

Five Trophically-transmitted Parasites from Adult Arctic Lampreys *Lethenteron camtschaticum* (Petromyzontiformes: Petromyzontidae): Biological Indicators of the Host's Marine Life as a Predator

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Five species of helminth endoparasite (two digeneans, *Brachyphallus crenatus* (Rudolphi, 1802) and *Lecithaster gibbosus* (Rudolphi, 1802); two cestodes, plerocercoids of *Nybelinia surmenicola* (Okada in Dollfus, 1929) and a tetraphyllidean; and an acanthocephalan, post-cystacanth of *Bolbosoma* sp.) were found in adults of Arctic lampreys *Lethenteron camtschaticum* (Tilesius, 1811) arriving in the lower part of the middle reaches of a river in Hokkaido, Japan, for spawning after a period of growth in the sea. These parasites are all common species previously reported from various marine fishes in the North Pacific and all have complex life-cycles involving host-to-host transmission via a predator-prey relationship. To have become infected with these food-borne parasites, Arctic lampreys need to have ingested various body parts of infected prey fishes at sea. Consequently, the endoparasites recovered suggest that the Arctic lamprey has a role as a predator in marine ecosystems.

Key Words: Arctic lampreys, parasites, biological indicators, mode of feeding.

Introduction

The Arctic lamprey *Lethenteron camtschaticum* (Tilesius, 1811) is a jawless primitive vertebrate, occurring in cold waters from the Varanger Fjord region in Norway, through the Arctic Sea along the coast of Siberia, to the North Pacific rim, including northern Japan and northern Canada (Hubbs and Potter 1971). This species has an anadromous migratory life-history, consisting of freshwater-larval and marine-growth periods (McDowall 1988). Fluvial individuals, which reside in fresh waters throughout their lives, have also been reported but occur only in a few locations (e.g., Yamazaki *et al.* 1998), and thus the species is principally considered a migratory form. In their early life-history, lamprey larvae spend several years in freshwater streams as detritus-feeders called ammocoetes (see Hardisty and Potter 1971a), which are noted for burrowing into soft substrates (Shirakawa *et al.* 2013). Subsequently, ammocoetes undergo a metamorphosis into young adults, which migrate down to marine habitats, where they grow until the onset of sexual maturation (Hardisty and Potter 1971b; McDowall 1988). In the Asian Far East, they tend to be found in coastal waters (Sviridov *et al.* 2007) and do not appear to migrate far from their natal streams (see Yamazaki *et al.* 2011).

Young adults are known to change their mode of feeding to become flesh feeders, consuming the surface tissues of

marine organisms by attaching to the latter with a disc-shaped mouth sucker (Renaud *et al.* 2009). Indeed, scarring caused by *L. camtschaticum* has been reported anecdotally from salmonids (Bugaev and Shevlyakov 2007; Shevlyakov and Parensky 2010). Due to this method of feeding, the Arctic lamprey has generally been considered to be a parasitic species. In addition to inflicting scars, the scooping out of trails, which likely represent fatal wounds, has also been reported in the case of small fishes (Roslyi and Novomodnyi 1996; Novomodnyi and Belyaev 2002). This suggests that the Arctic lamprey may have a combined role, not only as a parasite but also as a predator, in the coastal marine ecosystem, but details of its feeding habits are little understood because of methodological difficulties in field sampling of marine individuals.

Parasite species, which have a complex life-cycle involving transmission from host to host via predator-prey relationships, are sometimes used as biological indicators and provide useful information on the host's feeding habits (Marcogliese and Cone 1997). In the Petromyzontiformes, for example, Lethbridge *et al.* (1983) provided interesting insights into the biology of the Southern Hemisphere lamprey *Geotria australis* Gray, 1851, which indirectly consumes arthropods via the ingestion of the digestive organs of its host fishes, judging from the known infection routes of trophically-transmitted parasites. Such food-borne species have also been reported from Arctic lampreys (reviewed