Ichthyophonus hoferi as One of Possible Causes of Increased Marine Mortality in Post-Smolts of Atlantic Salmon

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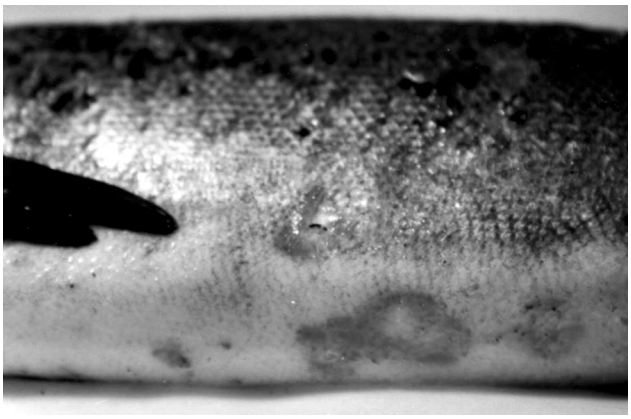
In July and August 2001 a number of adult Atlantic salmon (*Salmo salar*) from the Tuloma and Kola rivers (Kola Peninsula, Russia) were found to have multiple haemorrhages on the skin, necrosis of the fins and epidermis, extensive areas of scale loss, flat sores of 0.5–1.5 cm in diameter and epithelial tumours (Fig. 1). The muscles of examined fish were unnaturally soft.

In order to establish the cause of these symptoms, samples of liver, spleen, kidney and blood were cultured in mycological media. After 3 months' incubation at 4 – 5°C 9 cultures of a fungus identified as *Ichthyophonus hoferi* were derived.

Fig. 1. Hemorrhages and sores on the skin.



Histopathological examination of sections stained with hematoxylin-eosin revealed spores and fungal hyphae in the spleen, lumina of kidney tubules and the muscles below haemorrhages, sores and papillomas (Fig. 2). Spores were scarce, and their size was 3–10 µm. The lymphoid tissue in the spleen was reduced, kidneys showed necrosis of the tubules and haemorrahages in the parenchyma and body muscles exhibited lysis of muscle fibres and connective tissue in areas of localization of spores.

Epizootics of ichthyophonosis occasionally occur among commercial fish species in the North Atlantic, particularly in herring (McVicar 1977, 1982; ICES 1991; Hjeltnes and Skagen 1992; Karaseva et al. 1993; Sindermann and Chenoweth 1993; Karaseva and Donetskov 2001). *I.hoferi* attacks more than 70 species of fish, including salmon, and induces system mycosis (Lauckner 1984; McVicar 1977; Sindermann and Chenoweth 1993). Epizootics among salmonids thought to be caused by *I.hoferi* have been reported from trout farms in Europe and North America (Neish and Hughes 1980). In wild populations of salmonids a high prevalence of *Ichthyophonus hoferi* disease was reported for *Oncorhynchus tshawytscha* from the Yukon river (ICES 2001).

Symptoms of the disease are species-related and depend on the condition of individual fish (Neish and Hughes 1980). For example, Dorier and Degrange (1961) observed chaotic, spiral-wise movements of diseased farmed rainbow trout which develop when the nervous system has been affected. Some individuals ceased growth and became debilitated, while other, even severely affected, fish did not differ from healthy individuals.

Rucker and Gustafson (1953) noted that as the disease developed trout showed clear signs of agitation, and the skin along the lateral line and then in other areas of the body became darkened, and the belly was observed to protrude because of the increased size of the internal organs. However, the brain was seldom found to be affected.

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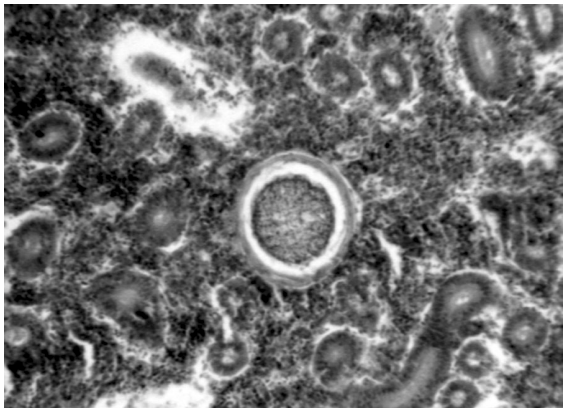
Fig. 2. A spore in the kidney tissue of Atlantic salmon.



The most comprehensive description of ichthyophonosis symptoms is given for herring, in which a major sign of the disease is small light nodules of connective tissue which develop beneath the skin and in the internal organs. However, the absence of such nodules does not prove that fish are uninfected with *I.hoferi* (Neish and Hughes 1980; Sindermann and Chenoweth 1993).

The symptoms of ichthyophonosis in Atlantic salmon are unknown. For example, nodules were not found in the salmon examined. However, external signs suggest that the development of symptoms in salmon follows the pattern typical of herring. A certain distortion of the clinical picture may be attributed to specific features of the physiological condition and immune status of fish.

According to a number of authors infection of fish with *I.hoferi* occurs during feeding on food containing viable spores of fungus (Rucker and Gustafson 1953; Dorier and Degrange 1961; Lauckner 1984). For example, Marshall and Orr (1955) referred to *I.hoferi* (*Ichthyosporidium*) as a parasite of Calanus.

According to data provided by Hansen and Pethon (1985) the diet of salmon at sea is dominated by crustaceans, squid and fish. Euphausiidae and Hyeriidae were the most frequent crustacean prey. No records of infection of these crustaceans with *I.hoferi* were found.

Calanus has not been identified as food for Atlantic salmon. However, it could be ingested by fish with other food. Besides, *Calanus finmarchicus* could play a role in the diet of post-smolts, and, hence, be a source of infection but at present only limited information is available on the diet of post-smolts.

Salmon show a dietary preference for other fish species. In samples obtained between 1969 and 1972 the frequency of occurrence of fish in salmon stomachs was on average 61.4% (Hansen and Pethon 1985). According to Grønvik and Klemetsen (1987), 85% of stomachs of salmon caught near Northern Norway contained herring. Therefore, it is quite likely that salmon may contract *I.hoferi* through feeding on infected herring.

Post-smolts may contract *I.hoferi* through transmission of the infectious agent from fish to fish during feeding migrations with herring shoals. For farmed salmon, feeds based on meal or mince of Clupeidae could be a source of infection. This possibility should not be disregarded, since the range of temperatures which spores can tolerate is unknown.

In the wild it is difficult to establish the cause of death of fish, except in the case of large-scale mortalities. For example, in 1991 during an outbreak of the disease in the Kattegat and Skagerrak the mortality of fish was so high that dead herring were found along the coast of Denmark (ICES 1991). Repercussions of the disease for wild populations of fish are, as a rule, identifiable only after an epizootic. They appear not only in the form of a decline in abundance but also as changes in population structure (Winters 1976; Neish and Hughes 1980).

Many attempts have been made to assess the magnitude or proportion of natural mortality caused by *Ichthyophonus* during an epizootic by using indirect methods (McVicar 1982; Munro et al., 1983; ICES 1993), but these were unsuccessful. Nevertheless, the results obtained and analysis of data available in the literature suggest that in recent years conditions have developed in northern seas which facilitate infection of both adults and post-smolts of Atlantic salmon with *I.hoferi*.

This is a dangerous disease, the consequences of which are difficult to assess for wild populations of fish. For shoaling species, ichthyophonosis often leads to mortality of a part of the population. Salmon represent both an intermediate (plankton-post-smolt) and a final (plankton-herring-predator) constituent of the food web, therefore, it can contract *Ichthyophonus*, and post-smolts are the most vulnerable link in this chain.

REFERENCES

Dorier, A., and C. Degrange. 1961. L'évolution de l'*Ichthyosporidium (Ichthyophonus) hoferi (Plehn et Mulsow)* chez les Salmonides d'élevage (Truite arc en ciel et Saumon de fontaine). Trav. Lab. Hydrobiol. Piscicult. Univ. Grenoble, 1960/1961: 7–44.

Grønvik, S., and A. Klemetsen. 1987. Marine Food and Diet Overlap of Co-Occurring Arctic Charr *Salvelinus alpinus* (L.), Brown Trout *Salmo trutta* L. and Atlantic Salmon *S. salar* L. off Senja, N. Norway. Polar Biol. 7: 173–177.

Hansen, L.P., and P. Pethon. 1985. The food of Atlatic salmon, *Salmo salar* L., caught by long-line in northern Norwegian waters. J. Fish Biol. 26: 553–562.

Hjeltnes, B., and D. Skagen. 1992. Ichthyophonus hoferi disease in the herring in Norwegian waters. ICES CM 1992/H: 27. 10 p.

ICES. 1991. Special meeting on the Ichthyophonus problem in European herring held at the Institute of Marine Research, Lysekil, Sweden, November 7, 1991. (Mimeo). 7 p.

ICES. 1993. Report of the second special Meeting on Ichthyophonus in herring Aberdeen, Scotland, 21–22 January 1993. ICES CM 1993/F: 9. 17 p.

ICES. 2001. Report of the Working Group on Pathology and Diseases of Marine Organisms. Santiago de Compostela, Spain, 13–17 March 2001. ICES CM 2001/F: 02. 55 p.

Karaseva, T.A., and V.V. Donetskov. 2001. Dynamics of Ichthyophonosis epizootic among Atlanto-Scandinavian herring in 1992–1999. *In* Diseases of Fish and Shellfish. 10th Internat. Confer. EAFP. Dublin. September 2001: O-031.

Karaseva, T.A., A.V. Serdyuk, V.V. Donetskov, and T.V. Shamray. 1993. Results from studies of *Ichthyophonus hoferi* epizootic in the Atlanto-Scandian herring. ICES CM 1993/H: 12. 12p.

Lauckner, G. 1984. Agents: Fungi. *In* Diseases of Marine Animals. Vol. IV. Part I. *Edited by* O. Kinne. Biologische Anstalt Helgoland. Hamburg. pp. 89–113.

Marshall, S. M., and A.P. Orr. 1955. Parasites. *In* The Biology of a Marine Copepod *Calanus finmarchicus* (Gunnerus). *Edited by* R. Cunningham. Edinburgh and Sons Ltd., Alva. pp. 142–145.

McVicar, A.H. 1977. Ichthyophonus as a pathogen in farmed and wild fish. Bull. Off. Int. Epiz. 87: 517–519.

McVicar, A.H. 1982. Ichthyophonus infection of fish. *In* Microbial diseases of fish. *Edited by* R.J Roberts. Academic Press, London. pp. 243–269.

McVicar, A.H. 1982. Ichthyophonus, systemic fungal disease of fish. ICES Working Group Leaflet No. 3: 5. Copenhagen.

Munro, A.L.S., A.H. McVicar, and R. Jones. 1983. The epidemiology of infections in commercially important wild marine fish. *In* Proceedings of ICES Special Meeting on Diseases of Commercially Important Marine Fish and Shellfish 1–3 October, 1980, Copenhagen. *Edited by* J. E. Stewart. Rapp. Pv. Reun. Cons. Int. Explor. Mer. 182: 21–32.

Neish, G.A., and G.C. Hughes. 1980. Fungal diseases of fishes. *In* Diseases of fish. *Edited by* S.F. Snieszko and H.R. Axelrod. T.F.H. Publications, Neptune. Book 6, pp. 61–153.

Rucker, R.R., and P.V. Gustafson. 1953. An epizootic among rainbow trout. Prog. Fish-Cult. 15: 179–181.

Sindermann, C.J., and J.F. Chenoweth. 1993. The fungal pathogen *Ichthyophonus hoferi* in sea herring, *Clupea harengus*: a perspective from the Western North Atlantic. ICES CM 1993/F: 41. 38p.

Winters, G.H. 1976. Recruitment Mechanisms of Southern Gulf of St. Lawrence Atlantic Herring (*Clupea harengus*). J. Fish. Res. Board Can. 33: 1751–1762.