton* [16]. For *Potamogeton lucens*, this kind of phenomenon was noted by Kudriavcev [12] in natural conditions.

Benson and Calvin [29] were the first to observe that during photosynthesis glycolic acid is excreted as an early product. For some time it was thought that glycolic

Table 1. Chemical properties of water in particular water bodies (n=5).

Specification	Dojlidy Pond	Fosa Pond	Supraśl River
Temperature (^{o}C)	19.5	17.0	18.0
pH	7.42	7.61	7.88
O_2 (mg dm^3)	7.80	3.65	9.20
BOD_5 (mg dm^3)	2.50	0.50	5.80
COD (mg dm^3)	12.35	22.97	7.84
CO_2 (mg dm^3)	11.15	18.80	11.95
Alkalinity in $CaCO_3$ (mval dm^3)	3.70	4.50	5.10
$N\text{-}NH_3$ (mg dm^3)	0.280	0.500	0.250
$N\text{-}NO_2$ (mg dm^3)	0.005	0.007	0.005
$N\text{-}NO_3$ (mg dm^3)	0.060	0.900	0.070
$P\text{-}PO_4$ (mg dm^3)	0.120	1.670	1.530
Sulphates (mg dm^3)	30.86	69.08	20.16
Chlorides (mg dm^3)	43.05	52.15	36.05
Total hardness Ca (mg dm^3)	60.48	56.16	72.25
Total hardness Mg (mg dm^3)	11.61	11.50	15.91
Fe (mg dm^3)	0.350	0.450	0.650
Dry residue (mg dm^3)	280.0	444.0	242.0
Dissolved solids (mg dm^3)	261.0	433.0	222.0
Suspended solids (mg dm^3)	19.0	11.0	20.0

Table 2. Zoosporic fungi found in water from particular water bodies in experiment (Co - control, Pl – with plants).

Species	Control			Plants			Ratio Co/Pl
	Dojlidy Pond	Fosa Pond	Supraśl River	Dojlidy Pond	Fosa Pond	Supraśl River	
Chytridiomycetes							
Olpidiales							
1. *Olpidium granulatum* Karling	x					x	1/1
Chytridiales							
2. *Amoebochytrium rhizidioides* Zopf						x	0/1
3. *Diplophlyctis laevis* Sparrow					x		0/1
4. *Entophlyctis helioformis* (Dang.) Ramsb.						x	0/1
5. *Obelidium mucronatum* Nowakowski						x	0/1
6. *Phlyctochytrium aureliae* Ajello	x						1/0
7. *Phlyctorhiza endogena* Hanson			x				1/0
8. *Podochytrium clavatum* Pfitzer	x						1/0
9. *Rhizophydium ampullaceum* (Braun) Fischer					x		0/1
10. *Rhizophydium braunii* (Zopf) Fischer						x	0/1
11. *Rhizophydium carpophilum* (Zopf) Fischer		x					1/0
12. *Rhizophydium nodulosum* Karling				x			0/1

Table 2. continues on next page...

Blastocladiales							
13. *Blastocladia gracilis* Kanouse					x		0/1
14. *Blastocladia rostrata* Minden						x	0/1
15. *Blastocladiopsis parva* (Whiffen) Sparrow		x	x		x	x	2/2
16. *Catenaria anguillulae* Sorokin						x	0/1
17. *Catenaria verrucosa* Karling	x			x			1/1
18. *Catenophlyctis variabilis* (Karling) Karling	x	x	x	x	x	x	3/3
Plasmodiophoromycetes							
Plasmodiophorales							
19. *Woronina polycistis* Cornu			x				1/0
Oomycetes							
Saprolegniales							
20. *Achlya ambisexualis* Raper				x			0/1
21. *Achlya americana* Humphrey	x	x	x	x	x		3/2
22. *Achlya apiculata* de Bary		x					1/0
23. *Achlya bisexualis* Coker et Couch			x				1/0
24. *Achlya caroliniana* Coker		x					1/0
25. *Achlya conspicua* Coker					x		0/1
26. *Achlya crenulata* Ziegler					x		0/1
27. *Achlya debaryana* Humphrey	x	x	x	x	x	x	3/3
28. *Achlya diffusa* Harvey		x		x	x		1/2
29. *Achlya dubia* Coker		x					1/0
30. *Achlya flagellata* Coker			x		x		1/1
31. *Achlya klebsiana* Pieters		x				x	1/1
32. *Achlya oblongata* de Bary	x			x	x		1/2
33. *Achlya orion* Coker						x	0/1
34. *Achlya polyandra* Hildebrand	x	x	x	x	x	x	3/3
35. *Achlya prolifera* Nees				x		x	0/2
36. *Achlya proliferoides* Coker					x		0/1
37. *Achlya racemosa* Hildebrand		x		x	x	x	1/3
38. *Achlya radiosa* Maurizio				x	x		0/2
39. *Achlya recurva* Cornu			x	x	x		1/2
40. *Achlya stellata* de Bary						x	0/1
41. *Achlya treleaseana* (Humphr.) Kauffm.				x			0/1
42. *Aphanodictyon papillatum* Huneycutt				x			0/1
43. *Aphanomycetes amphigynus* Cutter					x		0/1
44. *Aphanomycetes irregularis* Scott		x	x	x	x	x	2/3
45. *Aphanomycetes laevis* de Bary	x	x	x	x	x	x	3/3
46. *Aplanes androgynus* (Archer) Humphrey			x		x	x	1/2

Table 2. continues on next page...

47. *Cladolegnia subterranea* (Dissm.) Johan.	x						1/0
48. *Cladolegnia unispora* (Coker et Couch) Johan.	x			x			1/1
49. *Dictyuchus magnusii* Leitgeb						x	0/1
50. *Dictyuchus monosporus* Leitgeb		x	x	x	x	x	2/3
51. *Dictyuchus sterile* Coker		x				x	1/1
52. *Geolegnia inflata* Coker et Harvey			x				1/0
53. *Isoachlya anisospora* (de Bary) Coker	x		x	x			2/1
54. *Isoachlya monilifera* (de Bary) Kauffm.				x			0/1
55. *Isoachlya toruloides* Kauffm. et Coker	x						1/0
56. *Leptolegnia caudata* de Bary		x					1/0
57. *Leptolegniella keratinophila* Huneycutt		x			x	x	1/2
58. *Protoachlya paradoxa* (Coker) Coker					x		0/1
59. *Pythiopsis cymosa* de Bary		x		x	x	x	1/3
60. *Saprolegnia anisospora* de Bary					x		0/1
61. *Saprolegnia delica* Coker	x				x		1/1
62. *Saprolegnia diclina* Humphrey	x			x			1/1
63. *Saprolegnia ferax* (Gruith) Thuret	x	x	x	x	x	x	3/3
64. *Saprolegnia glomerata* (Tiesenh.) Lund			x			x	1/1
65. *Saprolegnia hypogyna* Pringsheim	x			x			1/1
66. *Saprolegnia lapponica* Gäumann						x	0/1
67. *Saprolegnia litoralis* Coker				x			0/1
68. *Saprolegnia monoica* Pringsheim						x	0/1
69. *Saprolegnia parasitica* Coker	x	x		x	x		2/2
70. *Saprolegnia torulosa* de Bary						x	0/1
71. *Saprolegnia unispora* (Coker et Couch) Seymour	x			x	x		1/2
72. *Thraustotheca clavata* (de Bary) Humphrey	x			x	x	x	1/3
Leptomitales							
73. *Apodachlya pirifera* Zopf		x		x			1/1
74. *Apodachlya seriata* Lund	x						1/0
75. *Aqualinderella fermentans* Emer. et Weston		x					1/0
76. *Leptomitus lacteus* (Roth) Agardh						x	0/1
77. *Rhipidium americanum* Thaxter						x	0/1
Lagenidiales							
78. *Olpidiopsis saprolegniae* (Braun) Cornu		x	x	x		x	2/2
79. *Olpidiopsis vexans* Barret			x				1/0
80. *Pseudolpidiella deformans* (Serbinov) Cejp				x	x		0/2
81. *Rozellopsis inflata* (Butler) Karling						x	0/1
Peronosporales							
82. *Phytophthora gonapodyoides* (Petersen) Buism.					x		0/1
83. *Pythium afertile* Kanouse				x			0/1

Table 2. continues on next page...

84. *Pythium aquaticum* Höhnk				x	x		0/2
85. *Pythium butleri* Subramaniam			x			x	1/1
86. *Pythium carolinianum* Matthews			x				1/0
87. *Pythium catenulatum* Matthews			x				1/0
88. *Pythium debaryanum* Hesse						x	0/1
89. *Pythium dissotocum* Drechsler		x			x		1/1
90. *Pythium helicandrum* Drechsler					x		0/1
91. *Pythium hypogynum* Middletoni				x			0/1
92. *Pythium inflatum* Matthews		x			x		1/1
93. *Pythium intermedium* de Bary					x		0/1
94. *Pythium middletonii* Sparrow	x						1/0
95. *Pythium myriotylum* Drechsler	x			x	x		1/2
96. *Pythium periplocum* Drechsler				x	x		0/2
97. *Pythium proliferum* Schenk					x		0/1
98. *Pythium pulchrum* Minden	x			x			1/1
99. *Pythium rostratum* Butler	x	x		x	x	x	2/3
100. *Pythium torulosum* Cuker et Patterson	x			x		x	1/2
101. *Pythium vanterpoolii* V. Kouyeas et H. Kouyeas						x	0/1
Zygomycetes							
Zoopagales							
102. *Zoopage phanera* Drechsler						x	0/1
103. *Zoophagus insidians* Sommerstorff						x	0/1
Total number	27	27	23	40	42	41	77/123

Table 3. Aquatic fungi found in particular containers.

Specification	Fungi (see Table2)	Number of fungi
Only control	6,7,8,11,19,22,23,24,29,47,52,55,56,73,74,79,86,87,94	19*
Only with plants	2,3,4,5,9,10,12,13,14,16,20,25,26,33,35,36,38,40,41,42,43,49,54,58,60,66,67,68,70, 76,77,80,81,82,83,84,88,90,91,93,96,97,101,102,103	45*
Control and with plants	1,15,17,18,21,27,28,30,31,32,34,37,39,44,45,46,48,50,51,53,57,59,61,62,63,64,65, 69,71,72,73,78,85,89,92,95,98,99,100	39

*Asterisks indicate differences significant at the ≤0.05% level

acid alone was excreted by phytoplankton [30,31]. Later studies confirmed that photosynthesizing hydrobionts excrete a number of other compounds produced during photosynthesis [1,2]. This refers not only to phytoplankton but to higher plants as well [11,32,33]. These substances include various organic compounds of carbon [34-36], free saccharides [37], free amino acids [38] and even a polymeric substance [39]. Recent studies have revealed a release of numerous enzymes [40], including glucosidase [41] and phosphatase [42] to the aquatic environment. All these forms of chemical compounds form certain types of interactions, such as competition or antagonism among bacteria, algae and aquatic weeds [43]. Organic substances dissolved in water [44] and amino acids are taken in by other hydrobionts [45,46], especially by heterotrophic bacteria [47-49] and even by mixotrophic organisms [50]. Dissolved organic compounds [51] and free amino acids [52] are used as nutrients by aquatic fungi. Certain species of aquatic plants show antagonistic properties, producing alkaloids of antibiotic properties [53,54] or allelochemicals, the polyphenol-type substances, which delimit the occurrence of periphyton on aquatic plant blades [55,56]. Lysine, a free amino acid, acts as an algicide [57].

The intensity of beyond-cell secretion of substances generated during photosynthesis changes in the respective developmental phases of a phytohydrobiont. The older the specimen, the greater the amount of the excreted substance, which refers both to cyanobacteria [15,58] and algae [10]. The experiment was performed in September, i.e. in the terminal phase of the growth of plants used for analysis.

Whether or not the presence of an aquatic plant affects the number of heterotrophic phytohydrobionts depends upon the kind of organic substances excreted by the plant [59, 60].

The largest number of fungus species were found in the plant-containing containers, the fewest in the control ones. It can be assumed that the substances excreted by plants may promote the growth of some fungi while inhibiting the growth of others. We observed this kind of phenomenon when studying the effect of cyanobacteria on the growth of zoosporic fungi [15]. Some of the fungi identified in the study grow both in control and in plant-containing containers. These are the species commonly encountered in the waters of various types of reservoirs in northeastern Poland and included the Blastocladiales – *Blastocladiopsis parva* and *Catenophlyctis variabilis*, the Saprolegniales – *Achlya americana, Achlya debaryana, Achlya polyandra, Aphanomyces irregularis, Aphanomyces laevis, Dictyuchus monosporus, Saprolegnia ferax* and *Saprolegnia parasitica;* the Lagenidiales – *Olpidiopsis saprolegniae;* and the Peronosporales – *Pythium rostratyum.* Most of these

Table 4. Aquatic fungi found in containers with particular plant species.

Plant	Fungi (see Table2)	Number of fungi
Ceratophyllum demersum L.	18,26,27,34,43,44,45,58,63,69,71,72,77,78,84,85,95,99	18*
Elodea canadensis Rich.	2,10,16,31,34,35,40,44,50,53,59,63,72,80,96	15*
Hydrocharis morsus-ranae L.	13,16,21,25,30,34,37,44,50,54,59,62,73,81,99,102	16*
Lemna minor L.	1,3,4,5,15,17,18,21,27,31,38,42,44,45,54,57,63,64,69,70,78,99,100,101	24*
Nuphar luteum (L.) Sm.	18,20,27,28,32,33,34,41,45,61,63,64,67,68,69,71,72,76,82,83,88,90,92,99,103	25*
Potamogeton natans L.	18,26,27,34,44,45,51,63,71	9*
Sagittaria sagittifolia L.	14,15,31,32,34,35,38,39,49,51,53,59,63,65,72,73,78,89,93,98	20*
Sparganium ramosum Huds.	9,18,21,37,44,45,48,50,53,54,60,62,63,66,69,78,84,91,96,98,99,100,103	23*
Stratiotes aloides L.	12,15,18,21,27,28,34,45,46,50,53,57,62,63,64,95,97,98,99,100,101,103	22*
Control	1,6,7,8,11,15,17,18,19,21,22,23,24,27,28,29,30,31,32,34,37,44,45,46,47,48,50,51, 52,53,55,56,57,59,61,62,63,64,65,69,71,72,73,74,75,78,79,85,86,87,89,92,94,95, 98,99,100	57*

*Asterisks indicate differences significant at the ≤0.05% level

Table 5. Number of fungi species found in control containers and containers with plants in particular water bobies (Co – control, Pl – containers with plant).

Plant	Pond Dojlidy		Pond Fosa		River Supraśl		Mean ratio Co/Pl
	Co	Pl	Co	Pl	Co	Pl	
Ceratophyllum demersum L.	3	4	4	6	3	6	3.5/5.3
Elodea canadensis Rich.	5	7	2	5	2	4	3.0/5.3
Hydrocharis morsus-ranae L.	1	3	2	4	2	4	1.7/3.7
Lemna minor L.	9	11	7	8	4	7	6.7/8.7
Nuphar luteum (L.) Sm.	3	7	4	6	6	10	4.3/7.7
Potamogeton natans L.	6	2	7	4	4	2	5.7/2.7
Sagittaria sagittifolia L.	2	4	2	3	1	4	1.7/3.7
Sparganium ramosum Huds.	6	4	6	5	7	7	6.3/5.3
Stratiotes aloides L.	4	5	5	6	4	7	4.3/6.0
Mean ratio Co/ Pl	4.3/5.2		4.3/5.2		3.7/5.7		

species grow in water containing cyanobacteria [15], and therefore they may be commonly found in rivers and lakes [61-71] of varied trophicity, in reservoirs of various levels of pollution. We observed a similar phenomenon when studying the effect of cyanobacteria on aquatic conidial fungi [14]. Common aquatic species appeared resistant to the action of cyanobacterial toxins.

The present study has revealed that the effect of respective aquatic plants on the growth of certain zoosporic fungus species depends on water chemistry. The more eutrophic water is, the fewer zoosporic fungus species grow in the presence of particular aquatic plants. The water in Fosa Pond compared to the Supraśl River was more eutrophic in nature and contained more sulphates and chlorides. This was also the case in Dojlidy Pond. The presence of sulphates and chlorides on the growth of zoosporic fungus species was also observed in 13 various types of water bodies [71]. The growth of fungus species in the presence of aquatic plants was inhibited in these waters (ratio Co/Pl - 4.3/52=0.83) compared to the Supraśl (ratio Co/Pl - 3.7/5.7=0.65). Also, the toxic action of cyanobacteria synergistic with chemical loading of water was previously observed when studying the effect of cyanobacteria on the growth of heterotrophic bacteria [13], and on the growth of conidial [14], and zoosporic fungi [15].

Of the new and rare species to Polish hydromycology, three species, namely *Entophlyctis helioformis, Obelidium mucronatum* and *Saprolegnia lapponica*, were found to grow in the Supraśl, the first two in containers with *Lemna minor* and with *Sparganium ramosum.* In the control container with the water from the river Supraśl, *Geolegnia inflata* was also noted. As it is known, the river Supraśl water was the least eutrophic and the most abundant in oxygen, calcium, magnesium and iron. *Entophlyctis helioformis* was first described by Dangeard [72] at the end of the 19th century from algae of the genus *Nitella*. Almost at the same time, Nowakowski [73] described *Obelidium mucronatum* as a zoosaprophyte on insect exuviae. *Saprolegnia lapponica*, a rare species, was described by Gaüman [74] from marshy grounds of Swedish Lapland. *Geolegnia inflata* was first reported from coastal waters in North America [75]. In the containers with water samples collected from Dojlidy Pond, two new Polish water species were isolated – *Cladolegnia subterranea* in the control container and *Pseudolpidiella deformans* in the presence of *Elodea canadensis*. This latter species was also found in the presence of the same plant in Fosa Pond. *Cladolegnia subterranea* was first described as *Isoachlya subtteranea* in soil conditions [76], while *Pseudolpidiella deformans* as a parasite of algae of the genus *Draparnaldia* [77]. Then Cejp [78] distinguished the genus *Pseudolpidiella,* referring the species *Pseudolpidiella deformans* to this genus. Dojlidy water compared to the other two reservoirs had the lowest alkalinity and the smallest amounts of $N\text{-}NO_3$, $P\text{-}PO_4$, iron, dry residue and dissolved solids. *Aqualinderella fermentans*, a rare fungus, was found to grow on buckwheat grains in a control container with water collected from Fosa. This species was first described by Emerson and Weston [79] from waters in Monrovia deprived of oxygen and containing large amounts of carbon dioxide. Therefore, mycological monographs refer this fungus to the subtropical and equatorial zone. Recent studies [81,82] have shown that this fungus may develop in aquatic reservoirs of Europe, colonizing not only juicy fruits but also dry fruits and seeds of certain plants.

Worthy of note is the fact that in Fosa Pond, where *Aqualinderella fermentans* can be found, a few days after its water sheet has been covered with ice, oxygen is replaced by hydrogen sulphide, known to destroy all living organisms except for hydrogen sulphide bacteria [5,6]. It can be assumed that some spores of *Aqualinderella fermentans* may survive winter "arrested" in the ice cover. This refers to all aquatic fungus species found in this type of aquatic reservoir [83].

Conclusions

Of the nine species of aquatic plants examined, seven caused an increase in the number of zoosporic fungus species in experimental conditions, while two (*Potamogeton natans*, *Sparganium ramosum*) had an inhibitory effect.

According to the authors, some photosynthesizing phytohydrobionts excrete organic substances that serve as nutrients for zoosporic fungi (dissolved organic matter, amino acids) while other compounds (cyanobacterial toxins, alkaloids, polyphenols) posses antibiotic properties that inhibit the growth of certain zoosporic fungus species.

Thus, the number of aquatic fungi in a water reservoir depends not only on abiotic factors (water chemistry) but also on biotic properties, especially on a variety of positive or negative interactions within a group of hydrobionts inhabiting the reservoir.

Acknowledgements

The authors are grateful to the Staff of the Narew National Park for their help in obtaining the plants.

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