Aetiology and histopathology of a systemic phaeohyphomycosis in farmed lumpfish, *Cyclopterus lumpus*

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Abstract
Lumpfish being reared as biological control agents for sea lice removal from farmed Atlantic salmon developed mycotic lesions in their skeletal muscle, heart, and kidneys. After necropsy and histopathology, the fish were diagnosed with phaeohyphomycosis, thought to be caused by *Exophiala* sp. Samples of lesions were sent for molecular analysis to confirm the diagnosis. PCR and DNA sequencing confirmed the presence of two fungal species of black yeasts (Chaetothyriales) *Exophiala psychrophilia* and *Cyphellophora* sp. *Exophiala* spp. are known pathogens of farmed salmon, wild fishes, and other animals including humans. *Cyphellophora* spp. are normally found colonising plants and land animals, but have not been reported from fish. Most phaeohyphomycoses in captive fish are thought to be secondary to a compromised immune system arising from infections with primary pathogens, and/or husbandry problems. The identification of these fungal infections in cultured lumpfish and the increasing reports of microsporidiosis in captive lumpfish, are a reminder that further research is needed to understand the physiology and husbandry needs of this relatively new fish to aquaculture, especially with respect to opportunistic pathogens. In addition, the zoonotic potential of these pathogens in the aquaculture environment should be evaluated.

Introduction

Caligid copepods are currently the most problematic parasites infecting farmed Atlantic salmon, *Salmo salar*, costing the industry millions of dollars annually to control (Costello, 2009). They also pose a threat to wild salmonids that come into contact with coastal aquaculture facilities (Bateman et al., 2016; Shepherd and Gargan, 2017). The copepods feed on host skin and mucus and cause physiological stress and behavioural changes in their hosts (Grimnes and Jakobsen, 1996; Dawson *et al.*, 1999; Finstad *et al.*, 2000). Extensive infections can cause direct host mortality as well as increasing the risk of secondary microbial infections (Pike and Wadsworth, 1999; Costello, 2006). Increasing resistance of sea lice to conventional chemotherapeutic agents, as well as the potential negative impact of these compounds on the environment, has called for alternative, economically and

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