河川生活期サクラマスOncorhynchus masou幼魚への鉤頭虫Acanthocephalus sp.寄生の季節変化

誌名	日本水産學會誌
ISSN	00215392
著者	真山, 紘
巻/号	55巻9号
掲載ページ	p. 1517-1522
発行年月	1989年9月

Nippon Suisan Gakkaishi 55(9), 1517-1522 (1989)

Seasonal Changes in the Infection of *Acanthocephalus* sp. (Acanthocephala) in Juvenile Masu Salmon *Oncorhynchus masou*

Hiroshi Mayama*

(Received April 15, 1989)

The seasonal occurrence of an echinorhynchid acanthocephalan *Acanthocephalus* sp. in stocked juvenile masu salmon *Oncorhynchus masou* was examined in the Mena River, southwestern Hokkaido. The prevalence of infection increased greatly soon after fish were stocked in May but decreased sharply in summer and early autumn and increased again in late autumn and winter. The mean intensity of infection exhibited more typically seasonal changes than did the prevalence and highly increased in late autumn and winter. Gravid female worms first appeared in June and were the largest proportion between July and September with a peak in August. They decreased in autumn and winter, but immature females increased during these seasons. Isopods *Asellus hilgendorfi* were infected with *Acanthocephalus* sp. larvae, and large-sized isopods (>4 mm) which had higher parasite prevalences than small-sized isopods, were heavily preyed on by juvenile masu salmon during October and January. Thus, the sharp increase in the infection level during late autumn and spring is in accordance with masu's heavy feeding on large-sized isopods in these seasons. The habitat changes of masu salmon from riffles to pools in winter appear to promote the masu's heavy predation on pool-dwelling isopods.

Masu salmon *Oncorhynchus masou* spend at least one year in rivers prior to their seaward migration. It is thus essential to obtain information on the freshwater life of masu salmon for effective stock enhancement and management.

The feeding ecology of fishes have been commonly investigated by examining their stomach contents. However, since food organisms are easily ingested for a short time, there is a limitat to how far stomach content analyses can be used as fish feeding studies. Certain fish parasites are known to use aquatic invertebrates as intermediate hosts in their life cycles, and such invertebrates are often important prey of fishes. The parasites mostly inhabit the host's digestive tract, and their occurrence could be good indications of fish feeding ecology.

In the Mena River, a tributary of the Shiribetsu River, southwestern Hokkaido, juvenile masu salmon were found to be heavily infected with an echinorhynchid acanthocephalan *Acanthocephalus* sp. Thus, the present study was undertaken to elucidate relations of seasonal acanthocephalan infections to feeding habits of masu salmon in this river. Since the taxonomy of the genus *Acanthocephalus* is still not known in Japan, identification to species level has not been made for the parasite examined in this study, although several species of the genus have been described from wild and cultured Japanese salmonids.[1] The parasite will be described elsewhere and voucher specimens deposited in the Meguro Parasitological Museum, Tokyo.

Material and Methods

The Mena River is a 16.5 km-long tributary stream of the Shiribetsu River which drains into the Sea of Japan (Fig. 1). In this river, the capture of masu salmon has been almost completely prohibited by the Hokkaido Prefecture governmental law. Recently, the river has been stocked with masu salmon fry and smolts[2] and is one of the most productive rivers of this salmon in Japan.

Parasitological surveys were conducted for two cohorts of masu salmon stocked as fry in late May of 1984 and 1985. Prior to stocking, no infections of fish with *Acanthocephalus* sp. were confirmed in the hatchery. Fish were recaptured at two sites, the main stream (7–8 m wide) and a tributary (2–3 m wide), once or twice a month from May 1984 to May 1986. Fish were collected with a cast

* Hokkaido Salmon Hatchery, Nakanoshima, Toyohira, Sapporo, Hokkaido 062, Japan (真山 紘: 水産庁北海道さけますふ化場).

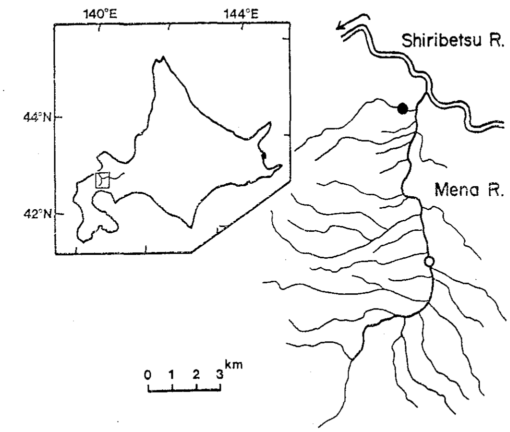

Fig. 1. Map of the Mena River, a tributary stream of the Shiribetsu River, southwestern Hokkaido. Open and closed circles indicate sampling sites in the main stream and the tributary, respectively.

net, dip net, and/or seine, and at least more than 20 fish were obtained at each collection. In winter months, however, sufficient numbers of samples were not often taken because of snow and ice cover of the river. Fish were fixed in 10% formalin soon after collection and brought to the laboratory. They were measured (fork length), weighed, sexed, and examined for *Acanthocephalus* sp. in the intestines. Scales were also removed for subsequent age determination. The terms prevalence and mean intensity follow the definitions given by Margolis *et al.*[3]

For the study of the parasite's recruitment and reproduction, the maturity of female worms from fish of mixed year-classes collected at the main stream site during April 1985 and April 1986 was recorded and assigned to one of three stages on the basis of development of acanthors;

stage I —immature female with ovarian balls but with no acanthors;

stage II —maturing female with immature acanthors; and

stage III—gravid female with shelled acanthors.

Contents of about 20 stomachs removed from masu salmon taken at the tributary site from June 1984 to May 1985 were examined from food analyses and identified to the family level. The number and wet weight of each content were recorded and the data were combined according to the order levels of food organisms.

The aquatic isopod *Asellus hilgendorfi* an intermediate host of *Acanthocephalus* sp., was collected with a dip net at the tributary site once a month from November 1986 to October 1987. Isopods were mainly taken from leaf litter and vegetation in pools near the sides of the stream. They were fixed in 10% formalin at the sampling site, brought to the laboratory, and examined for cystacanth larvae of *Acanthocephalus* sp. The body length of isopods was determined as the length from the anterior tip of the cephalothorax to the posterior tip of the telson.

The water temperature was recorded with the self-registering thermometer set at the middle-reaches of the Mena River. The 10-day changes in mean water temperature with maximum and minimum temperature are shown in Fig. 2.

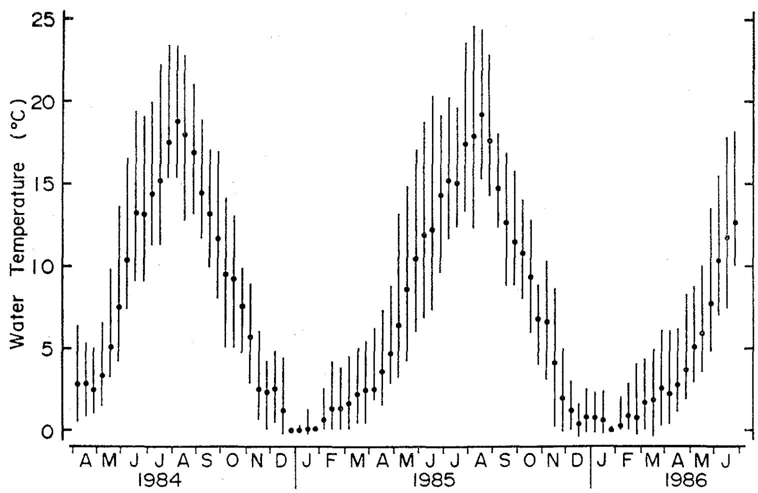

Fig. 2. Ten-day changes in water temperature in the middle reaches of the Mena River. Closed circles and bars indicate means and ranges of temperatures, respectively.

Results

Seasonal Occurrence of Acanthocephalus *sp. in Masu Salmon*

Of masu salmon stocked in May of 1984, 1,309 fish were recaptured at the main stream and tributary sites during the study and 923 (70.5%) fish were infected with a total of 5,392 worms (mean intensity 5.84). Also, among those stocked in May of 1985, 552 (77.0%) of 717 fish were parasitized by a total of 3,594 worms (mean intensity 6.51). There was a great difference in the level of infection between fish from the main stream and those from the tributary. The prevalence and mean intensity of infection with the parasite were consistently higher in fish from the latter site than in those from the former site except for June 1984 (Figs. 3, 4).

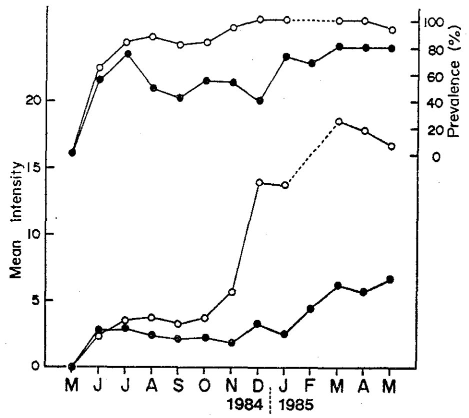

Fig. 3. Seasonal changes in the prevalence (upper) and mean intensity (lower) of *Acanthocephalus* sp. infection in juvenile masu salmon stocked in May 1984. ○, tributary; ●, main stream.

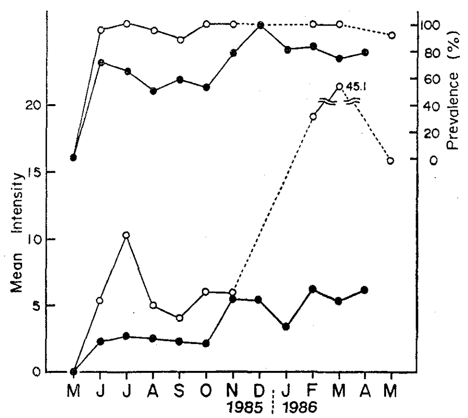

Fig. 4. Seasonal changes in the prevalence (upper) and mean intensity (lower) of *Acenthocephalus* sp. infection in juvenile masu salmon stocked in May 1985. ○, tributary; ●, main stream.

In both masu salmon cohorts stocked in 1984 and 1985, prevalence increased greatly soon after fish were released in May. However, the prevalence decreased slightly in the summer-autumn months and increased again in the late autumn or winter months. Mean intensity exhibited more typically seasonal changes than did prevalence. While the mean intensity increased after fish stocking and decreased slightly thereafter, it increased remarkably during late autumn and spring months, particularly in tributary fish (Figs. 3, 4).

Seasonal Changes in Maturation of Acanthocephalus *sp. in Masu Salmon*

In April, over 70% of female worms were immature (stage I) and the percentage of mature females (stage II) increased in May. Gravid females (stage III) first appeared in June and comprised the largest proportion between July and September with a peak (79.5%) in August. They decreased sharply in October and thereafter remained at a low level with a little increase in December. Immature females also increased during the autumn and winter months and were most abundant in March (Fig. 5).

Seasonal Occurrence of Acanthocephalus *sp. Larvae in* Asellus hilgendorfi

Prevalence in isopods was low (2.02%) throughout the study but a little higher in June-July (Table 1). The smallest infected isopod was 2.8 mm long, and the prevalence in isopods larger than 2.5 mm long was 4.43%.

New generations of *Asellus hilgendorfi* appeared mainly during August and September, when no

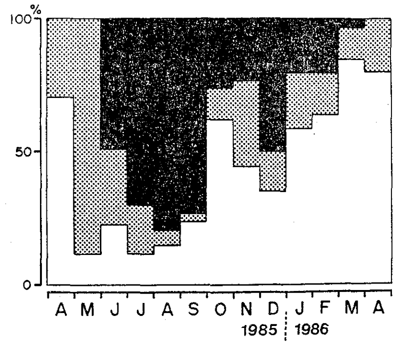

Fig. 5. Seasonal changes in the maturity composition of female *Acanthocephalus* sp. in juvenile masu salmon. ▭, immature (stage I); ▒, mature (stage II); ■, gravid (stage III).

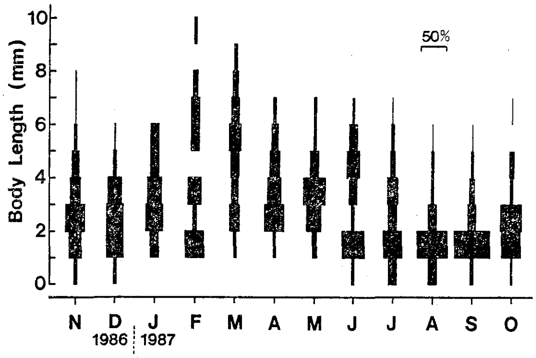

Fig. 6. Seasonal changes in the body length distribution of *Asellus hilgendorfi*.

infection was found. From the autumn to spring, isopods underwent growth and were rarely infected (Fig. 6, Table 1).

Seasonal Changes in Feeding Habits of Masu Salmon

Aquatic insects were major food items eaten by masu salmon juveniles. In particular, dipterans (mainly chironomids) were the most important prey and were heavily taken in winter months. Other aquatic insects such as ehemeropterans (mayflies) and trichopterans (caddisflies) often occurred from spring to early autumn. Aquatic animals rather than insects were eaten mainly in November-December and April-May and ter-

Table 1. Seasonal occurrence of *Acanthocephalus* sp. in *Asellus hilgendorfi* in the Mena River

Month	Number of Asellid		No. of worms found	Prevalence (%)
	examined	infected		
November	151	1	1	0.7
December	118	2	3	1.7
January	42	0	0	0
February	22	0	0	0
March	38	1	3	2.6
April	36	0	0	0
May	65	2	2	3.1
June	132	7	12	5.3
July	105	7	9	6.7
August	102	0	0	0
September	116	0	0	0
October	114	1	1	0.9
Total	1,041	21	31	2.02

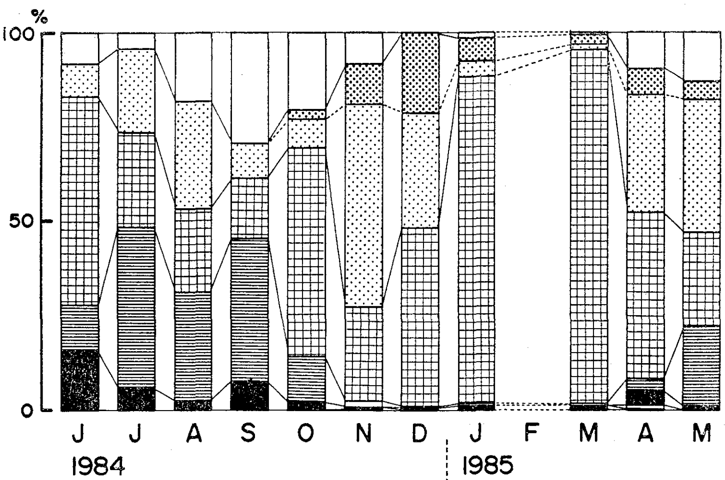

Fig. 7. Seasonal changes in the stomach content composition (% weight) of juvenile masu salmon stocked in May 1984. ▇, Ephemeroptera; ▤, Trichoptera; ▦, Diptera; ▒, *Asellus hilgendorfi*; ░, other aquatic animals; ☐, terrestrial animals.

restrial insects were also taken in the summer and early autumn (Fig. 7).

Asellus hilgendorfi, the intermediate host of *Acanthocephalus* sp. was of little important for masu's food in summer season, but it was frequently taken in the late autumn to spring months, especially in November and December (Fig. 7). The frequency of occurrence of isopods in the masu stomachs was over 40% during October and January and reached a peak (68.5%) in December. Most isopods preyed during these months were large-sized ones (>4 mm).

Discussion

In Japan, there are many papers dealing with Acanthocephalan parasites from wild and cultured salmonid fishes,[1] but little information is available concerning acanthocephalan infections of stream-dwelling masu salmon. Fukui and Morishita[4] reported *Acanthocephalus echigoensis* from this salmon in Yamanashi Prefecture, central Honshu. Nagasawa and Egusa[5] found *Echinorhynchus cotti* in this fish from Aomori Prefecture, northern Honshu. In the Mena River, *Acanthocephalus* sp. was found to parasitize charr *Salvelinus leucomaenis*, sculpin *Cottus nozawae* and forktongue goby *Chaenogobius annularis* as well as juvenile masu salmon.* Of these fishes, masu salmon juveniles are the most abundant in this river[6] and appear to play the most important role as the definitive host for parasites there. However, since most masu salmon migrate to the sea after spending one year in the river, a great loss of the population of *Acanthocephalus* sp. would occur there.

Although the level of infection with *Acanthocephalus* sp. increased soon after fish stocking, it decreased slightly in the summer months and increased again in late autumn and winter months. The decrease in summer season may be mainly caused by the fact that the parasites were lost from the host's intestine after parasite's spawning. Female worms began to be gravid in June and most females produced shelled acanthors in July-September. Similar loss from the host's intestine after parasites' maturation has been reported for some other acanthocephalans.[7-10]

It is considered that the increase in infection level during late autumn and winter results from masu's heavy feeding on *Asellus hilgendorfi* during these seasons. Large-sized isopods had higher parasite prevalences than small-sized isopods. Although masu salmon fed on small-sized isopods during the summer months, they took large-sized isopods heavily in late autumn and winter months. With decreasing water temperatures, juvenile masu salmon move from riffles, the main summer habitat, to the pools edged with rooted vegetation[11,12], and *A. hilgendorfi* is abundant in such pools. Thus, the overlapped habitats of both species would promote chances of masu's predation on isopods. Similarly, the rapid increase in the infection level soon after fish stocking is chiefly caused by the habitat coincidence of masu salmon fry and isopods. The swimming ability of stocked fry is so weak that they prefer pools or slow-flowing sites to riffles or fast-flowing ones. A similar phenomenon was observed by Nagasawa *et al.*[13] who have reported that pool-dwelling forktongue goby become heavily infected with *Acanthocephalus minor* by preying on isopods living there.

A obvious difference in the occurrence of the parasite between fish from the main stream and those from the tributary is seemed to result from differences in population density of the intermediate host between each habitat.*

The present study has definitely shown that the infection with *Acanthocephalus* sp. is closely associated with the feeding habitats of masu salmon, the life history of *A. hilgendorfi*, and the habitats of both species, which suggests that parasite studies are useful for elucidating ecological aspects of host fishes. Therefore, parasitological surverys on some other gastrointestinal helminths would produce more useful and significant information on the ecology of juvenile masu salmon.

Acknowledgements

I am grateful to Dr. K. Nagasawa, Hokkaido Fisheries Experimental Station, for his valuable advice, and to the staff of the Hokkaido Salmon Hatchery for assisting in the collection of samples.

References

1) K. Nagasawa, S. Urawa, and T. Awakura: *Sci. Rep. Hokkaido Salmon Hatchery*, **41**, 1–75 (1987).
2) H. Mayama, K. Ohkuma, T. Nomura, and K. Matsumura: *Sci. Rep. Hokkaido Salmon Hatchery*, **39**, 1–16 (1985).
3) L. Margolis, G. W. Esch, J. C. Holmes, A. M. Kuris, and G. A. Schad: *J. Parasitol.*, **68**, 131–

* Mayama, unpublished.

133 (1982).
4) T. Fukui and T. Morishita: *Zool. Mag.*, **48**, 759–764 (1936).
5) K. Nagasawa and S. Egusa: *Nippon Suisan Gakkaishi*, **47**, 1153–1156 (1981).
6) T. Tanaka, T. Ishida, H. Matsukawa, Y. Ishikawa, and M. Kunda: *Sci. Rep. Hokkaido Salmon Hatchery*, **25**, 1–17 (1971).
7) P. M. Muzzall and F. C. Rabalais: *Proc. Helminthol. Soc. Wash.*, **42**, 31–34 (1975).
8) J. W. Camp, Jr. and H. W. Huizinga: *J. Parasitol.*, **66**, 299–304 (1980).
9) S. Tedla and C. H. Fernando: *Can. J. Zool.*, **48**, 317–321 (1970).
10) H. Fure: *Parasitol.*, **73**, 355–370 (1976).
11) S. Inoue and K. Ishigaki: *Japan. J. Limnol.*, **29**, 27–36 (1968).
12) H. Mayama, T. Nomura, and K. Ohkuma: *Sci. Rep. Hokkaido Salmon Hatchery*, **42**, 21–36 (1988).
13) K. Nagasawa, S. Egusa, and K. Ishino: *Japan. J. Ichthyol.*, **29**, 229–231 (1982).

Nippon Suisan Gakkaishi : Formerly *Bull. Japan. Soc. Sci. Fish.*