



**Workshop on the Fungal Aetiology of  
Epizootic Ulcerative Syndrome  
(26th – 30th January 1998)**

**TIMETABLE  
AND  
BIBLIOGRAPHY**

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## Timetable

Mon 26 <sup>th</sup> Jan	08:30	Registration
	09:00	Opening Ceremony Tour of AAHRI
	10:30	Coffee
	11:00	Lecture - EUS and its spread across Asia (SC)
	12:00	Lecture - History of research into causative agents of EUS (JL)
	13:00	Lunch
	14:00	Discussion - Present status of EUS in participant's countries
	15:30	Coffee
	16:00	Discussion - Present status of EUS in participant's countries
Tues 27 <sup>th</sup> Jan	09:00	Lecture - Fungal aetiology of EUS (JL)
	10:30	Coffee
	11:00	Practical - Isolation of <i>Aphanomyces invadans</i> from fish (JL/RC) Maintenance of laboratory cultures of <i>A. invadans</i> (JL/RC)
	12:30	Lunch
	14:00	Practical - Isolation of <i>A. invadans</i> from water (JL/RC)
	15:30	Coffee
	16:00	Practical - Sporulation of Oomycete fungi (JL/RC)
Wed 28 <sup>th</sup> Jan	09:00	Lecture - Identification of <i>A. invadans</i> and other Oomycete fungi (JL)
	10:30	Coffee
	11:00	Practical - Identification of Oomycete fungi (JL/RC)
	12:30	Lunch
	14:00	Lecture - Histopathology of EUS (SC)
	15:30	Coffee
	16:00	Practical - Examination of EUS histology, including slides prepared from samples brought by participants (SC/JL)
Thurs 29 <sup>th</sup> Jan	09:00	Lecture - Control/treatment of EUS (RC)
	10:00	Coffee
	10:30	Practical - Susceptibility of fungi to chemical treatment (RC/JL)
	12:30	Lunch
	14:00	Lecture - Significance of water quality parameters in EUS outbreaks (MP)
	15:30	Coffee
	16:00	Practical - Measuring water quality parameters (MP)
Fri 30 <sup>th</sup> Jan	09:00	Lecture - Aspects of fungal taxonomy (TF)
	10:30	Coffee
	11:00	Discussion - EUS epidemiology and outbreak investigations (JL)
	12:30	Lunch
	14:00	Discussion - Identification of future research priorities (SC/SK/JL/RC/MP)
	15:30	Coffee
	16:00	Practical - Final examination of fungal isolates & treatment assays (JL/RC)
	18:00	Mahruay Hotel - Dinner and certificate presentation

SC – Dr Supranee Chinabut (AAHRI, Bangkok)

JL – Dr Jim Lilley (Institute of Aquaculture, Stirling University, UK)

RC – Dr Ruth Campbell (Institute of Aquaculture, Stirling University, UK)

MP – Dr Michael Phillips (Network of Aquaculture Centres in Asia-Pacific, Bangkok)

TF - Prof Tim Flegel (National Centre for Genetic Engineering & Biotechnology, Bangkok)

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## Lecture summaries

### Monday 26<sup>th</sup>

#### EUS and its spread across Asia (a.m. SC)

Reference: Chapters 1-4 in "EUS Technical Handbook"

The presentation will provide an overview of the main EUS outbreaks during its spread across Asia, the species affected, socio-economic impacts, and aspects of public health. EUS is now known to be the same disease as mycotic granulomatosis (MG) in Japan and redspot disease (RSD) in Australia, and reference to these outbreaks will also be made.

#### History of research into causative agents of EUS (a.m. JL)

References: Chapter 5 in "EUS Technical Handbook"

The main fungal, viral, bacterial and parasitic agents associated with EUS outbreaks will be discussed in the context of the "Causal Web" diagram (Figure 3 of the "EUS Technical Handbook")

### Tuesday 27<sup>th</sup>

#### Fungal aetiology of EUS (a.m. JL)

References: Willoughby's "Fungi & Fish Diseases"

Lilley *et al* (1997) Vet. Rec. 140, 11-12

An introduction to the most important group of fish-pathogenic fungi (family Saprolegniaceae, class Oomycetes) will be given, followed by a review of work on the saprolegniacean species associated with EUS (i.e. *Aphanomyces invadans*).

### Wednesday 28<sup>th</sup>

#### Identification of *A. invadans* and other Oomycete fungi (a.m. JL)

References: Chapter 5 (Fungi) in "EUS Technical Handbook"

Annexes 4-5 in "EUS Technical Handbook"

Willoughby's "Fungi & Fish Diseases"

Oomycete genera are distinguished primarily by their asexual reproductive structures, and fungi are usually identified to the species level on the basis of sexual characters. A short video will be shown highlighting the features of the main saprolegniacean genera (*Aphanomyces*, *Achlya* and *Saprolegnia*). The EUS pathogen (*A. invadans*) does not, however, produce sexual stages in culture and other means of identification will be discussed.

#### Histopathology of EUS (p.m. SC)

References: Chapter 7 in "EUS Technical Handbook"

Chinabut *et al* (1995) J. Fish Dis. 18, 41-47

Viswanath *et al* (1997) J. Aqua. Trop. 12, 35-42

Histological identification of distinctive mycotic granulomas, formed by the growth of *A. invadans* through internal fish tissues, is the primary means of diagnosing EUS. Fungal invasion and its associated pathology will be discussed in terms of fish species affected and temperature of infection.

### Thursday 29<sup>th</sup>

#### Control/treatment of EUS (a.m. RC)

References: Chapter 9 in "EUS technical Handbook"

Ahmed & Rab (1995) J. Fish Dis. 18, 263-271

Lilley & Inglis (1997) Aqua. Res. 28, 461-469

Control of EUS in natural waterways is almost impossible save for prevention of the spread of *A. invadans* to new areas. Strategies for the control of EUS in aquaculture systems include treatment or exclusion of fungal spores in the water, modification of environmental conditions (especially temperature, salinity, acidity),

reduction of stress to the fish, and farming of non-susceptible species. As yet, it is not possible to treat the fungus once it is growing within the fish.

### Significance of water quality parameters in EUS outbreaks (p.m. MP)

Reference: Chapter 6 in "EUS Technical Handbook"

EUS outbreaks tend to occur seasonally, in most countries that is during the cool season and after the monsoon season. This is due to the particular environmental conditions occurring during these times. The main water quality parameters that increase the likelihood of EUS outbreaks are: low temperature, low salinity and low pH. Low temperature is also associated with other saprolegniacean infections of fish (e.g. winter saprolegniosis of channel catfish).

## **Friday 30<sup>th</sup>**

### Aspects of fungal taxonomy (a.m. TF)

An overview of recent developments in protistan and fungal taxonomy is given.

### EUS epidemiology and outbreak investigations (a.m. JL)

References: Chapter 8 in "EUS Technical Handbook"

Annexes 7 in "EUS Technical Handbook"

A wider, epidemiological, view of EUS causation is explained in terms of "component causes", "sufficient causes" and "necessary causes". The outbreak investigation procedure given in the handbook is discussed.

## Practical summaries

### Tuesday 27<sup>th</sup>

#### 1. Isolation of *Aphanomyces invadans* from fish (a.m. JL/RC)

Follow the procedure given in Annex 1 of "EUS Technical Handbook". Any fungus growing on plates will be successively subcultured over the next few days to obtain axenic colonies.

#### 2. Maintenance of laboratory cultures of *A. invadans* (a.m. JL/RC)

Techniques given in Annex 3 of "EUS Technical Handbook" will be demonstrated.

#### 3. Isolation of *A. invadans* from water (p.m. JL/RC)

Follow the procedure given in Annex 2 of "EUS Technical Handbook". Spores will be grown from:

- (i) Fish-challenge tank water (this will simulate water from an active outbreak)
- (ii) Positive control 1: fish-challenge tank water "seeded" with *A. invadans* zoospores
- (iii) Positive control 2: APW "seeded" with *A. invadans* zoospores

#### 4. Sporulation of Oomycete fungi (p.m. JL/RC)

You have seven cultures of saprolegniacean fungi growing in GPY broth (labelled A-G).

- (i) Wash the nutrients out of the fungi as described in Annex 4 "EUS Technical Handbook". This will induce the production of zoosporangia in the fungi overnight. Tomorrow we will identify each culture according to its sporulation characteristics.
- (ii) Also subculture fungi on to GPY agar plates and incubate at 22°C to compare growth rates over the next few days.

### Wednesday 28<sup>th</sup>

#### 5. Identification of Oomycete fungi (a.m. JL/RC)

Identify each culture of saprolegniacean fungus (A-F) under the microscope using features described in Annex 5 of "EUS Technical Handbook" and illustrated in Figures 1-6 of Willoughby's "Fungi & Fish Diseases".

#### 6. Examination of EUS histology, including slides prepared from samples brought by participants (p.m. SC/JL)

Examine slides prepared by the histology unit at AAHRI of any fish samples you have brought to determine whether the fish were suffering from EUS.

### Thursday 29<sup>th</sup>

#### 7. Susceptibility of fungi to chemical treatment (a.m. RC/JL)

You have been given a fungal culture, either *Aphanomyces invadans* or *Saprolegnia* sp. Using a cork borer, transfer agar plugs into each chemical solution in the Replidish. Leave for one hour. After three 10-minute washes in sterile distilled water, dry the plugs on sterile filter paper, and transfer onto maintenance agar. Cultures will be examined for growth inhibition tomorrow.

#### 8. Measuring water quality parameters (p.m. MP/SK)

Use of standard equipment to measure water quality variables will be demonstrated.

## Friday 30<sup>th</sup>

### 9. Final examination of fungal isolates & treatment assays (p.m. JL/RC)

Final examination of:

Putative *A. invadans*. isolates obtained from fish (Prac. 1)

Putative *A. invadans* isolates obtained from water (Prac. 3), calculation of spore densities

Growth of fungal cultures exposed to treatments, compared to controls (Prac. 7)



## Bibliography of fish mycology references

About 650 references pertaining to mycoses of aquatic animals are listed here. The references are divided up according to the main subject of the paper. The first three lists are concerned with fungi associated with EUS/MG/RSD. These are followed by lists of fungal diseases of aquatic animals caused by *Aphanomyces* spp other than *Aphanomyces invadans*. References on the two other main saprolegniacean genera (*Achlya* and *Saprolegnia*) are then followed by other major fungal diseases. Review articles describing a number of different fish fungi are then listed. Where the reference is primarily concerned with a specific aspects of fungal biology, it is listed under one of the final eleven subject titles.

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### Fungi associated with epizootic ulcerative syndrome: EUS (also see MG and RSD)

- Bondad-Reantaso, M. G., Paclibare, J. O., Lumanlan-Mayo, S. C., and Catap, E. S. (1994) EUS outbreak in the Philippines: a country report. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, 25-27 January 1994. Pp.61-67 Aquatic Animal Health Research Institute, Bangkok.
- Callinan, R. B., Chinabut, S., Kanchanakhan, S., Lilley, J. H., and Phillips, M. J. (1997), Epizootic ulcerative syndrome (EUS) of fishes in Pakistan. A report of the findings of a mission to Pakistan. 919 March 1997. Prepared by collaboration between ACIAR, AAHRI, NACA, ODA, NSW-Fisheries and Stirling University.
- Catap, E. S., and Munday, B. L. (1997) Effects of variations of water temperature and dietary lipids on the expression of experimental epizootic ulcerative syndrome in sand whiting, *Sillago ciliata* Cuvier. In: Abstracts of the International Symposium on Diseases in Marine Aquaculture, Hiroshima, Japan, 3-6 October 1997. P. 101 Japanese Society of

Fish Pathology

- Chinabut, S. (1994) Fungi and lesions of EUS. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, 25-27 January 1994. Pp. 226-230 Aquatic Animal Health Research Institute, Bangkok.
- Chinabut, S. (1995) Epizootic ulcerative syndrome: the current state of knowledge. In: Shariff, M., Arthur, J. R., and Subasinghe, R. P. (Eds), Diseases in Asian Aquaculture II Pp. 285-290. Fish Health Section, Asian Fisheries Society, Manila.
- Chinabut, S. (1997) Epizootic ulcerative syndrome: updated information up to 1997. In: Abstracts of the International Symposium on Diseases in Marine Aquaculture, Hiroshima, Japan, 36 October 1997. P. 41 Japanese Society of Fish Pathology
- Chinabut, S., Roberts, R. J., Willoughby, L. G., and Pearson, M. D. (1995) Histopathology of snakehead, *Channa striatus* (Bloch), experimentally infected with the specific *Aphanomyces* fungus associated with epizootic ulcerative syndrome (EUS) at different temperatures. Journal of Fish Diseases 18, 41-47.
- Fraser, G., and Callinan, R. (1996) A technique for enumeration of propagules of the epizootic ulcerative syndrome fungus in pondwater. World Aquaculture 1996 Book of Abstracts, Queen Sirikit National Convention Centre, Bangkok, 29 January - 2 February 1996. P. 131 The World Aquaculture Society
- Kanchanakhan, S. (1996) Epizootic ulcerative syndrome (EUS): a new look at the old story. The AAHRI Newsletter, 5(1), 2-3. Aquatic Animal Health Research Institute, Bangkok.
- Karunasagar, I., Otta, S., and Karunasagar, I. (1994) Mycological aspects of epizootic ulcerative syndrome in India. International Symposium on Aquatic Animal Health, Program and Abstracts, University of California, School of Veterinary Medicine, 4-8 September 1994. P. 42.
- Khan, M. H. (1997). A study of the activity of the head kidney macrophages from rosy barb, *Puntius schwanenfeldi*; rainbow trout, *Oncorhynchus mykiss* and tilapia *Oreochromis niloticus* against *Aphanomyces invaderis* in vivo and in vitro. MSc thesis, University of Stirling, Scotland,
- Kumar, K. C. (1997). Therapeutic application of microalgal and herbal extract in fish disease. MSc thesis, University of Stirling, Scotland, 55 pp.
- Lilley, J. H. (1996) Comparative studies of the EUS *Aphanomyces* and other fungi associated with fish disease. World Aquaculture 1996 Book of Abstracts, Queen Sirikit National Convention Centre, Bangkok, 29 January - 2 February 1996. Pp. 226-227 The World Aquaculture Society
- Lilley, J. H. (1997). Studies on the comparative biology of *Aphanomyces invadans*. PhD thesis, University of Stirling, Scotland. 228 pp.
- Lilley, J. H. and Inglis, V. (1997) Comparative effects of various antibiotics, fungicides and disinfectants on *Aphanomyces invaderis* and other saprolegniceous fungi. Aquaculture Research 28(6), 461-469.
- Lilley, J. H. and Roberts, R. J. (1997) Pathogenicity and culture studies comparing the *Aphanomyces* involved in epizootic ulcerative syndrome (EUS) with other similar fungi. Journal of Fish Diseases 20, 135-144.
- Lilley, J. H., Hart, D., Richards, R. H., Roberts, R. J., Cerenius L., and Söderhäll, K. (1997) Pan-Asian spread of single fungal clone results in large scale fish-kills. Veterinary Record 140, 11-12.
- Lilley, J. H., Phillips, M. J., and Tonguthai, K (1992) A review of epizootic ulcerative syndrome (EUS) in Asia, Aquatic Animal Health Research Institute and Network of Aquaculture Centres in Asia-Pacific, Bangkok.
- Lilley, J. H., Thompson, K. D., and Adams, A. (1997) Characterization of *Aphanomyces invadans* by electrophoretic and Western blot analysis. Diseases of Aquatic Organisms 30(3), 187-197.
- Millar, S. D. (1994) Joint viral/fungal induction of EUS in snakeheads. Bacterial findings of an EUS survey in Bangladesh. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, 25-27 January 1994. Pp. 272-278 Aquatic Animal Health Research Institute, Bangkok.
- Mohan, C. V. and Shankar, K. M. (1995) Role of fungus in epizootic ulcerative syndrome of fresh- and brackishwater fishes of India: a histopathological assessment. In: Shariff, M., Arthur, J. R., and Subasinghe, R. P. (Eds), Diseases in Asian Aquaculture II. Pp. 299-305. Fish Health Section, Asian Fisheries Society, Manila.
- Paclibare, J. O., Catap, E. S., and Callinan, R. B. (1994) Fungal isolation from EUS-affected fish in the Philippines. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, Aquatic Animal Health Research Institute, Bangkok, 25-27 January 1994. Pp. 238-243. AAHRI, Bangkok.
- Pichyangkura, S. (1983) Histopathology of serpent head infection by *Achlya* sp. Pp. 206-211. The Symposium on Fresh Water Fishes Epidemic: 1982-1983. 23-24 June 1983. Chulalongkorn University, Bangkok. (In Thai, English abstract).
- Pichyangkura, S., and Bodhalamik, V. (1983) The study of *Achlya* sp of fishes disease in *Ophicephalus striatus*. The Symposium on Fresh Water Fishes Epidemic: 1982-1983. 23-24 June 1983. Pp. 197-205 Chulalongkorn University, Bangkok. (In Thai, English abstract).
- Pichyangkura, S., and Tangtrongpiros, J. (1985) The relationship between microscopic exam of *Achlya* sp. infection and characteristic of lesions *Ophicephalus striatus*. Proceedings of the Living Aquatic Resources, Chulalongkorn University, Bangkok, 7-8 March 1985. Pp. 19-23 (In Thai, English abstract)

- Qureshi, T. A., Chouhan, R., Prasad, Y., and Mastan, S. A. (1995) Mycological studies on EUS affected catfish, *Mystus cavasius*. Abstracts of the Fourth Asian Fisheries Forum, 16-20 October 1995. P. 38. Asian Fisheries Society, Manila and China Society Fisheries, Beijing.
- Roberts, R. J. (1994) Overview of the research knowledge of the cause of EUS. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, 25-27 January 1994. Pp.9-12 Aquatic Animal Health Research Institute, Bangkok.
- Roberts, R. J. (1994) Pathogenicity studies on fungi isolated from EUS. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, Aquatic Animal Health Research Institute, Bangkok, 25-27 January 1994. Pp. 244-247 AAHRI, Bangkok.
- Roberts, R. J., Frerichs, G. N., and Millar, S. D. (1990) Epizootic ulcerative syndrome - the current position. In: Shariff, M., Subasinghe, R. P., and Arthur, J. R. (Eds), Diseases in Asian Aquaculture 1 Pp. 431-436. Fish Health Section, Asian Fisheries Society, Manila.
- Roberts, R. J., Frerichs, G. N., Tonguthai, K., and Chinabut, S. (1994) Epizootic ulcerative syndrome of farmed and wild fishes. In: Muir, J. F. and Roberts, R. J. (Eds), Recent Advances in Aquaculture Vol. 5. Pp. 207-239. Blackwell Science, Oxford.
- Roberts, R. J., Willoughby, L. G., and Chinabut, S. (1993) Mycotic aspects of epizootic ulcerative syndrome (EUS) of Asian fishes. *Journal of Fish Diseases* 16, 169-183.
- Sharifpour, I. (1997). Histology of the inflammatory response of the carp (*Cyprinus carpio* L.) to various stimuli. PhD thesis, University of Stirling, Scotland.
- Skloris, G. (1995). EUS: a vaccine pilot study. MSc thesis, University of Stirling, Scotland, 59 pp.
- Subasinghe, R. P., Jayasinha, L. P., Balasuriya, K. S. W., and Kulathilake, M. (1990) Preliminary investigations into the bacterial and fungal pathogens associated with the ulcerative fish disease syndrome in Sri Lanka. In: Hirano, R. and Hanyu, I. (Eds), Proceedings of the Second Asian Fisheries Forum, Tokyo, Japan, 17-22 April 1990. Pp. 655-657. Asian Fisheries Society, Manila.
- Thompson, K. D., Lilley, J. H., and Adams, A. (1997) The antibody response of snakehead, *Channa striata* Bloch, to *Aphanomyces invaderis*. *Fish and Shellfish Immunology* 7, 349-353.
- Tonguthai, K. (1994) Overview of the epizootiology of the disease from 1972-1986. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, 25-27 January 1994. Pp.3-8 Aquatic Animal Health Research Institute, Bangkok.
- Tonguthai, K. (1985) A preliminary account of ulcerative fish diseases in the Indo-Pacific region (a comprehensive study based on Thai experiences). National Inland Fisheries Institute, Bangkok, Thailand. 39 pp.
- Vishwanath, T. S., Mohan, C. V., and Shankar, K. M. (1997) Mycotic granulomatosis and seasonality are the consistent features of epizootic ulcerative syndrome of fresh and brackishwater fishes of Karnataka, India. *Asian Fishery Science* 10, 155-160.
- Willoughby, L. G. (1993) A new destructive disease (epizootic ulcerative syndrome) of freshwater fishes in southeast Asia. *Freshwater Forum* 3(2), 110-121.
- Willoughby, L. G. (1995) *Aphanomyces invaderis*, the fungal pathogen of EUS. C/N ratios and morphogenesis. The AAHRI Newsletter, 4(1), 1-2. Aquatic Animal Health Research Institute, Bangkok.
- Willoughby, L. G. and Roberts, R. J. (1994) Improved methodology for isolation of the *Aphanomyces* fungal pathogen of epizootic ulcerative syndrome (EUS) in Asian fish. *Journal of Fish Diseases* 17, 541-543.
- Willoughby, L. G. and Roberts, R. J. (1994) Loss and recovery of zoospore motility in an isolate of *Aphanomyces* from a diseased fish. *Mycological Research* 98(12), 1463-1464.
- Willoughby, L. G. and Roberts, R. J. (1994) Zoospore motility, its loss and recovery, in an isolate of *Aphanomyces* from a diseased fish in Thailand. In: Mueller, G. J. (Ed), Salmon Saprolegniasis. Pp. 99-108. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Willoughby, L. G., and Chinabut, S. (1996) Self-staling in *Aphanomyces invaderis*, the fungal pathogen of freshwater, tropical fish affected by epizootic ulcerative syndrome (EUS). The AAHRI Newsletter, 5(2), 23. Aquatic Animal Health Research Institute, Bangkok.
- Willoughby, L. G., and Lilley, J. (1992) The ecology of aquatic fungi in Thailand, and the fish disease relationship. The AAHRI Newsletter, 1(1), 5-6. Aquatic Animal Health Research Institute, Bangkok.
- Willoughby, L. G., and Roberts, R. J. (1994) Improved methodology for isolation of the *Aphanomyces* fungal pathogen of Epizootic Ulcerative Syndrome (EUS), in Asian fishes. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, 25-27 January 1994. Pp. 231-237 Aquatic Animal Health Research Institute, Bangkok.
- Willoughby, L. G., Roberts, R. J., and Chinabut, S. (1995) *Aphanomyces invaderis* sp. nov., the fungal pathogen of freshwater tropical fishes affected by epizootic ulcerative syndrome (EUS). *Journal of Fish Diseases* 18, 273-275.

### **Mycotic Granulomatosis: MG (also see EUS and RSD)**

- Egusa, S. (1992) Mycotic granulomatosis. In: Infectious Diseases of Fish. Pp. 392-396. A.A. Balkema, Rotterdam.
- Egusa, S. and Masuda, N. (1971) A new fungal disease of *Plecoglossus altivelis*. *Fish Pathology* 6, 41-46. (In Japanese)

- Hatai, K. (1980) Studies on pathogenic agents of saprolegniasis in fresh water fishes. Special Report of Nagasaki Prefectural Institute of Fisheries No.8, Matsugae-cho, Nagasaki, Japan. (In Japanese)
- Hatai, K. (1994) Mycotic granulomatosis in ayu (*Plecoglossus altivelis*) due to *Aphanomyces piscicida*. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, 25-27 January 1994. Pp. 101-108. Aquatic Animal Health Research Institute, Bangkok.
- Hatai, K. and Egusa, S. (1978) Studies on the pathogenic fungus of mycotic granulomatosis - II. Some of the note on the MG-fungus. Fish Pathology 13(2), 85-89. (In Japanese, English abstract)
- Hatai, K. and Egusa, S. (1979) Studies on the pathogenic fungus of mycotic granulomatosis - III. Development of the medium for the MG-fungus. Fish Pathology 13(3), 147-152. (In Japanese, English abstract)
- Hatai, K., Egusa, S., Takahashi, S., and Ooe, K. (1977) Study on the pathogenic fungus of mycotic granulomatosis - I. Isolation and pathogenicity of the fungus from cultured ayu infected with the disease. Fish Pathology 11(2), 129-133. (In Japanese, English abstract)
- Hatai, K., Nakamura, K., Rha, S. A., Yuasa, K., and Wada, S. (1994) *Aphanomyces* infection in dwarf gourami (*Colisa lalia*). Fish Pathology 29(2), 95-99.
- Hatai, K., Takahashi, S., and Egusa, S. (1984) Studies on the pathogenic fungus of mycotic granulomatosis - IV. Changes of blood constituents in ayu *Plecoglossus altivelis*, experimentally infected and normally infected with *Aphanomyces piscicida*. Fish Pathology 19, 17-23. (In Japanese, English abstract)
- Hatai, K., and Wada, S. (1994) Visceral mycosis in dwarf gourami (*Colisa lalia*) due to *Aphanomyces* sp. In: Chou, L. M., Munro, A. D., Lam, T. J., Chen, T. W., Cheong, L. K. K., Ding, J. K., Hooi, K. K., Khoo, H. W., Phang, V. P. E., Shim, K. F., and Tan, C. H. (Eds), Proceedings of the Third Asian Fisheries Forum. Pp. 298-301 Asian Fisheries Society, Manila, Philippines.
- Miyazaki, T. (1994) Comparison among mycotic granulomatosis, saprolegniasis and anaaki-byo in fishes: a Japanese experience. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, Aquatic Animal Health Research Institute, Bangkok, 25-27 January 1994. Pp. 253-270 AAHRI, Bangkok.
- Miyazaki, T. and Egusa, S. (1972) Studies on mycotic granulomatosis in fresh water fishes - I. Mycotic granulomatosis in goldfish. Fish Pathology 7, 15-25. (In Japanese)
- Miyazaki, T. and Egusa, S. (1973) Studies on mycotic granulomatosis in fresh water fishes - II. Mycotic granulomatosis in ayu. Fish Pathology 7, 125-133. (In Japanese)
- Miyazaki, T. and Egusa, S. (1973) Studies on mycotic granulomatosis in fresh water fishes - III. Mycotic granulomatosis in blue-gill. Fish Pathology 8, 41-43. (In Japanese)
- Miyazaki, T. and Egusa, S. (1973) Studies on mycotic granulomatosis in fresh water fishes - IV. Mycotic granulomatosis in wild fishes. Fish Pathology 8, 44-47. (In Japanese)
- Rha, S.-A., Sinmuk, S., Wada, S., Yuasa, K., Nakamura, K., Hatai, K., and Ishii, H. (1996) Pathogenicity to ayu (*Plecoglossus altivelis*) of *Aphanomyces* sp. isolated from dwarf gourami (*Colisa lalia*). The Bulletin of the Nippon Veterinary and Animal Science University 45, 9-15.
- Wada, S., Rha, S.-A., Kondoh, T., Suda, H., Hatai, K., and Ishii, H. (1996) Histopathological comparison between ayu and carp artificially infected with *Aphanomyces piscicida*. Fish Pathology 31(2), 71-80.
- Wada, S., Yuasa, K., Rha, S., Nakamura, K., and Hatai, K. (1994) Histopathology of *Aphanomyces* infection in dwarf gourami (*Colisa lalia*). Fish Pathology 29(4), 229-237.
- Yuasa, K. and Hatai, K. (1994) An attempt of classification by biological characteristics of some pathogenic water moulds from freshwater fishes. Nippon Kingakukai Kaiho 35, 104-110. (In Japanese, English abstract)
- Yuasa, K. and Hatai, K. (1994) Physiological and biochemical characteristics of some water moulds from fishes in Japan. Pp. 298-301. In: L.M. Chou, A.D. Munro, T.J. Lam, T.W. Chen, L.K.K. Cheong, J.K. Ding, K.K. Hooi, H.W. Khoo, V.P.E. Phang, K.F. Shim and C.H. Tan (Eds). Proceedings of the Third Asian Fisheries Forum. Asian Fisheries Society, Manila.
- Yuasa, K. and Hatai, K. (1995) Drug sensitivity of some pathogenic water moulds isolated from freshwater fishes. Journal of Antibacterial and Antifungal Agents 23(4), 213-219. (In Japanese, English abstract)

### **Redspot disease: RSD (also see MG and EUS)**

- Callinan, R. B. (1985) Diseases of native Australian fishes. In: Humphrey, J. D and Langdon, J. S. (Eds), Proceedings of the First Australian Workshop on Diseases of Fish and Shellfish. Pp. 102-117. Australian Fish Health Reference Laboratory, Benalla, Victoria.
- Callinan, R. B. (1994) A comparative review of *Aphanomyces* species associated with epizootic ulcerative syndrome, red spot disease and mycotic granulomatosis. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, AAHRI, Bangkok, 25-27 January 1994. Pp. 248-252 Aquatic Animal Health Research Institute, Bangkok.
- Callinan, R. B. (1994) Red spot disease - EUS in Australia. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome, 25-27 January 1994. Pp. 82-88 Aquatic Animal Health Research Institute, Bangkok.
- Callinan, R. B., Fraser, G. C., and Virgona, J. L. (1990) Pathogenesis of red spot disease, a cutaneous ulcerative

- syndrome of estuarine fish in Australia. Abstracts from the Symposium on Diseases in Asian Aquaculture, Bali, Indonesia, 26-29 November 1990. P. 27. Fish Health Section, Asian Fisheries Society, Manila, Philippines.
- Callinan, R. B., Fraser, G. C., and Virgona, J. L. (1989) Pathology of red spot disease in sea mullet, *Mugil cephalus* L., from eastern Australia. *Journal of Fish Diseases* 12, 467-479.
- Callinan, R. B., Paclibare, J. O., Bondad-Reantaso, M. G., Chin, J. C., and Gogolewski, R. P. (1995) *Aphanomyces* species associated with epizootic ulcerative syndrome (EUS) in the Philippines and red spot disease (RSD) in Australia: preliminary comparative studies. *Diseases of Aquatic Organisms* 21, 233-238.
- Callinan, R. B., Paclibare, J. O., Reantaso, M. B., Lumanlan-Mayo, S. C., Fraser, G. C., and Sammut, J. (1995) EUS outbreaks in estuarine fish in Australia and the Philippines: associations with acid sulphate soils, rainfall and *Aphanomyces*. In: Shariff, M., Arthur, J. R., and Subasinghe, R. P. (Eds), *Diseases in Asian Aquaculture II*. Pp. 291-298. Fish Health Section, Asian Fisheries Society, Manila.
- Callinan, R. B., Sammut, J., and Fraser G.C. (1996) Epizootic ulcerative syndrome (red spot disease) in estuarine fish - confirmation that exposure to acid sulfate soil runoff and an invasive aquatic fungus, *Aphanomyces* sp., are causative factors. *Proceedings of the Second National Conference on Acid Sulfate Soils*. Pp. 146-151. Roberts J Smith and Associates and ASSMAC, Australia.
- Fraser, G. C., Callinan, R. B., and Calder, L. M. (1992) *Aphanomyces* species associated with red spot disease: an ulcerative disease of estuarine fish from eastern Australia. *Journal of Fish Diseases* 15, 173-181.
- Pearce, M. (1990) Epizootic ulcerative syndrome technical report, December 1987 - September 1989. Fisheries Report No.22. Northern Territory Department of Primary Industry and Fisheries, Northern Territory, Australia.

### Ulcerative mycosis: UM

- Faisal, M. and Hargis Jr, W. J. (1992) Augmentation of mitogen-induced lymphocyte proliferation in Atlantic menhaden, *Brevoortia tyrannus*, with ulcer disease syndrome. *Fish and Shellfish Immunology* 2, 33-42.
- Hearth, J. H. and Padgett, D. E. (1990) Salinity tolerance of an *Aphanomyces* isolate (oomycetes) and its possible relationship to ulcerative mycosis (UM) of Atlantic menhaden. *Mycologia* 82(3), 364-369.
- Levine, J. (1987) Estuarine monitoring for ulcerative mycosis. In: Gray, J. (Ed), *The Proceedings of the Workshop on Fishery Diseases for the Albemarle-Pamlico Estuarine Study*, Raleigh, NC, 22 September 1987. Pp. 25-30 Water Resources Research Institute, University of North Carolina, Raleigh.
- Levine, J. F., Hawkins, J. H., Dykstra, M. J., Noga, E. J., Moye, D. W., and Cone, R. S. (1990) Epidemiology of ulcerative mycosis in Atlantic menhaden in the Tar-Pamlico River Estuary, North Carolina. *Journal of Aquatic Animal Health* 2(3), 162-171.
- Levine, J. F., Hawkins, J. H., Dykstra, M. J., Noga, E. J., Moye, D. W., and Cone, R. S. (1990) Species distribution of ulcerative lesions on finfish in the Tar-Pamlico River Estuary, North Carolina. *Diseases of Aquatic Organisms* 8(1), 1-5.
- McGarey, D. J., Beatty, T. K., Alberts, V. A., Te, Strake D., and Lim, D. V. (1990) Investigations of potential microbial pathogens associated with ulcerative disease syndrome (UDS) of Florida fish. *Pathology in Marine Science*.
- Merriner, J., and Vaughan, D. (1987) Ecosystem and Fishery Implications of Ulcerative Mycosis. *The Proceedings of the Workshop on Fisheries Diseases for the Albemarle-Pimlico Estuarine Study*, 22 September 1987. University of North Carolina Water Resources Research Institute.
- Noga, E. J. (1994) Epidemic ulcerative diseases recently affecting estuarine fishes of the western Atlantic ocean. In: Roberts, R. J., Campbell, B., and MacRae, I. H. (Eds), *Proceedings of the ODA Regional Seminar on Epizootic Ulcerative Syndrome*, 25-27 January 1994. Pp. 89-100 Aquatic Animal Health Research Institute, Bangkok.
- Noga, E. J. and Dykstra, M. J. (1986) Oomycete fungi associated with ulcerative mycosis in menhaden, *Brevoortia tyrannus* (Latrobe). *Journal of Fish Diseases* 9, 47-53.
- Noga, E. J., Dykstra, M. J., and Wright, J. F. (1989) Chronic inflammatory cells with epithelial cell characteristics in teleost fishes. *Veterinary Pathology* 26, 429-437.
- Noga, E. J., Khoo, L., Stevens, J. B., Fan, Z., and Burkholder, J. M. (1996) Novel toxic dinoflagellate causes epidemic disease in estuarine fish. *Marine Pollution Bulletin*, 32(2), 219-224.
- Noga, E. J., Levine, J. F., Dykstra, M. J., and Hawkins, J. H. (1988) Pathology of ulcerative mycosis in Atlantic menhaden *Brevoortia tyrannus*. *Diseases of Aquatic Organisms* 4, 189-197.
- Noga, E. J., Wright, J. F., Levine, J. F., Dykstra, M. J., and Hawkins, J. H. (1991) Dermatological diseases affecting fishes of the Tar-Pamlico Estuary, North Carolina. *Diseases of Aquatic Organisms* 10(2), 87-92.

### Crayfish plague (*Aphanomyces astaci*)

- Alderman, D. J. (1993) Crayfish plague in Britain, the first twelve years. *Freshwater Crayfish* 9, 266-272.
- Alderman, D. J., Holdich, D., and Reeve, I. (1990) Signal crayfish as vectors in crayfish plague in Britain. *Aquaculture* 86, 3-6.
- Alderman, D. J. and Polglase, J. L. (1988) Pathogens, parasites and commensals. In: Holdich, D. M. and Lowery, R. S. (Eds), *Freshwater Crayfish: Biology, Management and Exploitation* Pp. 167-212.
- Alderman, D. J., Polglase, J. L., and Frayling, M. (1987) *Aphanomyces astaci* pathogenicity under laboratory and field

- conditions. *Journal of Fish Diseases* 10, 385-393.
- Alderman, D. J., Polglase, J. L., Frayling, M., and Hogger, J. (1984) Crayfish plague in Britain. *Journal of Fish Diseases* 7, 401-405.
- Baran, I. and Soyulu, E. (1989) Crayfish plague in Turkey. *Journal of Fish Diseases* 12, 193-197.
- Cerenius, L. and Söderhäll, K. (1992) Crayfish diseases and crayfish as vectors for important diseases. *Finnish Fisheries Research* 14, 125-133.
- Cerenius, L., Söderhäll, K., Persson, M., and Ajaxon, R. (1988) The crayfish plague fungus *Aphanomyces astaci*. Diagnosis, isolation and pathobiology. *Freshwater Crayfish* 7, 131-144.
- Cuellar, L. and Coll, M. (1983) Epizootiology of the crayfish plague (Aphanomycosis) in Spain. *Freshwater Crayfish* 5, 545-548.
- Diéguez-Urbeondo, J., Huang, T.-S., Cerenius, L., and Söderhäll, K. (1995) Physiological adaptation of an *Aphanomyces astaci* strain isolated from the freshwater crayfish *Procambarus clarkii*. *Mycological Research* 99(5), 574-578.
- Diéguez-Urbeondo, J. and Söderhäll, K. (1993) *Procambarus clarkii* Girard as a vector for the crayfish plague fungus, *Aphanomyces astaci* Schikora. *Aquaculture and Fisheries Management* 24, 761-765.
- Lowery, R. S., Hogger, J., Polglase, J. L., and Alderman, D. J. (1986) Crayfish mortalities in the U.K. rivers. *Freshwater Crayfish* 6, 234-238.
- Marren, P. (1986) The lethal harvest of crayfish plague. *New Scientist* 30, 46-50.
- Matthews, M. and Reynolds, J. D. (1990) Laboratory investigations of the pathogenicity of *Aphanomyces astaci* for Irish freshwater crayfish. *Hydrobiologia* 203, 121-126.
- Ninni, A. P. (1865) Sulla mortalità dei gamberi (*Astacus fluviatilis* L.) nel veneto e più particolarmente nella provincia trevigiana. *Atti Istituto Veneto, Series III* 10, 1203-9. (In Italian)
- Nybelin, O. (1934) Nya undersökningar över kräftpestens orsak. *Ny Svensk Fiskeritidskrift* 1934, 110-114. (In Swedish)
- Nybelin, O. (1936) Untersuchungen über die Ursache der in Schweden gegenwärtig vorkommenden Krebspest. Report of the Institute of Freshwater Research, Drottningholm 9, 3-29. (In German)
- Nyhlen, L., and Unestam, T. (1975) Ultrastructure of the penetration of the crayfish integument by the fungal parasite, *Aphanomyces astaci*, Oomycetes. *Journal of Invertebrate Pathology*, 26, 353-366.
- Nylund, V., Kirjavainen, J., Tulonen, J., and Westman, K. (1993) The spread of crayfish plague (*Aphanomyces astaci*) and its effects on the noble crayfish (*Astacus astacus*) population in the Lake Ormajärvi waterway in Finland in 1988-1991. *Freshwater Crayfish* 9, 273-279.
- Nylund, V. and Westman, K. (1995) The crayfish mortality register as an aid to the control of crayfish diseases in Finland. *Freshwater Crayfish* 10, 363-373.
- Rahe, R. and Soyulu, E. (1989) Identification of the pathogenic fungus causing destruction to Turkish crayfish stocks (*Astacus leptodactylus*). *Journal of Invertebrate Pathology* 54, 10-15.
- Rennerfelt, E. (1936) Untersuchungen über die Entwicklung und Biologie des Krebspestpilzes, *Aphanomyces astaci* Schikora. *Mitt. Anst. f. Binnenfischerei bei Drottningholm, Stockholm* 10, 21 pp. (In German).
- Rodgers, M. (1988). The biology of the crayfish plague (*Aphanomyces astaci*) in Great Britain. PhD thesis, City of London Polytechnic, UK.
- Schikora, F. (1903) Über die Krebspest und ihren Erreger. *Fischerei Zeitung* 6, 353-355. (In German)
- Schikora, F. (1906) Die Krebspest. *Fischerei Zeitung* 9, 529-532, 561-566, 581-583. (In German)
- Smith, V. J. and Söderhäll, K. (1986) Crayfish pathology: an overview. *Freshwater Crayfish* 6, 199-211.
- Söderhäll, K. (1989) The crayfish plague fungus *Aphanomyces astaci* and other diseases during aquaculture of crayfish. Skurdal, J., Westman, K., and Bergan, P. I. Crayfish Culture in Europe. Report from the Workshop on Crayfish Culture. 16-19 November 1987. Pp. 136-139, Trondheim, Norway.
- Southgate, P. (1983). Studies on the crayfish plague fungus, *Aphanomyces astaci*. MSc thesis, University of Stirling, Institute of Aquaculture. 109 pp.
- Svardson, G. (1992) Ecological co-evolution of the parasitic fungus *Aphanomyces astaci* and its crayfish host. *Finnish Fisheries Research* 14, 135-143.
- Unestam, T. and Ajaxon, R. (1978) The crayfish plague fungus, the ecological niche of a specialized fungus and the fate of the fungus in the crayfish host. *Freshwater Crayfish* 4, 399-402.
- Unestam, T. and Svensson, E. (1971) Physiological variation in strains of *Aphanomyces astaci*. *Physiologia Plantarum* 25, 414-416.
- Vey, A. (1986) Disease problems during aquaculture of freshwater crustacea. *Freshwater Crayfish* 6, 212-222.
- Vey, A., Söderhäll, K., and Ajaxon, R. (1983) Susceptibility of *Orconectes limosus* Raff. to the crayfish plague, *Aphanomyces astaci* Schikora. *Freshwater Crayfish* 5, 284-291.

### **Other *Aphanomyces* spp.**

- Cutter Jr, V. M. (1941) Observations on certain species of *Aphanomyces*. *Mycologia* 33, 220-240.
- Matthews, V. D. (1935) Notes on some Oomycetes from the vicinity of Mountain Lake, Virginia. *Journal of the Elisha Mitchell Scientific Society* 51, 306-311.
- Prowse, G. A. (1953) *Aphanomyces daphniae* sp. nov., parasitic on *Daphnia hyalina*. *Transactions of the British Mycological Society*, 22-28.
- Scott, W. W. (1961) A monograph of the genus *Aphanomyces*. Technical Bulletin No. 151, Virginia Agricultural Experiment Station, Blacksburg, Virginia, USA.
- Seymour, R., Cowgill, U. M., Klecka, G. M., Gersich, F. M., and Mayes, M. A. (1984) Occurrence of *Aphanomyces daphniae* in laboratory cultures of *Daphnia magna*. *Journal of Invertebrate Pathology* 43, 109-113.
- Shanor, L. and Saslow, H. B. (1944) *Aphanomyces* as a fish parasite. *Mycologia* 36, 413-415.
- Sinmuk, S., Suda, H., and Hatai, K. (1996) *Aphanomyces* infection in juvenile soft-shelled turtle, *Pelodiscus sinensis*, imported from Singapore. *Myoscience* 37, 249-254.
- Srivastava, R. C. (1979) Aphanomycosis - a new threat to fish population. *Mykosen* 22(1), 25-29.
- Valairatana, W., and Willoughby, L. G. (1994) The aquatic fungi *Aphanomyces* and *Pythium*, as wound pathogens on a soft shell turtle (*Trionyx cartilagineus*). *The AAHRI Newsletter*, 3(1), 2. Aquatic Animal Health Research Institute, Bangkok.

### ***Achlya* spp.**

- Jha, B. C., Seth, R. N., and Srivastava, K. P. (1977) Occurrence of *Achlya* sp. on a new host - *Mystus* spp. *Current Science* 46, 60.
- Johnson, Jr T. W. (1956) The genus *Achlya*: morphology and taxonomy. University of Michigan Scientific Series. Vol. XX. Lord Baltimore Press, Baltimore, Maryland, USA. 180 pp.
- Khulbe, R. D. and Sati, S. C. (1980) Studies of parasitic water molds of Kumaun Himalaya; host range of *Achlya americana* Humphrey on certain temperate fish. *Mykosen* 24, 177-180.
- Khulbe, R. D., Bisht, G. S., and Joshi, C. (1994) Epizootic infection due to *Achlya debaryana* in a catfish. *Mycoses* 37(1-2), 61-63.
- Kitancharoen, N., Hatai, K., Ogihara, R., and Daw Nwe Ni Aye. (1995) A new record of *Achlya klebsiana* from snakehead, *Channa striatus*, with fungal infection from Myanmar. *Myoscience* 36, 235-238.
- Sati, S. C. (1986) Two species of *Achlya* as fish parasites. *Current Science*, 55(1), 48-49.
- Sinmuk, S., Hanjavanit, C., Lawhavainit, O., and Hatai, K. (1997) A survey of EUS in Thailand, and a new species of genus *Achlya* isolated from the lesion in snakehead, *Channa striata*, with infection. In: Abstracts of the International Symposium on Diseases in Marine Aquaculture, Hiroshima, Japan, 3-6 October 1997. P. 100 Japanese Society of Fish Pathology
- Srivastava, G. C. and Srivastava, R. C. (1975) Fungal infection of the eggs of *Channa punctatus* (Bl.). *Geobios* 3, 160.
- Srivastava, G. C. and Srivastava, R. C. (1976) Ability of *Achlya flagellata* Coker parasitising certain fresh water fishes. *Geobios* 3, 139-140.
- Srivastava, G. C. and Srivastava, R. C. (1977) Host range of *Achlya prolifera* (Nees) de Bary on certain fresh water teleosts. *Mycopathologia* 61(1), 61-62.
- Srivastava, R. C. (1978) Host range of *Achlya orion* Coker and Couch on certain freshwater fishes. *Mycopathologia* 64, 49-51.
- Srivastava, R. C. and Srivastava, G. C. (1977) *Achlya carolineana* Coker - a new record from India. *Current Science* 46, 422.
- Tiffney, W. N. and Wolf, F. T. (1937) *Achlya flagellata* as a fish parasite. *Journal of the Elisha Mitchell Scientific Society* 53, 298-300.
- Valairatana, W., and Willoughby, L. G. (1993) Spore assay of *Achlya* (Fungi, Phycomycetes) from a fish pond; apparently demonstrating strains of the genus with widely differing growth rates. *The AAHRI Newsletter*, Pp. 12. Aquatic Animal Health Research Institute, Bangkok.

### ***Saprolegnia* spp.**

- Agersberg, H. P. K. (1933) Salient problems in the artificial rearing of salmonid fishes, with special reference to intestinal fungisitis and the cause of white spot disease. *Transactions of the American Fisheries Society* 63, 240-250.
- Aller Gancedo, J. M. (1988) Saprolegniosis, with special reference to salmonid fish. *Biologia (Lahore)* 8, 9-12.
- Bly, J. E., Lawson, L. A., Dale, D. J., Szalai, A. J., Durborow, R. M., and Clem, L. W. (1992) Winter saprolegniosis in channel catfish. *Diseases of Aquatic Organisms* 13, 155-164.
- Bly, J. E., Lawson, L. A., Szalai, A. J., and Clem, L. W. (1993) Environmental factors affecting outbreaks of winter saprolegniosis in channel catfish, *Ictalurus punctatus* (Rafinesque). *Journal of Fish Diseases* 16(6), 541-549.

- Bootsma, R. (1973) Infections with *Saprolegnia* in pike culture. *Aquaculture* 2, 385-394.
- Bruno, D. W. and Stamps, D. J. (1987) Saprolegniasis of Atlantic salmon, *Salmo salar* L., fry. *Journal of Fish Diseases* 10, 513-517.
- Carballo, M., and Muñoz, M. J. (1991) Effect of sublethal concentrations of four chemicals on susceptibility of juvenile rainbow trout (*Oncorhynchus mykiss*) to Saprolegniosis. *Applied and Experimental Microbiology*, 57(6), 1813-1816.
- Carberry, J. T. (1968) Ulcerative dermal necrosis of salmonids in Ireland. *Symp. Zool. Soc. Lond.* 24, 39-49.
- Carberry, J. T. and Strickland, K. L. (1968) Ulcerative dermal necrosis (UDN). *Irish Veterinary Journal* 22, 171-175.
- Copland, J. W. and Willoughby, L. G. (1982) The pathology of *Saprolegnia* infections of *Anguilla anguilla* L. elvers. *Journal of Fish Diseases* 5, 421-428.
- Cross, M. (1987). The susceptibility of salmonid fish to *Saprolegnia diclina*. MSc thesis, Plymouth University, Plymouth, UK.
- Davis, H. S. and Lazar, E. C. (1941) A new fungus disease of trout. *Transactions of the American Fisheries Society* 70, 264-271.
- Diéguez-Urbeondo, J., Cerenius, L., and Söderhäll, K. (1996) Physiological characterization of *Saprolegnia parasitica* isolates from brown trout. *Aquaculture* 140, 247-257.
- Dudka, I. A., Isayeva, N. M., and Davydov, D. N. (1989) Saprolegniaceae inducing fish mycosis. *Mikol. Fitopatol.* 23, 488-498.
- Egusa, S. (1963) Studies on saprolegniasis of the eels. I. Resistance of the eels to fungus infection. *Bulletin of the Japanese Society of Scientific Fisheries* 29, 27-36. (In Japanese)
- Egusa, S. (1965) The existence of a primary infectious disease in the so-called "fungus-disease" in pond-reared eels. *Bulletin of the Japanese Society of Scientific Fisheries* 31, 23-36.
- Egusa, S. (1966) An interim report of studies on saprolegniasis of eel fry. *Fish Pathology* 1, 23-36. (In Japanese)
- Egusa, S. and Nishikawa, T. (1965) Studies of a primary infectious disease in the so-called fungus disease of eels. *Bulletin of the Japanese Society of Scientific Fisheries* 31, 804-813.
- Frick, von W. and Reinhold, H. (1987) Nachweis und epizootologie fischpathogener *Saprolegnia* - Arten in Forellenzuchtanlagen. *Monatshefte fuer Veterinaermedizin* 42, 712-716. (In German)
- Gardner, M. L. G. (1974) Impaired osmoregulation in infected salmon, *Salmo salar* L. *Journal of the Marine Biological Association of the United Kingdom* 54, 635-639.
- Hardy, A. D. (1911) Association of alga and fungus in salmon disease (*Myxonema* and *Saprolegnia*). *Proceedings of the Royal Society, Victoria* 23, 27-32.
- Hatai, K. (1980) Saprolegniasis in salmonids. *Fish Pathology* 14(4), 199-206.
- Hatai, K. and Egusa, S. (1977) Studies on visceral mycosis of salmonids fry - II. Characteristics of fungi isolated from the abdominal cavity of amago salmon fry. *Fish Pathology* 11, 187-193. (In Japanese)
- Hatai, K., Egusa, S., and Awakura, T. (1977) *Saprolegnia australis* sp. nov. isolated from kokanee salmon associated with fish saprolegniasis. *Fish Pathology* 12, 105-110. (In Japanese)
- Hatai, K., Egusa, S., and Awakura, T. (1977) *Saprolegnia shikotsuensis* sp. nov., isolated from koka-nee salmon associated with fish saprolegniasis. *Fish Pathology* 12, 105-110.
- Hatai, K., Egusa, S., and Nomura, T. (1977) *Saprolegnia australis* Elliott isolated from body surface lesions of rainbow trout fingerlings. *Fish Pathology* 11, 201-206.
- Hatai, K. and Hoshiai, G. (1992) Mass mortality in cultured coho salmon (*Oncorhynchus kisutch*) due to *Saprolegnia parasitica* Coker. *Journal of Wildlife Diseases* 28(4), 532-536.
- Hatai, K. and Hoshiai, G.-I. (1992) Saprolegniasis in cultured coho salmon (*Oncorhynchus kisutch*). *Fish Pathology* 27(4), 233-234.
- Hoshiai, G.-I., Hatai, K., and Kubota, S. S. (1989) Studies on the saprolegniasis in coho salmon (*Oncorhynchus kisutch* Walbaum); VI. Pathogenicity of *Saprolegnia* isolated from cultured coho salmon (*Oncorhynchus kisutch* Walbaum) on salmonids. *Bull. Nippon Vet. Zootech. Coll.* 38, 44-51. (In Japanese)
- Hoshina, T., Sano, T., and Sunayama, M. (1960) Studies on the saprolegniasis of eel. *Journal of the Tokyo University of Fisheries* 47, 59-79.
- Hughes, G. C. (1994) Saprolegniasis: then and now: a retrospective. In: Mueller, G. J. (Ed), *Salmon Saprolegniasis* Pp. 3-32. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Hughes, G. C., Mueller, G. J., and Choi, T.-J. (1994) Bibliography *Saprolegnia* in salmon. In: Mueller, G. J. (Ed), *Salmon Saprolegniasis* Pp. 211-253. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Khulbe, R. D. (1990) A taxo-ecological review on different species of *Saprolegnia*, a common watermold. In: Agrawal, V. P. and Das, P. (Eds), *Recent Trends in Limnology* Pp. 205-215. Muzaffarnagar India Society of Biosciences
- Klebs, G. (1899) Zur Physiologie der Fortpflanzung einiger Pilze II. *Saprolegnia mixta* deBary. *Jahrbuecher fuer Wissenschaftliche Botanik* 33, 71-151. (In German)



- Kitancharoen, N. and Hatai, K. (1996) Experimental infection of *Saprolegnia* spp. in rainbow trout eggs. *Fish Pathology* 31(1), 49-50.
- Kitancharoen, N., Yuasa, K., and Hatai, K. (1995) Morphological aspects of *Saprolegnia diclina* Type 1 isolated from pejerrey, *Odonthestes bonariensis*. *Myoscience* 36, 365-368.
- Langvad, F. (1994) *Saprolegnia* in Norwegian fish farming. In: Mueller, G. J. (Ed), Salmon Saprolegniasis Pp. 189-201. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Lawhavit, O.-A., Hatai, K., and Kubota, S. S. (1986) Studies on fungal diseases of pejerrey *Odonthestes bonariensis* (C and V). I. *Aeromonas hydrophila* isolated from pejerrey with saprolegniasis. *Bull. Nippon Vet. Zootech. Coll.* 35, 135-140.
- Lawhavit, O.-A., Hatai, K., and Kubota, S. S. (1987) Studies on fungal diseases of pejerrey *Odonthestes bonariensis* (C and V). *Bull. Nippon Vet. Zootech. Coll.* 36, 63-69.
- Leano, E. M., Vrijmoed, L. L. P., and Jones, E. B. G. (1997) *Saprolegnia* sp. (straminipilous fungi) isolated from pond cultured red drum (*Sciaenops ocellatus*) in Hong Kong. In: Abstracts of the International Symposium on Diseases in Marine Aquaculture, Hiroshima, Japan, 3-6 October 1997. P. 104. Japanese Society of Fish Pathology
- Min, H.-K., Park, N.-Y., and Hatai, K. (1991) Experimental infection with *Saprolegnia diclina* Type 1 in eels (*Anguilla japonica*). *Fish Pathology* 3, 61-67.
- Miyazaki, T. (1973) Studies on epizootic characterized by epithelial necrosis and *Saprolegnia* infection - I. Histopathology. *Fish Pathology* 8, 48-54. (In Japanese)
- Mueller, G. J. (1994) Current research needs. In: Mueller, G. J. (Ed), Salmon Saprolegniasis. Pp. 207-209. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Mueller, G. J. and Whisler, H. C. (1994) Fungal parasites of salmon from the Columbia River watershed. In: Mueller, G. J. (Ed), Salmon Saprolegniasis Pp. 163-187. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Nagao, S., Sakai, K., and Takashima, F. (1986) Saprolegniasis in landlocked variety of *Oncorhynchus masou*. Concurrence with testicular maturation and environmental conditions. *Mycologia* 34, 119-125. (In Japanese)
- Nagao, S. and Takashima, F. (1986) Effects of photomanipulation on testicular maturation and saprolegniasis in yamame *Oncorhynchus masou*. *Aquaculture (Suison Zoshoku)* 34, 253-256. (In Japanese)
- Neish, G. A. (1977) Observations on saprolegniasis of adult sockeye salmon, *Onchorynchus nerka* (Walbaum). *Journal of Fish Biology* 10, 513-522.
- Nolard-Tintigner, N. (1971) Cause de la mort dans la Saprolegniose experimentale du poisson. *Bulletin Classe de Sciences, Academie Royale de Belgique* 57, 185-191. (In French)
- Nolard-Tintigner, N. (1973) Etude experimentale sur l'epidemiologie et la pathogenie de la Saprolegniose chez *Lebistes reticulatus* Peters et *Xiphophorus helleri* Heckel. *Acta Zoologica et Pathologica Antverpiensia* 57, 1-127. (In French)
- Padgett, D. E. (1976) An isolate of *Saprolegnia australis* from southeastern North Carolina. *Mycologia* 68(6), 1258-1260.
- Papatheodorou, B. T. (1981) Observations on *Saprolegnia australis* Elliott, a pathogenic agent of saprolegniosis in fish. *Bull. Fr. Piscic.* 283, 96-101.
- Puckeridge, J. T., Walker, K. F., Langdon, J. S., Daley, C., and Beakes, G. W. (1989) Mycotic dermatitis in a freshwater gizzard shad, the bony bream, *Nematalosa erebi* (Gunther), in the River Murray, South Australia. *Journal of Fish Diseases* 12, 205-221.
- Richards, R. H. and Pickering, A. D. (1978) Frequency and distribution patterns of *Saprolegnia* infection in wild and hatchery-reared brown trout *Salmo trutta* L. and char *Salvelinus alpinus* (L.). *Journal of Fish Diseases* 1, 69-82.
- Roberts, R. J., Ball, H. J., Munro, A. L. S., and Shearer, W. M. (1974) Studies on the ulcerative dermal necrosis of salmonids III. The healing process in fish maintained under experimental conditions. *Diseases of Fish* Pp. 165-173. MSS Information Corporation
- Roberts, R. J., Shearer, W. M., Elson, K. G. R., and Munro, A. L. S. (1974) Studies on the ulcerative dermal necrosis of salmonids II. The skin of the normal salmon head. *Diseases of Fish*. Pp. 138-149. MSS Information Corporation
- Roberts, R. J., Shearer, W. M., and Munro, A. L. S. (1974) Studies on the ulcerative dermal necrosis of salmonids IV. Failure to detect epithelial auto-antibodies in sera from diseased fish. *Diseases of Fish*. Pp. 174-178. MSS Information Corporation
- Roberts, R. J., Shearer, W. M., Munro, A. L. S., and Elson, K. G. R. (1974) Studies on the ulcerative dermal necrosis of salmonids II. The sequential pathology of the lesions. *Diseases of Fish*. Pp. 150-164. MSS Information Corporation
- Sati, S. C., Mer, G. S., and Khulbe, R. D. (1982) Studies on parasitic water molds: some new host records for *Saprolegnia parasitica* Coker. *Mykosen* 25, 638-640.
- Seymour, R. L. (1970) The genus *Saprolegnia*. Verlag Von J. Cramer, Germany, 124 pp.
- Smith, P. R. (1994) *Saprolegnia* in Ireland. In: Mueller, G. J. (Ed), Salmon Saprolegniasis. P. 203. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Smith, S. N., Armstrong, R. A., Springate, J., and Barker, G. (1985) Infection and colonization of trout eggs by

- saprolegniaceae. Transactions of the British Mycological Society 85(4), 719-723.
- Söderhäll, K., Dick, M. W., Clark, G., Fürst, M., and Constantinescu, O. (1991) Isolation of *Saprolegnia parasitica* from the crayfish *Astacus leptodactylus*. Aquaculture 92, 121-125.
- Srivastava, G. C. and Srivastava, R. C. (1977) Host range of *Saprolegnia ferax* (Gruith.) Thuret on certain fresh water teleosts. Current Science 46, 87.
- Stuart, M. R. and Fuller, H. T. (1968) Mycological aspects of diseased Atlantic salmon. Nature 217, 90-92.
- Stuart, M. R. and Fuller, H. T. (1968) *Saprolegnia parasitica* Coker in estuaries. Nature (London) 217, 1157-1158.
- Tiffney, W. N. (1939) The host range of *Saprolegnia parasitica*. Mycologia 31, 310-321.
- Wada, S., Hatai, K., and Ishii, H. (1993) Mycotic gastritis of juvenile ayu (*Plecoglossus altivelis*) caused by *Saprolegnia diclina* Type-1. Journal of Wildlife Diseases, 29(4), 587-590.
- Wada, S., Hatai, K., Kubota, S. S., and Komatu, T. (1989) Pathological studies on saprolegniasis of cultured salmonid fish - I. Comparison of developmental factors of saprolegniasis of masu salmon *Oncorhynchus masou* between two different hatcheries. (I) Comparison of frequency of occurrence of saprolegniasis and environmental conditions between the two hatcheries. Bull. Nippon Vet. Zootech. Coll. 38, 32-37. (In Japanese)
- Willoughby, L. G. (1968) Atlantic salmon disease fungus. Nature 217, 872-873.
- Willoughby, L. G. (1978) Saprolegnias of salmonid fish in Windemere: a critical analysis. Journal of Fish Diseases 1, 51-67.
- Willoughby, L. G. (1988) *Saprolegnia* parasitised by *Mortierella alpina*. Transactions of the British Mycological Society 90, 496-499.
- Willoughby, L. G. (1997) *Saprolegnia polymorpha* sp. nov., a fungal parasite on Koi carp, in the UK. Nova Hedwigia (In press)
- Yuasa, K. and Hatai, K. (1995) Relationship between pathogenicity of *Saprolegnia* spp isolates to rainbow trout and their biological characteristics. Fish Pathology 30(2), 101-106.
- Yuasa, K., Kitancharoen, N., and Hatai, K. (1997) Simple method to distinguish between *Saprolegnia parasitica* and *S. diclina* isolated from fish with saprolegniasis. Fish Pathology 32(3), 175-176.

## Lagenidiales

- Barnweg, G. and Bland, C. E. (1980) Comparative physiology and nutrition of *Lagenidium callinectes* and *Haliphthoros milfordensis*, fungal parasites of marine crustaceans. Bot. Marina 23, 689-698.
- Bian, B. Z. and Egusa, S. (1980) *Atkinsiella hamanaensis* sp. nov. isolated from cultivated ova of the mangrove crab *Scylla serrata* (Forsskal). Journal of Fish Diseases 3, 373-385.
- Bian, B. Z., Hatai, K., Lio-Po, G., and Egusa, S. (1979) Studies on the fungal diseases in crustaceans - I. *Lagenidium scyllae* sp. nov. isolated from the cultivated ova and larvae of the mangrove crab (*Scylla serrata*). Transactions of the Mycological Society of Japan 20, 115-124.
- Hamasaki, K. and Hatai, K. (1993) Experimental infection in the eggs and larvae of the swimming crab *Portunus trituberculatus* and the mud crab *Scylla serrata* with seven fungal strains belonging to Lagenidiales. Bulletin of the Japanese Society of Scientific Fisheries 59(6), 1059-1066. (In Japanese)
- Hatai, K. (1982) On the fungus *Haliphthoros milfordensis* isolated from temporarily held abalone (*Haliotis sieboldii*). Fish Pathology 17, 199-204. (In Japanese)
- Hatai, K., Bian, B. Z., Baticados, M. C. L., and Egusa, S. (1980) Studies on the fungal diseases in crustaceans - II. *Haliphthoros philippinensis* sp. nov. isolated from cultivated larvae of the jumbo tiger prawn (*Penaeus monodon*). Transactions of the Mycological Society of Japan 21, 47-55.
- Hatai, K. and Lawhavit, O.-A. (1988) *Lagenidium myophilum* sp. nova new parasite on adult northern shrimp (*Pandalus borealis* Krøyer). Transactions of the Mycological Society of Japan 29, 175-184.
- Hatai, K., Rhoobunjongde, W., and Wada, S. (1992) *Haliphthoros milfordensis* isolated from gills of juvenile kuruma prawn (*Penaeus japonicus*) with black gill disease. Transactions of the Mycological Society of Japan 33, 185-192.
- Kitancharoen, N. and Hatai, K. (1995) A marine oomycete *Atkinsiella panulirata* sp. nov. from philozoma of spiny lobster, *Panulirus japonicus*. Myoscience 36, 97-104.
- Kitancharoen, N., Nakamura, K., Wada, S., and Hatai, K. (1994) *Atkinsiella awabi* sp. nov. isolated from stocked abalone *Haliotis sieboldii*. Myoscience 35, 265-270.
- Nakamura, K. and Hatai, K. (1994) *Atkinsiella parasitica* sp. nov. isolated from a rotifer, *Brachionus plicatilis*. Myoscience 35, 383-389.
- Nakamura, K. and Hatai, K. (1995) *Atkinsiella dubia* and its related species. Myoscience 36, 431-438.
- Nakamura, K. and Hatai, K. (1995) Three species of Lagenidiales isolated from the eggs and zoeae of the marine crab *Portunus pelagicus*. Myoscience 36, 87-95.
- Nakamura, K., Nakamura, M., Hatai, K., and Zafran. (1995) *Lagenidium* infection in eggs and larvae of mangrove crab (*Scylla serrata*) produced in Indonesia. Myoscience 36, 399-404.
- Nakamura, K., Nakamura, M., and Hatai, K. (1994) *Atkinsiella* infection in the rotifer *Brachionus plicatilis*. Myoscience 35,

291-294.

Nestrud, L. B., and Anderson, R. L. (1994) Aquatic safety of *Lagenidium giganteum*: Effects on freshwater fish and invertebrates. *Journal of Invertebrate Pathology*, 64(3), 228-233.

Poernomo, A. (1985) A parasitic fungus on tiger prawn (*Penaeus monodon* Fab). *Coastal Aquaculture Research Journal* 1, 39-44. (In Indonesian)

### **Branchiomyces**

Chen, C.-H., Miyazaki, T., and Kubota, S. S. (1979) Branchiomycosis of the reared Japanese eel in Taiwan. *Fish Pathology* 13, 179-182. (In Japanese)

Egusa, S. and Ooiwa, Y. (1972) A new fungal disease due to *Branchiomyces* sp. found in gills of cultured eels. *Fish Pathology* 7, 79-83. (In Japanese)

Paperna, I. and Smirnova, M. (1998) *Branchiomyces*-like infection in a cultured tilapia (*Oreochromis hybrid*, Cichlidae). *Diseases of Aquatic Organisms* (in press)

### **Dermocystidium spp.**

Allen, R. L., Meekin, T. K., Pauley, G. B., and Fujihara, M. P. (1968) Mortality among chinook salmon associated with the fungus *Dermocystidium*. *Journal of the Fisheries Research Board of Canada* 25(11), 2467-2475.

Cervinka, S., Vitovec, J., Lom, J., Hoska, J., and Kubu, F. (1974) Dermocystidiosis - a gill disease of the carp due to *Dermocystidium cyprini* n. sp. *Journal of Fish Biology* 6, 689-699.

Hatai, K., Hirose, H., Hioki, M., Miyakawa, M., and Egusa, S. (1979) *Dermocystidium anguillare* found on the gills of the European eel, *Anguilla anguilla* cultured in Japan. *Fish Pathology* 13, 205-210. (In Japanese)

Höglund, J., Alfjorden, A., and Nikkilä, T. (1997) Infection of juvenile salmon *Salmo salar* with a *Dermocystidium*-like organism in Sweden. *Diseases of Aquatic Organisms* 30, 171-176.

Landsberg, J. H., and Paperna, I. (1992) Systemic granuloma in goldfish caused by a *Dermocystidium*-like aetiological agent. *Diseases of Aquatic Organisms*, 13, 75-78.

McVicar, A. H., and Wootten, R. (1980) Disease in farmed juvenile Atlantic salmon caused by *Dermocystidium* sp. In: W. Ahne (Ed), *Fish Diseases*. Springer-Verlag, Berlin.

Olson, R. E., Dungan, C. F., and Holt, R. A. (1991) Water-borne transmission of *Dermocystidium salmonis* in the laboratory. *Diseases of Aquatic Organisms* 12, 41-48.

Pauley, G. B. (1967) Prespawning adult salmon mortality associated with a fungus of the genus *Dermocystidium*. *Journal of the Fisheries Research Board of Canada* 24(4), 843-848.

Wootten, R. and McVicar, A. H. (1982) *Dermocystidium* from cultured eels, *Anguilla anguilla* L., in Scotland. *Journal of Fish Diseases* 5, 215-222.

### **Ichthyophonus**

Chien, C.-H., Miyazaki, T., and Kubota, S. S. (1979) Studies on *Ichthyophonus* disease of fishes - V. Artificial Infection. *Bull. Fac. Fish. Mie. Univ.* 6, 153-159. (In Japanese)

Chien, C.-H., Miyazaki, T., and Kubota, S. S. (1979) Studies on *Ichthyophonus* disease of fishes - VII. Morphology and life cycle. *Bull. Fac. Fish. Mie. Univ.* 6, 161-172. (In Japanese)

Holst, J. C., Salvanes, A. G. V., and Johansen, T. (1997) Feeding, *Ichthyophonus* sp. infection, distribution and growth history of Norwegian spring-spawning herring in summer. *Journal of Fish Biology* 50, 652-664.

Katayama, M., Hatai, K., Kubota, S. S., and Gotoh, M. (1988) *Ichthyophonus* disease of cultured ishidaï (*Oplegnathus fasciatus*). *Fish Pathology* 23, 273-274.

McVicar, A. H. (1982) *Ichthyophonus* infections of fish. In: Roberts, R. J. (Ed), *Microbial Diseases of Fish* Pp. 243-269. Academic Press, New York.

McVicar, A. H. and McLay, H. A. (1985) Tissue response of plaice, haddock and rainbow trout to the systemic fungus *Ichthyophonus*. In: Ellis, A. E. (Ed), *Fish and Shellfish Pathology* Pp. 329-346. Academic Press, London.

Miyazaki, T. and Jo, Y. (1985) Studies on *Ichthyophonus* disease of ayu. *Fish Pathology* 20(1), 45-48.

Miyazaki, T. and Kubota, S. S. (1977) Studies on *Ichthyophonus* disease of fishes - I. Rainbow trout fry. *Bull. Fac. Fish. Mie Univ.* 4, 45-56. (In Japanese)

Miyazaki, T. and Kubota, S. S. (1977) Studies on *Ichthyophonus* disease of fishes - II life cycle of *Ichthyophonus* affected rainbow trout. *Bull. Fac. Fish. Mie Univ.* 4, 67-80. (In Japanese)

Miyazaki, T. and Kubota, S. S. (1977) Studies on *Ichthyophonus* disease of fishes - II. Yearling rainbow trout - chronic infection. *Bull. Fac. Fish. Mie Univ.* 4, 57-65. (In Japanese)

Okamoto, N., Nakase, K., and Sano, T. (1987) Relationship between water temperature, fish size, infective dose and *Ichthyophonus hoferi* infection of rainbow trout. *Bulletin of the Japanese Society of Scientific Fisheries* 53, 581-584. (In Japanese)

Okamoto, N., Suzuki, H., Nakase, K., Nakai, Y., Fujii, K., and Sano, T. (1985) Life history and morphology of

*Ichthyophonus hoferi* in vitro. Fish Pathology 20(2/3), 273-285.

- Okamoto, N., Suzuki, H., Nakase, K., and Sano, T. (1987) Experimental oral infection of rainbow trout with spherical bodies of *Ichthyophonus hoferi* cultivated. Bulletin of the Japanese Society of Scientific Fisheries 53, 407-409. (In Japanese)
- Paperna, I. (1986) *Ichthyophonus* infection in grey mullets from Southern Africa: histopathological and ultrastructural study. Diseases of Aquatic Organisms, 1, 89-97.
- Rahimian, H. and Thulin, J. (1996) Epizootiology of *Ichthyophonus hoferi* in herring populations off the Swedish west coast. Diseases of Aquatic Organisms 27, 187-195.
- Rand, T. G. (1994) An unusual form of *Ichthyophonus hoferi* (Ichthyophonales: Ichthyophonaceae) from yellowtail flounder *Limanda ferruginea* from the Nova Scotia shelf. Diseases of Aquatic Organisms 18, 21-28.
- Spanggaard, B., Gram, L., Okamoto, N., and Huss, H. H. (1994) Growth of the fish-pathogenic fungus, *Ichthyophonus hoferi*, measured by conductimetry and microscopy. Journal of Fish Diseases 17, 145-153.
- Spanggaard, B., Huss, H. H., and Bresciani, J. (1995) Morphology of *Ichthyophonus hoferi* assessed by light and scanning electron microscopy. Journal of Fish Diseases 18, 567-577.
- Spanggaard, B., Skouboe, P., Rossen, L., and Taylor, J. W. (1996) Phylogenetic relationships of the intercellular fish pathogen *Ichthyophonus hoferi* and fungi, ciliates and the rosette agent. Marine Biology 126, 109-115.
- Uno, M. (1990) Effects of seawater acclimation on juvenile salmonids infected with *Tetraonchus* (Monogenea) and *Ichthyophonus* (Phycomycetes). Fish Pathology 25(1), 15-19. (In Japanese, English abstract)

### ***Aspergillus* spp.**

- Bhattacharya, U. (1988) *Aspergillus niger*: a new record as a fish pathogen. Environmental Ecology 6, 231-233.
- Bhattacharya, U., Prasad, J., and Dubey, N. K. (1988) *Aspergillus terreus* Thom. - a new record as a fish pathogen. Current Science 57, 622-623.
- Olufemi, B. E. (1985) The aspergilli as pathogens of cultured fishes. In: Muir, J. F. and Roberts, R. J. (Eds), Recent Advances in Aquaculture Vol. 2 Pp. 193-218. Croom Helm, Colorado, USA.
- Olufemi, B. E. (1986) Application of fluorescent antibody technique (FAT) to the demonstration of *Aspergillus* organisms in formalin fixed tissues of tilapia. Journal of Fish Diseases, 9, 91-93.
- Olufemi, B. E., Agius, C., and Roberts, R. J. (1983) Aspergillomycosis in intensively cultured tilapia from Kenya. The Veterinary Record 112, 203-204.
- Olufemi, B. E. and Roberts, R. J. (1983) Method for isolation of *Aspergillus* species pathogens of fish from clinical materials. The Veterinary Record 112, 15.
- Olufemi, B. E. and Roberts, R. J. (1986) Induction of clinical aspergillomycosis by feeding contaminated diet to tilapia, *Oreochromis niloticus* (L.). Journal of Fish Diseases 9, 123-128.

### ***Exophiala* & *Phialophora***

- Alderman, D. J. and Feist, S. W. (1985) *Exophiala* infection of kidney of rainbow trout recovering from proliferative kidney disease. Transactions of the British Mycological Society 84(1), 157-185.
- Blazer, V. S. and Wolke, R. E. (1979) An *Exophiala*-like fungus as the cause of a systemic mycosis of marine fish. Journal of Fish Diseases 2, 145-152.
- Carmichael, J. W. (1966) Cerebral mycetoma of trout due to *Phialophora*-like fungus. Sabouraudia 6, 120-123.
- Ellis, A. E., Wadell, I. F., and Minter, D. W. (1983) A systemic fungal disease in Atlantic salmon parr, *Salmo salar* L., caused by a species of *Phialophora*. Journal of Fish Diseases 6, 511-523.
- Langdon, J. S. (1987) A systemic infection of *Exophiala* in native Australian fishes. European Association of Fish Pathologists. Journal 5, 19-27.
- Langdon, J. S., and McDonald, W. L. (1987) Cranial *Exophiala pisciphila* infection in *Salmo salar* in Australia. Bulletin of the European Association of Fish Pathologists, 7(2), 35-37.
- McGinnis, M. R. and Ajello, L. (1974) A new species of *Exophiala* isolated from channel catfish. Mycologia 66, 518-520.
- Niemann, G. J., Van der Bij, A., Brandt-der Boer, B., Boon, J. J., and Baayen, R. P. (1991) Differential response of four carnation cultivars to races 1 and 2 of *Fusarium oxysporum* f. sp. *dianthi* and to *Phialophora cinerescens*. Physiological and Molecular Plant Pathology 38, 117-136.
- Otis, E. J. and Wolke, R. E. (1985) Infection of *Exophiala salmonis* in Atlantic salmon (*Salmo salar* L.). Journal of Wildlife Diseases 21, 61-64.
- Pedersen, O. A. and Langvad, F. (1989) *Exophiala psychrophila* sp. nov., a pathogenic species of the black yeasts isolated from farmed Atlantic salmon. Mycological Research 92(2), 153-156.
- Richards, R. H., Holliman, A., and Helgason, S. (1978) *Exophiala salmonis* infection in Atlantic salmon *Salmo salar* L. Journal of Fish Diseases 1, 357-368.
- Uijthof, J. M. J., Figge, M. J., and de Hoog, G. S. (1996) Molecular and physiological investigations of *Exophiala* species described from fish. Systematic and Applied Microbiology (in press)

### **Fusarium spp.**

- Frasca Jr, S., Dunn, J. L., Cooke, J. C., and Buck, J. D. (1996) Mycotic dermatitis in an Atlantic white-sided dolphin, a pygmy sperm whale, and two harbor seals. *Journal of the American Veterinary Medical Association* 208(5), 727-729.
- Hatai, K. and Egusa, S. (1978) Studies on the pathogenic fungus associated with black gill disease of kuruma prawn, *Penaeus japonicus* - II. Some of the note on the BG-*Fusarium*. *Fish Pathology* 12, 225-231. (In Japanese)
- Hatai, K., Furuya, K., and Egusa, S. (1978) Studies on the pathogenic fungus associated with black gill disease of kuruma prawn, *Penaeus japonicus* - I. Isolation and identification of the BG-*Fusarium*. *Fish Pathology* 12, 219-224. (In Japanese)
- Hatai, K., Kubota, S. S., Kida, N., and Udagawa, S. (1986) *Fusarium oxysporum* in Red Sea Bream (*Pagrus* sp.). *Journal of Wildlife Diseases*, 22(4), 570-571.
- Ishikawa, Y. (1968) On the black discoloration of the gills of cultured kuruma prawn due to fungal infection. *Fish Pathology* 3, 34-38. (In Japanese)
- Marasas, W. F., Smalley, E. B., Degurse, P. E., Bamberg, J. R., and Nichols, R. E. (1969) Acute toxicity to rainbow trout (*Salmo gairdnerii*) of a metabolite produced by the fungus *Fusarium tricinctum*. *Nature (London)* 214, 817-818.
- Momoyama, K. (1987) Distributions of the hyphae in kuruma shrimp, *Penaeus japonicus*, infected with *Fusarium solani*. *Fish Pathology* 22(1), 15-23. (In Japanese, English Abstract)
- Niemann, G. J., Van der Bij, A., Brandt-der Boer, B., Boon, J. J., and Baayen, R. P. (1991) Differential response of four carnation cultivars to races 1 and 2 of *Fusarium oxysporum* f. sp. *dianthi* and to *Phialophora cinerescens*. *Physiological and Molecular Plant Pathology* 38, 117-136.
- Ostland, V. E., Ferguson, H. W., Armstrong, R. D., Asselin, A., and Hall, R. (1987) Case Report: Granulomatous peritonitis in fish associated with *Fusarium solani*. *The Veterinary Record*.
- Rhoobunjongde, W., Hatai, K., Wada, S., and Kubota, S. S. (1991) *Fusarium moniliforme* (Sheldon) isolated from gills of kuruma prawn *Penaeus japonicus* (Bate) with black gill disease. *Bulletin of the Japanese Society of Scientific Fisheries* 57, 629-635.

### **Other Aquatic Animal Mycoses**

- Aho, R., Koshi, P., Salonen, A., and Rintamaeki, P. (1988) Fungal swimbladder infection in farmed Baltic salmon (*Salmo salar* L.) caused by *Verticillium lecanii*. *Mycoses* 31, 208-212.
- Ajello, L., McGinnis, M. R., and Camper, J. (1977) An outbreak of phaeohyphomycosis in rainbow trout caused by *Scolecobasidium humicola*. *Mycopathologia* 62, 15-22.
- Arasaki, S., Nozawa, K., and Miyake, M. (1958) On the pathogenetic water-mold - I. *Bulletin of the Japanese Society of Scientific Fisheries* 23, 534-538. (In Japanese)
- Arasaki, S., Nozawa, K., and Miyake, M. (1958) On the pathogenetic water-mold - II. *Bulletin of the Japanese Society of Scientific Fisheries* 23, 593-598. (In Japanese)
- Awakura, T. and Kimura, T. (1972) Gastro-tympanites occurred in pond-reared masu salmon. *Fish Pathology* 6, 121-124. (In Japanese)
- Bhargava, K. S., Swaup, K., and Singh, C. S. (1971) Fungi parasitic on certain freshwater fishes of Gorakhpur. *Indian Biologist* 3, 65-69.
- Bhattacharya, U. (1988) A new record of fungal fish pathogen *Helminthosporium nodulosum*. *Environmental Ecology* 6, 237-238.
- Bhattacharya, U. (1988) *Scolecobasidium humicola*, a new fungal fish infection from India. *Environmental Ecology* 6, 532-533.
- Bisht, G. S., Bisht, D., Joshi, C., and Khulbe, R. D. (1996) Potential threat to reservoir fishery by fungi in Kumaun Himalaya, India. *Current Science* 71(9), 720-723.
- Bucke, D., Cawley, G. D., Craig, J. F., Pickering, A. D., and Willoughby, L. G. (1979) Further studies of an epizootic of perch *Perca fluviatilis* L., of uncertain aetiology. *Journal of Fish Diseases*, 2, 297-311.
- Butty, A. K. N., Mhaisen, F. T., and Ali, N. M. (1989) Isolation of three water molds from two freshwater fishes and insect exuviae. *J. Environ. Sci. Health (Part A)* 24, 17-22.
- Chidamboram, K. (1942) Fungus disease of gourami (*Osphromenus goramy* Lacepede) in a pond at Madras. *Current Science* 11, 289-290.
- Chien, C.-Y. (1981) Observations on the growth and morphology of saprolegniaceous fungi isolated from rainbow trout (*Salmo gairdnerii*). *Fish pathology* 15(3/4), 241-247.
- Crooks, K. M. (1937) Studies on Australian aquatic Phycomycetes. *Proceedings of the Royal Society of Victoria*, 49, 206-233.
- Dudka, I. A. and Florinskaya, A. A. (1971) New and rare aquatic fungal species isolated from stock ponds in the Leningrad region. *Mikol. Fitopatol.* 5, 431-438.
- Egusa, S. (1970) On a *Mucor* infection of cultured soft-shelled turtle. *Fish Pathology* 5, 43-44. (In Japanese)

- Ermin, R. (1952) Fungus associated with a granuloma in a Turkish fish, *Aphanius chantrei* Gaillard. Zoologica: New York Zoological Society, 37(4), 43-53.
- Gydemo, R. (1996) Signal crayfish, *Pacifastacus leniusculus*, as a vector for *Psorospermium haeckeli* to noble crayfish, *Astacus astacus*. Aquaculture 148, 1-9.
- Hatai, K. and Egusa, S. (1975) *Candida sake* from gastro-tympanites of amago, *Oncorhynchus rhodurus*. Bulletin of the Japanese Society of Scientific Fisheries 41(9), 993.
- Hatai, K. and Kubota, S. S. (1989) A visceral mycosis in cultured masu salmon (*Oncorhynchus masou*) caused by a species of *Ochrocois*. Journal of Wildlife Diseases 25, 88-93.
- Hatai, K., Fugimaki, Y., and Egusa, S. (1986) A visceral mycosis in ayu fry, *Plecoglossus altielis* Temminck and Schlegel, caused by a species of *Phoma*. Journal of Fish Diseases, 9, 111-116.
- Henttonen, P, Huner, J. V., and Lindqvist, O. V. (1995) Observations on *Psorospermium haeckeli* in noble crayfish *Astacus astacus* (L.) (Decapoda, Astacidae), populations in Central Finland. Freshwater Crayfish 10, 339-351.
- Hoshina, T. and Ookuba, M. (1956) On a fungi-disease of eel. J. Tokyo Univ. Fish. 42, 1-13.
- Isayeva, N. M. and Davydov, O. N. (1989) Fish mycoses: a survey. Hydrobiologia 25, 81-86.
- Iwatsu, T., Udagawa, S.-I., and Hatai, K. (1990) *Scyrtidium infestans* sp. nov., isolated from striped jack (*Pseudocaranx dentex*) as a causal agent of systemic mycosis. Transactions of the Mycological Society of Japan 31, 389-397.
- Jha, B. C., Pisolkar, M. D., and Rao, Y. R. (1984) Occurrence of fungal infestation in silver carp, *Hypophthalmichthys molitrix* (Val.) in cages. Journal of the Inland Fisheries Society of India 13, 90.
- Khulbe, R. D. (1983) Pathogenicity of some species of *Pythium* Pringsheim on certain fresh water temperate fishes. Mykosen 26, 273-275.
- Khulbe, R. D. (1987) Some interesting water molds and their adaptability in Kumaun Himalaya. In: Hasija, S. K., Rajak, R. C., and Singh, S. M. (Ed), Perspectives in Mycological Research Vol. 1. Pp. 53-62.
- Khulbe, R. D. (1989) Infection ability of water molds in some temperate fishes of Himalaya, India. Mycoses 32(2), 84-86.
- Khulbe, R. D. (1992) Water molds and their activity in Kumaun Himalaya, India. In: Suzuki, M. (Ed), Water Quality International '92 Vol. 26, Chap. 1-12, Pp. 2595-2598., Washington DC.
- Khulbe, R. D., Joshi, C., and Bisht, G. S. (1995) Fungal diseases of fish in Nanak Sagar, Nainai Tal, India. Mycopathologia 130, 71-74.
- Kuroda, N., Hatai, K., and Kubota, S. S. (1986) A histopathological study on *Ochroconis* infection in yamame salmon; comparison of fish experimentally injected and those naturally infected with *Ochroconis*. Bull. Nippon Vet. Zootech. Coll. 35, 151-157. (In Japanese)
- Laurance, W. F., McDonald, K. R., and Speare, R. (1996) Epidemic disease and the catastrophic decline of Australian rainforest frogs. Conservation Biology 10(2), 406-413.
- Laurance, W. F., McDonald, K. R., and Speare, R. (1997) In defense of the epidemic disease hypothesis. Conservation Biology 11(4), 1030-1034.
- Marchenko, A. M. (1988) Fungi inducing fish mycoses at fish-breeding farms of Sakhalin Island. Mikol. Fitopatol. 22, 210-211.
- McGinnis, M. R. and Ajello, L. (1974) *Scolecobasidium tshawytschae*. Transactions of the British Mycological Society 63(1), 202-203.
- Miyazaki, T., Kubota, S. S., and Tashiro, F. (1977) Studies on visceral mycosis of salmonid fry - I. Histopathology. Fish Pathology 11, 183-186. (In Japanese)
- Morikawa, S. (1971) A short report on the death of sexually-matured one year-old amago salmon. Fish Pathology 5, 157. (In Japanese)
- Nylund, V. and Westman, K. (1995) On the chemical and taxonomic position of the crayfish parasite *Psorospermium haeckeli* Hilgendorf. Freshwater Crayfish 10, 352-362.
- Ogbonna, C. I. C. (1989) Fungi associated with diseases of fresh water fishes in Plateau State, Nigeria. Journal of Aquatic Science 4, 59-62.
- Ogbonna, C. I. C. and Alabi, R. O. (1991) Studies on species of fungi associated with mycotic infections of fish in a Nigerian freshwater fish pond. Hydrobiologia 220, 131-135.
- Ono, T., Kaneko, M., Awakura, T., and Aomi, A. (1966) Pathological studies on *Ichthyosporidium* disease in rainbow trout (*Salmo gairdnerii irideus* Gibbons). Scientific Reports of the Hokkaido Fish Hatchery 21, 43-53. (In Japanese)
- Oros, J., Ramirez, A. S., Poveda, J. B., Rodriguez, J. L., and Fernandez, A. (1996) Systemic mycosis caused by *Penicillium griseofulvum* in a Seychelles giant tortoise (*Megalochelys gigantea*). The Veterinary Record 139(12), 295-296.
- Pillai, C. T. and Freitas, Y. M. (1983) Fungal infection causing mass mortality of freshwater fish *Tilapia mossambica*. Seafood Export Journal 15, 15-17.
- Ross, A. J. and Yasutake, W. T. (1973) *Scolecobasidium humicola*, a fungal pathogen of fish. Journal of the Fisheries Research Board of Canada 30(7), 994-995.

- Ross, A. J., Yasutake, W. T., and Leek, S. (1975) *Phoma herbarum*, a fungal plant saprophyte, as a fish pathogen. Journal of the Fisheries Research Board of Canada 32(9), 1648-1652.
- Rug, M. and Vogt, G. (1995) Histology and histochemistry of developing and mature spores of two morphotypes of "*Psorospermium haeckeli*". Freshwater Crayfish 10, 374-384.
- Sati, S. C. (1983) Aquatic fungi parasitic on temperate fishes of Kamaun Himalaya, India. Mycoses 34, 437-441.
- Sati, S. C. and Khulbe, R. D. (1983) *Pythium gracile* as parasite on fish gills. Indian Phytopathology 36, 587-588.
- Shah, K. L., Jha, B. C., and Jhingran, A. G. (1977) Observations on some aquatic phycomycetes pathogenic to eggs and fry of freshwater fish and prawns. Aquaculture 12, 141-147.
- Shimizu, T. and Egusa, S. (1968) On the sero-types of *Aeromonas liquefaciens* isolated from eels with water mold disease. Fish Pathology 3, 12-15. (In Japanese)
- Söderhäll, K., Rantamaki, J., and Constantinescu, O. (1993) Isolation of *Trichosporon beigeli* from the freshwater crayfish *Astacus astacus*. Aquaculture 116, 25-31.
- Srivastava, A. K. (1979) Fungal infection of hatchling of *Labeo rohita*. Mykosen 22, 40.
- Srivastava, G. C. and Srivastava, R. C. (1976) A note on the destruction of the eggs of *Cyprinus carpio* var. *communis* by the members of the saprolegniaceae. Science and Culture 42, 612-614.
- Srivastava, G. C. and Srivastava, R. C. (1977) *Dictyuchus anomalous* (Nagai), a new pathogen of fresh water teleosts. Current Science 46(4), 118.
- Srivastava, G. C., Sinha, S. K., and Prabhuji, S. K. (1994) Observations on fungal infection of *Chela labuoca* Ham. with special reference to deep mycoses. Current Science 66(3), 237-239.
- Tashiro, F., Morikawa, S., and Arai, M. (1977) A new fungus disease of salmonid fry. Fish Pathology 11, 213-215. (In Japanese)
- Taugbøl, T. and Skurdal, J. (1995) Occurrence and relative abundance of *Psorospermium haeckeli* in Norwegian noble crayfish *Astacus astacus* populations. Freshwater Crayfish 10, 388-395.
- Vishniac, H. S., and Nigrelli, R. F. (1957) The ability of the saprolegniaceae to parasitise platyfish. Zoologica: New York Zoological Society, 42, 131-133.
- Wada, S., Hatai, K., Tanaka, E., and Kitahara, T. (1993) Mixed infection of an acid-fast bacterium and imperfect fungus in a Napoleon fish (*Cheilinus undulatus*). Journal of Wildlife Diseases 29, 591-595.
- Willoughby, L. G. and Roberts, R. J. (1991) Occurrence of the sewage fungus *Leptomitius lacteus*, a necrotroph on perch (*Perca fluviatilis*) in Windermere. Mycological Research 95(6), 755-768.
- Yamazaki, H. (1966) On the occurrence of water mold disease of cultured eel in 1966. Fish Pathology

## Reviews of fish fungi

- Alderman, D. J. (1976) Fungal diseases of marine animals. In: Jones, E. B. G. (Ed), Recent Advances in Aquatic Mycology. Pp. 223-260. Elek Science, London.
- Alderman, D. J. (1982) Fungal disease of aquatic animals. In: Roberts R.J. (Ed), Microbial Diseases of Fish Pp. 189-242. Academic Press, New York.
- Bruno, D. W. (1989) Fungal infections of farmed salmon and trout. Aquaculture Info. Ser. 5, P. 5.
- Coker, W. C. (1923) The Saprolegniaceae. 1969 Reprint. The University of North Carolina Press, Verlag Von J. Cramer, Lehre, Germany. 201 pp.
- Dick, M. W. (1973) Saprolegniales. In: Ainsworth, G. C., Sparrow, F. K., and Sussman, A. S. (Eds), The Fungi, An Advanced Treatise Vol. IVB, Academic Press, New York.
- Dick, M. W. (1990) Oomycota. In: Margulis, L., Corliss, J. O., Melkonian, M., Chapman, D. J., and McKhann, H. I. (Eds), Handbook of the Protoctista. The Structure, Cultivation, Habitats and Life Histories of the Eukaryotic Microorganisms and their Descendants Exclusive of Animals, Plants and Fungi. A Guide to the Algae, Ciliates, Foraminifera, Sporozoa, Water Molds, Slime Molds and the other Protoctists Pp. 661-685. Jones and Bartlett Publishers, Boston.
- Fuller, M. S. (1987) Representative zoosporic fungi. Introduction. In: Fuller, M. S. and Jaworski, A. (Eds), Zoosporic Fungi in Teaching and Research. Palfrey Contributions in Botany. No.3. Pp. 3-7.
- Goven-Dixon, B. A. (1993) Fungal and algal diseases of freshwater tropical fishes. In: Stoskopf, M. K. (Ed), Fish Medicine Pp. 563-568. W.B. Saunders Co., Philadelphia.
- Hatai, K. (1989) Fungal pathogens/parasites of aquatic animals. In: Austin, B. and Austin, D. A. (Eds), Methods for the Microbiological Examination of Fish and Shellfish Pp. 240-272. Ellis Horwood Limited, Chichester.
- Johnson, T. W. (1983) The Saprolegniaceae. University of North Carolina Press, Chapel Hill.
- Neish, G. A., and Hughes, G. C. (1980) Fungal diseases of fish. Diseases of Fishes No. Six. TFH Publications, NJ, USA.
- Noga, E. J. (1990) A synopsis of mycotic diseases of marine fish and invertebrates. In: Perkins, F. O. and Cheng, T. C. (eds), Pathology in Marine Science. Pp. 143-160. Academic Press, New York.

- Noga, E. J. (1993) Fungal diseases of marine and estuarine fishes. Couch, J. A. and Fournie, J. W. (Eds), Pathobiology of Marine and Estuarine Organisms. Pp. 85-110. CRC Press, Inc, Baton Raton, FL, USA.
- Noga, E. J. (1993) Water mold infections of freshwater fish: recent advances. Annual Review of Fish Diseases 3, 291-304.
- Noga, E. J. (1996) Fish Disease - Diagnosis and Treatment. Mosby, St Louis.
- Pickering, A. D. and Willoughby, L. G. (1982) *Saprolegnia* infections of salmonid fish. In: Roberts, R. J. (Ed), Microbial Diseases of Fish. Pp. 271-279. Academic Press, New York.
- Roberts, R. J. (1989) The mycology of teleosts. In: Fish Pathology (Second ed.). Pp. 320-336. Baillière Tindall, London.
- Scott, W. W. (1964) Fungi associated with fish diseases. Developments in Industrial Microbiology 5, 109-123.
- Scott, W. W. and O'Bier, A. H. (1962) Aquatic fungi associated with diseased fish and fish eggs. The Progressive Fish Culturist (January 1962), 3-14.
- Srivastava, R. C. (1976) Studies on fungi associated with fish diseases. PhD thesis, University of Gorakhpur, India, 101 pp.
- Srivastava, R. C. (1979) Studies in fish mycopathologia. A review. I. Mykosen 23, 325-332.
- Srivastava, R. C. (1980) Fungal parasites of certain freshwater fishes of India. Aquaculture 21, 387-392.
- Srivastava, R. C. (1980) Studies in fish-mycopathology - a review. Part II. Mykosen 23(7), 380-391.
- Srivastava, R. C. (1980) Studies in fish-mycopathology - a review. Part III. Mykosen 23(8), 462-469.
- Tiffney, W. N. (1939) The identity of certain species of saprolegniaceae parasitic to fish. Journal of the Elisha Mitchell Scientific Society 55, 134-153.
- Vinobaba, P. and Vinobaba, M. (1993) Fish diseases and fungi (a review). Vingnanam - Journal of Science 8, 47-52.
- Willoughby, L. G. (1994) Fungi and fish diseases. Pisces Press, Stirling, UK
- Wolke, R. E. (1975) Pathology of bacterial and fungal diseases affecting fish. In: W. E. Ribelin, and G. Migaki (Eds), The Pathology of Fishes. Pp. 33-116. University of Wisconsin Press, Winsconsin.

### Biochemical composition

- Bertke, C. C. and Aronson, J. M. (1992) Hyphal wall composition of *Lagenidium giganteum*. Mycologia 84(4), 571-574.
- Garrill, A., Lew, R. R., and Brent Heath, I. (1992) Stretch-activated  $Ca^{++}$  and  $Ca^{++}$ -activated  $K^{+}$  channels in the hyphal tip plasma membrane of the oomycete *Saprolegnia ferax*. Journal of Cell Science 101, 721-730.
- Girard, V., Bulone, V., and Fevre, M. (1992) Separation and partial peptide characterization of B1-3 glucan synthase from *Saprolegnia*. Plant Science 82, 145-153.
- Nakamura, K., Yuasa, K., Sinmuk, S., Hatai, K., and Hara, N. (1995) The ubiquinone system in Oomycetes. Myoscience 36, 121-123.

### Challenge studies, immunology, and interaction between fish and fungi

- Alvarez, F., Razquin, B., Villena, A., L'opez-Fierro, P., and Zapata, A. (1988) Alterations in the peripheral lymphoid organs and differential leukocyte counts in *Saprolegnia*-infected brown trout *Salmo trutta fario*. Veterinary Immunology and Immunopathology 18, 181-193.
- Balakhnin, I. A., Dudka, I. A., and Isaeva, N. M. (1990) Testing of fungi on their specific interaction with fish lectins. Mikologiya I Fitopatologiya 24(5), 416-420. (In Russian)
- Balakhnin, I. A. (1990) The interaction of fish mycopathogens with anti-B lectin of *Salmo gairdneri* eggs. Mikologiya I Fitopatologiya 24(3), 224-228. (In Russian)
- Bly, J. E., Lawson, L. A., Abdel-Aziz, E. S., and Clem, L. W. (1993) Channel catfish, *Ictalurus punctatus*, immunity to *Saprolegnia* sp. Journal of Applied Aquaculture 3(1-2), 35-50.
- Cross, M. L. and Willoughby, L. G. (1989) Enhanced vulnerability of rainbow trout (*Salmo gairdneri*) to *Saprolegnia* infection, following treatment of the fish with an androgen. Mycological Research 93(3), 379-402.
- Diéguez-Urbeondo, J., Cerenius, L., and Söderhäll, K. (1994) *Saprolegnia parasitica* and its virulence on three different species of freshwater crayfish. Aquaculture 120, 219-228.
- Durán, A., Rodríguez Aparicio, L. B., Reglero, A., and Pérez Díaz, J. (1987) Changes in serum enzymes of *Saprolegnia*-infected brown trout, *Salmo trutta* L. Journal of Fish Diseases 10, 505-507.
- El-Sharouny, H. M. and Badran, R. A. M. (1995) Experimental transmission and pathogenicity of some zoosporic fungi to Tilapia fish. Mycopathologia 132, 95-103.
- Hanke, A. R., Backman, S., Speare, D. J., and Friars, G. W. (1991) An uncommon presentation of fungal infection in Atlantic salmon fry. Journal of Aquatic Animal Health 3, 192-197.
- Hatai, K. and Hoshai, G.-I. (1994) Pathogenicity of *Saprolegnia parasitica* Coker. In: Mueller, G. J. (Ed), Salmon Saprolegniasis Pp. 87-98. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Hodkinson, M. and Hunter, A. (1970) Immune response of UDN-infected salmon to *Saprolegnia*. Journal of Fish Biology 2, 305-311.



- Hodkinson, M. and Hunter, A. (1971) The effects of culture media on *Saprolegnia* antigens. *Mycopathologia et Mycologia applicata* 43(3-4), 347-353.
- Hoffman, G. L. (1949) Isolation of *Saprolegnia* and *Achlya* with penicillin-streptomycin, and attempts to infect fish. *Progressive Fish Culturist* 11(3), 171-174.
- Hunter, A. (1976) Fungi and their antibodies in salmon. MSc thesis, University of Salford, England, 84 pp.
- Jarvenpaa, T., Nylund, V., Railo, E., and Westman, K. (1986) The effects of the crayfish plague fungus *Aphanomyces astaci* on the haemolymph of *Astacus astacus* and *Pacifastacus leniusculus*. *Freshwater Crayfish* 6, 223-233.
- Johansson, N., Svensson, K. M., and Fridberg, G. (1982) Studies on the pathology of ulcerative dermal necrosis (UDN) in Swedish salmon, *Salmo salar* L., and sea trout, *Salmo trutta* L., populations. *Journal of Fish Diseases* 5, 293-308.
- Kobayashi, M. and Söderhäll, K. (1990) Comparison of concanavalin A reactive determinants on isolated haemocytes of parasite-infected and non-infected freshwater crayfish. *Diseases of Aquatic Organisms* 9, 141-147.
- Kudo, S. and Teshima, C. (1991) Enzyme activities and antifungal action of fertilization envelope extract from fish eggs. *Journal of Experimental Zoology* 259, 392-399.
- Nilsson, J. (1992) Genetic variation in resistance of arctic Char to fungal infection. *Journal of Aquatic Animal Health* 4, 126-128.
- Persson, M., Cerenius, L., and Söderhäll, K. (1987) The influence of haemocyte number on the resistance of the freshwater crayfish, *Pacifastacus leniusculus* Dana, to the parasitic fungus *Aphanomyces astaci*. *Journal of Fish Diseases* 10, 471-477.
- Persson, M. and Söderhäll, K. (1983) *Pacifastacus leniusculus* Dana and its resistance to the parasitic fungus *Aphanomyces astaci* Schikora. *Freshwater Crayfish* 5, 292-298.
- Pickering, A. D. (1994) Factors influencing the susceptibility of salmonid fish to saprolegniasis. In: Mueller, G. J. (Ed), *Salmon Saprolegniasis* Pp. 67-84. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Pickering, A. D. and Willoughby, L. G. (1977) Epidermal lesions and fungal infection on the perch, *Perca fluviatilis* L., in Windermere. *Journal of Fish Biology* 11, 349-354.
- Pickering, A. D., and Duston, J. (1983) Administration of cortisol to brown trout *Salmo trutta* L., and its effects on the susceptibility to *Saprolegnia* infection and furunculosis. *Journal of Fish Biology*, 23, 163-175.
- Rand, T. G. and Munden, D. (1993) Involvement of zoospores of *Saprolegnia diclina* (Oomycotina: Saprolegniaceae) in the attachment to and invasion of eggs of brook trout under experimental conditions. *Journal of Aquatic Animal Health* 5, 233-239.
- Richards, R. H. and Pickering, A. D. (1979) Changes in serum parameters of *Saprolegnia*-infected brown trout, *Salmo salar* L. *Journal of Fish Diseases* 2, 197-206.
- Roberts, R. J., Shearer, W. M., Munro, A. L. S., and Elson, K. G. R. (1970) Studies on the ulcerative dermal necrosis of salmonids II. The sequential pathology of the lesions. *Journal of Fish Biology* 2, 373-378.
- Roth, R. R. (1972) Some factors contributing to the development of fungus infection in freshwater fish. *Journal of Wildlife Diseases* 8, 24-28.
- Singhal, R. N., Jeet, S., and Davies, R. W. (1987) Experimental transmission of *Saprolegnia* and *Achlya* to fish. *Aquaculture* 64, 1-7.
- Söderhäll, K. and Hall, L. (1984) Lipopolysaccharide-induced activation of prophenoloxidase activating system in crayfish haemocyte lysate. *Biochimica et Biophysica Acta* 797, 99-104.
- Söderhäll, K., Johansson, M. W., and Smith, V. J. (1988) Internal defence mechanisms. In: D.M. Holdich and R.S. Lowery (Eds). *Freshwater Crayfish: Biology, Management and Exploitation*. Pp. 213-235.
- Srivastava, R. C. and Srivastava, G. C. (1978) Fungi associated with the diseases of freshwater fishes. *Mycopathologia* 63(2), 121-126.
- Szalai, A. J., Bly, J. E., and Clem, L. W. (1994) Changes in serum concentrations of channel catfish (*Ictalurus punctatus* Rafinesque) phosphorylcholine-reactive protein (PRP) in response to inflammatory agents, low temperature-shock and infection by the fungus *Saprolegnia* sp. *Fish and Shellfish Immunology* 4, 323-336.
- Unestam, T. and Weiss, D. W. (1970) The host-parasite relationship between freshwater crayfish and the crayfish disease fungus *Aphanomyces astaci*: responses to infection by a susceptible and a resistant species. *Journal of General Microbiology* 60, 77-90.
- Willoughby, L. G. (1989) Continued defence of salmonid fish against *Saprolegnia* fungus, after its establishment. *Journal of Fish Diseases* 12, 63-67.
- Willoughby, L. G. and Pickering, A. D. (1977) Viable Saprolegniaceae spores on the epidermis of the salmonid fish *Salmo trutta* and *Salvelinus alpinus*. *Transactions of the British Mycological Society* 68(1), 91-95.
- Wilson, J. G. M. (1976) Immunological aspects of fungal disease in fish. In: Jones, E. B. G. (Ed), *Recent Advances in Aquatic Mycology* Pp. 573-601. Elek Science, London.
- Wood, S. E., and Willoughby, L. G. (1986) Ecological observations on the fungal colonization of fish by saprolegniaceae in Windermere. *Journal of Applied Ecology*, 23, 737-749.
- Wood, S. E., Willoughby, L. G., and Beakes, G. W. (1986) Preliminary evidence for inhibition of *Saprolegnia* fungus in the

mucus of brown trout, *Salmo trutta* L., following experimental challenge. Journal of Fish Diseases 9, 557-560.

Wood, S. E., Willoughby, L. G., and Beakes, G. W. (1988) Experimental studies on uptake and interaction of spores of the *Saprolegnia diclina-parasitica* complex with external mucus of brown trout (*Salmo trutta*). Transactions of the British Mycological Society 90(1), 63-73.

## Control and treatment

Alderman, D. (1997) Chemicals in the hatchery. Fish Farmer (March/April 1997) P. 13.

Alderman, D. J. (1982) *In vitro* testing of fisheries chemotherapeutants. Journal of Fish Diseases 5, 113-123.

Alderman, D. J. (1985) Malachite green: a review. Journal of Fish Diseases 8, 289-298.

Alderman, D. J. (1991) Malachite green and alternatives. Aquaculture and the Environment. No.14, P. 8.

Alderman, D. J. (1992) Malachite green and its alternatives as therapeutic agents. Aquaculture and the Environment. No.16, Pp. 235-244.

Alderman, D. J. (1994) Control of oomycete pathogens in Aquaculture. Salmon Saprolegniasis. Pp. 111-129. Bonneville Power Administration, US Department of Energy, Portland, USA.

Alderman, D. J. and Polglase, J. L. (1984) A comparative investigation of the effects of fungicides on *Saprolegnia parasitica* and *Aphanomyces astaci*. Transactions of the British Mycological Society 83(2), 313-318.

Alderman, D. J. and Polglase, J. L. (1985) Disinfection for crayfish plague. Aquaculture and Fisheries Management 16, 203-205.

Bailey, T. A. (1983) Method for *in vitro* screening of aquatic fungicides. Journal of Fish Diseases 6, 91-100.

Bailey, T. A. (1983) Screening fungicides for use in fish culture: evaluation of the agar plug transfer, cellophane transfer, and agar dilution methods. Progressive Fish Culturist 45(1), 24-27.

Bailey, T. A. (1984) Effects of twenty-five compounds on four species of aquatic fungi (Saprolegniales) pathogenic to fish. Aquaculture 38, 97-104.

Beakes, G. W. and Gay, J. L. (1980) Effects of streptomycin on the growth and sporulation of *Saprolegnia* spp. Journal of General Microbiology 119, 361-371.

Benoit, R. T. and Matlin, N. A. (1966) Control of *Saprolegnia* on eggs of rainbow trout (*Salmo gairdneri*) with ozone. Transactions of the American Fisheries Society 95, 430-432.

Bisht, G. S., Joshi, C., and Khulbe, R. D. (1996) Watermolds - potential biological control agents of malaria vector *Anopheles culicifacies*. Current Science 70(5), 393-395.

Bly, J. E., Quiniou, M. A., Lawson, L. A., and Clem, L. W. (1996) Therapeutic and prophylactic measures for winter saprolegniosis in channel catfish. Diseases of Aquatic Organisms 24, 25-33.

Bly, J. E., Quiniou, S. M. A., Lawson, L. A., and Clem, L. W. (1997) Inhibition of *Saprolegnia* pathogenic for fish by *Pseudomonas fluorescens*. Journal of Fish Diseases 20, 35-40.

Bowers, J. H., and Parke, J. L. (1993) Epidemiology of *Pythium* damping-off and *Aphanomyces* root rot of peas after seed treatment with bacterial agents for biological control. Phytopathology, 83(12), 1466-1473.

Cadwallader, P. L. and Gooley, G. J. (1981) An evaluation of the use of the amphipod *Austrochiltonia* to control growth of *Saprolegnia* on the eggs of Murray cod *Maccullochella peelii* (Mitchell). Aquaculture 24, 187-190.

Cerenius, L., Rufelt, S., and Söderhäll, K. (1992) Effects of ampropylfos ((RS)-1-aminopropylphosphonic acid) on zoospore formation, repeated zoospore emergence and oospore formation in *Aphanomyces* spp. Pesticide Science, 36(3), 189-194.

Chanratchakool, P. (1992) Potassium permanganate in aquaculture. The AAHRI Newsletter, 3(1), 3. Aquatic Animal Health Research Institute, Bangkok.

Chinabut, S. (1993) Malachite green - a therapeutic chemical. The AAHRI Newsletter, 2(2), 1. Aquatic Animal Health Research Institute, Bangkok.

Chinabut, S., Chanratchakul, P., and Lilley, J. H. (1992) A therapeutic chemical. The AAHRI Newsletter, 1(1), 4. Aquatic Animal Health Research Institute, Bangkok.

Chinabut, S., and Lilley, J. H. (1992) A therapeutic chemical - lime for aquaculture. The AAHRI Newsletter, 1(2), 2. Aquatic Animal Health Research Institute, Bangkok.

Dawson, V. K., Rach, J. J., and Schreier, T. M. (1994) Hydrogen peroxide as a fungicide for fish culture. Bulletin of the Aquaculture Association of Canada 94-2, 54-56.

Edgell, P., Lawseth, D., McLean, W. E., and Britton, E. W. (1993) The use of salt solutions to control fungus (*Saprolegnia*) infestations on salmon eggs. The Progressive Fish Culturist 55, 48-52.

Fitzpatrick, M. S., Schreck, C. B., and Chitwood, R. L. (1995) Evaluation of three candidate fungicides for treatment of adult spring chinook salmon. The Progressive Fish-Culturist 57, 153-155.

Froelich, S. L. and Engelhardt, T. (1996) Comparative effects of formalin and salt treatments on hatch rates of koi carp eggs. Progressive Fish-Culturist 58(3), 209-211.

- Hall, L. and Unestam, T. (1980) The effect of fungicides on survival of the crayfish plague fungus, *Aphanomyces astaci*, Oomycetes, growing on fish scales. *Mycopathologia* 72(3), 131-134.
- Hamasaki, K. and Hatai, K. (1993) Prevention of fungal infection in the eggs and larvae of the swimming crab *Portunus trituberculatus* and the mud crab *Scylla serrata* by bath treatment with formalin. *Bulletin of the Japanese Society of Scientific Fisheries* 59(6), 1067-1072. (In Japanese)
- Hatai, K., Nakajima, K., and Egusa, S. (1974) Effects of some fungicides on black gill disease of kuruma prawn, *Penaeus japonicus* caused by *Fusarium* sp. *Fish Pathology* 8, 156-160. (In Japanese)
- Hatai, K., Nakajima, K., Nishide, K., Kamata, and Egusa, S. (1974) Preliminary studies on the efficacy of some chemicals for gastro-tympanites in cultured salmonids. *Fish Pathology* 8, 171-174. (In Japanese)
- Hatai, K. and Willoughby, L. G. (1988) *Saprolegnia parasitica* from rainbow trout inhibited by a bacterium, *Pseudomonas fluorescens*. *Bulletin of the European Association of Fish Pathologists* 8, 27-29.
- Helgason, S. (1977). Effects of four antifungal agents on fungi associated with fish disease. MSc thesis, University of Stirling, 65 pp.
- Hoshina, T., Sano, T., Sunayama, M., and Nakano, I. (1956) Studies on the control of aquatic fungi occurring on the eggs of pond smelt, *Hypomesus olidus* (Pallas). *J. Tokyo Univ. Fish.* 42, 1-13. (In Japanese)
- Jozsef, F. and Janos, O. (1979) Ecology and sensitivity to fungicides of fish parasitic fungi. *Halhusterm. Fejl. Szarvas Hungary Haltenyesztesi Kutato Intezet.* No.8, P. 96.
- Kaji, S., Kanematsu, M., Tezuka, N., Fushimi, H., and Hatai, K. (1991) Effect of formalin for *Haliphthoros* infection on ova and larvae of the mangrove crab *Scylla serrata*. *Bulletin of the Japanese Society of Scientific Fisheries* 57, 51-55. (In Japanese)
- Kitancharoen, N., Ono, A., Yamamoto, A., and Hatai, K. (1997) The fungistatic effect of NaCl on rainbow trout egg saprolegniasis. *Fish Pathology* 32(3), 159-162.
- Kitancharoen, N., Yamamoto, A., and Hatai, K. (1997) Fungal infection on salmonid eggs and its treatment. In: Abstracts of the International Symposium on Diseases in Marine Aquaculture, Hiroshima, Japan, 36 October 1997. P. 102 Japanese Society of Fish Pathology
- Knittel, M. D. (1966) Topical application of malachite green for control of common fungus infections in adult spring chinook salmon. *The Progressive Fish-Culturist* 28, 51-53.
- Li, K. H., Wise, D. J., and Robinson, E. H. (1996) Chemical prevention and treatment of winter saprolegniosis (winter kill) in channel catfish *Ictalurus punctatus*. *Journal of the World Aquaculture Society* 27(1), 1-6.
- Lio-Po, G. D., Sanvictores, M. E. G., Baticados, M. C. L., and Lavilla, C. R. (1982) *In vitro* effect of fungicides on hyphal growth and sporogenesis of *Lagenidium* spp. isolated from *Penaeus monodon* larvae and *Scylla serrata* eggs. *Journal of Fish Diseases* 5, 97-112.
- Mahadevan, B. and Crawford, D. L. (1997) Properties of the chitinase of the antifungal biocontrol agent *Streptomyces lydicus*. *Enzyme and Microbiol Technology* 20(7), 489-493.
- Marking, L. L. (1991) Development of carbon filtration systems for removal of malachite green. In: Colt, J. and White, R. J. (Ed), *Fisheries Bioengineering Symposium*. No.10., 427 pp. Bioengineering Section, American Fisheries Society, Bethesda, MD, USA.
- Marking, L. L., Leith, D., and Davis, J. (1990) Development of a carbon filter system for removing malachite green from hatchery effluents. *Progressive Fish-Culturist* 52(2), 92-99.
- Marking, L. L., Rach, J. J., and Schreier, T. M. (1994) Evaluation of antifungal agents for fish culture. *The Progressive Fish-Culturist* 56(4), 225-231.
- Marking, L. L., Rach, J. J., and Schreier, T. M. (1994) Search for antifungal agents in fish culture. *Salmon Saprolegniasis*. Pp. 131-148. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Meinertz, J. R., Stehly, G. R., Gingerrich, W. H., and Allen, J. L. (1995) Residues of [14C]-malachite green in eggs and fry of rainbow trout, *Oncorhynchus mykiss* (Walbaum), after treatment of eggs. *Journal of Fish Diseases* 18, 239-247.
- Min, H.-K., Hatai, K., and Bai, S. (1994) Some inhibitory effects of chitosan on fish-pathogenic Oomycetes, *Saprolegnia parasitica*. *Fish Pathology* 29(2), 73-77.
- Murphy, T. M. (1981) The use of chemosterilants to lower the frequency of skin fungal infection amongst precocious male 1+ Atlantic salmon parr, *Salmo salar* L. *Journal of Fish Diseases* 4, 387-395.
- Oseid, D. M. (1977) Control of fungus growth on fish eggs by *Aspergillus militaris* and *Gammouarus pseudolimnaeus*. *Transactions of the American Fisheries Society* 106(2), 192-195.
- Perrucci, S., Cecchini, S., Pretti, C., Cognetti, A. M. V., Macchioni, G., Flamini, G., and Cioni, P. L. (1995) *In vitro* antimycotic activity of some natural products against *Saprolegnia ferax*. *Phytotherapy Research*, 9(2), 147-149.
- Petersen, A., Jegstrup, I., and Olson, L. W. (1994) Screening for bacterial antagonists against *Saprolegnia parasitica* with BASF Pluronic Polyol F127. *Salmon Saprolegniasis*. Pp. 149-160. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Rantamäki, J., Cerenius, L., and Söderhäll, K. (1992) Prevention of transmission of the crayfish plague fungus (*Aphanomyces astaci*) to the freshwater crayfish *Astacus astacus* by treatment with MgCl<sub>2</sub>. *Aquaculture* 104, 11-18.

- Ruch, D. G. and Bland, C. E. (1979) Ultrastructural changes induced in zoospores of *Lagenidium callinectes* by exposure to Captan. Canadian Journal of Botany 57(20), 2116-2121.
- Rucker, R. R., Taylor, W. G., and Toney, D. P. (1963) Formalin in the hatchery. The Progressive Fish-Culturist 25, 203-207.
- Sarkar, K. K. (1995) Banana commands ulceration. Abstracts of the Fourth Asian Fisheries Forum., Beijing, China, 16-20 October 1995. p. 45 Asian Fisheries Society and China Society Fisheries
- Sati, S. C. (1983) Uses of certain chemicals in controlling fungal parasites of fish. Bibliotheca Mycologica, 91, 673-683.
- Scott, W. W., and Warren, J. C. O. (1964) Studies of the host range and chemical control of fungi associated with diseased tropical fish. (Technical Bulletin No. 171). Virginia Agricultural Experiment Station, Blacksburg, Virginia, USA.
- Söderhäll, K., Svensson, E., and Unestam, T. (1977) An inexpensive and effective method for elimination of the crayfish plague: barriers and biological control. Freshwater Crayfish 3, 333-342.
- Srivastava, G. C. and Srivastava, R. C. (1980) A note on the potential applicability of malachite green oxalate in combating fish-mycoses. Mycopathologia 64(3), 169-171.
- Srivastava, R. C. (1980) Chemotherapeutic examination in cases of fish mycoses. Monatshefte fuer Veterinaermedizin 35(7), 267-269.
- Svensson, E., Söderhäll, K., Unestam, T., and Andersson, B.-O. (1976) Liming: an overestimated method for preventing the spread of the crayfish plague. Report No. 55. Institute of Freshwater Research, Drottningholm, Sweden.
- Taylor, S. G. and Bailey, J. E. (1979) *Saprolegnia*: control of fungus on incubating eggs of pink salmon by treatment with seawater. The Progressive Fish Culturist 41(4), 181-183.
- Theron, J., Prinsloo, J. F., and Schoonbee, H. J. (1991) Treatment of *Cyprinus carpio* L. and *Clarias gariepinus* (Burchell) embryos with formalin and malachite green: effect of concentration and length of treatment on their survival. Onderstepoort Journal of Veterinary Research 58, 239-243.
- Willoughby, L. G. and Roberts, R. J. (1992) Towards strategic use of fungicides against *Saprolegnia parasitica* in salmonid fish hatcheries. Journal of Fish Diseases 15, 1-13.
- Yuasa, K. and Hatai, K. (1996) Investigation of effective chemicals for treatment of saprolegniasis caused by *Saprolegnia parasitica*. Journal of Antibacterial and Antifungal Agents 24(1), 27-31. (In Japanese, English abstract)

## Enzymology

- Alberts, V. A., Khan, S. S., Lim, D. V., and Te, Strake D. (1989) Extracellular enzyme activity of some Saprolegniales from a Florida estuary. Mycologia 81(3), 460-463.
- Cerenius, L. and Söderhäll, K. (1984) Isolation and properties of B-glucans synthetase from the aquatic fungus, *Aphanomyces astaci*. Physiologia Plantarum 60, 247-252.
- Herman, R. P. and Luchini, M. M. (1989) Lipoxygenase activity in the Oomycete *Saprolegnia* is dependent on environmental cues and reproductive competence. Experimental Mycology 13, 372-379.
- Peduzzi, R., Nolard-Tintigner, N., and Bizzozero, S. (1976) Investigations on saprolegniasis. II. Study on the process of penetrations showing evidence of a proteolytic enzyme and histopathological aspects. Riv. Ital. Piscicoltura. Ittiopatol. 11, 109-117. (In French)
- Rand, T. G. and Munden, D. (1992) Enzyme involvement in the invasion of brook char, *Salvelinus fontinalis* (Mitchill), eggs by *Saprolegnia diclina* (Oomycotina: Saprolegniaceae). Journal of Fish Diseases 15, 91-94.
- Smith, S. N., Chohan, R., Howitt, S. G., and Armstrong, R. A. (1994) Proteolytic activity amongst selected *Saprolegnia* species. Mycological Research 98(4), 389-395.
- Söderhäll, K. (1978) Interactions between a parasitic fungus, *Aphanomyces astaci*, Oomycetes, and its crayfish host. II Studies on the fungal enzymes and on the activation of crayfish prophenoloxidase by fungal components. PhD thesis, Uppsala University, Sweden,
- Söderhäll, K. (1980) Components from fungi elicit defence reactions in animals. Abstracts of the Second Nordic Symposium on Mycology, University of Uppsala, Sweden. Pp. 44-45.
- Söderhäll, K. (1987) Protease activity measurements in aquatic fungi. Zoosporic Fungi in Teaching and Research. No.3, P. 224. Palfrey Contributions in Botany.
- Söderhäll, K. and Ajaxon, R. (1982) Effect of quinones and melanin on mycelial growth of *Aphanomyces* spp. and extracellular protease of *Aphanomyces astaci*, a parasite on crayfish. Journal of Invertebrate Pathology 39, 105-109.
- Söderhäll, K., Svensson, E., and Unestam, T. (1978) Chitinase and protease activities in germinating zoospore cysts of a parasitic fungus, *Aphanomyces astaci*, Oomycetes. Mycopathologia 64(1), 9-11.
- Söderhäll, K. and Unestam, T. (1975) Properties of extracellular enzymes from *Aphanomyces astaci* and their relevance in the penetration process of crayfish cuticle. Physiologia Plantarum 35, 140-146.
- Thompson, A. and Dix, J. (1985) Cellulase activity in the Saprolegniaceae. Transactions of the British Mycological Society 85(2), 361-366.
- Unestam, T. (1966) Chitinolytic, cellulolytic and pectinolytic activity *in vitro* of some parasitic and saprophytic Oomycetes.

Physiologia Plantarum 19, 15-30.

## Growth and morphology

- Cerenius, L., and Söderhäll, K. (1980) Asexual reproduction in *Aphanomyces astaci*. Abstract of the Second Nordic Symposium on Mycology, University of Uppsala, Sweden, Pp. 4-5.
- Dick, M. W. (1969) Morphology and taxonomy of the Oomycetes with special reference to Saprolegniaceae, Leptomitaceae and Pythiaceae I. Sexual reproduction. *New Phytologist* 68, 51-775.
- Dick, M. W. (1971) Oöspore structure in *Aphanomyces*. *Mycologia* 63, 686-688.
- Dick, M. W. (1972) Morphology and taxonomy of the Oomycetes, with special reference to Saprolegniaceae, Leptomitaceae and Pythiaceae. II. Cytogenetic systems. *New Phytologist* 71, 1151-1159.
- Dick, M. W. and Win-Tin. (1973) The development of the cytological theory in the Oomycetes. *Biological Review* 48, 133-158.
- Fowles, B. (1976) Factors affecting growth and reproduction in selected species of *Aphanomyces*. *Mycologia* 68, 1221-1232.
- Gleason, F. H. (1973) Uptake of amino acids by *Saprolegnia*. *Mycologia* 65, 465-468.
- Gleason, F. H., Rudolph, C. R., and Price, J. S. (1970) Growth of certain aquatic oomycetes on amino acids I. *Saprolegnia*, *Achlya*, *Leptolegnia*, and *Dictyuchus*. *Physiologia Plantarum* 23, 513-516.
- Heath, I. B. (1980) Behavior of kinetochores during mitosis in the fungus *Saprolegnia ferax*. *Journal of Cell Biology* (84), 531-546.
- Heath, I. B. and Greenwood, A. D. (1968) Electron microscopic observations of dividing somatic nuclei in *Saprolegnia*. *Journal of General Microbiology* 53, 287-289.
- Heath, I. B. and Greenwood, A. D. (1970) Centriole replication and nuclear division in *Saprolegnia*. *Journal of General Microbiology* 62, 139-148.
- Heath, I. B. and Rethoret, K. (1981) Nuclear cycle of *Saprolegnia ferax*. *Journal of Cell Science* 49, 353-367.
- Howard, K. L. (1971) Oöspore types in the saprolegniaceae. *Mycologia* 63, 679-686.
- Kaminskyj, S. G. W. and Heath, I. B. (1996) Studies on *Saprolegnia ferax* suggest the general importance of the cytoplasm in determining hyphal morphology. *Mycologia* 88(1), 20-37.
- Kanouse, B. B. (1932) A physiological and morphological study of *Saprolegnia parasitica*. *Mycologia* 24, 431-452.
- Kitancharoen N., Yuasa, K., and Hatai, K. (1996) Effects of pH and temperature on growth of *Saprolegnia diclina* and *S. parasitica* isolated from various sources. *Myoscience* 37, 385-390.
- Llanos, M. C., and Lockwood, J. L. (1960) Factors affecting zoospore production by *Aphanomyces euteiches*. *Phytopathology*, 50, 826-830.
- Neish, G. A. (1975) Observations on the growth and morphology of Emerson's *Saprolegnia* sp. 47-15a. *Canadian Journal of Botany* 53, 1423-1427.
- Nolan, R. A. (1976) Physiological studies of an isolate of *Saprolegnia ferax* from the larval gut of the blackfly *Simulium vittatum*. *Mycologia* 68, 523-540.
- Oláh, J. and Farkas, J. (1978) Effect of temperature, pH, antibiotics, formalin and malachite green on the growth and survival of *Saprolegnia* and *Achlya* parasitic on fish. *Aquaculture* 13, 273-288.
- Padgett, D. E. (1978) Salinity tolerance of an isolate of *Saprolegnia australis*. *Mycologia* 70, 1288-1293.
- Padgett, D. E. (1980) Vegetative propagation of some Saprolegniaceae under simulated-estuarine-culture conditions. *Mycologia* 72, 410-415.
- Padgett, D. E. (1984) Evidence for extreme salinity tolerance in Saprolegniaceous fungi (Oomycetes). *Mycologia* 76(2), 372-375.
- Padgett, D. E., Kendrick, A. S., Hearth, J. H., and Webster, W. D. (1988) Influence of salinity, temperature and nutrient availability of saprolegniaceous fungi (Oomycetes). *Holarctic Ecology* 11, 119-126.
- Peduzzi, R., Kappeli, F., and Turian, G. (1991) Repercussion de l'acidification de l'eau sur l'insurgence de la saprolegniose chez le poisson. *Sydowia* 43, 135-147. (In French)
- Powell Jr, J. R., Scott, W. W., and King, N. R. (1972) Physiological parameters of growth in *Saprolegnia parasitica* Coker. *Mycopathol. Mycol. Appl.* 47, 1-40.
- Robinson, P. M. and Bolton, S. K. (1984) Autotropism in hyphae of *Saprolegnia ferax*. *Transactions of the British Mycological Society* 83(2), 257-263.
- Schoulties, C. I., and Yang, C. Y. (1972) Sporulation of *Aphanomyces euteiches*. *Phytopathology*, 62, 788.
- Smith, S. N., Ince, E., and Armstrong, R. A. (1990) Effect of osmotic and matrix potential on *Saprolegnia diclina* and *S. ferax*. *Mycological Research* 94(1), 71-77.
- Smith, S. N., Jeffers, D., and DeVay, J. E. (1994) Effect of glucose and biotin on the growth and sporulation of *Fusarium* species, especially pathogenic and nonpathogenic isolates of *Fusarium oxysporum*. *Mycologia* 86(4), 547-554.

- Söderhäll, K. and Cerenius, L. (1987) Controlled growth and development in filamentous Oomycetes with emphasis on *Aphanomyces* spp. Zoosporic Fungi in Teaching and Research. No.3. Pp. 264-267. Palfrey Contributions in Botany
- Szaniaszlo P.J. (1965) A study of the effect of light and temperature on the formation of oogonia and oospheres in *Saprolegnia diclina*. Journal of the Elisha Mitchell Scientific Society 18, 10-15.
- Te Strake, D. (1959) Estuarine distribution and saline tolerance of some Saprolegniaceae. Øyton 12(2), 147-152.
- Unestam, T. (1965) Studies on the crayfish plague fungus *Aphanomyces astaci*. I. Some factors affecting growth *in vitro*. Physiologia Plantarum 18, 483-505.
- Unestam, T. (1969) On the adaptation of *Aphanomyces astaci* as a parasite. Physiologia Plantarum 22, 221-235.
- Unestam, T. and Gleason, F. H. (1968) Comparative physiology of respiration in aquatic fungi II. The Saprolegniales, especially *Aphanomyces astaci*. Physiologia Plantarum 21, 573-588.
- Whiffen, A. J. (1945) Nutritional studies of representatives of five genera in the Saprolegniaceae. Journal of the Elisha Mitchell Scientific Society 61(1-2), 114.
- Willoughby, L. G. and Copland, J. W. (1984) Temperature - growth relationships of *Saprolegnia* pathogenic to fish, especially eels cultivated in warm water. Nova Hedwigia 39, 35-55.
- Willoughby, L. G. and Hasenjäger, R. (1987) Formation and function of appressoria in *Saprolegnia*. Transactions of the British Mycological Society 89(3), 373-380.

### Maintenance and isolation

- Alderman, D. J. and Polglase, J. L. (1986) *Aphanomyces astaci*: isolation and culture. Journal of Fish Diseases 9, 367-379.
- Beghdadi, A., Richard, C., and Dostaler, D. (1992) L'*Aphanomyces euteiches* des luzernières du Québec: isolement, morphologie et variabilité de la croissance et du pouvoir pathogène. Canadian Journal of Botany 70, 1903-1911. (in French, English abstract)
- Neish, G. A. (1975) Carbenicillin as an aid in obtaining bacteria-free cultures of *Saprolegnia* species. Mycologia, 67, 1192-1197.
- Porter, D. (1987) Isolation of zoosporic marine fungi. In: Fuller, M. S. (Ed), Zoosporic Fungi in Teaching and Research Vol. 3, Pp. 128-129. Palfrey Contributions in Botany.
- Smith, D., & Onions, A. H. S. (1994) The preservation and maintenance of living fungi. Technical Handbooks No. 2. International Mycological Institute, Kew, UK

### Molecular biology

- Crowhurst, R. N., King, F. Y., Hawthorne, B. T., Sanderson, F. R., and Choipheng, Y. (1995) RAPD characterization of *Fusarium oxysporum* associated with wilt of angsana (*Pterocarpus indicus*) in Singapore. Mycological Research, 99(1), 14-18.
- Czaplicki, A., Galimova, L. M., and Bubenshchikova, S. N. (1986) The system of the saprolegniaceae checked by DNA analysis. Zhurnal Evolyutsionnoi Biokhimii Fiziologii 22, 117-122. (In Russian, English abstract)
- Edel, V., Steinberg, C., Cauteron, N., and Alabouvette, C. (1997) Evaluation of restriction analysis of polymerase chain reaction (PCR)-amplified ribosomal DNA for the identification of *Fusarium* species. Mycological Research 101(2), 179-187.
- Heinäaho, M. (1996) Identification of *Saprolegnia* sp. strains in salmon, *Salmo salar* and brown trout, *Salmo trutta*. BSc project thesis, University of Uppsala, Sweden, 20 pp.
- Huang, T.-S., Cerenius, L., and Söderhäll, K. (1994) Analysis of genetic diversity in the crayfish plague fungus, *Aphanomyces astaci*, by random amplification of polymorphic DNA. Aquaculture 126, 1-10.
- Kawasaki, M., Ishizaki, H., Nishimura, K., and Miyaji, M. (1993) Mitochondrial DNA analysis of *Exophiala moniliae*. Mycopathologia, 121(1), 7-10.
- Molina, F. I., Jong, S.-C., and Ma, G. (1995) Molecular characterization and identification of *Saprolegnia* by restriction analysis of genes coding for ribosomal RNA. Antonie van Leeuwenhoek 68, 65-74.
- Neish, G. A. and Green, B. R. (1976) Nuclear and satellite DNA base composition and the taxonomy of *Saprolegnia* (Oomycetes). Journal of General Microbiology 96, 215-219.
- Ragan, M. A., Goggin, C. L., Cawthorn, R. J., Cerenius, L., Jamieson, A. V. C., Plourde, S. M., Rand, T. G., Söderhäll, K., and Gutell, R. R. (1996) A novel clade of protistan parasites near the animal-fungal divergence. Proceedings of the National Academy of Sciences of the USA 93, 11907-11912.
- Uijthof, J. M. J. (1996) Relationships within the black yeast genus *Exophiala* based on ITS1 sequences. Mycological Research 100(10), 1265-1271.
- Yeh, Y. (1989). Inter- and intraspecific restriction fragment length polymorphisms in the genus *Aphanomyces*. PhD thesis, Texas AandM University,

### Spore assays and ecology

- Agina, S. E. and Kpu, R. S. (1988) A survey of aquatic phycmycetes of rockwater fish farms in Jos, Plateau State, Nigeria. Nigerian Journal of Applied Fisheries and Hydrobiology 3, 39-44.

- Alabi, R. O. (1971) Factors affecting seasonal occurrence of Saprolegniaceae in Nigeria. Transactions of the British Mycological Society 56(2), 289-299.
- Alabi, R. O. (1971) Seasonal periodicity of Saprolegniaceae at Ibadan, Nigeria. Transactions of the British Mycological Society 56(3), 337-341.
- Celio, D. A. and Padgett, D. E. (1989) An improved method of quantifying water mold spores in natural water columns. Mycologia 81(3), 459-460.
- Dick, M. W. (1966) The Saprolegniaceae of the environs of Blelham Tarn: sampling techniques and the estimation of propagule numbers. Journal of General Microbiology 42, 257-282.
- Dick, M. W. (1971) The ecology of Saprolegniaceae in lentic and littoral muds with a general theory of fungi in the lake ecosystem. Journal of General Microbiology 65, 325-337.
- Klich, M. A. and Tiffany, L. H. (1985) Distribution and seasonal occurrence of aquatic saprolegniaceae in northwest Iowa. Mycologia 77, 373-380.
- Lilley, J. H. (1992) Assaying pond water for spores of saprolegniaceous fungi. Proceedings of the Seminar on Fisheries. National Inland Fisheries Research Institute, 16-18 September 1992. Pp. 79-82 Department of Fisheries, Kasetsart University, Bangkok.
- Lilley, J. H. (1992) Assaying pond water for spores of saprolegniaceous fungi. AAHRI Newsletter, 1(2), 5. Aquatic Animal Health Research Institute, Bangkok.
- Padgett, D. E. (1978) Observations on estuarine distribution of Saprolegniaceae. Transactions of the British Mycological Society 70(1), 141-143.
- Petersen, A. B., Olson, L. W., and Rosendahl, S. (1996) Use of polyclonal antibodies to detect oospores of *Aphanomyces*. Mycological Research 100(4), 495-499.
- Pfender, W. F., Rouse, D. I., and Hagedorn, D. J. (1981) A most probable number method for estimating inoculum density of *Aphanomyces euteiches* in naturally infested soil. Phytopathology 71(11), 1169-1172.
- Roberts, R. E. (1963) A study of the distribution of certain members of the saprolegniales. Transactions of the British Mycological Society 46(2), 213-224.
- Seymour, R. and Fuller, M. S. (1987) Collection and isolation of water molds (Saprolegniaceae) from water and soil. In: M.S. Fuller (Ed). Zoospore Fungi in Teaching and Research. Pp. 125-127. Palfrey Contributions in Botany No.3.
- Smith, S. N., Armstrong, S. A., and Rimmer, J. J. (1984) Influence of environmental factors on zoospores of *Saprolegnia diclina*. Transactions of the British Mycological Society 82, 413-421.
- Waterstrat, P. R. (1997) Distribution and abundance of *Saprolegnia* in the water system of a chinook salmon hatchery. Journal of Aquatic Animal Health 9, 58-63.
- Willoughby, L. G. (1970) Mycological aspects of a disease of young perch in Windemere. Journal of General Microbiology 65, 325-337.
- Willoughby, L. G., Pickering, A. D., and Johnson, H. G. (1984) Polycell-gel assay of water for spores of Saprolegniaceae (fungi), especially those of the *Saprolegnia* pathogen of fish. Hydrobiologia 114, 237-248.
- Willoughby, L. G. and Roberts, R. J. (1992) The ecology of *Olpidiopsis incrassata*, *Rozellopsis septigena* and *Woronina polycystis*, biflagellate fungal parasites of *Saprolegnia* fungus in fresh water. Nova Hedwigia 55(1-2), 1-9.

## Taxonomy

- Beakes, G. and Ford, H. (1983) Esterase isoenzyme variation in the genus *Saprolegnia*, with particular reference to the fish-pathogenic *S. diclina* complex. Journal of General Microbiology 129, 2605-2619.
- Beakes, G. W., Wood, S. E., and Burr, A. W. (1994) Features which characterize *Saprolegnia* isolates from salmonid fish lesions - a review. In: Mueller, G. J. (Ed), Salmon Saprolegniasis Pp. 33-66. Bonneville Power Administration, US Department of Energy, Portland, USA.
- Bullis, R. A., Noga, E. J., and Levy, M. G. (1990) Immunological relationship of the fish-pathogenic Oomycete *Saprolegnia parasitica* to other Oomycetes and unrelated fungi. Journal of Aquatic Animal Health 2, 223-227.
- Bullis, R. A., Noga, E. J., and Levy, M. G. (1996) Production and preliminary characterization of monoclonal antibodies to *Saprolegnia parasitica*. Mycological Research 100(4), 489-494.
- Holub, E. B., Grau, C. R., and Parke, J. L. (1991) Evaluation of the *forma specialis* concept in *Aphanomyces euteiches*. Mycological Research 95(2), 147-157.
- Jong, S.-C., Davis, E. E., McManus, C., and Krichevsky, M. I. (1991) Computer coding of the strain features of the saprolegnian fungi. Mycotaxon XLI(2), 407-418.
- Peduzzi, R. and Bizzozero, S. (1977) Immunochemical investigation of four *Saprolegnia* species with parasitic activity in fish: serological and kinetic characterization of a chymotrypsin-like activity. Microbial Ecology 3, 107-118.
- Wood, S. E. (1988). The monitoring and identification of *Saprolegnia parasitica* and its infection of salmonid fish. PhD Thesis, University of Newcastle upon Tyne. 175 pp.

## Ultrastructure

- Armbruster, B. L. (1982) Sporangio genesis in three genera of the saprolegniaceae. I. Pre-sporangium hyphae to early primary spore initial stage. *Mycologia* 74(3), 433-459.
- Armbruster, B. L. (1982) Sporangio genesis in three genera of the Saprolegniaceae. II. Primary spore initial to secondary spore initial stage. *Mycologia* 74(6), 975-999.
- Beakes, G. (1983) A comparative account of cyst coat ontogeny in saprophytic and fish-lesion (pathogenic) isolates of the *Saprolegnia diclina* - *parasitica* complex. *Canadian Journal of Botany* 61, 603-625.
- Beakes, G. W. (1980) Electron microscopic study of oospore maturation and germination in an emasculate isolate of *Saprolegnia ferax*. 1 Gross changes. *Canadian Journal of Botany* 58, 182-194.
- Beakes, G. W. (1980) Electron microscopic study of oospore maturation and germination in an emasculate isolate of *Saprolegnia ferax*. 2 Wall differentiation. *Canadian Journal of Botany* 58, 195-208.
- Beakes, G. W. (1980) Electron microscopic study of oospore maturation and germination in an emasculate isolate of *Saprolegnia ferax*. 3 Changes in organelle status and associations. *Canadian Journal of Botany* 58, 209-227.
- Beakes, G. W. (1980) Electron microscopic study of oospore maturation and germination in an emasculate isolate of *Saprolegnia ferax*. 4 Nuclear cytology. *Canadian Journal of Botany* 58, 228-240.
- Beakes, G. W., Canter, H. M., and Jaworski, G. H. M. (1993) Sporangium differentiation and zoospore fine-structure of the chytrid *Rhizophyidium planktonicum*, a fungal parasite of *Asterionella formosa*. *Mycological Research* 97(9), 1059-1074.
- Beakes, G. W. and Gay, J. L. (1978) Light and electron microscopy of oospore maturation in *Saprolegnia furcata*. I. Cytoplasmic changes. *Transactions of the British Mycological Society* 71(1), 11-24.
- Beakes, G. W. and Gay, J. L. (1978) Light and electron microscopy of oospore maturation in *Saprolegnia furcata*. I. Wall development. *Transactions of the British Mycological Society* 71(1), 25-35.
- Berbee, M. L. and Kerwin, J. L. (1993) Ultrastructural and light microscopic localization of carbohydrates and peroxidase catalases in *Lagenidium giganteum* zoospores. *Mycologia* 85(5), 734-743.
- Burr, A. W. and Beakes, G. W. (1994) Characterization of zoospore and cyst surface structure in saprophytic and fish pathogenic *Saprolegnia* species (oomycete fungal protists). *Protoplasma* 181, 142-163.
- Cerenius, L., Olson, L. W., Lange, L., and Söderhäll, K. (1984) The secondary zoospore of *Aphanomyces astaci* and *A. laevis* (Oomycetes, Saprolegniales). *Nordic Journal of Botany* 4, 697-706.
- Durso, L., Lehnen Jr, L. P., and Powell, M. J. (1993) Characteristics of extracellular adhesions produced during *Saprolegnia ferax* secondary zoospore encystment and cystospore germination. *Mycologia* 85(5), 744-755.
- Gay, J. L., Greenwood, A. D., and Heath, I. B. (1971) The formation and behaviour of vacuoles (vesicles) during oosphere development and zoospore germination in *Saprolegnia*. *Journal of General Microbiology* 65, 233-241.
- Hallett, I. C. and Dick, M. W. (1986) Fine structure of zoospore cyst ornamentation in the Saprolegniaceae and Pythiceae. *Transactions of the British Mycological Society* 86(3), 457-463.
- Hatai, K. and Hoshiai, G.-I. (1993) Characteristics of two *Saprolegnia* species isolated from coho salmon with saprolegniasis. *Journal of Aquatic Animal Health* 5, 115-118.
- Hatai, K., Willoughby, L. G., and Beakes, G. W. (1990) Some characteristics of *Saprolegnia* obtained from fish hatcheries in Japan. *Mycological Research* 94(2), 182-190.
- Heath, I. B. and Greenwood, A. D. (1971) Ultrastructural observations on the kinetosomes, and golgi bodies during the asexual life cycle of *Saprolegnia*. *Zeitung Fur Zellforschung* 112, 371-389.
- Heath, I. B., Rethoret, K., and Moens, P. B. (1984) The ultrastructure of mitotic spindles from conventionally fixed and freeze-substituted nuclei of the fungus *Saprolegnia*. *European Journal of Cell Biology* 35, 284-295.
- Heath, I. B. and Unestam, T. (1974) Mycoplasma-like structures in the aquatic fungus *Aphanomyces astaci*. *Science* 183, 434-435.
- Holloway, S. A. and Heath, I. B. (1977) An ultrastructural analysis of the changes in organelle arrangement and structure between the various spore types of *Saprolegnia*. *Canadian Journal of Botany* 55, 1328-1339.
- Lehnen Jr, L. P. and Powell, M. J. (1988) Cytochemical localization of carbohydrates in zoospores of *Saprolegnia ferax*. *Mycologia* 80(4), 423-432.
- Lehnen Jr, L. P. and Powell, M. J. (1989) The role of kinetosome-associated organelles in the attachment of encysting secondary zoospores of *Saprolegnia ferax* to substrates. *Protoplasma* 149, 163-174.
- Lehnen Jr, L. P. and Powell, M. J. (1991) Formation of K2-bodies in primary cysts of *Saprolegnia ferax*. *Mycologia* 83(2), 163-179.
- Lehnen Jr, L. P. and Powell, M. J. (1993) Characterization of cell surface carbohydrates on asexual spores of the water mold *Saprolegnia ferax*. *Protoplasma* 175, 161-172.
- Manton, I., Clarke, B., and Greenwood, A. D. (1951) Observations with the electron microscope on a species of *Saprolegnia*. *Journal of Experimental Botany* 2(6), 321-331.
- Meier, H. and Webster, J. (1954) An electron microscope study of cysts in the Saprolegniaceae. *Journal of Experimental*



Botany 5(15), 401-409.

- Nyhlen, L. and Unestam, T. (1978) Cyst and germ tube wall structure in *Aphanomyces astaci*, Oomycetes. Canadian Journal of Microbiology 24(11), 1296-1299.
- Olson, L. W., Cerenius, L., Lange, L., and Söderhäll, K. (1984) The primary and secondary spore cysts of *Aphanomyces* (Oomycetes, Saprolegniales). Nordic Journal of Botany 4(5), 681-696.
- Pickering, A. D., Willoughby, L. G., and McGrory, C. B. (1979) Fine structure of secondary zoospore cyst cases of *Saprolegnia* isolates from infected fish. Transactions of the British Mycological Society 73(3), 427-436.
- Sjollema, K. A., Dijksterhuis, J., Veenhuis, M., and Harder, W. (1993) An electron microscopical study of the infection of the nematode *Pangrellus redivivus* by the endoparasitic fungus *Verticillium balanoides*. Mycological Research 97(4), 479-484.
- Xu, D. and Rogers, W. A. (1991) Electron microscopy of infection by *Saprolegnia* spp. in channel catfish. Journal of Aquatic Animal Health 3, 63-69.

## Zoospore behaviour

- Burr, A. W. (1991). Comparative diplanetism processes of salmonid-pathogenic and saprophytic isolates of the *Saprolegnia parasitica-diclina* complex. PhD thesis, University of Newcastle upon Tyne, 381 pp.
- Cerenius, L. and Söderhäll, K. (1984) Chemotaxis in *Aphanomyces astaci*, an arthropod-parasitic fungus. Journal of Invertebrate Pathology 43, 278-281.
- Cerenius, L. and Söderhäll, K. (1984) Repeated zoospore emergence from isolated spore cysts of *Aphanomyces astaci*. Experimental Mycology 8, 370-377.
- Cerenius, L. and Söderhäll, K. (1985) Repeated zoospore emergence as a possible adaptation to parasitism in *Aphanomyces*. Experimental Mycology 9, 259-263.
- Crump, E. and Branton, D. (1966) Behavior of primary and secondary zoospores of *Saprolegnia* sp. Canadian Journal of Botany 44, 1393-1400.
- Diéguez-Urbeondo, J. (1995). Adaption to parasitism of some animal pathogenic Saprolegniaceae. Comprehensive Summaries of Uppsala Dissertations 122, Faculty of Science and Technology. Acta Universitatis Upsaliensis, 43 pp.
- Diéguez-Urbeondo, J., Cerenius, L., and Söderhäll, K. (1994) Repeated zoospore emergence in *Saprolegnia parasitica*. Mycological Research 98(7), 810-815.
- Ho, H. H. (1975) Observations on the behavior of zoospores of a *Saprolegnia* species. Mycologia 67, 425-428.
- Hohnk, W. (1933) Polyplanetism and zoospore germination in saprolegniaceae and *Pythium*. American Journal of Botany 20, 45-61.
- Persson, M. and Söderhäll, K. (1986) CaCl<sub>2</sub>-induced germination and peptidase secretion in *Aphanomyces astaci*. Experimental Mycology 10, 205-213.
- Petersen, E. E., Semon, M. J., Kerwin, J. L., and Brower, J. M. (1997) Regulation of attachment, germination, and appressorium formation by zoospores of *Lagenidium giganteum* and related oomycetes by chitin, chitosan, and catecholamines. Protoplasma 197(1-2), 96-110.
- Rand, T. G. and Munden, D. (1993) Chemotaxis of zoospores of two fish-egg-pathogenic strains of *Saprolegnia diclina* (Oomycotina: Saprolegniaceae) toward salmonid egg chorion extracts and selected amino acids and sugars. Journal of Aquatic Animal Health 5, 240-245.
- Söderhäll, K. and Cerenius, L. (1983) Protein and nucleic acid synthesis during germination of the asexual spores of the aquatic fungus, *Aphanomyces astaci*. Physiologia Plantarum 58, 13-17.
- Svensson, E. and Unestam, T. (1975) Differential induction of zoospore encystment and germination in *Aphanomyces astaci*, Oomycetes. Physiologia Plantarum 35, 210-216.
- Unestam, T. (1966) Studies on the crayfish plague fungus *Aphanomyces astaci* II. Factors affecting zoospores and zoospore production. Physiologia Plantarum 19, 1110-1119.
- Unestam, T. (1969) On the physiology of zoospore production in *Aphanomyces astaci*. Physiologia Plantarum 22, 236-245.
- Willoughby, L. G. (1977) An abbreviated life cycle in the salmonid fish *Saprolegnia*. Transactions of the British Mycological Society 69(1), 133-166.
- Willoughby, L. G. (1986) An ecological study of water as the medium for growth and reproduction of the *Saprolegnia* from salmonid fish. Transactions of the British Mycological Society 87(4), 493-502.
- Willoughby, L. G., McGrory, C. B., and Pickering, A. D. (1983) Zoospore germination of *Saprolegnia* pathogenic to fish. Transactions of the British Mycological Society 80(3), 421-435.

## Relevant websites

### **Zoosporic/filamentous fungi**

<http://zoosporic-fungi.dmc.maine.edu/>  
<http://muse.bio.cornell.edu/~fungi/welcome.html>  
<http://www.cabi.org/institut/imi/imi.htm>  
<http://www.ucmp.berkeley.edu/chromista/oomycota.html>

### **Asian fish and fisheries**

<http://www.ku.ac.th/fish/mfish.html/index.html>  
<http://www.indiafisheries.com/>

### **AAHRI**

<http://www.agri-aqua.ait.ac.th/aahri/>

### **Institute of Aquaculture, Stirling University**

<http://www.stir.ac.uk/aqua>

### **NACA**

<http://www.agri-aqua.ait.ac.th/NACA/>

