Areolate grouper, *Epinephelus areolatus* (Perciformes: Serranidae), a new host record for *Lernaeenicus ramosus* (Copepoda: Pennellidae), with comments on the known hosts and distribution records of the copepod in the Indo-West Pacific region

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**Abstract.**—An ovigerous female of *Lernaeenicus ramosus* Kirtisinghe, 1956 was collected from an areolate grouper, *Epinephelus areolatus* (Forsskål, 1775), in coastal waters of Suruga Bay (western North Pacific Ocean), Shizuoka Prefecture, central Japan. This represents a new host and the easternmost distribution records for *L. ramosus*. Based on the literature published between 1956 and 2019, this paper tabulates the known hosts and distribution records of the species in the Indo-West Pacific region. The recent collections of *L. ramosus* from Japan further support a previous suggestion that the geographical distribution of the species in Japanese waters is affected by two warm currents, the Kuroshio, and its branch, the Tsushima Current.

**Key words:** fish parasite, geographical distribution, host range, pennellid, Serranidae

The pennellid copepod *Lernaeenicus ramosus* Kirtisinghe, 1956 is a mesoparasite of perciform fishes in the Indo-West Pacific region (Nagasawa & Uyeno, 2014). The species was originally described using females from comet grouper, *Epinephelus morrhua* (Valenciennes, 1833), in the Indian Ocean off Ceylon (now Sri Lanka) (Kirtisinghe, 1956) and since has been reported from groupers in India (Pillai, 1985) and Japan (see below) and from bluestriped fangblenny, *Plagiotremus rhinorhynchos* (Bleeker, 1852) (as *Runula rhinorhynchus*) in Australia (Boxshall, 1986).

Much information has been accumulated on various aspects of the biology, such as taxonomy, geographical distribution, host range, larval development, and pathogenicity, of *L. ramosus* in Japan, where the groupers are known to serve as hosts of the species (Shiino, 1958, 1964; Anonymous, 2004; Doi, 2007; Doi et al., 2008; Nagasawa et al., 2010, 2011, 2014; Okamoto, 2011; Nitta et al., 2017; Izawa, 2019). Recently, we collected an adult female of *L. ramosus* from an areolate grouper, *Epinephelus areolatus* (Forsskål, 1775), in Suruga Bay (western North Pacific Ocean), Shizuoka Prefecture, central Japan. This represents a new host and the easternmost distribution records for *L. ramosus*. The species has been well redescribed by Shiino (1958) and Izawa (2019) using specimens from Japan. Thus, this paper briefly reports on the morphology of *L. ramosus* from the bay and, based on the literature published between 1956 and 2019, gives a list of the known hosts and collection localities of the species.

An areolate grouper was caught using rod and line in coastal waters of Suruga Bay off Miho, Shimizu (35°02′02.1″N,138°52′45.5″E), Shizuoka Prefecture, on 19 September 2019. The fish was transported alive to the laboratory of the School of Marine Science and Technology, Tokai University, Shimizu, where it was measured for standard length (SL, mm) and examined for ecto- and endoparasites. One copepod was found, removed carefully, and fixed in
Crustacean Research 49

70% ethanol. Later, at the Aquaparasitology Laboratory, Shimizu, the copepod was examined for its morphology and identified as *L. ramosus*. A drawing was made with the aid of a drawing tube fitted on an Olympus SZX10 stereo microscope. The specimen preserved in 70% ethanol is deposited in the Crustacea (Cr) collection of the National Museum of Nature and Science, Tsukuba, Ibaraki Prefecture (NSMT-Cr 26743). The scientific and common names of fishes mentioned in this paper follow Froese & Pauly (2019).

An ovigerous female of *L. ramosus* inserted the anterior part of its body into the host (132 mm SL) near the base of the dorsal fin. This anterior part was embedded in the host musculature. The posterior part of the female protruded externally and was deep purple in color when fresh (arrowhead in Fig. 1).

Description of female: The anterior part of the body consists of the head, 2.0 mm long, with three pairs of branching holdfasts and a slender, cylindrical neck, 2.6 mm long (Fig. 2). The anterior and the middle pairs arise, respectively, from the dorsolateral and the ventrolateral corners in the anterior portion of the head, while the posterior pair does from the lateral surface in the posterior portion of the head (Fig. 2B, C). Each holdfast is swollen near its base and possesses slender branches. The posterior part of the body comprises the trunk and the abdomen: the former is longer (7.0 mm long) than the latter (4.8 mm long), which is well developed, nearly elongated, and ends bluntly without caudal rami (Fig. 2A).

*Lernaeenicus ramosus* was described from Sri Lanka (Kirtisinghe, 1956). Later, the species was redescribed by Shiino (1958) and, again, by Izawa (2019) based on the material from Japan. Pillai (1985) and Boxshall (1986) also described the species using specimens from Indian and Australia, respectively. All these authors examined metamorphosed females. Izawa (2019) stated that the females from Sri Lanka, Japan, and Australia are morphologically identical to each other. No morphological difference is observed between the specimen examined in this study and those reported by Shiino (1958) and Izawa (2019). However, it is desirable to identify the species, using molecular data as well, from these three countries and India, because Japan and Australia are far separated from Sri Lanka and India and it parasitizes groupers in Sri Lanka, India, and Japan but does not in Australia. Nitta et al. (2017) successfully obtained molecular data of *L. ramosus* from Hong Kong grouper, *Epinephelus akaara* (Temminck & Schlegel, 1842), in Japan.

Excluding the blenniid fish from Australia (Boxshall, 1986), the other known hosts are all groupers (Serranidae). The areolate grouper is added herein as a new host of *L. ramosus*, and a total of eight species of groupers is now known as its hosts (Table 1, seven species from Japan; one species from Sri Lanka and India). It is evident that *L. ramosus* almost exclusively uses groupers as its hosts, and Nagasawa et al. (2014) have suggested that the species will be discovered from other species of groupers in Japan, where they (subfamily Epinephelinae) consist of 65 species in 10 genera (42 spp. in *Epinephelus*, 12 spp. in *Cephalopholis*, 3 spp. in *Plectropomus*, 2 spp. in *Variola*, 1 sp. each in *Aethaloperca*, *Anpseudon*, *Chromileptes*, *Gracila*, *Saloptia*, and *Triso*) (Senou, 2013).

We need to explain that *E. morrhua* is listed in Table 1 as the host of *L. ramosus* from India.

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Fig. 1. Areolate grouper, *Epinephelus areolatus*, infected by *Lernaeenicus ramosus* (arrowhead) near the base of the dorsal fin, fresh specimen. The fish was caught in coastal waters of Suruga Bay off Miho, Shizuoka Prefecture, central Japan, on 19 September 2019. Scale bar: 10 mm.
In his monograph of the parasitic copepods of India, Pillai (1985: 721) reported three species of groupers (E. morrhua, E. akaara, E. tsirimenaria) as the hosts of L. ramosus from Sri Lanka, India, and Japan but did not specify the Indian host. However, the latter two species are the Japanese hosts (Shiino, 1958), thus the remaining species, E. morrhua, can be regarded as the Indian host, as earlier reported from Sri Lanka (Kirtisinghe, 1956).

Raja et al. (2016: table 3) listed the red grouper “Epinephelus morio (Valenciennes in Cuvier & Valenciennes, 1826)” as one of the hosts of L. ramosus but it is wrong: E. morio is a species found only in the western Atlantic Ocean (Froese & Pauly, 2019) and E. morrhua reported from Sri Lanka (Kirtisinghe, 1956) and India (Pillai, 1985) should have been listed. Moreover, Raja et al. (2016: table 3) included the Japanese threadfin bream, “Nemipterus japonicus” (Block, 1791)” (Nemipteridae) among Indian hosts of L. ramosus. This fish species (as “red snapper, Synagris japonica” Day” was reported by Rangnekar (1961) to harbor “L. ramosus” off Bombay (now Mumbai), but the copepod collected was not L. ramosus but Lernaeunicus nemipteri Gnanamuthu, 1953 (see Pillai, 1985: 721–722). The Japanese threadfin bream is apparently not the host of L. ramosus.

Lernaeunicus ramosus has been reported from off Sri Lanka, India, Australia, and Japan (Table 1). While no detailed information on the collection locality of the species in India is
### Table 1. Known hosts and collection localities of *Lernaeenicus ramosus*. The scientific and common names of the fishes listed follow Froese & Pauly (2019).

| Family         | Genus and species                  | Common name                     | Country       | Locality                      | Number in Fig. 2 | Reference                                                                 |
|----------------|------------------------------------|---------------------------------|---------------|-------------------------------|------------------|---------------------------------------------------------------------------|
| Serranidae     | *Epinephelus morrhua* (type host)  | Comet grouper                   | Sri Lanka     | Wadge Bank (type locality)    |                  | Kirtisinghe (1956)                                                       |
|                | *Epinephelus morrhua*              | Comet grouper                   | India         | Not reported                  |                  | Pillai (1985)*                                                           |
|                | *Epinephelus akaara*               | Hong Kong grouper               | Japan         | Momotori, Mie                 | 2                | Shiino (1958, as *E. tsirimenaria* [sic])                                  |
|                |                                    |                                 |               | Kobe, Hyogo                   | 6                | Doi (2007), Doi et al. (2008)                                             |
|                |                                    |                                 |               | Amakusa-nada Sea, Kumamoto    | 8                | Nitta et al. (2017)                                                       |
|                |                                    |                                 |               | Tsushima, Nagasaki            | 10               | Izawa (2019)                                                              |
|                |                                    |                                 |               | Hamada and adjacent coastal waters, Shimane | 12               | Anonymous (2004), Nagasawa et al. (2010), Okamoto (2011)                     |
|                | *Epinephelus areolatus*            | Areolate grouper                | Japan         | Miho, Shimizu, Shizuoka       | 1                | Shiino (1958, as *E. tsirimenaria* [sic])                                  |
|                | *Epinephelus awoara*               | Yellow grouper                  | Japan         | Shinkamigoto, Nagasaki        | 9                | Nagasawa et al. (2011)                                                    |
|                |                                    |                                 |               | Hamada and adjacent coastal waters, Shimane | 12               | Anonymous (2004), Nagasawa et al. (2010), Okamoto (2011)                     |
|                | *Epinephelus bruneus*              | Longtooth grouper               | Japan         | Furumugi, Tokushima           | 5                | Nagasawa et al. (2014)                                                    |
|                | *Epinephelus chlorostigma*         | Brownspotted grouper            | Japan         | Kowa-ura, Mie                 | 3                | Nagasawa et al. (2014)                                                    |
|                | *Epinephelus fasciatus*            | Blacktip grouper                | Japan         | Seto, Wakayama                | 4                | Shiino (1958, as *E. tsirimenaria* [sic])                                  |
|                |                                    |                                 |               | Oshima Strait, Amami-oshima Island, Kagoshima | 7                | Shiino (1964, as *E. fasciatus fasciatus*)                                 |
|                | *Hyporthodus septemfasciatus**      | Convict grouper                 | Japan         | Nishiyama and Murotsu, Shimonoseki, Yamaguti | 11               | Nagasawa et al. (2011, 2014)                                              |
|                |                                    |                                 |               | Hamada and adjacent coastal waters, Shimane | 12               | Anonymous (2004), Okamoto (2011, as *E. septemfasciatus*)                         |
| Blenniidae     | *Plagiotremus rhinorhynchos*       | Bluestriped fangblenny          | Australia     | Great Barrier Reef, Queensland |                  | Boxshall (1986, as *Runula rhinorhynchos* [sic])                           |

* Pillai (1985: 721) listed three species of groupers (*E. morrhua*, *E. akaara*, *E. tsirimenaria*) as hosts of *L. ramosus*, but only *E. morrhua* is listed herein as the Indian host because the two other grouper species were based on the record from Japan (Shiino, 1958).

** This species is listed as *Epinephelus septemfasciatus* in Senou (2013).
available (Pillai, 1985), those in India, Sri Lanka (Wadge Bank, Kirtisinghe, 1956), and Australia (Great Barrier Reef, Boxshall, 1986) are found in tropical waters. As indicated below, in Japan, the species occurs in subtropical to temperate waters. These indicate that *L. ramosus* has a wide distribution range from tropical through subtropical to temperate waters in the Indo-West Pacific region. The Japanese temperate waters are located at the northern limit of distribution of *L. ramosus*.

Based on the published information on collection localities of *L. ramosus* in Japan (Table 1), the species occurs in the western North Pacific (localities 1–5 and 7 in Fig. 3), the Seto Inland Sea (locality 6), the East China Sea (localities 8–10), and the Sea of Japan (localities 11–12). The specimen of *L. ramosus* reported herein extends its distribution range from Momotori, Mie Prefecture (locality 2) eastward to Suruga Bay, Shizuoka Prefecture (locality 1) off the Pacific coast of Japan. As indicated by Nagasawa et al. (2010, 2011), the geographical distribution of *L. ramosus* in Japanese waters is affected by two warm currents, the Kuroshio, and its branch, the Tsushima Current (Fig. 3). The species has been reported from the subtropical (locality 7) and temperate (other localities) waters.

In the Japanese temperate waters, adult females of *L. ramosus* have been most frequently found on groupers during the late summer to early winter (September to November, see Nitta et al., 2017). The specimen reported in this paper was also the ovigerous female collected in September. Seawater temperatures fluctuate seasonally in the Japanese temperate waters, and the maturation of *L. ramosus* may be accelerated by high seawater temperatures during the summer.

The outbreaks of *L. ramosus* occurred in the 2000’s among grouper populations in Japanese waters (Nagasawa et al., 2011). The recent collections of the species (Nitta et al., 2017; Izawa, 2019; this paper) may indicate that it has still maintained a high level of infection in the grouper populations and has been expanding its distribution range.

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