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Two gnathiid isopods utilizing empty tubes of the polychaete worm *Spirobranchus akitsushima* in the Seto Inland Sea, western Japan, with the description of a new species

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Abstract: Two gnathiid species were collected from around Kagawa Prefecture, Seto Inland Sea, western Japan. One species was described as *Caecognathia tubicola* sp. nov. with detailed morphological examinations of male and female adults and larvae. A total of 130 individuals of *C. tubicola* were obtained from empty tubes of the polychaetous annelid *Spirobranchus akitsushima* in the intertidal zone. This species probably completes its life cycle around the aggregation of empty calcareous tubes of *S. akitsushima* on bedrock, as larvae at all developmental stages were found. Some adult females have significantly narrow thoraxes, a morphology that may be adapted to the elongate tubes. Small numbers of *Elaphognathia cornigera* (Nunomura, 1992) were also found in empty *S. akitsushima* tubes.

Key words: *Caecognathia*, ectoparasite, intertidal zone, narrow thorax

Introduction

The polychaetous annelid *Spirobranchus akitsushima* Nishi, Abe, Tanaka, Jimi, and Kupriyanova, 2022 [Yakko-kanzashi-gokai in Japanese] inhabits the central part of intertidal zones of south- central Honshu, often growing in colonies and forming aggregations of tubes encrusting on bedrock (Nishi et al. 2022). These aggregations are inhabited by a variety of animals such as microscopic gastropods, crustaceans, and other annelids (Yamanishi 2023). Since 2023, the second author has been conducting a faunal survey of calcareous mats of *S. akitsushima* on intertidal bedrock along the coast of Kagawa Prefecture, Seto Inland Sea, western Japan. Two gnathiid isopod species were collected from empty tubes of *S. akitsushima*.

Gnathiid isopods are less than a few millimeters in body size in most species, and the larvae are temporary ectoparasites of fishes while adults are free-living (Smit & Davies 2004, Tanaka 2007). The family Gnathiidae comprises about 240 species in 12 genera around the world (Boyko et al. 2008, onwards), and 42 species in 6 genera have been recorded from Japanese adjacent waters (Ota et al. 2025). From the Seto Inland Sea, there are only four papers which reported three genera and four species: *Gnathia bungoensis* Nunomura, 1982, *Elaphognathia lucanoides* (Monod, 1926), *E. sugashimaensis* (Nunomura, 1981), *E. strombosa* (Nunomura, 2012) (Nunomura 1981, 1982, 2012, Müller 1989).

Closer examination of the two species from empty tubes of *S. akitsushima* revealed that one is new to science and the other is a new occurrence in the Seto Inland Sea. In this paper, we describe the first species as a new species using male, female and larval specimens and record the second species. We also discuss gnathiid isopods utilizing polychaete tubes.

Materials and Methods

Between September 2023 and May 2024, the second author collected aggregations of *Spirobranchus akitsushima* tubes using a crowbar (16 cm length) at low tide in intertidal areas of Kagawa Prefecture (Fig. 1). The aggregations of tubes were put in 50 mL polyethylene boxes. We took

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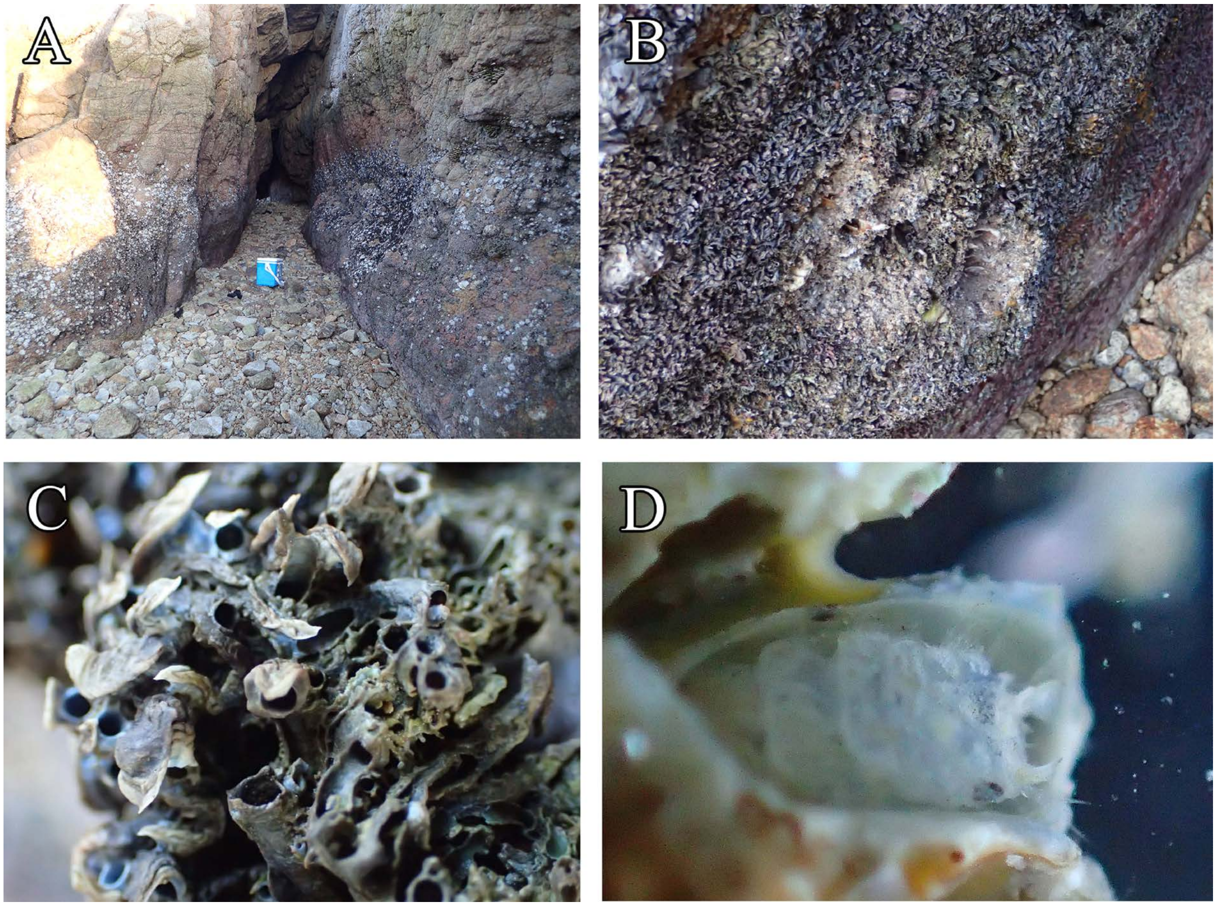

Fig. 1. Habitat of *Caecognathia tubicola* sp. nov. at Mitoyoshi City, Kagawa Prefecture (34°13.16′N, 133°36.35′E). A, intertidal rocky shore with mats of aggregations of tube of polychaete worm *Spirobranchus akitsushima*; B, encrusting calcareous tubes of *S. akitsushima*; C, mouth of empty tubes of *S. akitsushima*; D, male adult of *C. tubicola* in a tube. (Grayscale in printed body and color in pdf version).

the benthic substrata to the laboratory, sorted them under a stereomicroscope, and picked out the inhabiting gnathiids using tweezers. All the gnathiid samples were fixed in 70% ethanol and identified by the first author.

Body lengths were measured between the frontal margin of the cephalon (including the processes, excluding the mandibles) and the posterior tip of the pleotelson for male and female adults, and between the anterior margin of the clypeus and the posterior tip of the pleotelson for larvae. In order to investigate variations in the proportions of the thorax of female adults, we measured the length and maximum width of the center of the pereonite 4–6. In gnathiids, there are three stages of larvae, each with praniza larvae whose thoraxes are swollen with host body fluid and zuphea larvae with narrow thoraxes (e.g. Smit et al. 2019). In order to determine the stage of the larvae, the maximum width of the head was measured. The stage was estimated from the width of the head and determined them as 1st stage zuphea (Z1), 1st stage praniza (P1), 2nd stage zuphea (Z2), 2nd stage praniza (P2), 3rd stage zuphea (Z3), and 3rd stage praniza (P3).

In addition, for examination of morphological changes of the female adults during embryonic development in their brood pouches, we also classified females based on embryos in their brood pouches following Ota et al. (2008): compound eyes of the embryos in brood pouch were not visible (phase 1), the compound eyes of the embryos or the larvae were visible (phase 2), and empty brood pouch after the larvae left (phase 3).

Appendages of some specimens were removed with sharpened tungsten needles and mounted in CMCP-10 High Viscosity Mountant (Polyscience, Warrington, Pennsylvania, U.S.A.). Observations were made using a phase-contrast light microscope (Olympus, CX41), and drawings were made using a camera lucida.

Specimens prepared for scanning electron microscope (SEM) examination were dehydrated in 99% ethanol for a day, transferred to hexamethyldisilazane (HMDS) and air-dried for about 15 minutes. The dried specimens were mounted on double-sided conductive tape, sputter-coated with platinum, and photographed with a Joel JSM-6490LA or a Hitachi High Tec. SU3900.

Descriptive terminology follows Smit & Davies (2004) for setal classification and Cohen & Poore (1994) and Ota et al. (2025) for the male morphology. Most papers on taxonomy of Gnathiidae treat the fourth article of the antennula as the first article of the flagellum, but this article has penicillate setae that are characteristic of the peduncle, so it is treated as the fourth article of the peduncle. Voucher material is deposited in the Osaka Museum of Natural History (OMNH).

Results

A scatter plot of the midline length and maximum width of the pereonites 4–6 of female adults of *Caecognathia tubicola* sp. nov. (N = 13) is shown in Fig. 2. These specimens excluded damaged individuals and those used for SEM. Among these, two individuals with narrow thorax occurred. The ratios of length to width of the thorax were $\leqq$ 0.46 in females with narrow thoraxes, and $\geqq$ 0.49 in females with normal thoraxes. The embryonic developmental phases in brood pouches of 16 female specimens are summarized in Table 1. Two narrow thorax individuals were phase 1 and 2, respectively. Ten of the 14 normal thorax individuals were phase 1, one individual was phase 2 and three individuals were phase 3.

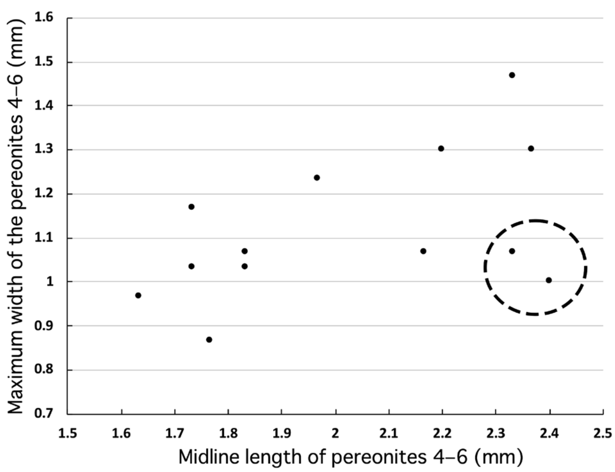

Fig. 2. Scatter plot of midline length and maximum width of pereonites 4–6 of female adults of *Caecognathia tubicola* sp. nov. Broken circle indicates narrow thorax individuals.

Developmental stages of *Caecognathia tubicola* larvae were estimated as followings: a head width of 0.20–0.23 mm (mean ± SD = 0.21 ± 0.01 mm, the number of Z1 = 13, the number of P1 = 3) was estimated as stage 1, 0.27–0.30 mm (0.28 ± 0.02 mm, Z2 = 3, P2 = 3) as stage 2, and 0.33–0.43 mm (0.39 ± 0.22 mm, Z3 = 1, P3 = 49) as stage 3.

Family Gnathiidae Leach, 1814

Genus *Caecognathia* Dollfus, 1901

Caecognathia Dollfus, 1901: p. 240; Tattersall, 1906: p. 61; Cohen and Poore 1994, pp. 310–311.
Gnathia (*Perignathia*) Monod, 1922: p. 645.
not *Gnathia* (*Perignathia*): Monod 1926, pp. 554–555.
Heterognathia Amar and Roman, 1974: p. 569.

Type species. *Anceus stygius* Sars, 1877; subsequent designation by Cohen and Poore (1994).

Caecognathia tubicola sp. nov. (Figs. 3–9)

[Japanese name: Kanzashi-umi-kuwagata]

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Materials examined

A total of 130 individuals were examined: 42♂, 16♀, 13Z1, 3P1, 2Z2, 4P2, 1Z3, 49P3. All materials were collected by Sadaaki Yoshimatsu.

Table 1. Developmental phases of the embryos in brood pouches of female *Caecognathia tubicola* sp. nov.

Sampling date	Locality	Thorax type	Body length (mm)	Phase	Note
23 Sep. 2023	Ogushi-no-hama	Normal	2.63	1	
		Narrow	3.63	1	Drawing
18 Jan. 2024	Ibuki Is.	Normal	2.63	1	
5 May 2024	Niro-hama	Normal	2.60	3	
11 May 2024	Niro-hama	Normal	2.80	1	
		Normal	2.77	1	
22 May 2024	Niro-hama	Normal	3.30	1	
		Normal	3.06	1	
		Normal	2.86	1	
4 Jun. 2024	Ibuki Is.	Normal	3.03	2	
		Normal	3.13	2	
		Normal	3.37	2	Drawing
		Normal	2.53	3	SEM
		Normal	—	3	damaged/SEM
		Narrow	3.40	1	
		Normal	2.60	1	

Holotype. OMNH Ar-13059, ♂ (body length 2.83 mm), Ogushi-no-hana, Sanuki City, Kagawa Prefecture, Seto Inland Sea, western Japan. 34°22.11′N, 134°12.68′E, 23 Sep. 2023. Paratypes. OMNH Ar-13060, 9♂ (body length 2.40–2.93 mm, mean ± SD = 2.46 ± 0.22 mm, 2♂ for SEM observation), 2♀ (2.63, 3.63 mm), 22 larvae including 12 Z1 (0.83–0.97 mm, 0.88 ± 0.05 mm), 3 P1 (1.1 mm, 0.11 ± 0 mm), 2 Z2 [1.63 mm and unknown (1 damaged individual)], 4 P2 (1.97–3.47 mm, 2.48 ± 0.86 mm, excluding one damaged individual), and 1 Z3 stages (damaged individual), same localities and date as holotype. OMNH Ar-13061, 32♂ (2.13–2.67 mm, 2.45 ± 0.16 mm, excluding 3 damaged individuals), 1♀ (2.63 mm), 30 P3 larvae (2.50–3.63 mm, 3.01 ± 0.32 mm, excluding 8 damaged individuals), Ibuki-jima Island, Kan-non-ji City, Kagawa Pref., 34°8.08′N, 133°31.93′E, 18 Jan. 2024. OMNH Ar-13062, 1♀ (2.60 mm), Niro-hama coast, Takuma Town, Kagawa Pref., 34°15.50′N, 133°34.24′E, 5 May 2024. OMNH Ar-13063, 2♀ (2.80, 2.77 mm), 5 P3 larvae (2.80–3.43 mm, 3.02 ± 0.36 mm, excluding 3 damaged individuals), Niro-hama coast, 11 May 2024. OMNH Ar-13064, 3♀ (2.86–3.30 mm, 3.08 ± 0.22 mm), 9 P3 larvae (2.43–3.37 mm, 2.96 ± 0.35 mm), Niro-hama coast, 22 May 2024. OMNH Ar-13065, 7♀ (2.53–3.40 mm, 3.01 ± 0.37 mm, excluding 1 damaged individual, 2♀ for SEM), 6 larvae including 5 P3 (2.50–3.17 mm, 2.81 ± 0.29 mm, 2 P3 for SEM) and 1 Z1 larvae (0.90 mm), Ibuki-jima Island, 4 Jun. 2024.

Diagnosis. Dorsal surface of cephalosome, pereonites 1–3, and anterior part of pereonite 4 densely covered with fine granules; frontal border rounded, slightly dentate, fringed with fine setae; paraocular ornamentation multiple projections, covering part of eyes in dorsal view; pereonite 1 not fused with cephalon and divided into 3 parts; epimera not prominent on pleonites 1–5; pleotelson covered with pectinate scales on anterior half and fine spines on posterior part.

Description of male adult (Figs. 3A, B, 4, 5, 9A–D)

Pigmentation. Pale yellow and sparsely dark red chromatophores on whole body and dark red eyes in live (Fig. 3A, B) and 70% ethanol preserved specimens. Hindgut in pereonites 4–6 yellow in both dorsal and ventral view in live specimens and pale yellow in 70% ethanol preserved specimens but varying with host's fluid compositions. Body length 2.13–2.93 mm (mean ± SD = 2.46 ± 0.18 mm). Cephalosome (Figs. 4A–C, 9A, B) oval shaped, length 0.2 times of body, width 1.4 times of length, posterior margin concave; dorsal surface covered with granules and long setae. Eyes well-developed, occupying 0.3 times of head length; paraocular ornamentation with multiple projections, covering part of eyes in dorsal view; supraocular lobe and accessory supraocular prominent. Dorsal sulcus U-shaped; two oval spaces transparent in center. Frontal border round, slightly dentate, fringed with fine setae; external scissura narrow and deep; 4 pairs of simple setae on medial side of base of mandible.

Pereon (Figs. 4A, 9A) widest at pereonite 5; pereonites 1–3 and anterior half of pereonite 4 covered with granules and long setae. Pereonite 1 not fused with cephalon and divided into 3 parts; central part slightly convex in anterior margin and 2 lateral parts visible in lateral view. Pereonite 2 2.8 times longer than pereonite 1, convex in anterior margin. Pereonite 3 1.4 times longer than pereonite 2. Pereonite 4 as long as pereonite 3, rectangularly concave in anterior margin, slightly convex in posterior margin. Pereonite 5 with dorsal sulcus with thin groove, 1.2 times longer than pereonite 4; areae laterales visible. Pereonite 6 1.1 times longer than pereonite 5; lobi laterales and lobuii visible. Pereonite 7 0.5 times as long as pleonite 1. Pleon (Figs. 4A, 9A) with 2 pairs of setae on lateral margins and dorsal surfaces of each pleonite. Epimera not prominent. Pleotelson (Figs. 4D, 9D) 1.1 times as long as wide; dorsal surface covered with pectinate scales in anterior half and fine spines in posterior part; lateral margin slightly concave, fringed with spines in posterior part; apex slightly bifid; 1 pair of simple setae on central surface, posterior surface, and apex, respectively.

Antennula (Fig. 4E) 0.7 times as long as antenna; peduncles 2.1 times as long as flagellar articles; 2 and 4 penicillate setae on distal margins of peduncles 1 and 2, respectively; 1 aesthetasc on each of flagellar articles 2–4; article 4 terminating in 3 simple setae and 1 penicillate seta. Antenna (Fig. 4F): peduncles 1.5 times as long as flagellar articles; 1, 3, and 3 penicillate setae on peduncles 1, 3, and 4, respectively; 1 or 2 simple setae on each distal margin of flagellar articles 1–6; article 7 terminating in 4 simple setae. Mandible (Fig. 4A–C) 0.4 times of head length; apex curved inward; dentate blade occupying 0.5 times of mandible length; basal neck and erisma prominent; mandibular seta on mid-dorsal surface; incisor prominent; internal lobe lacking. Maxilliped (Fig. 5A): endite of basis reaching basal margin of palp article 2; 3, 6, 5, and 7 plumose setae on external margin of palp articles 1–4, respectively; 1 stout spine near inner distal margin of article 1; 3 simple setae on distal margin of article 4. Pylopod (Fig. 5B): article 1 oval with 2 areolae, 34 plumose setae, bearing 6 simple setae subdistally; article 2 oval with 1 simple seta distally; article 3 semicircular with 2 simple setae.

Pereopod 2 (Fig. 5C) covered with pectinate scales on ischium, merus, carpus, and propodus; basis covered with long setae, 3.1 times as long as wide, outer margin with 2 penicillate setae; ischium 0.6 times as long as basis, 2.5 times as long as wide, 1 spine-like projection on inner basal margin, 3 tubercles on distal margin; merus 0.6 times as long as ischium, 1.6 times as long as wide, superior margin with 3 simple setae, inferior margin with 2 simple setae; carpus 0.8 times as long as merus, 1.6 times as long as wide, inner distal margin with 1 robust seta and 2 simple setae; propodus 1.4 times as long as carpus, 3.3 times as long as wide, superior margin with 1 penicillate seta, inner margin with 2 robust setae; dactylus 0.4 times as long as propodus. Pereopod 3 similar to pereopod 2. Pereopod 4

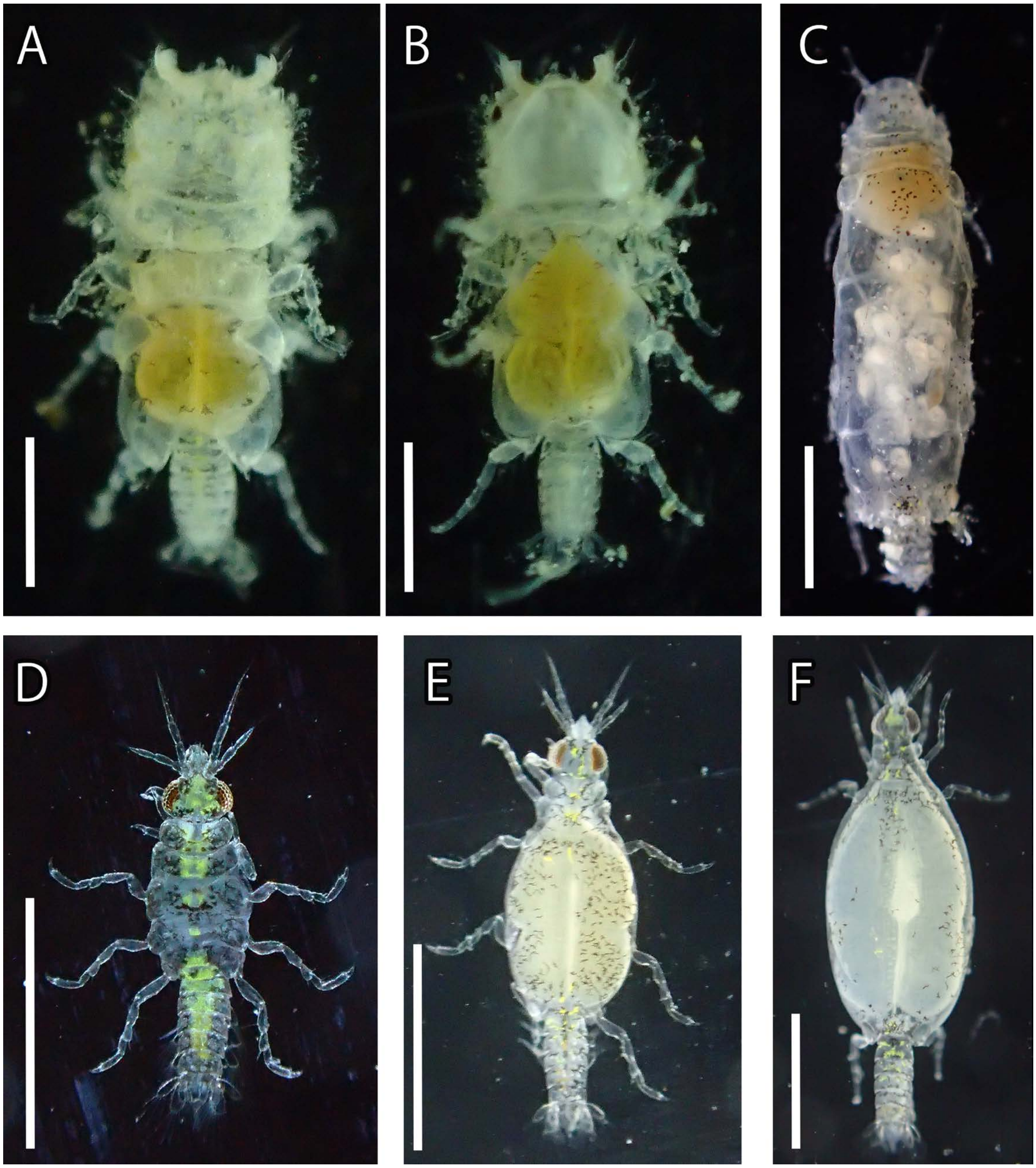

Fig. 3. Live specimens of *Caecognathia tubicola* sp. nov. (non types) A, B, male adult in dorsal view (A) and ventral view (B), body length = 3.2 mm; C, narrow thorax individual of female adult, 3.5 mm; D, Z2 larva, 1.4 mm; E, P2 larva, 2.0 mm; F, P3 praniza, 3.5 mm. Scale bar = 1 mm. (Grayscale in printed body and color in pdf version).

(Fig. 5D) 0.9 times as long as pereopod 2, largest width 0.9 times as wide as that of pereopod 2; inner margins of ischium, carpus, and propodus sparely covered with pectinate scales; both margins of basis, inner margins of ischium and merus covered with tubercles; robust setae on carpus and propodus not developed as large as those of pereopod 2. Pereopod 5 (Fig. 5E) as long as pereopod 4; largest width 0.7 times as wide as that of pereopod 4; pectinate scales and tubercles less than those of pereopod 4. Pereopod 5 similar to pereopod 6. Penes (Fig. 5F) composed of 2 contiguous, non-prominent papillae. Pleopod 2 (Fig. 5G) lacking appendix masculina; peduncle with 1 simple seta and 2 coupling hooks on distolateral and distomesial margins, respectively; endopod with 1 small seta on distal margin; exopod with 7 simple setae on distal margin. Other pleopods almost same shape as pleopod 2; setation varying 1–2 simple setae in endopods; 5–7 simple setae in exopods.

Uropodal rami (Fig. 4D): outer margins of both rami fringed with small spines. Exopod just reaching apex of pleotelson, 3.3 times as long as wide, 0.9 times as long as endopod; lateral margin with 6 simple setae and 4 plumose

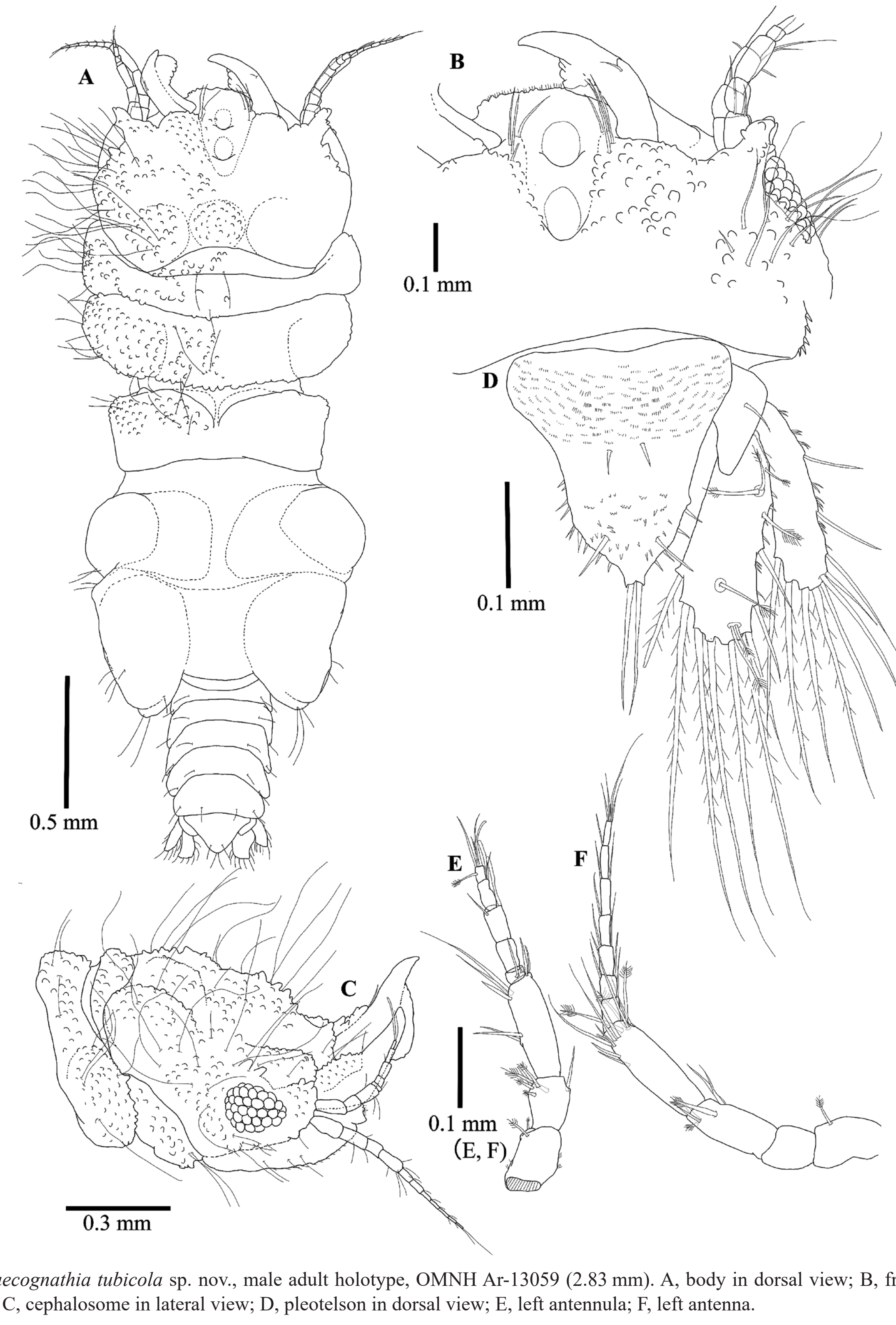

Fig. 4. *Caecognathia tubicola* sp. nov., male adult holotype, OMNH Ar-13059 (2.83 mm). A, body in dorsal view; B, frontal border in dorsal view; C, cephalosome in lateral view; D, pleotelson in dorsal view; E, left antennula; F, left antenna.

setae. Endopod leaching beyond apex of pleotelson, 2.4 times as long as wide; lateral margin with 3 simple setae and 6 plumose setae; 7 penicillate setae on dorsal surface.

Description of adult female (Figs. 3C, 6, 7, 9E, F)

Since there is no distinct difference in morphology between the two types (narrow thorax and normal thorax) other than the proportions of the thorax, the following descriptions without thoraxes are based on specimens with a

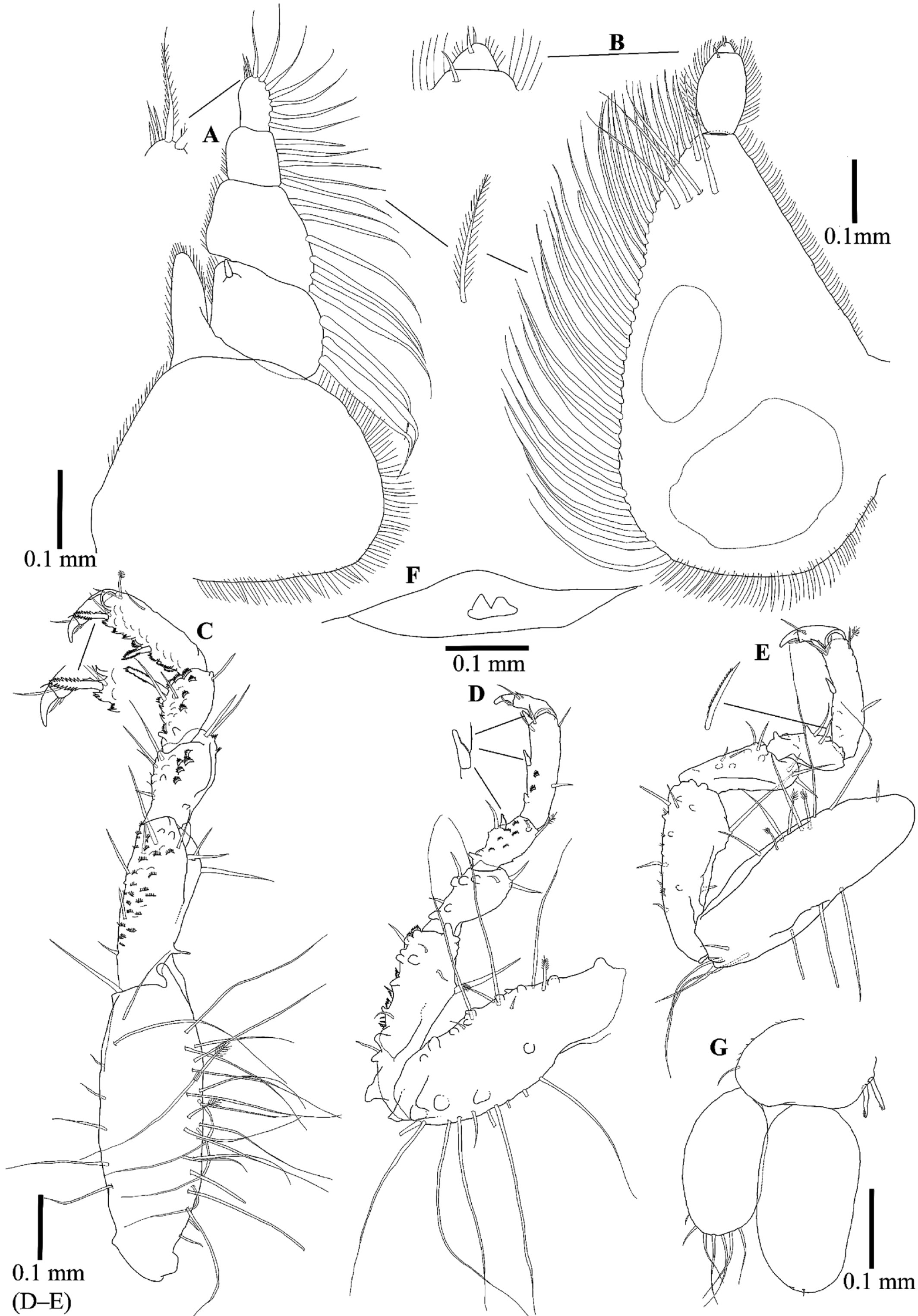

Fig. 5. *Caecognathia tubicola* sp. nov., male adult holotype, OMNH Ar-13059 (2.83 mm). A, left maxilliped in ventral view; B, left pylopod in ventral view; C, left pereopod 2; D, right pereopod 4; E, left pereopod 5; F, penes; G, left pleopod 2.

narrow thorax.

Pigmentation. White body with sparsely dark red chromatophores, pale yellow eggs, and dark red eyes in live (Fig. 3C) and 70% ethanol preserved specimens. Hindguts in pereonites 3 and 4 yellow in live specimens and pale yellow in 70% ethanol preserved specimens but varying with host's fluid compositions. Body length/maximum width of narrow thorax individuals 3.40/1.30

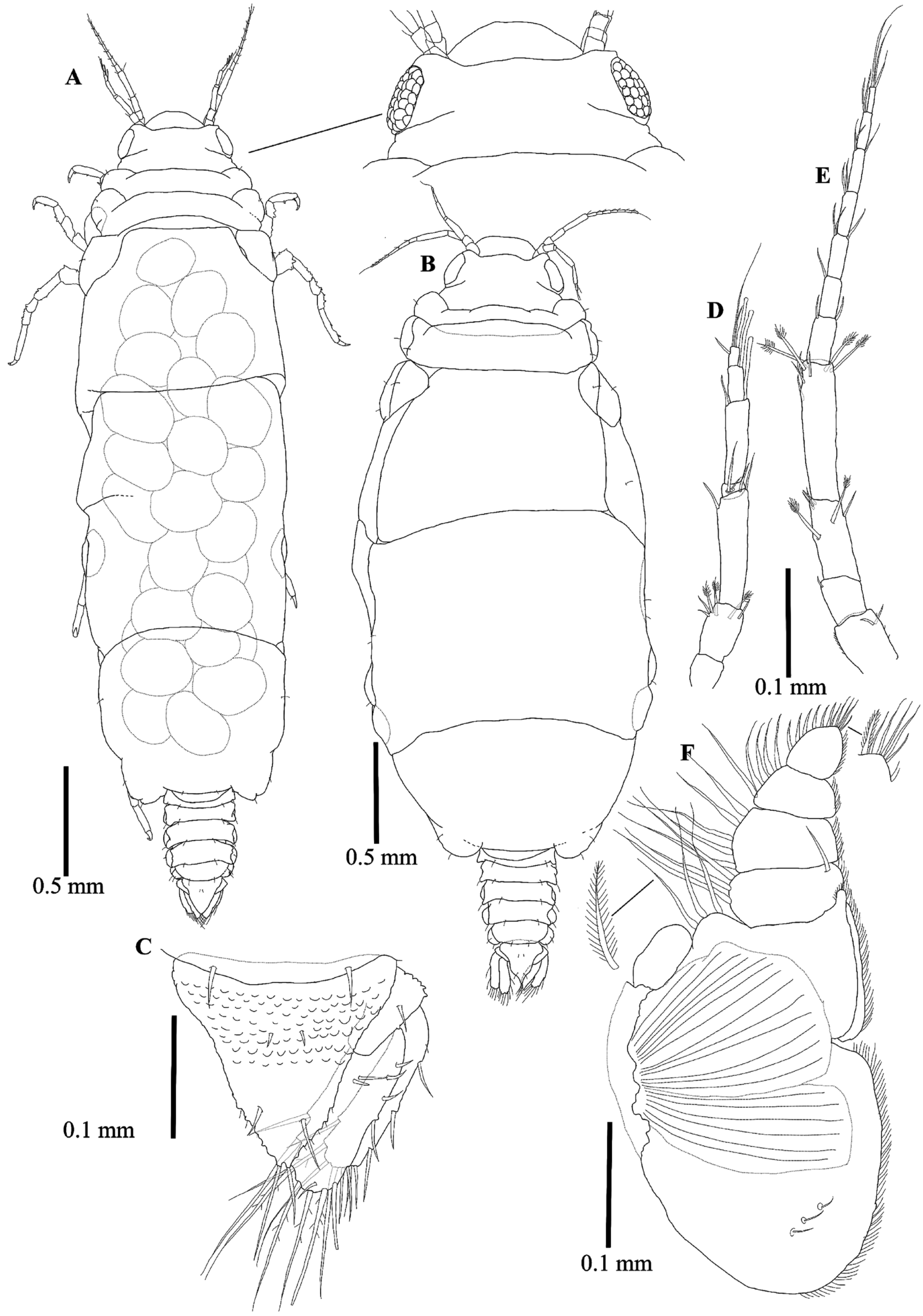

Fig. 6. *Caecognathia tubicola* sp. nov., female adults. A, body of narrow thorax individual in dorsal view; B, body of normal thorax individual in dorsal view; C, pleotelson in dorsal view; D, left antennula; E, left antenna; F, right maxilliped in dorsal view. B = paratype OMNH Ar-13065 (3.37 mm), other parts = paratype, OMNH Ar-13060 (3.63 mm).

and 3.63/1.00 mm, respectively. Body length of normal thorax individuals 2.53–3.37 mm (mean ± SD = 2.87 ± 0.28 mm, N = 13), while maximum width 0.87–1.46 mm (1.14 ± 0.17 mm, N = 11, excluding damaged individuals and those used for SEM). Narrow thorax individuals 0.7 times narrower than normal thorax individuals; pereonite 2–6 3.1 times as long as wide in narrow thorax individuals while 1.9 times in normal thorax individuals.

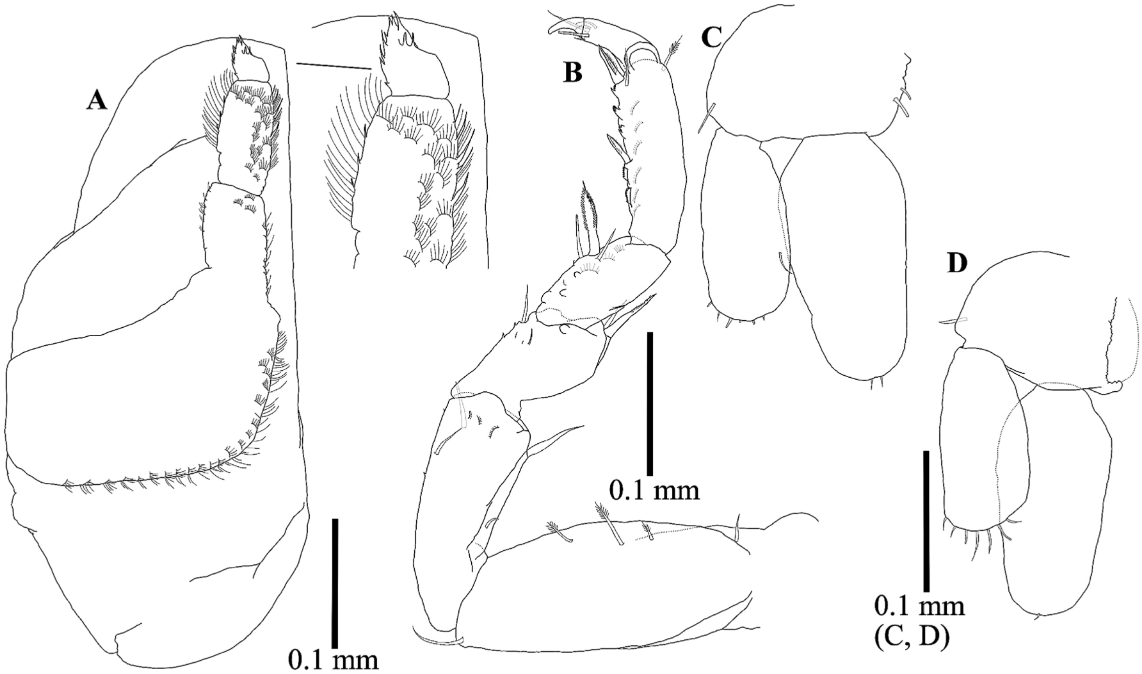

Fig. 7. *Caecognathia tubicola* sp. nov., female adult paratype, OMNH Ar-13060 (3.63 mm). A. right pylopod in dorsal view; B, left pereopod 2; C, left pleopod 1; D, left pleopod 2.

Cephalosome (Figs. 6A, B, 9E) pentagonal with 1 pair of small setae on dorsal surface, length 0.06 times of body length in narrow thorax individuals and 0.08 times of body length in normal thorax individuals, width 2.1 times of length. Frontal border smoothly rounded and slightly concave. Pereon (Fig. 6A) widest at pereonite 4 in narrow thorax individuals or pereonite 5 in normal thorax individuals. Pereonite 1 fused to cephalon, lateral parts visible in dorsal view. Pereonites 2 and 3 concave anteriorly; 1 small seta on lateral margins. Pereonites 4–6 swollen with 2 sutures. Pereonite 7 0.5 times as long as pleonite 1. Lateral shields of pereopods 3–5 visible dorsally. Pleonites 1–5 (Figs. 6A, B, 9F) each with 1 pair of small setae on dorsal surface. Epimera prominent on pleonites 2–5; 1 or 2 pairs of small setae present on each epimera. Pleotelson (Fig. 6C) 0.9 times as long as wide; anterior half of dorsal surface covered with pectinate scales; lateral margin slightly concave, serrated, and fringed by fine setae posteriorly; 1 pair of simple setae on central surface, near apex, and apex, respectively.

Antennula (Fig. 6D) composed of 4 peduncular and 3 flagellar articles; 0.6 times as long as antenna; peduncles 1.8 times as long as flagellar articles; 3 penicillate setae on distal margins of peduncle 3; 1 aesthetasc on each of articles 1–3; article 3 terminating in 2 simple setae. Antenna (Fig. 6E) with 4 peduncular and 7 flagellar articles; peduncles 1.1 times as long as flagellar articles; 2 and 4 penicillate setae on peduncles 3, 4, respectively; 1–3 simple setae on each distal margin of flagellar articles 1–6; 3 simple setae on flagellar article 7. Maxilliped (Fig. 6F): coxa oval shaped with 3 simple setae near posterior margin of oostegite; 3, 3, 5, 5, and 6 plumose setae on external margin of basis and palp articles 1–4, respectively; 5 simple setae on distal margin of article 4. Pylopod (Fig. 7A): article 1 curved with pectinate scales on inner and outer distal margins; article 2 rectangular with pectinate scales on outer and distal margins and 5 sharp projections on inner distal margin; article 3 convex shaped with 5 and 3 sharp projections on outer and distal margin, respectively; 2 sharp projections near distal margin. Pylopodal oostegite oval shaped.

Pereopod 2 (Fig. 7B) similar shape to that of male adult but long setae and pectinate scales sparser. Pleopods (Fig. 7C, D) similar shape as that of male adult; endopod with 1 or 2 vestigial setae; exopods 6 or 7 vestigial setae on distal margin. Uropodal rami (Fig. 6C), exopod almost reaching apex of pleotelson, 3.6 times as long as wide, same length as endopod; lateral margin with 6 simple setae and 4 vestigial plumose setae. Endopod extending beyond apex of pleotelson, 2.8 times as long as wide; lateral margin with 3 simple setae and 6 vestigial plumose setae; 6 simple setae on dorsal surface of endopod.

Description of third stage praniza (Figs. 3F, 8, 9G–I)

Pigmentation. Pale yellow and brown chromatophores sparsely present on whole body and dark red eyes in live (Fig. 3F) and 70% ethanol preserved specimens. Body length 2.43–3.63 mm (mean ± SD = 2.98 ± 0.32 mm, N = 39). Cephalosome (without clypeus) (Figs. 8A, 9G) semicircular, 1.7 times as long as wide. Clypeus triangular with slightly concave anterior margin. Eyes occupying 0.9 length of cephalosome. Pereon widest at swollen pereon-

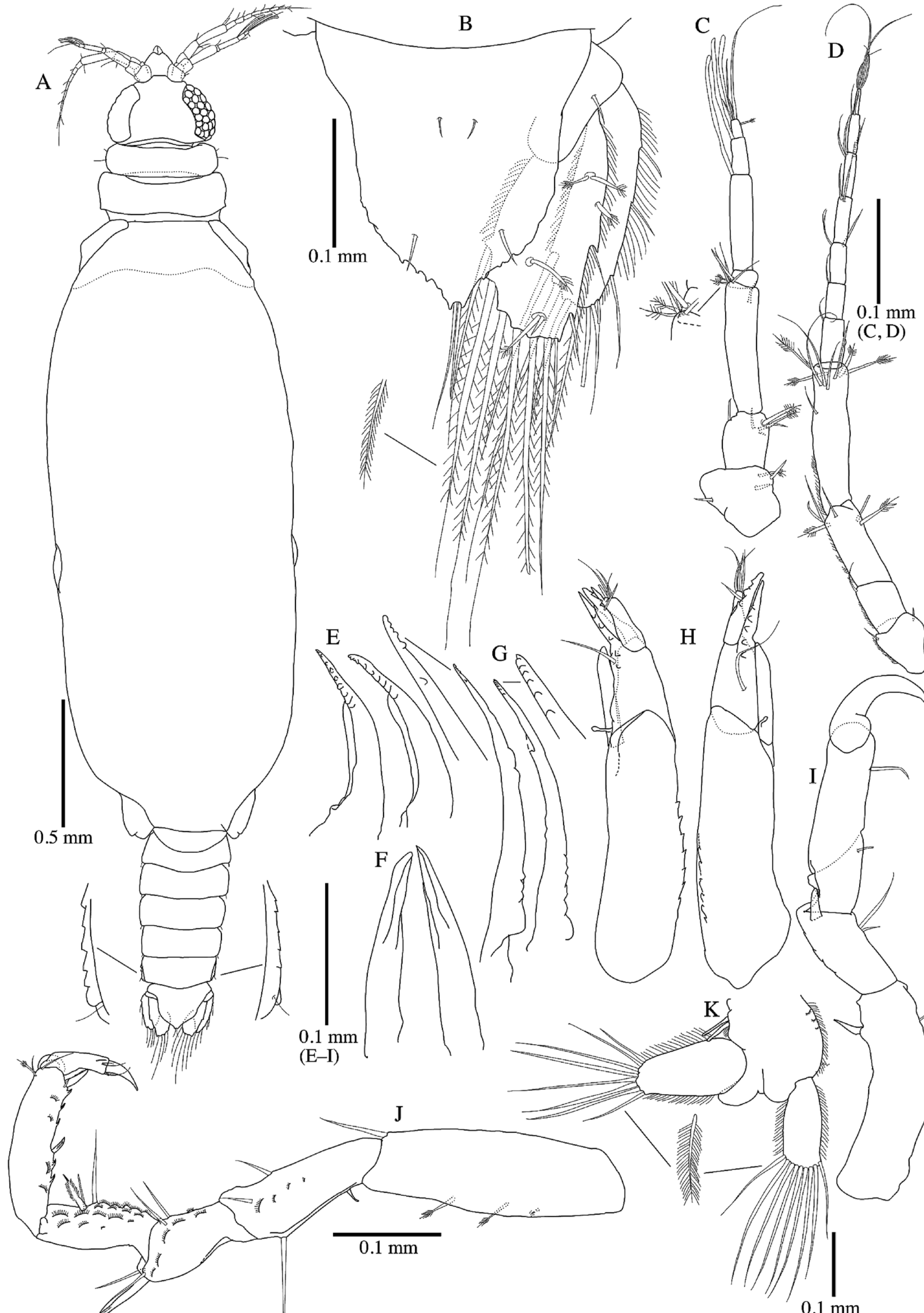

Fig. 8. *Caecognathia tubicola* sp. nov., P3 larva, OMNH Ar-13061 (3.63 mm). A, body in dorsal view; B, pleotelson in dorsal view; C, left antennula; D, left antenna; E, mandible; F, paragnath; G, maxillule; H, maxilliped; I, pereopod 1; J, left pereopod 2; K, left pleopod 2 with deformed peduncle.

ites 4–6. Pereonite 1 (Fig. 8A) not reaching lateral margin of cephalon. Pereonite 2 rectangular, with 2 setae on lateral margin. Pereonite 3 slightly broader than pereonite 2. Pereonites 4–6 fused; lateral shields of pereonites 4–6 slightly visible in dorsal view, elliptical. Pereonite 7 0.7 times as long as pleopod 1. Pleon (Figs. 8A, 9H) covered with pectinate scales and with 1 pair of short setae laterally; epimera not prominent in pleonites 1–4; dentate epim-

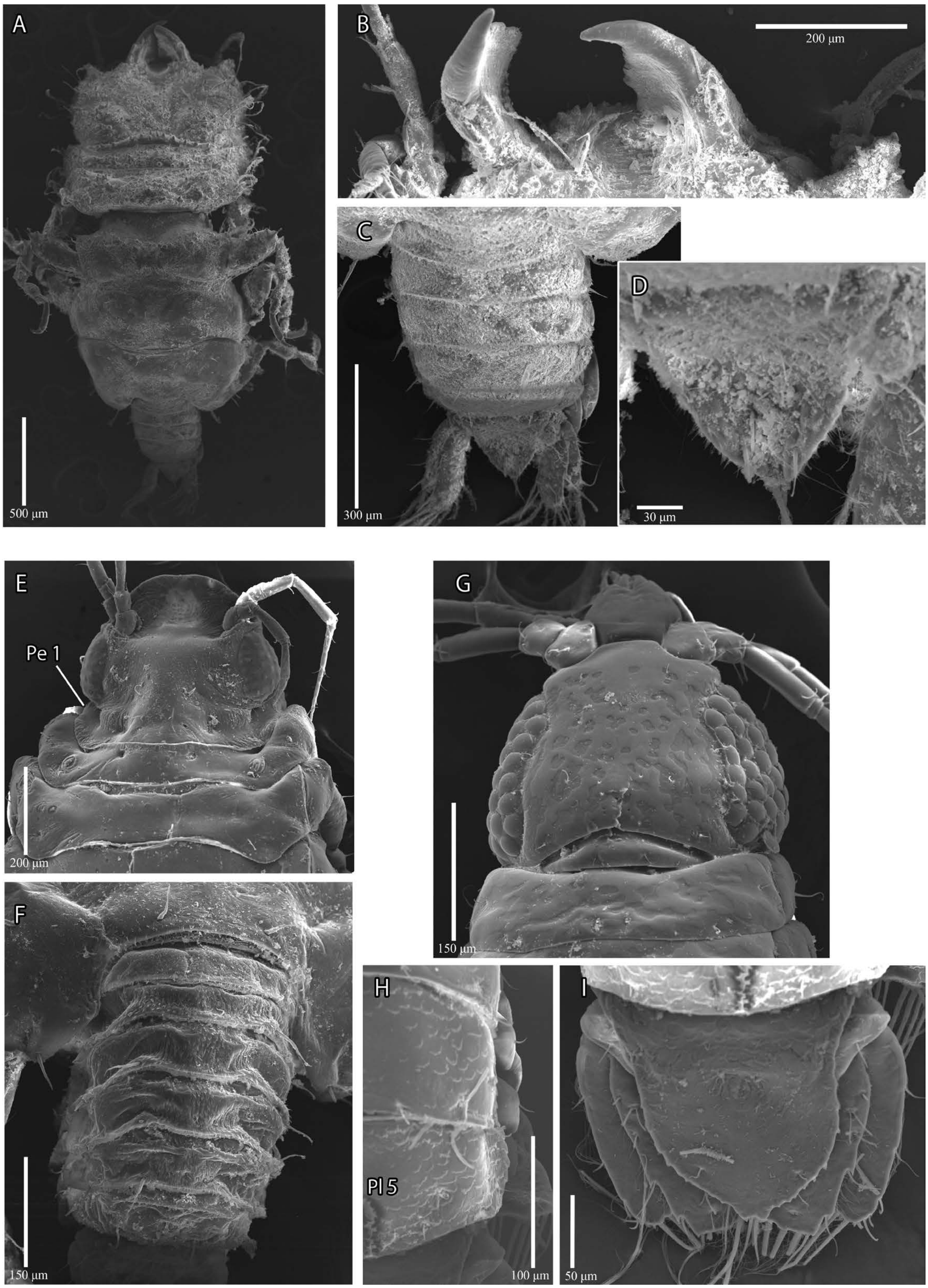

Fig. 9. Photographs of *Caecognathia tubicola* sp. nov. paratypes in dorsal view under SEM. Male adult, OMNH Ar-13060 (A, C, D: 2.93 mm, B: 2.27 mm). A, body; B, frontal border with mandibles; C, pereonite 7 and pleonites 1–5; D, pleotelson. Female adult, OMNH Ar-13065 (E: 2.53 mm, F: body length unknown due to damaged specimen). E, cephalosome and pereonites 1–3, F, pereonite 7 and pleonites 1–5. P3 larva, OMNH Ar-13065 (G–I: 3.17 mm), G, cephalosome and pereonites 1 and 2; H, lateral margin of pleonites 4 and 5; I, pleotelson. Pe 1 = pereonite 1, Pl 5 = pleonite 5.

era slightly visible in dorsal pleonite 5. Pleotelson (Figs. 8B, 9I) same length as width; anterior half covered with pectinate scales; lateral margin convex and posterior margin slightly dentate; dorsal surface and apex with 2 pairs of short setae.

Antennula (Fig. 8C) composed of 4 peduncular and 3 flagellar articles; 0.7 times as long as antenna; peduncles 1.6 times as long as flagellar articles; peduncle article 1 trapezoidal. Antenna (Fig. 8D) composed of 4 peduncular and 7 flagellar articles; peduncles 1.2 times as long as flagellar articles. Mandible (Fig. 8E) with 8–9 teeth. Paragnath (Fig. 8F) slightly curved. Maxillule (Fig. 8G) with 5 or 6 teeth on apex. Maxilliped (Fig. 8H), basis with endite and single coupling hook on inner margin; posterior outer margin dentate; apex of palp 1 with 5 teeth and 1 simple seta; inner apex of palp 2 with 2–4 teeth and 1 simple seta; outer apex part of palp 2 with 4 simple setae and 1 spine. Pereopod 1 (Fig. 8I) smaller than other pereopods; carpus reduced; 1 stout spine on outer distal margin of basis and merus. Pereopod 2 (Fig. 8J): long setae and pectinate scales sparser than adult males, merus and carpus more slender; merus 1.9 times as long as wide (1.6 times in adult male), carpus 2.2 times as long as wide (1.6 times in adult male). Pleopod 2 (Fig. 8K) fringed with fine setae on basis, endopod, and exopod; 7 or 8 plumose setae on distal margin of endopod; 8 or 9 plumose setae on distal margin of exopod. Uropod (Fig. 8B), both rami fringed with fine setae. Exopod not reaching apex of pleotelson; 3.1 times as long as wide; same length as endopod; lateral margin with 6 simple setae and 4 plumose setae. Endopod beyond apex of pleotelson; 2.1 times as long as wide; lateral margin with 3 simple setae and 6 plumose setae.

Remarks

Following the key to genera in Ota et al. (2025), the present species belongs to the genus *Caecognathia* Dollfus, 1901 because of the following characteristics in adult male: 1) pylopod is 3-articled, the article 1 is wide and covering maxilliped, 2) maxilla 1 (maxillule) is absent, 3) mandible is nipper-shaped, and 4) frontal border is rounded and frontal processes on the frontal border is lacking. The genus *Caecognathia* has 47 described species worldwide on the basis of adult male morphologies (Boyko et al. 2008, onwards). Of these, the adult male of *C. polaris* (Hodgson, 1902) is most similar to that of *C. tubicola* sp. nov. because they share anterior body surface covered with long setae and tubercles, pereonite 1 not reaching lateral side of the cephalon, and non-developed epimera of the pleonites. However, *C. polaris* can be distinguished from *C. tubicola* by the posterior body surface covered with long setae (scarcely covered in *C. tubicola*), the slender pleotelson (2.2 times as long as wide in *C. polaris*, but 0.9 times in *C. tubicola*), and the not-distinct paraocular ornamentation (multiple projections covering part of eyes in *C. tubicola*) (Hodgson 1902, Brandt & Wägele 1991). In Japanese adjacent waters, only *C. nipponensis* (Monod, 1926) has been described among the genus. *Caecognathia nipponensis* has an anterior body without long setae and tubercles, paraocular ornamentation as one large protrusion, developed epimera, and appendix masculina on the pleopod 2 (lacking in *C. tubicola*) (Monod 1926).

Adult female morphologies of 13 *Caecognathia* species have been described so far, of which 10 were briefly described and three are described in detail (Monod 1926, Seed 1979, Wägele 1987, Thing et al. 2015b, Khalaji-Pirbalouty & Al-Kandari 2023). In addition, no female adults have been described in this genus from Japan. Comparing these descriptions of adult females, *C. tubicola* is most similar to *C. coralliophila* because of the rounded frontal margin of the cephalosome and the shape of the pleotelson. However, *C. coralliophila* can be easily distinguished because individuals with a long pereonites do not occur as in *C. tubicola*, and it differs in that pereonite 1 is not fused and the pylopod is 2-segmented (3-segmented in *C. tubicola*) (Thing et al. 2015b).

Larval morphologies of 12 *Caecognathia* species have been described, but only the cephalosome and pleotelson or whole body are described for 8 species described (Monod 1926, Menzies & Kruczynski 1983; described as female but actually larvae), while 4 species are described in detail (Seed 1979, Wägele 1987, Svavarsson 1999, Thing et al. 2015b). Of these, this species closely resembles *C. coralliophila* because of the eye length in relation to the cephalosome and the shape of the pleotelson. However, *C. coralliophila* is different from *C. tubicola* in that lateral margin of the pleotelson is not serrated as in *C. tubicola*, the anterior margin of the clypeus is gently rounded and concave (with a narrow slit in *C. tubicola*), and the carpus of pereopod 1 is distinctly segmented (not in *C. tubicola*) (Thing et al. 2015b).

In the family Gnathiidae, the life cycle of four genera and ten species including three *Caecognathia* species has been reported, and in all cases, the larvae last up to three stages, and when P3 larvae molt, they metamorphose into male or female adults (Smit & Davies 2004, Hadfield et al. 2009, Ota et al. 2012, Hispano et al. 2014, Thing et al. 2015b). In *Caecognathia tubicola*, we found a large number of 1–3 stage larvae of both zuphea and praniza as well as adults in the empty tubes of *Spirobranchus akitsushima*. Therefore, *C. tubicola* probably completes its life cycle around aggregations of empty tubes of *S. akitsushima*.

Etymology. The specific name *tubicola* is a compound noun in nominative case, derived from the Latin meaning “*tubus*” (= tube; noun) and “*cola*” (= dweller; suffix). Japanese name “Kanzashi” is derived from the Japanese name “Yakko-kanzashi-gokai” of *Spirobranchus akitsushima.*

Distribution. Around Kagawa Prefecture, Seto Inland Sea, western Japan.

Depth. Intertidal zone.

Habitat of adults. Empty tube of polychaete worm *Spirobranchus akitsushima*

Host and site of infection in larval stages. Unknown.

Elaphognathia cornigera (Nunomura, 1992)

[Japanese name: Shikatsuno-umi-kuwagata]

Gnathia cornigera Nunomura, 1992: pp. 59–61, fig. 1.
Elaphognathia cornigera (Nunomura, 1992): Cohen & Poore 1994, pp. 273, 289, tables 1, 4; Nunomura, 2006, p. 9.

Materials examined

OMNH Ar-13066, 3♂, (body length 2.06, 1.87, 1.60 mm), Kamono-koshi, Takuma Town, Mitoyo City, Kagawa Prefecture, Seto Inland Sea, western Japan. 34°13.27′N, 133°36.57′E, 1 Nov. 2023. OMNH Ar-13067, 1♂ (body length 1.97 mm), Kamono-koshi, 2 Jan. 2024. OMNH Ar-13068, 1♂ (body length 2.0 mm), Kamono-koshi, 13 Jan. 2024. OMNH Ar-13069, 2♂ (body length 1.37, 1.87 mm), Namari, Takuma Town, Mitoyo City, Kagawa Pref. 34°14.12′N, 133°34.46′E, 31 Jan. 2024. OMNH Ar-13070, 1♂ (body length 1.63 mm), Namari, 10 Mar. 2024. OMNH Ar-13071, 1♂ (body length unknown, damaged), Kamono-koshi, 23 Apr. 2024. OMNH Ar-13072, 2♂ (2.10 mm, unknown, one damaged specimen), Nirohama coast, Takuma Town, Kagawa Pref., 34°15.50′N, 133°34.24′E, 22 May 2024. All materials were collected from the intertidal zone, inside of empty tubes of *Spirobranchus akitsushima* by Sadaaki Yoshimatsu.

Remarks

These specimens were identified as *Elaphognathia cornigera* (Nunomura, 1992) because of the concave frontal margin with one triangular mediofrontal process, the pereonite 1 fused to the head and not distinguishable, the bifid apex of the mandible, the three articled pylopod, and the ten plumose setae on the pylopod (Nunomura 1992, Ota et al. 2010).

This species has been recorded from Amakusa, Kyushu (Nunomura 1992, Ota et al. 2010), Shimoda, Izu Peninsula, Honshu (Tanaka & Aoki 1998, Nunomura, 2006), and Miura Peninsula, Honshu (Ota et al. 2010). This is the first record from the Seto Inland Sea. In these previous studies, both male and female adults, and larvae of *E. cornigera* were found in several demosponges such as *Haliclona* sp. [Murasaki-kaimen in Japanese] and *Halichondria okadai* (Kadota, 1922) [Kuroiso-kaimen] in the intertidal rocky shores. This survey revealed for the first time that it utilizes the empty tubes of *Spirobranchus akitsushima*. However, only a few adult males have been found so far, and the use of tubes of *S. akitsushima* appears to be a secondary habitat.

Distribution. Between Kyushu and Miura Peninsula.

Depth. Intertidal zone.

Benthic habitat. Inside of sponges, *Haliclona* sp. and *Halichondria okadai* (Kadota, 1922). Empty tube of polychaete worm *Spirobranchus akitsushima* (secondary habitat; present study).

Host and site of infection in larval stages. Skin of *Chaenogobius annularis* Gill, 1859 [Ago-haze] (Tanaka 2002).

Discussion

In the family Gnathiidae, adults have been shown to utilize various specific substrates on the seafloor for reproduction and for larvae to molt to the next life cycle. For example, they utilize sponge cavities (Klitgaard 1991, Barthel & Brandt 1995, Tanaka & Aoki 1998), dead coral rubble (Tanaka 2004), and mud burrows excavated by themselves (Monod 1926, Ota et al. 2007). Among the gnathiid species that utilize polychaete tubes, *Caecognathia agwillisi* (Seed, 1979) has been found in the habitats of the polychaete genera *Rhamphobrachium* and *Galeolaria* in southern Australia (Seed 1979). *Elaphognathia discolor* (Nunomura, 1988) has been reported to live in tubes of *Nicolea gracilibranchis* (Grube, 1878) and other polychaete species at depths of 1–5 m in northern Japan, together with the live host polychaetes (Tanaka & Nishi 2008). *Gnathia africana* Barnard, 1914 has been obtained from tubes of polychaete worms (Serpulidae) in the intertidal zone of South Africa, but has also been obtained from a variety of other substrates, including sponges and tunicates (Barnard 1914a, Smit et al. 1999), and so far only females have been obtained from the tubes of polychaete worms (Barnard 1914a, b). Based on these findings, *C. agwillisi* and *E. discolor* utilize polychaete tubes and *C. tubicola* is the third gnathiid species that utilizes such a habitat.

Some adult females of *C. tubicola* have markedly narrow thoraxes. Gnathiid females are semelparous and brood their eggs in brood pouch on their thorax until the eggs hatch (Smit & Davies 2004, Tanaka 2007). Thus, female gnathiids can only hold a limited number of eggs during their life cycle. Internal diameter of the tubes in adult polychaetes *Spirobranchus akitsushima* range from 1.00 and 2.10 mm (mean = 1.45 mm) (Nishi et al. 2022). Maximum body widths of female *C. tubicola* body were 1.00–1.30 mm in narrow thorax individuals and 0.87–1.46 mm in normal thorax individuals. The polychaete tubes are narrower at the deeper end, and the tubes of immature polychaetes would be narrower than those of mature individuals. Thus, females of *C. tubicola* may be able to settle in more breeding sites if the width is narrower. Adult females of *C. agwillisi* reported by Seed (1979) also have markedly elongated thoraxes. There are no details of how *C. agwillisi* dwell in the polychaete tubes, but if the width of the tube in which this species lives fits exactly with the width of this species, it is probably similarly adapted as *C. tubicola*. On the other hand, *E. discolor* seems to utilize polychaete tubes wider than its body width (Fig. 3 in Tanaka 2006), and the width of the thorax of adult females also seems to widen laterally (see, Fig. 1 in Tanaka 2007).

In the females of *C. tubicola*, the question arises whether the two morphological types are polymorphic within the species or fall within a continuous variation. An analysis with a greater sample size would be needed to clarify this point. Therefore, this issue is a subject for future study. One thing that can be said is that it is unlikely that normal thorax individuals have secondarily longer thoraxes by the post-maturation developmental plasticity since both normal thorax individuals and long thorax individuals have eggs that are not yet embryonic (Table 1).

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