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Two new species of *Cardiodectes* Wilson, 1917 (Copepoda: Siphonostomatoida: Pennellidae) from gobiid fishes (Actinopterygii: Perciformes) in the western Pacific Ocean

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Abstract

Two new species of the genus *Cardiodectes* Wilson, 1917 (Siphonostomatoida: Pennellidae) are described based on females from gobiid fishes (Actinopterygii: Perciformes) in coastal waters of the Pacific Ocean. Both new species belong to the ‘*rubosus*’ group sharing a trunk without an abdomen. *Cardiodectes bellwoodi* n. sp. parasitizes *Istigobius nigroocellatus* (Günther) in Australian waters and differs from members of the ‘*rubosus*’ group by having a trunk length less than twice its width, and a pair of large anterior lobes with branched processes. *Cardiodectes shini* n. sp. is similar to *C. asper* Uyeno & Nagasawa but is distinguishable by the presence of a well-developed, bilobed process between the bases of the maxillae, and by the cephalothorax bearing only two pairs of lobes.

Key words: parasitic copepods, pennellid, mesoparasite, goby, Ryukyu Islands, *Cardiodectes bellwoodi* n. sp., *Cardiodectes shini* n. sp.

Introduction

The pennellid genus *Cardiodectes* Wilson, 1917 is known to be a mesoparasite on marine fishes (e.g. Bellwood 1981; Perkins 1983; Uyeno & Nagasawa 2010). Two species, *C. bellottii* (Richiardi) and *C. medusaeus* (Wilson), were originally described as members of the genus *Peroderma* Heller and *Lernaenicus* Le Sueur, respectively. Wilson (1917) established the genus *Cardiodectes* based on the former, and 12 species (*C. anchorellae* Brian & Gray; *C. asper* Uyeno & Nagasawa, 2010; *C. bertrandi* Uyeno & Nagasawa; *C. boxshalli* Bellwood; *C. cristatus* Shiino; *C. frondosus* Schuurmans Stekhoven; *C. hardenbergi* Markevich; *C. krishnai* Sebastian; *C. longicervicus* Shiino; *C. rotundicaudatus* Izawa; *C. rubosus* Leigh-Sharpe; *C. spiralis* Bellwood) have been subsequently described (Brian & Gray 1928; Markevich 1936; Schuurmans Stekhoven 1937; Shiino 1958; Sebastian 1968; Izawa, 1970; Bellwood 1981; Uyeno & Nagasawa 2010). Boxshall (2000), however, subsequently implied that *C. bellottii* is a senior synonym of *C. medusaeus*. The life cycle of the genus has been described for *C. medusaeus* that utilizes pelagic gastropods as intermediate hosts and lanternfishes as definitive hosts, respectively (Perkins 1983). Recently, increased attention has been paid to pennellid copepods, including many *Cardiodectes* species, because of the expansion of macro-photography by SCUBA divers. This increased awareness has resulted in the discovery of numerous undescribed species. In this study, two new species are described based on females collected from gobiid fishes (Actinopterygii: Perciformes) in the coastal waters of the Pacific Ocean, off North Australia and Japan.

Material and methods

All of the gobiid fishes examined in this study were collected while SCUBA diving . Parasitic copepods (Fig. 1)

were carefully removed from fresh or fixed hosts and preserved in 80% ethanol. Copepods were subsequently soaked in lactophenol for about half a day, dissected, and examined using the wooden slide method of Humes & Gooding (1964). Drawings were made with the aid of a drawing tube. The terminology follows Huys & Boxshall (1991). The copepod body parts were measured using an ocular micrometer and measurements are given in micrometers as the range followed by the mean and standard deviation in parentheses. The body and cephalothorax length were measured from the rostrum. Type specimens are deposited in the crustacean collection of the Australian Museum, Sydney (AM), the National Museum of Nature and Science, Tsukuba (NSMT), and the University of the Ryukyus Museum, Fujukan (RUMF), Okinawa.

Results

Order Siphonostomatoida Burmeister, 1835

Family Pennellidae Burmeister, 1835

Genus *Cardiodectes* Wilson, 1917

Cardiodectes bellwoodi n. sp.

(Figs 1A, B, 2–3)

Type material. Holotype female (AMP.90285) and 1 paratype female (AMP.90286), ex *Istigobius nigroocellatus* (Günther) (Perciformes: Gobiidae), Pioneer Bay, Orpheus Island (18°35'S, 146°20'E), Great Barrier Reef, Australia, 4–6 m depth, 12–17 April, 2011, reg. D. Bellwood.

Description of postmetamorphic adult female. Body (Fig. 2A) 4170 long, comprising large cephalothorax, neck region and trunk. Cephalothorax (Fig. 2B, C, D) wider than long 1032 × 1565, bearing paired anterior lobes forming branching processes and expanded laterally forming paired, rounded lobes. Neck region (Fig. 2B, C, D) narrow. Trunk (Fig. 2A, E) broad bean shaped, less than twice as long as wide 2460 × 1360, with posterior margin straight. Egg sac spiral (Fig. 2A) uniseriate, originating at posterolateral genital apertures.

Rostrum, antennules, and antennae situated closely to each other on anterodorsal surface of cephalothorax (Fig. 3A). Rostrum convex with rounded free margin (Fig. 3A). Antennule (Fig. 3A, B) unsegmented, bearing 8 setae mainly on anterior margin; distal tip bearing 8 setae, 2 bifurcate setae, and 1 aesthetasc. Antenna (Fig. 3A, C) 3-segmented, chelate, typical pennellid in form; proximal segment unarmed; middle segment bearing pointed projection on inner medial margin and pocket; terminal claw with 1 small basal seta on posterior surface. Mouth tube, maxillule, and maxilla located on anterior part of ventral surface of cephalothorax. Maxillule (Fig. 3D) rod-like, situated to side of mouth tube, armed with bifid process at distal tip and simple process at base; processes elongate tapering towards tip. Maxilla (Fig. 3E) 2-segmented, located closely behind maxillule; proximal segment unarmed; terminal segment incompletely 2-segmented, with rounded distal part bearing pointed process, covered with small spinules. Maxilliped absent.

Legs 1 and 2 (Fig. 3F, G) biramous, situated on posterior half of cephalothorax (Fig. 2D). Leg 3 (Fig. 3H, I) uniramous, situated behind lobe on neck. Armature formula of all three legs as follows:

	Protopod	Exopod	Endopod
Leg 1	1–1	1–1; 7	0–0; 7
Leg 2	1–0	1–1; 7	0–0; 7
Leg 3	0–0	0–0; 6	absent

Protopod of legs 1 to 3 (Fig. 3F, G, H, I) separated from respective intercoxal sclerites by long gaps.

Variability of female morphology. The morphology of the female paratype is as in the holotype. The measurements of the paratype are as follows: body length 3809; cephalothorax length 1024; cephalothorax width 1180; trunk length 2717; trunk width 1507.

Attachment site. The cephalothorax and neck of the copepod were embedded in the musculature of the host's trunk at the base of the pectoral fin and penetrated the cardiac region, while its trunk and egg sacs remain outside the fish's body wall (Fig. 1A, B).

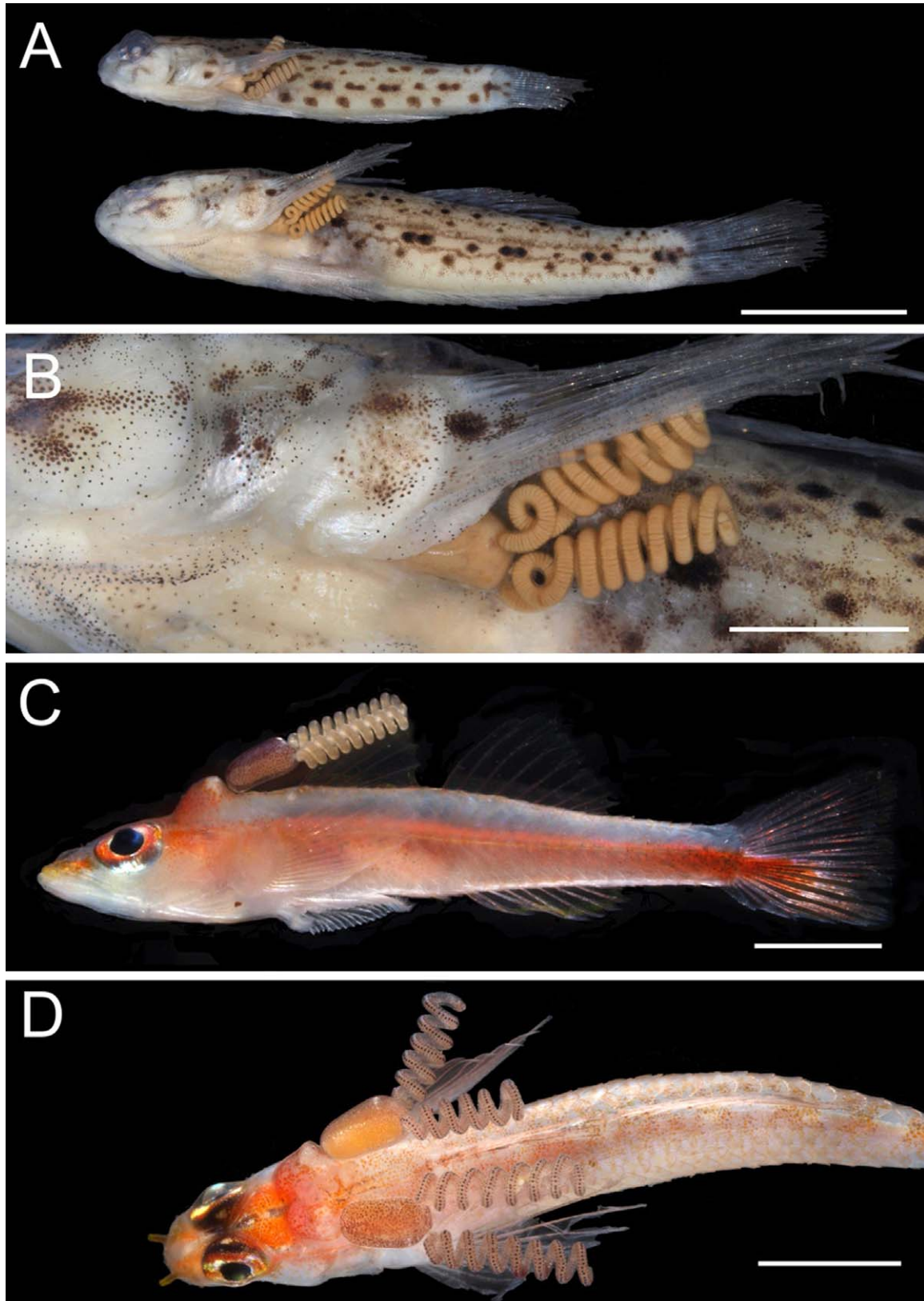


FIGURE 1. Postmetamorphic adult females of *Cardiodectes bellwoodi* n. sp. and *C. shini* n. sp. attached to their hosts. A, two specimens of *Istigobius nigroocellatus* (Günther) carrying the type series of *C. bellwoodi* n. sp.; B, a holotype (AMP.90285) of *C. bellwoodi* n. sp. attached to the host; C, a specimen of *Pleurosicya micheli* Fourmanoir carrying a holotype (NSMT–Cr 22332) of *C. shini* n. sp.; D, a specimens of *Eviota sebreei* Jordan & Seale carrying paratypes (NSMT–Cr 22335) of *C. shini* n. sp. Scale bars: A, 10mm; B, C, D, 3mm.

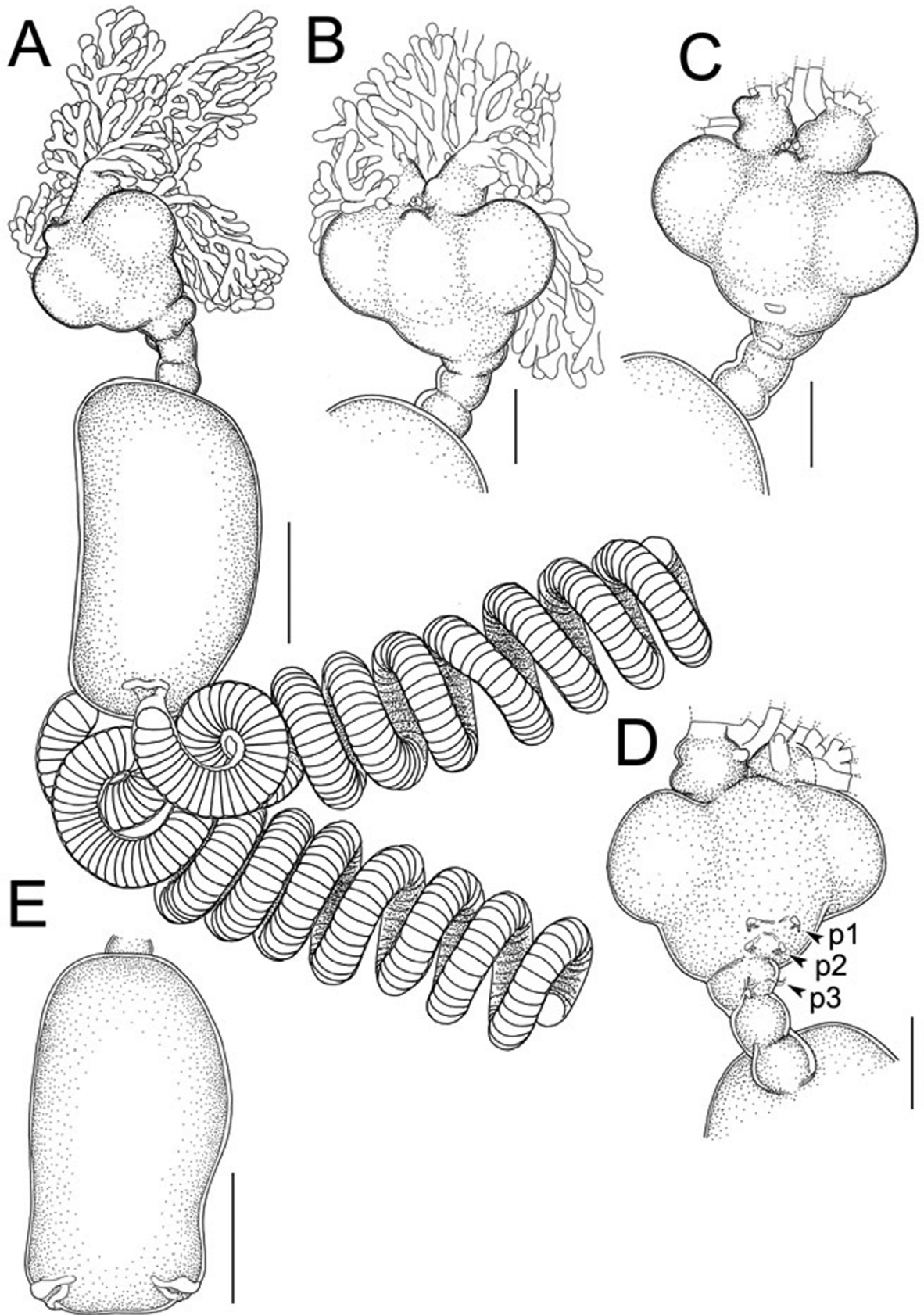


FIGURE 2. *Cardiodectes bellwoodi* n. sp., postmetamorphic adult female, holotype AMP.90285. A, habitus; B, cephalothorax and neck region, dorsal; C, cephalothorax and neck region with digitiform processes removed, dorsal; D, same, ventral, p1 = leg 1, p2 = leg 2, p3 = leg 3; E, trunk, dorsal. Scale bars: A, E, 1000µm; B–D, 500µm.

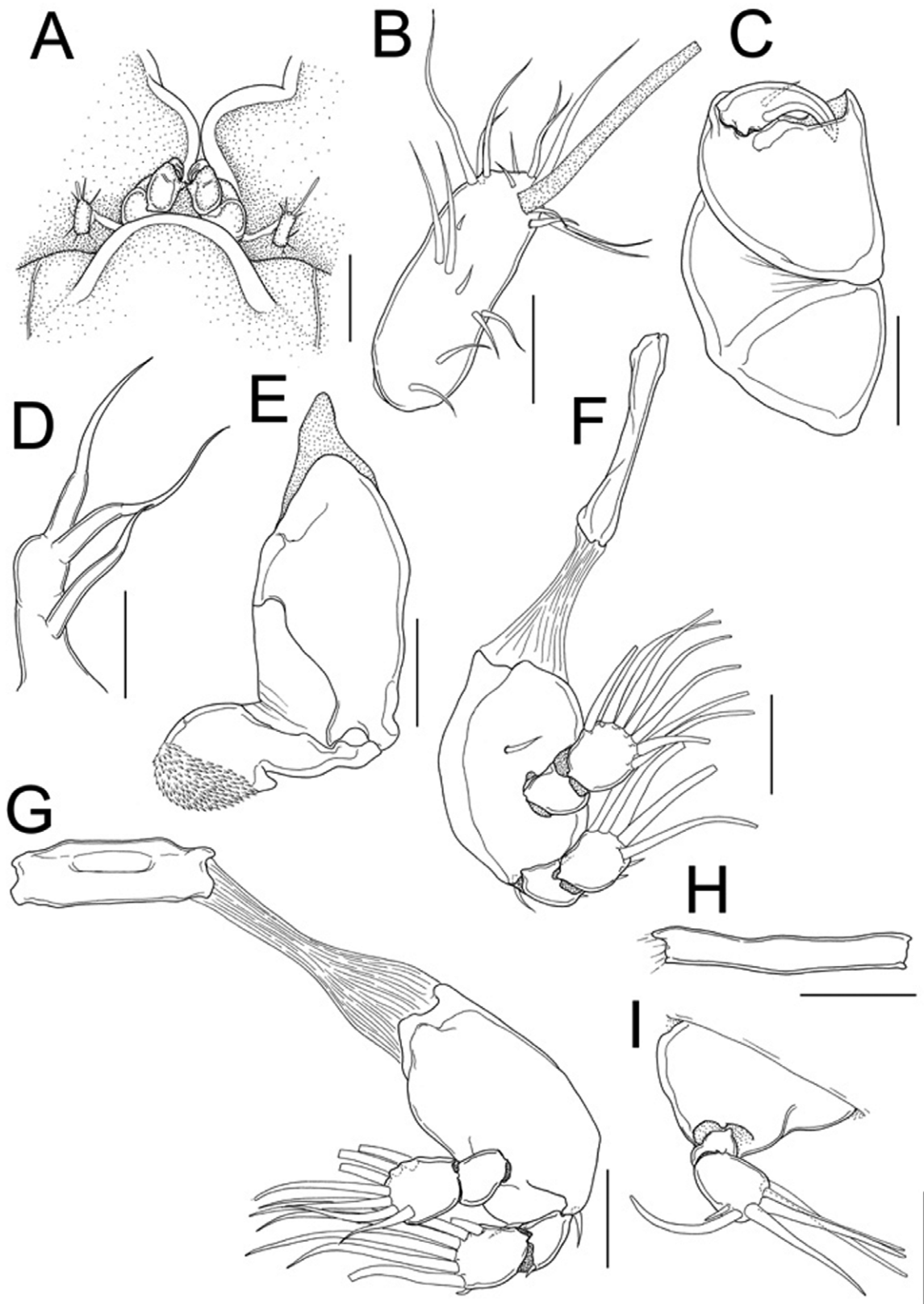


FIGURE 3. *Cardiodectes bellwoodi* n. sp., postmetamorphic adult female, holotype AMP.90285. A, anterior part of cephalothorax with antennules, antennae and rostrum; B, right antennule, anterior; C, left antenna, anterior; D, right maxillule; E, right maxilla, posterior; F, right leg 1 with intercoxal sclerite; G, left leg 2 with intercoxal sclerite; H, intercoxal sclerite of leg 3; I, right leg 3. Scale bars: A, 100µm; B, D, E, 20µm; C, F–I, 30µm.

Remarks. The fourteen nominal species of the genus *Cardiodectes* are separated into two groups, the ‘*medusaeus*’ group and the ‘*rubosus*’ group by the presence or absence of a defined abdomen (Izawa 1970; Bellwood 1981). Since *C. bellwoodi* n. sp. has a trunk without an abdomen, it belongs to ‘*rubosus*’ group which contains 8 species, *C. asper*, *C. bertrandi*, *C. boxshalli*, *C. hardenbergi*, *C. krishnai*, *C. rotundicaudatus*, *C. rubosus*, and *C. spiralis*. The four species, *C. hardenbergi*, *C. krishnai*, *C. rotundicaudatus* and *C. rubosus*, differ from *C. bellwoodi* n. sp. by having a trunk more than twice as long as wide. The trunk of the new species is less than twice its width. The short trunk is also shared with *C. asper*, *C. bertrandi*, *C. boxshalli*, and *C. spiralis*, but the new species is distinguished from these species by having a pair of large anterior lobes forming branched processes (vs. anterior lobes absent or present but without branched processes) (Bellwood 1981; Uyeno & Nagasawa 2010).

Etymology. The specific name of the new species, *bellwoodi*, honors Dr. David Bellwood who has greatly contributed to the taxonomy of the genus *Cardiodectes*. He collected the gobies infected by the new species.

***Cardiodectes shini* n. sp.**

(Figs 1C, D, 4–5)

Type material. Holotype: female (NSMT–Cr 22332), ex *Pleurosicya micheli* Fourmanoir (Perciformes: Gobiidae), Oura Bay (26°31’N, 128°4’E), Okinawa-jima Island, Ryukyu Islands, North Pacific Ocean, Japan, 33 m depth, 29 April 2012, reg. D. Uyeno and S. Nishihira. Paratypes: 3 females (NSMT–Cr 22333), ex *Eviota* sp., off Zatsun (26°49’N, 128°14’E), Okinawa-jima Island, Ryukyu Islands, East China Sea, Japan, 15 m depth, 27 June 2010, reg. D. Uyeno; 1 female (RUMF–ZC– 2391), ex *P. micheli*, Oura Bay (26°31’N, 128°4’E), Okinawa-jima Island, Ryukyu Islands, North Pacific Ocean, Japan, 31 m depth, 17 April 2012, reg. D. Uyeno and S. Nishihira; 1 female (NSMT–Cr 22334), ex *P. micheli*, Oura Bay (26°31’N, 128°4’E), Okinawa-jima Island, Ryukyu Islands, North Pacific Ocean, Japan, 30 m depth, 29 April 2012, reg. D. Uyeno and S. Nishihira; 2 female (NSMT–Cr 22335), ex *Eviota sebreei* Jordan & Seale (Perciformes: Gobiidae), Oura Bay (26°31’N, 128°4’E), Okinawa-jima Island, Ryukyu Islands, North Pacific Ocean, Japan, 28 m depth, 29 April 2012, reg. D. Uyeno and S. Nishihira; 1 female (RUMF–ZC– 2392), ex *Priolepis* sp. (Perciformes: Gobiidae), off Kyoda (26°32’N, 127°57’E), Nago Bay, Okinawa-jima Island, Ryukyu Islands, East China Sea, Japan, 33 m depth, 16 August 2012, reg. N. Shirakawa.

Description of postmetamorphic adult female. Body (Fig. 4A, B) 2705 long, comprising cephalothorax, neck and trunk. Cephalothorax (Fig. 4C, D, E) wider than long 725 × 917, bearing nodular and branching anterior processes on distal part of ventral surface and a pair of anterior digitiform lobes, as well as an expanded posterolateral pair of round lobes; anterior processes covering anterior half of cephalothorax (Fig. 4A, B, C). Neck region (Fig. 4C, D, E) narrow, bearing pair of lobes, and bending through 90°. Trunk (Fig. 4A, B) less than twice as long as wide 1900 × 980, oval with greatest width at posterior ¾ and with convex posterior margin. Egg sac spiral (Fig. 4A) uniseriate, originating at posterior lateral genital apertures.

Rostrum, antennules, and antennae situated closely on anterodorsal surface of cephalothorax (Fig. 5A). Rostrum (Fig. 5A) hemispherical, situated between bases of antennules. Antennule (Fig. 5A, C) unsegmented, bearing 8 setae mainly on anterior margin; distal tip bearing 8 setae, 2 bifurcate setae, and 1 aesthetasc. Antenna (Fig. 5A, D) 3-segmented, chelate, typical pennellid in form; proximal segment with highly sclerotized ridge on surface; middle segment bearing inner medial pointed projection; terminal claw with 1 small basal seta on posterior surface. Mouth tube, maxillule, and maxilla located on anterior part of ventral surface of cephalothorax (Fig. 5B). Maxillule (Fig. 5E) in form of bilobate knob, located lateral to base of mouth tube; each knob bearing 2 and 1 simple blunt processes. Maxilla (Fig. 5B, F) 2-segmented; proximal segment with pointed anteromedial process; terminal segment indistinctly 2-segmented by constriction, covered with fine spinules at middle. Conspicuous bilobed process present between bases of maxillae (Fig. 5B). Maxilliped absent.

Both legs 1 and 2 (Fig. 5G, H) biramous, present centrally on cephalothorax (Fig. 5D, E). Leg 3 (Fig. 5I, J) uniramous, situated behind lobe on neck. Armature formula of all three legs as follows:

	Protopod	Exopod	Endopod
Leg 1	1–1	1–1; 7	0–0; 7
Leg 2	1–0	1–1; 7	0–0; 7
Leg 3	0–0	0–0; 6	Absent

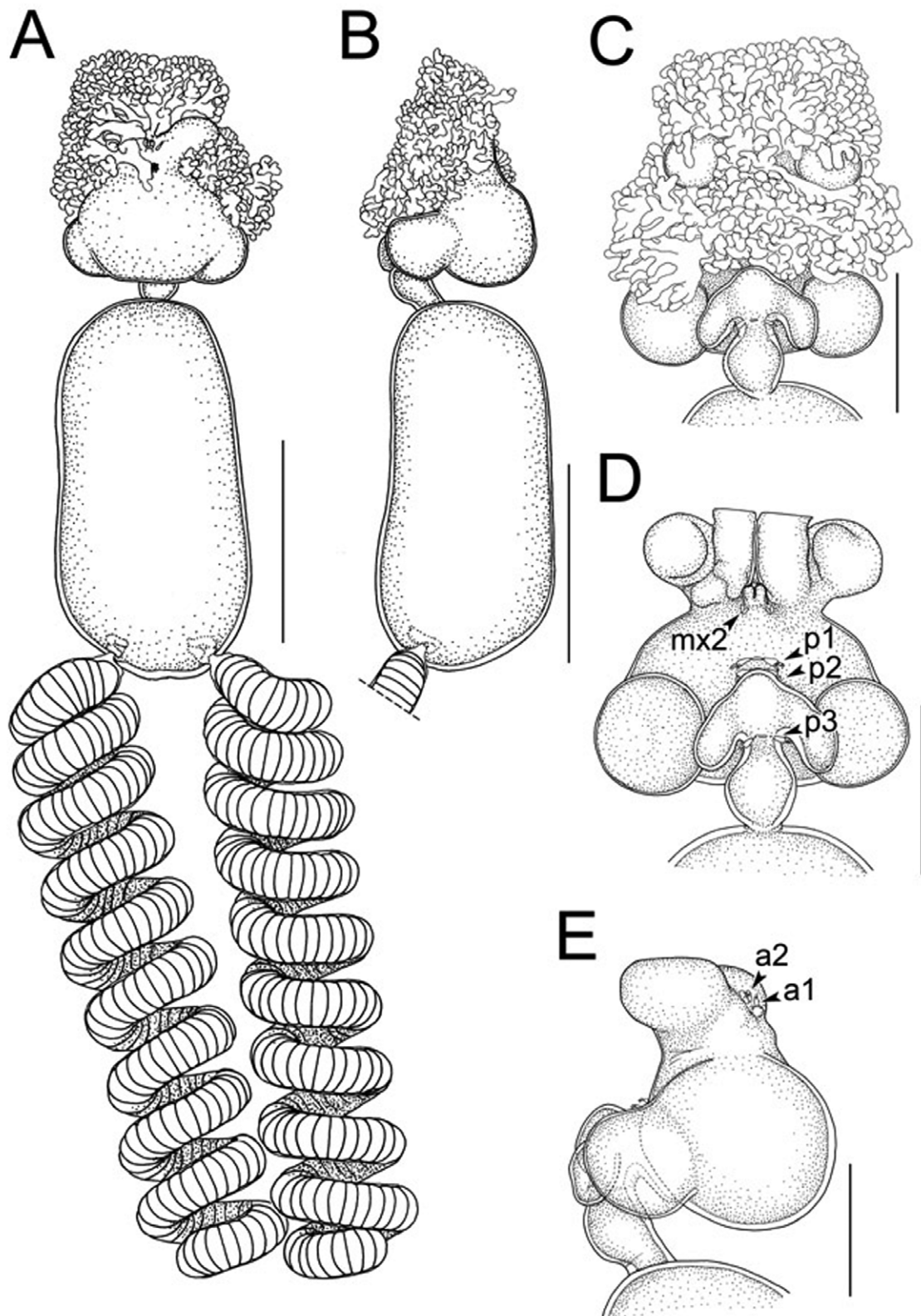


FIGURE 4. *Cardiodectes shini* n. sp., postmetamorphic adult female, holotype, NSMT-Cr 22332. A, habitus, dorsal; B, same, lateral; C, cephalothorax and neck region, ventral; D, cephalothorax and neck region with digitiform processes removed, ventral, mx2 = maxilla, p1 = leg 1, p2 = leg 2, p3 = leg 3; E, same, lateral, a1 = antennule, a2 = antenna. Scale bars: A, B, 1000µm; C, D, 500µm; E, 400µm.

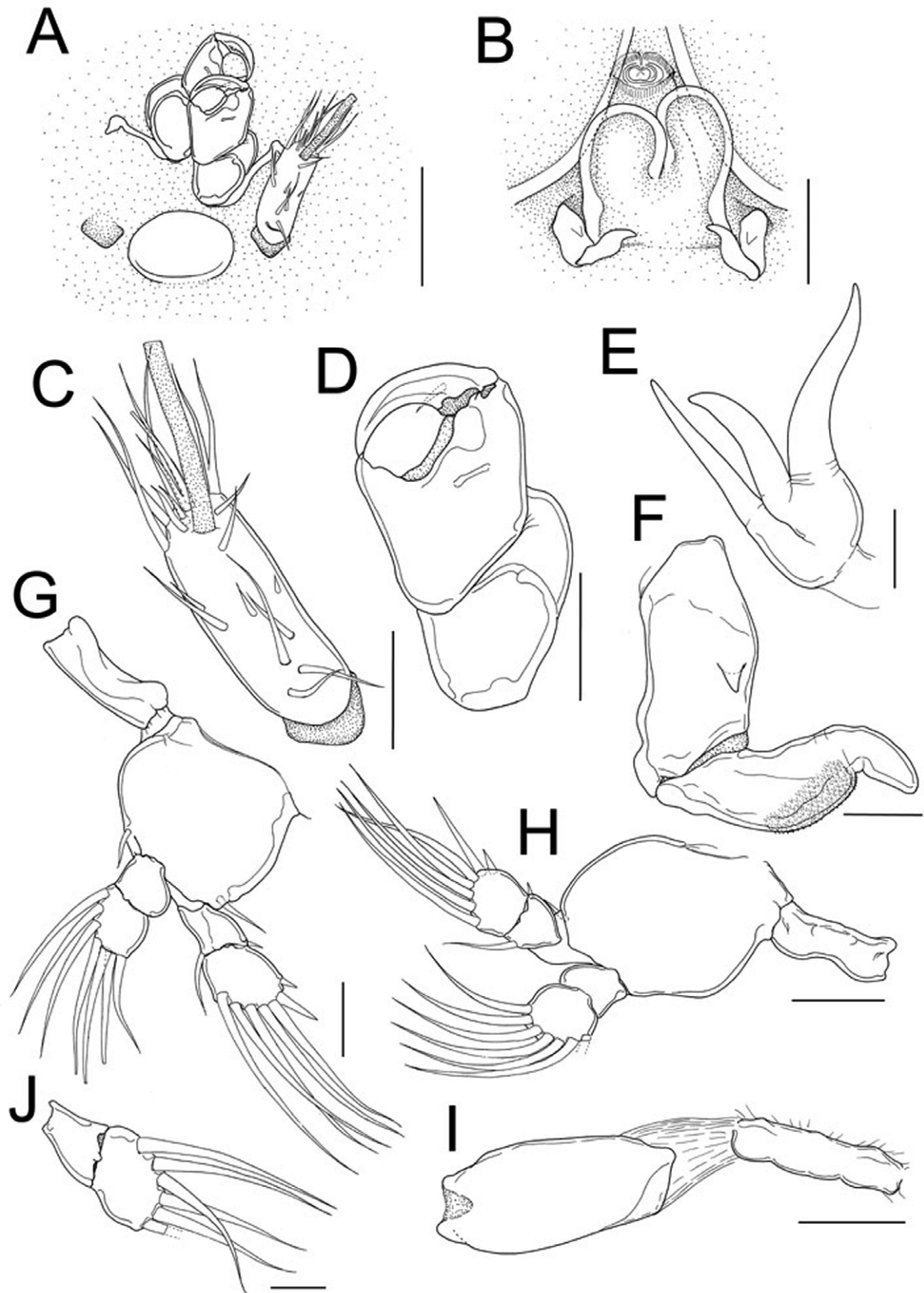


FIGURE 5. *Cardiodectes shini* n. sp., postmetamorphic adult female, holotype, NSMT-Cr 22332. A, anterior part of cephalothorax with antennule, antennae and rostrum; B, oral cone, maxillae and bilobed process; C, right antennule, anterior; D, right antenna, anterior; E, left maxillule; F, right maxilla, anterior; G, left leg 1 with intercoxal sclerite; H, right leg 2 with intercoxal sclerite; I, right leg 3 protopod with intercoxal sclerite; J, right leg 3 exopod. Scale bars: A, B, 50 μ m; C, D, J, 10 μ m; E-I, 20 μ m.

Leg 3 bearing protopod separated from intercoxal sclerite.

Variability of female morphology. The morphology of the female paratypes is as in the holotype. The measurements of the type series (n = 9) are as follows: body length 2038–2767 (2494 ± 253); cephalothorax length 495–840 (643 ± 98); cephalothorax width 616–957 (808 ± 115); trunk length 1462–1986 (1813 ± 199); trunk width 870–1250 (1050 ± 116).

Attachment site. The cephalothorax and neck region of the copepod were embedded in the host's head musculature, while its trunk and egg sacs stick out into the water (Fig. 1C, D).

Remarks. As *C. bellwoodi* n. sp., *C. shini* n. sp. is assigned to the 'rubosus' group because of the absence of a defined abdomen (see Izawa 1970; Bellwood 1981). *Cardiodectes shini* n. sp. differs from *C. hardenbergi*, *C. krishnai*, *C. rotundicaudatus*, and *C. rubosus* by having a trunk less than twice as long as wide (vs. more than twice as long as wide, Leigh-Sharpe 1934; Markevich 1936; Sebastian 1968; Izawa 1970; Bellwood 1981). Of the remaining five species, *C. asper*, *C. bellwoodi* n. sp., *C. bertrandi*, *C. boxshalli*, and *C. spiralis*, only *C. asper* shares the following characters with *C. shini* n. sp.: the neck region bends through 90° in the middle and bears a well-developed pair of lobes, and leg 3 is located on the posterior part of the base of the neck lobes (Bellwood 1981; Uyeno & Nagasawa 2010). These two species resemble each other, but *C. shini* n. sp. is distinguishable by the presence of the well-developed, bilobed process between the bases of the maxillae and by the cephalothorax bearing two pairs of lobes (vs. without the well-developed bilobed process and the cephalothorax with 3 pairs of lobes (see Uyeno & Nagasawa 2010)). In addition, legs 1 and 2 of *C. shini* n. sp. have protopods which are not separated from their intercoxal sclerites (vs. separated in *C. asper* (see Uyeno & Nagasawa 2010)).

Etymology. The specific name of the new species, *shini*, is after Shin "Snufkin" Nishihira, a President of Diving Team Snuck Snufkin, who is the best explorer of the Oura Bay, Okinawa-jima Island.

Newly established Japanese name for *Cardiodectes shini* n. sp. Shin-no-kanzashi.

Discussion

The body form of adult female of pennellid copepods has been shown to be highly labile during postmating metamorphosis (Kabata 1979; Boxshall & Halsey 2004). It may therefore be difficult to separate morphological variability from species differences, especially with regard to the holdfast (e.g. *Sarcotretes* Jungersen, 1911 and *Pennella* Oken, 1815). However, because extreme morphological variation in the neck has not been reported in *Cardiodectes* species, the shape and ornamentation of the holdfast is considered to be of some utility for species identification.

Before Uyeno & Nagasawa (2010), there were 12 nominal *Cardiodectes* species: five species, *C. bellottii*, *C. cristatus*, *C. frondosus*, *C. longicervicus*, and *C. medusaeus*, from lanternfishes (Myctophiformes: Myctophidae) (e.g. Wilson 1908, 1917; Schuurmans Stekhoven 1937; Shiino 1958; Perkins 1983; Boxshall 2000); two species, *C. anchorellae* and *C. hardenbergi*, from anchovies (Clupeiformes: Engraulidae) (Brian & Gray 1928; Markevich 1936); *C. krishnai* from a lightfish (Stomiiformes: Phosichthyidae) (Sebastian 1968); *C. boxshalli* from a parrotfish (Perciformes: Labridae) (Bellwood 1981); *C. rubosus* from a cardinalfish (Perciformes: Apogonidae) (Leigh-Sharpe 1934); *C. spiralis* from a fairy basslet (Perciformes: Serranidae) (Bellwood 1981); and *C. rotundicaudatus* from a gobiid fish (Perciformes: Gobiidae). Uyeno & Nagasawa (2010) described two *Cardiodectes* species, *C. asper* and *C. bertrandi*, on tiny gobiid fishes, and postulated that many undescribed pennellid copepods will be found in the future by SCUBA divers in littoral regions. In this study, two new species, *C. bellwoodi* sp. n. and *C. shini* sp. n., were described based on gobiid fishes, collected in shallow waters, by SCUBA divers.

Generally, parasitic crustaceans are known to have various negative impacts on host fishes, including direct mortality, and reduced growth and performance (e.g. Fogelman & Grutter 2008; Fogelman *et al.* 2009; Grutter *et al.* 2008, 2010a, b). Negative impacts on the hosts have been also reported for pennellids (e.g., Kabata & Forrester 1974; Nagasawa & Maruyama 1986; Becheikh *et al.* 1997; Palacios-Fuentes *et al.* 2012). *Cardiodectes bellwoodi* sp. n. attached to the trunk of *Istigobius nigroocellatus*, and its embedded head reached the heart of its host. The same parasitic mode is known for the congeneric *C. medusaeus* (Kabata 1970; Perkins 1983). The body size of *Cardiodectes* species can often attain a large percentage of that of the host. In particular, the body length of *C. shini* sp. n. reaches more than 15% of that of the host, thus these copepods may have a serious impact on the host. The effects on the host caused by the embedded cephalothoraces and neck regions of *C. shini* sp. n. and *C. asper* in the head of their hosts are not yet resolved.

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References

- Becheikh, S., Rousset, V., Maamouri, F., Hassine O.K.B. & Raibaut, A. (1997) Pathological effects of *Peroderma cylindricum* (Copepoda: Pennellidae) on the kidneys of its pilchard host, *Sardina pilchardus* (Osteichthyes: Clupeidae), from Tunisian coasts. *Diseases of Aquatic Organisms*, 28, 51–59.
<http://dx.doi.org/10.3354/dao028051>
- Bellwood, D.R. (1981) Two new species of *Cardiodectes* Wilson (Copepoda: Siphonostomatoida). *Systematic Parasitology*, 2, 149–156.
<http://dx.doi.org/10.1007/BF00009904>
- Boxshall, G.A. (2000) Parasitic copepods (Copepoda: Siphonostomatoida) from deep-sea and mid-water fishes. *Systematic Parasitology*, 47, 173–181.
- Boxshall, G.A. & Halsey, S.H. (2004) *An Introduction to Copepod Diversity*. The Ray Society, London, 966 pp.
- Brian, A. & Gray, P. (1928) Morphologie externe et interne d'un nouveau Copépode parasite *Cardiodectes anchorellae* n. sp. trouvé à Madras. *Bollettino dei Musei etc.*, 8, 1–10.
- Fogelman, R.M. & Grutter, A.S. (2008) Mancae of the parasitic cymothoid isopod, *Anilocra apogonae*: early life history, host-specificity, and effect on growth and survival of preferred young cardinal fishes. *Coral Reefs*, 27, 685–693.
<http://dx.doi.org/10.1007/s00338-008-0379-2>
- Fogelman, R.M., Kuris, A.M. & Grutter, A.S. (2009) Parasitic castration of a vertebrate: effect of the cymothoid isopod, *Anilocra apogonae*, on the five-lined cardinalfish, *Cheilodipterus quinquelineatus*. *International Journal for Parasitology*, 39, 577–583.
<http://dx.doi.org/10.1016/j.ijpara.2008.10.013>
- Grutter, A.S., Pickering, J.L., McCallum, H. & McCormick, M.I. (2008) Impact of micropredatory gnathiid isopods on young coral reef fishes. *Coral Reefs*, 27, 655–661.
<http://dx.doi.org/10.1007/s00338-008-0377-4>
- Grutter, A.S., Crean, A.J., Curtis, L.M., Kuris, A.M., Warner, R.R. & McCormick, M.I. (2010a) Indirect effects of an ectoparasite reduce successful establishment of a damselfish at settlement. *Functional Ecology*, 25, 586–594.
<http://dx.doi.org/10.1111/j.1365-2435.2010.01798.x>
- Grutter, A.S., Cribb, T.H., McCallum, H., Pickering, J.L. & McCormick, M.I. (2010b) Effects of parasites on larval and juvenile stages of the coral reef fish *Pomacentrus moluccensis*. *Coral Reefs*, 29, 31–40.
<http://dx.doi.org/10.1007/s00338-009-0561-1>
- Humes, A.G. & Gooding, R.U. (1964) A method for studying the external anatomy of copepods. *Crustaceana*, 6, 238–240.
<http://dx.doi.org/10.1163/156854064X00650>
- Huys, R. & Boxshall, G.A. (1991) *Copepod Evolution*. The Ray Society, London, 468 pp.
- Izawa, K. (1970) A parasitic copepod, *Cardiodectes rotundicaudatus* n. sp., (Caligoida: Lernaeidae) obtained from a deepsea gobiid fish in Japan. *Annotationes Zoologicae Japonenses*, 43, 219–224.
- Kabata, Z. (1970) *Crustacea as Enemies of Fishes*. T.F.H. Publications, Jersey City, 171 pp.
- Kabata, Z. (1979) *Parasitic Copepoda of British Fishes*. The Ray Society, London, 468 pp.
- Kabata, Z. & Forrester, C.R. (1974) *Atherestes stomias* (Jordan and Gilbert 1880) (Pisces: Pleuronectiformes) and its eye parasite *Phrixocephalus cincinnatus* Wilson 1908 (Copepoda: Lernaeoceridae) in Canadian Pacific waters. *Journal of the Fisheries Research Board of Canada*, 31, 1589–1595.
<http://dx.doi.org/10.1139/f74-200>
- Leigh-Sharpe, W.H. (1934) The Copepoda of the Siboga Expedition. Part II. Commensal and parasitic Copepoda. *Siboga Expeditie, Monograph*, 29b, 1–43.
- Markevich, A.P. (1936) *Cardiodectes hardenbergi*, ein neuer parasitischer Copepode aus der Java See. *Treubia, Bogor (formerly Buitenzorg)*, 15, 407–411.
- Nagasawa, K. & Maruyama, S. (1986) Occurrence and effects of *Haemobaphes diceraus* (Copepoda: Pennellidae) on brown sole *Limanda herzensteini* off the Okhotsk coast of Hokkaido. *Nippon Suisan Gakkaishi*, 53, 991–994.
<http://dx.doi.org/10.2331/suisan.53.991>

- Palacios-Fuentes, P., Landaeta, M.F., Munoz, G., Plaza, G. & Ojeda, F.P. (2012) The effects of a parasitic copepod on the recent larval growth of a fish inhabiting rocky coasts. *Parasitology Research*, 111, 1661–1671.
<http://dx.doi.org/10.1007/s00436-012-3005-8>
- Perkins, P.S. (1983) The life history of *Cardiodectes medusaeus* (Wilson), a copepod parasite of lanternfishes (Myctophidae). *Journal of Crustacean Biology*, 3, 70–87.
<http://dx.doi.org/10.2307/1547854>
- Schuurmans Stekhoven, J.H. (1937) Crustacea Parasitica. I. Parasitica Copepoda. *Résultats Scientifiques des Croisières du Navire-École 'Mercator', 1. Mémoires du Musée Royal d'Histoire Naturelle de Belgique*, 2, 11–24.
- Sebastian, M.J. (1968) *Cardiodectes krishnai*, a new species of lernaeid copepod from the fish, *Vinciguerria lucetia* (Garman). *Crustaceana, Supplement*, 1, 136–140.
- Shiino, S.M. (1958) Copepods parasitic on Japanese fishes. 17. Lernaeidae. *Report of the Faculty of Fisheries, Prefectural University of Mie*, 3, 75–100.
- Uyeno, D. & Nagasawa, K. (2010) Three new species of the family Pennellidae (Copepoda: Siphonostomatoida) from gobiid fishes (Actinopterygii: Perciformes) in coastal waters of the western Pacific Ocean. *Zootaxa*, 2687, 29–44.
- Wilson, C.B. (1908) North American parasitic copepods: a list of those found upon the fishes of the Pacific coast, with descriptions of new genera and species. *Proceedings of the United States National Museum*, 35, 431–481.
<http://dx.doi.org/10.5479/si.00963801.35-1652.431>
- Wilson, C.B. (1917) North American parasitic copepods belonging to the Lernaeidae with a revision of the entire family. *Proceedings of the United States National Museum*, 53, 1–150.
<http://dx.doi.org/10.5479/si.00963801.53-2194.1>