Citation

Tsertou M. I., Antonopoulou E., Katharios P. 2022. Chronic diseases of the lateral line organ in fish. *In* F.S.B. Kibenge, B. Baldisserotto & R. S-M. Chong (Ed.). Aquaculture Pathophysiology, Vol I, Finfish Diseases, pp 721-725. London, Academic Press Elsevier

Chapter 3.9.4

Chronic ulcerative dermatopathy (Chronic diseases of the fish lateral line organ)

Maria Ioanna Tsertou[1,2], Efthimia Antonopoulou[1] and Pantelis Katharios[2,*]

1. Laboratory of Animal Physiology, Department of Zoology, School of Biology, Faculty of Sciences, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
2. Institute of Marine Biology, Biotechnology and Aquaculture, HCMR, Former American Base of Gournes, Heraklion 71003, Crete, Greece

*Corresponding author. e-mail address: katharios@hcmr.gr

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Abstract

Several conditions affecting the lateral line organs have been reported in the literature. Initially, most reports were about ornamental aquarium fishes, however similar diseases have recently described in cultured fish species, both in marine and freshwater environments. The common element of these conditions is the erosion of the epidermis overlaying the canals of the lateral line in the head and the trunk of the fish, which progressively become open ulcers. Up to date there is no evidence for an infectious aetiology and there is a consensus that the disease is linked to water quality. In cultured fish it has been shown that the disease is caused when groundwater is used, however it is not yet known what element of the water is responsible.

Keywords: lateral line, neuromast, erosion, ulceration, water quality

Chapter starts here

3.9.4.0. Introduction

Chronic Erosive Dermatopathy (CED), Chronic Ulcerative Dermatopathy (CUD), hole-in-the-head, Head and Lateral Line Erosion syndrome (HLLE) and Lateral Line Depigmentation (LLD) are chronic pathological disorders that affect the lateral line canals of the head and the trunk of various marine and freshwater fish species. The lateral line is a mechanosensory system found in all fishes and in the larvae of aquatic amphibians, which is used for the detection of water movements and/or pressure fluctuations (Bleckmann and Zelick, 2009; Webb and Shirey, 2003). The receptors of the lateral line that detect water flow are called neuromasts and they are distributed on the head, the trunk and the tail of the fish. Neuromasts can be either superficial on the skin or enclosed inside the fluid-filled canals of the lateral line, which are connected to the environment through a series of pores (Bleckmann and Zelick, 2009; Webb, 1989).

3.9.4.1 Chronic Ulcerative Dermatopathy

Chronic Ulcerative Dermatopathy (CUD) is a newly described condition affecting the lateral line canals of many cultured fish species, both freshwater and marine ones. Initially, it was referred as Chronic Erosive Dermatopathy (CED) but later the term 'ulcerative' replaced 'erosive' as more appropriate to describe the condition (Baily *et al*., 2005). It was first described in the Australian freshwater fish Murray cod, *Maccullochella peelii peelii* (Mitchell), when reared in sites supplied by groundwater (Baily *et al*., 2005; Ingram *et al*., 2004; Schultz *et al*., 2011, 2008). The disease results in focal erosion, ulceration and loss of epidermis around the lateral line canals of the head and the trunk, and fin erosion. It has been associated with reduced growth rates, increased mortalities and significant reduction of marketability due to the severe disfigurement of the affected fish (Baily *et al*., 2005; Ingram *et al*., 2004; Schultz *et al*., 2008). Although there is overwhelming evidence that the disease is directly linked with the use of groundwater, the actual causative agent of CUD is still unknown.

Baily *et al*. (2005) described the development of CUD in 6-week old Murray cod and young goldfish, *Carassius auratus* (L.) after exposure to groundwater. In

Murray cod fingerlings, the first gross signs appeared approximately three weeks after exposure to groundwater and consisted of enlargement of the pores of the head and trunk canals. After four to five weeks, the elongated pores began to coalesce, resulting in exposure of the bed of the canal. As the disease progressed, all the canal beds were exposed while ulceration on the head started to extend into surrounding areas. Histologically, marked hyperplasia and necrosis were the first changes noted three weeks after exposure of Murray cod to groundwater, while two weeks later the tissue overlaying the canals was completely necrotic; however, the canal's neuromasts were not degenerated. It was shown that when CUD-affected Murray cod were transferred to river water, the majority of the fish were structurally recovered after a period of 8-10 weeks. The same changes were also observed in goldfish when exposed to groundwater. Due to the localization of the lesions exclusively on the lateral line canals, it was hypothesized that the disease mechanism involved the binding of an unknown waterborne toxin to the mucus content of the sensory canals, resulting in focal hyperplasia and necrosis. The initial lesions are observed in the tissue surrounding the pores since these are the foremost entry points of the lateral line canal. Based on these results and with the absence of viral or bacterial agents, it was suggested that some component of the groundwater was the driving force for the development of CUD. However, after several analyses of basic water quality parameters as well as heavy metal and pesticide/insecticide content of the groundwater, the exact component of the water which could have resulted to the development of the disease could not be identified.

Due to the nature of lesions and the associated to ion losses across the damaged epidermis, CUD-affected fish may be threatened by severe osmoregulatory disturbance. Schultz *et al.* (2008) examined the osmoregulatory status of CUD-affected Murray cod. For that study, three groups of adult Murray cod (~700g) were used: non-affected, CUD-affected and fish with no lesions correlated to CUD, which were transferred to groundwater for monitoring the development of the disease in healthy grown individuals. The lesions were similar to those described by Baily *et al.* (2005), however the onset of the disorder in adult Murray cod was later compared to the juveniles, as the first visuals signs of CUD appeared five months after exposure to groundwater. Moreover, it was shown that CUD had no effect on the osmoregulation of Murray cod based on the results of blood plasma electrolytes, osmolality and gill Na^+, K^+, -ATPase activities. In addition, detailed chemical analyses of groundwater

from affected sites compared to unaffected ones have failed to identify any noteworthy differences between the sources. Histological analysis of the gills in CUD-affected fish revealed a proliferation of mucus cells and rodlet cells. Schultz *et al*. (2014) found a significantly greater number of rodlet cells in the gills and proximal tubules of the kidneys of CUD-affected Murray cod compared to healthy counterparts. No pathogens were identified in any tissue examined, so it was assumed that the secretory nature of rodlet cells might be connected to defense mechanisms of fish against some toxicant in the water.

Chronic Ulcerative Dermatopathy has also been reported to affect marine fish species **(Figure 3.9.4.1A-1D)**. The development of CUD in sharpsnout seabream, *Diplodus puntazzo* (Walbaum, 1792) when cultured in saline groundwater and the recovery of the lesions following transfer of the fish to natural sea water, was studied by (Katharios *et al.*, 2011). Using sharpsnout seabream eggs from the same broodstock, two rearing trials were conducted; one using only saline groundwater and the other using only natural sea water. The first lesions of CUD in sharpsnout seabream were observed at 70 days post hatch (dph) manifested as bilateral microscopic grooves at the area of the lateral line canals. Histological analysis confirmed that the head canals were open grooves with degenerated neuromasts. At 130dph all fish reared in saline groundwater had gross bilateral lesions in the head canals and eroded fins, while fish reared in natural sea water had no visible lesions. Histological examination of CUD-affected sharpsnout seabream at 130dph revealed ulceration of the lateral line canals of the head and the trunk. The roof of the canals was always absent leaving the bed of the canal and the neuromasts exposed **(Figure 3.9.4.1E & 1F)**. These exposed neuromasts varied from apparently normal to degenerated and necrotic. Sharpsnout seabream affected with CUD (130dph) were transferred to natural sea water and after approximately 4 months, all fish had partially recovered with 38.4% of them recovered completely. No pathogen was isolated following several attempts in various nutrient media. In addition, many different treatments of affected fish using various chemicals such as acriflavine and antibiotics, feed additives and filters have been used by the same team over the years in order to identify the aetiological factor with no positive results. From the physicochemical analysis of the two water sources it was found that the pH was lower (7.4-7.8) and CO_2 (3.44 mg/L) higher in groundwater in comparison with natural seawater (8.2-8.3 and 0.806 mg/L, respectively). It was hypothesized that

groundwater, which is usually rich in CO_2, as indicated also by the lower pH compared to the pH of natural seawater, increases the enzymatic activity of the osteoclasts. It has been demonstrated that the lateral line canals develop through a bone remodeling process with the involvement of both osteoblasts, which are specialized cells implicated in bone apposition and osteoclasts which are implicated in bone resorption. CO_2 activates osteoclasts, which are in close proximity with the environment, such as the osteoclasts of the lateral line canals. In this scenario, there would be an environmentally induced imbalance between osteoclasts and osteoblasts that would cause the lesions seen in the fish, located exclusively in the lateral line canals, since osteoclasts release osteolytic and proteolytic enzymes like tartrate resistant acid phosphate (TRAP), proteases and cathepsin K. A range of marine fishes were reported as CUD-sensitive including several species kept in aquaria but also new aquaculture species like the meagre (*Argyrosomus regius*) (Katharios *et al*., 2011; Rigos and Katharios, 2010) **(Figure 3.9.4.1C & D)**. European seabass (*Dicentrarchus labrax*), which is one of the most important marine aquaculture species, is also sensitive to CUD **(Figure 3.9.4.1B)**. However, the lesions in this species become visible when the fish is more than 5 g in weight. The common practice is to grow this fish in inland facilities until 2-3 g and then transfer it to sea cages. Most of the hatcheries in the Mediterranean use saline groundwater but since the fish leave the hatchery before lesions become visible, the disease is usually undetected. It was only until very recently, when many hatcheries changed their strategy and grew the seabass juveniles in larger size that the disease became apparent and therefore a bigger concern for the producers since the damaged epidermis could affect the susceptibility of the fish to a wide range of pathogens in the sea.

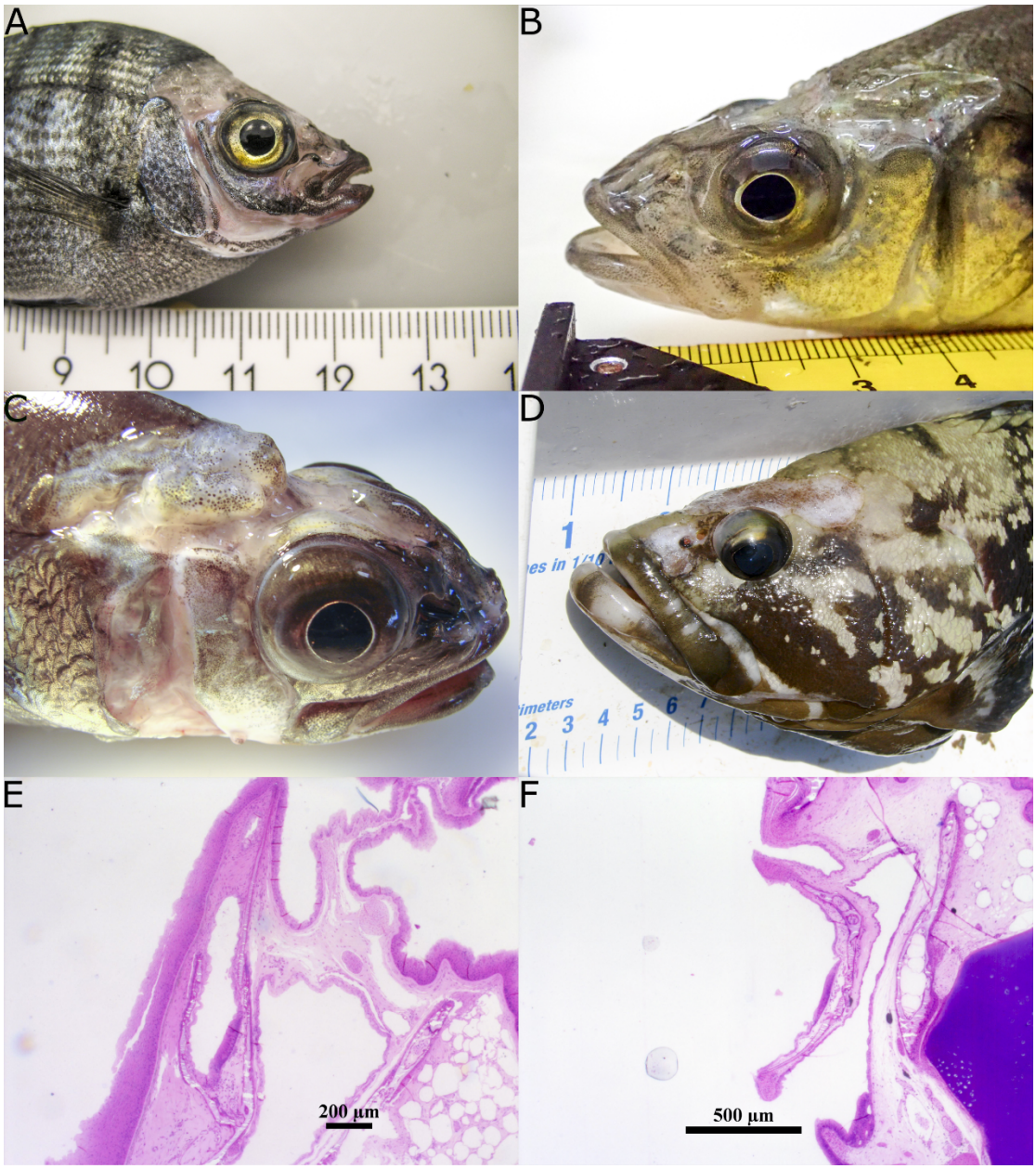

Figure 3.9.4.1. (A) Sharpsnout seabream juvenile with severe CUD lesions in the area of the head. **(B)** Adult European seabass grown in saline groundwater with visible lesions in the head. **(C)** Severe disfigurement of meagre, *Argyrosomus regius* grown continuously in groundwater. **(D)** Grouper, *Epinephelus marginatus* from the quarantine of a public aquarium using groundwater. Lesions are visible in the supraorbital canal (over the eye) and in the nares. **(E)** Cross section of the infraorbital (under the eye) canal of a healthy sharpsnout seabream grown in natural seawater. The canal is covered by a thick epidermal roof. **(F)** Cross section of the same canal in a CUD-affected sharpsnout seabream. The canal is wide open and the epidermal roof is missing. All photographs are courtesy of Dr. Pantelis Katharios.

Following the association of groundwater with the disease, several water treatment methods were evaluated in order to reduce the severity of the lesions on

Murray cod, including electrolyte enrichment, pre-treatment with UV irradiation and pre-conditioning of groundwater either in a vegetated earthen pond or in tanks containing artificial macrophytes (Schultz *et al*., 2011). Pre-conditioning of the water for 72h into a vegetated earthen pond or a tank containing biofilms growing on an artificial macrophyte, found to be an effective method for the reduction of both the incidence and the severity of CUD in juvenile Murray cod (Schultz *et al*., 2011).

3.9.4.2 Lateral Line Depigmentation in fish

A similar condition with CUD, common in both marine and freshwater fish is Head and Lateral Line Erosion syndrome (HLLE) or "hole in the head" or Lateral Line Depigmentation (LLD). The key diagnostic feature of this condition is mild to severe, focally depigmented skin along the lateral line of the head and the trunk (Noga, 2010). Thus, the most accurate term to describe this condition is as lateral line depigmentation (Corrales *et al*., 2009; Noga, 2010). LLD most commonly affects ornamental marine fish of the families Acanthuridae and Pomacentridae and tropical freshwater fish of the families Anabantidae, Belontidae and Cichlidae (Corrales *et al*., 2009; Noga, 2010). Despite the high occurrence of LLD in aquarium fish, the aetiological factor of the condition still remains unknown. There are several existing theories about the cause of LLD based mainly on the popular aquarium literature and the few published scientific reports, including infectious agents, poor water quality, poor nutrition with vitamin deficiencies or stress from over-crowding (Corrales *et al*., 2009; Gratzek, 1988; Morrison *et al*., 2007; Noga, 2010).

Paull and Matthews (2001) reported LLD in cichlids, angelfish, *Pterophyllum scalare* (Lichtenstein, 1823) and discus, *Symphysodon discus* (Heckel, 1840). They isolated the hexamitid, *Spironucleus vortens* from the head lesions and intestines of both angelfish and discus fish and from the kidney, liver and spleen of discus, hypothesizing that the parasite is the cause of LLD in the head either through direct infection of the tissue or indirectly through the blood vessels of the lateral line system. Moreover, Varner and Lewis (1991) isolated a reovirus-like agent from a moribund angelfish (*Pomacanthus semicirculatus*) with visual signs of LLD although there was no evidence that the virus was the aetiological factor of the condition.

Morrison *et al*. (2007) found LLD in Nile tilapia (*Oreochromis niloticus*) reared in high fish density. The gross lesions were eliminated after reduction of the densities, however the condition appeared again after a break in the water supply,

which resulted in dirty water entering the tanks. In this study, histopathology of the lesions during the last outbreak were described. The most remarkable head lesions were found in the region where the supraorbital, infraorbital and otic cranial lateral line canals meet, behind the eye of the fish. Due to the simple epithelial lining of these small canals, it was hypothesized that this area constitutes the portal for contaminants of the water or bacteria. Ulceration was also observed resulting to exposure of the epithelial lining of the canal, mucous cell hyperplasia and infiltration of eosinophilic granular cells and lymphocytes. Small groups of bacteria were seen in the lesions that may be involved in development of these lesions, which are not however the aetiological factor of the disease. It was proposed that the condition could be controlled with the use of good water quality and by avoiding high fish destinies in the facilities.

In a later study (Corrales *et al*. 2009), an extensive description of LLD was published in channel catfish, *Ictalurus punctalus* (Rafinesque, 1818). These authors induced LLD in channel catfish after exposure to chronic nutritional stress (12 months of starvation). Fish exhibited bilateral, focal, skin depigmentation alongside the lateral line due to the loss of melanocytes. Histologically, severe epithelial loss and melanocyte aggregation in the epidermis was observed without any signs of inflammation.

Chronic diseases that affect the lateral line organ of both cultured and ornamental fish have for many years puzzled researchers. There are many common elements in the development of these conditions and there is a consensus that all these diseases are not of infectious aetiology. These diseases are not directly linked with mortality; however, they definitely compromise the welfare and the appearance of the fish and therefore their marketability. More research is needed in order to elucidate the causative agents and the mechanism of disease development of Chronic diseases of the fish lateral line organ.

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