NOTE

First record of Proliferative Kidney Disease in Iceland

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Abstract

Proliferative kidney disease caused by the myxozoan parasite Tetracapsuloides bryosalmonae is reported for the first time in Iceland. Infections were confirmed in both arctic charr and brown trout but only arctic charr showed clinical signs. The last two decades, populations of arctic charr in several lakes in Iceland have greatly declined. Possible relation of this decline with increasing water temperature has been speculated. It is hypothesized that PKD may play a significant role in this decline. Studies on the distribution of PKD and its effect on wild populations of arctic charr and brown trout in Iceland are presently in progress.

For decades, Proliferative kidney disease (PKD) has been considered one of the most serious diseases of farmed salmonids in Europe and North America, causing mortality up to 90% (Clifton-Hadley et al., 1984; Hedrick et al., 1993). The impact on wild fish populations is however poorly known. The causative agent is a myxozoan species Tetracapsuloides bryosalmonae whose life cycle involves different species of freshwater Bryozoa (Anderson et al., 1999; Canning et al., 1999; Longshaw et al., 1999). Most salmonid species are susceptible to infections and one non-salmonid, northern pike (Esox lucius L.), has been reported to show myxozoan forms resembling those observed in PKD infected salmonids (Bucke et al., 1991).

Since the year 2007, a study investigating the prevalence of Renibacterium salmoninarum infections in the Ellidaár river system has been in progress with emphasis on Atlantic salmon, Salmo salar L. Part of the material was resident arctic charr, Salvelinus alpinus (L.), and brown trout, Salmo trutta L., from Lake Ellidavatn (64°06´ N and 21°47´W). Lake Ellidavatn is a shallow spring fed lake (mean depth 1.5m) with a surface area of 1.5 km² and a water volume approx. 2.7 million m³. Two rivers flow into the lake and it is discharged into river Ellidaár (rate of flow approx. 5 m³/s). In addition to arctic charr and brown trout the lake harbours eel Anguilla anguilla (L.), three spined stickleback Gasterosteus aculeatus L. and migrating Atlantic salmon.

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Fish were sampled on October 3rd 2008, using a series of gillnets of monofilament nylon with mesh sizes 12-50 mm (knot-to-knot). This combination of mesh sizes sampled arctic char and brown trout in the length interval of 13-50 cm. A total of 18 arctic char and 60 brown trout were examined. During dissection, three of 18 char showed clinical signs resembling proliferative kidney disease, i.e. extensive renal swelling (kidney 4 to 5 times normal size) with a pale mottled like appearance. None of the trout showed clinical signs. Kidney samples from these three char were fixed in 10% buffered formalin for histological examination. No further examination was made on fish without clinical signs.

Giemsa- and HE stained histological sections showed extensive numbers of forms resembling extrasporogonic stages of Tetracapsuloides bryosalmonae (Figure 1A). For confirmation, immunohistochemistry was applied using Mab against T. bryosalmonae (Aquatic Diagnostics Ltd) (Figure 1B).

In light of these results, six arctic char (length 24.4-34.2cm) and 41 brown trout (length 12.2-42.2cm) from a nearby lake, Lake Víflilsstadavatn, were sampled on November 21st 2008, using the same mesh size combination of gillnet series as described before. Lake Víflilsstadavatn is a shallow spring fed lake (mean depth 0.5m) with a surface area of 0.27 km² and discharged into a small brook. Apart from arctic char and brown trout, the lake is inhabited by eels and three spined sticklebacks.

All fish sampled were screened for the presence of T. bryosalmonae; none of which had clinical signs of PKD. However, examination of stained histological slides (HE and immunostaining) showed all six char and 5 of the 41 brown trout to be infected with T. bryosalmonae. Infections were very light, only few forms detected in each sample which in many cases seemed to be degenerating.

This is the first report of PKD in Iceland and consequently extends its known geographic distribution which is wide; found in various species of salmonids in most European countries and North America (e.g. Clifton-Hadley et al., 1984; Hedrich et al., 1993). As mentioned before, the impact of PKD on wild salmonid populations is in general poorly known. However, PKD is thought to be an important factor in the extreme decline of wild populations of brown trout in Swiss rivers (Wahli et al., 2002). Furthermore, PKD is considered the main cause of mass mortality of Atlantic salmon fry in Norwegian rivers in the years 2002-2004 and 2006, reducing the smolt production in River Åelva by 50-75% (Forseth et al., 2007; Sterud et al., 2007). In both these cases an increase in temperature due to global warming is mentioned as a potential factor intensifying the effect of PKD on salmonid populations.

The last two decades, populations of arctic char in several lakes in Iceland, including Lake Ellidavatn and Lake Víflilsstadavatn, have greatly declined. Populations of brown trout in these lakes have however remained steady during this same period (Einarsson and Árnason, 2001; Antonsson et al., 2007; Bjarnadóttir, 2007; Malmquist et al., 2009). Possible reasons for this decline have been studied in Lake Ellidavatn. The most likely
Figure 1. Histological sections of kidney of arctic charr from Lake Ellidavatn showing numerous extrasporegonic stages of *Tetracapsuloides bryosalmonae*. (A) HE staining. (B) Immunostaining.
factor of influence is thought to be the water temperature which significantly increased in all summer months from 1988 to 2006, e.g. the mean temperature in August (= 14°C in 2006) increasing of 2.3°C over the period (Antonsson et al., 2007, Malmquist et al., 2009). However, the nature of this relationship remains to be explained. PKD is associated with rising temperature, symptoms most frequently occurring when temperature reaches 12 to 15°C and above (Morris et al., 2005; Tops et al., 2006).

Previous studies have shown that infected fish that recover from the disease are resistant to further infection (Foott and Hedrick, 1987). Consequently, juvenile fish (fry and fingerlings) are generally more susceptible to infections than older fish.

Our results demonstrate the presence of *T. bryosalmonae* in the lakes Ellidavatn and Vífilsstadarvatn. Furthermore, the results indicate that arctic charr is more susceptible to PKD than brown trout; three of 18 arctic charr from Lake Ellidavatn showed clinical signs of PKD but none of the 40 trout examined. The prevalence in arctic charr from Lake Vífilsstadarvatn was also much higher than in brown trout, i.e. 100% and 12%, respectively. The limited studies made on PKD in arctic charr have shown this species to be extremely susceptible to PKD (Brown et al., 1991; Kent et al., 2000). According to these studies, arctic charr seem to develop PKD at a lower temperature than other salmonid species (Brown et al., 1991; Kent et al., 2000). This could possibly be the case for brown trout and arctic charr in Iceland.

Given that *T. bryosalmonae* is widespread in the lakes examined, one could assume that many of the older fish in these lakes have previously been exposed to the pathogen and acquired resistance. The great majority of the fish examined in present study ranged from 20 to 45 cm in length (age 2 to 8 years). Of the three fish showing clinical sign of PKD, two were of age group 1+ and one 2+. This leads to speculations regarding the effect on the younger fish in the lakes being exposed to the pathogen for the first time.

*Tetracapsuloides bryosalmonae* occurs in a broad range of bryozoan hosts (Anderson et al., 1999; Longshaw et al., 1999; Okamura and Wood, 2002) but species of the genera *Plumatella* and *Fredericella* are considered the most important hosts (Okamura and Wood, 2002). Five bryozoan species, i.e. *Plumatella fungosa*, *P. repens*, *Fredericella sultana*, *Hyalinella punctata* and *Christatella muceda*, have been found in Icelandic lakes (Steingrimsson, 1985). Two of them, *F. sultana* and *P. repens*, have been studied in the Lake Urridakotsvatn which is about 5 km away from Lake Ellidavatn and 2 km from Lake Vífilsstadarvatn. Even though the existence of bryozoans has not been confirmed in Lake Ellidavatn and Lake Vífilsstadarvatn, in light of our results one must assume they do.

We hypothesize that PKD, as a consequence of increased temperature in Lake Ellidavatn, could be a considerable factor of significance in the declining population of arctic charr in the lake. Extensive studies on the distribution of PKD and its effect on wild populations of arctic charr and brown trout in Iceland are presently in progress.
References


