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ZOOSPORIC FUNGI GROWING ON THE DEAD GLASS EEL (MONTÉE) AND ELVER'S (*ANGUILLA ANGUILLA* L.)

GRZYBY ZOOSPOROWE ROZWIJAJĄCE SIĘ NA MARTWYM NARYBKU WĘGORZA SZKLISTEGO I WSTĘPUJĄCEGO – *ANGUILLA ANGUILLA* L.

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The authors investigated the mycoflora developing on the dead glass eel (montée) and elvers (*Anguilla anguilla* L.)

INTRODUCTION

Due to its tasty and fatty meat the eel plays an important role in fisheries. However, the pollution of rivers, particularly of those bigger ones which fall into the Atlantic, causes that only small amounts of eel fry migrate upstream (Williamson 1993; Robak 1994, 1997). For some time now the glass eel known also as the montée has been caught at sea far from the coasts of western Europe (Stachowiak 1997). The so called elvers or the eel which are ready for their upstream migration, can be observed in the storage ponds. Later they are shipped to inland aquatic basins, also to Polish waters. Both the transport and the new environment cause that part of the montée and the elvers is weakened, suffers from stress (Willemse et al. 1984), and dies. In the first year following fish stocking, the losses amount to 70%, in the second year reaching approximately 20% of the population (De Leo and Gatto 1995).

The studies on the occurrence of fungi on eels have been carried out by several researchers. In the last century Schnetzler (1887) and Smith (1878) found *Saprolegnia ferax* on eel larvae. The growth of this fungus was also observed on adult individuals of the European eel, *Anguilla anguilla* L. by Drew (1909) and Agersborg (1933) Tiffney (1939a, b), reported the presence of *Saprolegnia parasitica* on the specimens of the American ell, *Anguilla rostrata* (Lesueur), while Hoshina et al. (1960)—on the Japanese eel, *Anguilla japonica* Temminck et Schlegel. Mycotic infections were also studied in

cultured populations of the Japanese eel (Hoshina and Ookubo 1956; Egusa and Nishikawa 1965; Inman and Bland 1981) and of the European eel (Copland and Willoughby 1982; Willoughby and Copland 1984). Czeczuga (1994) found the growth of *Saprolegnia ferax*, *Saprolegnia monoica*, and *Candida albicans* on montée fry in natural conditions of Mikołajki Lake.

The aim of the present study was to establish species composition of aquatic fungi growing on dead glass eel and elvers in the water of different trophicity. The fungus species known as fish parasites or necrotrophs were taken into consideration. We wanted to detected parasitic fungus species, which apart from saprophytic fungi, grow on dead eel fry and cause infection of healthy fish of other species.

MATERIAL AND METHODS

The present study carried on dead glass eel and elvers of *Anguilla anguilla* L. which were obtained in the spring of 1997 from A. Lityński Stock Centre of the Polish Academy of Sciences in Gawrych Ruda near Suwałki.

The water for the experiments was collected from six different bodies of water: Cypisek Spring, Biała River, Supraśl River, Fosa Pond, Dojlidy Pond, and Komosa Lake. Nineteen parameters of these water samples were determined (Tab. 1) according to the generally accepted methods (APHA 1975).

Table 1

Chemical composition (in $mg \cdot dm^{-3}$) of water from different sampling sites

Specification	Cypisek Spring	Biała River	Supraśl River	Fosa Pond	Dojlidy Pond	Komosa Lake
Temperature °C	7.00	1.50	1.00	0.60	2.00	0.50
pH	7.09	6.94	7.48	7.08	7.31	7.21
O_2	9.00	2.60	13.60	11.00	11.00	11.80
BOD_5	3.00	2.60	4.00	4.60	4.00	2.40
Oxidability (COD)	3.00	12.24	9.38	6.40	9.00	6.80
CO_2	15.40	28.60	4.40	8.80	15.40	8.80
Alkalinity in $CaCO_3$ (in $mval \cdot dm^{-3}$)	5.20	6.70	3.00	3.90	4.70	4.10
N (NH_3)	0.052	0.685	0.280	0.310	0.640	0.125
N (NO_2)	0.0146	0.0121	0.010	0.009	0.011	0.014
N (NO_3)	0.050	0.050	0.030	0.020	0.055	0.030
PO_4	1.290	3.400	0.007	1.500	1.500	0.800
Cl	23.00	48.00	26.00	17.00	40.00	14.00
Total hardness in Ca	118.08	97.20	56.88	72.00	92.16	66.24
Total hardness in Mg	17.20	20.64	13.76	10.32	22.36	10.32
SO_4	49.78	37.44	38.26	42.78	68.70	23.04
Fe	0.48	0.68	0.70	0.48	0.90	0.68
Dry residue	321	546	224	462	532	366
Dissolved solids	303	472	117	230	496	283
Suspended solids	18	74	107	232	36	83

For the determinations of the presence of aquatic fungus species on the dead fry, the following procedure was employed. Batches of glass eel and elvers (100–200) were transferred to thirty a 1.0-litre vessels (5 in each) and placed in the laboratory at the temperature approaching that of the given hatchery. The subsamples from each vessel were observed under a microscope and the presence of mycelium (forming zoospores and oogonia) of aquatic fungi growing on fry was record. The methods were described in detail by Smith et al. (1985) and Fuller and Jaworski (1986). The samples of juvenile eel were examined through one (or one and half) week. The experiments were carried out for three weeks.

The fungi were identified using the following keys: Johnson (1956), Sparrow (1960), Seymour (1970), Batko (1975), and Dick (1990).

RESULTS

The results of chemical analysis of the water used for the experiments have been listed in Tab. 1. The most eutrophicated was the water from the Biała River and Fosa Pond; however, the water from Komosa Lake and Supraśl River had the lowest content of nutritive compounds.

In the water from northeastern Poland a total of fifty-two zoosporic fungus species were found on dead eels (Tab. 2), 31 species on the montée and 42 on the elvers. Among them, twenty-eight fungus species were fish parasites. Worth noting is also the finding of *Phlyctochytrium hirsutum*, *Saprolegnia paradoxa*, and especially *Saprolegnia turfosa* (Fig. 1), which was a new record for dead eel fry in Poland.

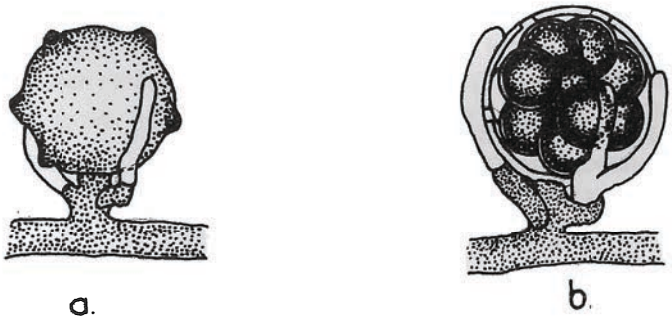

Fig. 1. *Saprolegnia turfosa*: a, general aspect of oogonia with antheridia; b, oogonia with oospores and antheridia

Table 2

Aquatic fungi found on the dead fry of *Anguilla anguilla* L.

	Species of fungi	Montée	Elvers
1.	*Achlya americana* Humphrey *	×	×
2.	*Achlya apiculata* de Bary		×
3.	*Achlya bisexualis* Coker et Couch *		×
4.	*Achlya colorata* Pringsheim		×
5.	*Achlya dubia* Coker *	×	
6.	*Achlya flagellata* Coker *	×	×
7.	*Achlya hypogyna* Coker et Pemberton		×
8.	*Achlya klebsiana* Pieters *	×	×
9.	*Achlya megasperma* Humphrey	×	×
10.	*Achlya oblongata* de Bary	×	×
11.	*Achlya oligacantha* de Bary		×
12.	*Achlya orion* Coker et Couch *	×	×
13.	*Achlya polyandra* Hildebrand *	×	×
14.	*Achlya prolifera* C.G. Nees *	×	×
15.	*Achlya treleaseana* (Humphrey) Kauffman		×
16.	*Aphanomyces laevis* de Bary *	×	×
17.	*Aplanes androgynus* (Archer) Humphrey		×
18.	*Calyptralegnia achlyoides* (Coker et Couch) Coker *	×	
19.	*Calyptralegnia basraensis* Muhsin		×
20.	*Cladolegnia eccentrica* (Coker) Johannes		×
21.	*Cladolegnia unispora* (Coker et Couch) Johannes	×	×
22.	*Dictyuchus sterilis* Coker *		×
23.	*Isoachlya monilifera* (de Bary) Kauffman *	×	×
24.	*Isoachlya torulosa* (de Bary) Cejp	×	
25.	*Leptolegnia caudata* de Bary *	×	×
26.	*Leptomitus lacteus* (Roth) Agardh *	×	×
27.	*Phlyctochytrium hirsutum* Karling		×
28.	*Pythiopsis cymosa* de Bary *		×
29.	*Pythium artotrogus* var. *macranthium* Sideris *	×	
30.	*Pythium debaryanum* Hesse		×
31.	*Pythium intermedium* de Bary	×	
32.	*Pythium middletonii* Sparrow	×	
33.	*Pythium ultimum* Trow	×	
34.	*Rozella septigena* Cornu		×
35.	*Saprolegnia asterophora* de Bary		×
36.	*Saprolegnia australis* Elliott *	×	×
37.	*Saprolegnia delica* Coker *	×	×
38.	*Saprolegnia diclina* Humphrey *	×	×
39.	*Saprolegnia ferax* (Gruith.) Thuret *	×	
40.	*Saprolegnia glomerata* (Tiesenhausen) Lund		×
41.	*Saprolegnia hypogyna* (Pringsheim) de Bary	×	
42.	*Saprolegnia litoralis* Coker		×

Table 2 (cont.)

	Species of fungi	Montée	Elvers
43.	*Saprolegnia mixta* de Bary *		×
44.	*Saprolegnia monoica* Pringsheim *	×	×
45.	*Saprolegnia paradoxa* Maurizio *		×
46.	*Saprolegnia parasitica* Coker *	×	×
47.	*Saprolegnia shikotsuensis* Hatai et al. *	×	×
48.	*Saprolegnia subterranea* Dissmann *	×	
49.	*Saprolegnia torulosa* de Bary *	×	×
50.	*Saprolegnia turfosa* (Minden) Gäumann		×
51.	*Thraustotheca clavata* (de Bary) Humprey *		×
52.	*Zoophagus insidians* Sommerstorff	×	×
Total number		31	42

* species known in literature as parasites or necrotrophs of fish

DISCUSSION

Phlyctochytrium hirsutum was first described by Karling (1937) from algae *Hydrodictyon reticulatum*. *Saprolegnia paradoxa* was found at the end of the last century in the waters of Switzerland (Maurizio 1899). In the literature of the subject it has been known as a saprophyte and facultative fish parasite in aquaria and fish ponds (Batko 1975). *Saprolegnia turfosa* was first described by Minden (1912) as *Saprolegnia monoica* var. *turfosa*. Gäumann (1918) studying fungi of Lapland treated it as a separate species *Saprolegnia turfosa*. Then Coker (1927) included it in the genus *Aplanes*. Seymour (1970) shared Gaumann's opinion, leaving it in the genus *Saprolegnia*. It has been encountered in fresh water and soil, quite common in sphagnum bogs, cypres swamps, and damp acidic soil of Iceland (Johnson 1968), Europe (Seymour 1970), USA (Beneke 1948), and Japan (Suzuki 1961).

Of 28 fungus species known as fish pathogenes, some cause considerable losses (Dudka et al. 1989). For instance, saprolegniosis was the cause of death of almost the whole fry of *Labeo rohita* on a fish farm in Bangladesh (Sanaullah 1984). *Achlya bisexualis* and *Achlya hypogyna* infected the eggs of whitefish (Lartseva and Dudka 1990). *Achlya flagellata* and *Achlya prolifera* caused death of all *Tor tor* eggs during incubation in a hatchery in India (Sati and Khulbe 1981). *Achlya polyandra* is frequently detected on eggs of salmonids in Armenia (Osipian et al. 1988). *Aphanomyces laevis* is usually encountered on eggs of many fish species in hatcheries (Florinskaja 1969; Czeczuga and Woronowicz 1993). *Leptolegnia caudata*, together with other species of the genera *Achlya* and *Saprolegnia*, causes heavy eggs losses (Lartseva 1986). The so called sewage fungus *Leptomitus lacteus* grows both on eggs in hatcheries and on young and adult fishes in their natural environment; it was found on eggs of *Coregonus albula* (cf. Czeczuga and Woronowicz

1993; Czeczuga and Muszyńska 1998). In Lake Windermere in Great Britain it attacks young and adult perch, *Perca fluviatilis* (cf. Willoughby 1970; Wood and Willoughby 1986). A few species of the genus *Saprolegnia* cause heavy losses on fish farms. One of them is *Saprolegnia australis* known to have caused a mass death of roach, *Rutilus rutilus* in fish ponds in Toluouse, France (Papatheodoru 1981). *Saprolegnia diclina* attacks various fish species at different latitudes. Together with other species of the genus *Saprolegnia*, it infects perch in Swiss lakes (Meng 1980), various fish species in India (Sati and Khulbe 1983), eggs of acipenserids in Russia (Lartseva and Dudka 1990), and eggs of salmonids in Armenia (Osipian et al. 1988). *Saprolegnia mixta* and *Saprolegnia monoica* cause great losses in acipenserid hatcheris in Russia (Lartseva 1986). However, the most severe losses, both in natural conditions and on farms are due to *Saprolegnia ferax* and *Saprolegnia parasitica* (cf. Neish and Hughes 1980). *Saprolegnia ferax* has been known since the previous century (Stirling 1880a, b) when it caused huge losses in the populations of the Atlantic salmon, *Salmo salar*. In hatcheries on the Volga, this fungus is the main cause of mass infections in the eggs of star sturgeon (Lartseva et al. 1987). *Saprolegnia parasitica* frequently causes deaths on eel-breeding farms in Japan (Hoshina et al. 1960; Egusa and Shimizu 1965) and on Pacific salmon farms in Japan (Hatai et al. 1990). *Saprolegnia parasitica* is a common cause of mass death of coho salmon, *Oncorhynchus kisutch* in Miyagi Prefecture, which largely disturbs pond farming there (Hatai and Hoshiai 1992a, b).

In the present study, more zoosporic fungus species were found to grow on the dead fry of eel in water from Komosa Lake and the Supraśl River (Tab. 3), in which the water is less abundant in nutrients than the water of the Biała River and Fosa Pond.

Table 3

Aquatic fungi found on the dead fry of *Anguilla anguilla* L. at different sites

Water from	Fungi (see Table 2)	Total number
Cypisek Spring	1, 5, 14, 15, 16, 18, 19, 32, 36, 37, 39, 43, 46, 48, 51	15
Biała River	4, 11, 13, 14, 15, 21, 23, 24, 25, 26, 27, 28, 31, 37, 41, 44	16
Supraśl River	3, 10, 12, 13, 14, 15, 16, 17, 19, 22, 23, 25, 26, 29, 38, 40, 41, 46, 48, 50	20
Fosa Pond	3, 7, 8, 9, 10, 16, 20, 24, 25, 31, 37, 43, 44, 45, 46, 52	16
Dojlidy Pond	1, 2, 6, 8, 14, 16, 25, 28, 29, 30, 38, 40, 51, 52	14
Komosa Lake	12, 13, 15, 20, 22, 33, 34, 35, 36, 38, 40, 42, 44, 46, 47, 49, 52	17

The data indicate that dead fry of eel, *Anguilla anguilla* is a substrate for many zoosporic fungus species which are parasites or necrotrophs of various fish species

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Bazyli *CZECZUGA*, Elżbieta *MUSZYŃSKA*

GRZYBY ZOOSPOROWE ROZWIJAJĄCE SIĘ NA MARTWYM NARYBKU WĘGORZA SZKLISTEGO I WSTĘPUJĄCEGO – *ANGUILLA ANGUILLA* L.

STRESZCZENIE

Badano w warunkach laboratoryjnych występowanie grzybów wodnych na martwym narybku węgorza szklistego i wstępującego *Anguilla anguilla* L.

Do doświadczeń używano wody ze źródła, 2 rzek, 2 stawów oraz z jeziora, uwzględniając w niej poszczególne parametry hydrochemiczne.

Ogólnie stwierdzono na badanym narybku rozwój 52 gatunków grzybów zoosporowych, w tym 33 na narybku szklistym i 42 na wstępującym. Ponadto 3 gatunki grzybów okazały się nowymi dla hydromikologii Polski. Spośród stwierdzonych grzybów 28 gatunków znanych jest w piśmiennictwie jako pasożyty względnie nekrotrofy ryb.

Najwięcej gatunków grzybów rozwijało się na martwym narybku węgorza w wodzie rzeki Supraśl oraz jeziora Komosa.

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