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Summary of Significant Fungal Infections in Mollusca and Crustacea

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Abstract: The adverse social, economic and environmental consequences of uncontrolled movement of live aquatic animals and their products have increased global awareness of the need for improved health management standards. The serious impact of unrestricted international movements of aquatic animals has led to the development of health certification and risk reduction methodologies. The increased development of shellfish aquaculture and recent advances in diagnostic techniques, along with diversification of cultured species, continue to provide a seemingly inexhaustible reserve of new or emerging infectious disease problems. Numerous species of fungi have been described from various shellfish, especially representatives of the Mollusca. Some fungi have had a serious impact on wild populations and shellfish aquaculture production. This article provides a summary of the most important agents causing fungal infections in molluscs and crustaceans.

Key words: Fungi, Infections, Mollusca, Crustacea

Some of the earliest records of mass mortalities of shellfish were caused by various disease agents, e.g. the phycomycete fungus *Ostracoblabe implexa* responsible for 'foot disease' in European oyster (*Ostrea edulis*) and the iridoviral agent of 'gill diseases' in Portuguese oysters (*Crassostrea angulata*). Increasing development of shellfish aquaculture and the recent advances in diagnostic techniques, along with diversification of cultured species, continue to provide a seemingly inexhaustible reserve of new or emerging infectious disease problems. They have also significantly broadened the scope of microbial pathogen research and are proving useful for differentiating between primary pathogens and the ubiquitous microbial fauna that surrounds shellfish in their natural environment. Note is also made of apparently non-significant pathogens, since, given the right conditions, even the most benign infectious organism may transform into a serious disease agent. Knowledge on how to distinguish between primary and opportunistic pathogens is also important for optimizing their control or treatment.

The importance of containing the threat of diseases in production of aquatic animals is a matter of global concern, especially with increased trade and increased transboundary movements of goods, which include live fish and other aquatic organisms. Due to this concern, the minimum EU Community measures for the control of the fish diseases are referred to in the Lists I and II of the Annex A to Directive 91/67/EEC (concerning the animal health conditions governing the placing on the market of aquaculture animals and products). The diseases are categorised in three lists. Two agents of diseases of molluscs are placed in the List II disease (*Bonamia ostreae* and *Marteilia refringens*), where are important endemic diseases that should be contained and eradicated in the long term. If fish is suspected of being infected or infected with a

Table 1. Summary of significant fungal infections in Mollusca and Crustacea

Group	Common name or disease name	Host species	Impact on the host	Occurrence	Culture
Phycomycetes (Fig. 1, 2)	*Ostracoblabe implexa,* maladie de la charnière, (‘hinge disease’), maladie du pied (‘foot disease’ erroneously), Dutch shell disease	*Ostrea edulis,* *Crassostrea gigas,* *C. angulata,* *Saccostrea cucullata,* *Cardium edule*	Disease is limited to the shell, first appearing as small round white spots, which are slightly raised and have a clear centre. These spots coalesce. Shell decalcification. If the area beneath the adductor muscle is infected, attachment is weakened.	Appears at t>20ºC; in Europe, India, and Canada	Dense mycelial network of hyphae 1.5–2.5 µm in diameter. Small oval dilatations (chlamydospores).
Deuteromycetes (Fig. 3)	*Fusarium* spp. ‘burn-spot’ or ‘black-gill’ disease - *Fusarium solani*	Wide range of crustaceans *Astacus astacus* *Orconectes limosus* many penaeid shrimps	Lesions on exoskeleton, gills, eyes, appendages or other integument surfaces. Significant mortality.	Larvae; ubiquitous	Proliferation of hyphal and conidial stages cause spot formations, which progress from white to orange to brown-black. Micro- (single-celled) and macroconidia (two- to ten-celled) at the tips of infected gill lamellae are characteristically elongate and curved.
Hyphomycetes (Fig. 4)	*Ramularia astaci*, *Didymaria cambari,* ‘burn spot disease‘	*Astacus astacus*, *Orconectes limosus*	Affect exoskeleton and gills.	Widespread in Europe	
Oomycete (Fig. 5, 6)	*Aphanomyces astaci* - -	*Pacifastacus eniusculus,* *Procambarus clarkii* *Astacus astacus*, *A. leptodactylus,* *A. pallipes*	Superficial lesions but not associated with epizootic mortality. Hyphae penetrate non-calcified sections of cuticle and spread systemically, often along the nerve cord; die within 2 weeks of exposure	Ubiquitous in North America. Since 1960’s, spreading in Europe	Delicate, branching, aseptate hyphae (7–9 µm in diameter), with granular cytoplasm.
Oomycetes	*Atkinsiella dubia* *A. hamanaensis*	Many crabs	Due to mycelial growth on the wounds, locomotory difficulties may occur	Captive eggs and larvae; ubiquitous	Broad (12–45 µm), sparsely septate, hyphae, which terminate in short or elongate zoosporangia.

Fig. 1. Inner surface of *Crassostrea gigas* shell

Fig. 2. Shell of *Crassostrea gigas* with abnormal shell growth (arrow) caused by *Ostracoblabe implexa* at the site of adductor muscle attachment

Fig. 4. Burn spot disease caused by *Ramularia astaci*

Fig. 3. Black, melanized lesions of the gills of a subadult *Penaeus californiensis* due to infection by *Fusarium solani*

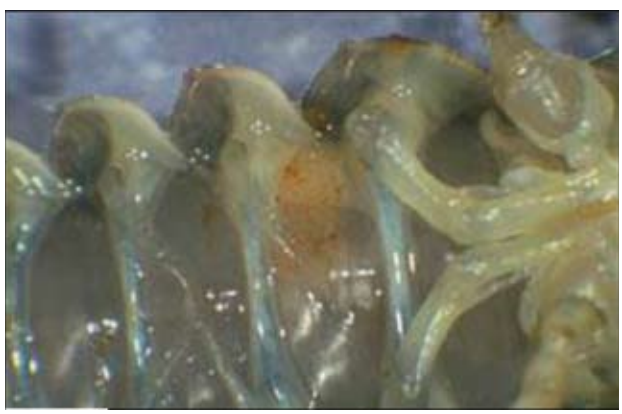

Fig. 5. Crayfish plague. Segment with brown markings shows signs of typical infection from fungus. Segments either side indicate healthy muscle tissue

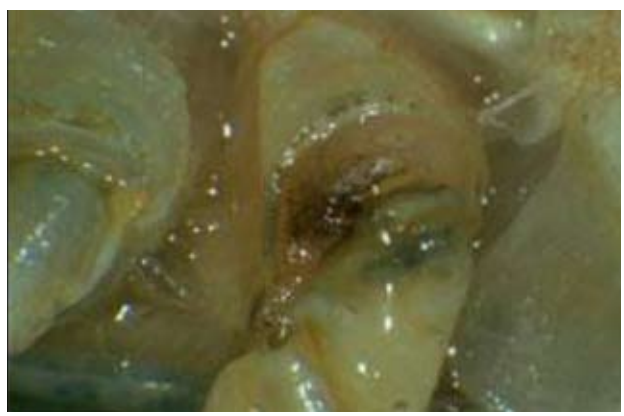

Fig. 6. Crayfish plague, showing classic darkening at base of walking legs

List II disease, an official investigation must be initiated to confirm or rule out the presence of this disease. Approved farms and zones will loose their status as free from the disease until it is proven that the disease is eradicated. All farms rearing or keeping fish susceptible to List I or List II disease must be registered by the official service and keep record of mortality and the movement into and out of the farm.

Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals provides for a list of exotic and non-exotic diseases and a list of species sensitive to them. The diseases on this list have substantial economic repercussions or an adverse effect on the environment of wild aquatic animals. Exotic diseases are those that are not recorded in the European Community aquaculture and whose pathogens are not present in EC waters. These include the following disease of molluscs: infection with *Bonamia exitiosa,* infection with *Xenohaliotis californiensis,* Taura syndrome or even yellowhead disease. Non-exotic diseases of molluscs included on the list are: infection with *Marteilia refringens,* infection *with Bonamia ostreae,* and white spot disease.

In this article, we present data about the most important fungal diseases of molluscs and crustaceans for the aquaculture in Europe.

Numerous species of fungi have been described from various Mollusca and Crustacea. Some fungi have had a serious impact on wild populations and shellfish aquaculture production (Woo & Bruno 1999, Ostrander 2000, Hristovski & Stojanovski 2005, Woo 2006, USDHH 2011, Kopper et al. 2014, WOAH 2016). The most important information about significant fungal diseases of the Mollusca and Crustacea is presented here in table format (Table 1).

References

Directive 1991/67/EEC of 28 January 1991 concerning the animal health conditions governing the placing on the market of aquaculture animals and products.

Directive 2006/88/EC concerning animal health requirements for aquaculture animals (and products), the placing on the market and the prevention and control of certain diseases in aquatic animals.

Hristovski M. & Stojanovski S. 2005: Biology, Culture and Pathology of Fish (on Macedonian). University book. Skopje, Cetis print. Skopje. (In Macedonian).

Kopper G., Mirecki S., Kljujev I. S., Raicevic V. B., Lalevic B. T., Petrovic-Jovicic J., Stojanovski S. & Blažeković-Dimovska D. 2014. Chapter 23. Hygiene in primary production. In: Motarjemi Y. & H. Lelieveld, H. (Eds.) 2014: Food safety management. A practical guide for the food industry. Amsterdam (Elsevier & Academic Press), pp. 560-623.

Ostrander G., K. (Ed.) 2000: The Laboratory Fish. In: Bullock G. & Bunton T. (Eds.) (Handbook of Experimental Animals). Academic Press. 678 p.

USDHHS (U.S. Department of Health and Human Services) 2011. Fish and Fishery Products Hazards and Controls Guidance. Fourth Edition. Food and Drug Administration. Center for Food Safety and Applied Nutrition. 468 p.

WOAH (World Organization for Animal Health) 2016. Manual of Diagnostic Tests for Aquatic Animals, Seventh Edition. http://www.oie.int/international-standard-setting/aquatic-manual/access-online

Woo P. T. K. 2006: Fish Diseases and Disorders, Volume 1: Protozoan and Metazoan Infections. Second Edition. CAB International. 800 p.

Woo P. T. K. & Bruno D. W. 1999: Fish Diseases and Disorders. Volume 3. Viral, Bacterial and Fungal Infections. CAB International. 940 p.