別寒辺牛川のサクラマス幼魚におけるヤマメナガクビムシ(新称)Salmincola californiensisの寄生状況

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Infection of *Salmincola californiensis* (Copepoda: Lernaeopodidae) on Juvenile Masu Salmon (*Oncorhynchus masou*) from a Stream in Hokkaido

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Abstract. – The parasitic copepod *Salmincola californiensis* infected 18 (94.7%) of 19 masu salmon juveniles collected from the Bekanbe-ushi River in eastern Hokkaido in the springs of 1982 and 1983, while the parasite was not found on white-spotted charr nor Sakhalin taimen from the river. The mean intensity of the parasite on masu salmon was 10.3 (intensity range, 1-26). There was a significant increase in intensity of infection as the size of the host fish increased. Most of the copepods found were mature adult females, followed by chalimus larvae and young adult females. The mature adult females were attached almost exclusively to the gills and the inner surface of the operculum. The chalimus larvae were found on the gills. The distal ends of the gill filaments attached by adult females were damaged, but there were no significant correlations between condition factor and intensity of infection. This paper is the first confirmed record of *S. californiensis* from Hokkaido.

Key words : parasitic Copepoda, *Salmincola californiensis*, host range, masu salmon, prevalence, infection site, Hokkaido

Introduction

The lernaeopodid copepod *Salmincola californiensis* (Dana, 1852) is an ectoparasite of freshwater salmonids in the North Pacific rim countries (Kabata 1969). In Japan, the hitherto known hosts of this copepod are masu salmon (*Oncorhynchus masou*), Japanese charr (*Salvelinus leucomaenis pluvius*) and possibly also amago salmon (*O. masou ishikawae* [previously as *O. rhodurus*]) (Nagasawa et al. 1987). Since *S. californiensis* has been reported from both wild and farmed fish in Japan (Hoshina and Suenaga 1954; Hoshina and Nishimura 1976; Nishimura and Hoshina 1977), it is generally believed to frequently occur on Japanese salmonids. However, there is actually no information about the occurrence of the species on salmonids from Japan. During a parasitological survey of salmonids collected in the Bekanbe-ushi River, eastern Hokkaido, we found that juvenile masu salmon were infected with *S. californiensis*. The known localities of the copepod in Japan are limited to the central area of Honshu (Nagano and Gunma prefectures), and this finding is the first record from outside Honshu in this country. As a preliminary study to understand the biology of *S. californiensis* in Japan, we examined the occurrence of the parasite on juvenile masu salmon from the river.

Materials and Methods

Juvenile masu salmon (*Oncorhynchus masou*) were collected at two brooks (Toraibetsu and Chiraikaribetsu) in the Bekanbe-ushi River (Fig. 1) by rod and line in April of 1982 (n=10) and 1983 (n=4). Some additional fish were taken in June 1982 (n=5). In addition, six white-spotted charr (*Salvelinus leucomaenis*) and three Sakhalin taimen (*Hucho perryi*) were caught in a brook (Toraibetsu) in April and June 1982. All fish were fixed in 10% formalin and brought to the laboratory, where they were measured

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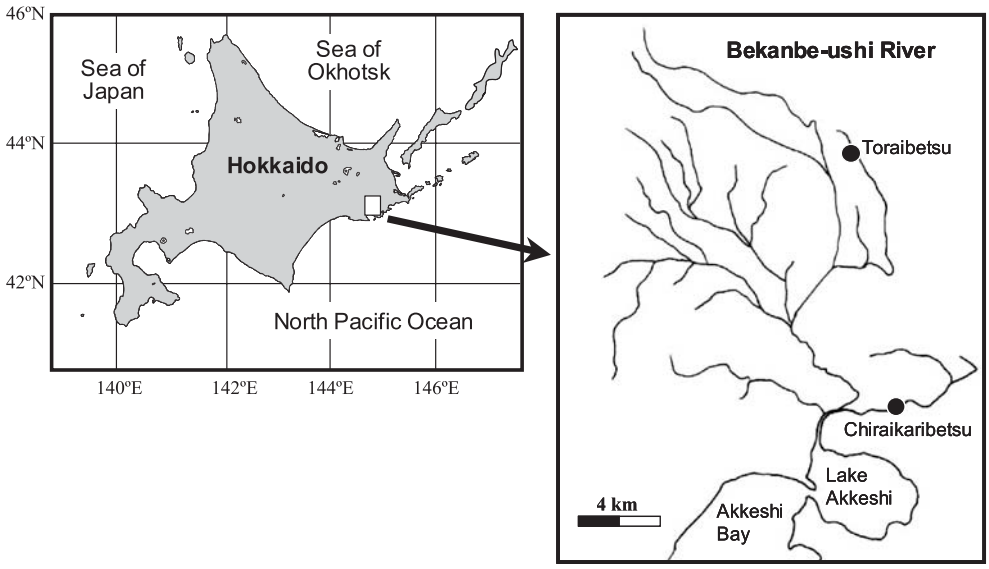

Fig. 1. Maps showing the Bekanbe-ushi River where masu salmon juveniles were collected for the present study (closed circles).

to the nearest millimeter (fork length) and weighed to the nearest gram. Based on the body size and coloration, masu salmon were thought to be age-1 fish and consisted of 18 parrs and one smolt. The branchial cavity, body surface, fins, and fin bases were examined for the presence of *S. californiensis* using a dissecting microscope. When found, the copepods were removed and preserved in 70% ethanol. For the distribution of *S. californiensis* on the host fish, attachment sites were recorded from the fish (n=14) collected in April of 1982 and 1983. Based on morphological characters of *S. californiensis* given by Kabata and Cousens (1973), the copepods were designated into one of the following three categories: chalimus larvae (with frontal filaments), young adult females, and mature adult females. To assess the effect of *S. californiensis* on juvenile masu salmon, the condition factor (CF) of the fish (n=17, one heavily damaged fish and one smolt were excluded) was calculated as follows: $CF = 10^5 \times BW/FL^3$, where BW is body weight (g) and FL is fork length (mm).

Results

Eighteen (94.7%) of the 19 juvenile masu salmon examined were infected with *S. californiensis* (Table 1). The parasite was not found on white-spotted charr (n=6) nor Sakhalin taimen (n=3), although a young adult female of *S. carpionis* infected the gill arch of the former species. The mean intensity of *S. californiensis* on masu salmon was 10.3, and the largest number of copepods found on a single host was 26 (Appendix). The fish ranged from 95 to 195 (mean 137) mm in fork length, and there was a significant increase in intensity of infection as the size of the host fish increased ($r=0.82$, $p<0.001$)(Fig. 2).

A total of 185 copepods of *S. californiensis* was found (Appendix). Most of the copepods were

Table 1. Prevalence and mean intensity of *Salmincola californiensis* on salmonids caught in the Bekanbe-ushi River in the springs of 1982 and 1983.

Brook	Fish			*Salmincola californiensis*	
	Species	Fork length (mm)*	Number of samples	Prevalence (%)	Intensity*
Chiraikaribetsu	masu salmon	157±5	3	100	12.3±4.7
Toraibetsu	masu salmon	133±29	16	93.8	9.9±8.4
	white-spotted charr	147±30	6	0	0
	Sakhalin taimen	225±63	3	0	0

* Mean±SD.

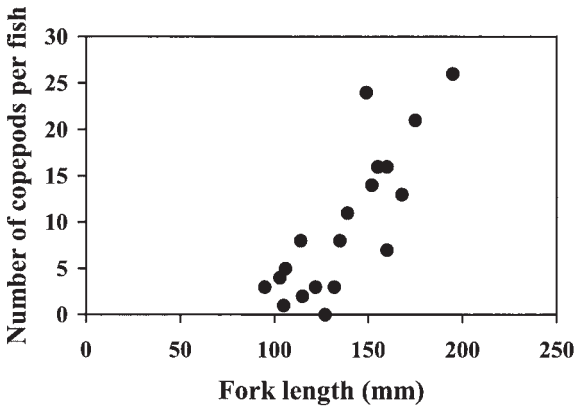

Fig. 2. Relationship between juvenile masu salmon length and intensity of infection with *Salmincola californiensis*.

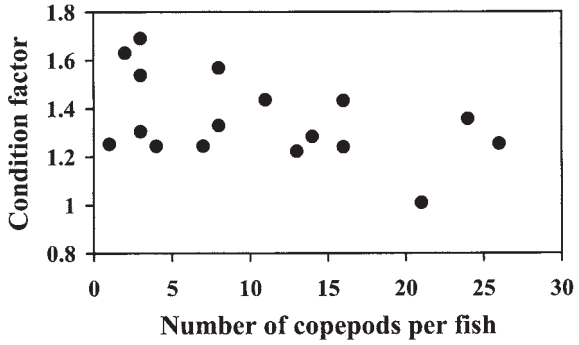

Fig. 3. Scatterplot of intensity of infection with *Salmincola californiensis* versus condition factor of juvenile masu salmon.

mature adult females (82.7%), followed by chalimus larvae (12.4%) and young adult females (4.9%). The majority (74.1%) of the mature adult females carried egg sacs, but some (8.6%) had no egg sacs. Of the 158 copepods examined for attachment sites, mature adult females (n=130) were the most common on the gills (49.1%) and the inner surface of the operculum (43.1%). Some mature adults were found on the pectoral and pelvic fins (5.4%) and near the bases of the fins (2.3%). Young adult females (n=5) also occurred on the same sites. Chalimus larvae (n=23) were found on the gills. There was a difference in infection site on the gills between developmental stages: the adult females were attached to distal ends of the gill filaments, whereas the chalimus larvae were found on basal and middle regions of the gill filaments.

The distal ends of the gill filaments of juvenile masu salmon attached by adult females were damaged, and such gill portions were lost. The condition factor showed a slight decreasing trend with an increase in intensity of infection (Fig. 3), but there were no significant correlations between condition factor and intensity of infection ($r= -0.46$, $p>0.05$).

Discussion

The present paper is the first confirmed record of *S. californiensis* from Hokkaido. Prior to this report, there was a record of *S. falculata* from this region. Yamaguti (1939) described this species from kokakee (*Oncorhynchus nerka*) taken in Lake Penke, eastern Hokkaido. Subsequently, in his review paper on the genus *Salmincola*, Kabata (1969) synonymized *S. falculata* with *S. californiensis*, and thus the latter species had been believed to be distributed in Hokkaido (cf. Hoshina and Nishimura 1976; Nishimura and Hoshina 1977). However, Nagasawa et al. (1995) noted that the copepods reported by Yamaguti (1939) were not *S. californiensis* but *S. carpionis*, and this view has been currently accepted. *Salmincola californiensis* is the third species of the genus found in Hokkaido, and *S. stellatus* has been reported to occur in this region (Kabata 1986, Nagasawa and Urawa 1991, Nagasawa et al. 1994).

Salmincola californiensis was recorded from salmon belonging to the genus *Oncorhynchus* in western North America (Kabata 1969). The present survey confirmed that white-spotted charr and Sakhalin taimen, cohabited with juvenile masu salmon, were not infected, although Nishimura and Hoshina (1977) reported *S. californiensis* from Japanese charr reared at a hatchery along the Shinano River System in Nagano. It may be necessary to reconfirm the presence of the parasite on Japanese charr in that area, because Japanese charr is commonly infected with *S. carpionis* (Nagasawa et al. 1995).

The intensity of *S. californiensis* increased with increasing body length of masu salmon. Similar results have been reported for other species of the genus *Salmincola* (Bowen and Stedman 1990 for *S. corpulentus*; Nagasawa et al. 1995, 1998 for *S. carpionis*). In a laboratory study, Poulin et al. (1991) demonstrated that larger brook trout (*Salvelinus fontinalis*) acquired more infections with *Salmincola edwardsii*. This is because larger fish have a greater surface for attachment of infective larvae and are exposed to parasites for a longer period .

Most of the adult females found were attached to

the gills and the inner surface of the operculum. This result is consistent with the finding by Kabata and Cousens (1977), who reported that adult *S. californiensis* were the most common in the branchial cavity of juvenile sockeye salmon (*O. nerka*) under laboratory conditions. However, these authors found that *S. californiensis* were the most abundant in the region of the pectoral and pelvic fins in case of sockeye salmon fry, and it has been suggested that, with an increase in fish length, the gills become a major attachment site for adult copepods (Kabata and Cousens 1977; Sutherland and Wittrock 1985). In the present study, the chalimus larvae were found on the basal and middle regions of the gill filaments, suggesting that larval attachments occur in these regions and preadult females move to distal ends of the gill filaments and the inner surface of the operculum for the final attachment (Kabata and Cousens 1977; Sutherland and Wittrock 1985).

Gill tissue destruction caused by adult *S. californiensis* has been reported (Hoshina and Suenaga 1954; Kabata and Cousens 1977; Sutherland and Wittrock 1985). Up to 25% loss of the gill surface due to this parasite is known (Kabata and Cousens 1977). Although we did not measure the missing surface areas of infected gills, we recognized similar damaged conditions reported by Kabata and Cousens (1977, Fig. 8) and Sutherland and Wittrock (1985, Fig. 5). Some histopathological studies on infected gill tissues have been made (Hoshina and Suenaga 1954; Kabata and Cousens 1977; Sutherland and Wittrock 1985), but little information is available on the effect of the parasite on the body condition of infected fish. We did not find a significant decrease in condition factor for the infected fish, but since *S. californiensis* has been documented to reduce the egg production of hatchery-reared rainbow trout (*O. mykiss*) (Gall et al. 1972), it is desirable to assess the impact of this parasite on the growth, maturation, and physiology of the host fish.

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別寒辺牛川のサクラマス幼魚におけるヤマメナガクビムシ（新称）*Salmincola californiensis* の寄生状況

長澤和也・浦和茂彦

北海道東部の別寒辺牛川で1982年と1983年の春季に採集したサケ科魚類におけるヤマメナガクビムシ*Salmincola californiensis*の寄生状況を調べた．検査したサクラマス幼魚19個体中，18個体（94.7%）が寄生を受け，1個体当たりの平均寄生数は10.3虫体であった．アメマスとイトウには本虫の寄生がみられなかった．寄生数は，サクラマス幼魚の体長の増加とともに有意に増加した．採集されたヤマメナガクビムシは成熟雌，未成熟雌，カリムス幼生から成り，成熟雌の多くは鰓や鰓蓋内面に寄生していた．カリムス幼生は鰓のみに見られた．成熟雌が鰓先端部に寄生した場合には，寄生部位は欠損していた．寄生数の増加に伴ってサクラマス幼魚の肥満度は有意に減少しなかった．わが国におけるヤマメナガクビムシの記録はこれまで長野県と群馬県に限られ，本報告が北海道からの初記録となる．なお，*Salmincola*属とこの属に含まれる種に対して和名がないことから，本属に対してヤマメナガクビムシ属，*S. carpionis*にイワナナガクビムシ，*S. stellatus*にイトウナガクビムシ，*S. edwardsii*にオショロコマナガクビムシの和名を提案する．

Appendix. A record of *Salmincola californiensis* on salmonids caught in the Bekanbe-ushi River.

Brook	Date of catch	Fish			Number of parasites				
		Species	Fork length (mm)	Weight (g)	Chalimus larvae	Young adult females	Adult females with egg sacs	Adult females with no egg sacs	Total
Chiraikaribetsu	April 29, 1982	masu salmon	152	45.1	5	0	9	0	14
Chiraikaribetsu	April 29, 1982	masu salmon	160	58.7	0	0	16	0	16
Chiraikaribetsu	April 29, 1982	masu salmon	160	51.0	0	1	6	0	7
Toraibetsu	April 29, 1982	masu salmon	155	46.2	0	0	16	0	16
Toraibetsu	April 29, 1982	masu salmon	149	44.9	10	0	11	3	24
Toraibetsu	April 29, 1982	masu salmon	114	19.7	5	0	3	0	8
Toraibetsu	April 29, 1982	masu salmon	103	13.6	3	0	1	0	4
Toraibetsu	April 29, 1982	masu salmon	95	11.2	0	0	2	1	3
Toraibetsu	April 29, 1982	masu salmon	105	14.5	0	0	1	0	1
Toraibetsu	April 29, 1982	masu salmon	106	12.2	0	0	4	1	5
Toraibetsu	June 27, 1982	masu salmon	139	38.6	0	2	9	0	11
Toraibetsu	June 27, 1982	masu salmon	122	30.7	0	0	1	2	3
Toraibetsu	June 27, 1982	masu salmon	135	38.6	0	2	2	4	8
Toraibetsu	June 27, 1982	masu salmon	132	35.4	0	0	1	2	3
Toraibetsu	June 27, 1982	masu salmon	115	24.8	0	0	0	2	2
Toraibetsu	April 23, 1983	masu salmon	175	54.2	0	3	18	0	21
Toraibetsu	April 23, 1983	masu salmon	168	58.0	0	0	13	0	13
Toraibetsu	April 23, 1983	masu salmon	195	93.0	0	1	24	1	26
Toraibetsu	April 23, 1983	masu salmon*[1]	127	22.1	0	0	0	0	0
Toraibetsu	April 29, 1982	white-spotted charr*[2]	181	63.4	0	0	0	0	0
Toraibetsu	June 27, 1982	white-spotted charr	185	85.6	0	0	0	0	0
Toraibetsu	June 27, 1982	white-spotted charr	120	24.9	0	0	0	0	0
Toraibetsu	June 27, 1982	white-spotted charr	120	28.9	0	0	0	0	0
Toraibetsu	June 27, 1982	white-spotted charr	125	26.2	0	0	0	0	0
Toraibetsu	June 27, 1982	white-spotted charr	150	47.6	0	0	0	0	0
Toraibetsu	April 23, 1983	Sakhalin taimen	162	42.9	0	0	0	0	0
Toraibetsu	June 27, 1982	Sakhalin taimen	227	170.2	0	0	0	0	0
Toraibetsu	June 27, 1982	Sakhalin taimen	287	318.2	0	0	0	0	0

*[1] Smolt. Other masu salmon were parrs.

*[2] One preadult of *Salmincola carpionis* infected the gill arch.