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Two species of copepods, *Lernanthropus atrox* and *Hatschekia pagrosomi*, parasitic on crimson seabream, *Evynnis tumifrons*, in Hiroshima Bay, western Japan

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Abstract Two species of copepods, *Lernanthropus atrox* Heller, 1865, and *Hatschekia pagrosomi* Yamaguti, 1939, were collected from the gills of crimson seabream, *Evynnis tumifrons* (Temminck and Schlegel, 1843), in Hiroshima Bay, the Seto Inland Sea, western Japan. This collection represents a new host record for *L. atrox* and the first record of *H. pagrosomi* from *E. tumifrons* in Japan. The hosts and geographical distribution of these copepods are also reviewed.

Key words: Copepoda, *Evynnis tumifrons*, fish parasite, *Hatschekia pagrosomi*, Hiroshima Bay, *Lernanthropus atrox*

INTRODUCTION

Sparids are widely distributed and commercially caught in coastal temperate and subtropical waters of Japan, where they consist of 13 species in three subfamilies and four genera (Nakabo, 2013). Of these species, red seabream, *Pagrus major* (Temminck and Schlegel, 1843), is the most important species in fisheries and abundantly caught in various waters of Japan. The parasite fauna of this species has been well studied in Japan: for example, as many as 24 species of metazoan parasitic helminths (3 monogeneans, 13 digneans, 4 cestodes, 3 nametodes, and 1 acanthocephalan) were reported only by Dr. Satyu Yamaguti (Kamegai and Ichihara, 1972), and four species of parasitic copepods are known to infect the fish species in the Seto Inland Sea, western Japan (Nagasawa, 2011). In contrast, much remains poorly known about the parasites of other Japanese sparids. Crimson seabream, *Evynnis tumifrons* (Temminck and Schlegel, 1843), is one of such sparids, and as its crustacean parasites, only the cymothoid isopod, *Ceratothoa verrucosa* (Schioedte and Meinert, 1883), and some unidentified parasitic copepods have been reported in Japan (Madinabeitia and Nagasawa, 2013; Nagasawa and Isozaki, 2016). The latter unidentified copepods were recorded from Hiroshima Bay, part of the western Seto Inland Sea, and belong to five families (Bomolochidae, Philichthyidae including "*Colobomatus* sp. 1", Lernaeopodidae, Lernanthropidae, and Caligidae) (Madinabeitia and Nagasawa, 2013: tables 1-2), but their identification has not been made to species level. Recently, I examined individuals of *E. tumifrons* caught in Hiroshima Bay and collected two species of parasitic copepods, *Lernanthropus atrox* Heller, 1865, and *Hatschekia pagrosomi* Yamaguti, 1939.

MATERIALS AND METHODS

Eleven fresh individuals of *E. tumifrons* commercially caught in Hiroshima Bay on 8 April 2015

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(*n*=2), 19 November 2016 (*n*=7), and 15 April 2017 (*n*=2) were purchased on the same days at a fish market in Higashi-Hiroshima, Hiroshima Prefecture. They were brought on ice to the laboratory of Hiroshima University, where they were measured for standard length (SL) and examined for copepods on the gills. When copepods were found on 19 November 2016 and 15 April 2017, their sites of attachment on the gills were recorded. The copepods were fixed and preserved in 70% ethanol. These specimens are retained by the author but will be deposited, together with other specimens of parasitic copepods from fishes in the Seto Inland Sea including Hiroshima Bay, in the Crustacea collection of the National Museum of Nature and Science, Tsukuba, Ibaraki Prefecture. The scientific and common names of fishes used in this paper follow those recommended by Froese and Pauly (2017), except for those of *E. tumifrons*, which follow Iwatsuki *et al.* (2007).

RESULTS

Order **Siphonostomatoida** Burmeister, 1835
Family **Lernanthropidae** Kabata, 1979
Genus ***Lernanthropus*** de Blainville, 1822
Lernanthropus atrox Heller, 1865
(Japanese name: Tai-no-hitogatamushi)
(Fig. 1A-B)

Ten (90.9%) of the 11 individuals of *E. tumifrons* examined (150-218 [mean 180] mm SL) were found to be infected by *L. atrox*. The number of copepod per host ranged from 1-12 (mean 3.5). In total, 35 specimens of *L. atrox* were collected, consisting of 19 females and 16 males. Eighteen (81.8%) of the 22 specimens of *L. atrox* collected on 19 November 2016 and 15 April 2017 were attached to the first gills, whrereas the remaining four specimens (18.2%) to the second gills. No infection was found on the third and fourth gills. The cephalothorax of the female specimens is wider than long (Fig. 1A-B), as previously illustrated by Shishido (1898: third figure on page 216), Shiino (1955: fig. 3A-B), and Ho and Do (1985: figs. 52 and 54). Body (from cephalothrorax to abdomen excluding caudal rami) of *L. atrox* collected on 19 November 2016 is 2.1-2.4 (mean 2.3) mm long in female (*n*=5) and 1.5-1.6 (mean 1.5) mm long in male (*n*=5).

Remarks: *Lernanthropus atrox* is a gill parasite of sparids in Australia (see below for the literature), Japan (Nagasawa and Uyeno, 2011, also see below for the literature), and China (Song and Chen, 1976; Song and Kuang, 1980). This species has been recorded exceptionally from Pacific rudderfish, *Psenopsis anomala* (Temminck and Schlegel, 1844) (Centrolophidae), in Japan (Ichihara *et al.*, 1965, see Ho and Do, 1985). The copepod is also known from the Sea of Japan off the Russian Far East without providing any information on its host(s) (Markevitch and Titar, 1978). Despite extensive research on the lernanthropids, *L. atrox* has not been found from New Zealand (Roubal *et al.*, 1983; Roubal, 1996) and Taiwan (Ho *et al.*, 2008, 2011; Liu *et al.*, 2009a, 2009b). In addition, a record of *L. atrox* from the Persian Gulf (Bassett-Smith, 1898; see also Gnanamuthu, 1949) has been regarded as a misidentification (Shiino, 1955; Ho and Do, 1985). While Chin (1947: 29) gave a new name, *Lernnathropus shishidoi*, for *L. atrox*, but the former name has not been accepted.

The known sparid hosts of *L. atrox* include: silver seabream, *Pagrus auratus* (Forster, 1801) (reported as *Pagrus guttulatus* in Heller, 1865, and Heider, 1879; *Chrysophrys auratus* in Roubal *et al.*, 1983), yellowfin bream, *Acanthopagrus australis* (Günther, 1859) (as *Mylio australis* in Kabata, 1979),

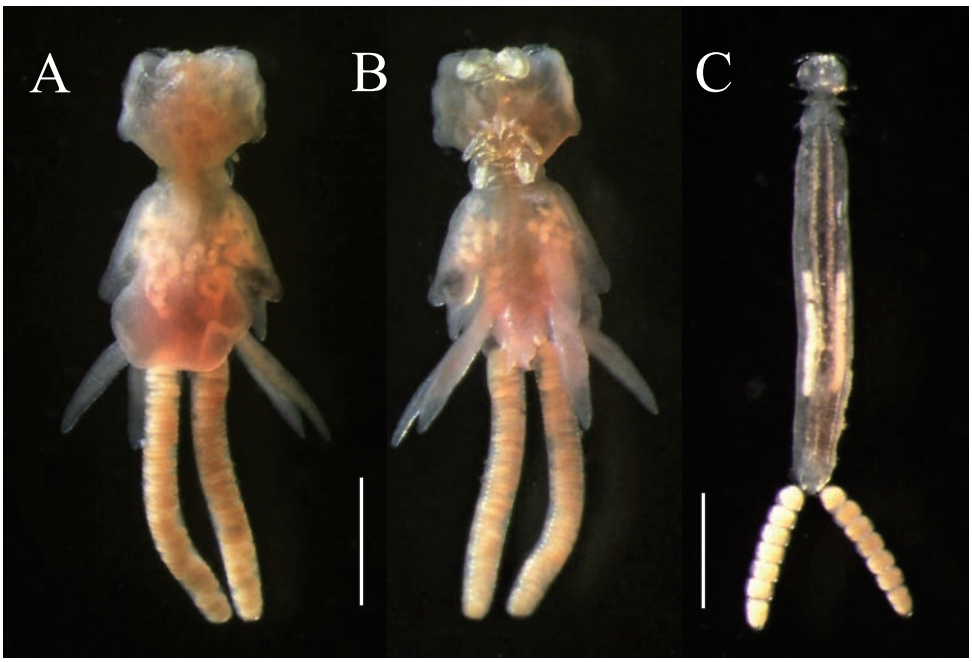

Fig. 1. An ovigerous female of *Lernanthropus atrox* (A, dorsal view; B, ventral view) and an ovigerous female of *Hatschekia pagrosomi* (C, dorsal view) removed from the gills of *Evynnis tumifrons* in Hiroshima Bay, western Japan, on 19 November 2016. Scale bars: 1 mm in A and B; 0.5 mm in C.

black bream, *Acanthopagrus butcheri* (Munro, 1949), and yellowfin seabream, *Acanthopagrus latus* (Houttuyn, 1782), from Australia (Heller, 1865; Heider, 1879; Kabata, 1979; Roubal, 1981, 1986, 1989, 1990a, 1990b, 1995, 1996; Roubal *et al.*, 1983; Byrnes, 1988; Byrnes and Rohde, 1992); blackhead seabream, *Acanthopagrus schlegelii* (Bleeker, 1854), and red seabream, *P. major*, from Japan (Shishido, 1898; Yamaguti, 1936; Shiino, 1955, 1959; Ho and Do, 1985); and blackhead seabream, *A. schlegelii* (as *Sparus macrocephalus*), from China (Song and Chen, 1976; Song and Kuang, 1980). In the present study, *L. atrox* was collected for the first time from *E. tumifrons*, which represents a new host record for the copepod. This fish species is a third sparid host of *L. atrox* in Japan. The unidentified species of Lernanthropidae reported from *E. tumifrons* in Hiroshima Bay (Madinabeitia and Nagasawa, 2013: table 1) may be identifiable as *L. atrox* because the present material of copepod was collected from the same host species of the same locality.

The localities of *L. atrox* recorded from Japan are: Tokyo Bay and Sagami Bay (Shishido, 1898, see Nagasawa and Uyeno, 2011); the Seto Inland Sea including Hiroshima Bay (Yamaguti, 1936; this paper); Momotori and Tsu, Mie Prefecture (Shiino, 1955, 1959); Tassha, Sado Island, Niigata Prefecture (Ho and Do, 1985); and Seto, Wakayama Prefecture (Izawa, 2014) (Fig. 2). These localities are in the temperate region of Japan and more or less affected by the warm current, Kuroshio, and its branch, the Tsushima Current (Fig. 2). Toward a further understanding of the geographical distribution of *L. atrox* in Japanese waters, it is desirable to examine sparids in southern Japan ranging from Shikoku through Kyushu to the Ryukyu Islands. It is interesting to note that *L. atrox* occurs in coastal waters of Hainan Island off southern China (Song and Chen, 1976; Song and Kuang, 1980) but has not been discovered from Taiwan (Ho *et al.*, 2008, 2011; Liu *et al.*, 2009a, 2009b).

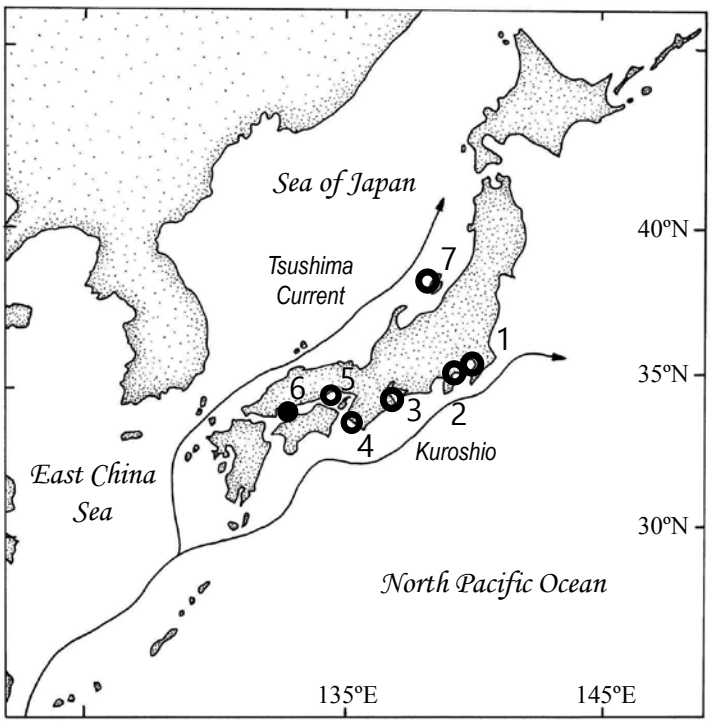

Fig. 2. Map of the Japanese Archipelago, showing the localities where *Lernanthropus atrox* was collected in the previous (open circles) and present (closed circle) studies. Localities 1, 2, 3, 4, 5, 6, and 7 are: Tokyo Bay (Shishido, 1898); Sagami Bay (Shishido, 1898); Momotori and Tsu, Mie Prefecture (Shiino, 1955, 1959); Seto, Wakayama Prefecture (Izawa, 2014); the Seto Inland Sea (Yamaguti, 1936); Hiroshima Bay (present study); and Tassha, Sado Island, Niigata Prefecture (Ho and Do, 1985), respectively. The routes of the warm current, Kuroshio, and its branch, the Tsushima Current, are also shown.

In Australia, the famale of *L. atrox* did not prefer any gills of *A. australis* (Roubal, 1981: table 8, fig. 251) but was slightly more abundant in the first and second gills than the third and fourth gills of *P. auratus* (Roubal *et al.*, 1983: table 7). These distribution patterns of *L. atrox* on Australian sparids are different from those observed in the present study: most specimens of *L. atrox* were found on the first gills of *E. tumifrons* from Hiroshima Bay.

Comments are necessary on the names of the hosts reported in Japan. In the first paper of *L. atrox* from Japan (Shishido, 1898), only Japanese common names, "kudodai" and "madai", were given as the hosts' names, which are currently *A. schlegelii* and *P. major*, respectively. Subsequently, *P. major* was reported using different scientific names: *Pagrosomus unicolar* (Yamaguti, 1936), *Pagrosomus major* (Shiino, 1955, 1959), and *Chrysophrys major* (Ho and Do, 1985). Also, *A. schlegelii* was reported as *Sparus macrocephalus* by Shiino (1955). Moreover, Shiino (1965, 1979) reported "madai *Sparus macrocephalus*" as one of the Japanese hosts of *L. atrox*, but because "madai" and "*Sparus macrocephalus*" represent two species of sparids, *P. major* and *A. schlegelii*, respectively, the host's name reported by Shiino (1965, 1979) is not correct.

Order **Siphonostomatoida** Burmeister, 1835
Family **Hatschekiidae** Kabata, 1979
Genus ***Hatschekia*** Poche, 1902
Hatschekia pagrosomi Yamaguti, 1939
(Japanese name: Madai-no-eranomi)
(Fig. 1C)

Two (11.1%) of the 11 individuals of *E. tumifrons* examined were found individually to harbor three and one ovigerous females of *H. pagrosomi* on the gills (three and one on the first and fourth gills, respectively). These females measure 1.5-2.1 (mean 1.9) mm (*n=4*) in body length (from cephalothorax to abdomen excluding caudal rami).

Remarks: *Hatschekia pagrosomi* is a gill parasite of sparids in Japan (Yamaguti, 1939; Nagasawa and Uyeno, 2012), Korea (Kim, 1998), Australia (Roubal *et al.*, 1983; Kabata, 1991; Roubal, 1996), and New Zealand (Roubal *et al.*, 1983). The species has also been reported from two non-sparid fishes in Japan: Chinese emperor, *Lethrinus haematopterus* (Temminck and Schlegel, 1844) (Lethrinidae) (Yamaguti, 1939), and Japanese jack mackerel, *Trachurus japonicus* (Temminck and Schlegel, 1844) (Carangidae) (as *Trachurus trachuri*) (Yamaguti and Yamasu, 1960; see Jones, 1985, for synonymy). The known sparid hosts of *H. pagrosomi* are: red seabream, *P. major*, from Japan (Yamaguti, 1936); crimson seabream, *E. tumifrons* (as *E. tanaka*), from Korea (Kim, 1998); and silver seabream, *P. auratus* (as *Chrysophrys auratus* in Roubal *et al.*, 1983; Kabata, 1991), from Australia and New Zealand (Roubal *et al.*, 1983; Kabata, 1991; Roubal, 1996). The collection of *H. pagrosomi* in this study represents its second record from *E. tumifrons* and its first record from this fish species in Japan. The Seto Inland Sea is the only known locality of *H. pagrosomi* in Japan (Yamaguti, 1939; Yamaguti and Yamasu, 1960; this paper). While Kabata (1991) states that *H. pagrosomi* was collected by Ichihara *et al.* (1964) from *T. japonicus* in Sagami Bay, central Japan, his citation is wrong because the latter authors did not collect the copepod from the bay.

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広島湾産チダイに寄生していたカイアシ類2種，タイノヒトガタムシとマダイノエラノミ

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要　旨　広島湾で漁獲されたチダイの鰓に寄生するカイアシ類を調べたところ，ヒトガタムシ科のタイノヒトガタムシ *Lernanthropus atrox* Heller, 1865とエラノミ科のマダイノエラノミ *Hatschekia pagrosomi* Yamaguti, 1939の寄生を認めた。チダイはタイノヒトガタムシの新宿主であり，わが国のチダイからマダイノエラノミが見出されたのは初めてある。寄生率や寄生数を示すとともに，両寄生虫の宿主や地理的分布に関する考察を行った。

キーワード：カイアシ類，魚類寄生虫，タイノヒトガタムシ，チダイ，広島湾，マダイノエラノミ