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Occurrence of *Pseudorhadinorhynchus leuciscus* (Acanthocephala: Illiosentidae) in big-scaled redfin, *Tribolodon hakonensis*, in coastal marine waters of Hokkaido, northern Japan

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Abstract. The illiosentid acanthocephalan *Pseudorhadinorhynchus leuciscus* (Krotov & Petrochenko, 1956) was collected from the intestine of big-scaled redfin, *Tribolodon hakonensis* (Günther, 1877), at four sites in coastal marine waters of Hokkaido, northern Japan. These collections indicate that this acanthocephalan is an intestinal parasite of *T. hakonensis* inhabiting the coastal marine waters. The host fish is known to consist of two ecologically different, river-resident and anadromous, individuals. We suggest a practical use of *P. leuciscus* as a biological tag to identify the anadromous individuals of *T. hakonensis* that migrate from the sea to and stay in rivers during their spawning period.

Key words: *Pseudorhadinorhynchus leuciscus*, Acanthocephala, fish parasite, *Tribolodon hakonensis*, biological tag

Introduction

The big-scaled redfin, *Tribolodon hakonensis* (Günther, 1877), is a cyprinid with a unique life history. Cyprinids are primary freshwater fishes that complete their life cycles only in fresh waters, but exceptionally, *T. hakonensis* contains both anadromous (= sea-migrating) and fluvial (= river-resident) individuals in the same populations (Tabeta & Tsukahara, 1964; Nakamura, 1969; Sakai, 1995). The anadromous individuals are hatched in fresh waters, go to the sea for growth, and then return to rivers for reproduction. During their spawning season, both fluvial and anadromous individuals co-occur in the same rivers, but as these fish are morphologically very similar, it is difficult to externally distinguish them from each other. Under these situations, Hashimoto (2000), who studied the parasites of fluvial and anadromous individuals of *T. hakonensis* from two rivers of northern Honshu, Japan, has suggested that an intestinal parasite *Pseudozoogonoides ugui* Shimazu, 1974 (Platyhelminthes: Digenea) can be used to identify the anadromous fish in the rivers because those fish were very often (up to 97.3%) infected by the digenean of possibly marine origin.

The illiosentid acanthocephalan *Pseudorhadinorhynchus leuciscus* (Krotov & Petrochenko, 1956) is an intestinal parasite of *T. hakonensis* in coastal marine waters of northern Japan (Machida & Araki, 1982; Araki & Machida, 1987). Hashimoto (2000) found *P. leuciscus* in his samples of *T. hakonensis* from the middle- and lower reaches of the Hei River but did not discuss a possible use of this acanthocephalan as a biological indicator to study the ecology of *T. hakonensis* because no data had been available on the acanthocephalan's occurrence in marine

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T. hakonensis. Recently, we collected *P. leuciscus* in *T. hakonensis* at four sites in coastal marine waters of Hokkaido, northern Japan. Based on the data obtained, we herein discuss a potential use of *P. leuciscus* as a biological tag to identify anadromous individuals of *T. hakonensis* in rivers.

Materials and Methods

In total, 74 individuals of *T. hakonensis* were collected with rod and line at Esashi (41°52′08″N, 140°07′31″E), Moheji (41°45′22″N, 140°36′18″E), Hama-atsuma (42°36′22″N, 141°49′03″E), and Tomihama (42°29′38″N, 142°01′05″E), Hokkaido, in the summer and fall of 2016 (Table 1). The fish from Esashi and Moheji were transported alive to the laboratory of Hokkaido University, Hakodate, where they were measured for standard length (SL) and examined for the presence or absence of *P. leuciscus* in the intestine. The fish from Hama-atsuma and Tomihama were frozen and transported to the laboratory of Hiroshima University, Higashi-Hiroshima, where they were thawed, measured for SL, and examined for *P. leuciscus*. In both laboratories, the number of acanthocephalans was recorded for each fish, and most of them were flattened and fixed in 70% ethanol with coverslip pressure, but some from Esashi, Moheji, and Tomihama were fixed in 99.5% ethanol for future molecular analysis. The specimens fixed in 70% ethanol were later stained with Heidenhain's iron hematoxylin or alum carmine, dehydrated, and mounted in Canada balsam. These stained specimens will be described elsewhere because this paper focuses on the occurrence of *P. leuciscus* in coastal marine *T. hakonensis*. Three terms, *i.e*., prevalence, intensity, and mean intensity, follow those defined by Bush *et al*. (1997).

Results

Forty-two (56.8%) of the 74 individuals of *T. hakonensis* examined were found to be infected by *P. leuciscus* (Table 1). While the prevalence of the acanthocephalan was low (14.3%) at Tomihama on 23–31 July 2016, it was much higher (54.6–90.0%) at the other sampling sites. The most frequent intensity of *P. leuciscus* was one (42.9% of the 42 infected fish), but up to 15 worms were found in a single fish from Moheji. The worms were as large as up to 12.5 mm in trunk length (based on 10 flattened and stained specimens) and usually colored bright yellow or orange, which made them well visible when the host's intestine was opened (Fig. 1). The worms inserted their proboscis, neck, and anterior part of the trunk deeply into the host's intestinal wall. Such inserted portions were surrounded by the host's tissues and easily recognized as protrusions from the outer surface of the host's intestine.

Table 1. Occurrence of *Pseudorhadinorhynchus leuciscus* in *Tribolodon hakonensis* at four sites in coastal marine waters of Hokkaido.

Sampling site	Sampling date	Standard length (mean) in mm	No. of fish examined	Prevalence (%)	Intensity	Mean intensity
Esashi	18 July 2016	121–163 (147)	4	75.0	0–1	1.0
Moheji	21 July 2016	116–191 (164)	7	85.7	0–15	5.5
Tomihama	23–31 July 2016	87–285 (150)	21	14.3	0–1	1.0
	16 October 2016	74–275 (165)	22	54.5	0–6	2.0
Hama-atsuma	31 July 2016	97–198 (128)	20	90.0	0–7	2.8
Total		74–285 (150)	74	56.8	0–15	2.7

Fig. 1. *Pseudorhadinorhynchus leuciscus* infecting the intestine of *Tribolodon hakonensis* caught at Moheji on the coast of Hokkaido on 21 July 2016. Ten worms of *P. leuciscus* inserted their anterior body deeply into the host's intestinal wall. Scale bar: 5 mm.

Discussion

The observations and data in this study indicate that *P. leuciscus* is a well-visible large common parasite of *T. hakonensis* in coastal marine waters of Hokkaido and firmly attached to the host's intestine. As *P. leuciscus* was also found in *T. hakonensis* from the middle- and lower-reaches of the Hei River (Hashimoto, 2000), it is highly likely that the acanthocephalan is not dislodged from the host's intestine soon after the fish return to rivers but remains in the intestine while they stay in fresh waters. In other words, *P. leuciscus* has a high potential as a biological tag to identify those individuals of *T. hakonensis* that migrate from the sea to and stay in the rivers during their spawning season. Nevertheless, much remains poorly known on the biology of *P. leuciscus*. For a practical use of *P. leuciscus* in ecological studies of *T. hakonensis*, we need more information on various aspects of the biology of the acanthocephalan, such as the geographical distribution, prevalence and intensity in different localities and seasons, life history including the intermediate host (probably amphipods, see Nagasawa & Fujioka, 2015), and a period of survival in the intestine of the host staying in fresh waters.

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