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Implication of the Occurrence of Chalimus Larvae (Copepoda, Caligidae) on the Larvae of *Maurolicus muelleri* (Pisces, Sternoptychidae) in the Sea of Japan

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The larvae of the pearlsides [*Maurolicus muelleri* (Gmelin)], ranging from 8.71 to 13.12 mm in total length, collected off central Honshu in the Sea of Japan were found carrying the chalimus larvae (chalimus I, II, III, and IV) of a species of *Caligus*. The larvae of *M. muelleri* are considered acting as an intermediate host for this species of *Caligus* whose adult is yet to be reported from the teleost(s) of the Sea of Japan. However, it bears close resemblance to *Caligus seriolae* Yamaguti" occurring on a coastal fish, *Lateolabrax japonicus* (Cuvier). This would indicate that the larvae of *M. muelleri* have spent sometime in the neritic waters.

Key words: parasitic copepod, pearlsides, *Caligus*, *Maurolicus muelleri*, Sea of Japan

Introduction

Pearlsides [*Maurolicus muelleri* (Gmelin)] is a dominant microneckton fish in the Sea of Japan serving the major trophic link between the primary consumers (zooplankton) and higher carnivorous fishes and marine mammals (Okiyama, 1971; Ohshimo, 1998). It is widely distributed in that sea except for the waters off Hokkaido (Nishimura, 1957; Okiyama, 1971). According to Okiyama (1971), the spawning of this fish in the Sea of Japan occurs throughout the year, except for a few months during the winter, in the coastal region of the shelf edge off central Honshu (Sanin and Hokuriku Districts). The larvae of *M. muelleri* have the same vertical migration like their adults, staying at the depths of 150-250 m in the daytime and migrate to shallower depths of 50 m or less in the evening (Nishimura, 1957; Okiyama, 1971).

Copepods of the Caligidae (Siphonostomatoida) are parasites of marine teleosts and commonly known as sea lice." In general, the development of the caligid copepods comprises nine stages, viz., two stages of nauplius, one stage of copepodid, four stages of chalimus, one or two stages of preadult, and adult. While two naupliar stages are free-living, the remaining larval and adult stages are parasitic. Copepodid is the infective stage. It actively seeks the suitable host, attaches by means of the prehensile antennae, moves to a suitable site, reattaches with the newly formed frontal filament, and then molts into the chalimus. The successive four chalimus stages, chalimus I, II, III, and IV, use the same frontal filament. In other words, the frontal filament is not discarded at the time of molting during the development through the chalimus stages. The preadult breaks away from the frontal filament and, like the adult, moves freely on the host body. It can also swim in the water if dislodged from the host. Therefore, it is not uncommon to find the sea lice with their larval stages occurring on one fish and the adults, on another fish.

In 1993, Okiyama reported the occurrence of chalimus larvae on the larvae of *M. muelleri*, measuring 8.3 to 13.0 mm in total length, collected during October and November throughout the offshore waters in the Sea of Japan. The chalimus stages, consisting of chalimus I, II, and III, were suspected by Okiyama (1993) to be the larvae of *Caligus macarovi* Gusev, which is known to parasitze on several species of fishes in the Sea of Japan including an epipelagic fish - Pacific saury [*Cololabis saira* (Brevoort)]. Nevertheless, we consider it is impossible to identify a third stage of chalimus as a larva of *Caligus*, because its characteristic structure - the lunule - is not yet formed in this stage. Our recent examination of the larvae of *M. muelleri*, measuring 8.71 to 13.12 mm in total length, collected from the waters off Sanin District revealed that the chalimus larvae harbored by them are *Caligus* but not identifiable with *C. macarovi*. This paper reports the result of our finding and its implication.

Materials and Methods

The larvae of pearlsides (*M. muelleri*) were collected on 18 October 1999 by H. Kato (Ocean Research Institute, University of Tokyo) on board the R/V *Hakuho Maru* with the MOCNESS net at 37°14.76'N, 134°25.08'E during the daytime and again at 37°12.34'N, 134°25.24'E in the evening. The specimens were preserved in formaldehyde and then transferred to and stored in 70% alcohol. Twelve pearlsides larvae infected with the caligid chalimus larvae were received from K. Hashizume (National Japan Sea Fisheries Research Institute), to whom H. Kato sent the collected ichthyoplankton for identification. The chalimus larvae were carefully

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Table 1. Chalimus larvae of *Caligus* parasitic on the larvae of pearlsides (*Maurolicus muelleri*) in the Sea of Japan.

Fish number	Total length of fish (mm)	Attachment site of parasite	Stage of parasite
Collected at 37° 14.76'N, 134° 25.08'E (100 - 150 m) on October 18, 1999 at 12:01			
No. 1	10.28	right operculum, lower edge	chalimus III
Collected at 37° 12.34'N, 134° 25.24'E (95 - 100 m) on October 18, 1999 at 18:34			
No. 2	10.29	right operculum, lower edge	chalimus II
No. 3	10.14	right operculum, lower edge	chalimus I
		left operculum, lower edge	chalimus IV
No. 4	12.56	right operculum, lower edge	chalimus III
		left operculum, lower edge	chalimus II
		right eye, upper-posterior edge	chalimus I
No. 5	10.00	right operculum, lower edge	chalimus I
No. 6	8.71	right operculum, lower edge	chalimus II
No. 7	10.14	right operculum, lower edge	chalimus II
		left operculum, lower edge	chalimus III
No. 8	13.12	right operculum, lower edge	chalimus IV
No. 9	10.29	right operculum, lower edge	chalimus III
		left operculum, lower edge	chalimus I
No. 10	9.28	right operculum, lower edge	chalimus I
		left operculum, lower edge	chalimus I
No. 11	13.42	right operculum, lower edge	chalimus II
		left operculum, lower edge	chalimus III
No. 12	9.71	left operculum, lower edge	chalimus I

removed from their host under the dissection microscope. The hanging drop method devised by Humes and Gooding (1964) was employed in the examination of chalimus larvae. Identification of the stages of chalimus larvae was based on the information provided in the works of Piasecki (1996) and Lin *et al*. (1997).

The specimens of chalimus larvae studied in this paper have been deposited in the National Science Museum, Tokyo (NSMT-Cr 16637).

Results

Nineteen parasitic copepods in chalimus stages, with seven in chalimus I, five in chalimus II, another five in chalimus III, and two in chalimus IV, were recovered from 12 larvae of *M. muelleri* ranging from 8.71 to 13.12 mm in total length (Table 1). Most parasites attached to the host fish on the lower margin of the operculum (behind the mouth). While six hosts carried one parasite, there were five bearing two parasites with each one hanging at the lower edge of the operculum on each side of the head. On the fish that carried three parasites (No. 4 in Table 1), two attached to the host like those carrying two parasites but the third one was found attaching to the upper edge of the host's right eye. Apparently, the parasite showed a preference for the lower margin of the host's operculum over the other available sites on the head as well as the general body surface.

With the presence of a pair of lunules

underneath the cuticle of the frontal plates (Fig. 1A), the parasites are unmistakably a species of *Caligus*. However, they are not *C. macarovi* as suspected by Okiyama (1993), because the exopod of leg 4 is equipped with 5 (instead of 4) spiniform processes (Fig. 1B).

So far as we are aware, nine species of *Caligus* are known from fishes of the Sea of Japan. They are: *C. hoplognathi* Yamaguti and Yamasu, 1959; *C. latigenitalis* Shiino, 1954; *C. macarovi* Gusev, 1951; *C. orientalis* Gusev, 1951; *C. parvilatus* Kim, 1998; *C. pelamydis* Krøyer, 1863 [note: this species reported by Kim (1998) from the Korean waters was recently synonymized with *C. kanagurta* Pillai, 1962 by Ho *et al*. (2000)]; *C. punctatus* Shiino, 1953; *C. quadratus* Shiino, 1954; and *C. tanago* Yamaguti, 1939. Being equipped with three or four (but not five) spiniform processes on the exopod of leg 4, *C. orientalis* and *C. punctatus*, as in the case of *C. macarovi*, can be excluded from the list for comparison with the present chalimus larvae. By the same token the following four species, *C. latigenitalis*, *C. parvilatus*, *C. kanagurta* and *C. quadratus*, can also be excluded due to the possession of a shorter (about as long as wide) or longer (at least 4 times as long as wide) abdomen. Of the remaining two species, *C. hoplognathi* differs by the possession of rows of teeth (instead of hairs) on the outer surface of the second segment of the endopod of leg 2. Thus, only *C. tanago* remains to be considered further.

As far as the structure of the abdomen is concerned, our specimens of chalimus IV do not fit well with the description of *C. tanago* given by either Yamaguti (1939) or Kim (1998). The abdomen of *C. tanago* was illustrated by both Yamaguti (1939: Plate XIV, Fig. 9) and Kim (1998: Fig. 326A) to be slender and without a trace of 2-segmented structure. However, as in Fig. 1A, the abdomen in our specimens of chalimus IV is broad and 2-segmented. Accordingly, our chalimus specimens are not identified with *C. tanago*. Thus, apparently, the adult of the chalimus larvae obtained from *M. muelleri* is yet to be reported from the teleost(s) of the Sea of Japan.

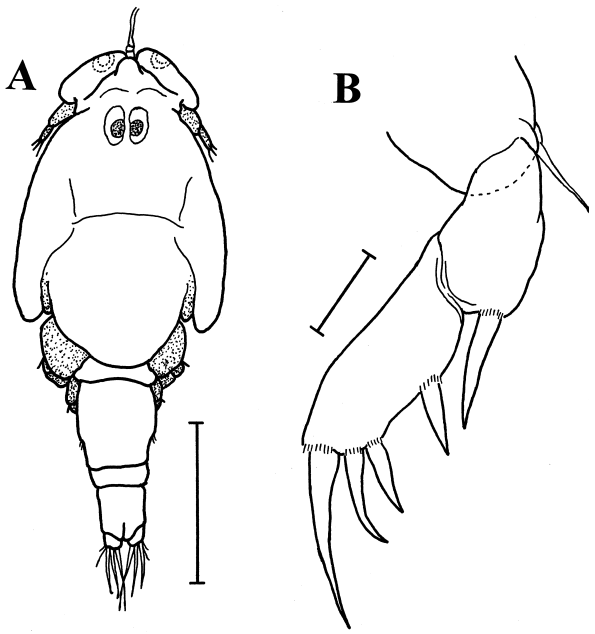

Fig. 1. Chalimus IV of a species of *Caligus* parasitic on the larvae of pearlsides (*Maurolicus muelleri*) in the Sea of Japan. A. habitus, dorsal; B. exopod of leg 4, ventral. Scale=1.0 mm (A) and 50 μm (B).

Discussion

Based on the information obtained from the ecological observations made in conjunction with morphological studies, Okiyama (1971) divided the development of *M. muelleri* into eight stages: prolarva (<3mm), early postlarva (3-6 mm), middle postlarva (6-9.5 mm), late postlarva (9.5-12.5 mm), early juvenile (12.5-17.5 mm), late juvenile (17.5-21.0 mm), young (21-25 mm), and adult (>25 mm). According to this classification, the larvae of *M. muelleri* infected with the chalimus of *Caligus* in the Sea of Japan are found in three consecutive stages ranging from the middle postlarva through the late postlarva and into the early juvenile (Table 1). Judging from the fact that a middle postlarva (No. 6 in Table 1) carried a parasites in the second stage of chalimus, the infection of this fish must have occurred when the host was in an earlier stage, perhaps the early postlarval stage.

In order to determine if the adult of *M. muelleri* carries also the adult *Caligus*, we examined 236 adult specimens of pearlsides (measuring 48.7-55.8 mm in total length) kept at the Seikai National Fisheries Research Institute located in Nagasaki. The specimens were collected off the west coast of the Oki Islands with a midwater trawl at the depths of 20-30 m in the evening of 17 May 1994. However, no copepod parasite was found. Accordingly, the three stages of the larvae of pearlsides (middle postlarva, late postlarva, and early juvenile) are considered the carrier, serving as the intermediate host of an unknown species of *Caligus* in the Sea of Japan.

It is interesting to point out that the chalimus IV carried by the larvae of *M. muelleri* bears close resemblance to *Caligus seriolae* Yamaguti, 1936. *C. seriolae* is known to occur in the waters of Japan (Yamaguti, 1936) and Korea (Kim, 1998). Yamaguti (1936) reported it from the yellowtail (*Seriola quinqueradiata* Temminck and Schlegel) occurring in the Inland Sea and Kim (1998), from the Japanese seaperch [*Lateolabrax japonicus* (Cuvier)] caught in the Yellow Sea. Thus, it is very likely that *C. seriolae* occurs also on the teleost(s) in the Sea of Japan.

It should be noted that Kim's (1998) redescription of *C. seriolae* differs in the fine structure of leg 4 from Yamaguti's (1936) original description. The terminal three spiniform processes on the exopod of leg 4 are shown to be subequal in Yamaguti's (1936: Plate I, Fig. 13) report, but in Kim's (1998: Fig. 325C) redescription the terminal

process is shown, like Fig. 1B in this report, distinctly longer than both penultimate and antepenultimate processes. At this point of time it is impossible to give further comments on this discrepancy between Yamaguti's (1936) and Kim's (1998) reports. Nevertheless, at least, it is certain that our specimens of chalimus obtained from the larvae of *M. muelleri* collected off the Sanin District of Honshu are identifiable with *C. seriolae* reported by Kim (1998: 684) from the Japanese seaperch in the Yellow Sea.

Although the copepodids of *Caligus* are capable to swim, they are incapable of making a distant movement, either vertical or horizontal. Besides, they are short living larvae and die within a couple of days if they fail to find a suitable host (Lin and Ho, 1993). In other words, the infective copepodid larvae of *Caligus* are generally found in the water not far from where they were hatched, or where the adults are located.

The Japanese seaperch is a coastal teleost. Therefore, if the larvae of *Caligus* occurring on the larvae of *M. muelleri* are confirmed to be " *Caligus seriolae* Yamaguti " reported by Kim (1998), it would imply that the larvae of *M. muelleri* have spent sometime in the neritic waters during the early stages of their life. This implication would lend a support to Okiyama's (1981: 246) finding that " A rich spawning (of *Maurolicus muelleri*) was observed in the coastal region around, or just outside, the shelf edge. "

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References

Ho, J.-S., C.-L. Lin, and S.-N. Chen. 2000: Species of *Caligus* Müller, 1785 (Copepoda: Caligidae) parasitic on marine fishes of Taiwan. *Systematic Parasitology*, **46**: 159-179.

Humes, A. G., and R. U. Gooding. 1964: A method for studying the external anatomy of copepods. *Crustaceana*, **6**: 238-240.

Kim, I.-H. 1998: Illustrated Encyclopedia of Fauna and Flora of Korea, Vol. 38, Cirripedia, Symbiotic Copepoda, Pycnogonida. 1038 pp. (in Korean)

Lin, C.-L., and J.-S. Ho. 1993: Life history of *Caligus epidemicus* Hewitt parasitic on tilapia (*Oreochromis mossambicus*) cultured in brackish water. *In*: G. A. Boxshall and D. Defaye eds. Pathogens of Wild and Farmed Fish: Sea Lice," Ellis Horwood, New York, pp. 5-15.

Lin, C.-L., J.-S. Ho, and S.-N. Chen. 1997: Development of *Caligus multispinosus* Shen, a caligid copepod parasitic on the black sea bream (*Acanthopagrus schlegeli*) cultured in Taiwan. *Journal of Natural History*, **31**: 1483-1500.

Nishimura, S. 1957: Vertical distribution of the floating eggs of *Maurolicus japonicus* Ishikawa, a gonostomatid fish, in the sea. *Bulletin of the Japan Sea Regional Fisheries Research Laboratory*, **3**: 13-22.

Okiyama, M. 1971: Early life history of the gonostomatid fish, *Maurolicus muelleri* (Gmelin) in the Japan Sea. *Bulletin of the Japan Sea Regional Fisheries Research Laboratory*, **23**: 21-53.

Okiyama, M. 1981: Abundance and distribution of eggs and larvae of sternoptychid fish, *Maurolicus muelleri*, in the Japan Sea, with comments on the strategy for successful larval life. *Rapport et Proces-Verbaux des Reunions Conseil International pour L'Exploration de la Mer*, **178**: 246-247.

Okiyama, M. 1993: Chalimus larvae of fish louse parasitic on the larvae of pearlsides. 1993 Spring Meeting of the Japanese Society of Scientific Fisheries, Abstracts, p. 123. (in Japanese.)

Oshimo, S. 1998: Distribution and stomach contents of *Maurolicus muelleri* in the Sea of Japan (East Sea). *Journal of the Korean Society of Fisheries Research*, **1**: 168-175.

Piasecki, W. 1996: The developmental stages of *Caligus elongates* von Nordmann, 1832 (Copepoda: Caligidae). *Canadian Journal of Zoology*, **74**: 1459-1478.

Yamaguti, S. 1936: Parasitic copepods from fishes of Japan. Part 2, Caligoida, I. Published by author, 22 pp.

Yamaguti, S. 1939: Parasitic copepods from fishes of Japan. Part 5, Caligoida, III. *Volumen Jubilare pro Professor Sadao Yoshida*, **2**: 443-487.

日本海のキュウリエソ稚魚に寄生していたウオジラミ類のカリムス幼生

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摘　要

本州沖合の日本海で採集されたキュウリエソ稚魚（全長8.81－13.12mm）にウオジラミ属（*Caligus*）のカリムス幼生（Ⅰ，Ⅱ，Ⅲ，Ⅳ期）の寄生が認められた．この寄生虫の成虫はキュウリエソ成魚には認められず，キュウリエソ稚魚はこの寄生虫の中間宿主の役割を果たすと考えられる．また，この寄生虫は韓国沿岸（東シナ海）のスズキから報告された *Caligus seriolae* Yamagutiに形態が極めて似ているが，成虫は日本海から報告されていない．この寄生虫が本当に沿岸性魚類に寄生する種であるならば，キュウリエソが稚魚のときに近海で過ごすことを示唆するものであろう．

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