

Pseudomonas anguilliseptica infection as a threat to wild and farmed fish in the Baltic Sea



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The transport of live fishes related to the growth of the fish farming industry worldwide may increase the transfer of previously known bacterial pathogens into new geographic areas and new host species, but also facilitate the introduction of completely new bacterial pathogens. Species belonging to the genera *Vibrio* and *Aeromonas* are well known in many countries, infecting a large number of fish species. Other bacterial fish pathogens like *Pseudomonas anguilliseptica* species, up to now considered less harmful, may constitute a potential threat to a developing fish farming industry, especially of European whitefish.

Pseudomonas anguilliseptica is a fish pathogenic bacterium infecting mainly farmed fish in brackish and marine environments. The pathogen was initially reported from diseased farmed Japanese eel (*Anguilla japonica*) in Japan in 1971, and named 'sekiten-byo' or red spot disease¹. Since 1981, *P. anguilliseptica* has also been isolated from cultured European eel (*Anguilla anguilla*) in different European countries^{2–5}. Although *P. anguilliseptica* was initially considered a pathogen closely associated with eel culture it appeared that this pathogen infects a number of different fish species in different water areas. It has been isolated from farmed fish species, like ayu (*Plecoglossus altivelis*)⁶, cod (*Gadus morhua*)⁷, gilthead seabream (*Sparus aurata*)⁸, sea bass (*Dicentrarchus labrax*), turbot (*Scophthalmus maximus*)⁹, striped beakperch (*Oplegnathus fasciatus*)¹⁰ and recently from lump-sucker (*Cyclopterus lumpus*)¹¹.

The disease signs associated with *P. anguilliseptica* infections in fish are characterised by petechial haemorrhages in the peritoneum and in the skin on the ventral side of the fish (Figure 1). Sometimes haemorrhages are also present in the liver and adipose tissue of visceral organs. Occasionally spleen and kidney are soft in consistency and enlarged^{1,12,13}. *P. anguilliseptica* has in some occasions caused significant mortalities in farmed eel^{3,14} and Atlantic salmon¹³ suggesting this pathogen has the potential to be a serious problem for farmed fish especially if left untreated.

P. anguilliseptica is an aerobic, motile, Gram-negative rod, producing slow-growing colonies on agar plates. The bacterium is cytochrome oxidase-positive, catalase positive and does not produce acid from glucose and has a low metabolic reactivity for many different carbohydrates. The inclusion of this pathogen into the genus *Pseudomonas* has been questioned, and it has been suggested that it could be classified into *Alcaligenes* or *Deleya* or even to a newly described genus¹⁵.

In the Baltic Sea area in northern Europe, in the middle of the 1980s *P. anguilliseptica* has been almost simultaneously isolated from farmed European eel in Denmark¹⁶, in Sweden (*Eva Jansson, pers. comm.*) and from different farmed salmonids in Finland (Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta* m. *trutta*), European whitefish (*Coregonus lavaretus*) and rainbow trout (*Oncorhynchus mykiss*)¹³. Subsequently, occasional disease outbreaks associated with *P. anguilliseptica* have been reported from farmed eel in Sweden (*Eva Jansson, pers. comm.*), although the number of eel farms in the Baltic Sea area were rather low during the past 20–30 years. Although in the northern Baltic Sea, initially *P. anguilliseptica* was isolated from several farmed salmonid species, it is today mainly associated with disease in European whitefish and to lesser extent with diseased rainbow trout. Both species are farmed in net pens in brackish water (salinity = 4–6‰). During 1986–1991, 2 to 17 disease outbreaks associated with *P. anguilliseptica* were recorded per year¹⁷. Lately, 2–5 disease outbreaks both in European whitefish and in rainbow trout have been recorded per year (T. Wiklund, unpubl. data)¹⁸. Initially *P. anguilliseptica* was often co-isolated with other bacterial fish pathogens like *Vibrio anguillarum*, and *Aeromonas salmonicida* subsp. *salmonicida*¹⁷, suggesting a compromised immune system of the fish facilitating the infection with several bacterial species. Now the majority of farmed European whitefish and rainbow trout in Finland are vaccinated against vibriosis and furunculosis, but *P. anguilliseptica* is still causing disease outbreaks, mainly in European whitefish.

So far, Finland seems to be one of the few countries where *P. anguilliseptica* is causing disease outbreaks in farmed salmonids



Figure 1. Farmed European whitefish (*Coregonus lavaretus*) with *Pseudomonas anguilliseptica* infection showing haemorrhages in the skin and loss of scales.

from marine and brackish water. In Sweden *P. anguilliseptica* was recently reported from diseased rainbow trout in freshwater (Eva Jansson, pers. comm.). Disease outbreaks in fish from freshwater associated with *P. anguilliseptica* are uncommon. *P. anguilliseptica* has previously been isolated from tilapia farmed in fresh water¹⁹ and the bacterium seems to be present also in fresh water environment as reported from a river in India in rather high concentrations²⁰.

Reports of *P. anguilliseptica* in wild fish are rather rare in literature. The pathogen has been isolated from wild European eel¹⁷ and from wild Atlantic salmon, sea trout and Baltic herring (*Clupea harengus membras*) with eye lesions in the Baltic Sea²¹. The Baltic herring suffered from haemorrhages in the eyes and in some specimens the cornea was punctured. Additionally haemorrhages in the fins and head and blood containing ascites were present. The isolates from Baltic herring were, however, of low pathogenicity for rainbow trout. The role of *P. anguilliseptica* as the etiological agent of the observed eye lesions in Baltic herring remained unsolved, and the authors concluded that the bacterium might have been a secondary invader²¹.

Although *P. anguilliseptica* has been associated with disease outbreaks in different fish species in the Baltic Sea, the most significant impact today is on European whitefish. Infections with *P. anguilliseptica* have been treated with trimethoprim/sulfamethoxazole or florfenicol. Both antibiotics are efficient if the treatment is applied immediately in the onset of a disease outbreak. In contrast, oxytetracycline has been reported to be of limited effect against this pathogen¹³. In Japan and Scotland *P. anguilliseptica* infections in eels have been controlled by raising the water temperature temporary to above 27°C^{3,22}. However, this procedure to treat the infection is not possible for salmonids.

It can be concluded that *P. anguilliseptica* seems to be present in different areas of the Baltic Sea. The pathogen has the potential to negatively impact future large scale farming of European whitefish and European eel in brackish water.

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References

1. Wakabayashi, H. and Egusa, S. (1972) Characteristics of a *Pseudomonas* sp. from an epizootic of pond-cultured eels (*Anguilla japonica*). *Bull. Jap. Soc. Sci. Fish.* **38**, 577–587. doi:10.2331/suisan.38.577
2. Nakai, T. and Muroga, K. (1982) *Pseudomonas anguilliseptica* isolated from European eels (*Anguilla anguilla*) in Scotland. *Fish Pathol.* **17**, 147–150. doi:10.3147/jfsfp.17.147
3. Stewart, D.J. et al. (1983) An outbreak of 'Sekiten-byo' among cultured European eels, *Anguilla anguilla* L., in Scotland. *J. Fish Dis.* **6**, 75–76. doi:10.1111/j.1365-2761.1983.tb00052.x

4. Michel, C. et al. (1992) Phenotypic and genotypic studies of *Pseudomonas anguilliseptica* strains isolated from farmed European eels (*Anguilla anguilla*) in France. *Gyohyo Kenkyu* **27**, 229–232. doi:10.3147/jfsfp.27.229
5. Haenen, O.L.M. and Davidse, A. (2001) First isolation and pathogenicity studies with *Pseudomonas anguilliseptica* from diseased European eel *Anguilla anguilla* (L.) in The Netherlands. *Aquaculture* **196**, 27–36. doi:10.1016/S0044-8486(00)00566-4
6. Nakai, T. et al. (1985) First records of *Pseudomonas anguilliseptica* infection in cultured ayu, *Plecoglossus altivelis*. *Fish Pathol.* **20**, 481–484. doi:10.3147/jfsfp.20.481
7. Ferguson, H.W. et al. (2004) *Pseudomonas anguilliseptica* infection in farmed cod, *Gadus morhua* L. *J. Fish Dis.* **27**, 249–253. doi:10.1111/j.1365-2761.2004.00537.x
8. Doménech, A. et al. (1999) Association of *Pseudomonas anguilliseptica* infection with 'winter disease' in sea bream, *Sparus aurata* L. *J. Fish Dis.* **22**, 69–71. doi:10.1046/j.1365-2761.1999.00124.x
9. Berthe, F.C.J. et al. (1995) Identification of *Pseudomonas anguilliseptica* isolated from several fish species in France. *Dis. Aquat. Organ.* **21**, 151–155. doi:10.3354/dao021151
10. Kim, S.-R. et al. (2010) Recovery of *Pseudomonas anguilliseptica* from diseased striped beakperch (*Oplegnathus fasciatus*) in Korea. *Fish. Aqua. Sci.* **13**, 190–194.
11. Alarcón, M. et al. (2016) Pasteurellosis in lump sucker *Cyclopterus lumpus*, farmed in Norway. *J. Fish Dis.* **39**, 489–495. doi:10.1111/jfd.12366
12. Ellis, A.E. et al. (1983) Histopathology of 'Sekiten-byo' caused by *Pseudomonas anguilliseptica* in the European eel, *Anguilla anguilla* L., in Scotland. *J. Fish Dis.* **6**, 77–79. doi:10.1111/j.1365-2761.1983.tb00053.x
13. Wiklund, T. and Bylund, G. (1990) *Pseudomonas anguilliseptica* as a pathogen of salmonid fish in Finland. *Dis. Aquat. Organ.* **8**, 13–19. doi:10.3354/dao008013
14. Muroga, K. and Nakajima, K. (1981) Red spot disease of cultured eels – methods for artificial infection. *Fish Pathol.* **15**, 315–318. doi:10.3147/jfsfp.15.315
15. Austin, B. and Austin, D. (2007) Bacterial fish pathogens, diseases of farmed and wild fish. Springer, Praxis Publishing Ltd, Chichester, UK.
16. Møllergaard, S. and Dalsgaard, I. (1986) Håndbog i ålesygdomme. *Danmarks Fiskeri og Havundersøgelser-rapport*, **293**, 46 pp., (in Danish).
17. Wiklund, T. and Lönnström, L. (1994) Occurrence of *Pseudomonas anguilliseptica* in Finnish fish farms during 1986–1991. *Aquaculture* **126**, 211–217. doi:10.1016/0044-8486(94)90037-X
18. Viljamaa-Dirks, S. (2016) Katsaus kalaterveyteen 2015/Översikt över fiskhälsan 2015. In *Kalaterveyspäivä/Fiskhälsodagen*, 11.3.2016, *Luentokokoomelma/Föreläsningsserie*, pp. 2–7, EVIRA, (in Finnish and Swedish).
19. El-Attar, A.A. and Moustafa, M. (1996) Some studies on tail and fin rot disease among cultured *Tilapia* fishes. *Assuit. Vet. Med. J.* **35**, 155–162.
20. Bhasin, S. et al. (2015) Observation on *Pseudomonas* diversity from a tropical-river Kshipra M.P. India. *Eur. J. Acad. Ess.* **2**, 39–45.
21. Lönnström, L. et al. (1994) *Pseudomonas anguilliseptica* isolated from Baltic herring *Clupea harengus membras* with eye lesions. *Dis. Aquat. Organ.* **18**, 143–147. doi:10.3354/dao018143
22. Muroga, K. (1978) Red spot disease of eels. *Fish Pathol.* **13**, 35–39. doi:10.3147/jfsfp.13.35

Biography

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