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Redescription of a symbiotic poecilostomatoid copepod *Anthessius graciliunguis* Do & Kajihara from plankton: the second record of the species and first record of the male

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Abstract: The symbiotic poecilostomatoid copepod *Anthessius graciliunguis* was redescribed from plankton samples collected in Ariake Bay, Japan. This species was created based on a single female in a blue mussel from Japan; the present study is the second record of the species and the first record of the male. Specimens described as *A. graciliunguis* from scallops in Korea belong to a different species because of differences in the caudal setae and ornamentation of the male maxilliped. Copepods were not rare in plankton (9 copepods in 200-liter water) as compared with limited previous information of *Anthessius* species from plankton samples and they occurred in the same season of the two years studied. This suggests that the free-swimming animals are not straying ones but result from usual behavior. The possible advantages of the behavior are releasing nauplii from egg sacs and changing the host.

Key words: *Anthessius graciliunguis*, poecilostomatoid copepod, symbiotic, plankton, Ariake Bay

Introduction

Anthessius is a genus of symbiotic poecilostomatoid copepods associated with marine bivalves or gastropods and presently includes 42 species throughout the world. Two species, *A. pectinis* Tanaka, 1961 and *A. graciliunguis* Do & Kajihara, 1984, have been recorded from Japan. *Anthessius pectinis* was described from mantle cavity of *Pecten albicans* Schrøter, 1802, collected from Sasebo Bay, Nagasaki (Tanaka 1961). Another species, *A. graciliunguis*, was described from the mantle cavity of *Mitylus galloprovincialis* Lamarck, 1819, collected in Himeji Harbor, Hyogo, based on a single female (Do & Kajihara 1984). There are no other records of *Anthessius* from Japan. Although the fauna of symbiotic copepods in Japan have not been intensively studied, very limited information on *Anthessius* from Japan suggests rarity of these species.

We found several *A. graciliunguis* copepods in plankton samples collected from Ariake Bay. This is the second finding of the species from Japan. Kim (1998) redescribed this species from scallops in Korea. However, his specimens are significantly larger and have somewhat different characters as compared with the original description from Japan. Since free-swimming adult and copepodid stages of *Anthessius* are very rarely known, we report them herein together with a redescription of the species and the first description of the male for comparison with the Korean population.

Materials and Methods

Plankton samples were taken in the surf zone at a bathing beach near Miike Harbor, Ohmuta, on the east coast of Ariake Bay, at the daytime low tide on 7 April and 9 May in 1998 and 17 February, 2 and 16 March, and 2 April in 1999. The sampling point was about 80 cm deep when samplings were done, and the bottom sediment was composed of muddy sand or silt. A 200-liter water was sampled on each date using a bucket and sieved with a plankton net with 0.1-mm mesh opening for collecting copepods. Water temperature and salinity at the sampling point were obtained by measuring with a mercury thermometer simultaneously with sampling and by taking a water sample and measuring with a salinometer later, respectively. The plankton samples were fixed in a 5% formalin solution immediately after sampling. *Anthessius* specimens were sorted

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from the whole samples, and other copepods were identified and counted in a 1/20 subsample. Examination, measurement and dissection of *Anthessius* specimens were made in lactophenol with bright-field and with differential interference microscopes. Drawings were made with a camera lucida.

Results

Field collection

We found 12 specimens of *Anthessius graciliunguis* in total, of which six were females, two of which were ovigerous, two males and a copepodid on 9 May, 1998 and two females and a copepodid on 2 April, 1999. No *Anthessius* specimens were discovered from samples on the other dates. The temperature and salinity when the specimens were collected were 27.4°C and 30.9 psu on 9 May 1998 and 14.6°C and 32.8 psu on 2 April 1999, respectively; the extreme difference in temperature is due to the difference in weather between the dates. The densities of copepods were 54.7 and 4.7 inds. l^{-1} on 9 May 1998 and 2 April 1999, respectively. The dominant species were *Pseudodiaptomus marinus* Sato, 1913 (99%) on 9 May 1998 and *Oithona davisae* Ferrari & Orsi, 1984 (49%) on 2 April 1999.

Taxonomic description

Anthessius graciliunguis Do & Kajihara, 1984

(Figs. 1–3)

Materials examined:

All adult specimens (eight females and two males) were examined. Two females, one of which was dissected and mounted on a glass side with gum chloral, and one dissected male were deposited in the National Science Museum in Tokyo (NSMT-Cr. 16672–16674).

The following descriptions are based mainly on variations and characters not described or different from those described by Do & Kajihara (1984) and Kim (1998).

Female:

Body (Fig. 1A) length 1.25–1.39 mm. Prosome depressed dorsoventrally, 1.5–1.8 times longer than wide and 1.7–1.9 times longer than urosome. Genital double somite (Fig. 1B, C) 1.1–1.2 times longer than wide. Anal somite (Fig. 1C) ventrally with 4–6 large denticles on each side of proximal region. Caudal ramus (Fig. 1B) 3.1–3.5 times longer than wide; lateral seta curved medially at distal one third; lateralmost terminal seta (Fig. 1D) characteristic, bearing setules only on medial side; other terminal setae normal, with setules on both sides. Egg number in paired egg sacs 338–340 and egg diameter 52.5–62.5 μm.

Antennule (Fig. 1E) 7-segmented; setation as follows: I=4, II=15, III=6, IV=3, V=4+1 aesthetasc (ae), VI=2+1 ae, VII=7+1 ae. Mandible (Fig. 1F) with usual apical lash and lash-like auxiliary seta; apical lash with denticles on proximal three fourths of lateral margin and on distal half of medial margin; auxiliary seta with denticles only on lateral margin. Maxillule (Fig. 1G) with long seta and 3 unequal distal setae along lateral margin and several rows of minute spinules on surface, distal row of them with longer spinules. Maxilla (Fig. 1H) 2-segmented; 1st segment without ornamentation; 2nd segment tapering into pointed process, with 2 unequal spines on anterior surface, 5–6 long spines on lateral margin, and 3–7 long spinules on medial margin.

Free segment of leg 5 (Fig. 1I) oval-shaped, 1.9–2.0 times longer than wide, with large spinules along distal three fourths of lateral margin between base of segment and lateral spine and along distal half of medial margin, and ventrally with 3–4 spinules at base of each spine; length ratios of medial, middle, and lateral spines to segment 0.7, 0.6, and 0.6, respectively. Other characters as in the female specimens described by Do & Kajihara (1984) and Kim (1998).

Male:

Body (Fig. 2A) length 1.23 mm. Prosome 1.9 or 2.0 times longer than wide and 1.6 times longer than urosome. Genital somite (Fig. 2B, C) 1.0 or 1.1 times longer than wide, ventrally with row of several minute denticles near distal margin. Anal somite (Fig. 2C, D) ventrally with 1–4 long denticles on each side of proximal region. Caudal ramus (Fig. 2B) 2.9 or 3.1 times longer than wide, with setae as in female.

Antennule (Fig. 2E) with 3 and 1 aesthetasc on 2nd and 4th segments, respectively; seta and aesthetasc numbers on other segments as in female. First segment of antenna (Fig. 2F) with enlarged seta reaching mid-length of terminal segment. Mandible (Fig. 2G) and maxillule (Fig. 2H) as in female. Maxilla (Fig. 3A) with 4–5 long spines on lateral margin and 4–6 long spinules on medial margin of terminal segment. Maxilliped (Fig. 3B) 4-segmented; 1st segment with row of spinules on distal margin; 2nd segment robust, bearing seta each on medial margin and anterior surface (arrowed in Fig. 3B), 2 longitudinal rows of spinules, one of them along medial margin and the other on anterior surface with intermittence at seta, and oblique row of spinules on proximal part of anterior surface, its spinules proximally larger and contiguous to short spinules of longitudinal row; 3rd segment small, with long medial seta; terminal segment expanded into long, curved claw with corrugated membrane along medial margin and small seta near base. Third endopodal segment of leg 1 (Fig. 3C) with 2 pointed apical projections, lateral one fringed with serrate hyaline membrane, 2 spines, apical one plumose proximally, with 4 setae (1 specimen with 3 setae on right leg). Free segment of leg 5 (Fig. 3D) 2.0 times longer than wide; length ratios of medial, middle, and lateral spines to segment 1.2, 0.9, and 0.8, respectively. Leg 6 (Fig. 2C) represented by a triangular process and 2 unequal setae on posterolateral border of genital somite. Other characters as in female.

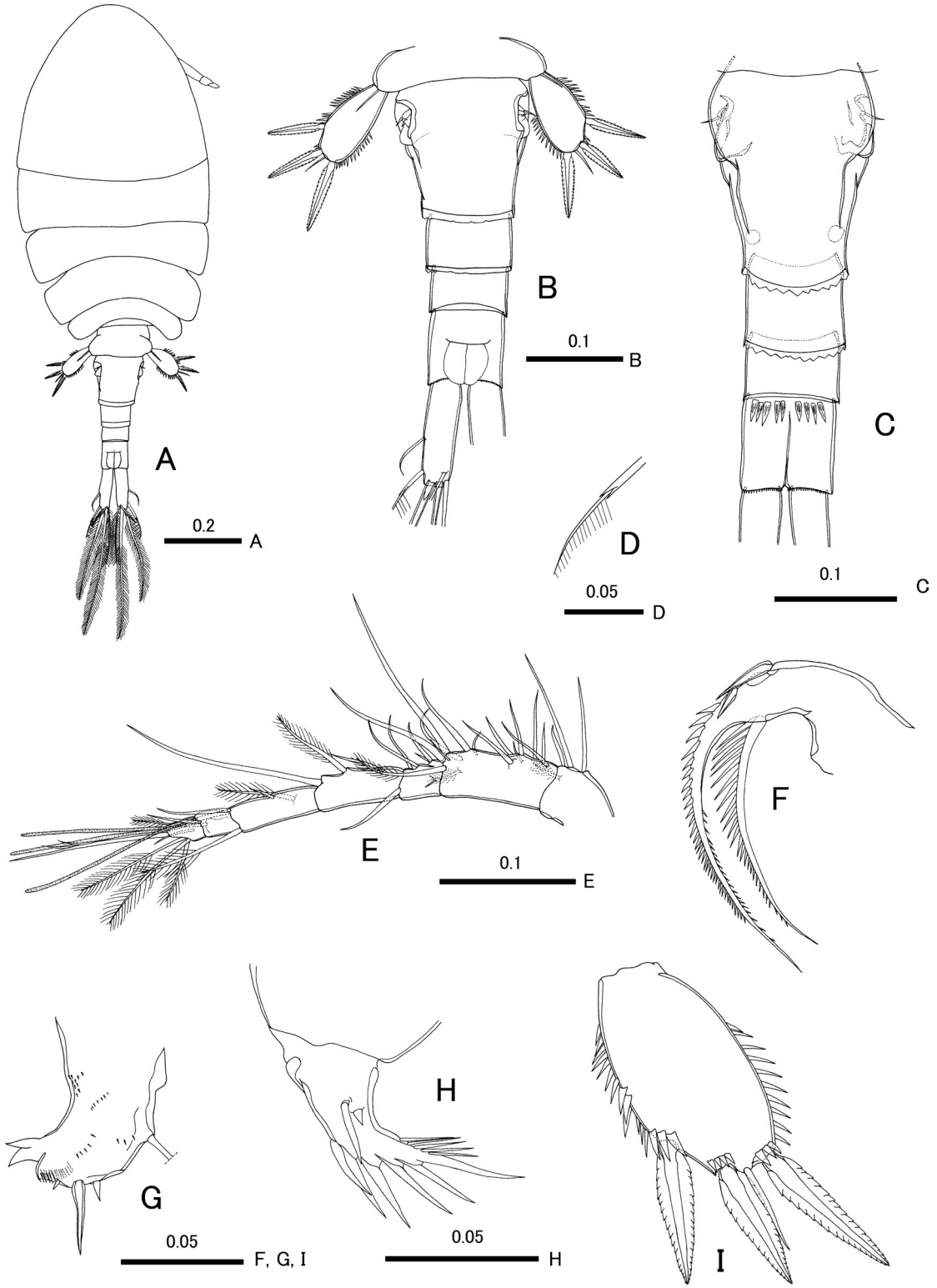

Fig. 1. *Anthessius graciliunguis*, female. A. Habitus, dorsal view; B. Urosome, dorsal view; C. Genital double somite and abdominal somites, ventral view; D. Lateralmost terminal caudal seta,; E. Antennule; F. Mandible; G. Maxillule; H. Maxilla; I. Free segment of leg 5. Scales in mm.

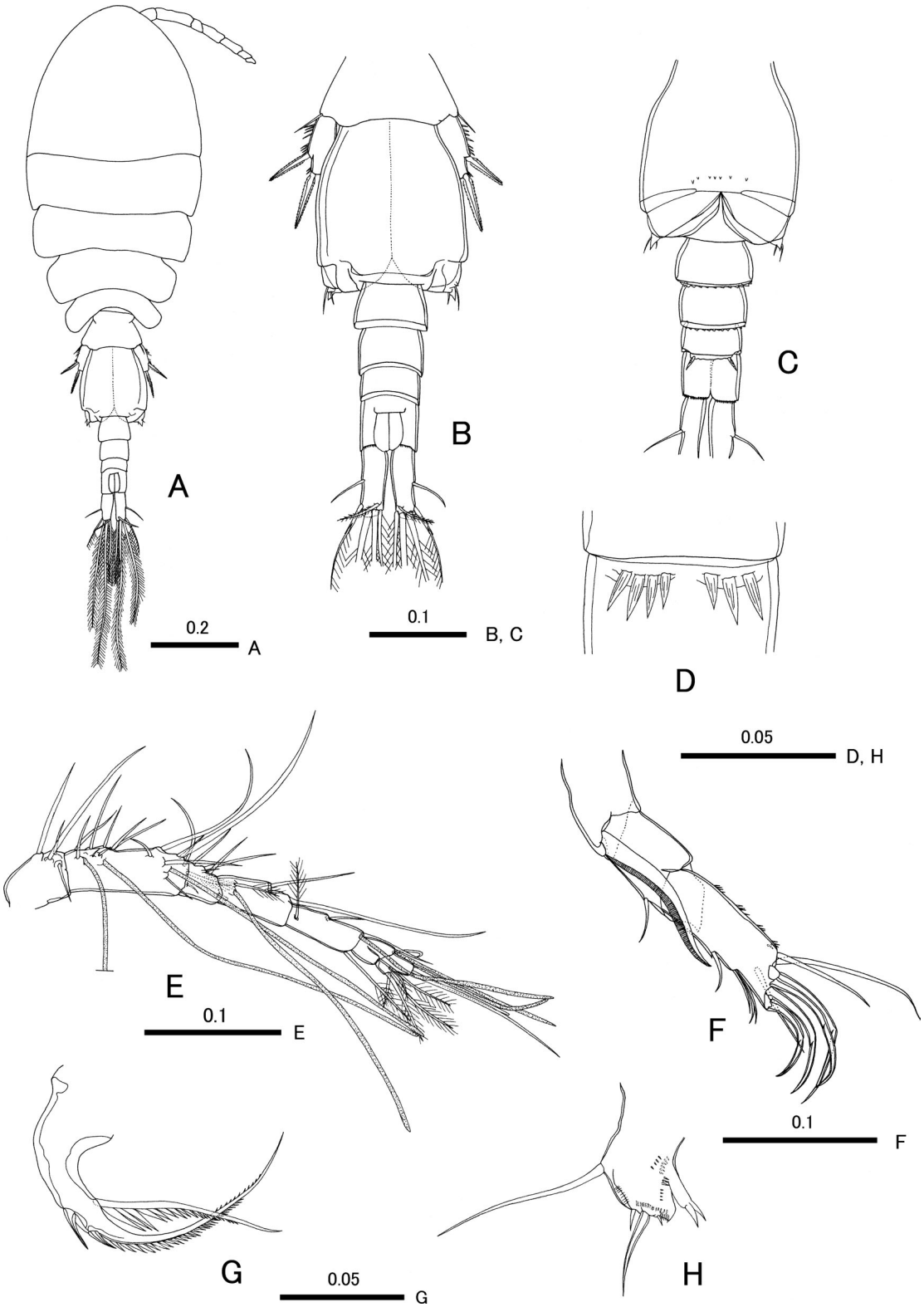

Fig. 2. *Anthessius graciliunguis*, male. A. Habitus, dorsal view; B. Urosome, dorsal view; C. Genital and abdominal somites, ventral view; D. Anal somite, ventral view; E. Antennule; F. Antenna; G. Mandible; H. Maxillule. Scales in mm.

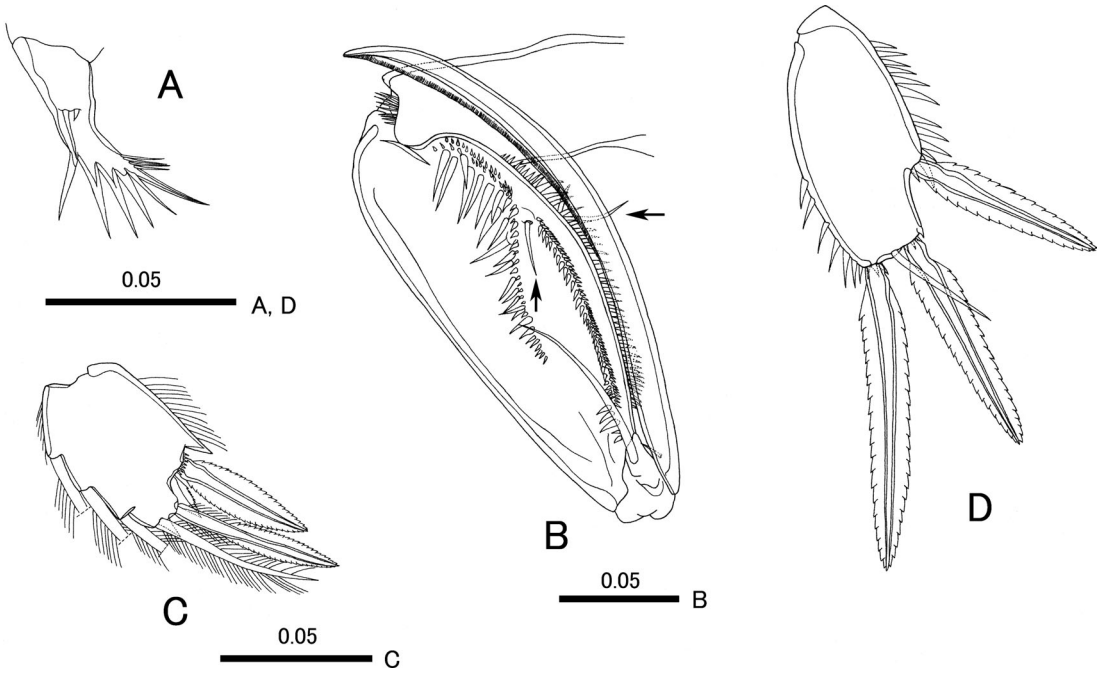

Fig. 3. *Anthessius graciliunguis*, male. A. Maxilla; B. Maxilliped, setae on the second segment are arrowed; C. Third endopodal segment of leg 1; D. Free segment of leg 5.

Discussion

The present specimens are different from the original description of *Anthessius graciliunguis* in the following female characters (corresponding characters in the original description are presented in brackets): the antennule has 1 aesthetasc each on the fifth to seventh segments [0, 1, 2 aesthetascs each on these segments]; the seventh antennular segment has 7 setae [6 setae]; a lateral seta on the maxillule is present [absent]; the maxilla has 2 unequal spines on the anterior surface and 5–6 spines along the lateral margin [1 and 4 spines, respectively]. The difference in aesthetascs and setae on the antennule is likely due to overlooking of them in the original description, since the seventh segment with 6 setae and 2 aesthetascs is unusual for the genus; usually 7 setae and 1 aesthetasc are present (e.g., Stock et al. 1963, Humes & Ho 1965, Ho & Kim 1992, Kim 1998, Lin & Ho 1999) and these characters are difficult to identify under a regular microscope. It is also likely that the absence of a lateral seta on the maxillule in the original description was due to it being broken or lost, because this seta is always present in congeners as far as the present authors are aware. The difference in the number of lateral spines on the maxilla is probably within the range of variation, because it is known that the number of these spines varies by 1 or 2 within a species (Illg 1960, Stock et al. 1963, Humes & Ho 1965). Thus, the present specimens are undoubtedly identified as *A. graciliunguis* in spite of the differences noted above.

Korean specimens (Kim 1998) differ from Japanese ones (Do & Kajihara 1984, the present study) in the following characters (corresponding characters of Japanese specimens are presented in brackets): the female body length 1.86 mm is much larger [1.25–1.39 mm]; the caudal ramus has a characteristic lateral seta and a normal lateralmost terminal seta in both sexes [a normal lateral seta and a characteristic lateralmost terminal seta]; the medialmost terminal seta of the caudal ramus is plumose only on the medial side [plumose on both sides]; denticles on medial margin of mandibular auxiliary seta are present [absent]; the spinule row on the proximal part of anterior surface of the second segment of the male maxilliped is apart from the longitudinal medial row [these rows are proximally contiguous to each other]. These differences indicate that Kim's Korean specimens belong to a different species according to the following reasons. First, the characters noted above are hardly able to be overlooked. Second, these characters do not show significant variations between the original description from Himeji Harbor, the Seto Inland Sea, and our specimens from Ariake Bay, the distance between which is comparative to that between Ariake Bay and Korea. This suggests that the morphological difference between Japanese and Korean specimens is not of a geographical cline. Third, as far as we know, intra-specific variations equivalent to differences between Japanese and Korean *A. graciliunguis* specimens have never been recorded for the characters noted above, except for the body length.

According to Ho (1997), all species of *Anthessius* are parasitic on or in bivalves and gastropods, and considered to feed on the host tissue with their characteristic cephalic appendages, such as raptorial antennae and piercing mandibles. He also noted six species of *Anthessius* col-

lected not from molluscs, e.g., from weed washings, plankton samples, and gill cavities of a fish. The copepods reported as living separate from host animals are two females and eight males of *A. concinnus* (Scott, 1909), in plankton samples collected by 0–2000 m vertical tows of a net at a tropical oceanic station in the East Pacific on 14 November, 1899 (Scott 1909), a female of *A. dilatatus* (Sars 1918) from a fjord in Norway (Sars 1918), three females of *A. groenlandicus* (Hansen 1923) in a fishing net from west Greenland (Hansen 1923), and a female of *A. brevifurca* Sewell, 1949 and a male of *A. investigatoris* Sewell, 1949 in weed washings from tropical waters of the Indian Ocean (Sewell 1949). Among them, ovigerous females were recorded for *A. concinnus* and *A. groenlandicus*. Ho (1997) considered that they are most likely nothing but stray individuals wandering from their normal hosts because of there being only a single finding of each species and because of the low numbers of collected copepods. In the present study, however, nine individuals of *A. graciliunguis* were found in a 200-liter water sample on 9 May, 1998, which is not a low number of free-living individuals as compared with previous findings, and they occurred again in a similar season in the next year. This likely indicates that the occurrence of *A. graciliunguis* in the plankton results not from accidental straying but from their normal habit to foray out from their hosts. The fact that *Anthessius* copepods have three-segmented biramous legs with well-developed plumose setae, as with planktonic copepods, also suggests that swimming activity is necessary for their life history strategy. The high ratios of ovigerous females in the free-swimming copepods (two of six females on 9 May, 1998 in the present study and two of five cases in the previous studies) may suggest an advantage of swimming out on forays from hosts as related to some reproductive strategy, i.e. mating, spawning, and releasing nauplii from egg sacs. Of these, the release of nauplii is the most likely to be advantageous because mating and spawning are possible even within their hosts, judging from records of males and ovigerous females in the same host (e.g., Humes & Stock 1965, Humes 1976, Devi 1979). In addition, the presence of males and immature copepods in the plankton suggests some advantage other than that concerning the release of nauplii, for example, changing the host for some reason.

Do & Kajihara (1984) considered the mussel *Mitylus galloprovincialis* as a fortuitous host of *Anthessius graciliunguis*, because only one female was discovered from nearly two thousand mussels examined. The specimens described as *A. graciliunguis* in Korea were collected from three scallops, *Patinopecten yessoensis* (Jay, 1857), *Pecten albicans*, and *Chlamys squamata* (Gmelin, 1791) (Kim, 1998). Proper hosts of *A. graciliunguis* in Japan may be scallops as in Korea. Three species of Pectinidae, *P. albicans*, *C. nobilis* (Reeve, 1852) and *Sinonovacula constricta* (Lamarck, 1818), are known to inhabit the sandy bottom of Ariake Bay (the Saga Prefectural Ariake Fisheries Research and Development Center, pers. comm) and *C. nobilis* is cultured in scallop farms around the mouth of the bay. It can be inferred that hosts of the present specimens live near the sampling site, which is more than 50 km from the mouth of the bay, because the copepods are unable to live apart from their hosts for a long time due to their feeding habit depending on host tissue (Ho 1997). Therefore, scallops in the sandy bottom around the sampling site are more likely hosts than those in the scallop farms.

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