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Pallasea quadrispinosa G.O. Sars Specimens as Vectors of Aquatic Zoosporic Fungi Parasiting on Fish

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Abstract

The authors investigated the mycoflora developing on the dead specimens of *Pallasea quadrispinosa* from Lake Hańcza. Water for experiments was collected from four different bodies of water: Hańcza Lake, Wigry Lake, Supraśl River and Fosa Pond. A total of 41 zoosporic fungus species were found to grow on the dead of *Pallasea quadrispinosa* specimens, including 17 species inducing mycosis in a number of freshwater fish species: *Achlya debaryana, A. diffusa, A. dubia, A. klebsiana, A. orion, A. polyandra, A. prolifera, A. proliferoides, Aphanomyces laevis, Dictyuchus monosporus, Leptolegnia caudata, Saprolegnia delica, S. ferax, S. hypogyna, S monoica, S. parasitica* and *Thraustotheca clavata*. *Aphanomyces astaci* as a parasite of noble crayfish, causing the so called crayfish plague, was also observed on *Pallasea quadrispinosa*.

Keywords: zoosporic fungi, *Pallasea quadrispinosa*, mycoflora, Lake Hańcza, chemical analysis, fish pathogens, mycotic diseases, aquatic invertebrates, fish bred, losses in fish-farms

Introduction

It was still in the first half of the 19th century that certain aquatic fungus species were found to parasite on freshwater fish [1]. Stirling [2] described fungus-induced mass death of salmons reaching British rivers for spawning. Nowadays, mass losses are reported in aquacultures [3]. In Russia, in the hatcheries of acipenserid fish in the Volga river-mouth, 80% egg losses are sometimes noted [4]. In India, even a total loss is noted of the eggs of *Tor tor*, a farm-bred species [5]. On salmonid fish farms, on the Pacific in Japan, the losses may reach 50% [6]. The fungi of the genus *Achlya* and *Saprolegnia* are mainly involved in these mycoses [7, 8]. As shown in our studies [9, 10, 11, 12, 13, 14, 15], some aquatic invertebrates serve as vectors of these fungi for a number of fish species.

We decided to determine which fungus species, being fish parasites, are found to grow on *Pallasea quadrispinosa*, a crustacean that serves as food for benthos fish, especially whitefish and lake trout [16, 17, 18, 19, 20]. Therefore, for certain fungus species, being fish parasites, *Pallasea quadrispinosa* specimens are vectors for benthosophagous fish.

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Material and Methods

Pallasea quadrispinosa G. O. Sars representatives were collected for the experiment in the summer of 2002 from Lake Hańcza in the Suwałki Region.

The water for the experiments was collected from four different bodies of water: lakes Hańcza and Wigry, Supraśl River and Fosa Pond. Nineteen parameters of these water samples were determinated (Table l) according to the generally accepted methods [21].

The following procedure was followed while determining the presence of aquatic fungus species on the fragments of crustaceans. The crustacean fragments (20-30) were transferred to thirty 1.0 dm^{-3} vessels (altogether 12 vessels) and placed in the laboratortory at the temperature approaching that of respective body of water. The subsamples from each vessel were observed under a microscope and the presence of mycelium (forming zoo-

Table 1. Chemical composition (in mg l^{-1}) of water from the different sites (mean from 3 samples).

Specification	Water bodies			
	Hańcza Lake	Wigry Lake	Supraśl River	Fosa Pond
Temperature (°C)	23.5	22.8	21.4	20.8
pH	7.25	8.2	7.21	7.04
O_2	12.6	9.8	12.8	5.5
BOD_5	3.0	4.2	5.2	7.04
COD (Oxidability)	6.3	13.3	16.4	19.06
CO_2	4.4	6.6	19.2	13.4
Alkalinity in $CaCO_3$ (mval l^{-1})	2.7	4.3	4.2	4.1
$N\text{-}NH_3$	0.14	0.230	0.210	0.650
$N\text{-}NO_2$	0.001	0.006	0.009	0.015
$N\text{-}NO_3$	0.020	0.021	0.018	0.082
$P\text{-}PO_4$	0.011	0.250	0.460	2.850
Sulphates	15.22	25.095	62.0	84.27
Chlorides	18.0	23.0	40.0	45.2
Total hardness in Ca	35.28	59.04	87.84	74.2
Total hardness in Mg	7.74	15.91	20.62	52.3
Fe (total)	0.15	0.30	0.40	0.50
Dry residue	102.0	208.0	190.0	356.0
Dissolved solids	77.0	179.0	120.0	325.0
Suspended solids	25.0	29.0	70.0	31.0

spores, antheridia and oogonia) of aquatic fungi growing on fragments of crustaceans was recorded. The methods were described in detail by Seymour and Fuller [22]. The samples of were fragments of crustacean were examined for one (or one and a half) week. The experiments were carried out for three weeks.

The fungi were identified using the following keys: Johnson [23], Sparrow [24], Seymour [25], Batko [26], Dick [27], and Watanabe [28].

Results

As shown by chemical analysis of the water samples used for the experiment, especially such parameters as oxidability and total content of nitrogen and phosphates, the water in Fosa Pond was the most eutrophic, while in Hańcza Lake was oligotrophic. Moreover, Fosa had the highest levels of sulphates and chlorides (Table 1).

Forty-one zoosporic fungus species were found on dead specimens of *Pallasea quadrispinosa* altogether, including 16 in Hańcza, 21 in Wigry, 17 in the Supraśl and 13 in Fosa (Table 2, Fig. 1). Worth note is the finding of *Aphanomyces astaci* on the *Pallasea quadrispinosa* specimens in Hańcza and Wigry. Moreover, *Karlingia spinosa* was observed in Wigry. Of the 42 fungus species found on *Pallasea quadrispinosa* specimens, 17 species induce mycosis in a number of freshwater fish species.

Discussion

As revealed in the present study, the smallest number of zoosporic fungus species were found to grow on *Pallasea quadrispinosa* specimens in Fosa, in which the water was the most eutrophic of all the remaining reservoirs. We observed this phenomenon while investigating the number of fungus species growing on both zooplankton [13,14] and other benthos crustaceans [11,29]. The fungi, which are not fish parasites but were found on the substrate examined, included *Karlingia spinosa*, *Aphanomyces astaci*, *Saprolegnia furcata* and two species of the genus *Olpidiopsis*, such as *Olpidiopsis achlyae* and *Olpidiopsis aphanomyci*s. *Karlingia spinosa* was first described from soil samples from Brazil [30] as a plant saprophyte and thus in the literature of the subject [26] this species is described as leading a saprophytic life on vegetable remnants, in soil and in water. *Aphanomyces astaci* was observed on *Pallasea quadrispinosa* specimens only in lakes Hańcza and Wigry. It was described by Schikora [31] as a parasite of noble crayfish causing the so-called

Table 2. Zoosporic fungi found on the studied specimens of *Pallasea quadrispinosa*.

Taxa	Hańcza Lake	Wigry Lake	Fosa Pond	Supraśl River
Chytridiales				
Karlingia chitinophila Karling	x	x		
Karlingia spinosa Karling		x		
Rhizophydium keratinophilum Karling				x
Blastocladiales				
Catenaria anguillulae Sorokin		x		
Saprolegniales				
**Achlya debaryana* Humphrey		x		
**Achlya diffusa* Harvey ex Johnson			x	
**Achlya dubia* Coker		x		
**Achlya klebsiana* Pieters		x	x	
**Achlya orion* Coker and Couch			x	
**Achlya polyandra* Hildebrand				x
**Achlya prolifera* Nees	x			
**Achlya proliferoides* Coker			x	x
Achlya treleaseana (Richter) Johannes				x
Aphanomyces astaci Schikora	x	x		
Aphanomyces irregularis Scott				x
**Aphanomyces laevis* de Bary	x	x		x
Aplanes androgynus (Archer) Humphrey		x		
Apodachlya pyrifera Zopf	x			
**Dictyuchus monosporus* Leitgeb	x	x		x
**Leptolegnia caudata* de Bary				x
Protoachlya paradoxa (Coker) Coker			x	
Protoachlya polyspora (Lindstedt) Apinis			x	
Saprolegnia anisospora de Bary	x	x	x	x
**Saprolegnia delica* Coker				x
**Saprolegnia ferax* (Gruith.) Thuret	x	x	x	x
Saprolegnia furcata Maurizio			x	
Saprolegnia glomerata (Tiesenh.) Lund	x	x		x
**Saprolegnia hypogyna* (Pringsheim) de Bary	x			
Saprolegnia latvica Apinis		x		
**Saprolegnia monoica* Pringsheim	x	x		
**Saprolegnia parasitica* Coker	x	x	x	x
Saprolegnia unispora (Coker et Couch) Seymour				x
**Thraustotheca clavata* (de Bary) Humphrey		x	x	
Lagenidiales				
Olpidiopsis achlyae McLarty		x		
Olpidiopsis aphanomyces Cornu		x		
Olpidiopsis saprolegniae (Braun) Cornu	x	x		

Table 2. continues on next page...

Olpidiopsis varians Shanor	x			
Peronosporales				
Pythium aquatile Höhnk	x			x
Pythium debaryanum Hesse	x	x	x	x
Pythium rostratum Butler				x
Entomophthorales				
Zoophthora rhizospora (Thaxter) Batko			x	
Total number	16	21	13	17

*species known as parasites or necrotrophs of fishes

crayfish plague, responible for mass crayfish death [32]. We observed this fungus on dead specimens of plankton and benthos crustaceans [13, 14, 29], on fragments of aquatic insects [10] and recently on the carapace of the common tick [33]. *Saprolegnia furcata* was described at the end of the 19th century [34] as a saprophyte found on peatbogs and in wet soil. It is a rare species, living mainly in such European countries as Germany, former Czechoslovakia and England [25]. In our study, it was found on *Pallasea quadrispinosa* in the most eutrophic reservoir – Fosa Pond. However, the two species of the genus *Olpidiopsis* are parasites of other aquatic fungi. *Olpidiopsis achlyae* parasites on the species of the genus *Achlya*, while *Olpidiopsis aphanomycis* on the mycelium of *Aphanomyces* [26].

Of the 17 species being fish parasites found on *Pallasea quadrispinosa* specimens, 13 species induce mycotic diseases and cause great losses. *Achlya debaryana* and *Achlya diffusa* causing fish diseases at various latitudes has a particular role here [7]. *Achlya debaryana* and *Achlya dubia* frequently occurs on fish bred in ponds [35, 36]. *Achlya orion* is responsible for great losses in fish farms on the subcontinent of India. *Achlya polyandra* is frequently active on coregonid fish in Lake Sevan in

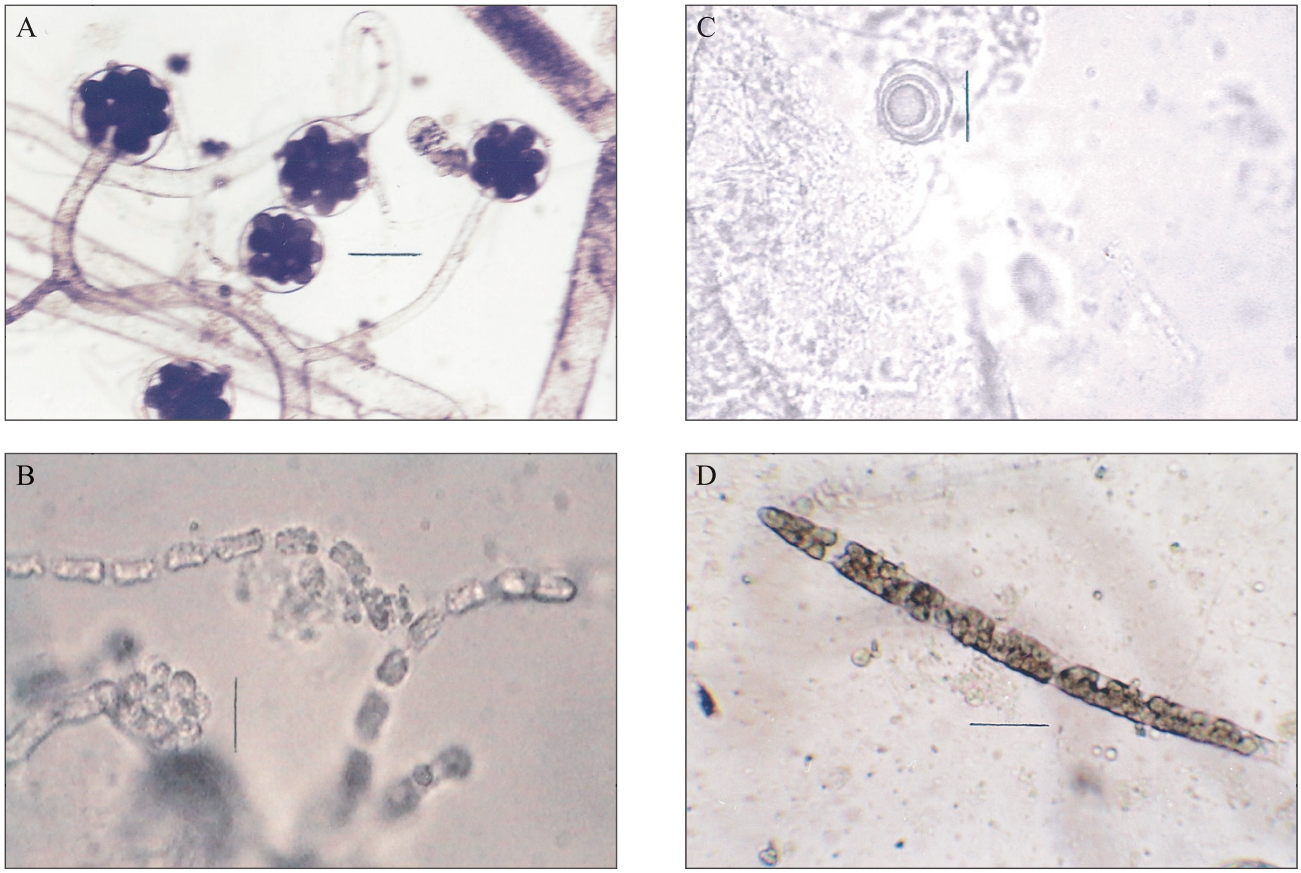

Fig. 1. Some zoosporic fungus species growing on the specimens of *Pallasea quadrispinosa*. Scale bar = 50 µm. A - *Achlya polyandra* - - oogonia, B - *Aphanomyces astaci* - sporangium, C - *Aphanomyces irregularis* - oogonium, D - *Dictyuchus monosporus* - sporangium.

Armenia [37], while such species as *Achlya prolifera* and *Achlya proliferoides* are known from fish farms in India [5,38]. Worth special note is the occurrence of *Aphanomyces laevis* on *Pallasea quadrispinosa* specimens, known as fish pathogen in ponds [39], and first of all in hatcheries [4]. *Leptolegnia caudata* quite frequently occurs on the eggs of acipenserid fish in Russia [40]. Fish death at various latitudes is frequently caused by such representatives of the genus *Saprolegnia* as *Saprolegnia delica* [41], *Saprolegnia ferax* [4, 42], *Saprolegnia hypogyna* [43], *Saprolegnia monoica* [37] and mainly *Saprolegnia parasitica* [6]. Since the 1860s, *Thraustotheca clavata* has been frequently observed on various continents [7, 40, 44].

All these fish-parasite fungus species have been encountered on the eggs of coregonid and other various fish species living in Polish waters [45, 46, 47].

In conclusion, the relict crustacean *Pallasea quadrispinosa* found in larger and deep lakes in Pomerania, Warmia, Mazury and in the Suwałki Region [48], is a good substrate for the growth of aquatic zoosporic fungi, especially for 17 species of fish parasites. This crustacean serving as food for benthos fishes, especially for whitefish and lake trout, is a vector of these fungi, which are fish parasites, in aquatic reservoirs.

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