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AQUATIC FUNGI GROWING ON THE EGGS OF FISHES REPRESENTING 33 CYPRINID TAXA (CYPRINIDAE) IN LABORATORY CONDITIONS

GRZYBY WODNE ROZWIJAJĄCE SIĘ NA IKRZE RYB REPREZENTUJĄCYCH 33 TAKSONY RYB KARPIOWATYCH (CYPRINIDAE) W WARUNKACH LABORATORYJNYCH

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The authors investigated of the mycoflora developing on the eggs of fishes representing 33 cyprinid taxa.

INTRODUCTION

The family Cyprinidae is most numerously represented in our inland waters. Their contribution to human nutrition, compared with other fish families is significant. This refers to rivers, lakes, and first of all ponds. Progressing pollution of rivers and lakes eliminates economically valuable species, particularly threatening their reproduction. Thus, the populations of some species are maintained on a high level, mainly due to artificial reproduction in hatcheries.

Mycotic infections of eggs or hatch frequently reduce efficiency of hatcheries, which concerns all fish species, including cyprinids (Neish and Hughes 1980). Losses may reach even several dozen percent or more of the incubated eggs or hatch (Wolf 1958; Florinskaya 1971; Sati and Khulbe 1981; Dudka et al. 1989; Lartseva and Dudka 1990).

MATERIAL AND METHODS

The present study covered the eggs of fishes representing 33 taxa during their spawning season (Tab. 1). The eggs were collected in Poland within 1994–1998. They were transported in a thermos flask in physiological solution.

Table 1

Fish species investigated and fungi found on the eggs

	Taxa of fish	Collected from	Fungi (see Table 3)	Total number
1	*Abramis ballerus* (L.)	Szczecin Lagoon	27, 32, 42, 43, 45, 50, 56, 64, 84, 90	10
2	*Abramis brama* (L.)	Necko Lake	17, 40, 43, 50, 53, 63, 67, 84, 89, 95	10
3	*Abramis sapa* (Pallas)	Bug River	2, 7, 13, 28, 43, 44, 58, 59, 64, 82, 87, 91, 92, 94	14
4	*Alburnoides bipunctatus* (Bloch)	Omul River	8, 23, 24, 50, 51, 59, 74, 75, 80, 82, 90	11
5	*Alburnus alburnus* (L.)	Ełk River	19, 23, 35, 40, 47, 52, 58, 59, 62, 74, 75, 76, 78	13
6	*Aristichthus nobilis* (Richardson)	Hatchery in Żabieniec	43, 50, 64, 74, 75, 84, 89, 94, 96	9
7	*Aspius aspius* (L.)	Narew River	12, 23, 24, 28, 32, 34, 37, 40, 43, 44, 45, 47, 50, 53, 57, 59, 64, 65, 66, 69, 71, 72, 73, 74, 75, 76, 84, 85, 87, 89, 93, 94	32
8	*Barbus barbus* (L.)	Wisła River	28, 45, 47, 49, 50, 53, 61, 64, 74, 84, 90	11
9	*Barbus petenyi* Heckel	Wisła River	32, 42, 53, 64, 74, 84, 87, 89, 93	9
10	*Blicca bjoerkna* (L.)	Necko Lake	47, 50, 53, 63, 82, 84, 89, 93, 95, 96	10
11	*Carassius auratus gibelio* (Bloch)	Dojlidy Pond	20, 21, 25, 28, 45, 50, 51, 55, 66, 71, 84, 96	12
12	*Carassius carassius* (L.)	Dojlidy Pond	2, 15, 21, 26, 31, 36, 39, 49, 50, 53, 54, 55, 59, 63, 66, 74, 75, 86, 91	19
13	*Carassius carassius* m. *humilis* (Heckel)	Kolno Lake	20, 21, 23, 32, 49, 50, 61, 69, 74	9
14	*Chondrostoma nasus* (L.)	Dunajec River	8, 9, 12, 16, 17, 20, 22, 23, 28, 30, 32, 34, 35, 37, 40, 43, 47, 50, 51, 52, 54, 56, 57, 59, 64, 68, 74, 75, 80, 81, 82, 84, 85, 89, 94	35
15	*Ctenopharyngodon idella* (Valen.)	Hatchery in Żabieniec	10, 40, 45, 50, 53, 54, 87, 93	8
16	*Cyprinus carpio* L.	Knyszyn Pond	3, 5, 6, 24, 29, 43, 44, 48, 53, 55, 57, 60, 69, 74, 75, 77, 91, 93, 99	19
17	*Gobio albipinnatus* Lukasch	Rozoga River	9, 23, 33, 45, 49, 53, 54, 61, 66, 67	10
18	*Gobio gobio* (L.)	Supraśl River	8, 34, 45, 48, 50, 56, 58, 61, 62, 64, 71, 74, 75, 89	14
19	*Gobio kessleri* Dybowski	San River	24, 45, 50, 51, 53, 74, 75, 82, 92	9
20	*Hypophthalmichthys molitrix* (Valen.)	Hatchery in Żabieniec	7, 19, 43, 47, 82, 84, 89, 94, 96	9

Table 1 (cont.)

	Taxa of fish	Collected from	Fungi (see Table 3)	Total number
21	*Leucaspius delineatus* (Heckel)	Dojlidy Pond	23, 37, 49, 50, 51, 59, 74, 82, 84, 96, 97	11
22	*Leuciscus cephalus* (L.)	Sunowo Lake	7, 14, 16, 24, 42, 43, 45, 46, 51, 59, 62, 64, 71, 74, 83, 85, 90, 100	18
23	*Leuciscus idus* (L.)	Narew River	7, 14, 28, 38, 42, 45, 53, 64, 74, 84, 96, 100	12
24	*Leuciscus leuciscus* (L.)	Laźna Struga River	7, 17, 20, 34, 41, 43, 54, 61, 64, 70, 74, 75, 82, 85, 96	15
25	*Pelecus cultratus* (L.)	Vistula Lagoon	4, 19, 37, 45, 53, 54, 84, 89, 100	9
26	*Phoxinus* (*Moroco*) *percnurus* (Pallas)	Pond in the Włodawka basin	1, 12, 15, 17, 20, 21, 22, 23, 28, 30, 34, 35, 37, 39, 40, 43, 50, 51, 52, 53, 56, 59, 62, 63, 64, 65, 67, 68, 72, 74, 75, 76, 78, 80, 81, 90, 94	37
27	*Phoxinus phoxinus* (L.)	Słoja River	4, 15, 16, 17, 19, 23, 24, 28, 30, 32, 34, 35, 39, 43, 45, 50, 54, 56, 59, 61, 64, 65, 66, 67, 68, 71, 74, 75, 80, 82, 85, 87	32
28	*Pseudorasbora parva* (Schlegel)	Knyszyn Pond	23, 43, 45, 49, 53, 59, 82, 84, 93, 96	10
29	*Rhodeus sericeus amarus* (Bloch)	Kortowo Lake	7, 14, 32, 42, 43, 45, 47, 53, 69, 88, 93, 96	12
30	*Rutilus rutilus* (L.)	Ełk Lake	6, 11, 18, 24, 27, 32, 38, 39, 43, 47, 49, 53, 61, 62, 64, 89, 90, 96	18
31	*Scardinius erythrophthalmus* (L.)	Białe Lake	9, 23, 34, 50, 51, 53, 58, 61, 62, 71, 84, 90, 100	13
32	*Tinca tinca* (L.)	Ełk Lake	2, 8, 23, 32, 43, 47, 49, 51, 53, 66, 74, 93, 98	13
33	*Vimba vimba* (L.)	Wisła River	45, 50, 53, 66, 72, 74, 79, 89, 90	9

The water for experiments was collected from five different water bodies:

I The Cypisek Spring, located in south part of the Knyszyńska Forest; limnokrenic type; width 0.41 m.; depth 0.17 m, discharge 0.6 dm^3/sec.

II The Biała River; length 9.8 km; left-bank tributary of the Supraśl River flowing through the city of Białystok.

III The River Supraśl; length 106.6 km; right-bank tributary of the middle part of the Narew River, flowing trough the Knyszyńska Forest.

IV Pond Fosa in the Palace Park; area 2.5 ha; max. depth 1.75 m.; breeding site of swans, known for the presence of wild ducks; culture of crucian carp and tench intended for anglers.

V Lake Komosa; area 12.1 ha; max. depth 2.25 m.; surrounded densely by coniferous trees of the Knyszyńska Forest.

Table 2

Chemical composition (in mg/dm^3) of water from individual sites (n-5)

Specification	Cypisek Spring	Biała River	Supraśl River	Fosa Pond	Komosa Lake
Temperature °C	4.2	14.2	13.4	15.6	13.8
pH	7.2	7.1	7.3	7.1	7.2
O_2	16.4	9.2	18.6	8.4	14.8
Oxidability (COD)	9.9	15.8	11.2	14.2	9.0
CO_2	37.4	26.9	22.4	32.4	18.6
Alkalinity in $CaCO_3$*	4.6	4.3	3.6	5.0	3.8
N (NH_3)	0.254	0.622	0.315	0.284	0.196
N (NO_2)	0.015	0.128	0.037	0.122	0.018
N (NO_3)	0.245	0.470	0.312	0.198	0.072
PO_4	0.920	1.820	1.020	1.524	0.706
Cl	40.5	66.4	50.2	71.8	35.4
Total hardness in Ca	110.9	98.2	93.6	102.4	76.6
Total hardness in Mg	21.8	17.4	17.2	18.2	18.4
SO_4	36.8	73.2	50.4	56.2	40.6
Fe	0.38	0.92	0.47	0.48	0.26
Dry residue	174.2	434.0	412.0	460.4	220.0
Dissolved solids	150.0	324.0	384.0	420.0	198.0
Suspended solids	24.2	110.0	28.0	40.4	22.0

* in mval/dm^3

Sixteen water parameters of the above sampling sites were determined (Tab. 2) following to the methods of Golterman and Clymo (1969).

For the determination of the presence of aquatic fungal species on the eggs, the following procedure was employed: a certain number of eggs (100–200) of each fish species was transferred to two samples of water representing each site, in an 1.0 dm^3 vessel (all together ten vessels for each species) and placed in the laboratory at ambient temperature. A part of eggs from each vessel was observed under a microscope and the mycelium (zoosporic and oogonia and for *Saprolegnia parasitica*—secondary cysts) of aquatic fungi growing on the eggs was recorded. The methods are described in detail by Smith et al. (1985) and Fuller and Jaworski (1986). The eggs of the various fish species were observed under a microscope for one and a half weeks. The majority of eggs was alive but some were dead. The

duration of the experiments was three weeks. Identification of the fungi was aided the following keys: Johnson (1956), Sparrow (1960), Seymour (1970), Batko (1975), Karling (1977), and Dick (1990).

RESULTS

Hydrochemical parameters of water used in the experiments are presented in Tab. 1. The most eutrophic was the water of the Biała River and pond Fosa, however, the water of the Cypisek Spring, Supraśl River and Komosa Lake had the lowest content of biogenic compounds.

Hundred fungus species were found to grow on the eggs of fishes representing 33 cyprinid taxa (Tab. 3). The eggs of the majority of the fishes examined revealed the presence of *Achlya diffusa*, *Aphanomyces laevis*, *Aphanomyces stellatus*, *Dictyuchus sterilis*, *Leptolegnia caudata*, *Saprolegnia ferax*, *Saprolegnia parasitica*, *Saprolegnia shikotsuensis*, and *Pythium artotrogus*. The record of a few fungus species new to the hydromycology of Poland is worth special note, including *Achlya oblongata* var. *gigantica*, *Aphanomyces bosminae*, *Blastocladiella stübenii*, *Circinella umbellata*, *Pythium gracile*, *Saprolegnia crustosa*, *Saprolegnia torulosa*, and *Saprolegnia terrestris*. Moreover, some fungi rarely occuring on fishes were found on the eggs of a number of fish species. The eggs of *Ctenopharyngodon idella* were least infected with fungi, while on the eggs of *Phoxinus* (*Moroco*) *percnurus* most fungus species were found.

The highest number of fungus species developed on eggs in the water from the Cypisek spring, Komosa Lake, and the Supraśl River, while the lowest number—in the water of the Biała River and Fosa Pond (Tab. 4).

Table 3

Aquatic fungi found on the eggs of cyprinid fishes

Taxa of fungi	Fish (see Table 1)	Number of fish
Chytridiomycetes		
Olpidiales		
1. *Rozella septigena* Cornu	26	1
Chytridiales		
2. *Polyphagus euglenae* Nowakowski	3, 12, 32	3
3. *Rhizophlyctis petersenii* Sparrow	16	1
4. *Rhizophydium keratinophilum* Karling	25, 27	2
Blastocladiales		
5. *Blastocladiella simplex* Matthews	16	1
6. *Blastocladiella stübenii* Couch et Whiffen	16, 30	2
7. *Blastocladiopsis parva* (Whiffen) Sparrow	3, 20, 22, 23, 24, 29	6

Table 3 (cont.)

Taxa of fungi	Fish (see Table 1)	Number of fish
8. *Allomyces anomalus* Emerson	4, 14, 18, 32	4
9. *Allomyces arbuscula* Butler	14, 17, 31	3
10. *Allomyces macrogynus* (Emer.) Emerson et Wilson	15	1
Monoblepharidales		
11. *Monoblepharis macranda* (Lagerheim) Woronin	30	1
Plasmodiophoromycetes		
Plasmodiophorales		
12. *Woronina polycystis* Cornu	7, 14, 26	3
Oomycetes		
Lagenidiales		
13. *Lagenidium humanum* Karling	3	1
14. *Olpidiopsis aphanomycis* Cornu	14, 23, 29	3
15. *Olpidiopsis saprolegniae* (Braun) Cornu	12, 27	2
Saprolegniales		
16. *Achlya ambisexualis* Raper	14, 22, 27	3
17. *Achlya americana* Humphrey	2, 14, 24, 26, 27	5
18. *Achlya apiculata* de Bary	30	1
19. *Achlya bisexualis* Coker et Couch	5, 20, 25, 27	4
20. *Achlya caroliniana* Coker	11, 13, 14, 24, 26	5
21. *Achlya colorata* Pringsheim	11, 12, 13, 26	4
22. *Achlya debaryana* Humphrey	14, 22	2
23. *Achlya diffusa* Harvey et Johnson	4, 5, 7, 13, 14, 17, 21, 26, 27, 28, 31, 32	12
24. *Achlya dubia* Coker	4, 7, 16, 19, 22, 27, 30	7
25. *Achlya flagellata* Coker	11	1
26. *Achlya glomerata* Coker	12	1
27. *Achlya hypogyna* Coker et Pemberton	1, 30	2
28. *Achlya klebsiana* Pieters	3, 7, 8, 11, 14, 23, 26, 27	8
29. *Achlya megasperma* Humphrey	16	1
30. *Achlya oblongata* de Bary var. *gigantica* Forbes	14, 26, 27	3
31. *Achlya oligocantha* de Bary	12	1
32. *Achlya orion* Coker et Couch	1, 7, 9, 13, 14, 27, 29, 30, 32	9
33. *Achlya papillosa* Humphrey	17	1
34. *Achlya polyandra* Hildebrand	7, 14, 18, 24, 26, 27, 31	7
35. *Achlya prolifera* Nees	5, 14, 26, 27	4
36. *Achlya proliferoides* Coker	12	1
37. *Achlya racemosa* Hildebrand	7, 14, 21, 25, 26	5
38. *Achlya stellata* de Bary	23, 30	2
39. *Achlya treleaseana* (Humphrey) Kauffman	12, 26, 27, 30	4
40. *Aplanes androgynus* (Archer) Humphrey	2, 5, 7, 14, 15, 26	6
41. *Aphanomyces bosminae* Scott	24	1

Table 3 (cont.)

Taxa of fungi	Fish (see Table 1)	Number of fish
42. *Aphanomyces irregularis* Scott	1, 9, 22, 23, 29	5
43. *Aphanomyces laevis* de Bary	1, 2, 3, 6, 7, 14, 16, 20, 22, 24, 26, 27, 28, 29, 30, 32	16
44. *Aphanomyces parasiticus* Coker	3, 7, 16	3
45. *Aphanomyces stellatus* de Bary	1, 7, 8, 11, 15, 17, 18, 19, 22, 23, 25, 27, 28, 29, 33	15
46. *Brevilegnia diclina* Harvey	22	1
47. *Calyptralegnia achlyoides* (Coker et Couch) Coker	5, 7, 8, 10, 14, 20, 29, 30, 32	9
48. *Dictyuchus anomalus* Nagai	16, 18	2
49. *Dictyuchus monosporus* Leitgeb	8, 12, 13, 17, 21, 28, 30, 32	8
50. *Dictyuchus sterilis* Coker	1, 2, 4, 6, 7, 8, 10, 11, 12, 13, 14, 15, 18, 19, 21, 26, 27, 31, 33	19
51. *Isoachlya anisospora* (de Bary) Coker	4, 11, 14, 19, 21, 22, 26, 31, 32	9
52. *Isoachlya monilifera* (de Bary) Kauffman	5, 14, 26	3
53. *Leptolegnia caudata* de Bary	2, 7, 8, 9, 10, 12, 15, 16, 17, 19, 23, 25, 26, 28, 29, 30, 31, 32, 33	19
54. *Protoachlya paradoxa* (Coker) Coker	12, 14, 15, 17, 24, 25, 27	7
55. *Protoachlya polyandra* (Lindstedt) Apinis	11, 12, 16	3
56. *Pythiopsis cymosa* de Bary	1, 14, 18, 26, 27	5
57. *Saprolegnia anisospora* de Bary	7, 14, 16	3
58. *Saprolegnia asterophora* de Bary	3, 5, 18, 31	4
59. *Saprolegnia australis* Elliott	3, 4, 5, 7, 12, 14, 21, 22, 26, 27, 28	11
60. *Saprolegnia crustosa* Maurizio	16	1
61. *Saprolegnia delica* Coker	8, 13, 17, 18, 24, 27, 30, 31	8
62. *Saprolegnia diclina* Humphrey	5, 18, 22, 26, 30, 31	6
63. *Saprolegnia eccentrica* (Coker) Seymour	2, 10, 12, 26	4
64. *Saprolegnia ferax* (Gruith) Thuret	1, 3, 6, 7, 8, 9, 14, 18, 22, 23, 24, 26, 27, 30	14
65. *Saprolegnia glomerata* (Tiesenhausen) Lund	7, 26, 27	3
66. *Saprolegnia hypogyna* (Pring.) de Bary	7, 11, 12, 17, 27, 32, 33	7
67. *Saprolegnia invaderis* Davis et Lazar	2, 17, 26, 27	4
68. *Saprolegnia irregularis* Johnson et Seymour	14, 26, 27	3
69. *Saprolegnia litoralis* Coker	7, 13, 16, 29	4
70. *Saprolegnia megasperma* Coker	24	1
71. *Saprolegnia mixta* de Bary	7, 11, 18, 22, 27, 31	6
72. *Saprolegnia monoica* Pringsheim	7, 26, 33	3
73. *Saprolegnia paradoxa* Maurizio	7	1
74. *Saprolegnia parasitica* Coker	4, 5, 6, 7, 8, 9, 12, 13, 14, 16, 18, 19, 21, 22, 23, 24, 26, 27, 32, 33	20
75. *Saprolegnia shikotsuensis* Hatai et al.	4, 5, 6, 7, 12, 14, 16, 18, 19, 24, 26, 27	12
76. *Saprolegnia subterranea* Dissmann	5, 7, 26	3

Table 3 (cont.)

Taxa of fungi	Fish (see Table 1)	Number of fish
77. *Saprolegnia terrestris* Cookson et Seymour	16	1
78. *Saprolegnia torulosa* de Bary	5, 26	2
79. *Saprolegnia turfosa* (Minden) Gauman	33	1
80. *Saprolegnia unispora* (Coker et Couch) Seymour	4, 14, 26, 27	4
81. *Thraustothexca clavata* (de Bary) Humphrey	14, 26	2
Leptomitales		
82. *Leptomitus lacteus* (Roth) Agardh	3, 4, 10, 14, 19, 20, 21, 24, 27, 28	10
Peronosporales		
83. *Pythium aristosporum* Vanterpool	22	1
84. *Pythium artotrogus* de Bary	1, 2, 6, 7, 8, 9, 10, 11, 14, 20, 21, 23, 25, 28, 31	15
85. *Pythium debaryanum* Hesse	7, 14, 22, 24, 27	5
86. *Pythium gracile* Schenk	12	1
87. *Pythium intermedium* de Bary	3, 7, 9, 15, 27	5
88. *Pythium marsipium* Drechsler	29	1
89. *Pythium middletonii* Sparrow	2, 6, 7, 9, 10, 14, 18, 20, 25, 30, 33	11
90. *Pythium proliferum* de Bary	1, 4, 8, 22, 26, 30, 31, 33	8
91. *Pythium pulchrum* Minden	3, 12, 16	3
92. *Pythium rostratum* Butler	3, 19	2
93. *Pythium ultimum* Trow	7, 9, 10, 15, 16, 28, 29, 32	8
94. *Zoophagus insidians* Sommerstorff	3, 6, 7, 14, 20, 26	6
Zygomycetes		
Mucorales		
95. *Circinella umbellata* v. Tieg. et Le Mon.	2, 10	2
Zoopagales		
96. *Zoopage phanera* Drechsler	6, 10, 11, 20, 21, 23, 24, 28, 29, 30	10
Endomycetes		
Endomycetales		
97.*Candida albicans* (Robin) Berkhout	21	1
Hyphomycetes		
98. *Fusarium aquaeductum* (Radlk. et Rabenh.) Lagerh.	32	1
99. *Fusarium culmorum* (W.G. Sm.) Sacc.	16	1
100. *Trichosporon cutaneum* (de Beur. et al.) Ota	22, 23, 25, 31	4

Table 4

Aquatic fungi found on the eggs of cyprinid fish in the different water

Water from	Fungi (see Table 3)	Only in one water	Total number
Cypisek Spring	1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 28, 30, 32, 34, 35, 37, 39, 40, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 56, 57, 59, 60, 61, 62, 63, 64, 65, 66, 67, 70, 71, 72, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 89, 92, 93, 94, 99, 100	2, 11, 18, 77, 99	77
Biała River	7, 8, 17, 20, 21, 22, 23, 25, 26, 28, 29, 32, 34, 35, 36, 39, 40, 43, 45, 47, 50, 51, 52, 53, 54, 55, 56, 59, 61, 62, 63, 64, 66, 67, 68, 71, 72, 74, 75, 80, 81, 82, 84, 87, 89, 92, 93, 94, 96, 97	26, 29	50
Supraśl River	4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 19, 20, 21, 23, 24, 27, 28, 32, 34, 35, 36, 37, 38, 40, 41, 42, 43, 45, 46, 47, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 61, 62, 63, 64, 65, 66, 67, 68, 69, 71, 72, 73, 74, 75, 76, 78, 79, 80, 82, 84, 85, 87, 89, 90, 93, 94, 95, 96, 100	10, 41, 55, 73,	73
Fosa Pond	1, 4, 6, 7, 8, 12, 14, 16, 17, 20, 22, 23, 24, 27, 28, 30, 32, 34, 35, 37, 38, 39, 40, 42, 43, 45, 47, 49, 50, 51, 52, 53, 54, 59, 61, 62, 63, 64, 66, 67, 69, 70, 71, 72, 74, 75, 76, 78, 79, 80, 81, 82, 84, 97, 88, 89, 90, 92, 93, 94, 95, 96, 100		63
Komosa Lake	3, 4, 6, 7, 8, 9, 12, 17, 19, 20, 23, 24, 27, 28, 30, 31, 32, 33, 34, 35, 37, 38, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 56, 57, 58, 59, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 74, 75, 76, 78, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 93, 94, 95, 96, 97, 98, 100	31, 33, 86, 91, 98	74

DISCUSSION

Worth noting is the finding of some fungi of the genus *Achlya* on the eggs of *Carassius auratus gibelio*, *Carassius carassius*, *Carassius carassius* m. *Humilis*, and *Phoxinus* (*Moroco*) *percnurus*. The species found—*Achlya colorata* is new to fishes. It is known as an aquatic saprophyte (Johnson 1956; Batko 1975). Interesting is also the finding of *Achlya oblongata* var. *gigantica* on the eggs of *Chondrostoma nasus* and a species representing the genus *Phoxinus*. The above fungus is new both to fishes and to Polish waters. The variety *gigantica* of the species *Achlya oblongata* was described by Forbes (1935), who studied aquatic fungi in Britain. The typical form of *Achlya oblongata* was encountered on the eggs of *Cobitis aurata* (cf. Czeczuga and Muszyńska 1997). *Achlya papillosa,* known as an aquatic phytosaprophyte, is new to fishes. In our study it was found on the eggs of gudgeon, *Gobio albipinnatus.* Also the fourth species of the genus *Achlya,* namely *Achlya stellata* is new to fishes. It is known as a saprophyte of dead insects found in water and soil (Skirgiełło 1954). In the present study, it was found on the eggs of ide, *Leuciscus idus* and roach, *Rutilus rutilus.*

Two species of the genus *Allomyces* are new to fishes. Up to now, *Allomyces anomalus* has been the only one found in fish (Neish and Hughes 1980; Srivastava 1980; Dudka et al. 1989). *Allomyces arbuscula* was first described by Butler (1911), while *Allomyces macrogynus* by Emerson and Wilson (1954). These species are found both in water and soil on substrates of plant or animal origin. They show, like all species of this genus, a complex developmental cycle (Emerson 1941; Jeffrey and Willoughby 1964; Carlile and Machlis 1965). The developmental cycles of these two species of the genus *Allomyces,* whose stages can occur on fishes, have been described in details by Hatch (1936), Sorgel (1937), Ritchie (1947), Sost (1955), Turian and Kellenberger (1956), Renaud and Swift (1964), and Karling (1977). In the present study *Allomyces arbuscula* was found to grow on the eggs of *Chondrostoma nasus*, *Gobio albipinnatus*, and *Scardinius erythrophthalmus,* while *Allomyces macrogynus*—on the eggs of grass carp, *Ctenopharyngodon idella. Aphanomyces irregularis,* new to fishes, in our study was found on the eggs of *Abramis ballerus, Leuciscus cephalus, Leuciscus idus, Barbus petenyi*, and *Rhodeus sericeus amarus.* It is known as a saprophyte of insect exuviae found in water, and even as a parasite of fungus species of the genus *Achlya* (Batko 1975). It grows on other substrates containing chitin (Czeczuga and Godlewska 1994) and keratin (Czeczuga and Muszyńska 1994). *Aphanomyces bosminae* is new to Polish hydromycology and to fishes. It was first described by Scott (1961), who investigated fungi in America. It has been known as a parasite of freshwater crustacean of the genus *Bosmina.* We found it on the eggs of *Leuciscus leuciscus* in the water from the Supraśl River. Two species of the genus *Blastocladiella*: *B. simplex* and *B. stübenii,* soil and water saprophytes, are also new to fish. *Blastocladiella*

simplex was described from dead flies by Matthews (1937). We found it on the eggs of *Cyprinus carpio. Blastocladiella stübenii* was observed on dead house-flies (Couch and Whiffen 1942). We found it on the eggs of *Cyprinus carpio* and *Rutilus rutilus. Brevilegnia diclina*, also new to fishes, was found on the eggs of *Leuciscus cephalus.* Seven species of the former genus are known (Coker and Couch 1927) to inhibit wet soils, water banks, bottom sediments of shallow reservoirs and ditches. Two species of *Brevilegnia unisperma,* whose growth was observed on the eggs of *Coregonus lavaretus hartmanni* in our earlier study, are known in Europe (Czeczuga and Muszyńska 1998).

Circinella umbellata, a representative of the family Mucoraceae of the order Zygomycetes (Skirgiełło 1954) is also new to fishes. It has been encountered as a plant and animal saprophyte and on various excrements. We found it on the eggs of common bream *Abramis brama* and white bream *Blicca bjoerkna. Olpidiopsis aphanomycis*, new to fishes, is known as a parasite of fungi of the genus *Aphanomyces.* We found it on the eggs of undermouth, *Chondrostoma nasus*, of ide, *Leuciscus idus*, and bitterling, *Rhodeus sericeus amarus. Pythiopsis cymosa,* an aquatic and soil saprophyte, found on twigs and dead insects lying in water, is rare in fishes. It was first described on the eggs of sturgeon *Acipenser ruthenus* (Czeczuga et al. 1995). In the present study it was found on the eggs of five species. Nine fungus species of the genus *Pythium* were observed on the eggs of certain fish species examined. Some of them had already been encountered in fishes. *Pythium ultimum* was found on the eggs of *Lepomis macrochirus* (Scott and O'Bier 1962) and sturgeon *Acipenser nudiventris* (Czeczuga et al. 1995). *Pythium artotrogus* was observed on the eggs of whitefish, vendace, and pike (Czeczuga and Woronowicz 1993), and sturgeon *Acipenser nudiventris* (Czeczuga et al. 1995). *Pythium proliferum* was found on the eggs of several fish species in a hatchery (Florynskaya 1969). Such species as *Pythium aristosporum*, *Pythium debaryanum*, *Pythium gracile*, *Pythium intermedium*, *Pythium marsipium*, *Pythium middletonii*, *Pythium rostratum* are new to fishes (Czeczuga 1996). *Pythium aristosporum* was first reported from infected wheat roots (Vanterpool 1938). It is mainly known as a parasite of various plants (Ichitani and Kinoshita 1990). In our study it was found on the eggs of chub, *Leuciscus cephalus. Pythium debaryanum* has been known since the middle of the previous century as a phytopathogenic fungus (Hesse 1874) and has been encountered in various water reservoirs (Czeczuga 1995). We found it on the eggs of five species. *Pythium gracile*, new to Polish waters and to fishes, has been known since the middle of the previous century (Schenk 1859) as an intracellular parasite of aquatic green algae. In the present study, this fungus developed on the eggs of *Carassius carassius* in spring and lake water. *Pythium intermedium*, known as a soil phyto- and zoosaprophyte (Hardnan and Dick 1987), and an aquatic saprophyte (Batko 1975), was observed on the eggs of five species. *Pythium marsipium*, first described in the 1930s (Ito 1936, Drechsler 1941), was found on

the eggs of bitterling, *Rhodeus sericeus amarus*. *Pythium middletonii* is observed in northeastern Poland in various water reservoirs (Czeczuga 1994a), including the eggs of numerous cyprinid species. *Pythium rostratum* was described from soil samples (Butler 1907) and various water reservoirs (Czeczuga 1995). In the present study it was found on the eggs of zobel, *Abramis sapa* and gudgeon, *Gobio kessleri*. Worth noting is also the finding of *Rhizophlyctis petersenii* on *Cyprinus carpio*, while *Rhizophydium keratinophilum* on the eggs of sichel, *Pelecus cultratus* and *Phoxinus phoxinus*. *Rhizophlyctis petersenii* was first described by Sparrow (1937) from insect exuviae. It is known to occur on other chitin-containing substrates (Czeczuga and Godlewska 1994). *Rhizophydium keratinophilum* was described by Karling (1946) on human hair. Czeczuga and Muszyńska (1994) observed its growth on other keratin-containing substrates. It is a common fungus in northeastern Poland (Czeczuga 1995).

Fungi of the genus *Saprolegnia* observed on the eggs of various fish species before the present study including *Saprolegnia delica*, *Saprolegnia diclina*, *Saprolegnia ferax*, *Saprolegnia hypogyna*, *Saprolegnia litoralis*, *Saprolegnia mixta*, *Saprolegnia monoica*, *Saprolegnia monoica* var. *floccosa*, *Saprolegnia monoica* var. *glomerata*, *Saprolegnia parasitica* (Scott and O'Bier 1962; Florynskaya 1969, 1971; Srivastava and Srivastava 1976; Smith et al. 1985; Lartseva 1986; Lartseva and Altufiev 1987; Osipian et al. 1988; Lartseva and Dudka 1990; Czeczuga 1994b; Czeczuga and Muszyńska 1999). Those found on the body of various species were: *Saprolegnia australis* (cf. Hatai et al. 1977a), *Saprolegnia invaderis* (cf. Davies and Lazar 1941), *Saprolegnia megasperma* (cf. Vishniac and Nigrelli 1957), *Saprolegnia shikotsuensis* (cf. Hatai et al. 1977b), *Saprolegnia subterranea* (cf. Pickering and Willoughby 1977) and *Saprolegnia unispora* (cf. Vishniac and Nigrelli 1957; Domashova 1971). Such species found in our studies since 1993 (Czeczuga and Woronowicz 1993) as *Saprolegnia anisospora*, *Saprolegnia asterophora*, *Saprolegnia crustosa*, *Saprolegnia eccentrica*, *Saprolegnia terrestris*, *Saprolegnia torulosa*, and *Saprolegnia turfosa* are new to fish eggs and to fishes in general, except for *Saprolegnia anisospora*, whose growth was observed on dead roach (Newby 1948). That fungus was first described at the end of the previous century (de Bary 1888) and it is known to occur at various latitudes as an aquatic and soil saprophyte (Seymour 1970). We observed *Saprolegnia anisospora* first on the eggs of salmon *Oncorhynchus kisutch* (Czeczuga and Muszyńska 1996), and in cyprinids on the eggs of rapfen, *Aspius aspius*, undermouth, *Chondrostoma nasus*, and carp, *Cyprinus carpio*. *Saprolegnia asterophora* was first described in the previous century (de Bary 1860). It is reported from many countries as an aquatic and soil saprophyte, which prefers acidified environment (Seymour 1970), but lives also on dead fishes (Hayren 1928) and *Leuciscus* sp. (Petersen 1909, 1910). We found it on the eggs of rainbow trout *Oncorhynchus mykiss* (Czeczuga and Muszyńska 1996), and in

cyprinds on the eggs of *Abramis sapa*, *Alburnus alburnus*, *Gobio gobio*, and *Scardinius erythrophtalmus*. *Saprolegnia eccentrica* was described by Coker (1923) as a soil saprophyte, although it sporadically occurs in water. We observed it on the eggs of salmon *Oncorhynchus keta* var. *autumnalis* (cf. Czeczuga and Muszyńska 1996), and in cyprinid representatives on the eggs of *Abramis brama*, *Blicca bjoerkna*, *Carassius carassius*, and *Phoxinus (Moroco) percnurus*. *Saprolegnia torulosa* has been known since the previous century (de Bary 1881). It is also called *Isoachlya torulosa* (cf. Cejp 1959). In our material it was found to grow on the eggs of *Alburnus alburnus* and *Phoxinus* (*Moroco*) *percnurus*. *Saprolegnia turfosa*, the most recent of the new *Saprolegnia* fungi, was first described by Minden (1915) as *Saprolegnia monoica* var. *turfosa* and then by Gaumann (1918) as *Saprolegnia turfosa*. We observed its growth on the eggs of vimba, *Vimba vimba*. It occurs in fresh waters, sometimes in soil particularly in acid-polluted soil, in sphagnum bogs, cypress swamps (Seymour 1970), and in running waters (Jacenko 1992).

Worth of special interest is the finding of two *Saprolegnia* species, namely *Saprolegnia crustosa* and *Saprolegnia terrestris*, which appear new not only to fish eggs but also to Polish waters. They were both found to grow on *Cyprinus carpio* eggs. *Saprolegnia crustosa* was first described by Maurizio still at the end of the previous century (1899). It is known as a phyto- and zoosaprophyte (dead fish) from certain European countries (Lund 1934). According to Batko (1975) it is also a facultative fish parasite. *Saprolegnia terrestris* was first isolated by Cookson (1937) from soil in Australia. It was also encountered in the waters of Japan (Suzuki 1961), England (Dick 1964) and New Zealand (Elliott 1968). Moreover, worth noting is the finding of *Zoophagus insidians* on the eggs of six species, first described by Sommerstorff (1911) as a predacious fungus catching rotifiers. Our studies (Czeczuga 1993) revealed that it was the most common predacious fungus in the waters of northeastern Poland.

Worth noting is also the finding of *Candida albicans* on the eggs of *Leucaspius delineatus*. Until now, the growth of yeast-like fungi has been observed on the eggs of salmonid and coreginid fry. Bauer et al. (1973) reported yeast infections of salmon fry (1973), while Nagornaya et al. (1996) observed growth of several species of the genus *Candida* on the eggs of *Oncorhynchus mykiss*. In coregonids, growth of *Candida albicans* was observed on the eggs of *Coregonus albula* in a hatchery (Czeczuga and Woronowicz 1993). Cyprinid fish species extend the list of fish being a substrate for yeast-like fungi.

The finding of *Fusarium culmorum* and *Fusarium aquaeductum* on fish eggs is also worth noting. These fungi belong to en abundant genus comprising saprophitic and phytopathogenic species and facultative parasites of animals, mainly invertebrates (Wollenweber 1931; Booth 1971). Some species of this genus are also known as parasites of human nails (Ritchie and Pinkerton 1959). *Fusarium culmorum*, which in our study was found to grow

on the eggs of *Cyprinus carpio* is known to cause lethal mycosis of the carp skin (Hörter 1960). This fungus was observed to grow in the eggs of vendace and whitefish (Czeczuga and Muszyńska 1998). *Fusarium aquaeductum* in our study was found to grow on the eggs of *Tinca tinca.* This fungus was observed to grow in the body of certain invertebrate species (Alton 1985) and on the eggs of vendace, whitefish and peled incubated in hatcheries of northeastern Poland (Czeczuga and Woronowicz 1993). According to Marčenko (1988), *Fusarium avenaceum* var. *herbarum* causes mycosis of the swim bladder of salmonids in the Far East.

According to the data obtained a varied number of aquatic fungus species developed on the eggs of particular cyprinid fish. The smallest number of fungi were found on the eggs of *Ctenopharyngodon idella* (8), the largest on the eggs of *Phoxinus* (*Moroco*) *percnurus* (37). What can explain such significant differences in the susceptibility to mycotic infections between various fish species. This may be a multifactorial phenomenon, associated with the aquatic environment itself, and the nature and conditions of the eggs (Sumpter et al. 1987; Peters et al. 1988; Ayson 1989). As our own and this studies have revealed, oligotrophic-type water promotes the growth of a larger number of zoosporic fungi on the eggs of the same fish species than eutrophic-type water (Czeczuga and Kiziewicz 1998). That might be explained by the fact, well known in hydrobiology, that oligotrophic reservoirs exhibit a great plankton species variety, with small density of individuals of each species. In eutrophic waters, however, the number of species is small, while their biomass is great. The character of the water reservoir itself promotes mycoflora species diversity (Tab. 4). Environmental extremes (temperature, oxygen concentration, and others) in the prespawning time induce stress in the female, largely affecting eggs immunity of a particular species (Śnieszko 1974; Billard et al. 1981; Barton and Schreck 1987; Kime 1995). Of importance is also eggs accessibility, mucous lining and eggs capsule structure (Wessler and Werner 1957; Lartseva and Altufiev 1987). Food procurement may be a stressogenic factor, and food type consumed by the female may affect eggs immunity (Barton et 1988; Ako et al. 1994). Stressogenic factors in the prespawning season impair endocrine processes in females, which in turn affects the course of spawning and eggs quality (Axelrod and Reisine 1984; Pickering et al. 1987; Pankhurst et al. 1995). However, it is the genetic factor that plays the most important part (Fevolden et al. 1992, 1994; Heath et al. 1993; Pottinger et al. 1994). Therefore, a search is conducted for stress-immune variaties of cyprinid fish bred in fish farms, which are thus insusceptible to bacterial and mycotic infections (Iwama et al. 1997). So, the occurrence of one or other zoosporic fungus species and their number are the resultant of the effect of all the above mentioned abiotic and biotic factors.

CONCLUSIONS

A total of 100 aquatic fungus species was found in laboratory conditions in the spring water, pond, lake, and the river on the eggs of fishes representing 33 of cyprinid species inhabiting Polish waters.

The fewest species were observed on the eggs of grass carp *Ctenopharyngodon idella* (8), the most on the eggs of lake minow *Phoxinus* (*Moroco*) *percnurus* (37).

Achlya diffusa, *Aphanomyces laevis*, *Aphanomyces stellatus*, *Dictyuchus sterilis*, *Leptolegnia caudata*, *Saprolegnia ferax*, *Saprolegnia parasitica*, *Saprolegnia shikotsuensis*, and *Pythium artotrogus* are the most frequently encountered fungus species on the eggs of the cyprinids examined.

The largest number of aquatic fungi occurred on eggs in the water poor in biogenes, the smallest number in the water abundant in these compounds.

Among the fungus species found, some are new to fish and to Polish hydromycology.

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Bazyli *CZECZUGA*, Elżbieta *MUSZYŃSKA*

GRZYBY WODNE ROZWIJAJĄCE SIĘ NA IKRZE RYB REPREZENTUJĄCYCH 33 TAKSONY RYB KARPIOWATYCH (CYPRINIDAE) W WARUNKACH LABORATORYJNYCH

STRESZCZENIE

Analizowano w warunkach laboratoryjnych występowanie grzybów wodnych na ikrze 33 taksonów ryb z wód Polski należących do rodziny karpiowatych. Do doświadczeń używano wody ze źródła, stawu, jeziora i rzek, uwzględniając w niej poszczególne parametry hydrochemiczne.

Ogólnie stwierdzono na ikrze badanych ryb rozwój 100 gatunków grzybów wodnych. Najmniej gatunków rozwijało się na ikrze amura *Ctenopharyngodon idella* (8), najwięcej – na ikrze strzebli przekopowej *Phoxinus* (*Moroco*) *percnurus* (37). Wśród stwierdzonych gatunków grzybów szereg okazało się nowymi gatunkami dla ryb w ogóle oraz dla hydromikologii Polski.

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