Aquatic fungi and chromistan organisms (fungus-like organisms) growing on dead individuals of free-floating plants in water bodies of north-eastern Poland

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Abstract. The authors investigated aquatic fungi and chromistan organisms growing on the dead specimens of 11 species of free-floating plants in the water from three limnological and trophical different water bodies (spring, river and pond). On the specimens investigated plants in the water of water bodies of north-eastern Poland they identified 129 species including 57 chromistan organisms and 72 fungus species. The most common taxa were *Aphanomyces laevis, Thraustotheca clavata, Pythium inflatum, P. rostratum, Anguillospora filiformis, A. pseudolongissima, Angulospora aquatica, Heliscus submersus, Lemonniera aquatica, Pithomyces obscuriseptatus, Tetracladium marchalianum, Tricellula aquatica.* Most fungus species were observed on the specimens of *Utricularia minor, U. vulgaris* (each 36) and *Hydrocharis morsus-ranae* (34), fewest on *Lemna gibba* (22), *Aldrowanda vesiculosa* and *Lemna minor* (each 23). The most taxa were growing in the water from River Supraśl (64), the fewest in the water from Spring Jaroszówka (55). A number of chromistan organisms and fungus species (2 and 11 respectively) appeared new to Polish waters.

Key words: chromistan organisms, free-floating plants, hydrochemistry, Poland, water bodies, water fungi

Introduction

In quiet gulfs, small lakes or ponds and also in scrubs of lakes and rivers, often in big amounts group of plants without roots or with roots pendant in the water counted to free-floating plants are developing (Bernatowicz & Wolny 1974; Hutchinson 1975; Catarino *et al.* 2001; Fare *et al.* 2001). They are unstriked, free flowing on water surface and interpendence on moves of water. Sometimes its can even cover all surface not large basins. In autumn period its in masses dead being substrate for different kind of bacteria, chromistan organisms and fungal species.

From several years keeping studies of aquatic fungi and chromistan organisms developing on dead fragments of aquatic plants (Czeczuga *et al.* 2003b, 2005; Czeczuga & Muszyńska 2005), this time we paid attention on plant species belonging to free-floating plants association.

Material and Methods

The study included 11 species of free-floating plants (Table 2) collected at the end of the vegetative season from water bodies of north-eastern Poland (from the others than those, from

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which the water was taken to the experiments). The water for experiments was collected from three different water bodies; two running (spring Jaroszówka and river Supraśl) and one stagnant (pond Dojlidy):

- Spring Jaroszówka, localized in the north part of Białystok: Limnokrenic type, width 0.65 m, depth 0.12 m, discharge 2.4 l/s, surrounding without trees. spring is surrounded by cultivated fields. The bed is covered with sand.
- River Supraśl, right-bank tributary of the middle part of the Narew River, flowing through the 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 Supraśl. The sampling site is surrounded by meadows. The bed is muddy.
- Pond Dojlidy, localized in the near of Białystok: Area 34.2 ha, max. depth 2.85 m, its south shores border with coniferous woods and its western part with the town of Białystok. The samples were collected from the western part of this pond, which is used by the inhabitants of the town as a beach.

On the beginning of the experiment nineteen water parameters of the above sampling sites were determined (Table 1) according to the methods recommended by *Standard Methods for the Examination of Water and Wastewater* (Greenberg *et al.* 1995).

For the determination of the presence of aquatic chromistan organisms and fungal species on the free-floating plants the following procedure was employed: a certain number of pieces (rewashed with destilled water to remove from their surface periphyton and fungi) about 2 mg of each plant species was transferred to two samples of water representing each site, in an 1.0 dm^3 vessel (all together six vessels for each species) and placed in the laboratory at ambient temperature. Apart of pieces from each vessel was observed under a light microscope and the mycelium of chromistan organisms and aquatic fungi on the pieces of plant was recorded. The methods are described in detail by Seymour & Fuller (1987). The pieces of the various plant species were observed under a microscope for one a half weeks. The duration of the experiments was four weeks. Identification of fungi species was based on morphology and biometric data of antheridia, oogonia and conidiophores and conidia of the anamorphic fungi.

Identification of the fungi was aided by the following keys: Johnson (1956), Seymour (1970), Batko (1975), Karling (1977), Plaats-Niterink (1981), Dick (1990), Pystina (1998) and for anamorphic fungi – Dudka (1974), Ingold (1975), Carmichael *et al.* (1980), Matsushima (1993) and works of the authors who were the first to describe the respective speciese. The investigate parameter data of water and fungal flora for these investigations were processed by numerical analysis (Podani 2000).

Table 1. Chemical and physical properties of water in particular water bodies

Specyfication	Spring Jaroszówka	River Supraśl	Pond Dojlidy
Temperature (°C)	2.5	3.1	3.5
pH	7.92	7.52	7.84
O_2 (mg l^{-1})	10.8	11.4	9.6
BOD_5 (mg l^{-1})	1.8	7.2	5.4
COD (mg l^{-1})	2.50	7.00	7.03
CO_2 (mg l^{-1})	11.0	8.8	13.2
Alkalinity in $CaCO_3$ (mval l^{-1})	5.8	4.3	4.6
N-NH_3 (mg l^{-1})	0.12	0.23	0.61
N-NO_2 (mg l^{-1})	0.013	0.008	0.013
N-NO_3 (mg l^{-1})	2.25	0.37	0.36
P-PO_4 (mg l^{-1})	1.29	1.20	0.45
Sulphates (mg l^{-1})	53.07	34.97	23.61
Chlorides (mg l^{-1})	11.0	11.0	18.0
Total hardness (mg Ca l^{-1})	45.28	70.56	88.56
Total hardness (mg Mg l^{-1})	16.77	12.47	16.34
Fe (mg l^{-1})	0.40	0.50	0.70
Dry residue (mg l^{-1})	414	166	296
Dissolved solids (mg l^{-1})	410	141	280
Suspended solids (mg l^{-1})	4	15	16

Table 2. Occurrence of aquatic fungi and fungus-like organisms on fragments of the investigated free-floating plants

	Species of free-floating plants	Fungi and fungus-like organisms (see Table 3)	Number of species
1	*Aldrowanda vesiculosa* L.	4, 5, 11, 14, 26, 29, 30, 39, 61, 63, 80, 87, 90, 92, 96, 102, 103, 105, 106, 108, 109, 112, 122, 124	24
2	*Hydrocharis morsus-ranae* L.	2, 7, 8, 9, 11, 15, 16, 18, 30, 35, 36, 40, 44, 45, 46, 48, 50, 54, 65, 67, 74, 75, 79, 82, 87, 89, 90, 96, 108, 109, 114, 123, 126, 129	34
3	*Lemna gibba* L.	12, 15, 39, 41, 45, 53, 55, 57, 58, 59, 64, 68, 71, 89, 90, 91, 93, 106, 108, 112, 114, 127	22
4	*L. minor* L.	8, 9, 12, 44, 45, 47, 53, 54, 58, 60, 62, 65, 68, 71, 87, 90, 98, 105, 107, 108, 111, 114, 123	23
5	*L. trisulca* L.	2, 7, 8, 12, 19, 24, 27, 28, 38, 42, 45, 46, 50, 53, 54, 55, 62, 66, 71, 85, 87, 89, 90, 94, 101, 106, 108, 114, 115, 118, 123	31
6	*Salvinia natans* (L.) All.	8, 19, 22, 30, 35, 45, 50, 52, 61, 67, 76, 86, 87, 90, 94, 104, 105, 106, 108, 112, 116, 121, 122, 123, 128	25
7	*Spirodela polyrrhiza* (L.) Schl.	8, 12, 16, 20, 37, 38, 45, 51, 53, 54, 58, 59, 62, 83, 87, 89, 90, 96, 105, 106, 109, 111, 113, 114, 119, 120, 122, 127, 128	29
8	*Stratiotes aloides* L.	1, 8, 13, 15, 25, 38, 43, 46, 51, 56, 61, 62, 63, 67, 69, 72, 78, 79, 88, 90, 95, 97, 100, 103, 106, 108, 112, 117, 122, 123, 125, 126	32
9	*Utricularia minor* L.	8, 10, 15, 17, 18, 25, 28, 30, 31, 32, 34, 38, 40, 44, 45, 47, 49, 54, 61, 69, 70, 72, 75, 77, 84, 86, 87, 88, 89, 90, 99, 106, 108, 110, 113, 122	36
10	*U. vulgaris* L.	8, 10, 13, 15, 17, 18, 21, 28, 30, 31, 32, 34, 37, 38, 40, 45, 47, 49, 54, 61, 69, 70, 73, 75, 77, 84, 85, 87, 89, 90, 99, 106, 108, 110, 113, 122	36
11	*Wolffia arrhiza* (L.) Wimm.	3, 5, 6, 7, 12, 13, 20, 23, 25, 27, 28, 30, 32, 33, 45, 52, 53, 81, 90, 94, 105, 106, 109, 111, 114, 122, 123, 128	28

Results

Chemical analysis of water used to experiments showed that it different in contents of particular parameters (Table 1). As for water from the spring Jaroszówka it was the richest in nitrogen, phosphate, sulphates and magnesium, and it showed maximum alkalinity indicator. Whereas in minimal amounts occurred ammonium nitrogen, calcium and iron. Moreover oxidation and BOD_5 were the lowest. Next water of the river Supraśl characterized maximum content of oxygen and maximum indicator of BOD_5. Simultaneously it contained minimal amounts of nitrogen, sulphates, magnesium and it had the largest alkalinity. As for water from the pond Dojlidy it contained great amount of CO_2, ammonium nitrogen, chlorides, calcium, iron and it had the greatest oxidation. Oxygen, nitrogen and phosphates occurred in minimum amounts.

As for fungi growing on dead fragments of free-floating plants, detected 129 species inclusive of 57 chromistan organisms and 72 fungal species (Table 3, Fig. 1). The most often occurring chromistan organisms were *Aphanomyces laevis* (8), *Thraustotheca clavata* (6), *Pythium inflatum* (10) and *Pythium rostratum* (6 species). As for fungi species the most often occurring on this kind plant substrate (dead free-floating plants) were *Anguillospora filiformis* (8), *A. psudolongissima* (6), *Angulospora aquatica* (11), *Heliscus submersus* (9), *Lemonniera aquatica* (9), *Pithomyces obscuriseptatus* (6), *Tetracladium marchalianum* (7) and *Tricellula aquatica* (on 6 free-floating plants). From 57 species of chromistan organisms 2 proved new for Polish water and from fungal species 11 species detected. The most number species of fungi growing on fragments *Utricularia minor* and *U. vulgaris* (each 36), and the least amount on *Lemna gibba* (22) and *Aldrowanda vesiculosa* (23 species). Fewest chromistan organisms and fungal species were found on the free-floating plants in the water collected from spring Jaroszówka (55), the most in water from river Supraśl (64 species) (Table 4). Some species growing only on fragments of single free-floating plants (Table 5). Studies made by method of numerical analysis showed that the mycoflora of the spring Jaroszówka was affected by considerably the levels of sulphates, showing negative correlation (-0.7897, level of significance 0.04). In the river Supraśl and pond Dojlidy, a positive correlation was revealed in the case of calcium concentration (respectively +0.8924 and +0.8712, level of significance 0.04).

Table 3. Aquatic fungi and fungus-like organisms found on free-floating plants

	Species	Plant (see Table 2)	Number of plants
	Chromista		
	Oomycetes		
	Lagenidiales		
1	*Lagenidium podbielkowski* A. Batko	8	1
2	*L. rabenhorstii* Zopf	2, 5	2
	Saprolegniales		
3	*Achlya colorata* Pringsh.	11	1
4	*A. flagellata* Coker	1	1
5	*A. klebsiana* Pieters	1, 11	2
6	*A. polyandra* Hildebr.	11	1
7	*A. racemosa* Hildebr.	2, 5, 11	3
8	*Aphanomyces laevis* de Bary	2, 4, 5, 6, 7, 8, 9, 10	8
9	*Brevilegnia unisperma* (Coker et Braxton) Coker et Braxton	2, 4	2
10	*Dictyuchus monosporus* Leitg.	9, 10	2
11	*Isoachlya anisospora* (de Bary) Kauffman	1, 2	2
12	*I. monilifera* (de Bary) Kauffman	3, 4, 5, 7, 11	5
13	*Leptolegnia caudata* de Bary	8, 10, 11	3
14	*Protoachlya paradoxa* (Coker) Coker	1	1
15	*P. polyspora* (Lindst.) Apinis	2, 3, 8, 9, 10	5
16	*Pythiopsis cymosa* de Bary	2, 7	2
17	*P. humphreyana* Coker	9, 10	2
18	*Saprolegnia anisospora* de Bary	2, 9, 10	3
19	*S. ferax* (Gruith.) Thur.	5, 6	2
20	*S. glomerata* (Tiesenh.) A. Lund	7, 11	2
21	*S. hypogyna* (Pringsh.) de Bary	10	1
22	*S. latvica* Apinis	6	1
23	*S. litoralis* Coker	11	1
24	*S. megasperma* Coker	5	1
25	*S. mixta* de Bary	8, 9, 11	3
26	*S. papillosa* (Humphrey) Apinis	1	1
27	*S. parasitica* Coker	5, 11	2
28	*S. torulosa* de Bary	5, 9, 10, 11	4
29	*S. turfosa* (Minden) Gäum.	1	1
30	*Thraustotheca clavata* (de Bary) Humphrey	1, 2, 6, 9, 10, 11	6
	Leptomitales		
31	*Apodachlya brachynema* (Hildebr.) Pringsh.	9, 10	2
32	*A. pyrifera* Zopf	9, 10, 11	3
33	*Leptomitus lacteus* (Roth) C. Agardh	11	1
	Peronosporales		
34	*Pythiogeton utriforme* Minden	9, 10	2

Table 3. (continued)

	Species	Plant (see Table 2)	Number of plants
35	*Pythium afertile* Kanouse et T. Humphrey	2, 6	2
36	*P. angustatum* Sparrow	2	1
37	*P. artotrogus* de Bary	7, 10	2
38	*P. butleri* Subraman.	5, 7, 8, 9, 10	5
39	*P. carolinianum* V.D. Matthews	1, 3	2
40	*P. debaryanum* R. Hesse	2, 9, 10	3
41	*P. echinulatum* V.D. Matthews	3	1
42	*P. elongatum* V.D. Matthews	5	1
43	*P. gracile* Schenk	8	1
44	*P. hydnosporum* (Mont.) J. Schröt.	2, 4, 9	3
45	*P. inflatum* V.D. Matthews	1, 2, 3, 4, 5, 6, 7, 9, 10, 11	10
46	*P. intermedium* de Bary	2, 5, 8	3
47	*P. myriotylum* Drechsler	4, 7, 9, 10	4
48	*P. oedochilum* Drechsler	2	1
49	*P. oryzae* S. Ito et Tokun.	9, 10	2
50	*P. perniciosum* Serbinow	2, 5, 6	3
51	*P. polysporum* Sorokin	7, 8	2
52	*P. pyrilobum* Vaartaja	6, 11	2
53	*P. pythioides* (Roze et Cornu) Ramsb.	3, 4, 5, 7, 11	5
54	*P. rostratum* E.J. Butler	2, 4, 5, 7, 9, 10	6
55	*P. tardicrescens* Vanterp.	3, 5	2
56	*P. tenue* Gobi	8	1
57	*P. torulosum* Coker et P. Patt.	3	1
	Fungi		
	Chytridiomycetes		
	Olpidiales		
58	*Reessia amoeboidea* C. Fisch	3, 4, 7	3
59	*R. lemnae* (A. Fisch.) Karling	3, 7	2
	Chytridiales		
60	*Blyttiomyces spinulosus* (A. Blytt) A.F. Bartsch	4	1
61	*Chytridium xylophilum* Cornu	1, 6, 8, 9, 10	5
62	*Cladochytrium hyalinum* Berdan	4, 5, 7, 8	4
63	*C. tenue* Nowak.	1, 8	2
64	*C. replicatum* Karling	3	1
65	*Endochytrium digitatum* Karling	2, 4	2
66	*Entophlyctis texana* Karling	5	1
67	*Karlingia rosea* (de Bary et Woronin) A.E. Johanson	2, 6, 8	3
68	*Nephrochytrium aurantium* Whiffen	3, 4	2
69	*Nowakowskiella elegans* (Nowak.) J. Schröt.	8, 9, 10	3
70	*N. hemisphaerospora* Shanor	9, 10	2
71	*N. profusa* Karling	3, 4, 5	3
72	*Phlyctochytrium aureliae* Ajello	8	1

Table 3. (continued)

	Species	Plant (see Table 2)	Number of plants
73	*Polyphagus euglenae* Nowak.	9, 10	2
74	*Rhizidium richmondense* Willoughby	2	1
75	*Rhizophlyctis petersenii* Sparrow	2, 9, 10	3
76	*Rhizophydium ampullaceum* (A. Braun) A. Fisch.	6	1
77	*R. carpophilum* (Zopf) A. Fisch.	9, 10	2
	Monoblepharidiales		
78	*Gonapodya prolifera* (Cornu) A. Fisch.	8	1
79	*Monoblepharis macrandra* (Lagerh.) Woronin	2, 8	2
	Zygomycetes		
80	*Zoophagus insidians* Sommerst.	1	1
	Endomycetes		
	Endomycetales		
81	*Hansenula anomala* (E.C. Hansen) Syd. et P. Syd.	11	1
	Ustilaginales		
82	*Tracya hydrocharidis* Lagerh.	2	1
83	*T. lemnae* (Setch.) Syd. et P. Syd.	7	1
	Anamorphic fungi		
84	*Acrodictys bambusicola* M.B. Ellis	9, 10	2
85	*A. elaeidicola* M.B. Ellis	5, 10	2
86	*A. martini* J.L. Crane et Dumont	6, 9	2
87	*Anguillospora filiformis* Greath.	1, 2, 4, 5, 6, 7, 9, 10	8
88	*A. longissima* (Sacc. et P. Syd.) Ingold	8, 9	2
89	*A. pseudolongissima* Ranzoni	2, 3, 5, 7, 9, 10	6
90	*Angulospora aquatica* Sv. Nilsson	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	11
91	*Arbusculina fragmentans* Marvanová	3	1
92	*Arthrobotrys stilbacea* J.A. Mey.	1	1
93	*Beverwykella pulmonaria* (Beverw.) Tubaki	3	1
94	*Calcarispora hiemalis* Marvanová et Marvan	5, 6, 11	3
95	*Canalisporium caribense* (Hol.-Jech. et Mercado) Nawawi et Kuthub.	8	1
96	*Centrospora aquatica* S.H. Iqbal	1, 2, 7	3
97	*Cladosporium peruamazonicum* Matsush.	8	1
98	*Clavatospora longibrachiata* (Ingold) Sv. Nilsson	4	1
99	*Corynesporella simpliphora* Matsush.	9, 10	2
100	*Dactylaria fusiformis* Shearer et J.L. Crane	8	1
101	*Dactylella ramiformis* Xing Z. Liu et W.F. Qiu	5	1
102	*Flagellospora curvula* Ingold	1	1
103	*F. stricta* Sv. Nilsson	8	1
104	*Heliscella stellata* (Ingold et V.J. Cox) Marvanová	6	1

Table 3. (continued)

	Species	Plant (see Table 2)	Number of plants
105	*Heliscus lugdunensis* Sacc. et Therry	1, 4, 6, 7, 11	5
106	*H. submersus* H.J. Huds.	1, 3, 5, 6, 7, 8, 9, 10, 11	9
107	*Kylindria keitae* Rambelli et Onofri	4	1
108	*Lemonniera aquatica* De Wild.	1, 2, 3, 4, 5, 6, 8, 9, 10	9
109	*Lunulospora curvula* Ingold	1, 2, 7, 11	4
110	*Melanocephala manuensis* Matsush	9, 10	2
111	*Microstella pluvioriens* K. Ando et Tubaki	4, 7, 11	3
112	*Mirandina corticola* G. Arnaud ex Matsush.	1, 3, 6, 8	4
113	*Phialogeniculata multiseptata* Matsush.	7, 9, 10	3
114	*Pithomyces obscuriseptatus* Matsush.	2, 3, 4, 5, 7, 11	6
115	*Polycladium equiseti* Ingold	5	1
116	*Polystratorictus fusarioideus* Matsush.	6	1
117	*Pseudocercospora manuensis* Matsush.	8	1
118	*Ramichloridium clavulisporum* Matsush.	5	1
119	*Sigmoidea prolifera* (R.H. Petersen) J.L. Crane	7	1
120	*Sporidesmium acutifusiforme* Matsush.	7	1
121	*Taeniolina deightonii* J.L. Crane et Schokn.	6	1
122	*Tetracladium marchalianum* De Wild.	1, 6, 7, 8, 9, 10, 11	7
123	*Tricellula aquatica* J. Webster	2, 4, 5, 6, 8, 11	6
124	*Trifurcospora irregularis* (Matsush.) K. Ando et Tubaki	1	1
125	*Trinacrium subtile* Riess	8	1
126	*Vargamyces aquaticus* (Dudka) Tóth	2, 8	2
127	*Varicosporium delicatum* S.H. Iqbal	3, 6, 7	3
128	*Veronaea botryosa* Cif. et Montemart.	7, 11	2
129	*Ypsilina graminea* (Ingold *et al.*) Descals *et al.*	2	1

Table 4. Aquatic fungi and fungus-like organisms found on the free-floating plants in different water bodies

Water from	Fungi and fungus-like organisms (see Table 3)	Only in one water bodies	Total number of species
Spring Jaroszówka	4, 7, 9, 10, 11, 12, 15, 16, 18, 19, 20, 22, 23, 27, 28, 30, 35, 39, 40, 41, 42, 46, 47, 51, 52, 56, 58, 60, 61, 70, 72, 76, 77, 82, 83, 84, 86, 87, 88, 89, 91, 94, 95, 96, 98, 99, 100, 105, 109, 112, 113, 115, 119, 126, 128	4, 18, 20, 40, 41, 42, 51, 56, 60, 70, 73, 77, 82, 83, 84, 86, 89, 91, 94, 96, 98, 99, 105, 109, 112, 115, 119, 126, 128	55 (29)*
River Supraśl	1, 2, 5, 7, 8, 9, 10, 11, 12, 16, 19, 24, 25, 26, 27, 29, 31, 32, 34, 36, 37, 38, 45, 46, 47, 49, 50, 52, 53, 54, 58, 59, 61, 62, 63, 65, 67, 69, 72, 74, 75, 76, 80, 87, 88, 90, 93, 95, 97, 101, 102, 106, 107, 108, 112, 114, 117, 118, 119, 120, 121, 122, 123, 125	2, 5, 24, 25, 29, 32, 34, 36, 37, 49, 63, 65, 69, 72, 73, 74, 80, 92, 97, 114, 117, 118, 120, 121	64 (24)
Pond Dojlidy	1, 3, 6, 8, 13, 14, 15, 17, 21, 22, 23, 26, 28, 30, 31, 33, 35, 38, 39, 43, 44, 45, 48, 50, 53, 54, 55, 57, 59, 61, 62, 64, 66, 67, 68, 71, 76, 78, 79, 81, 85, 90, 92, 100, 101, 102, 103, 104, 106, 107, 108, 110, 111, 112, 113, 116, 122, 123, 124, 125, 127, 129	3, 6, 13, 14, 17, 21, 33, 43, 44, 48, 55, 57, 64, 66, 68, 71, 78, 79, 81, 85, 102, 103, 104, 110, 111, 116, 124, 127, 129	62 (29)

*only in this water bodies

Discussion

As is known aquatic plants species composing group named free-floating plants the most often occupy poly- and eutrophic water basin types. Perhaps it is a reason that in water of the spring Jaroszówka which the richest in N-NO_3 and phosphates, developed on dead representants researched specimens of free-floating plants the greatest number of aquatic chromistan organisms and fungal species. If it water of the river Supraśl grew only 24 species that in water in the spring Jaroszówka 29 species. As showed comparisons particular hydrochemical parameters with amount of species growing on examined substratum, the limiting factors were sulphates (negative) and calcium (positive). Similar phenomenon was observed when studying fungi of limnologically different types of lakes in the Wigry National Park (Czeczuga *et al.* 2001). In other types of water bodies number of fungus species depended on the other number of chemical factors – for example, chlorides, magnesium, nutrients (nitrogens or phosphates), oxidability and others (Czeczuga *et al.* 2002a, b, 2003). Perhaps therefore number of chromistan orgasms and fungal species in eutrophic lakes often is fewest and in oligo-mesotrophic lakes is most (Czeczuga *et al.* 2001, 2003). The inhibitional effects of organic pollutions on growth of chromistan organisms and fungal species population in stream was investigated by Cooke (1961) and the effect of sulphur-containing compound on *Catenaria anguillulae* as representatives of Phycomycetes was described by Nolon (1970). The investigated also the effect of the sulphide on the number of anomorphic fungus species (Chandrashekar *et al.* 1991). The number of anamorphic fungus species in sulphur spring (3.1 mg·l^{-1} sulphide) in the Western Ghat region (India) was greatly reduced. They were entirely absent in the spring proper and far from the spring in the stream which flows from it, the amount of sulphide decreased (to 0.1 mg·l^{-1}) and the number of anamorphic fungus species increased to 20.

As is known with eutrophication some basin amount of sulphates is increasing (Häkanson 1999). On growth and enzymatic activity of fungus species by higher contents of calcium ions in water environment (Chamier & Dixon 1983; Chamier 1992; Juvvadi & Chivukula 2004).

Most chromistan organisms and fungus species found on the fragments of free-floating plants were found to grow on at least a few plant species. However, a number of chromistan organisms and fungus species were observed on single plant species. *Blyttiomyces spinulosus* was found only on *Lemna minor* in water from spring Jaroszówka. *Lagenidium podbielkowski* on *Stratiotes aloides* in water from pond Dojlidy. Fragments of *Stratiotes aloides* constituted a substrate for 11 species. On the fragments of *Utricularia minor* were found the species which growing on other plants, and on *Utricularia vulgaris* only one species *Saprolegnia hypogyna*. A number of other fungus species were noted only on single species out of the 11 free-floating plant examined.

The number of chromistan organisms and fungus species in a given water body was influenced generally three groups of factors: substrate and its availability on the one hand, abiotic factors especially chemical composition of water on the other and biotic factors such as cyanobacteria, aquatic plants and animals. Up to now, our studies have shown that the substances excreted by cyanobacteria considerably inhibit the growth of fungus species (Czeczuga & Orłowska 2000; Czeczuga *et al.* 2003). However the substances excreted by aquatic plants may either stimulate or inhibit the growth of chromistan organisms and fungus species (Czeczuga *et al.* 2005). Chromistan organisms and fungus species are also included in certain trophic chains of water bodies, as food for pelagic and benthic crustaceans (Rossi *et al.* 1983; Czeczuga *et al.* 2003), as well so for larvae of numerous aquatic insects (Cargill *et al.* 1985). The relations between these three groups of factors differ in time in the various water bodies, the factors limiting the number of chromistan organisms and fungus species differ in the various water bodies and also in different years in the same water body.

As for new for Polish hydromycology of chromistan oranisms as we mentioned were two species. There are

Table 5. Fungi and fungus-like organisms growing only on fragments of single free-floating plants

	Species of plants	Fungi and fungus-like organisms (see Table 3)	Number of species
1	*Aldrowanda vesiculosa* L.	4, 14, 26, 29, 80, 92, 102, 124	8
2	*Hydrocharis morsus-ranae* L.	36, 48, 74, 82, 129	5
3	*Lemna gibba* L.	41, 57, 64, 91, 93	5
4	*L. minor* L.	60, 98, 107	3
5	*L. trisulca* L.	24, 42, 66, 101, 115, 118	6
6	*Salvinia natans* (L.) All.	22, 76, 104, 116, 121	5
7	*Spirodela polyrrhiza* (L.) Schl.	83, 119, 120	3
8	*Stratiotes aloides* L.	1, 43, 56, 72, 78, 95, 97, 100, 103, 117, 125	11
9	*Utricularia minor* L.	–	–
10	*U. vulgaris* L.	21	1
11	*Wolffia arrhiza* (L.) Wimm.	3, 6, 23, 33, 81	5

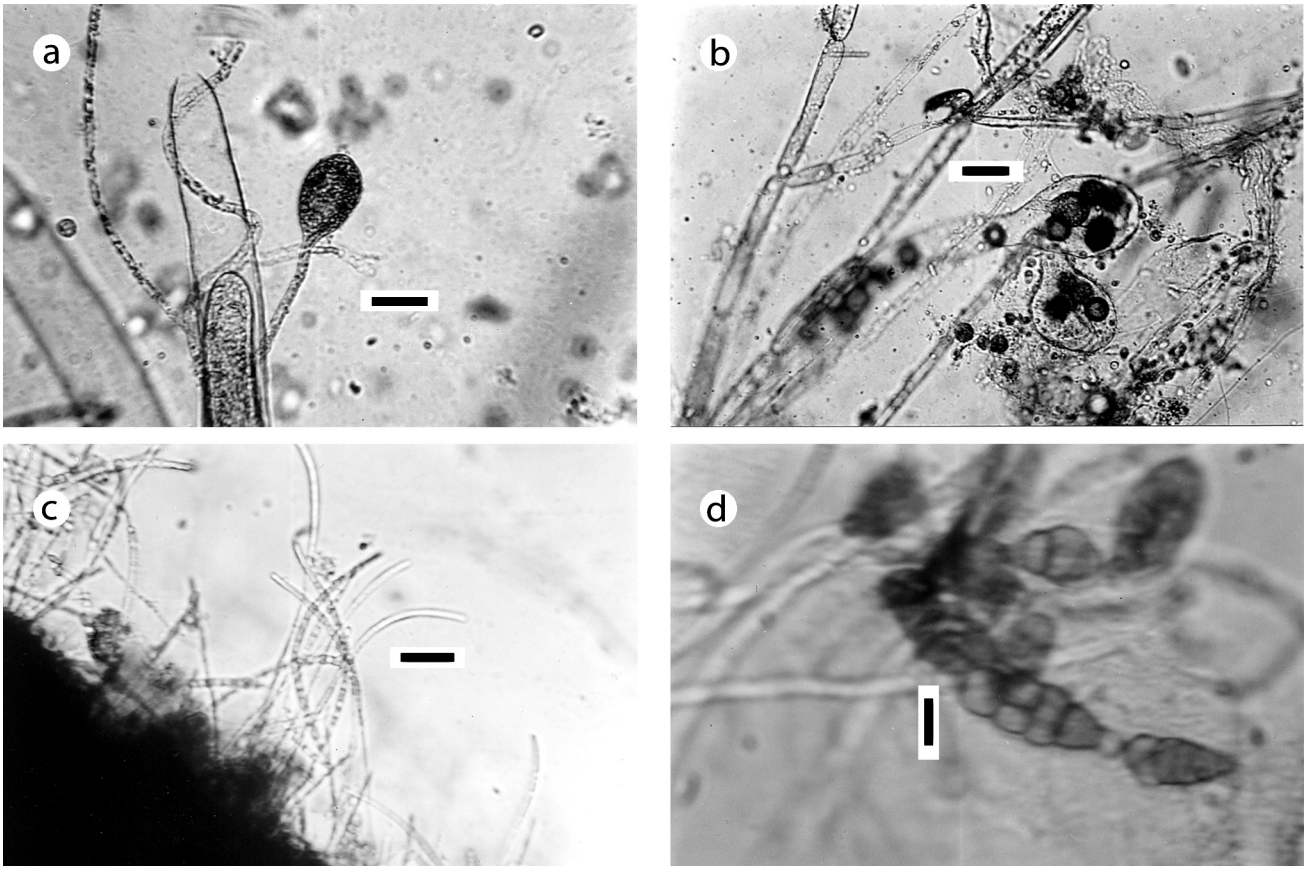

Fig. 1. Some chromistan organisms (a, b) and anamorphic fungi (c, d) found on free-floating plants: **a** – *Saprolegnia ferax* – proliferation of saprolegnia; **b** – *Saprolegnia parasitica* – hyphae from oogonium; **c** – *Anguillospora longissima* – hyphae from conidium; **d** – *Pithomyces obscuriseptatus* – hyphae from conidium. Scale bar = 25 µm

representant of Peronosporales – *Pythium oryzae,* its growing we observed in water of the river Supraśl on individuals both studied species from genus *Utricularia.* At the first time it was described on rice roots by Ito & Tokunaga (1933). Although recently it seems (Dick 1990) that it is species *Pythium dissotocum* described earlier by Drechsler (1930). For Poland new species proved also 11 detected to fungus species. Whereas as for both species belonging to *Reessia* genus in literature (Fisch 1884; Karling 1943, 1977; Wagner 1969). They are described as parasites of species of genus *Lemna.* In our studies *Reessia amoeboidea* developed on dead fragments of *Lemna gibba, L. minor* and *Spirodela polyrrhiza.* Besides on *Lemna gibba* and *Spirodela polyrrhiza* grew second species – *Reessia lemnae.* This observations show that besides of parasitic style of live this two species can growing as a saprotrophs, but *Spirodela polyrrhiza* fragments make a new substrate which were undescribable for those species of up to now. On parts of *Lemna minor* in water of the spring Jaroszówka the fungus *Blyttiomyces spinulosus* were growing. It is known in literature as a parasite of algae from genus *Spirogyra* and *Mougeotia* (Bartsch 1939). *Entophlyctis texana* also new species for Polish water, developed on *Lemna trisulca* only in water of the pond Dojlidy. First time it was described by on fallen leaves of corn from New Zealand (Karling 1967). New species for Polish water also proved representant of Chytridiales – *Nephrochytrium aurantium,* which in our studies developed on *Lemna gibba* and *L. minor* only in water of the pond Dojlidy. At the first time it has been described by Whiffen (1941) as a saprotroph on grass leaves. For Poland new species proved also all three detected species of Endomycetes. *Hansenula anomala* in our studies belonged to var. *anomala,* which is known as saprotroph of different waters and soils (Batko 1975). Growth of this fungus we observed on *Wolffia arrhiza* in water of the pond Dojlidy. Both parasites *Tracya hydrocharidis* parasitize on *Hydrocharis morsus-ranae, Tracya lemnae* on *Spirodela polyrrhiza.* In our studies those two species from genus *Tracya* grew on dead individuals of citized plant species in water of the spring Jarszówka.

With four species of anamorphic fungi, which to this time weren't meeting in Polish waters. Those three of them as *Cladosporium peruamazonicum, Pseudocercospora manuensis* and *Ramichloridium clavulisporum* were described at the first time in river basin of the Amazon in South America and up to the present its were known only from this region (Matsushima 1993). In our studies those three species grew in water from the river Supraśl. First two species grew on fragments of

Stratiotes aloides and *Ramichloridium clavulisporum* on *Lemna trisulca.* Also fourth species *Dactylella ramiformis* grew on parts *Stratiotes aloides* but in the pond Dojlidy and the river Supraśl. This species were detected by first time in China (Liu & Qiu 1992). Such other six Amazonic species of anamorphic fungi as *Corynesporella simpliphora, Melanocephala manuensis, Phialogeniculata multiseptata, Pithomyces obscuriseptatus, Polystratorictus fusarioideus* and *Sporidesmium acutifusiforme* were observed on the free-floating plants. These species already were noted in water bodies of north-eastern Poland (Czeczuga *et al.* 2001, 2002a, b, 2003a, b, c). To present time in water bodies of north-eastern Poland already were found 56 Amazonic anamorphic fungus species (Czeczuga 2004) which were described by Matsushima (1993) at the first time in basin of the Amazon River. Very important are new positions those four species of anamorphic fungi is remote from places its were described. As is known among water fungi cosmopolitism is often occurrence. Geographical obstacles haven't a big influence on occurrence particular species especially conidial, because spore forms are moved on large distances by streams of wind and water birds. Occurrence particular species of water fungi in specified types of water bodies is result of environmental types of water bodies is results of environmental factor occurring in this reservoir (Czeczuga 2004; Czeczuga *et al.* 2004).

The aquatic fungus species, including chromistan organisms (Unestam 1966; Bodeumann *et al.* 1985) and anamorphic fungi (Chamier 1985) colonizing a given substratum secrete enzymes which break it down. They also possess enzymes which decompose plant cellular walls including four group enzymes. The cell-walls of mono-and dicotyledonous plants are polymers. All cell-walls content of pectic polysaccharides, cellulose and hemicelluloses in primary and secondary of walls, lignin and of the wheat straw. This substrates are decomposited by group of enzymes produced by fungus species. The pectic polysaccharides are degradation by pectinases (Chamier & Dixon 1983), hemicelluloses by hemicellulases (Dekker & Richards 1976), cellulose by group of the enzymes cellulases (Singh 1982). Lignin is extremely difficult to assess chemically. Fisher *et al.* (1983) have demonstrated cavity and erosion of lignin by some species of anomorphic fungi.

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