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A NEW SLIPPER LOBSTER OF THE GENUS *PETRARCTUS* (CRUSTACEA: DECAPODA: SCYLLARIDAE) FROM THE WEST PACIFIC

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ABSTRACT. – A new species of slipper lobster, *Petrarctus holthuisi*, new species, is found from the recent expeditions to the Philippines and Vanuatu. The new species resembles *P. rugosus* (H. Milne Edwards, 1837) but has a different colouration and several morphological differences. Comparisons of the partial sequence of cytochrome c oxidase subunit I (COI) show high degree of divergence (12.5–22.3%) among all the species of *Petrarctus*. The molecular genetic analysis also suggests that the recent separation of *Scyllarus* sensu lato may need to be revised. A key to all *Petrarctus* species is provided.

KEY WORDS. – Scyllaridae, Slipper lobster, *Petrarctus*, new species.

INTRODUCTION

Slipper lobsters of the genus *Scyllarus* Fabricius, 1775, in the Indo-Pacific was recently separated into 13 genera by Holthuis (2002). The genus *Petrarctus* Holthuis, 2002, was established for the "*Scyllarus rugosus* H. Milne Edwards, 1837" species group which can be characterized by their wide transverse grooves and distinct median longitudinal carina (generally those on somite III being highest) on the dorsal surface of the abdomen, either U- or V- shaped and non-sunken anterior margin of the thoracic sternum, the absence of a distinct outer additional carina at the fourth antennal segment, and the presence of dorsal fringes of long hairs on the dactylus of the fourth pereiopod. Four species are currently included in *Petrarctus* viz. *P. rugosus*, *P. brevicornis* (Holthuis, 1946), *P. demani* (Holthuis, 1946) and *P. veliger* Holthuis, 2002.

The third author (TYC) participated in the recent expeditions (PANGLAO 2004, PANGLAO 2005 and AURORA 2007) to the Philippines, and SANTO 2006 to Vanuatu organized by the Muséum national d'Histoire naturelle, Paris, and collected a good number of *Petrarctus* specimens. Careful examination of these specimens revealed that there were three species present. *Petrarctus brevicornis* was found from both the Philippines and Vanuatu Expeditions. More specimens of the rare species, *P. veliger*, were found from the Philippines. The third species is similar to *P. demani* by having a dark circular spot on the first abdominal somite, but it is morphologically closer to *P. rugosus*. This new species is described herein and a new key to the *Petrarctus* is provided. A comparison of the partial COI sequences among all the species of *Petrarctus* also supported the specific status of the new form.

MATERIALS AND METHODS

Unless stated otherwise, the specimens are deposited in the National Taiwan Ocean University, Keelung (NTOU). Other specimens are deposited in the Philippines National Museum, Manila (NMCR), Muséum national d'Histoire naturelle, Paris (MNHN) and the Zoological Reference Collections, Raffles Museum of Biodiversity Research, National University of Singapore (ZRC). The carapace length (cl) is measured along the dorsal midline from the base of the rostrum to the posterior margin of the carapace. The abbreviations CP and AT before the station number refers to the 4.2 m beam trawl used in the sample collection. The terminology used mainly follows Holthuis (2002). The Philippines expeditions contain the following specimens of *Petrarctus* except for the new species:

***Petrarctus brevicornis*. – PANGLAO 2004:** Balicasag Island, Bohol, tangle nets, 01–05 May 2004, 1 ovig. female 17.0 mm cl, 1 female 18.6 mm cl; Stn. T10, 9°33.4'N 123°49.6'E, 117–124 m, 1 m beam trawl, 15 Jun.2004, 1 female 18.5 mm cl. **PANGLAO 2005:** Stn. CP 2377, 8°40.6'N 123°20.3'E, 82.4–85.3 m, 28 May 2005, 1 female 18.5 mm cl. **AURORA 2007:** Stn. CP2661, 15°47'N 121°44'E, 160–167 m, 21 May 2007, 1 ovig. female 16.2 mm cl; Stn. CP 2719, 14°27'N 121°48'E, 155–160 m, 29 May 2007, 1 female 15.1 mm cl; Stn. CP 2741, 16°03'N 121°54'E, 194–203 m, 01 Jun.2007, 1 female 13.0 mm cl; Stn. CP 2747, 15°55'N 121°42'E, 120–124 m, 02 Jun.2007, 1 ovig. female 14.8 mm cl.

***Petrarctus veliger*. –** Balicasag Island, Bohol, tangle nets, Dec.2000, 1 male 17.6 mm cl, 1 ovig. female 18.5 mm cl; Jan.2004, 1 female 21.0 mm cl (NTOU M00740). **PANGLAO 2004:** Balicasag Island, Bohol, tangle nets, Mar.2004, 1 male 16.5 mm cl.

The *Petrarctus* material of **SANTO 2006** has not been thoroughly examined and most of the identification was based on photographs.

Specimens of *P. rugosus* and *P. demani* used for comparison are:

***Petrarctus rugosus*. –** Taiwan: 1 male 22.3 mm cl (NTOU M00737), 16 males 9.6–19.09 mm cl, 7 ovig. females 16.0–21.1 mm cl, 18 females 11.4–23.5 mm cl. South China Sea: 1 male 17.0 mm cl, 2 females 20.3–21.7 mm cl. Indonesia: 1 male 16.6 mm cl (NTOU M00738).

***Petrarctus demani*. –** South China Sea: 2 males 18.4–20.3 mm cl, 1 female 21.5 mm cl. Thailand: 2 males 18.9–19.8 mm cl, 1 female 18.1 mm cl (NTOU M00734).

The individuals for molecular analysis were listed in Table 1, including an additional *P. veliger* specimen from Thailand (Phuket fishing port, off Andaman Sea, Dec.1998, 1 male 19.3 mm cl). Originally the closest genus *Antarctus* Holthuis, 2002 [containing a single species *A. mawsoni* (Bage, 1938)] was used as the outgroup (see Holthuis, 2002: generic key). However, when *A. mawsoni* was nested within *Petrarctus* in the molecular analysis, the next closest genus *Bathyarctus* Holthuis, 2002 (with the species *B. chani*) was used as an additional outgroup. Muscle tissues (10–20 mg) from the sixth abdomen were used. All specimens have been preserved in 70–95% ethanol, and the Genomic DNA Mini kit (Geneaid) was used for the extraction of genomic DNA. The partial sequence of mitochondrial cytochrome c oxidase I (COI) gene was amplified by conserved primer: LCO1490/ HCO2198 (Folmer et al., 1994). Total 50 µl reaction for amplification contained 50 to 200 ng of the DNA extraction, 5 mM of dNTP (PROTECH Inc.), 10 mM $MgCl_2$, 1 mM each primer (MDBio Inc.), 1 units of *Taq* polymerase (5 units/µl, SUPER-THERM), 5 µl of 10× polymerase buffer (SUPER-THERM), and extra 0.3 µl of 1% bovine serum albumin (BSA; stock concentration-0.5 mg/µl). The cycling profiles for COI was as follows: 5 min at 94°C for initial denaturation, then 40 cycles of 30 sec at 94°C, 35 sec at 47.8°C, 40 sec at 72°C, and final extension for 10 min at 72°C. The size and quality of PCR products were visualized on 1% agarose gels. PCR products were purified using the High Pure PCR Product purification kit (Roche Applied Science) before sequencing. The purified PCR products were employed for cycle sequencing in ABI 310 Genetic Analyzer (Applied Biosystems). The data set of the sequences was converted by the Data Analysis in Molecular and Evolution (DAMBE, ver 4.2.13, Xia and Xie, 2001) into a NEXUS format for Bayesian inference (MrBayes, ver. 3.1.2, Ronquist et al., 2005). The Molecular Evolutionary Genetics Analysis (MEGA, ver. 3.1, Kumar et al, 2004) was used for calculating the nucleotide divergence). MrModeltest 2.2 (Nylander, 2004) was used to evaluate a best-fit model of DNA substitution and all parameters for consequent analysis. Two independent Markov Chain Monte Carlo (MCMC) search were run with four chains each for 1,000,000 generations with trees sampled every 1,000 generations. The 50% majority rule consensus tree and posterior probabilities for nodes were assembled from all post-burn-in sampled trees.

TAXONOMY

Petrarctus holthuisi, new species
(Figs.1, 2B, E, H, 3)

***Material examined*. –** Holotype: Philippines, AURORA 2007, Stn. CP 2653, 16°05.8'N 121°58.8'E, 83 m, 20 May 2007, ovig. female 17.0 mm cl (NMCR).

Paratypes: Philippines, Balicasag Island, Bohol, tangle nets, about 200–300 m, Dec.2000, 1 female 14.7 mm cl (ZRC 2001.0326). PANGLAO 2004: Balicasag Island, Bohol, tangle nets, Mar.2004, 2 females 15.7–16.2 mm cl (ZRC); Balicasag Island, Bohol, tangle nets, Apr.2004, 2 males 11.8–12.9 mm cl, 1 ovig. female 15.0 mm cl, 1 female 13.9 mm cl; Stn. PN1, tangle nets, 29 May 2004, 1 male 15.4 mm cl, 1 ovig. female 15.0 mm cl (NTOU M00735); Stn. P3, 9°31.1'N 123°41.5'E, about 100 m, tangle nets, 31 May 2004, 1 male 10.3 mm cl (ZRC); Stn. T38, 9°32.3'N 123°42.3'E, 80–140 m, 1 m beam trawl, 4 Jul.2004, photographs only, specimen not located. AURORA 2007: Stn. CP 2654, 16°04.3'N 121°57'E, 98–107 m, 20 May 2007, 2 males 12.1–12.5 mm cl, 2 females 12.2–16.0 mm cl; Stn. CP 2747, 15°55'N 121°42'E, 120–124 m, 2 Jun.2007, 1 female 14.2 mm cl.

***Other material examined*. –** Vanuatu, SANTO 2006: Stn. AT4, 15°32.9'S 167°13.3'E, 97–101 m, 15 Sep.2006, 1 male 8.8 mm cl (MNHN); Stn. AT50, 15°36.8'S 167°14.1'E, 140–153 m, 30 Sep.2006, 1 ovig. female 11.4 mm cl (MNHN); Stn. AT56, 15°36.1'S 167°01.3'E, 98–105 m, 2 Oct.2006, 1 female 9.0 mm cl (MNHN); Stn. AT78, 15°37.6'S 167°02.5'E, 155–166 m, 10 Oct.2006, 1 male 6.9 mm cl (MNHN).

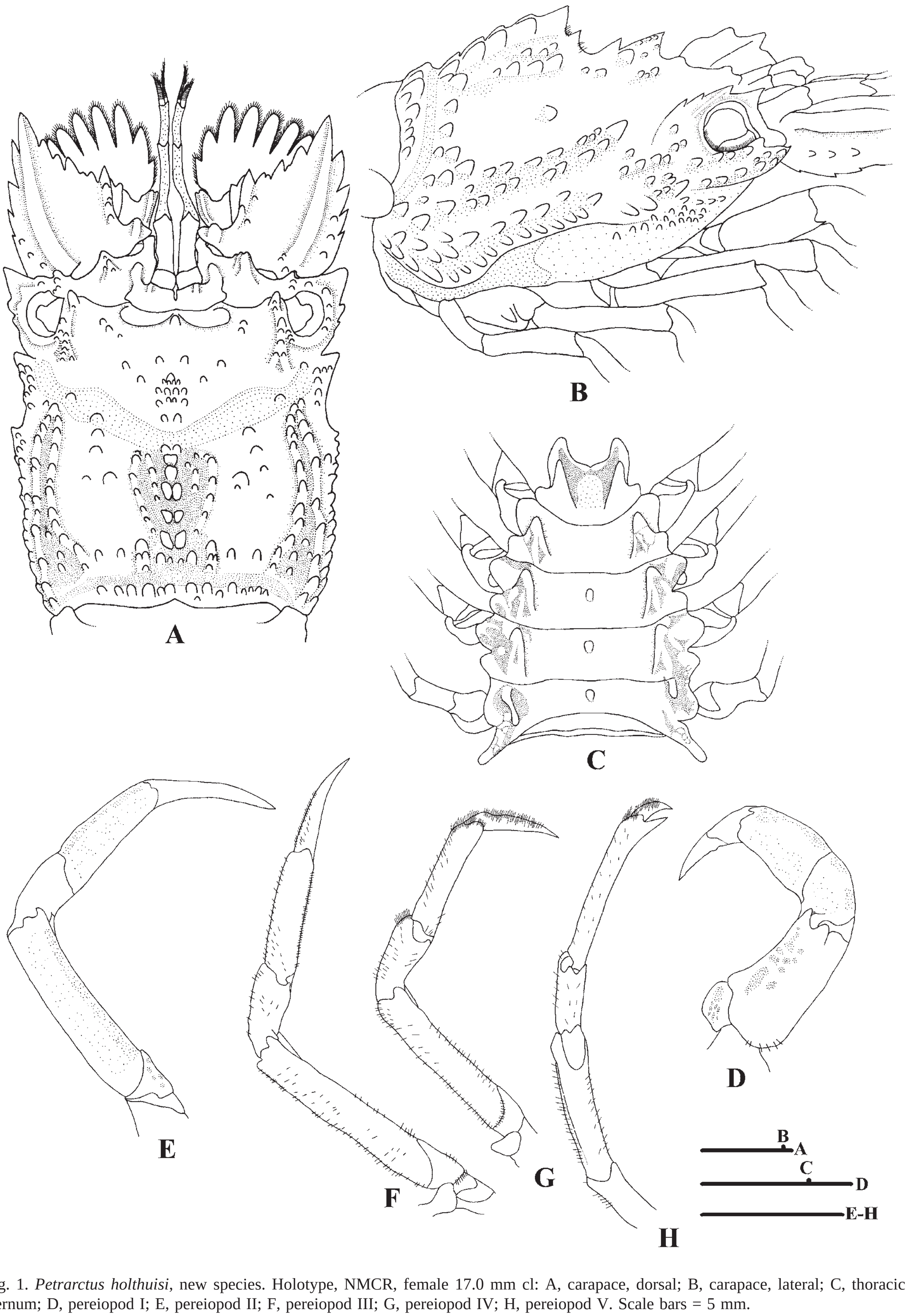

Fig. 1. *Petrarctus holthuisi*, new species. Holotype, NMCR, female 17.0 mm cl: A, carapace, dorsal; B, carapace, lateral; C, thoracic sternum; D, pereiopod I; E, pereiopod II; F, pereiopod III; G, pereiopod IV; H, pereiopod V. Scale bars = 5 mm.

Description. – Body robust, rough, stone-like, with teeth and tubercles generally high and sharp. Rostrum (Fig. 1A) narrow and terminates into a distinct tubercle. Pregastric tooth absent, replaced by a pair of sharp tubercle. Anterior submedian ridge composed of 3–4 tubercles in oblique row. Gastric tooth (Fig. 1B) strong and directed anterodistally, followed posteriorly by 4 transverse rows of tubercles, anterior 3 rows with 4 tubercles and anteriormost row smallest, last row with 2 larger tubercles and distinctly separated from other tubercles. Cardiac tooth highly elevated, blunt, sometimes bifurcated, with pair of sharp tubercles in front and double rows of 4–5 tubercles behind it. Posterior submedian carina oblique, usually long, extending near to posterior carina, bearing 5–6 tubercles, anteriorly with one small tubercle. Two to three extra tubercles present between posterior submedian and postrostral carinae. Anterior and posterior branchial carinae separated far apart by the cervical groove; anterior branchial carina anteriorly terminated into 2 distinct teeth; posterior branchial carina terminated into 1 distinct tooth, followed posteriorly by double rows of 7–9 sharp tubercles. Four to five rounded intermediate tubercles present; 1 large blunt tubercle present between intermediate tubercles and posterior submedian carina. Lateral margin of the carapace with 4 anterolateral, 3–4 mediolateral and 2 rows of 11–13 posterolateral teeth. 3–4 larger tubercles present between posterolateral margin and posterior branchial carina. Postorbital carina with 1–2 tubercles. Intercervical carina longitudinal and with 4–5 tubercles. Marginal groove along posterior margin of carapace wide and deep; anterior margin with transverse row of distinct but unequal tubercles, of which 2 submedian tubercles largest; posterior margin also with transverse row of distinct tubercles. Posterior margin of carapace distinctly incised medially.

Anterior margin of thoracic sternum (Fig. 1C) deeply U-shaped and medially incised; lateral border highly elevated and ridged, with 2 distinct anterolateral teeth. Median tubercle present at anterior half of thoracic sternites II to V, that on sternite II often weak and sometimes absent. Lateral borders of thoracic sternum distinctly ridges and lobulated.

Abdomen (Fig. 2 E, H) with wide transverse grooves. Tergite I smooth except for lateral median transverse groove. Articulated part of tergites II to V smooth. Non-articulated parts of tergites II to V with distinct median carina, highly elevated and lobulated in tergites II to IV, highest and large hump-like in tergite III, those of tergites II and IV more or less similar high and about half in height and size as that of tergite III, that of tergite V not elevated and slightly lobulated. Transverse ridges on articulated parts of tergites nearly smooth or faintly lobulated in tergite II, somewhat lobulated in tergite III and distinctly lobulated in tergites IV and V. Posterior margins of tergites I and II smooth, distinctly incised medially. Posterior margin of tergite III smooth to faintly crenulate, medially overhung by large hump. Posterior margin of tergite IV smooth, not serrated, medially overhung by longitudinal carina. Posterior margins of tergites V and VI with about 6 tubercles and a median spine. Pleuron I very short and sharply lobulated. Pleura II to V broad, bluntly pointed ventrally, with tuberculated median carina as well as some additional tubercles, posterior margins crenulate to serrated. Calcified part of telson with 2 pairs of tubercles, anterior pair at submedian region, posterior pair wider apart than anterior pair; posterior margin bearing 2 pairs of teeth, outer pair broad and bluntly triangular, inner pair smaller but sharper and narrower.

Anterior margin of antennular somite (Fig. 1A) nearly straight but with a pair of blunt tooth laterally.

Antenna (Fig. 2B) with anterior margin of the segment VI (last segment) with 5–6 long, rounded teeth and one inner short tooth, incisions and space between teeth rather deep and wide. Antero-internal angle of segment V ending in two teeth, inner tooth bearing dorsal carina behind. Segment IV with anterior margin having 7–9 teeth, inner second tooth largest; outer margin of this segment bearing 4–5 distinct teeth, each of which with indistinct dorsal carina; dorsal surface with strong, sharp and oblique median carina; one short row of tubercles arranged like weak ridge at near outer margin of segment.

Pereiopod I (Fig. 1D) short but more robust than other pereiopods; propodus glabrous dorsally. Dactylus of pereiopod II (Fig. 1E) longest in all pereiopods. Dactyli of pereiopods I and II naked, those of pereiopods III to V (Fig. 1F–H) with short pubescence at basal part as well as at proximal part of dorsal surface. Propodus of pereiopod III as broad as that of pereiopod II but wider than that of pereiopod IV. Pereiopods III to V with fringes of dorsal setae from propodi to meri.

Eggs numerous and small, about 0.45–0.55 mm in diameter (not eyed).

Colouration. – Body generally red-brown to dark brown, tips of tubercles and teeth somewhat lighter in colour (Fig. 3). A large V-shaped white mark (occasionally with some orange-yellow colour in front) often present on dorsal carapace anterior to cervical groove. Branchial region sometimes whitish. Eyes light brown. Long teeth on antennal segment VI whitish. Legs banded with white and brown. Articulated part of abdominal tergite I whitish with large dark brown median circular spot, sometimes junction of articulated and non-articulated parts orange-yellow. Abdominal somite VI and tail-fan whitish, sometimes parts of other abdominal somites (including pleura) also whitish, but abdominal tergite III always brownish and occasionally even with dorsal hump somewhat purplish.

Distribution. – Known only from the Philippines (type locality) and Vanuatu, from depths of about 80–300 m.

Etymology. – This species is named after L. B. Holthuis, the greatest carcinologist of our time and for his many significant contributions to lobster taxonomy, and in particular, the Scyllarinae. This new species is named in memory of the passing of this great giant in carcincology early this year (2008).

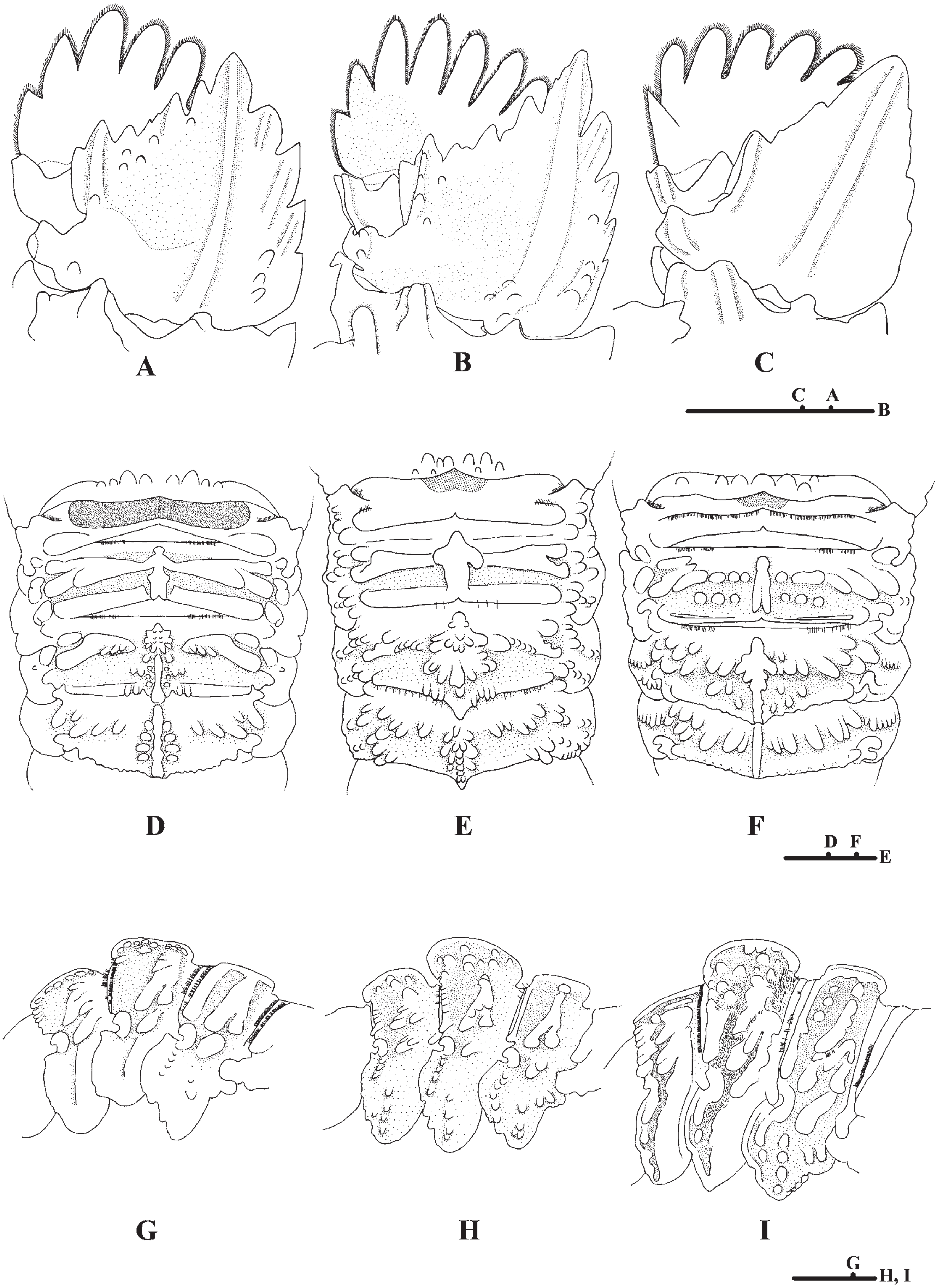

Fig. 2. A, D, G, *Petrarctus rugosus*, Taiwan, NTOU, female 23.5 mm cl; B, E, H, *P. holthuisi*, new species, holotype, NMCR, female 17.0 mm cl; C, F, I, *P. demani*, Thailand, NTOU M00734, male, 19.8 mm cl. A–C, right antenna, dorsal; D–F, abdominal somites I–IV, dorsal; G-I, abdominal somites II–IV, lateral. Scale bars = 5 mm.

Fig. 3. *Petrarctus holthuisi*, new species. A, holotype, NMCR, female 17.0 mm cl, dorsal; B, AURORA 2007, Stn. CP 2747, NTOU, female 14.2 mm cl; C–D, PANGLAO 2004, Stn. T38, C, dorsal view, D, lateral view.

***Remarks.* –** *Petrarctus holthuisi*, new species, appears to be intermediate between *P. rugosus* and *P. demani* (Fig. 2), but the presence of a large dark circular spot on abdominal somite I aligns it with *P. demani* (Fig. 2E, F). However, morphologically it is generally more similar to *P. rugosus*, which has the articulated part of the abdominal somite I bright blue and without any dark spot (Fig. 2D; Chan & Yu, 1986, 1992). *Petrarctus demani* differs from *P. rugosus* and *P. holthuisi*, new species, in: (1) the absence of tubercle from the position of the pregastric tooth (Holthuis, 2002: fig. 18A); (2) short posterior submedian carina that is far apart from the posterior carina of the carapace (Holthuis, 1946: pl. 9a); (3) short and obtuse anterior teeth of the antennal segment VI (Fig. 2C); (4) a straight median ridge of the antennal segment IV, which lacks tubercles from the outer part and large teeth from the outer margin (Fig. 2C); (5) a "V"-shaped anterior margin of thoracic sternum that lacks median incision and additional tooth or tubercle behind the "V"-shaped tips (Holthuis, 1946: pl. 8b); and (6) strongly lobulated transverse ridges of abdominal tergites II and III, dorsal hump of abdominal somite III is medially incised posteriorly, and dorsal carina of abdominal somite IV is not elevated nor lobulated (Fig. 2F, I).

Petrarctus holthuisi, new species, can readily be separated from *P. rugosus* by the following characters: (1) anterior and posterior branchial carinae are separated far apart (Fig. 1A, vs. very close in *P. rugosus*, Holthuis, 2002: fig. 12A); (2) lateral borders of the thoracic sternum are distinctly ridged and lobulated (Fig. 1C, vs. not ridged and somewhat eroded in *P. rogusus*, Holthuis, 2002: fig. 13B); (3) the posterior margin of the abdominal somites I and II are distinctly incised medially (Fig. 2E, vs. broadly incised in *P. rugosus*, Fig. 2D); (4) transverse ridges of the abdominal tergite II are faintly lobulated and those of the tergite III are distinctly lobulated (Fig. 2E, vs. smooth in tergite II and faintly lobulated in tergite III in *P. rugosus*, Fig. 2D); (5) the posterior margin of the abdominal tergite IV is smooth and not serrated (Fig. 2E, vs. distinctly serrated in *P. rugosus*, Fig. 2D); and (6) the surfaces of the abdominal pleura II to V bear distinct tubercles (Fig. 2H, vs. nearly smooth or only faintly tuberculate in *P. rugosus*, Fig. 2G). Moreover, *P. holthuisi*, new species, generally has the tubercles on the body sharper and the lateral ridges of the thoracic sternum more distinct than those of *P. rugosus* and *P. demani*. The distance between the anterior and posterior branchial carinae is also wider in *P. holthuisi*, new species, as compared to *P. demani*. The most obvious character separating *P. holthuisi*, new species, from *P. rugosus* and *P. demani* is the posterior margin of the abdominal tergite IV being smooth in *P. holthuisi*, new species, (Fig. 2E) but serrated in both *P. rugosus* and *P. demani* (Fig. 2D, F). The *P. demani* specimens examined in the present study still have a dark circular spot on the abdominal somite I and with the pereiopods covered with dark bands. On the other hand, the dark median spot on the abdominal somite I in *P. holthuisi*, new species, has more or less faded away after preservation. Thus, it is possible that preserved specimens of *P. holthuisi*, new species, have a generally appearance similar to *P. rugosus*. All the Philippines and Vanuatu material in the present study contained only *P. holthuisi*, new species, and no *P. rugosus* was found. Therefore, the *P. rugosus* specimens reported from the Philippines and Vanuatu by Holthuis (2002) will need to be re-examined to confirm their identities.

Arctus tuberculatus Bate, 1888, is generally considered as a junior synonymn of *P. rugosus* (see Holthuis, 2002). The type locality of *A. tuberculatus* is the Arafura Sea, which is in between the Philippines and Vanuatu. Nevertheless, the original figures of *A. tuberculatus*, given by Bate (1888), shows diagnostic characters of *P. rugosus*, i.e. a short gap between anterior and posterior branchial carinae; distinctly serrated abdominal tergite IV; and not-tuberculate abdominal pleura. This suggests that *A. tuberculatus* is very likely a junior synonym of *P. rugosus*. The following is a key to the five species of *Petrarctu*s.

Key to *Petrarctus* species

1. Antennal segment IV with median ridge straight, outer margin only with about 5 serrations and without large teeth; anterior teeth of antennal segment VI short, dorsal carina on abdominal tergite IV not lobulated nor elevated; articulated part of abdominal somite I with large dark circular median spot .... *P. demani*

– Antennal segment IV with median ridge oblique or curved, outer margin with 2–5 large teeth; anterior teeth of antennal segment VI long, dorsal carina on abdominal tergite IV distinctly long, sometimes also highly elevated 2

2. Dorsal carina on abdominal somite III not highly elevated; carpus of pereiopod III armed with a large distal spine; articulated part of abdominal somite I bright blue .... *P. brevicornis*

– Dorsal carina on abdominal somite III highly elevated and hump-like; carpus of pereiopod III without distal spine 3

3. Cardiac tooth huge, transverse ridges of abdominal tergite II distinctly lobulated; dorsal carinae of abdominal somites III and IV similar high; articulated part of abdominal somite I with large dark circular median spot .... *P. veliger*

– Cardiac tooth low to moderately large; transverse ridges of abdominal tergite II more or less smooth; dorsal carina of abdominal somite III much higher than that of somite IV... 4

4. Anterior end of posterior branchial carina almost reaching posterior end of anterior branchial carina; lateral borders of thoracic sternum not ridged and somewhat eroded; posterior margin of abdominal tergite IV distinctly serrated; articulated part of abdominal somite I bright blue .... *P. rugosus*

– Anterior end of posterior branchial carina far separated from posterior end of anterior branchial carina; lateral borders of thoracic sternum distinctly ridged and lobulated; posterior margin of abdominal tergite IV smooth; articulated part of abdominal somite I with large dark circular median spot .... *P. holthuisi*, new species

MOLECULAR DATA AND SEQUENCE COMPARISONS

658 basepairs fragments of COI gene were amplified. Except for *P. brevicornis*, more than two individuals of *Petrarctus* species were analyzed in this study (Table 1). Ten operational taxonomic units (OTUs) and two outgroups (*A. mawsoni* and *B. chani*) were included in the molecular

Table 1. Specimens used for molecular analysis.

Species	Locality	Number of individuals	Voucher numbers	Genbank accession numbers
Petrarctus holthuisi, new species	Philippines, PANGLAO 2004 Stn. PN1	1	NTOU M00735	EU982695
Petrarctus holthuisi, new species	Vanuatu, SANTO 2006 Stn. AT4	1	NTOU M00736	EU982696
Petrarctus rugosus	Taiwan, Cijin fishing port, Kaohsiung City	1	NTOU M00737	EU982697
Petrarctus rugosus	Indonesia, ANAMBAS Stn. EA-TT04	1	NTOU M00738	EU982698
Petrarctus veliger	Thailand: Phuket fishing port	1	NTOU M00739	EU982699
Petrarctus veliger	Philippines: Balicasag Island	1	NTOU M00740	EU982700
Petrarctus brevicornis	Taiwan: Dasi fishing port, Yilan County	1	NTOU M00741	EU982701
Petrarctus demani	Thailand: Pattani fishing port	3	NTOU M00734	EU982694
Antarctus mawsoni	Australia: Victoria	1	NTOU M00742	EU982702
Bathyarctus chani	Taiwan: Nannfang-ao fishing port, Yilan County	1	NTOU M00059	EU982703

Table 2. Nucleotide divergence based on 658 bps of mitochondrial cytochrome c oxidase I gene.

	Phol1	Phol2	Prug1	Prug2	Pvel1	Pvel2	Pbre	Pdem	Amaw	Bcha
Phol1	*									
Phol2	0.017	*								
Prug1	0.132	0.129	*							
Prug2	0.128	0.125	0.009	*						
Pvel1	0.163	0.151	0.151	0.143	*					
Pvel2	0.169	0.158	0.149	0.141	0.038	*				
Pbre	0.189	0.193	0.184	0.179	0.167	0.160	*			
Pdem	0.196	0.202	0.201	0.199	0.223	0.222	0.193	*		
Amaw	0.193	0.198	0.167	0.169	0.185	0.182	0.195	0.211	*	
Bcha	0.190	0.195	0.207	0.201	0.196	0.192	0.216	0.216	0.210	*

Phol1, *P. holthuisi*, new species; Philippines; Phol2, *P. holthuisi*, new species; Vanuatu; Prug1, *P. rugosus*; Taiwan; Prug2, *P. rugosus*; Indonesia; Pvel1, *P. veliger*; Thailand; Pvel2, *P. veliger*; Philippines; Pbre, *P. brevicornis*; Pdem, *P. demani*; Amaw, *Antarctus mawsoni*; Bcha, *Bathyarctus chani*.

analysis. Sequences have been deposited with GenBank. The Hasegawa-Kishino-Yano (HKY) model (Hasegawa et al., 1985) with a proportion of invariable sites (I=0.5882) and with a variable sites gamma distribution shape parameter (G=0.9327), "HKY+I+G", was a best-fit model. The number of substitution types (nst) = 2 for the data set was selected by Akaike Information Criterion (AIC) in MrModeltest 2.2. The resulted Bayesian tree is shown in Fig. 4.

The nucleotide divergence of *P. demani* specimens from the same locality was 0%. Specimens of the same species but from different localities have sequence divergences varying from 0.9 (in *P. rugosus* between Taiwan and Indonesia) to 3.8% (in *P. veliger* between Thailand and Philippines) (Table 2). At a species level, *P. holthuisi* shows the shortest divergence distance (12.5–13.2%) with *P. rugosus*. This great sequence divergences in COI are generally considered as of interspecific (Ravago & Juinio-Meñez, 2002; Hualkasin et al., 2003; Munasinghe et al., 2003; Quan et al., 2004) or even generic (De Francisco & Galetti, 2005) differences in decapod crustaceans. It is interesting to note that the nucleotide divergences of *P. demani* and *P. brevicornis* from the other species of the genus (16.0–22.3%) are even higher than that between *A. mawsoni* and the latter species (16.6–19.8%). The nucleotide divergences of *P. demani* from *P. rugosus*/ *P. holthuisi*/ *P. veliger* (19.6–22.3%) are even comparable to that between *B. chani* and the latter species (19.0–20.4%). Moreover, *P. holthuisi* has the row of tubercles at the outer part of the antennal segment IV somewhat carina-like (Figs. 1A, 2B), which is similar to one of the diagnostic characters of *Antarctus* (i.e. antennal segment IV with a distinct additional carina at outer half of upper surface). This suggests that some of the generic separations of *Scyllarus* sensu lato by Holthuis (2002) may not be natural and an extensive molecular genetic analysis on the Scyllarinae will be necessary to fully understand the phylogenetic relationship of the species in this group.

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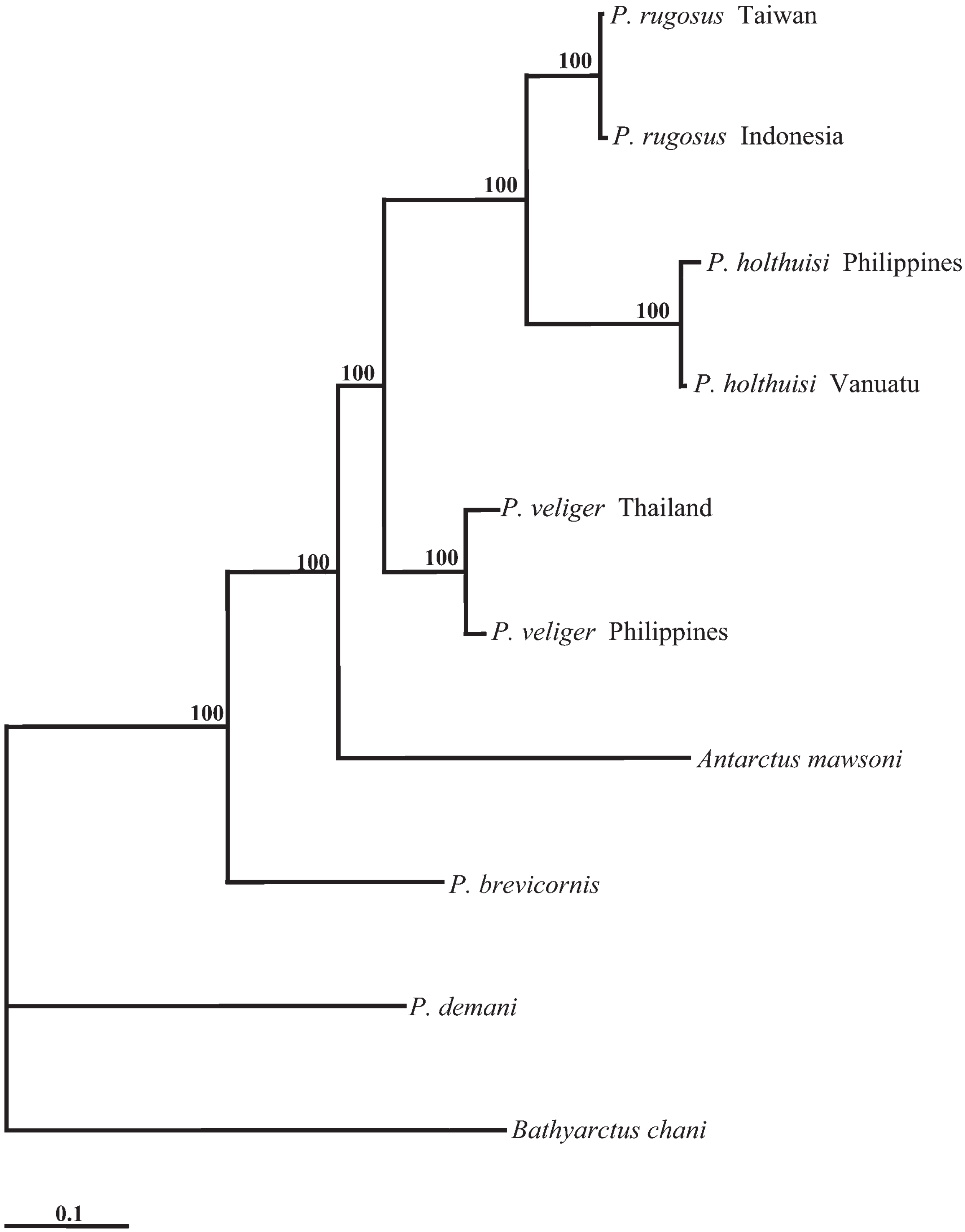

Fig. 4. Bayesian phylogenetic tree from COI gene data set among *Petrarctus* species and outgroups basing on the best-fit model (HKY+I+G). Numbers above branches were supplied by posterior probability from Bayesian inference.

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