

## ZOOSPORIC FUNGI GROWING ON DEAD DRAGONFLIES (ODONATA)

Bazyli Czczuga, Anna Godlewska & Edyta Mrozek

Department of General Biology, Medical University, Kilinskiego 1,  
15-230 Białystok 8, Poland.

(e-mail: Dzia/Nau@AMB.AC.Bialystok.PL)

Received 8 July 1999, revised 8 September 1999, accepted 24 September 1999.

Key words: Odonata, dragonfly, zoosporic fungi, Poland.

### Abstract

The mycoflora developing on dead specimens of 11 species of dragonfly, collected while floating on the water surface, was investigated under laboratory conditions. Sixty-six zoosporic fungus species were found to grow on the fragments of dragonfly investigated, including 15 Chytridiomycetes and 51 Oomycetes. Of these 66 species, 18 are known as parasites or necrotrophs of fish. Three fungus species were recorded for the first time from Poland.

### Introduction

While studying chitinophilic aquatic fungus species we paid attention to the presence of already known species in different water basins (Czczuga & Godlewska, 1994), finding also some new species (Czczuga & Godlewska, 1998). We made a list of fungi growing on the carapaces of dead zooplankton (Czczuga et al., 1999) and on four higher crayfish species inhabiting Polish waters, particularly *Aphanomyces astaci* Schikora that causes crayfish plague (Czczuga et al., 1998b).

The larvae of Odonata live in various types of water bodies with which their adults are closely associated. Because literature on the subject included only two fungus species growing on Odonata (Sparrow, 1960; Batko, 1975), we decided to examine fragments of adults of various odonate species.

### Material and Methods

Specimens of the following 11 dragonfly species (females and males) were collected from northeastern Poland: *Aeshna cyanea* (Müll.), *A. grandis* (L.), *A. juncea* (L.), *A. mixta* Latr., *Calopteryx virgo* (L.), *Coenagrion puella* (L.), *Cordulia aenea* (L.), *Somatochlora metallica* (Vand.), *Sympetrum flaveolum* L., *S. sanguineum* (Müll.) and *S. vulgatum* (L.). Dragonflies were collected while floating on the water surface; they were then killed by decapitation and experimental observations began the next day.

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

- (I) Spring Cypisek (limnokrenic type; width 0.41 m, depth 0.17 m, discharge 0.6 l/s) is in the southern part of Knyszynska Forest.
- (II) River Suprasl (length 106.6 km) is the right-bank tributary of the middle part of the Narew River, flowing through the Knyszynska Forest.
- (III) Pond Akcent (0.45 ha, max. depth 1.50 m) contains wild ducks and breeding swans.
- (IV) Pond Fosa (2.5 ha, max. depth 1.75 m) is in the Palace Park, and contains wild ducks and breeding swans, as well as crucian carp and tench bred for anglers.
- (V) Lake Komosa (12.1 ha, max. depth 2.25 m) is surrounded by the extensive coniferous woods of Knyszynska Forest.

Locations of these water bodies are as follows: I, III and IV, 53°21'N, 22°43'E; II and V, 53°35'N, 22°52'E.

Nineteen parameters of these water samples were determined (Table 1) according to the methods of Golterman & Clymo (1969).

To determine the presence of aquatic fungi on the dragonflies, the following procedure was employed: 10-15 small fragments of each species of dragonfly were transferred to each of two samples for each water basin in a 1-litre vessel (altogether ten vessels for each species) and placed in a glass tank (50 x 75 x 75 cm) at ambient temperature in the laboratory. Some pieces of dragonflies from each vessel were observed under a microscope and the mycelium (zoosporic and oogonia and for *Saprolegnia parasitica* secondary cysts) of aquatic fungi growing on the dragonflies was recorded. The methods are described in detail by Smith et al. (1985) and Fuller & Jaworski (1986). The pieces of the various dragonfly species were observed under a microscope once a week, and each experiment lasted three weeks. To identify the fungi, keys by Johnson (1956), Seymour (1970), Batko (1975), Karling (1977) and Dick (1990) were used. The authorities for the scientific names of fungi found on dragonflies are listed in Table 2.

## Results

Chemical analysis of water showed differences in the content of certain biogenic elements (Table 1). The Spring Cypisek water contained the smallest number of these elements, the largest number being found in Pond Akcent. In the water collected for analysis from five chemically different water bodies, 66 zoosporic fungus species belonging to two classes were found on fragments of 11 dragonfly species. Fifteen species belonged to the class Chytridiomycetes and the remaining 51 to the Oomycetes. Certain fungus species were found on single dragonfly species, whereas fungi such as *Achlya klebsiana*, *A. polyandra*, *A. proliferoides*, *Aphanomyces irregularis*, *A. stellatus*, *Pythium butleri*, *P. debaryanum*, *P. rostratum*, *Saprolegnia anisospora*, *S. ferax*, *S. glomerata* and *S. uliginosa* were observed on all 11 dragonfly species. Fungi such as *Aphanomyces helicoides*, *Pythium periplocum* and *S. uliginosa* appeared new to Polish hydromycology. Most fungus species were found to grow on the dragonfly *Aeshna cyanea* (43 species), and the fewest on *Coenagrion puella* and *Calopteryx virgo* (Table 2). Most aquatic fungus species were found on dragonflies in Spring Cypisek (61), and the fewest in Pond Fosa (35). The water

Table 1. Chemical composition (in mg l<sup>-1</sup>) of the different water samples (s - spring, sr - summer, a - autumn, w - winter).

Variable	Cypisek Spring				River Suprasl				Fosa Pond				Pond Akcent				Lake Komosa			
	s	sr	a	w	s	sr	a	w	s	sr	a	w	s	sr	a	w	s	sr	a	w
Temperature °C	9.2	12.8	11.0	7.0	3.0	18.0	6.5	0.5	1.0	1.7	9.0	0.1	2.0	17.5	9.7	3.0	4.8	16.8	6.3	0.3
pH	6.85	6.63	7.00	7.09	6.73	6.27	7.09	7.21	6.63	7.68	7.11	6.94	6.93	6.55	7.41	6.96	6.39	6.74	7.16	7.08
O <sub>2</sub>	12.34	13.12	12.60	14.27	12.24	14.15	10.81	13.08	7.28	5.32	5.00	6.56	5.12	4.18	3.10	2.06	12.25	11.60	13.64	12.30
BOD (Biochemical Oxygen Demand)	6.92	7.14	8.05	6.08	11.16	10.20	12.05	9.04	13.86	15.06	16.02	17.24	16.12	17.02	18.12	15.04	9.25	10.12	9.10	8.14
CO <sub>2</sub>	8.80	15.40	24.20	15.40	8.80	15.40	8.80	8.80	4.40	8.80	17.60	28.60	11.00	24.20	28.60	17.60	2.20	11.00	17.60	8.80
Alkalinity in CaCO <sub>3</sub> (mval l <sup>-1</sup> )	5.1	5.8	5.7	5.2	3.6	4.5	4.3	4.1	5.0	3.7	5.1	6.7	6.4	7.2	7.0	3.9	3.3	4.7	4.5	3.9
N-NH <sub>3</sub>	0.022	0.020	0.051	0.052	0.265	0.420	0.250	0.125	0.380	0.515	0.535	0.685	0.380	3.025	4.290	5.500	0.350	0.380	0.250	0.310
N-NO <sub>2</sub>	0.008	0.008	0.006	0.015	0.012	0.011	0.011	0.011	0.004	0.011	0.006	0.012	0.030	0.014	0.008	0.124	0.012	0.010	0.003	0.009
N-NO <sub>3</sub>	0.236	0.700	0.480	0.050	0.070	0.340	0.104	0.030	0.050	0.090	0.030	0.050	0.090	0.090	0.050	0.110	0.050	0.070	0.140	0.020
PO <sub>4</sub>	0.600	0.800	0.130	0.290	0.750	0.100	0.170	0.800	0.135	0.215	0.120	3.400	0.215	11.800	2.700	11.800	0.230	0.900	0.045	0.500
Cl	20	24	30	23	29	18	32	14	52	52	46	48	37	44	46	44	24	19	25	17
Total hardness in Ca	121.68	125.28	131.04	118.08	76.32	71.28	72.00	66.24	88.56	57.60	67.68	97.20	140.40	133.20	136.80	70.56	72.00	72.00	77.76	72.00
Total hardn. ss in Mg	18.92	20.21	26.66	17.20	9.89	12.90	20.64	10.32	32.25	22.36	24.08	20.64	26.23	21.93	27.52	14.62	15.48	13.33	17.63	10.32
SO <sub>4</sub>	58.83	57.18	63.77	49.78	12.75	21.39	22.21	23.04	31.27	49.37	39.49	37.44	83.51	95.03	85.98	64.59	37.43	31.68	41.96	42.78
Fe	0.50	0.30	0.00	0.48	0.80	0.73	0.45	0.68	0.75	0.50	0.45	0.68	1.20	0.48	0.50	0.68	0.75	0.85	0.30	0.48
Dry residue	525	572	520	321	273	305	305	366	430	605	325	546	605	636	520	382	280	240	363	262
Dissolved solids	505	532	479	303	254	295	265	283	429	470	304	472	555	629	477	377	263	191	270	230
Suspended solids	18	40	41	18	19	10	40	83	1	135	21	74	50	7	43	5	17	49	93	32





Table 2. Continued.

Taxa	Species of dragonfly (initials of species name; see Material and Methods)											
	A.c.	A.g.	A.j.	A.m.	C.p.	C.v.	C.a.	S.m.	S.f.	S.s.	S.v.	
Oomycetes												
* <i>Leptolegnia caudata</i> de Bary					+	+	+		+			+
* <i>Saprolegnia parasitica</i> Coker		+		+	+	+	+	+				+
<i>Saprolegnia torulosa</i> de Bary	+	+	+	+	+	+			+			+
<i>Saprolegnia uliginosa</i> Johannes	+	+	+	+	+	+	+	+	+			+
* <i>Traustothecca clavata</i> (de Bary) Humphrey												+
Total number of species	43	35	33	34	29	29	30	33	35	38		39

\* Known in literature as parasites or necrotrophs of fish.

of Spring Cypisek, Pond Fosa, Pond Akcent and River Suprasl contained the largest number of fungi in spring months, and the water of Lake Komosa in summer (Table 3). The smallest number of fungi grew on dragonflies in summer in Spring Cypisek, Pond Akcent and River Suprasl, and in winter in Pond Fosa and Lake Komosa.

## Discussion

Species of Chytridiomycetes were found only on dragonfly wings, whereas Oomycetes were found mainly on the thorax, abdomen and limbs.

The mycoflora found to grow on fragments of dragonflies included 3 fungus species new to Polish waters. One of them - *Aphanomyces helicoides* - was first described from German waters by Minden (1916). We found it only on *Aeshna mixta* in autumn in Spring Cypisek and River Suprasl. *Pythium periplocum*, known as a saprophyte, was described by Drechsler (1930) from fallen fruits of *Citrullus vulgaris* Schraed; Balakrishnan (1948) isolated it, as var. *coimbatorensis*, from vegetable debris in water near Coimbatore in India. In our study this fungus was found on all three species of *Sympetrum* only in summer in Pond Fosa. The third species new to Polish waters - *Saprolegnia uliginosa* - was first described by Johannes (1950) from bogs near Hanover. Later it was reported by Shibuya (1959) from the Sanshiro Pond in the vicinity of Tokyo University. In our study, *Saprolegnia uliginosa* was observed on all 11 dragonfly species and in the water of all five water bodies. It was found on dragonflies in all seasons except winter.

The fragments of dragonflies examined were inhabited by a number of fungus species which frequently cause significant losses in fish farming, including *Achlya flagellata*, *A. polyandra*, *Aphanomyces laevis*, *Leptolegnia caudata*, *Pythium proliferum*, *Saprolegnia ferax*, *S. monoica* and *S. parasitica*. Several years ago on a fish farm in England more than half of the *Salmo trutta* L. population died of saprolegniosis (Ferguson & Ride, 1980).

*Achlya flagellata* infects the eggs of many fish species (Florinskaya, 1971; Sati & Khulbe, 1981), and *A. polyandra* infects the eggs of salmonid fishes (Osipian et al., 1988). *Aphanomyces laevis* frequently attacks acipenserid fishes (Lartzeva, 1986). Likewise, *Leptolegnia caudata* occurs on acipenserid eggs (Dudka et al., 1989). *Pythium proliferum* is encountered on both eggs and adults of various fish species (Florinskaya, 1969; Czczuga, 1996). Fungi of the genus *Pythium* are frequently found on fish; however, because of the difficulty of determining species of *Pythium*, only the generic name is used (Scott & O'Bier, 1962; Stuart & Fuller, 1968; Shah et al., 1977). Our detailed studies demonstrated that several species of *Pythium* inhabited the eggs of various species of freshwater fish (Czczuga, 1996). Three species of *Saprolegnia* known as fish parasites (Neish & Hughes, 1980) were found on the fragments of dragonflies. *Saprolegnia monoica* occurs on eggs of salmonids (Florinskaya, 1971; Osipian et al., 1988), coregonides (Czczuga & Muszynska, 1998) and other fishes (Czczuga & Muszynska, 1999). However, the major losses in fish farms are due to the other two species: *Saprolegnia ferax* and *S. parasitica* (Chien 1981; Frick & Reinhold, 1987; Dudka et al., 1989). *Saprolegnia ferax*, together with other fungi,

Table 3. Aquatic fungi found on dragonflies.

Taxa	Water from:				
	Spring Cypisek	River Suprasl	Pond Fosa	Pond Akcent	Lake Komosa
<b>Chytridiomycetes</b>					
<i>Asterophlyctis irregularis</i>		s,sr	w,sr		
<i>Blastocladiella britannica</i>	a				
<i>Catenophlyctis variabilis</i>		a			
<i>Chytriomycetes aureus</i>	s,sr			a,w	s,sr
<i>Chytriomycetes hyalinus</i>	a,w		a,w	a,s	a,w
<i>Karlingia chitinophila</i>	a,w,s	a,w,s	w,s,sr	a,w	a
<i>Phlyctochytrium aureliae</i>	sr		sr	a	sr
<i>Phlyctorhiza endogena</i>	a,w	sr	a,w,s	w	
<i>Podochytrium chitinophilum</i>	s	w			
<i>Polychytrium aggregatum</i>	a	a	sr		
<i>Rhizidiomycetes bivellatus</i>				s	
<i>Rhizidium chitinophilum</i>	s	a,w,sr	s	s	a
<i>Rhizidium nowakowski</i>	s	s		s	
<i>Rhizidium petersenii</i>	a,s		sr	sr	
<i>Siphonaria variabilis</i>		s			
<b>Oomycetes</b>					
* <i>Achlya caroliniana</i>	w,s	a,w	s		
<i>Achlya colorata</i>	w	s			
<i>Achlya debaryana</i>	s,sr	w,s	s	s	sr
* <i>Achlya diffusa</i>	a	w			
* <i>Achlya flagellata</i>	w		a		
* <i>Achlya klebsiana</i>	a,w,s,sr	a,w,s,sr	a,w,sr	w	a,w,s,sr
* <i>Achlya orion</i>	w	a,w,s	s	w	a
<i>Achlya polyandra</i>	w	a,w,s,sr	a,s	s	a,w,s
* <i>Achlya proliferoides</i>	a,w,s,sr	a,s			a,w,sr
* <i>Achlya racemosa</i>	a				
<i>Achlya treleaseana</i>	w	sr			
<i>Aphanomyces amphigynus</i>	s,sr				sr
<i>Aphanomyces helicoides</i>	a	a			
<i>Aphanomyces irregularis</i>	a,w,s,sr	a,w,s,sr	a,w,s,sr	a,w,s,sr	a,w,s,sr
* <i>Aphanomyces laevis</i>	a	a,sr	a,s	w,s	a,w,s,sr
* <i>Aphanomyces stellatus</i>	a,w,s	a,w,s	a,s,sr	a,w,s	a,w,s,sr
<i>Apodachlya pyriferia</i>	s	sr			sr
<i>Cladolegnia unisporea</i>	s,sr	s,sr	sr	w	w
<i>Pythium oligandrum</i>			sr		
<i>Pythium periplocum</i>			sr		



Table 3. Continued.

Taxa	Water from:				
	Spring Cypisek	River Suprasl	Pond Fosa	Pond Akcent	Lake Komosa
Oomycetes					
* <i>Pythium proliferum</i>				a	
<i>Pythium pulchrum</i>				sr	sr
<i>Pythium rostratum</i>	a,w	w	w	w	w
* <i>Pythium ultimum</i>			sr	s	sr
<i>Saprolegnia anisospora</i>	a,w,s,SR	sr	a,w,s,SR		a,s
<i>Saprolegnia asterophora</i>	w	w,s		w,s	w,SR
* <i>Saprolegnia delica</i>	sr	a,s		s	s
* <i>Saprolegnia ferax</i>	a,w,s,SR	a,w,s,SR	a,w,SR	a	a,w,s,SR
<i>Saprolegnia furcata</i>		a			
<i>Saprolegnia glomerata</i>	w,s,SR	w,SR	a,w,s,SR	w,s,SR	
<i>Saprolegnia latvica</i>	sr	a,s	a		a,w,s
<i>Saprolegnia litoralis</i>	a				sr
* <i>Saprolegnia monoica</i>	w,s	a,s			w
* <i>Saprolegnia parasitica</i>	a,w,SR	w		s	w,s,SR
<i>Saprolegnia torulosa</i>	a,s	a,w,s	a	a,s	a,s
<i>Saprolegnia uliginosa</i>	a,s,SR	a,s,SR	s	s	a,s,SR
* <i>Traustotheca clavata</i>					s
Total number of species	a - 27 61: w - 26 s - 29 sr - 20	a - 26 46: w - 20 s - 27 sr - 19	a - 16 35: w - 13 s - 18 sr - 17	a - 12 37: w - 18 s - 20 sr - 8	a - 19 38: w - 16 s - 20 sr - 23

\* Known in literature as parasites or necrotrophs of fish.

causes death in acipenserid fish hatcheries, where losses in incubated eggs can reach 70% (Lartzeva & Dudka, 1990). Many cases of saprolegniosis caused by *Saprolegnia ferax* are known (Neish & Hughes, 1980; Dudka et al., 1989). Destructive actions of *Saprolegnia parasitica* were reported from fish farms in Miyagi Prefecture, where in 1987 alone about 30-50% of the salmonid *Oncorhynchus kisutch* (Walbaum) died (Hatai & Hoshiai, 1992). Apart from *Saprolegnia ferax*, *S. parasitica* is the commonest fungus found in saprolegniosis-induced fish death and growing on the spawn of certain amphibians (Czeczuga et al., 1998a).

The present study indicates that dragonflies are a substrate for a number of zoosporic fungus species which lead a parasitic or necrophitic mode of life on fish. Thus dragonfly habitats are foci for fungi parasitizing fish.

## Acknowledgements

We thank the anonymous referee for helpful comments on the manuscript.

## References

- Balakrishnan, M.S., 1948. South Indian Phycomycetes. 2. Some little-known species of *Pythium* occurring in South India. Proceedings of the Indian Academy of Sciences 28B: 27-34.
- Batko, A., 1975. Zarys hydromikologii [Hydromycology - an overview]. PWN, Warszawa, [In Polish.]
- Chien Chiu Yuan, 1981. Observations on the growth and morphology of Saprolegniaceous fungi isolated from rainbow trout (*Salmo gairdneri*). Fish Pathology 15: 241-247.
- Czczuga, B., 1996. Species of *Pythium* isolated from eggs of fresh-water fish. Acta Mycologica 31: 151-161.
- Czczuga, B. & A. Godlewska, 1994. Aquatic fungi growing on substrates containing chitin. Acta Mycologica 29: 189-200.
- Czczuga, B. & A. Godlewska, 1998. Chitinophilic zoosporic fungi in various types of water bodies. Acta Mycologica 33: 43-58.
- Czczuga, B. & E. Muszynska, 1998. Aquatic fungi growing on coregonid fish eggs. Acta Hydrobiologica 40: 239-264.
- Czczuga, B. & E. Muszynska, 1999. Aquatic fungi growing on percid fish eggs (Percidae) in Poland. Polish Journal of Environmental Studies 8: 31-34.
- Czczuga B., A. Godlewska & A. Krzeminska, 1998a. Aquatic fungi growing on the spawn of certain amphibians. Amphibia - Reptilia 19: 239-251.
- Czczuga, B., E. Muszynska & A. Godlewska, 1998b. Aquatic fungi on certain species of crayfish in water from different water bodies. Polish Journal of Environmental Studies 7: 75-82.
- Czczuga, B., A. Godlewska & M. Kozłowska, 1999. Zoosporic fungi growing on the carapace of dead zooplankton organisms. Limnologia 29: (in press).
- Dick, M.W., 1990. Keys to *Pythium*. College of Estate Management, Whiteknights, Reading, U.K. 64 pp.
- Drechsler, C., 1930. Some new species of *Pythium*. Journal of Washington Academy of Sciences 20: 398-418.
- Dudka, I.A., N.M. Isayeva & O.N. Davydov, 1989. Saprolegniaceae inducing fish mycosis. Mycology and Phytopathology 23: 488-498
- Ferguson, H.W. & D.W. Ride, 1980. Post-spawning mortalities in brown trout *Salmo trutta* L. Journal of Fish Diseases 3: 153-160.
- Florinskaya, A.A., 1969. Data on the species composition and ecology of moulds-agents of fish saprolegniosis in Leningrad district. Izvestia Gosudarstvennogo NIORCH 69: 103-123.
- Florinskaya, A.A., 1971. On finding *Saprolegnia* on eggs and fishes during artificial cultivation in the region of Leningrad. Trudy Wsesojuznogo nauczno - issledowatelskogo Instituta prудowogo rybno go choziajstwa 18: 222-226.
- Frick, W. von & H. Reinhold, 1987. Nachweis und Epizootologie fischpathogener *Saprolegnia* - Arten in Forellenzuchtanlagen. Monatsheft Veterinär-Medizin 42: 712-716.
- Fuller, M.S. & J. Jaworski, 1986. Zoosporic Fungi in Teaching and Research. Southeastern Publishing Corporation, Athens, Georgia.
- Golterman, H.L. & R.S. Clymo, 1969. Methods for Chemical Analysis of Fresh Waters. I.B.P. Handbook No 8 Blackwell Scientific Publications, Oxford.

- Hatai, K. & G. Hoshiai, 1992. Mass mortality in cultured coho salmon (*Oncorhynchus kisutch*) due to *Saprolegnia parasitica* Coker. *Journal of Wildlife Diseases* 28: 532-535.
- Johannes, H., 1950. Zwei neue Arten des Saprolegniaceen. *Archiv für Microbiologie* 14: 594-601.
- Johnson, T.W., 1956. The genus *Achlya*: Morphology and Taxonomy. University of Michigan Press, Ann Arbor.
- Karling, J.S., 1977. Chytridiomycetorum Iconographia. An Illustrated and Brief Descriptive Guide to the Chytridiomycetous genera with a supplement of the Hypochytriomycetes. Lubrech and Cramer, Vaduz.
- Lartzeva, L.V., 1986. *Saprolegnia* on the spawn of sturgeons and salmon. *Hydrobiological Journal* 22: 103-107.
- Lartzeva, L.V. & I.A. Dudka, 1990. Dependence of Saprolegniaceae development on the sturgeon and salmon eggs fishproductive quality. *Mycology and Phytopathology* 24: 112-116.
- Minden, M. von, 1916. Beiträge zur Biologie und Systematik einheimischer submerser Phycomyceten. *Falck, Mykologische Untersuchungen und Berichte* 2: 146-255.
- Neish, G.A. & G.C. Hughes, 1980. Diseases of fishes. Book 6: Fungal diseases of fishes. Neptune: T.F.H. Publication, Reigate.
- Osipian, L.L., L.A. Hakobian & G.S. Vardamian, 1988. On the species composition of Oomycetes of the lake Sevan, developing on the fish caviar. *Biological Journal of Armenia* 41: 170.
- Sati, S.S. & R.D. Khulbe, 1981. A new host record for the fungal genus *Achlya*. *Current Science (India)* 50: 313.
- Scott, W.W. & A. H. O'Bier, 1962. Aquatic fungi associated with diseased tropical fish and fish eggs. *Progressive Fish-Culturist* 24: 3-15.
- Seymour, R.L., 1970. The genus *Saprolegnia*. *Nova Hedwigia* 19: 1-124.
- Shah, K.L., B.C. Jha & A.G. Jhingran, 1977. Observations on some aquatic phycomycetes pathogenic to eggs and fry of freshwater fish and prawns. *Aquaculture* 12: 141-147.
- Shibuya, Y. 1959. On some species of Saprolegniaceae found in the Sanshiro Pond in the University of Tokyo. *Journal of Japanese Botany* 34: 146-151.
- Smith, S.N., R.A. Armstrong, J. Springate & G. Barker, 1985. Infestation and colonization of trout eggs by Saprolegniaceae. *Transactions of the British Mycological Society* 85: 719-723.
- Sparrow, F.K., 1960. *Aquatic Phycomycetes*. University Michigan Press, Ann Arbor.
- Stuart, K.L. & H.T. Fuller, 1968. Mycological aspects of diseased Atlantic salmon. *Nature (London)* 217: 90-92.