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ON THE TAXONOMY OF THE SLIPPER LOBSTER *CHELARCTUS CULTRIFER* (ORTMANN, 1897) (CRUSTACEA: DECAPODA: SCYLLARIDAE), WITH DESCRIPTION OF A NEW SPECIES

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ABSTRACT. — The slipper lobster *Chelarctus cultrifer* (Ortmann, 1897), a putatively wide-spread Indo-West Pacific species, is well-known in Japan. However, recent collections from Taiwan and the Philippines, and comparisons with material from Indonesia and elsewhere revealed that there are actually two species confused under this name. The two species differ markedly in morphology and colour. On the basis of the lectotype designation of *C. cultrifer* by Holthuis (2002, from Indonesia), the material from Taiwan and Japan is shown to be actually undescribed and is named herein. *Chelarctus cultrifer* sensu stricto is restricted to the material from the more southern localities in the Philippines westwards to Îles Glorieuses. Genetic comparison of sequences of the barcoding gene, mitochondrial cytochrome c oxidase subunit (COI), supported the species separation. The molecular data further suggested that two genetic forms are present within *C. cultrifer* sensu stricto, and therefore, the subspecific name *C. cultrifer meridionalis* (Holthuis, 1960) is resurrected.

KEY WORDS. — Scyllaridae, *Chelarctus*, new species, subspecies

INTRODUCTION

Chelarctus cultrifer (Ortmann, 1897) is the first achelate lobster known to have a subchelate third pereiopod. This species is mostly recorded from Japan but believed to have a very wide geographical distribution in the Indo-West Pacific. The name of this slipper lobster has been associated with many nomenclatural problems (see Ortmann, 1897; Holthuis, 1946). Moreover, it has been proposed that two subspecies are present in *C. cultrifer* (Holthuis, 1960). However, the taxonomy of *C. cultrifer* was believed to be settled after the revision of Holthuis (2002), which concluded that subspecies ranks were unwarranted for this species (see also Chan, 2010).

During the Philippines "PANGLAO 2004 and 2005" expeditions, many specimens of *C. cultrifer* were collected. In addition, large numbers of *C. cultrifer* were also recently collected from Taiwan (also see Chan & Yu, 1993). However, careful comparison of the *C. cultrifer* material from the Philippines and Taiwan show many differences. This situation recalls our recent studies on *Galearctus aurora* (Holthuis, 1982) and *G. kitanoviriosus* (Harada, 1962) that revealed additional species in the material previously identified under these names (Yang & Chan, 2010; Yang et al., 2011). Re-examination of the many specimens identified as *C. cultrifer* in the Muséum national d'Histoire naturelle, Paris, showed that all the material from the Philippines and all but one lot of two specimens from the Madagascar in the other southern localities are different from the specimens in Taiwan and Japan. Genetic comparison of sequences of the barcoding gene, mitochondrial cytochrome c oxidase subunit (COI), strongly indicate that the Taiwanese and the Philippine forms represent different species. Unexpectedly, the molecular data also suggests that there are two genetic forms in the predominantly southern species (hereafter referred as the "southern species").

Initially, it appeared that the name *C. cultrifer* (Ortmann, 1897) could be restricted to the species in Taiwan (hereafter referred as the "northern species") allowing the subspecies name *C. cultrifer meridionalis* (Holthuis, 1960) to be resurrected for the southern species. However, closer examination in literature revealed confusions in the lectotype selection of *C. cultrifer* (Ortmann, 1897). Holthuis (1960, 2002) had inadvertently selected a lectotype for *C. cultrifer* on two separate occasions based on different specimens. As the original description of *Arctus cultrifer* by Ortmann (1897)

Table 1. *Chelarctus* species and outgroups used for partial COI sequences (657 bp) analysis.

Species	Voucher no.	Locality	GenBank accession no.
C. virgosus, new species	NTOU M01294	Taiwan	JX262266
C. cultrifer cultrifer (Indonesia 1)	MNHN-IU-2011-5154	Indonesia	JX486082
C. cultrifer cultrifer	MNHN-IU-2011-5106	Îles Glorieuses	JX486083
C. cultrifer meridionalis (Philippines 1)	NTOU M01574	Philippines	JX262267
C. cultrifer meridionalis (Philippines 2)	MNHN-IU-2011-5102	Philippines	JX486084
C. cultrifer meridionalis (Indonesia 2)	MNHN-IU-2011-5171	Indonesia	JX486085
C. aureus	NTOU M00979	Taiwan	JF411065
C. crosineri	MNHN-IU-2010-6138	Vanuatu	JX486086
Petrarctus rugosus	NTOU M00737	Taiwan	EU982697
Remiarctus bertholdii	NTOU M00983	Philippines	JN701675

is a composite one (see Holthuis, 1960, 2002), Holthuis (1960) originally stated that "the species *Scyllarus cultrifer* (Ortmann, 1897) needs to be divided into two subspecies. Ortmann's (1897, Zool. Jb. Syst., 10: 272) original description of *Arctus cultrifer* is a composite one, being based on its two subspecies and on *Scyllarus bicuspidatus* (De Man). By selecting the lectotype of *Arctus cultrifer* Ortmann from among the material collected by Döderlein from Tokyo Bay in 1880–1881, which material was reported upon by Ortmann, the Japanese form of the present species becomes the nominate subspecies." Holthuis (2002), however, inexplicably (probably in lapsus) selected another specimen, a female from Bate's (1888) "CHALLENGER" material from Indonesia as the lectotype. Ortmann's (1897) series contained five specimens from Japan, but Holthuis' (1960) first lectotype selection did not specify which specimen was selected as the lectotype. Therefore, Holthuis' (1960) lectotype selection is invalid according to article 74.3 of the International Code of Zoological Nomenclature (ICZN, 1999), which requires that an individual specimen must be selected. Thus, only the later lectotype selection of Holthuis (2002) is valid and the name *C. cultrifer* must now be applied to the southern species. The northern species, although usually regarded as the typical form of *C. cultrifer*, is now unnamed and a new name needs to be applied. Moreover, the subspecific name *C. cultrifer meridionalis* can probably be resurrected for one of the genetic forms in *C. cultrifer*, even though the type locality of the nominate subspecies is in Indonesia which is more further than the type locality Philippines of the subspecies, which has a name *meridionalis* meaning "southern".

MATERIAL AND METHODS

Specimens examined are deposited in the Muséum national d'Histoire naturelle, Paris (MNHN); the Natural History Museum (formerly British Museum), London (BMNH); National Museum of Natural History, Washington D. C. (USNM); and National Taiwan Ocean University, Keelung (NTOU). The measurement given is carapace length (cl), which is measured along the dorsal midline from the tip of the rostrum to the posterior margin of the carapace. The terminology used mostly follows Holthuis (2002) and Yang et al. (2011). As three forms are now discovered in the material previously identified as *C. cultrifer*, the synonymy listed excludes those that cannot yet be verified, such as those only appearing in species lists and larval records.

In the molecular analysis, all species in the genus *Chelarctus* are included (Table 1). *Remiarctus bertholdii* (Paulson, 1875) and *Petrarctus rugosus* (H. Milne Edwards, 1837) are chosen as the closer and distant outgroups, respectively, according to the latest molecular phylogeny of Scyllaridae (Yang et al., 2012). Genomic DNA was extracted from the abdominal somite VI muscle tissue (10–20 mg) by using the Genomic DNA Mini kit (Geneaid). Universal primer set: LCO1490/ HCO2198 (Folmer et al., 1994) used to amplify partial segment of COI gene. The PCR reaction components, temperature cycling condition and sequencing reaction follows that of Yang et al. (2011). The sequence dataset was aligned by BIOEDIT v. 7.1.3 (Hall, 1999) then converted into NEXUS format by DAMBE v. 5.2.31 (Xia & Xie, 2001). MrModeltest 2.3 (Nylander, 2004) was used to estimate a best-fit model of DNA substitution, and the pairwise divergence was calculated by MEGA v. 5.05 (Tamura et al., 2011). Two independent Bayesian inference (MrBayes v.3.1.2, Ronquist et al., 2005) runs were performed with 5,000,000 generations each sampled every 1000 generations. A 50% majority-rule consensus tree was obtained from all post-burn-in sampled trees. Posterior probabilities (Pp) >0.5 are presented for supporting the clades.

TAXONOMY

Chelarctus cultrifer (Ortmann, 1897)
(Figs. 1, 2, 4A)

Arctus sordidus – Bate, 1888: 66, pl. 9, Fig. 3 [not Stimpson, 1860]

Arctus haanii – Ortmann, 1891: 42 (in part) [not *Scyllarus Haani* Berthold, 1845]

Arctus cultrifer Ortmann, 1897: 272 (in part) (lectotype locality: Kai Islands, Indonesia)

Scyllarus cultrifer meridionalis Hothuis, 1960: 150 (type locality: Philippines)

Scyllarus cultrifer – Chan, 1997: 413

Chelarctus cultrifer – Holthuis, 2002: 572 (in part), Figs. 26C, 27

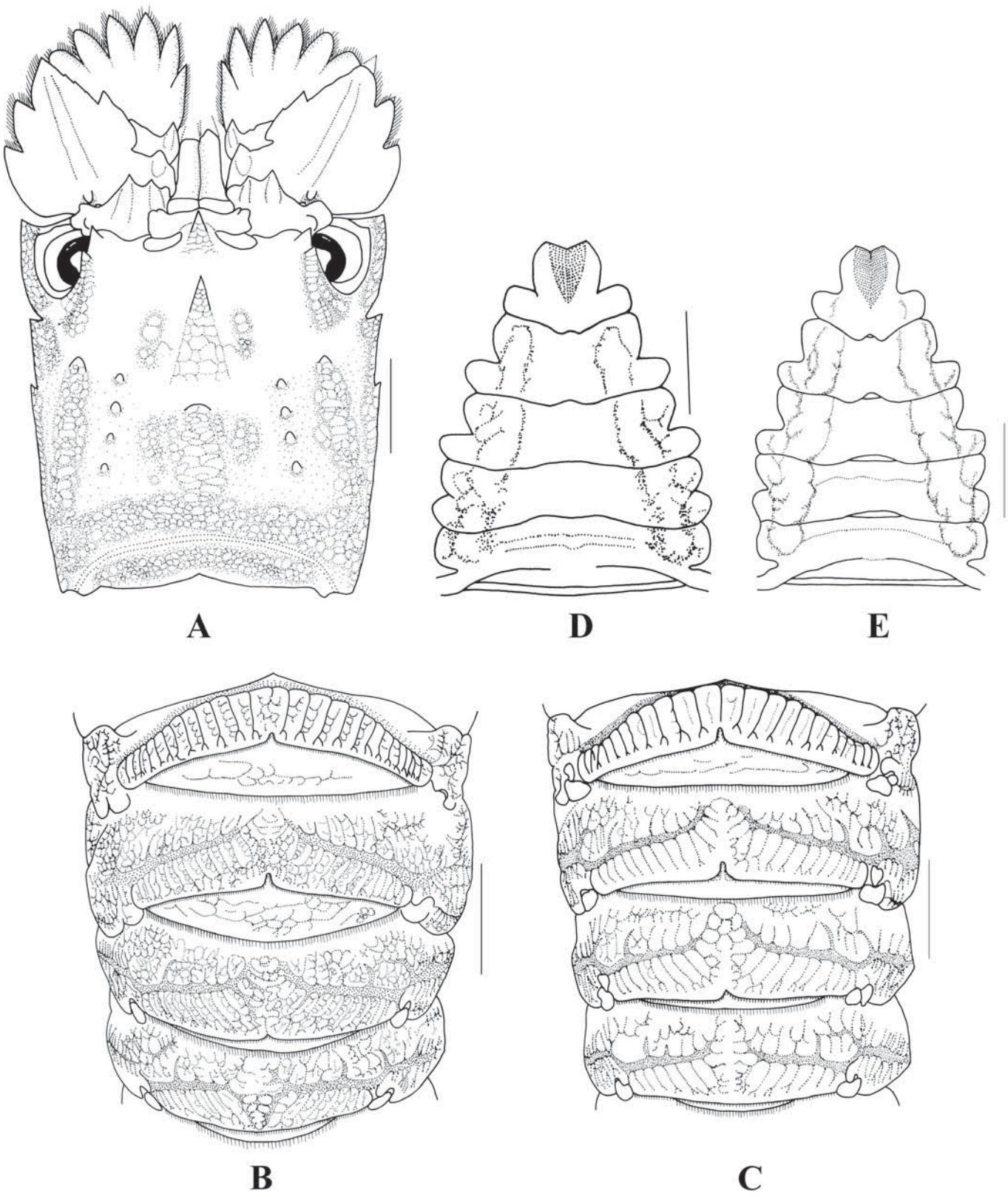

Fig. 1. A, B, D, *Chelarctus cultrifer meridionalis* (Holthuis, 1960), holotype, Philippines, female 22.0 mm cl, USNM 104525; C, E, *Chelarctus cultrifer cultrifer* (Ortmann, 1897), lectotype, Indonesia, female 23.0 mm cl, BMNH 1888.22. A, carapace, dorsal; B, C, abdomen, dorsal; D, E, thoracic sternum. Scale bars = 5 mm.

[Not] *Arctus cultrifer* – Ortmann, 1897: 272 (in part); Yokoya, 1933: 46 [=*Chelarctus virgosus*, new species]

[Not] *Scyllarus cultrifer* – Balss, 1914: 80; Parisi, 1917: 9; Utinomi, 1956: 62, pl. 31, Fig. 5; Kubo, 1960: 98, pl. 49, Fig. 5; 1965: 627, Fig. 1023; Miyake, 1961: 9; 1972: 67, unnumbered fig.; 1975: 106, unnumbered fig.; 1982: 84, pl. 29, Fig. 1; Harada, 1962: 114, Figs 3–5, pl. 8, pl. 12, Fig. 13, pl. 13, Fig. 17; 1965: 36, Fig. 1a, b; Ikematsu, 1963: 10; Nishimura & Suzuki, 1971: 89, pl. 30, Fig. 4; Matsuzawa, 1977: pl. 76, Fig. 1; Shirai, 1980: 411, unnumbered fig; Takeda, 1982: 43, Fig. 129; Baba, 1986: 163, Fig. 114; Hayashi, 1995: 345, pl. 92, Fig. 4; Masuda et al., 1996: 104, unnumbered fig; Chan & Yu, 1993: 217, unnumbered fig; Debelius, 1999: 225, unnumbered fig; Minemizu et al., 2000: 123, unnumbered figs; Kato & Okuno, 2001: 63, unnumbered fig. [=*Chelarctus virgosus*, new species]

[Not] *Scyllarus cultrifer* – Holthuis, 1946: 93, pl. 8, Figs. c, e [=*Galearctus timidus* (Holthuis, 1960)]

[Not] *Scyllarus cultrifer* – Barnard, 1950: 557, Fig. 104a [? =*Galeractus timidus* (Holthuis, 1960)]

[Not] *Scyllarus cultrifer* – Hwang & Yu, 1983: 264, Fig. 5 [=*Petrarctus rugosus* (H. Milne Edwards, 1837)]

[? Not] *Scyllarus cultrifer* – Wang et al., 1998: 446 [=*Chelarctus virgosus*, new species]

[Not] *Chelarctus cultrifer* – Holthuis, 2002: 572 (in part), Fig. 26A, B; Humann & DeLoach, 2010: 153, unnumbered fig. [=*Chelarctus virgosus*, new species]

[? Not] *Chelarctus cultrifer* – Zhang & Liu, 2006: 20, Fig. 1-4, 1-5, 1-6, 4-6 [=*Chelarctus virgosus*, new species]

Material examined. — Philippines, ALBATROSS, station D 5398, Gigantangan Island, 11°35'12"N, 124°13'48"E, 209 m, 15 Mar.1909, female 22.0 mm cl, holotype of *Chelarctus cultrifer meridionalis* (USNM 104525). –MUSORSTOM 1, station 27, 14°00.5'N, 120°15.7"E, 188–192 m, trawl, 22 Mar.1976, 1 ovigerous female 26.0 mm cl (MNHN-IU-2011-5102, ex. MNHN-Pa 1057); station 35, 14°08.0'N, 120°16.5'E, 186–187 m, trawl, 23 Mar.1976, 1 male 22.0 mm cl (MNHN-IU-2011-5103, ex. MNHN-Pa 1053); station 61, 13°59.7'N, 120°16.8'E, 184–202 m, trawl, 27 Mar.1976, 1 female 22.0 mm cl (MNHN-IU-2011-5099, ex. MNHN-Pa 1055); station 72, 14°13.1'N, 120°28.8'E, 122–127 m, trawl, 28 Mar.1976, 1 juvenile 9.0 mm cl (MNHN-IU-2011-5101, ex. MNHN-Pa 1048). –MUSORSTOM 2, station 51, 14°00.4'N, 120°17.6'E, 170–187 m, trawl, 27 Mar.1976, 1 ovigerous female 26.0 mm cl (MNHN-IU-2011-5100, ex. MNHN-Pa 1052). –MUSORSTOM 3, station DR130, 11°37'N, 121°43'E, 178–195 m, 5 Jun.1985, 1 female 7.8 mm cl (MNHN-IU-2011-5170, ex. MNHN-Pa 1087). –Balicasag Island, Bohol, tangle nets, 200–300 m, Dec.2000, 1 ovigerous female 25.6 mm cl (NTOU M01572). –PANGLAO 2004, station PN1, tangle nets, 29 May 2004, 5 females 24.3–29.2 mm cl (NTOU M01573); station P4, 9°31.1'N, 123°41.5'E, 100 m, tangle nets, 31 May 2004, 1 ovigerous female 28.0 mm cl (NTOU M01574). –PANGLAO 2005, station CA2366, 8°53.8'N, 123°16.4'E, 64 m, 26 May 2005, 1 female 26.6 mm cl (NTOU M01575).

Indonesia, CHALLENGER, station 192, Kai Islands, 5°49'15"S, 132°14'15"E, 256 m, 26 Sep.1874, female 23.0 mm cl, lectotype, 2 males 18.0–19.0 mm cl, paralectotypes (BMNH 1888.22). –KARUBAR, station DW24, Kai Islands, 5°32'S, 132°51'E, 243–230 m, 26 Oct.1991, 1 female 9.0 mm cl (MNHN-IU-2011-5171, ex. MNHN-Pa 1912); station DW 32, Kai Island, 5°47'S, 132° 51'E, 170–206 m, 26 Oct.1991, 1 female 8.1 mm cl (MNHN-IU-2011-5155); station CP36, Kai Islands, 6°05'S, 132°44'E, 268–210 m, 27 Oct.1991, 4 males 10.4–16.6 mm cl, 12 females 10.8–18.7 mm cl (MNHN-IU-2011-5154, ex. MNHN-Pa 1880).

Îles Glorieuses, BENTHEDI, station 8 DR, 11°29.2'S, 47°18.2'E, 250 m, 19 Mar.1977, 1 ovigerous female 28.0 mm cl (MNHN-IU-2011-5106, ex. MNHN-Pa 601).

Diagnosis. — Rostrum with sharp rostral tooth. Pregastric tooth absent while gastric tooth strong and highly elevated. Cardiac tooth slightly elevated, truncate or rarely represented by 2 weak and blunt tubercles. Cervical groove weak but not very narrow. Anterolateral, mediolateral and posterolateral teeth squamiform and flat except for anteriormost tooth (Fig. 1A). Abdomen with arborescent sculpture, without elevated median dorsal carina. Articulating surfaces of abdominal tergites II–V each bearing 1 or 2 transverse grooves, often with squamae. Arborescent sculpture on non-articulating surface of abdominal tergites I–V with longitudinal grooves rather parallel and not distinctly branched, giving impression of consisting of rows of large rectangular squamae (Fig. 1B, C); sometimes longitudinal grooves also interconnected by smaller squamae in between (Fig. 1B). Posterior margins of abdominal tergites I–III distinctly incised medially, that of tergite IV weakly or not (mostly) incised medially (Fig. 1B, C). Abdominal pleura II–IV acutely pointed posteroventrally. Anterior margin of antennal segment VI with 6 teeth. Antennal segment IV with outer margin bearing 2 large teeth; dorsal surface with 1 oblique carina; anterior margin armed with 1 large tooth, sometimes also with smaller teeth or denticles (Figs. 1A, 2A). Anterior margin of fused antennal segments II and III with anterior margin bearing 2 teeth, outer tooth larger, but not as large as rostral tooth. Only pereiopod III distinctly subchelate (Fig. 2B, D). Propodus of pereiopod IV with small to minute anteroventral tooth (Fig. 2C, E). Anterior part of thoracic sternum anteriorly produced and nearly truncate or somewhat bifurcate, with medial part "V"-shapedly sunken, lateral non-sunken part slightly narrower than median sunken part. Thoracic sternum with lateral parts not ridged or tuberculated, median fissure only sometimes present on thoracic sternite IV posterior to median sunken area (Fig. 1D, E). Last thoracic sternite without median tubercle, posterolateral angle with small tooth in males but unarmed in females.

Colouration. — Body generally light rusty brown, with squamae on carapace and anterior 2 abdominal somites more brownish (Fig. 4A). Articulate surface of abdominal tergite I with some longitudinal brown lines. Antennule with bluish brown markings. Eyes light brown. Abdominal somite VI and tail fan greyish white. Pereiopods dull yellow and covered with rusty brown bands.

Distribution. — Known with certainty from the Philippines, Indonesia, and Îles Glorieuses, probably also in Somalia, Kenya, Saya de Malha Bank, Seychelles and Hawaii (see "Remarks"), at depths of 64–300 m.

Remarks. — *Chelartus cultrifer* is restricted to localities from the Philippines and southwards, so seems that its taxonomy would be straight forward since the type localities of the two subspecies in *C. cultrifer* are from Indonesia and the Philippines. Although the Indonesian and Philippine specimens examined are nearly identical, genetic analysis shown that there are two distinct sister clades in these populations (Fig. 5). One clade consists of both Indonesian and Philippine material, while an Indonesian specimen is grouped with the specimen from Îles Glorieuses. The COI

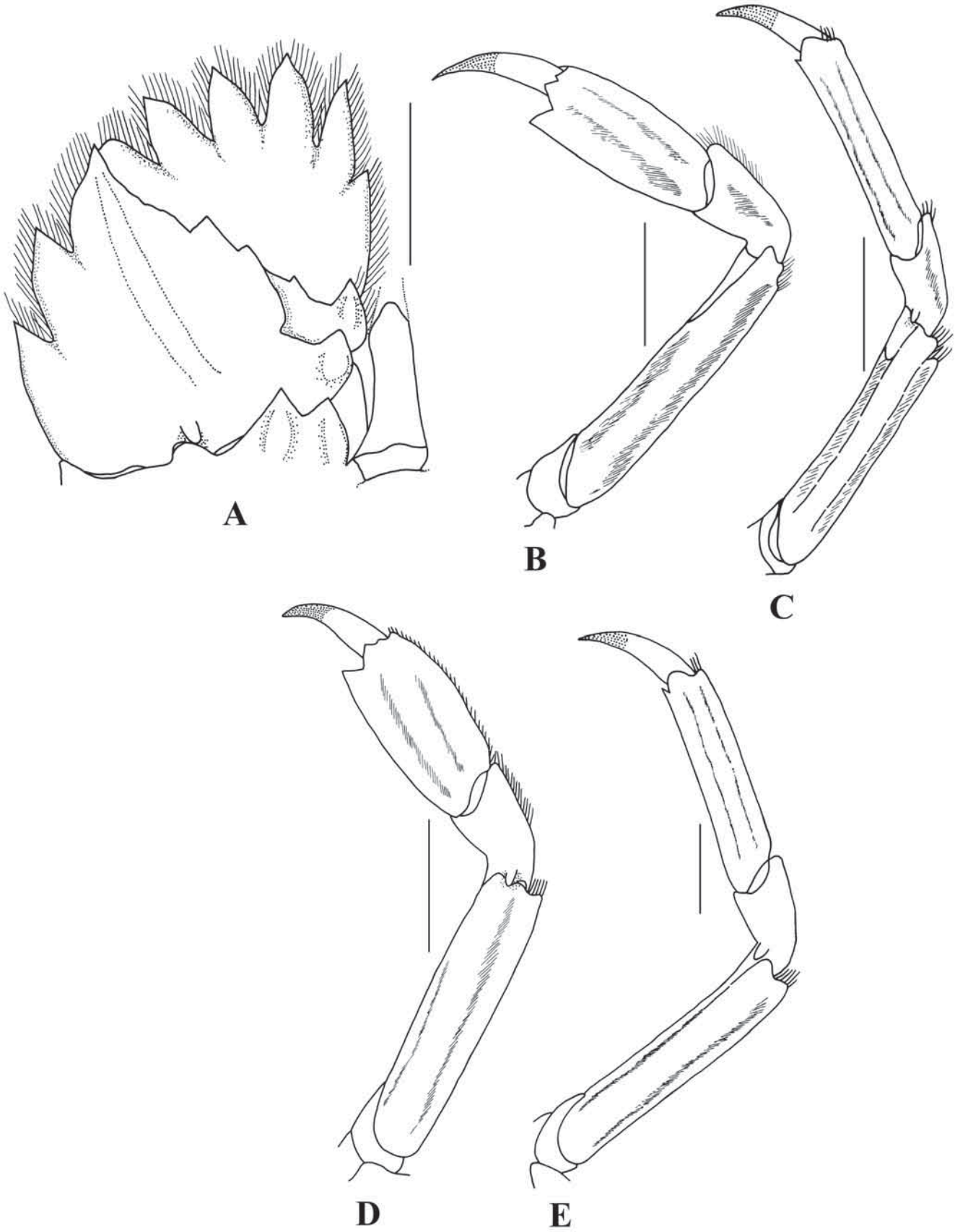

Fig. 2. A, D, E, *Chelarctus cultrifer cultrifer* (Ortmann, 1897), lectotype, Indonesia, female 23.0 mm cl, BMNH 1888.22; B, C, *Chelarctus cultrifer meridionalis* (Holthuis, 1960), Philippines, PANGLAO 2004, ovigerous female 28.0 mm cl, NTOU M01574. A, left antenna, dorsal; B, D, right pereiopod III; C, E, right pereiopod IV. Scale bars = 5 mm.

divergences between these two clades are 5.6–8.3%, whereas within each clade only 1.4–2.6% divergence is recorded (Table 2). The genetic difference between these two clades in *C. cultrifer* is quite large for decapod crustaceans in general (Matzen da Silva et al., 2011) but somewhat lower than the usual specific difference for Scyllarinae (i.e., 12.5–15.8%; see Yang et al., 2008; Yang & Chan, 2010; Yang et al., 2011). Thus, it may be necessary to resurrect the subspecies in *C. cultrifer*. Unfortunately, the primary type specimens of both the nominate form and *C. cultrifer meridionalis* are old specimens (collected from 1874 and 1909, respectively) and failed to generate any genetic data.

Detailed examination of the specimens used for genetic analysis showed that the arborescent sculpture on the abdomen is more complicated in those specimens of the clade containing material from the Philippines. In these specimens, the rectangular squamae on the non-articulating surfaces are somewhat interconnected by smaller squamae (Fig. 1B). In the other clade, these smaller squamae are absent or rather indistinct (Fig. 1C). All the Philippines specimens examined, including the holotype of *C. cultrifer meridionalis*, bear these smaller squamae (see also Holthuis, 1960). The Indonesian specimens, however, usually do not have these smaller squamae except for the KARUBAR station DW24 female, which has these squamae; this female is also genetically closer to the Philippine material. Nevertheless, the lectotype and paralectotypes of *C. cultrifer* do not have these small squamae (Fig. 1C). Thus, if *C. cultrifer* is to be subdivided, the nomino-typical form can probably be referred to those without interconnecting small squamae in the abdominal sculpture while the subspecies name, *C. cultrifer meridionalis*, can be applied to those having these interconnecting small squamae. More DNA workable specimens from various localities will be necessary to elucidate if there are indeed two subspecies in *C. cultrifer* and their exact morphological differences. On the other hand, re-examination of the other specimens identified as "*C. cultrifer*" in Holthuis (2002) will be necessary to ascertain the exact distribution of this species as discussed in the "Remarks" of the new species. However, it is pertinent to highlight that the "*Scyllarus cultrifer*" specimen reported by Barnard (1947, 1950, and originally reported as "*Scyllarus sordidus*" in Barnard, 1926) from Mozambique does not belong to *Chelarctus* but to *Galearctus* according to the shape of the anterior part of the thoracic sternum. Barnard's (1926, 1947, 1950) Mozambique specimen is likely to be *G. timidus* (Holthuis, 1960) but re-examination of the specimen will be necessary to determine its correct identity.

Chelarctus virgosus, new species
(Figs. 3, 4B)

Arctus haanii – Ortmann, 1891: 42 (in part) [not *Scyllarus Haani* Berthold, 1845]

Arctus cultrifer – Ortmann, 1897: 272 (in part); Yokoya, 1933: 46 [not Ortmann, 1897]

Scyllarus cultrifer – Balss, 1914: 80; Parisi, 1917: 9; Utinomi, 1956: 62, pl. 31, Fig. 5; Kubo, 1960: 98, pl. 49, Fig. 5; 1965: 627, Fig. 1023; Miyake, 1961: 9; 1972: 67, unnumbered fig.; 1975: 106, unnumbered fig.; 1982: 84, pl. 29, Fig. 1; Harada, 1962: 114, Figs. 3–5, pl. 8, pl. 12, Fig. 13, pl. 13, Fig. 17; 1965: 36, Fig. 1a, b; Ikematsu, 1963: 10; Nishimura & Suzuki, 1971: 89, pl. 30, Fig. 4; Matsuzawa, 1977: pl. 76, Fig. 1; Shirai, 1980: 411, unnumbered fig; Takeda, 1982: 43, Fig. 129; Baba, 1986: 163, Fig. 114; Hayashi, 1995: 345, pl. 92, Fig. 4; Masuda et al., 1996: 104, unnumbered fig; Chan & Yu, 1993: 217, unnumbered fig; Debelius, 1999: 225, unnumbered fig; Minemizu et al., 2000: 123, unnumbered figs.; Kato & Okuno, 2001: 63, unnumbered fig. [not Ortmann, 1897]

[?] *Scyllarus cultrifer* – Wang et al., 1998: 446 [not Ortmann, 1897]

Chelarctus cultrifer – Holthuis, 2002: 572 (in part), Fig. 26A, B; Humann & DeLoach, 2010: 153, unnumbered fig. [not Ortmann, 1897]

[?] *Chelarctus cultrifer* – Zhang & Liu, 2006: 20, Figs. 1-4, 1-5, 1-6, 4-6. [not Ortmann, 1897]

Material examined. — Holotype. Taiwan, Hepingdao fishing port, Keelung City, lobster gill net, 7 Jun.2000, ovigerous female 26.0 mm cl (NTOU M01571).

Paratypes: Taiwan, Hepingdao fishing port, Keelung City, lobster gill net, Apr.1998, 2 females 26.9–27.2 mm cl (NTOU M01293); 7 Jun.2000, 8 ovigerous females 26.3–31.6 mm cl, 1 female 26.4 mm cl (NTOU M01294). Dasi fishing port, Yilan County, commercial trawlers, 10 Apr.2000, 1 male 22.8 mm cl (NTOU M01290); Jul.2004, 1 male 12.8 mm cl (NTOU M01291); 29 Jun.2011, 1 female 10.9 mm cl (NTOU M01292). Su-ao fishing port, Yilan County, commercial trawler, 9 Dec.1992, 1 male 22.3 mm cl (NTOU M01289).

Non-type specimens: Madagascar, Majunga, 1 male 19.1 mm cl, 1 ovigerous female 21.0 mm cl (MNHN-IU-2011-5172).

Description. — Rostrum rather broad, with large sharp rostral tooth. Pregastric tooth absent. Gastric tooth strong, highly elevated and followed posteriorly by 5 or 6 transverse rows of squamae (Fig. 3A, C). Anterior submedian carina composed of 2 or 3 large squamae. Cardiac tooth only slightly elevated but distinctly bifurcate, flanked with patch of 6 or 7 clustered squamae; cardiac tooth continuous posteriorly with 6 or 7 transverse rows of 2 or 3 flattened squamae; 4 or 5 intermediate tubercles present. Cervical groove weak but not very narrow; 2 large sharp teeth present on anterior branchial carina. Posterior branchial carina anteriorly terminating in acute tooth, followed posteriorly by double rows of 7 or 8 irregular squamiform tubercles. Postorbital carina distinct. Anterolateral, mediolateral and posterolateral teeth squmiform and flat except for anteriormost tooth. Posterior marginal groove narrow but deep. Posterior margin of carapace incised medially (Fig. 3A).

Abdomen with arborescent sculpture, without elevated median dorsal carina and only with median areas bluntly arched. Articulating surfaces of tergites II–V each with 1 or 2 often interrupted but rather simple transverse grooves. Arborescent sculpture on non-articulating surfaces of tergites I–V consisting of rather simple grooves, distinctly forked distally, particularly prominent on tergite I. Posterior margins of tergites I–III distinctly incised medially, that of tergite IV weakly (mostly) or not incised medially (Fig. 3B). Pleura II–IV acutely pointed posteroventrally. Calcified part of telson with 2 pairs of teeth along posterior margin.

Table 2. Uncorrected pairwise distance of partial COI gene (657 bp) amongst species of *Chelarctus*. *Petrarctus rugosus* and *Remiarctus bertholdii* are outgroups.

	C. virgosus, new species	*C. cultrifer cultrifer* (Indonesia 1)	*C. cultrifer cultrifer* (Îles Glorieuses)	*C. cultrifer meridionalis* (Philippines 1)	*C. cultrifer meridionalis* (Philippines 2)	*C. cultrifer meridionalis* (Indonesia 2)	*C. aureus*	*C. crosineri*	*P. rugosus*
***C. cultrifer cultrifer* (Indonesia 1)**	0.156	—							
***C. cultrifer cultrifer* (Îles Glorieuses)**	0.165	0.014	—						
***C. cultrifer meridionalis* (Philippines 1)**	0.155	0.065	0.072	—					
***C. cultrifer meridionalis* (Philippines 2)**	0.158	0.056	0.063	0.016	—				
***C. cultrifer meridionalis* (Indonesia 2)**	0.165	0.076	0.083	0.014	0.026	—			
C. aureus	0.199	0.162	0.172	0.165	0.165	0.17	—		
C. crosineri	0.172	0.146	0.153	0.148	0.148	0.151	0.16	—	
P. rugosus	0.170	0.165	0.172	0.163	0.163	0.169	0.158	0.178	—
R. bertholdii	0.176	0.172	0.172	0.176	0.172	0.172	0.181	0.199	0.197

Anterior margin of antennal segment VI with 6 or 7 teeth, including inner short tooth. Antennal segment IV with anterior margin bearing 2 large teeth, often accompanied with some small serrations; outer margin armed with 2 large teeth only; dorsal surface with 1 oblique carina. Anterior margin of fused antennal segments II and III with 2 teeth, outer tooth much larger and even larger than rostral tooth (Fig. 3A).

Pereiopod I robust and shorter than other pereiopods (Fig. 3D). Pereiopod II slender (Fig. 3E). Propodi of pereiopod III and IV with 2 parallel long setose grooves on outer surface, with large anteroventral tooth which act as subchela with dactylus. Propodus of pereiopod III very broad, subchela very prominent (Fig. 3F). Propodus of pereiopod IV rather slender but with subchela still quite distinct (Fig. 3G). Carpi of pereiopods III–V each with 1 setose groove on outer surface (Fig. 3F–H). Meri of pereiopods II–V each with 2 setose grooves (Fig. 3E–H).

Anterior part of thoracic sternum greatly produced anteriorly, anterior margin somewhat truncate, medial part deeply sunken and continuous posteriorly as median fissure extending to posterior end of thoracic sternite IV (pereiopod I); median sunken parts broad while non-sunken lateral parts rather narrow, with latter less than half as wide as former. Median parts of thoracic sternites V–VII rather deeply excavate and often with distinct median fissure (sometimes interrupted) on thoracic sternites V and VI. Lateral parts of thoracic sternum not ridged, without distinct tubercle (Fig. 3I). Thoracic sternite VIII without median tubercle, posterolateral angle with small tooth in males but unarmed in females.

Egg small and numerous, about 0.3 mm in diameter.

Colouration. — Carapace yellowish brown with some dark brown patches. Large teeth on carapace and antenna distally orangish brown with white tips. Eyes black brown. Pereiopods dull yellowish and with thick dark blue bands. Antennules also dull yellowish and with short brown bands, flagella somewhat orange. Abdomen generally brownish, articulating surface of abdominal tergite I somewhat with 3 large orange-brown spots. Abdominal somite VI to tail fan somewhat dull yellowish (Fig. 4B).

Distribution. — Known with certainty from Japan, Taiwan and Madagascar, probably also in East and South China Seas, Somalia and the Seychelles (see "Remarks"); 5–146 m.

Etymology. — The Latin "*virgosus*" (meaning full of twigs) refers to the arborescent sculpture on the abdomen in this species has a clear branching pattern as compared to its congeners.

Remarks. — Although there are numerous reports over the last century of this species from Japan, mostly under the name "*Scyllarus cultrifer*" (see synonymy), the present study discovered that it is actually unnamed, following the valid lectotype selection of *Arctus cultrifer* Ortmann, 1897 by Holthuis (2002) using a Philippines female. Even though no specimen from Japan had been examined, the Taiwanese

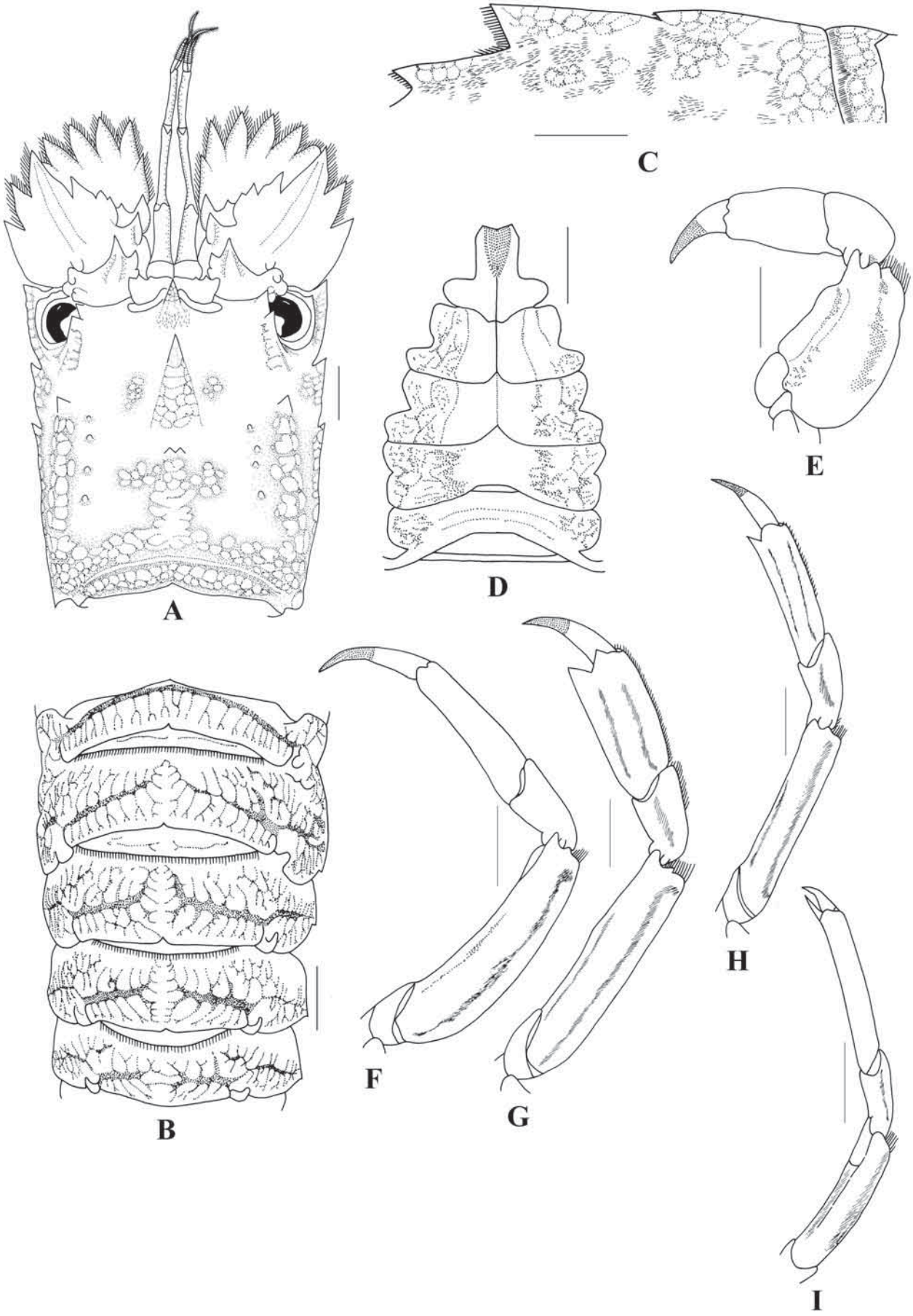

Fig. 3. *Chelarctus virgosus*, new species. Holotype, Taiwan, ovigerous female 26.0 mm cl, NTOU M01571. A, carapace, dorsal; B, abdomen, dorsal; C, carapace, lateral; D, thoracic sternum; E, right pereiopod I; F, right pereiopod II; G, right pereiopod III; H, right pereiopod IV; I, pereiopod. Scale bars = 5 mm.

specimens almost certainly belong to the same species as the Japanese material as they are almost identical in both morphology and colouration based on the abundant Japanese literature.

The Taiwan-Japan form, now with the name *C. virgosus*, new species, can be readily separated from the true *C. cultrifer* by many obvious characters. The cardiac tooth is distinctly bifurcate in *C. virgosus*, new species (Fig. 3A), but either truncate or at most represented by two weak blunt tubercles (in 11 of the 36 specimens examined) in *C. cultrifer* (Fig. 1A). The outer tooth on the anterior margin of the fused antennal segments II and III is very large, being much larger than the inner tooth and even larger than the rostral tooth in *C. virgosus*, new species (Fig. 3A). In *C. cultrifer*, the outer tooth on the anterior margin of fused antennal segments II and III is smaller than the rostral tooth (Fig. 1A). The number of large teeth on anterior margin of the antenna segment IV is always two in *C. virgosus*, new species (Fig. 3A), but only one in *C. cultrifer* (Figs. 1A, 2A). The anteroventral tooth at the propodus of pereiopod IV is large in *C. virgosus*, new species (Fig. 3G), but small to minute in *C. cultrifer* (Fig. 2C, E). Thus, pereiopod IV is distinctly subchelate in *C. virgosus*, new species, but essentially not subchelate in *C. cultrifer*. The arborescent sculpture is simpler but with the branches distinctly forked in *C. virgosus*, new species, thus giving a general impression of irregular branching lines on the abdomen (Fig. 3B). The abdominal sculpture is more complex in *C. cultrifer*, with the longitudinal grooves rather parallel with each other and not distinctly branched. Therefore, the arborescent sculpture of *C. cultrifer* appeared to be composed of rows of large rectangular squamae (Fig. 1B, C). Such differences in sculpture pattern are more pronounced at the non-articulating surface of the abdominal tergite I. The thoracic sternum is generally more deeply excavated in *C. virgosus*, new species (Fig. 3I), than in *C. cultrifer* (Fig. 1D, E), and with the lateral regions of the anterior part of the thoracic sternum distinctly narrower in the new species (i.e., lateral part less than half as wide as median sunken part versus lateral part distinctly more than half as wide as median sunken part). Moreover, the median fissure extends from the median sunken area to at least the posterior end of thoracic sternite IV and sometimes to thoracic sternite V (in 8 of the 18 specimens examined) or even to the thoracic sternite VI (in 5 of the 18 specimens examined) in *C. virgosus*, new species (Fig. 3I). However, *C. cultrifer* often lacks a median fissure behind the median sunken area at the anterior part of the thoracic sternum (Fig. 1D, E). In the few specimens

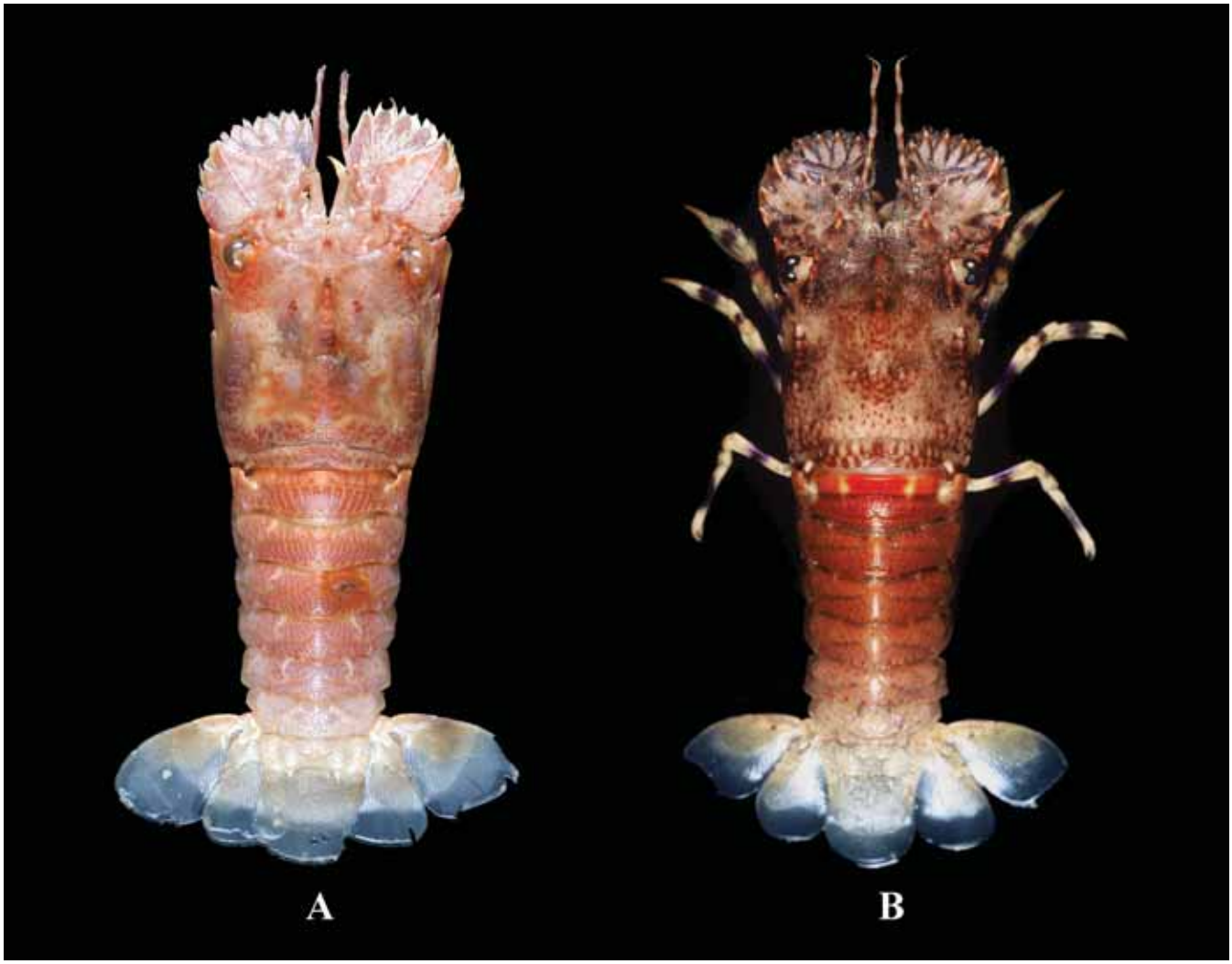

Fig. 4. A, *Chelarctus cultrifer meridionalis* (Holthuis, 1960), Philippines, PANGLAO 2005, female 26.6 mm cl, NTOU M01575; B, *Chelarctus virgosus*, new species, Taiwan, paratype male 22.3 mm cl, NTOU M01289.

(i.e., 2 of the 37 specimens examined) with a distinct median fissure, it is restricted to thoracic sternite IV.

Of the four characters used by Holthuis (1960) to separate the material from Japan and the Philippines, the characters on the abdominal tergite I and the anterior part of the thoracic sternum is essentially the same as those discussed above. The other two characters on the postrostral carina and abdominal somite IV are rather variable. For example, in 2 of the 37 *C. cultrifer* specimens examined there is a minute median incision on the posterior margin of the abdominal tergite IV.

Comparison of the barcoding gene sequence COI shows 15.5–16.5% nucleotide divergence between *C. virgosus*, new species, and *C. cultrifer* (Table 2, Fig. 5). This difference is higher than the minimal divergence amongst the other species in the genus *Chelarctus* (i.e., 14.6%, between *C. cultrifer* and *C. crosnieri*, Table 2), and well accepted to represent specific differences in Scyllarinae (Yang et al., 2008; Yang &Chan, 2010; Yang et al., 2011). Moreover, there are distinct difference in the colour pattern between *C. virgosus*, new species, and *C. cultrifer*, with the colouration of the latter being much duller (Fig. 4). The generally appearance of *C. virgosus*, new species, is orangish brown with blue bands on the pereiopods and with blurred large spots on the articulate surface of the abdominal tergite I. However, the overall impression of *C. cultrifer* is dull brown with dull bands on the pereiopods and only longitudinal lines on the articulating surface of abdominal tergite I.

Amongst the southern material identified as "*C. cultrifer*" in the Muséum national d'Histoire naturelle, Paris, one lot and two specimens from Madagascar are morphologically identical with the Taiwanese material. Although these two Madagascan specimens were collected in 1912 and failed to generate genetic sequence for comparisons, there is little doubt that they are *C. virgosus*, new species, instead of the true *C. cultrifer*. Therefore, *C. virgosus*, new species, is not strictly a northern species, although it does range further north than *C. cultrifer*. On the other hand, *C. virgosus*, new species, is usually collected from less than 50 m deep in Taiwan and Japan (Chan & Yu, 1993; Minemizu et al., 2000) while the true *C. cultrifer* examined in this study were mostly from deeper than 150 m. This recalls a similar situation shown in *Galearctus kitanoviriosus* (Harada, 1962), which was recently found to contain two species that have different depth ranges (Yang et al., 2011). The collection depth of the two Madagascan specimens identified here as *C. virgosus*, new species, is not known. However, another MNHN lot from Îles Glorieuses, which is adjacent to Madagascar, and collected from 250 m deep represents true *C. cultrifer*. Thus, the exact distribution of *C. virgosus*, new species, will need to be verified, particularly by re-examining those "*C. cultrifer*" specimens reported in Holthuis (2002) and from shallower depths (e.g., those from Somalia and Seychelles), as well as those Chinese records (Wang et al., 1998, Zhang & Liu, 2006). The source of the Wang et al. (1998) South China Sea record is unknown as there is no specimen cited in the report. The East China Sea specimen reported in Zhang & Liu (2006) has the anteroventral tooth at the propodus of pereiopod IV smaller than usual but this maybe due to the specimen being a very small juvenile (see Zhang & Liu, 2006: Figs. 4–6). The true identity of these two Chinese records probably will never be determined unless adult specimens can be collected from the East China Sea. It may also be useful to point out

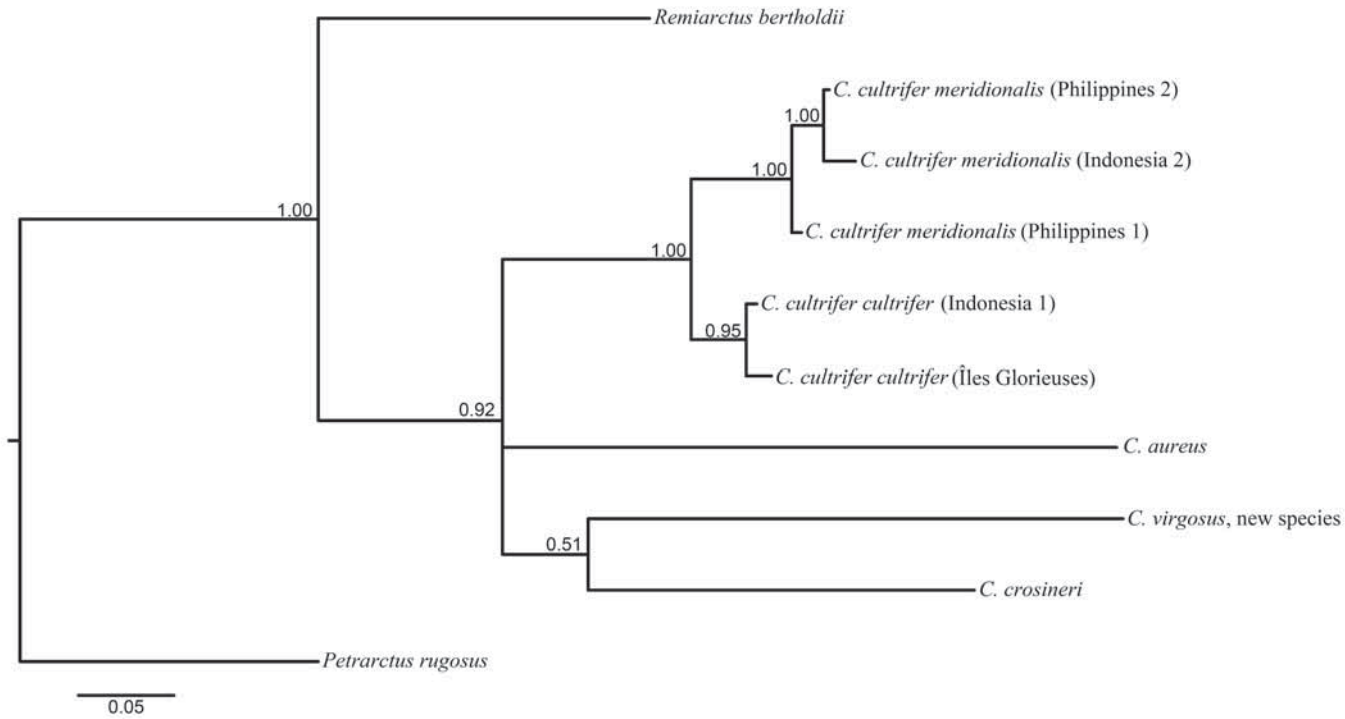

Fig. 5. Bayesian phylogenetic tree from partial segment (657 bp) of COI gene among *Chelarctus* species and outgroups. Posterior probability estimated by Bayesian inference shown on branches.

that the photograph in Humann & DeLoach (2010) under the name "*Chelarctus cultrifer*" without locality specified is the same photograph (but with image in reverse) used in Debelius (1999) for "*Scyllarus cultrifer*" taken in Japan. Thus, the photographs of both Humann & DeLoach (2010) and Debelius (1999) show the same Japanese specimen of *C. virgosus*, new species.

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