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AQUATIC FUNGI GROWING ON THE EGGS OF SOME ANADROMOUS FISH SPECIES OF THE FAMILY CLUPEIDAE

GRZYBY WODNE ROZWIJAJĄCE SIĘ NA IKRZE NIEKTÓRYCH ANADROMICZNYCH GATUNKÓW NALEŻĄCYCH DO RODZINY CLUPEIDAE

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The authors investigated of the mycoflora developing on the eggs of six species of the genus *Alosa*.

INTRODUCTION

The family Clupeidae abounds in numerous economically important species They live solely in sea water preying on planktonic animals. The family includes species leading anadromous life, i.e. growing and maturing in sea water, and migrating to fresh waters to spawn. This is so in the case of the genus *Alosa*.

Carrying out the studies on fungi growing on fish eggs (Czeczuga and Woronowicz 1993; Czeczuga 1994; Czeczuga et al. 1995, 1996), we decided to concentrate on some species of the genus Alosa, whose representatives spawn in riverine waters.

The present study is concerned with anadromous *Alosa* species, which due, to their tasty meat and thus being economically important, are priced both in the basin of the Baltic Sea (Manyukas 1989; Wikońska and Garbacik-Wesołoska 1996), in North America (Miller 1957; Scott and Grossman 1973; Carscadden and Legget 1975; Eck and Wells 1987), and in the basin of the Caspian-Black Sea (Pušbarnek 1987; Kovtun and Nikulšin 1989).

The literature on clupeid fish mycosis is very scarce. Science saprolegniosis hardly ever affects marine fish species. Only Ryder (1881) observed the growth of fungi on the eggs of *Alosa sapidissima*, while Dykstra et al. (1986) found mycosis epizooty off the coast of the United Sates of the America in the Atlantic menhaden (*Brevoortia tyrranus* Latrobe), caused by salinity-resistant fungal strains of *Aphanomyces* sp. and *Saprolegnia* sp.

MATERIAL AND METHODS

The investigations included the eggs (non fertilised) of the following fish species:

1. *Alosa alosa* (L.)
2. *Alosa caspia* (Eichw.)
3. *Alosa fallax* (Lacépéde)
4. *Alosa kessleri* Grimm
5. *Alosa pseudoharengus* (Wilson)
6. *Alosa sapidissima* (Wilson)

The eggs were collected from female individuals of the species investigated, during their spawning migration. The survey involved to having species and sites: *Alosa alosa* from the coast of Norway; *Alosa fallax* from the coast of Finland; *Alosa pseudoharengus* and *Alosa sapidissima* entering the rivers of the Great Lakes region in North America; *Alosa caspia* and *Alosa kessleri* leaving the Caspian Sea for the river Volga. The materials were transported in a thermos flask in a physiological solution by air mail.

Water for experiments was collected from three different bodies of water: Supraśl River, a pond in the Branicki Park, and Komosa Lake. Nineteen parameters of these water samples were determined (Tab. 1) according to the generally accepted methods (Golterman and Clymo 1969).

Table 1

Chemical composition (in mg/dm^3) of water from the different sites (October, 1995)

Specification	Pond	Lake Komosa	River Supraśl
Temperature °C	6.2	5.8	5.4
pH	7.1	7.4	7.4
O_2	6.5	7.8	12.6
BOD_5	4.4	1.8	2.2
Oxidability	9.2	7.0	7.4
CO_2	13.4	14.8	16.3
Alkalinity in $CaCO_3$*	4.4	3.8	4.0
N (NH_3)	0.68	0.15	0.20
N (NO_2)	0.08	0.02	0.03
N (NO_3)	0.72	0.12	0.13
PO_4	6.82	0.26	0.42
Cl	64.00	24.0	30.20
Total hardness in Ca	82.12	66.18	70.44
Total hardness in Mg	24.12	24.46	27.14
SO_4	50.42	18.12	20.08
Fe	1.54	0.25	0.44
Dry residue	422.0	324.0	368.0
Dissolved solids	384.0	306.0	326.0
Suspended solids	38.0	18.0	42.0

* in mval/dm^3.

To detect the presence of aquatic fungi species on the eggs, the following procedure was employed: a certain amounts of eggs (100–200) of each species of fish was transferred to two 1-litre dishes, and placed in the laboratory at a temperature approaching that of the given hatchery. Part of the eggs from each dish was observed under a microscope and the mycelium (form zoospore, oogonia, and conidia) of aquatic fungi growing on the eggs was recorded. The methods were described in detail in the papers of Smith et al. (1985) and Fuller and Jaworski (1986). The eggs of various fish species were examined for one to one and a half weeks. The eggs were mostly live but sometimes they were dead.

The length of time of these experiments was three weeks.

For identification of the fungi the following keys were used: Johnson (1956), Sparrow (1960), Seymour (1970), Karling (1977), and Dick (1990).

RESULTS

Forty-eight aquatic fungus species were found on the eggs of six species of the genus *Alosa* (Tab. 2). Such fungi as *Olpidiopsis saprolegniae*, *Pythium sylvaticum*, *Skirgiellia septigena* and *Zoophagus insidianis* are new to fishes (Fig. 1). Worth noting the finding of *Saprolegnia invanderis* on the eggs of *Alosa caspia*, *Saprolegnia shikotsuensis*—on the eggs of *Alosa fallax* and *Zoopage phanera*—on the eggs of *Alosa pseudoharengus*. The eggs of the fish species examined were most heavily infected in the water from lake Komosa, and least infected in the pond water (Tab. 3). Moreover, apart from *Pythium sylvaticum*, five other fungus species of the genus *Pythium* were found to grow on the eggs examined.

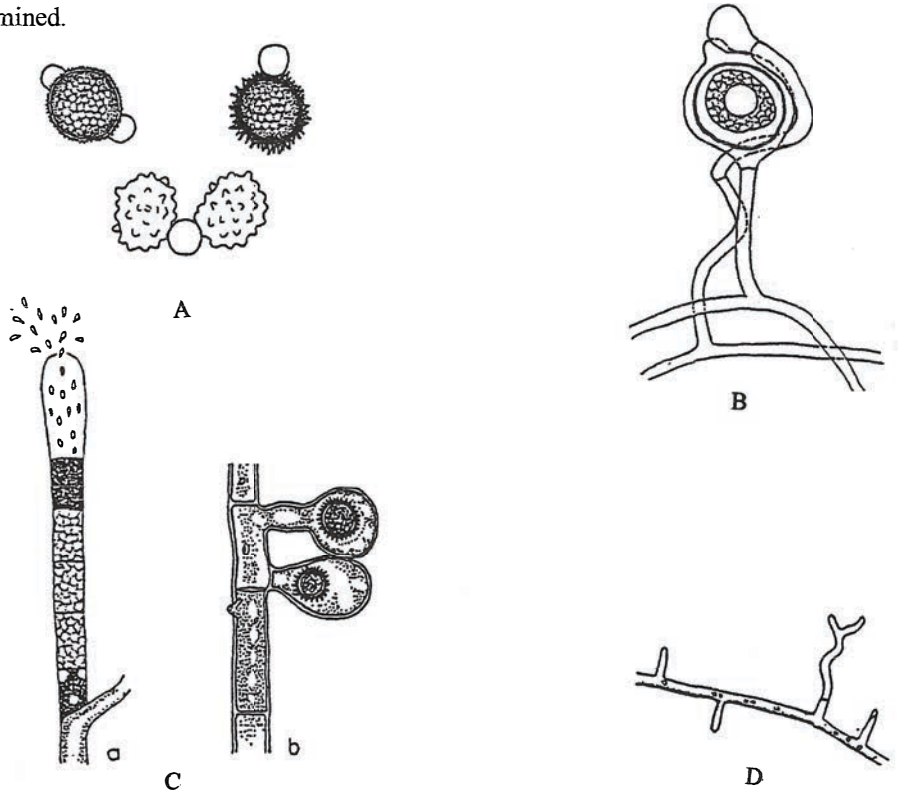

Fig. 1. Aquatic fungi new to fishes. A—*Olpidiopsis saprolegniae*: spores (from spiny7–9 μm; smooth 50–95 μm). B—*Pythium sylvaticum*: oogonium (20 μm with aplerotic oospores and diclinous antheridium). C—*Skirgiellia septigena*: a – sporangium from zoospors, b –sporangium from spores. D—*Zoophagus insidians*: part of mycelium from prehensile apparatus.

Table 2

Aquatic fungi found on the eggs of *Alosa* species

Species of fungi	*Alosa* species (see Materials and Methods)
1. *Achlya ambisexualis* Raper	1
2. *Achlya americana* Humphrey	1
3. *Achlya caroliniana* Coker	1, 4
4. *Achlya colorata* Pringsheim	3
5. *Achlya diffusa* Harvey et Johnson	2, 3, 4, 6
6. *Achlya dubia* Coker	1
7. *Achlya hypogyna* Coker et Pemberton	5
8. *Achlya polyandra* Hildebrand	1, 4, 6
9. *Achlya prolifera* Nees	4
10. *Achlya radiosa* Maurizio	4, 5
11. *Achlya treleaseana* (Humphrey) Kauffman	3, 5
12. *Aphanomyces irregularis* Scott	1, 6
13. *Aphanomyces laevis* de Bary	1, 3, 4, 6
14. *Aphanomyces stellatus* de Bary	1, 5
15. *Aplanes androgynus* (Archer) Humphrey	2, 4
16. *Blastocladiopsis parva* (Whiffen) Sparrow	4, 6
17. *Calyptralegnia achlyoides* (Cocker et Couch) Cocker	3
18. *Dictyuchus monosporus* Leitgeb	2, 5
19. *Dictyuchus sterilis* Coker	1, 2, 4
20. *Isoachlya anisospora* (de Bary) Coker	1, 6
21. *Leptolegnia caudata* de Bary	2, 3, 4, 5
22. *Leptomitus lacteus* (Roth) Agardh	2, 3, 4
23. *Olpidiopsis saprolegniae* (Braun) Coker	2
24. *Polyphagus euglenae* Nowakowski	3
25. *Protoachlya paradoxa* (Coker) Coker	1
26. *Pythiopsis cymosa* de Bary	1, 2
27. *Pythium artotrogus* de Bary	3
28. *Pythium debaryanum* Hesse	1, 2
29. *Pythium middletonii* Sparrow	5
30. *Pythium proliferum* de Bary	6
31. *Pythium sylvaticum* Campbell et Hendrix	6
32. *Pythium ultimum* Trow	5
33. *Saprolegnia asterophora* de Bary	4
34. *Saprolegnia australis* Elliott	2, 6
35. *Saprolegnia delica* Coker	1, 4
36. *Saprolegnia ferax* (Gruith) Thurnet	1, 2, 4
37. *Saprolegnia hypogyna* (Pringsheim) de Bary	1
38. *Saprolegnia invaderis* Davies et Lazar	2
39. *Saprolegnia megasperma* Coker	1
40. *Saprolegnia mixta* de Bary	6
41. *Saprolegnia monoica* Pringsheim	2
42. *Saprolegnia parasitica* Coker	1, 2, 3, 4, 6
43. *Saprolegnia shikotsuensis* Hatai et al.	2, 3
44. *Skirgiellia septigena* (Cornu) Batko	2
45. *Traustotheca clavata* (de Bary) Humphrey	2
46. *Trichosporon cutaneum* (de Beur et al.) Ota	2, 5
47. *Zoopage phanera* Drechsler	1, 5
48. *Zoopagus insidians* Sommerstorff	1

Table 3

Aquatic fungi found on the eggs of individual *Alosa* species

Alosa species	Fungi (see Table 2)	Number of fungi
1. *Alosa alosa*	1, 2, 3, 6, 8, 12, 13, 14, 19, 20, 25, 26, 28, 35, 36, 37, 39, 42, 47, 48	20
2. *Alosa caspia*	5, 15, 18, 19, 21, 22, 23, 26, 28, 34, 36, 38, 41, 42, 43, 44, 45	17
3. *Alosa fallax*	4, 5, 11, 13, 17, 21, 22, 24, 27, 42, 43	11
4. *Alosa kessleri*	3, 5, 8, 9, 10, 13, 15, 16, 19, 21, 22, 33, 35, 36, 42	15
5. *Alosa pseudoharengus*	7, 10, 11, 14, 18, 21, 29, 32, 46, 47	10
6. *Alosa sapidissima*	5, 8, 12, 13, 16, 20, 30, 31, 34, 40, 42	11

DISCUSSION

Olpidiopsis saprolegniae, new to fishes, is known as a parasite of other aquatic fungi of the genus *Saprolegnia* (Batko 1975) and as a saprophyte of rivers and lakes in Poland (Stpiczyńska-Tober 1965; Czeczuga 1995). *Olpidiopsis saprolegniae* was found to grow on the eggs of *Alosa caspia*. *Pythium sylvaticum*, another fungus new to fishes, is mainly known as a soil saprophyte (Campbell and Hendrix 1967) and as a pathogenic factor that causes damage to plant roots (Kusonoki and Ichitani 1994). In our studies, *Pythium sylvaticum* grew on the eggs of *Alosa sapidissima*. *Skirgiellia septigena*, known as a parasite of other fungi of the genus *Achlya* and *Saprolegnia* (cf. Sparrow 1960), was also found on the eggs of *Alosa sapidissima*. *Zoophagus insidians* is known as a predacious fungus that catches rotifers (Dick 1990). It was first described by Sommerstorff (1911) in aquarium water. It was also reported in water bodies of various types. Among fungi, it is the most common predator in the waters of north-eastern Poland (Czeczuga 1993). *Saprolegnia invaderis*, an aquatic fungus species rare to fishes, was found on the eggs of *Alosa caspia*. It was first described by Davis and Lazar (1940) as a parasite of trout.

Saprolegnia shikotsuensis, an interesting species found on the eggs of *Alosa fallax*, was first described as a parasite of salmon *Oncorhynchus nerka* var. *adonis* in Lake Shikotsu, on the island of Hokkaido, in Japan (Hatai et al. 1977). In the presently studied conditions, the growth of *Saprolegnia shikotsuensis* was observed on the eggs of a few acipenserid fish species (Czeczuga et al. 1995). It occurred in pond water and in Lake Komosa on the eggs of *Acipenser güldenstädti*, *Acipenser nudiventris*, *Acipenser ruthenus* and *Huso huso*. Moreover, *Saprolegnia shikotsuensis* was observed on the eggs of 3 out of 10 salmon species of the Pacific – *Oncorhynchus keta*, *Oncorhynchus kisutch* and *Oncorhynchus masou* (Czeczuga and Muszyńska 1996).

Zoophagus phanera was first described as a predacious fungus catching soil creepers (Drechsler 1935). In fishes, we observed this fungus for the first time in the autumn, on the eggs of *Coregonus albula*, in a hatchery at Ruciane-Nida supplied with the lake water, and on the eggs of *Coregonus peled* in a hatchery at Dgał. This fungus winds its thin hyphae round soil creepers, damaging them (Jones 1958, 1959). During our studies of the free-living aquatic fungus species in water bodies of various types in north-eastern Poland, we found this fungus twice. First it was observed in the coastal water of Bleak Bay of Lake Wigry (Czeczuga 1991b), and then, in a small marsh in the palace park near our School (Czeczuga and Muszyńska 1993).

Scott and O'Bier (1962) were the first to observe fungi of the genus *Pythium* on fish. These data are presented in the surveys of fungi parasitic on fishes by Wilson (1976), Srivastava (1980), neish and Hughes (1980), Hatai (1981), Griščenko (1985), and Dudka et al. (1989). No more data on fungi of the genus *Pythium* that grows on fishes is available in literature. Therefore, we will give more attention to the fungi of the genus *Pythium* found on the fish eggs of the genus *Alosa*. We found species of the genus *Pythium* on the eggs of all the fish species examined except *Alosa kessleri*. The genus *Pythium* includes mainly land-, and to a smaller extend, aquatic parasites and saprophytes of plants (Plaats-Niterink Van der 1981; Yu and Ma 1989). About 100 species are known, half of which live in an aquatic environment (Waterhouse 1967, 1968). In waters, species of the genus *Pythium* are encountered in springs (Czeczuga et al. 1989), rivers (Park and McKee 1978; Park 1980), stagnant waters like ponds (Abdelzaher et al. 1984a, b), or various types of lakes (Czeczuga 1991a, 1991b, 1995). *Pythium artotrogus*, found in the present study, is mainly a saprophyte living on plant fragments and on dead flies in water (Skirgiełło 1954). In our present study, this fungus was found on the eggs of *Alosa fallax*, and earlier on the eggs of *Coregonus albula*, *Coregonus lavaretus*, *Esox lucius* (cf. Czeczuga and Woronowicz 1993), and on the eggs of sturgeon—*Acipenser nudiventris* (cf. Czeczuga et al. 1995). *Pythium debaryanum* was first described in the previous century (Hesse 1874) as a soil phytophatogen. It is found in soil (Johnson 1971) and in water bodies of varied trophicity (Czeczuga 1995). Prevoiusly, we observed its growth on the eggs of *Leuciscus cephalus* (cf. Czeczuga 1996). In the present study it was found on the eggs of *Alosa alosa* and *Alosa caspia*. *Pythium middletonii*, the third species of this genus, grew on the eggs of *Alosa pseudoharengus*. It is frequently observed, like *Pythium proliferum*, in various water bodies of north-eastern Poland (Czeczuga 1996). *Pythium proliferum* was found on the eggs of *Alosa sapidissima*. Its growth on the eggs of various fish species was reported by Florinskaja (1969) from hatcheries in the district of St. Petersburg in Russia. *Pythium ultimum*, another species of the genus *Pythium*, was observed on the eggs of *Alosa pseudoharengus*. Earlier, it was found on the eggs of sturgeon—*Acipenser nudiventris* (cf. Cze-

czuga et al. 1995). Scott and O'Bier (1962) observed it on fish individuals of *Lepomis macrochirus*. This species is usually found in soil (Drechsler 1960); its varieties live both in soil ((Ichitani et al. 1991; Tojo et al. 1993), growing most intensively in spring months (Tojo et al. 1992), and in water (Batko 1975).

While studying the aquatic fungi growing on the eggs of salmonid fish (Czeczuga and Muszyńska 1996; Czeczuga et al. 1996), we found some species new to fishes, such as *Achlya prolifera*, *Polyphagus euglenae*, and *Saprolegnia megasperma*. These species were found to grow also on the eggs of some species of *Alosa*. We isolated *Achlya prolifera* from the eggs of *Alosa kessleri*, *Polyphagus euglenae* from *Alosa fallax* and *Saprolegnia megasperma* from *Alosa alosa*.

In the present study most aquatic fungus species developed on the eggs of the *Alosa* species in the water of lake Komosa, least in the moat-pond (Tab. 4). The water used for the experiments had variable chemical composition. Our previous studies revealed that in the water of the same water basin the eggs of some fish species were affected by fewer fungus species, while the eggs of others—by more. Almost twice more fungi were found on the eggs of acipenserid fishes in pond water than in the water of lake Komosa (Czeczuga et al. 1995). We observed almost the same pattern while studying fungi growing on the eggs of North Pacific salmons of the genus *Oncorhynchus* (cf. Czeczuga and Muszyńska 1996). Fungi growing on the eggs of nine salmonid species of the genus *Hucho*, *Salmo*, and *Salvelinus* had better conditions to develop in the water of lake Komosa than in the pond (Czeczuga et al. 1996).

Table 4

Aquatic fungi found on the eggs of *Alosa* species from different sites

Water from	Fungi (see Table 2)	Total number
Pond	1, 2, 5, 8, 11, 12, 13, 14, 16, 18, 20, 21, 27, 28, 29, 36, 39, 40, 42, 46, 47	21
Lake	1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 14, 15, 16, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 33, 35, 36, 37, 38, 39, 41, 42, 43, 44, 45, 47, 48	40
River	3, 4, 5, 7, 8, 11, 13, 14, 15, 17, 18, 19, 20, 21, 22, 26, 27, 28, 30, 31, 32, 34, 35, 36, 42, 43, 47	27

Thus, water quality can have a significant effect on the growth of fungi on the eggs incubated in hatcheries, which may result in the limitation of the hatchery's efficiency. Rapid growth of *Saprolegnia* fungi can destroy a major part of the incubated eggs (Lartseva 1986; Lartseva and Altufiev 1987) or devastate it completely (Sati and Khuble 1981; Dudka et al. 1989).

Susceptibility of fishes and their parts, eggs inclusive, to mycotis infections, depends on a number of factors, both of abiotic and biotic nature. Also, the structure of the egg capsule and the thickness of mucous layer covering it, play a role in the occurrence of different fungus species on fish eggs (Lartseva and Altufiev 1987).

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GRZYBY WODNE ROZWIJAJĄCE SIĘ NA IKRZE NIEKTÓRYCH ANADROMICZNYCH GATUNKÓW RYB NALEŻĄCYCH DO RODZINY CLUPEIDAE

STRESZCZENIE

Autorzy badali w warunkach laboratoryjnych występowanie grzybów wodnych na ikrze sześciu gatunków ryb z rodzaju *Alosa*. Badaniami objęto ikrę *Alosa alosa*, *Alosa caspia*, *Alosa fallax*, *Alosa kessleri*, *Alosa pseudoharengus* oraz *Alosa sapidissima*. Do doświadczeń używano wody ze stawu, z jeziora i rzeki, uwzględniając w niej poszczególne parametry hydrochemiczne.

Ogólnie stwierdzono na ikrze rozwój 48 gatunków grzybów wodnych. Najmniej gatunków rozwijało się na ikrze *Alosa pseudoharengus* (10), najwięcej — na ikrze *Alosa alosa* (20). Wśród stwierdzonych gatunków grzybów takie jak *Olpidiopsis saprolegniae*, *Pythium sylvaticum*, *Skirgiellia septigena* oraz *Zoophagus insidians* okazały się nowymi gatunkami dla ryb w ogóle.

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