



## Revisiting *Pagurus pilosipes* (Stimpson, 1858) (Crustacea: Decapoda: Anomura: Paguridae)

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### Abstract

The study of newly collected samples from Okinawa, Ryukyu Islands, revealed that males of *Pagurus pilosipes* (Stimpson, 1858) have a prominent right sexual tube directed posterolaterally. Comparison of specimens previously identified as *Pagurus pilosipes* and newly collected specimens, combined with a molecular genetic analysis using partial sequences of the mitochondrial cytochrome c oxidase I (COI) gene, shows that Stimpson's taxon occurs in the Japanese mainland, the Ogasawara Islands, the Okinawa Islands, and Korea. Stimpson's taxon is transferred to the genus *Boninpagurus* Asakura and Tachikawa, 2004. Based on morphological and molecular evidence, *Boninpagurus acanthocheles* Asakura & Tachikawa, 2004, the type species of *Boninpagurus*, is synonymized with *B. pilosipes* n. comb. Affinity of *Boninpagurus* is briefly discussed.

**Key words:** Crustacea, Decapoda, Anomura, Paguridae, *Boninpagurus*, new combination, synonym, Japan

### Introduction

Komai (2003) redescribed the rarely collected hermit crab species *Pagurus pilosipes* (Stimpson, 1858) on the basis of topotypic specimens from Okinawa, Ryukyu Islands, including one male and three females, of which the largest female was selected as a neotype. The sole male specimen used by Komai (2003) had no sexual tube development, and at the time was considered to fit into the generic diagnosis of *Pagurus* Fabricius, 1775 (cf. McLaughlin & Forest 1999). Asakura & Tachikawa (2004) established a new genus, *Boninpagurus*, to accommodate a single species, *B. acanthocheles* Asakura & Tachikawa, 2004, described from the Ogasawara Islands, Japan. One of the characteristics of *Boninpagurus* is the possession of a right sexual tube of medium length (cf. McLaughlin 2003). Asakura & Tachikawa (2004) considered that *Boninpagurus* was most closely allied to the genus *Anapagrdes* de Saint Laurent-Dechancé, 1966, currently represented by three species (Komai 1999b; Osawa & Okuno 2007). Subsequently, however, Komai & Takeda (2006) pointed out that except for the presence of the distinct right sexual tube in males, *B. acanthocheles* is superficially similar to certain species of *Pagurus*, rather than to species of *Anapagrdes*.

In recent years, we have accumulated material of shallow-water hermit crabs from various localities in Japan, amongst which we found many specimens referable to *Boninpagurus*. We initially recognized two morphs distinguished by the coloration in life (Fig. 1); one of them has a distinct black transverse band on the distal segment of the antennular peduncle (Fig. 1E), and the second lacks such a band on that segment (Fig. 1D). The former is represented by specimens from the Japanese mainland, and the latter by specimens from Okinawa and Ogasawara Islands. Males of these specimens all have a moderately long right sexual tube that is two or more times the coxal length and is directed posterolaterally. The male specimen used by Komai (2003) had both gonopores developed, but there was no development of sexual tubes, as mentioned above, although it closely agrees with other specimens with right sexual tubes in every diagnostic aspect. The specimen is the smallest male currently available, and the absence of sexual tubes in that specimen is likely due to immaturity. Therefore, in this study, *Pagurus pilosipes* is

transferred to *Boninpagurus*. The close similarity in the morphology and the coloration in life between *B. pilosipes* and *B. acanthocheles* led us to critically compare material from the Okinawa and Ogasawara Islands, although Asakura & Tachikawa (2004) did not mention the similarity between the two taxa. We failed to identify significant differences in the morphology and coloration in life, although the two groups of specimens came from remote localities. Comparison using a partial sequence of the barcoding gene mitochondrial cytochrome c oxidase I (COI) (Hebert *et al.* 2003; Costa *et al.* 2007; Bucklin *et al.* 2011) strongly supports the conspecificity of the two populations. The molecular analysis also supports that specimens from the Japanese mainland are conspecific with the populations in the Okinawa and Ogasawara Islands, in spite of the existence of the constant difference in the coloration of the antennular peduncle. Therefore, we synonymize *B. acanthocheles* with *B. pilosipes*.

## Material and methods

Specimens examined in this study are deposited in the Coastal Branch of Natural History Museum and Institute, Chiba (CMNH), the Natural History Museum and Institute, Chiba (CBM), and the National Taiwan Ocean University, Keelung (NTOU). The shield length, abbreviated as SL, is measured from the tip of the rostrum to the midpoint of the posterior margin of the shield. For detailed observation of the surface structure on the integument, specimens (including removed appendages) were stained with methylene blue. Terminology used in the description, for the most part, follows that of McLaughlin *et al.* (2007), with exception of the numbering of the thoracic sternite. The length of the male sexual tube is indicated in accordance with the protocol suggested by McLaughlin (2003). The drawings were made with the aid of a drawing tube mounted on a Leica MZ8 stereomicroscope.

One or two specimens from the Japanese mainland, Okinawa and Ogasawara Islands were used for genetic analysis (Table 1). For obtaining the partial sequence of the mitochondrial COI gene, total DNA was extracted from fourth and fifth pereopods by the Genomic DNA Mini kit (Geneaid), and used the universal primer (LCO1490/HCO 2198) to amplify 657 bp sequence (Folmer *et al.* 1994). PCR reaction was performed in totally 50  $\mu$ l reactions with 50 to 200 ng of the DNA extraction, 5.0  $\mu$ l of 10  $\times$  polymerase buffer (SUPER-THERM), 10 mM magnesium chloride (MgCl<sub>2</sub>), 2.5 mM of deoxyribonucleotide triphosphate mix (dNTP) (PROTECH Inc.), 5.0  $\mu$ M each primer (MDBio Inc.), one units of *Taq* polymerase (five units/ $\mu$ l, SUPER-THERM), and additional 0.3  $\mu$ l of 1.0% bovine serum albumin (BSA; stock concentration- 0.5 mg/ $\mu$ l). The PCR cycling condition was as follows: 5 min at 95°C for initial denaturation, then 40 cycles of 30 sec at 95°C, 40 sec at 47.8°C, 40 sec at 72°C, and final extension for 10 min at 72°C. One % agarose gel for electrophoresis to check the size and quality of PCR products, and then the High Pure PCR Product Purification kit (Roche Applied Science) was used to purify the PCR products, and employed for cycle sequencing on an ABI 310 Genetic Analyzer (Applied Biosystems) by the same PCR primer set. The Molecular Evolutionary Genetics Analysis (MEGA, ver. 3.1; Kumar *et al.* 2004) was used for calculating the nucleotide divergence.

**TABLE 1.** Specimens of *Boninpagurus pilosipes* (Stimpson, 1858) used for partial sequence of cytochrome c oxidase (COI) gene analysis.

Locality	Voucher no.	GenBank accession no.
Sagami Bay	NTOU M01037	JF495166
Sagami Bay	NTOU M01038	JF495167
Ogasawara Is.	NTOU M01039	JF495168
Ogasawara Is.	NTOU M01040	JF495169
Okinawa Is.	CBM-ZC 10275	JF495170

## Systematics

### Genus *Boninpagurus* Asakura & Tachikawa, 2004

[New Japanese name: Okinawa-akashima-hon-yadokari-zoku]

*Boninpagurus* Asakura & Tachikawa, 2004: 157.

**Type species.** *Boninpagurus acanthocheles* Asakura & Tachikawa, 2004 [= *Boninpagurus pilosipes* (Stimpson, 1858), n. comb]. Original designation.

**Emended diagnosis.** Eleven pairs of biserial phyllobranchiate gills, including 2 pairs of arthrobranchiae above bases of third maxilliped to fourth pereopod and 1 pleurobranch on seventh thoracic somite (above base of fourth pereopod). Rostrum (Fig. 2A) broadly triangular, not particularly developed. Ocular acicles (Fig. 2A) each with submarginal spine. Antennal peduncle (Fig. 2A) with supernumerary segmentation; acicles well developed. Maxillule with produced external lobe on endopod (Fig. 2B). Third maxilliped with well developed crista dentata consisting of fine row of corneous teeth and accessory tooth on ischium (Fig. 2D). Chelipeds distinctly unequal with right longer and stouter than left (Figs 1A–C, 3, 4A, C). Second and third pereopods generally similar (Figs 1A–C, 4D, E). Fourth pereopods semichelate, lacking preungual process on dactylus; propodal rasp of more than 2 rows of corneous scales (Fig. 2E). Fifth pereopods chelate. Coxa of right fifth pereopod in male bearing sexual tube of medium length, directed laterally or posterolaterally (Fig. 2G, H, L); coxa of left fifth pereopod with short protrusion of vas deferens (Fig. 2J). Female with paired gonopores. Male pleon with 3 unequally biramous left pleopods; female pleon with 4 unequally biramous left pleopods. Telson (Fig. 2K) with lateral indentations; posterior lobes separated by median cleft, left larger; terminal margins oblique, each with spines.

**Remarks.** The original generic diagnosis of *Boninpagurus* given by Asakura & Tachikawa (2004) contains a few minor discrepancies or inconsistencies, and therefore is slightly emended herewith. The rostrum was described as “well developed”, but examination of the present series of specimens has shown that the rostrum is usually broadly triangular, not showing particular development. The original authors stated that the propodal-carpal articulation of the left cheliped was rotated counter-clockwise 30° from the horizontal plane, but we found no particular degree of rotation in our specimens.

As noted above, males of the newly collected specimens from Okinawa Islands have the right sexual tube of a medium length (about 5.0 times of the coxal length; see Fig. 2C). In every diagnostic aspect, *Pagurus pilosipes* agrees with the diagnosis of *Boninpagurus* given by Asakura & Tachikawa (2004), and thus the species is herein transferred to *Boninpagurus*. As discussed below, conspecificity between *B. pilosipes* and *B. acanthocheles* is strongly supported by comparisons of morphology and barcoding gene.

### *Boninpagurus pilosipes* (Stimpson, 1858), n. comb.

(Figs 1–4)

*Eupagurus pilosipes* Stimpson, 1858: 249 (87) [type locality: Loo Choo (= Okinawa Island)]; Alcock 1905: 177; Stimpson 1907: 133; Manning & Reed 2006: 285 (list).

*Pagurus pilosipes*. — Oh 1983: 106 (in part), pl. 1, figs 3, 4, pl. 2, figs 1–5; Komai 2003: 117, figs 1–5, 24A; Hong *et al.* 2006: 254; McLaughlin *et al.* 2010: 34. [See Remarks]

*Boninpagurus acanthocheles* Asakura & Tachikawa, 2004: 158, figs 1–7 [type locality: Ogasawara Islands]; Asakura 2006: 145, figs 8, 9. McLaughlin *et al.* 2010: 27.

*Boninpagurus* sp. — Okuno *et al.* 2006: 153; McLaughlin *et al.* 2010: 88, 89, fig. 12C.

Not *Pagurus pilosipes*. — Miyake 1978: 91, fig. 34 (= mixture of seven species; see Komai, 2003); Miyake & Imafuku 1980: 60, pl. 2, fig. 5 (= *Pagurus nigrivittatus* Komai, 2003); Miyake 1982: 132, pl. 44, fig. 5 (= *P. nigrivittatus*); Oh 1983: pl. 1, figs. 3, 4, pl. 3, figs. 1–5 (= *P. nigrivittatus*); Takeda 1986: 124, unnumbered fig. (= *P. nigrivittatus*); Asakura 1991: 798 (= *P. nigrivittatus*); Wang 1992: 61 (list); 1994: 570 (list); Asakura 1995: 363, pl. 97, fig. 9 (= *P. nigrivittatus*); Minemizu 2000: 148, unnumbered fig. (= *P. nigrivittatus*).

**Material examined.** Neotype: female (SL 2.5 mm), CBM-ZC 6383, Heshikiya, Katsuren Peninsula, Okinawa Island, intertidal, on small colony of *Pocilopora* sp., 23 June 1994, coll. T. Komai.

Japanese mainland: 1 female (SL 2.7 mm), CMNH-ZC 629, Igai-jima Islet, Kamogawa, 16 m, 29 June 2001, SCUBA diving, coll. J. Okuno; 1 male (SL 3.7 mm), 1 ovigerous female (SL 3.2 mm), CMNH-ZC 630, similar

locality, 20 m, 16 November 2001, SCUBA diving, coll. J. Okuno; 1 ovigerous female (SL 2.7 mm), CMNH-ZC 631, same data; 1 male (SL 2.3 mm), CMNH-ZC, Ubara Islet, Katsuura, Boso Peninsula, 24 October 2001, SCUBA diving, coll. J. Okuno; 1 male (SL 2.7 mm), CMNH-ZC 1330, Awatone, off Kamogawa, 15–20 m, 18 December 2002, SCUBA diving, coll. H. Tachikawa; 1 male, CMNH-ZC 1331, same data as CMNH-ZC 1330; 1 male (SL 3.1 mm), CMNH-ZC 1346, Ashika-ne, off Kamogawa, Boso Peninsula, 26 m, 26 November 2000, SCUBA diving, coll. J. Okuno; 1 female (SL 2.5 mm), CMNH-ZC 1347, same data as CMNH-ZC 1346; 1 male (SL 3.4 mm), CMNH-ZC 1378, Hatto-ne, off Kamogawa, 15 m, 26 November 2000, SCUBA diving, coll. J. Okuno; 1 ovigerous female (SL 2.1 mm), CMNH-ZC 1615, Mankuro-ne, off Kamogawa, 20 m, 1 October 2003, SCUBA diving, coll. H. Tachikawa *et al.*; 1 female (SL 2.9 mm), CMNH-ZC 1729, Akino-hama, Izu-Oshima Island, Izu Islands, 15 m, 23 February 2004, SCUBA diving, coll. H. Arima; 1 ovigerous female (SL 1.8 mm), CMNH-ZC 1740, same locality, 15 m, 6 March 2004, SCUBA diving, coll. H. Arima; 1 male (SL 1.7 mm), CMNH-ZC 1743, same locality, 25 m, 13 March, 2004, SCUBA diving, coll. H. Arima; 1 male (SL 2.8 mm), CMNH-ZC 1837, Masaki, Shimizu, Suruga Bay, 8 m, 4 November 2005, SCUBA diving, coll. J. Okuno; 1 female (SL 2.0 mm), CMNH-ZC 1838, same data as CMNH-ZC 1837; 1 female (SL 2.0 mm), CMNH-ZC, Tatsunokuchi, Nagasaki, Kyushu, 2 m, 13 September 2003, SCUBA diving, coll. J. Okuno; 1 male (SL 2.0 mm), CMNH-ZC 1982, Mankuro-ne, off Kamogawa, Boso Peninsula, 18 m, 11 August 2005, SCUBA diving, coll. J. Okuno; 2 males (SL 2.8, 3.0 mm), CBM-ZC 10000, Sagami Bay, Hayama, Miura Peninsula, ca. 10 m, 23 September 2009, SCUBA diving, coll. I. Itou and S. Komai; 1 male (SL 2.2 mm), NTOU M01037, 1 male (SL 2.1 mm), NTOU M01038, same data as CBM-ZC 10000.

Okinawa Islands, Japan: 1 male (SL 1.9 mm), 2 females (SL 2.2, 2.4 mm), CBM-ZC 6384, same data as neotype; 2 males (SL 2.0, 2.0 mm), 1 female (SL 1.7 mm), CBM-ZC 10209, Heshikiya, Katsuren Peninsula, Okinawa Island, subtidal, dead coral, 17 July 2003, coll. M. Osawa; 1 male (SL 2.8 mm), CBM-ZC 10206, Kouri Fishing Port, Kouri Island, 2.0–2.5 m, 25 February 2007, trap, coll. T. Komai; 1 ovigerous female (SL 3.3 mm), CBM-ZC 10275, Motobu Fishing Port, Motobu, Okinawa Island, 3–4 m, March 2010, trap, coll. T. Komai.

Ogasawara Islands, Japan: 2 males (SL 1.4, 1.7 mm), 2 females (SL 1.5, 1.5 mm), 2 juveniles (SL 1.2, 1.3 mm), CBM-ZC 10207, same locality, subtidal, coral rubble, 17 July 2009, coll. T. Komai; NTOU M 01039, 1 male (SL 1.4 mm), NTOU M01040, 1 female (SL 1.4 mm), same data as CBM-ZC 10207.

**Diagnosis.** Shield (Fig. 2A) as long as wide or slightly longer than wide; rostrum moderately broadly triangular, overreaching obtuse anterolateral projections; dorsal surface with distinct paragastric grooves. Ocular peduncles (Fig. 2A) moderately slender, 0.7–0.8 times as long as shield; corneas not dilated; ocular acicles each with 1 submarginal terminal spine. Antennular peduncles (Fig. 2A) overreaching distal corneal margins by 0.2–0.3 length of ultimate segment. Antennal peduncles (Fig. 2A) reaching nearly to distal corneal margins; second segment with distolateral angle produced, reaching midlength of fourth segment, dorsomesial distal angle with small spine; antennal acicle slightly arcuate, reaching base of cornea. Third maxilliped (Fig. 2C, D) with crista dentata consisting of closely spaced corneous teeth increasing in size proximally; carpus with small dorsodistal and ventrodistal spines. Chelipeds with scattered moderately long setae on dorsal surfaces of chela and carpus. Right cheliped (Figs 3A, B, 4A, B) moderately stout; dactylus subequal in length to palm in males, distinctly longer than in females, dorsal surface with longitudinal row of small spines or spinulose tubercles adjacent to dorsomesial margin delimited by row of small spines; palm with 5–7 irregular rows of small spines or spiniform tubercles on dorsal surface, dorsolateral and dorsomesial margins each delimited by row of small spines; carpus with row of strong spines on dorsomesial margin and additional row of spines adjacent to dorsomesial margin, dorsolateral face rounded; merus with row of spines on ventrolateral and ventrodistal margins. Left cheliped (Figs 3C, D, 4C) moderately slender; dactylus about twice as long as palm, without distinct spines on surfaces; palm with 2 or 3 rows of small to moderately small spines extending onto fixed finger on dorsal surface, dorsal midline weakly elevated, dorsolateral margin delimited by row of small spines, dorsomesial margin with tiny blunt tubercles; carpus weakly widened distally, with row of small spines on dorsolateral and dorsomesial margins; merus with row of small spines on ventrolateral and ventromesial margins. Ambulatory legs (Fig. 4D, E) with tufts of stiff setae on dorsal and ventral margins; dactyli 1.0–1.1 times longer than propodi, each with 6–11 corneous spines on ventral margin, mesial face unarmed (second) (Fig. 4F) or armed with row of spinules adjacent to dorsal margin (third) (Fig. 4G); propodi each with 1 or 2 corneous spinules on ventrodistal margin and 1 or 2 spinules on ventral margin; carpi only with dorso-distal spine; meri each with few small spines on ventral margin (second) or unarmed (third). Coxa of right fifth pereopod of male with sexual tube of medium length (2–4 times coxal length), straight or slightly curved, directed laterally or posterolaterally, gradually tapering distally to truncate tip, proximal half opaque, and remaining distal

portion transparent. Sixth thoracic sternite (Fig. 2F, J) with subrectangular anterior lobe. Eighth thoracic sternite (Fig. 2G, L) consisting of 2 rounded lobes. Telson (Fig. 2K) with terminal margins slightly to somewhat oblique, each with 4 or 5 moderately large spines.

**Coloration in life** (Fig. 1A, B, D). General background color gray- or green-brown. Shield mottled grayish or greenish brown, paler laterally, with 2 or 3 paired spots. Posterior carapace also mottled brown, with conspicuous pair of spots on either side of posteromedian plate. Ocular peduncles generally light brown, proximally with dark brown transverse band; proximal half of dorsal surface grayish. Antennular peduncles generally grayish or greenish brown; ultimate segment with 2 longitudinal dark brown stripes on dorsal surface; median part of dorsal surface of penultimate segment paler; articulation between segments whitish; dorsal flagellum pale brown. Antennal peduncles generally greenish or grayish brown; fifth segment with brown longitudinal stripes laterally and mesially; antennal flagellum entirely light brown, without particular pattern. Right cheliped with tips of fingers whitish; palm generally brown or grayish brown, with rather obscure longitudinal stripes laterally and mesially; carpus apparently with longitudinal stripes of brown and light gray on dorsal surface, latter consisting of longitudinal row of light gray spots; merus with subdistal, narrow, transverse brown band and irregular dark brown patches or blotches. Left cheliped with similar pattern to right cheliped, but longitudinal stripes on palm, carpus and merus more clearly delineated.

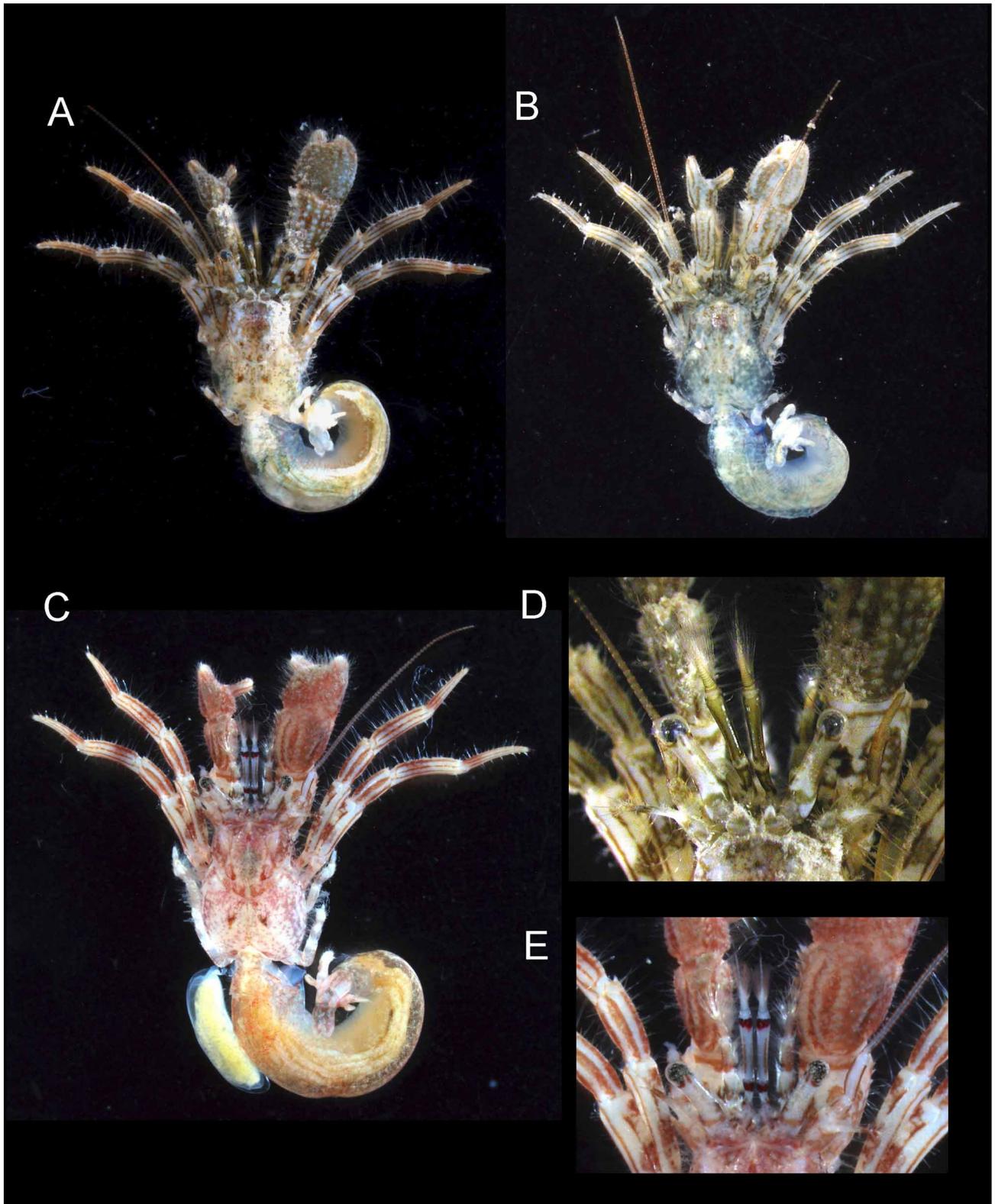
**Distribution.** Okinawa Islands (Katsuren and Motobu Peninsulas on Okinawa Island, and Kouri Port on Kouri Island), Chichi-jima Island of the Ogasawara Islands, Izu-oshima Island of the Izu Islands, mainland of Japan (Boso Peninsula on Honshu southward to Nagasaki on Kyushu), and southern part of Korea); intertidal to 25 m depth.

**Remarks.** Asakura & Tachikawa (2004) did not compare their new taxon *B. acanthocheles* with *P. pilosipes* in spite of close similarities, perhaps because the latter species was considered to lack sexual tube development at the time. The present newly collected male specimens from Okinawa Islands show sexual tube development, closely agreeing with that seen in *B. acanthocheles*. In this study, we examined specimens from various localities in Japan, including those from Okinawa and Ogasawara Islands, representing the type localities of the two taxa. As mentioned before, two morphs separated by the color of the antennular peduncle are recognized. Nevertheless, we could not find a single morphological character or a suite of characters that will separate one species from another. Comparison of partial sequence of the barcoding gene COI (657 bp) shows that there are only 0.6–1.5% genetic divergences amongst the specimens from the Japanese mainland, and Okinawa and Ogasawara Islands, while specimens from the same locality have genetic divergences of 0.5–1.4% (Table 2). Such a low genetic divergence is generally considered as an intraspecific variation in decapod crustaceans (e.g. Khamnamtong *et al.* 2009; Rhyne *et al.* 2009; Silva *et al.* 2010; Yang *et al.* 2010). Thus, our initial suspicion that two species might be represented in the present collections was not supported by either morphological or molecular comparison. Consequently, we propose to synonymize *B. acanthocheles* under *B. pilosipes*, and refer all examined specimens to *B. pilosipes*.

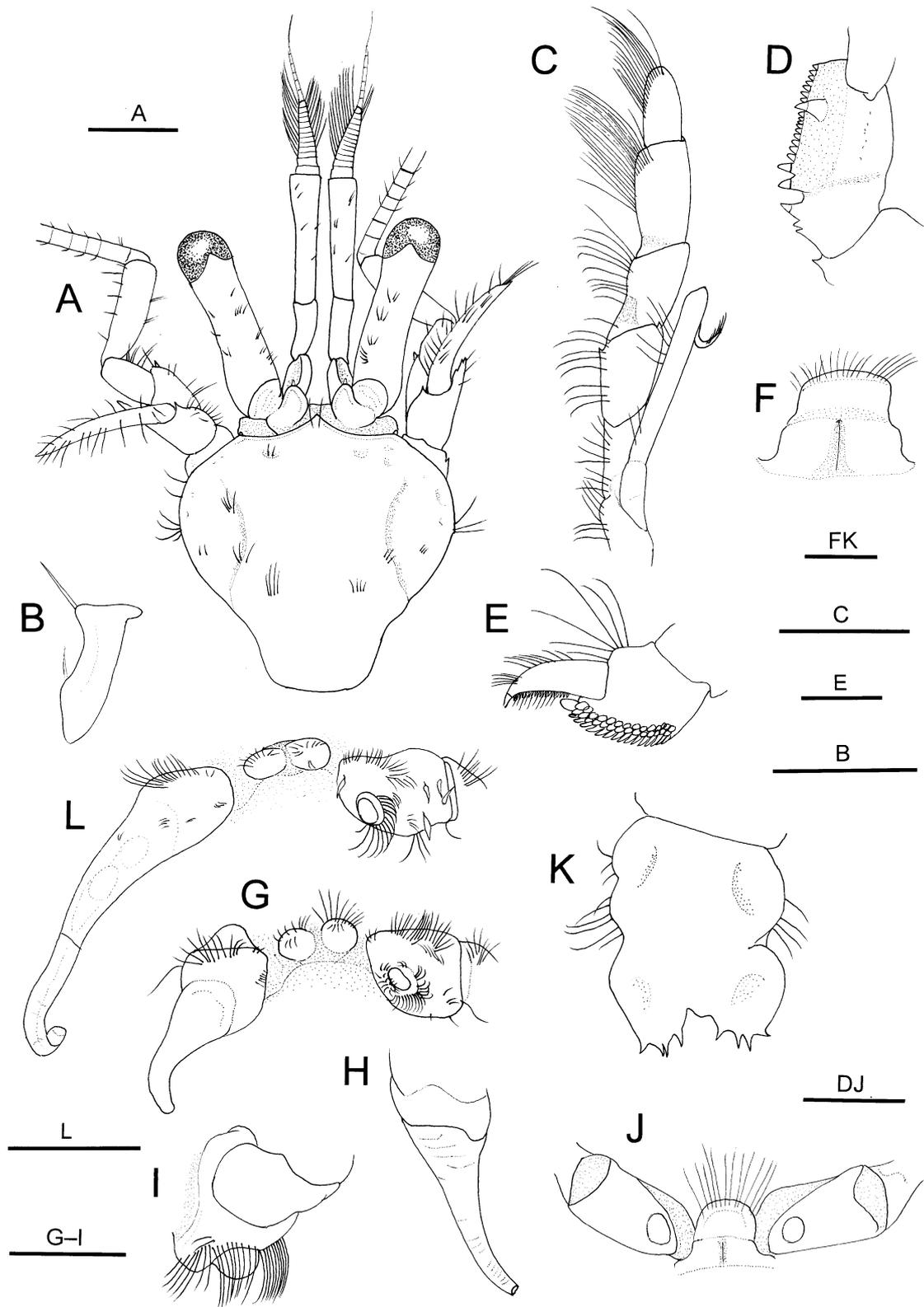
Komai (2003) designated a neotype for *Pagurus pilosipes* in the interests of nomenclatural stability, because it was considered that the type was destroyed in the Great Chicago Fire of 1871 (Evans 1967). Subsequently, Manning & Reed (2006) published a list of crustaceans that were shipped by W. Stimpson in 1859 to the Zoological Museum in Copenhagen (ZMC). In the list, *Pagurus pilosipes* is mentioned (as *Eupagurus*), but no specimen was located in the collection of the ZMC. Therefore, the action by Komai (2003) is still warranted.

**TABLE 2.** The partial COI gene nucleotide divergence (657 bp) of *Boninpagurus pilosipes* (Stimpson, 1858) from different localities.

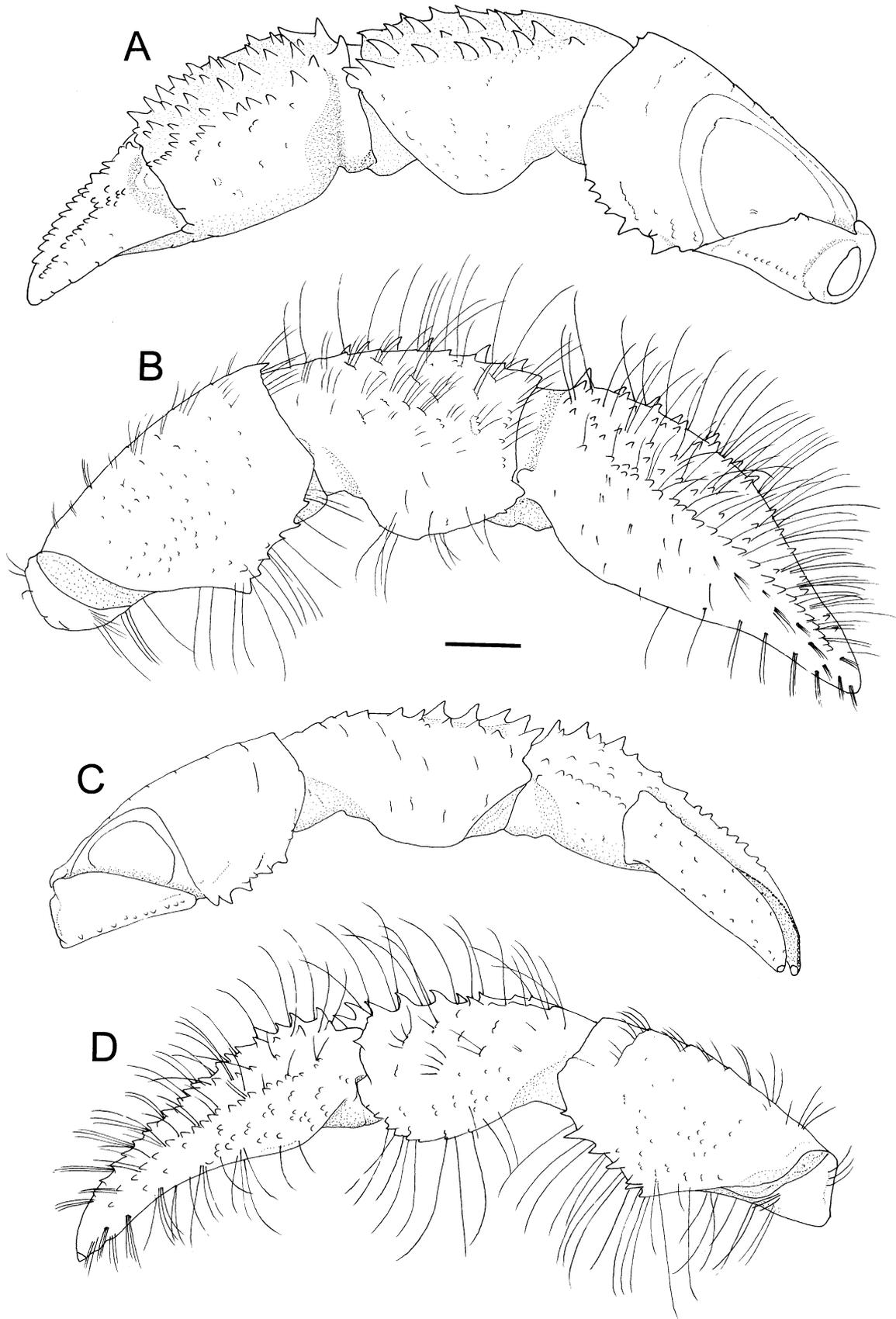
	Sagami Bay (NTOU M01037)	Sagami Bay (NTOU M01038)	Ogasawara Is. (NTOU M01039)	Ogasawara Is. (NTOU M01040)
Sagami Bay (NTOU M01038)	0.005	--		
Ogasawara Is. (NTOU M01039)	0.008	0.006	--	
Ogasawara Is. (NTOU M01040)	0.012	0.008	0.014	--
Okinawa Is. (CBM-ZC 10275)	0.008	0.009	0.011	0.015



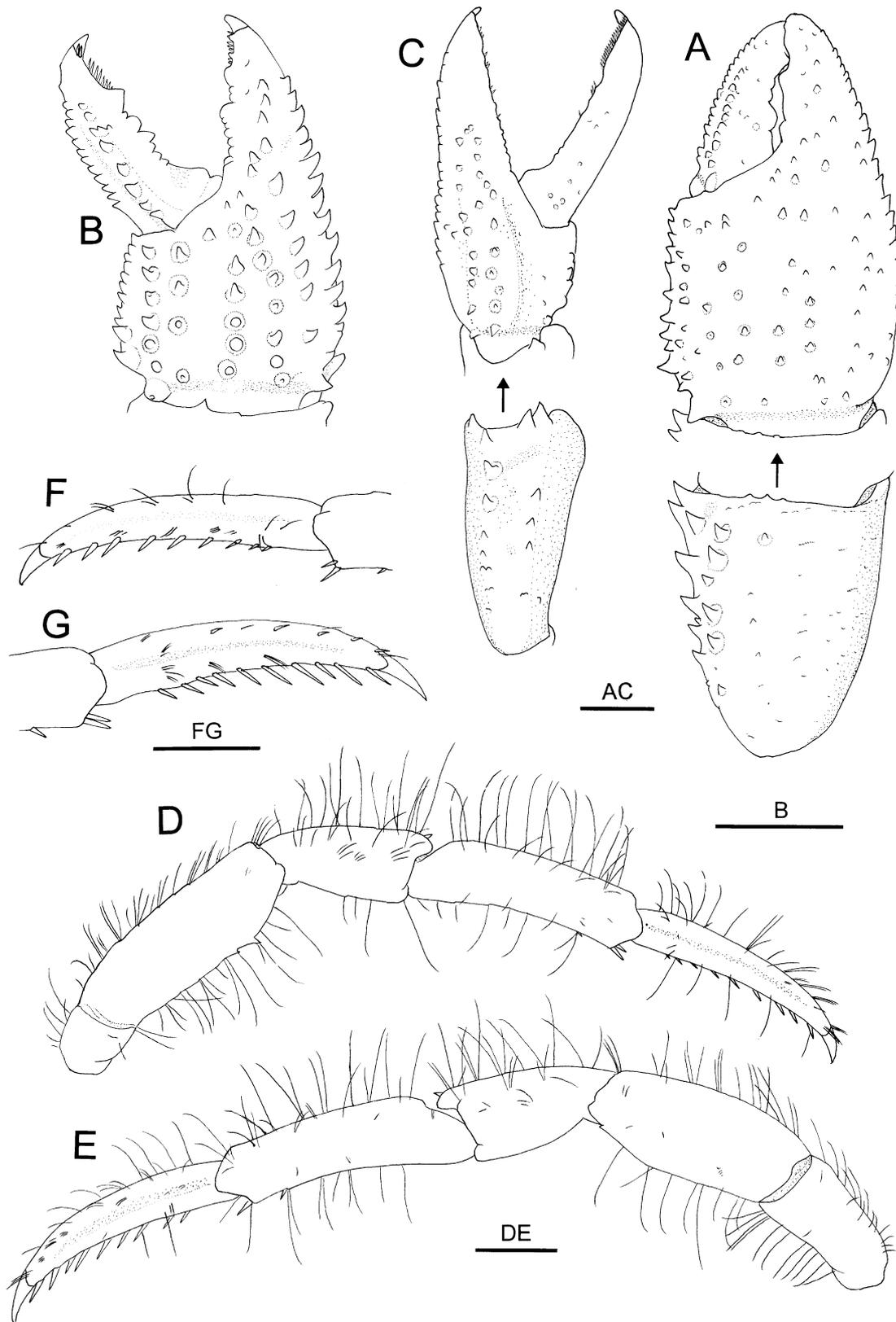
**FIGURE 1.** *Boninpagurus pilopsipes* (Stimpson, 1858), n. comb. A, D, male (SL 2.8 mm; CBM-ZC 10206), Kouri Island, Okinawa Islands; B, male (SL 1.7 mm; CBM-ZC 10207), Maehama, Chichi-jima Island, Ogasawara Islands; C, E, male with rhizocephalan parasite attached to pleon (SL 3.0 mm; CBM-ZC 10000), Hayama, Sagami Bay. A, B, C, entire animal, dorsal view; D, E, close up of cephalic appendages, showing differences in color pattern of antennular peduncle.



**FIGURE 2.** *Boninpagurus pilosipes* (Stimpson, 1858), n. comb. A–I, male (SL 3.0 mm; CBM-ZC 10000), Sagami Bay; J, female (SL 2.7 mm; CMNH-ZC 629), Boso Peninsula; L, male (SL 2.8 mm; CBM-ZC 10206), Kouri Island, Okinawa Islands. A, shield and cephalic appendages, dorsal view; B, endopod of left maxillule, lateral view; C, left third maxilliped, lateral view; D, same, ischium and basis, ventral view (setae omitted); E, dactylus and propodus of left fourth pereopod, lateral view; F, sixth thoracic sternite, ventral view; G, L, coxae of fifth pereopods and eighth thoracic sternite, ventral view; H, right sexual tube, lateral view; I, left coxa of fifth pereopod, lateral view; J, coxae of third pereopods and sixth thoracic sternite. Scale bars: Scale bars: 1 mm for A, C, G–J, L; 0.5 mm for B, D–F, K.



**FIGURE 3.** *Boninpagurus pilosipes* (Stimpson, 1858), n. comb., male (SL 3.0 mm; CBM-ZC 10000), Sagami Bay. A, right cheliped, mesial view (setae omitted); B, same, lateral view; C, left cheliped, mesial view (setae omitted); D, same, lateral view. Scale bar: 1 mm.



**FIGURE 4.** *Boninpagurus pilosipes* (Stimpson, 1858), n. comb. A, C–G, male (SL 3.0 mm; CBM-ZC 10000), Sagami Bay; B, female (SL 2.7 mm; CMNH-ZC 629), Boso Peninsula. A, chela and carpus of right cheliped, dorsal view (setae omitted); B, chela of right cheliped, dorsal view (setae omitted); C, chela and carpus of left cheliped, dorsal view (setae omitted); D, right second pereopod, lateral view; E, left third pereopod, lateral view; F, dactylus of right second pereopod, mesial view; G, dactylus of left third pereopod, mesial view. Scale bars: 1 mm.

## Discussion

Taxonomic confusion regarding to *Boninpagurus pilosipes* in previous literature was substantially clarified by Komai (2003; as *Pagurus pilosipes*). Asakura (2006) identified a specimen from Kushimoto, Kii Peninsula, Honshu mainland of Japan, with *B. acanthocheles*, but this record is now referred to *B. pilosipes*. Hong *et al.* (2006) reported *Pagurus pilosipes* from Takeshima Island in the Sea of Japan based on a single ovigerous female, collected at a depth of 10 m. Furthermore, they suggested that Oh's (1983) record of *Pagurus pilosipes* from Mara Island, Korea, was correct, although Komai (2003) referred Oh's record to *Pagurus nigrivittatus*. Oh (1983: 107) mentioned that the ambulatory legs have three or four reddish stripes in his specimens, although the photographs of the second and third pereopods (Oh 1983, pl. 3, figs. 3, 4) showed a color pattern that is well consistent with that of *Pagurus nigrivittatus* in having a median stripe on the lateral face of the propodi. The number of longitudinal stripes visible on the lateral surfaces of the ambulatory propodi is species specific, i.e., three stripes in *P. nigrivittatus* and four stripes in *B. pilosipes*. It is likely that Oh's (1983) material contained both *B. pilosipes* and *P. nigrivittatus*.

Asakura & Tachikawa (2004) considered that *Boninpagurus* was most similar to *Anapagrides*. However, *Anapagrides* is considerably different from *Boninpagurus* in the structure of the thoracic appendages and of the male sexual tube (McLaughlin 1986; McLaughlin & Sandberg 1995; McLaughlin 1997; Komai 1999b; unpublished data). The palms are devoid of spines arranged in rows or tufts of long setae on the dorsal surfaces in *Anapagrides*, while they are armed with rows of small to moderately large spines and tufts of long setae on the dorsal surface in *Boninpagurus*. The ambulatory legs are also less setose in *Anapagrides* than in *Boninpagurus*. The dactyli of the third pereopods are unarmed on the mesial faces in *Anapagrides*, rather than armed with a row of corneous spinules adjacent to the dorsal margins in *Boninpagurus*. The propodal rasp of the fourth pereopod consists of a single row of corneous scales in *Anapagrides*, but of more than two rows of corneous scales in *Boninpagurus*. Although both genera exhibit a right sexual tube development, the structure of the tube is quite different. The right sexual tube of *Boninpagurus* is of medium length, oriented toward posterolateral, and tapering distally, while that of *Anapagrides* is very short to short, directed ventrally or posteroventrally. Most of the features of *Boninpagurus* mentioned above are also seen in certain species of *Pagurus*, including those returned or transferred from *Parapagurodes* McLaughlin & Haig, 1973 by McLaughlin & Asakura (2004), i.e. *P. hartae* (McLaughlin & Jensen, 1996), *P. imaii* (Yokoya, 1939), *P. insulae* Asakura, 1991, *P. erythrogrammus* Komai, 2003, *P. nigrivittatus* Komai, 2003, and *P. quinquelineatus* Komai, 2003. *Pagurus hartae* and *P. imaii* have a right sexual tube, although much shorter than that of *Boninpagurus*. Other similarities include the armature of the dactylus of the right cheliped and of the carpus of the left cheliped, although these characters are rather common in species of *Pagurus*. The dactylus of the right cheliped bears rows of small spines, one on the dorsal mid-line and the second on the dorsomesial margin. The carpus of the left cheliped is armed with rows of spines on the dorsolateral and dorsomesial margins.

As mentioned previously, the generic diagnosis of *Boninpagurus* given by Asakura & Tachikawa (2004) is nearly identical with the generic diagnosis of *Parapagurodes* provided by McLaughlin & Jensen (1996) except for the detailed structure of the right sexual tube. Neither McLaughlin & Jensen (1996) nor Komai (1999a) considered the structure of the right sexual tube, but only its length, for diagnosing *Parapagurodes*. McLaughlin & Asakura (2004), reviewing *Parapagurodes*, also do not mention *Boninpagurus*. *Boninpagurus* can be distinguished from *Parapagurodes* rediagnosed by McLaughlin & Asakura (2004) primarily by the normally developed male and female pleopods. In the two species of *Parapagurodes* the pleopods show tendency toward loss or reduction (McLaughlin & Haig 1973; McLaughlin & Asakura 2004). The male third and fourth pleopods are occasionally absent and the female fifth pleopod is rudimentary or absent in *Parapagurodes*.

In spite of the suggested similarities to certain species referred to *Pagurus*., e.g., *P. imaii* and *P. hartae*, the sister group of *Boninpagurus* remains unclear. Except for the right sexual tube development, there are no other unique characters separating *Boninpagurus* from *Pagurus*. Nevertheless, because of the the structure of the right sexual tube, *Boninpagurus* is acceptable as a valid taxon at present.

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