Recognizing two new Hippolyte species (Decapoda, Caridea, Hippolytidae) from the South China Sea based on integrative taxonomy

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Hippolyte shrimps exhibit abundant biological diversity and display great ecological significance in seaweed bed ecosystems. Dozens of Hippolyte specimens were collected from Hainan Island and the Xisha Islands in the South China Sea. Detailed examination indicates that some of these specimens represent new Hippolyte species. Based on morphological, genetic, and ecological data, H. chacei sp. nov. and H. nanhaiensis sp. nov. are described. H. chacei sp. nov. was collected from the Sargassum sp. biotope in Hainan Island and is distinguished from congeners by its unique mandible and the dactylus of the third to fifth pereiopods; this species has a basal position in the Indo-West Pacific species clade in the phylogenetic tree which is reconstructed based on 16S rRNA gene. H. nanhaiensis sp. nov. was collected from the biotopes of Galaxaura sp. or Halimeda sp. in the Xisha Islands, and it differs from congeners in series of characters associated with rostrum, scaphocerite, antennular peduncle, and spines on the dactylus of the third to fifth pereiopods. Additionally, it is sister to H. australiensis in the phylogenetic tree. A key to identify mature female Hippolyte species of the Indo-West Pacific and neighboring seas is provided.
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Abstract
*Hippolyte* shrimps exhibit abundant biological diversity and display great ecological significance in seaweed bed ecosystems. Dozens of *Hippolyte* specimens were collected from Hainan Island and the Xisha Islands in the South China Sea. Detailed examination indicates that some of these specimens represent new *Hippolyte* species. Based on morphological, genetic, and ecological data, *H. chacei* sp. nov. and *H. nanhaiensis* sp. nov. are described. *H. chacei* sp. nov. was collected from the *Sargassum* sp. biotope in Hainan Island and is distinguished from congeners by its unique mandible and the dactylus of the third to fifth pereiopods; this species has a basal position in the Indo-West Pacific species clade in the phylogenetic tree which is reconstructed based on 16S rRNA gene. *H. nanhaiensis* sp. nov. was collected from the biotopes of *Galaxaura* sp. or *Halimeda* sp. in the Xisha Islands, and it differs from congeners in series of characters associated with rostrum, scaphocerite, antennular peduncle, and spines on the dactylus of the third to fifth pereiopods. Additionally, it is sister to *H. australiensis* in the phylogenetic tree. A key to identify mature female *Hippolyte* species of the Indo-West Pacific and neighboring seas is provided.

Introduction
Shrimps of the genus *Hippolyte* Leach, 1814 display high diversity in morphology, coloration, and ecological habits. They occur mainly in tropical and temperate oceans, although some species, such as *H. varians* Leach, 1814, are known from the Arctic Circle (D’Udekem d’Acoz,
2007). Most Hippolyte species inhabit seaweed beds, but some are obligate or facultative symbionts of other organisms, such as gorgonians and crinoids (D’Udekem d’Acoz, 2007; Marin et al., 2011). The taxonomy, phylogeny, and biology of Hippolyte taxa have attracted considerable attention in recent years (Manjón-Cabeza et al., 2011; Marin et al., 2011; Terossi & Mantelatto, 2012; Liasko et al., 2015; Duarte & Flores, 2017; Duarte et al., 2017; Gan & Li, 2017a; 2017b; Liasko et al., 2017; Terossi et al., 2017). Currently, a total of 35 valid species are recognized worldwide (D’Udekem d’Acoz, 1996; 2007; De Grave & Fransen, 2011; Marin et al., 2011; Gan & Li, 2017a, 2017b; Terossi et al., 2017), of which about 12 species occur in the Indo-West Pacific region. Additional unnamed and cryptic species have been reported (Hayashi, 1986; D’Udekem d’Acoz, 1996; 2007; Terossi et al., 2017).

Due to its morphological diversity and characters overlap, and the complexity of information in published literature, taxonomic research of Hippolyte based on morphological characters is difficult (D’Udekem d’Acoz, 1996; Gan & Li, 2017a). The situation is particularly complicated in a complex of species referred to ‘H. ventricosa H. Milne Edwards, 1837’, including: H. acuta (Stimpson, 1860), H. australiensis (Stimpson, 1860), H. ngi Gan & Li, 2017, H. singaporenensis Gan & Li, 2017, H. ventricosa H. Milne Edwards, 1837, and Hippolyte sp. A from Australia, Hippolyte sp. B from Hawaii, Hippolyte sp. C from the Malay Archipelago, and Hippolyte sp. D from Madagascar (D’Udekem d’Acoz, 1996; Gan & Li, 2017a, 2017b). Genetic analysis (Terossi et al., 2017) has also recently detected four cryptic or pseudocryptic species referred to: H. ventricosa group-sp. 1 and sp. 2 from Indonesia, H. ventricosa group-sp. 3 from Fiji, and H. ventricosa group-sp. 4 from Taiwan, all with morphological features closely similar to H. ventricosa redescribed by D’Udekem d’Acoz (1999).

During recent biodiversity surveys of the Hainan and Xisha islands (2014–2018) in the South China Sea, dozens of Hippolyte specimens were collected. After detailed examination and multiple analyses, we described two new species of the ‘H. ventricosa H. Milne Edwards, 1837’ species complex based on integrative methods.

Materials & Methods
Sample collection and morphological examination. The information on biodiversity surveys are listed in Table 1. Although seaweed beds and coral reefs were sampled, species of Hippolyte were found only among algae and sea grass (Sargassum sp., Zostera sp., Galaxaura sp., and Halimeda sp.). All specimens were collected using handheld nets while snorkeling. After being photographed, specimens were preserved in 95% ethanol. Dissection and illustrations were carried out using Nikon stereo- and compound microscopes (SMZ 1500 and AZ100). Measurements and length ratios were calculated following D’Udekem d’Acoz (1996). All specimens are deposited in the Marine Biological Museum of the Chinese Academy of Sciences (MBM), in the Institute of Oceanology of Chinese Academy of Sciences, Qingdao, China (IOCAS).

Molecular data and analysis. Total genomic DNA was extracted from pleopods of specimens using a QIAamp DNA Mini Kit (QIAGEN, Germany), following manufacturer
instructions. Extracted DNA was eluted in 100 μl of double-distilled H₂O (ddH₂O). Partial sequences of 16S rRNA genes were amplified from the diluted DNA via polymerase chain reaction (PCR). Reactions were carried out in a 50-μl volume containing: 25 μl Premix Taq (TaKaRa Taq™ Version 2.0 plus dye, Japan), 1 μl each of forward and reverse primers (10 μM) respectively, 3 μl DNA template, and 20 μl ddH₂O. Primers 16S-AR/1472 (5’-CGCCTGTTTATCAAAAACAT-3’/5’-AGATAGAAACCAACCTGG-3’) was used (Crandall & Fitzpatrick, 1996). The PCR profile involved: 3 min at 94°C for initial denaturation, 35 cycles of denaturation at 94°C for 30 s, annealing at 52°C for 40 s, elongation at 72°C for 50 s, and final extension at 72°C for 10 min. PCR products were purified using a QIAquick Gel Extraction Kit (QIAGEN, Germany), and bidirectionally sequenced using the same primers with an ABI 3730xl Analyzer (Applied Biosystems, USA). Sequences were checked and proofread by ContigExpress 6.0 (a component of the Vector NTI Suite 6.0).

In addition to sequences obtained by PCR (Table 2, Dataset S1), we downloaded Hippolyte sequences from Genbank, including those previously reported cryptic or pseudocryptic taxa namely H. ventricosa group-sp. 1 (KX588914), H. ventricosa group-sp. 2 (KX588915), H. ventricosa group-sp. 3 (KX588915), and H. ventricosa group-sp. 4 (KX588915) of Terossi et al. (2017), and H. ventricosa group-sp. 5 (KF023090) of De Grave et al. (2014).

Molecular data (Dataset S2), including 37 sequences of 16S rRNA genes, were aligned using MUSCLE 3.8 (Edgar, 2004). Highly divergent and poorly aligned sites were omitted from alignment according to Gblocks 0.91b (Castresana, 2000). The best-fitting nucleotide base substitution model (GTR+I+G) for the alignment data was determined by Modeltest 3.7 (Posada & Crandall, 1998). A maximum likelihood (ML) tree was constructed using PhyML 3.1 (Guindon & Gascuel, 2003) with 1000 bootstrap reiterations. A Bayesian inference (BI) tree was constructed using MrBayes 3.2 (Huelsenbeck & Ronquist, 2001). Markov chains were run for 2,000,000 generations, sampled every 2,000 generations; the first 25% trees were discarded as burn-in, after which remaining trees were used to construct the 50% majority-rule consensus tree and to estimate posterior probabilities. Genetic distances were calculated using the Kimura 2-parameter (K2P) model in MEGA 7.0 (Kumar et al., 2016).

**Ecological data.** The biotope (mainly the algal colony) in which a shrimp lived was recorded on capture.

The following abbreviations are used: CL, carapace length, the length from the posterior orbital margin to the posterior dorsal border of the carapace; Coll., collector (s).

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Results

Taxonomy

Order Decapoda Latreille, 1802

Family Hippolytidae Spence Bate, 1888

Genus Hippolyte Leach, 1814

Hippolyte chacei sp. nov.

(Figs. 1–4, 5A)

Material examined. Holotype: MBM285015, non-ovigerous female, 3.3 mm CL, Hongtang bay, Hainan Island, northern South China Sea, 1–3 m, Coll. Z B, Gan, 25 March 2018 (GenBank accession number of 16S rRNA gene: MK231007). Paratypes: MBM285016, 1 male, 2.3 mm CL, same collection data as holotype (GenBank accession number of 16S rRNA gene: MK231008); MBM285017, 2 non-ovigerous female, 2.7–3.0 mm CL, Houhai bay, Hainan Island, northern South China Sea, 2–3 m, Coll. Z B. Gan, 22 March 2018.

Description. Outline robust (Fig. 1). Ratio lateral length/height of carapace 1.56–1.72. Rostrum long, slightly shorter than carapace, distinctly overreaching antennular peduncle, nearly reaching to the end of scaphocerite. Rostrum without lateral carina, superior border slightly concaved, unarmed in the female specimens (Fig. 2A,B) and armed with only one proximal tooth in the male specimen (Fig. 2C); inferior border slightly convex, armed with 4 teeth in the distal half length. Carapace smooth and glabrous, location of supraorbital spine behind of the posterior orbital margin; tip of antennal spine slightly overreaching inferior orbital angle; tip of hepatic spine falling short of anterior edge of carapace. Inferior orbital angle strongly produced, knob-like (Fig. 2B,D). Branchiostegal margin with a distinct notch. Pterygostomial region rounded, strongly produced (Fig. 1,2B).

Abdominal segments smooth (Fig. 1). Third abdominal segment geniculately curved. Ratio dorsal length/height of the sixth abdominal segment 1.95–2.10. Telson (Fig. 2E) longer than the sixth abdominal segment, posterior margin rounded, armed with 8 strong spines, outer spines smallest, medial two longest, without intermediate spine or seta; dorsal surface armed with 2 pairs of spines situated on distal 0.31–0.35 and 0.59–0.63 telson length.

Eye (Fig. 2A) well developed, tip of cornea nearly reaching to the end of first segment of antennular peduncle when extended forward; unpigmented part of eyestalk longer than broad; cornea semispherical, distinctly shorter than unpigmented part of eyestalk.

Antennular peduncle (Fig. 2F) slightly overreaching mid-length of scaphocerite. First segment of antennular peduncle with one well developed distolateral tooth, inner ventral tooth (Fig. 2G) on 0.47–0.50 of first segment (excluding distolateral tooth). Stylocerite robust, reaching to 0.56–0.62 (distolateral tooth included), or 0.69–0.75 (distolateral tooth excluded) of first segment. Second segment of antennular peduncle 0.81–0.86 times as long as broad in dorsal view, approximately 0.86–0.98 times as long as third segment in dorsal view. Outer antennular flagellum shorter than inner one and proximal 6–8 segments thicker than distal ones.
Scaphocerite (Fig. 2H) 3.06–3.18 times as long as wide, distolateral spine of scaphocerite far from reaching distal margin of blade, distolateral spine and blade separated by a distinct notch.

Mandible (Fig. 3A,B) without palp, incisor process with 15–17 acute teeth. Maxillula (Fig. 3C) with broad curved palp, distal margin of upper lacinia armed with 14–18 spines and scattered simple long setae. Maxilla (Fig. 3D) with short palp, scaphognathite broad and long, lateral border nearly straight; inner lacinia bilobed, distal margin furnished with row of spines and long plumose setae; proximal endite round, with long setae on distal margin. Epipod of first maxilliped (Fig. 3E) slightly bilobed; endopod broad, with distal long setae; exopod well-developed, caridean lobe broad. Second maxilliped (Fig. 3F) with well-developed exopod, flagelliform; endopod normal, dactylar segment oval, terminal margin furnished with simple and spinous setae; propodal segment with anteromedial margin round, bearing simple setae; carpus broader than long, shorter than merus; ischium and basis fused. Third maxilliped (Fig. 3G) reaching to 0.32–0.39 of scaphocerite when extended forward; exopod relatively short, only reaching to the mid-length of antepenultimate segment of endopod; ultimate segment (excluding apical spine) of endopod 1.23–1.32 times as long as penultimate segment, distal half armed with 7–9 strong spines; antepenultimate segment nearly equal length to the last two segments combined.

First pereiopod (Fig. 4A) shortest among pereiopods, robust and oblique, reaching to the end of basicerite when extended forward. Ventral margin of ischium, merus and carpus furnished with long simple setae. Terminal margin of carpus cotylloid. Cutting edges of chela non-denticulate, outer margin of fingers with long simple setae, tip of fingers armed with 3 acute spines respectively (Fig. 4B).

Second pereiopod (Fig. 4C) slightly overreaching the end of third maxilliped when extended forward. Carpus with 3 subsegments, first subsegment 1.70–1.85 times as long as second subsegment, third subsegment slightly longer than or subequal to first subsegment; first subsegment 2.45–2.56 times as long as wide, second subsegment 1.08–1.12 times as long as wide, third subsegment 2.06–2.12 times as long as wide. Cutting edges of chela not denticulate, outer margin of fingers with long simple setae, tip of fixed finger and dactylus armed with 3 acute spines respectively (Fig. 4D).

Third to fifth pereiopods long and robust. Third pereiopod (Fig. 4E) reaching to the distolateral spine of scaphocerite when extended forward; dactylus with 13–16 spines, the last 2–3 subdorsal spines distinctly shorter than the neighbouring ones (Fig. 4F); propodus 5.56–5.62 times as long as wide, armed with 6–7 pairs of spines on ventral margin; carpus 2.66–2.73 times as long as wide, armed with one proximal lateral spine; merus 5.58–5.62 times as long as wide, armed with 3 lateral spines. Ratio length of third pereiopod dactylus with longest apical spine/length of propodus 0.45–0.49; ratio length of third pereiopod dactylus with longest apical spine/length of carpus 0.79–0.83; ratio length of dactylus without spines/breadth of dactylus without spines 2.61–2.69; ratio length of dactylus with longest spines/breadth of dactylus without spines 2.95–3.10; ratio length of longest spine of dactylus/breadth of dactylus without spines 0.62–0.71; ratio length of longest spine of dactylus/length of dactylus without spines 0.22–0.28.
Third pereiopod (Fig. 4G,H) of male specimen with propodus and dactylus forming a prehensile apparatus. Fourth and fifth pereiopods (Fig. 4I,J,K,L) similar in shape to third pereiopod of female specimen, but slightly decreasing in size. Merus of fourth pereiopod armed with 2 lateral spines; merus of fifth pereiopod without lateral spine.

First pleopod (Fig. 4M) of female specimen normal, endopod about 0.54–0.62 times as long as exopod. First pleopod (Fig. 4N) of male specimen with endopod about 0.41–0.46 times as long as exopod. Second pleopod (Fig. 4O) of male specimen with endopod about 0.81–0.89 times as long as exopod, appendix masculina with 9 apical setae, about 0.39–0.43 times as long as appendix interna (Fig. 4P).

Coloration. Generally light brown over body (Fig. 5A), with few tawny stripes on carapace and faint tawny spots on abdomen.

Biotope. All specimens were captured among gulfweed (Sargassum sp.) at depths of 1–3 m. Numerous Hippolyte cf. ventricosa were captured simultaneously.

Distribution. Hongtang and Houhai bays, Hainan Island, northern South China Sea. Presumably, this species also occurs in Malayan Archipelago and Madagascar (see discussion).

Etymology. The new species is named after Dr. Fenner A. Chace, Jr. in recognition of his great contribution to the crustacean taxonomy.

**Hippolyte nanhaiensis** sp. nov.

(Figs. 6–9, 5B–E)

Material examined. Holotype: MBM285018, ovigerous female, 1.6 mm CL, Ganquan Island, Xisha Islands, the South China Sea, 1–3 m, Coll. Z B, Gan, 15 May 2015 (GenBank accession number of 16S rRNA gene: MK231005). Paratypes: MBM285019, 1 male, 1.1 mm CL, same collection data as holotype (GenBank accession number of 16S rRNA gene: MK231006); MBM189210, 4 ovigerous female, 1.3–1.6 mm CL, 2 female, 1.2–1.3 mm CL, 2 male, 0.9–1.1 mm CL, 1 juvenile 0.6 mm CL, same collection data as holotype; MBM189211, 19 ovigerous female, 1.3–1.9 mm CL, 6 female, 1.0–1.4 mm CL, 5 male, 0.8–1.1 mm CL, 5 juvenile 0.6-0.8 mm CL, Bei Island, Xisha Islands, the South China Sea, 1–3 m, Coll. Z B. Gan, 13 May 2015.

Description. Outline stout (Fig. 6). Ratio lateral length/height of carapace 1.49–1.58. Rostrum distinctly shorter than carapace, reaching to or slightly overreaching the end of antennular peduncle. Rostrum without lateral carina, superior border straight, armed with 1 or 2 teeth in proximal position (Fig. 7A–D); inferior border armed with 1 subdistal tooth in female specimens (Fig. 7C), unarmed or only with a tiny distal notch in male specimens (Fig. 7D). Carapace smooth and glabrous. Location of supraorbital spine behind of the posterior orbital margin. Antennal spine small, slightly overreaching inferior orbital angle. Hepatic spine reaching to or slightly overreaching anterior edge of carapace. Inferior orbital angle produced, knob-like (Fig. 7B,C). Branchiostegal margin sinuous. Pterygostomian region rounded, strongly produced (Fig. 7C).

Abdominal segments smooth (Fig. 6), without or with few long plumose setae on tergum. Third abdominal segment geniculately curved. Ratio dorsal length/height of the sixth abdominal segment 1.91–2.08. Telson (Fig. 7E) longer than sixth abdominal segment, posterior margin
rounded, armed with 8 strong spines, outer spines smallest, medial two longest, without or with 2
intermediate long plumose setae; dorsal surface armed with 2 pairs of spines situated on distal
0.21–0.26 and 0.43–0.49 telson length.

Eye (Fig. 7A) well developed, tip of cornea falling short of the first segment of antennular
peduncle when extended forward; unpigmented part of eyestalk slightly longer than broad;
cornea semispherical, slightly shorter than unpigmented part of eyestalk.

Antennular peduncle (Fig. 7F) distinctly overreaching mid-length of scaphocerite. First
segment of antennular peduncle with one distolateral tooth; inner ventral tooth (Fig. 7G) on
0.59–0.66 of first segment (excluding distolateral tooth), small. Stylocerite robust, reaching to
0.86–0.92 (distolateral tooth included), or 0.76–0.81 (distolateral tooth excluded) of first
segment. Second segment of antennular peduncle 0.88–0.96 times as long as broad in dorsal
view, 0.83–0.95 times as long as third segment. Outer antennular flagellum shorter than inner
one and proximal 7–9 segments thicker than distal ones. Scaphocerite (Fig. 7H) 2.19–2.38 times
as long as wide, distolateral spine of scaphocerite far from reaching distal margin of blade,
distolateral spine and blade separated by a notch.

Mouthparts with morphology typical for the genus *Hippolyte*. Mandible (Fig. 8A) without
palp, incisor process with 5 acute teeth. Maxillula (Fig. 8B) with curved palp, distal margin of
upper lacinia armed with 8–10 spines and 2 long plumose setae. Maxilla (Fig. 8C) with short
palp; scaphognathite broad in upper half and narrow in lower half, lateral border nearly straight;
inner lacinia bilobed, distal margin furnished with spinous setae; proximal endite round, with
long plumose setae on distal margin. Endopod of first maxilliped (Fig. 8D) slender, with long
plumose setae; exopod with feeble caridean lobe on base. Second maxilliped (Fig. 8E) with well-
developed exopod, flagelliform; endopod normal, dactylar segment arched, terminal margin
armed with row of long spines; propodal segment bearing few long plumose setae; carpus longer
than broad, shorter than merus. Third maxilliped (Fig. 8F) reaching to mid-length of scaphocerite
when extended forward; exopod reaching to 0.72–0.79 of antepenultimate segment; ultimate
segment (excluding apical spine) of endopod 1.61–1.78 times as long as penultimate segment,
distal half armed with 6–9 strong spines; antepenultimate segment slightly shorter than the last
two segments combined.

First pereiopod (Fig. 9A) shortest among pereiopods, oblique, nearly reaching to mid-length of
the scaphocerite when extended forward. Ventral margin of basis, ischium, and merus furnished
with long plumose setae. Terminal margin of carpus cotyloid. Cutting edges of chela non-
denticulate, outer margin of fingers with long simple setae, tip of fixed finger with 3 acute
spines, tip of dactylus with 4 acute spines (Fig. 9B).

Second pereiopod (Fig. 9C) slightly overreaching the distolateral spine of scaphocerite when
extended forward. Carpus with 3 subsegments, first subsegment 2.13–2.26 times as long as
second subsegment, third subsegment slightly shorter than first subsegment; first subsegment
2.65–2.76 times as long as wide, second subsegment 1.08–1.16 times as long as wide, third
subsegment 1.76–1.83 times as long as wide. Cutting edges of chela not denticulate, outer
margin of fingers with long simple setae, tip of fixed finger with 3 acute spines, tip of dactylus with 4 acute spines (Fig. 9D).

Third to fifth pereiopods long and robust. Third pereiopod (Fig. 9E) reaching beyond terminal blade of scaphocerite by dactylus when extended forward; dactylus with 8–10 spines, all spines in ventral and apical position (none in dorsal or subdorsal position), with 2 apical spines larger than others (the ultimate one longer but thinner than the penultimate one) (Fig. 9F); propodus 6.98–7.12 times as long as wide, armed with 4–6 pairs of spines on ventral margin; carpus 2.96–3.14 times as long as wide, armed with one proximal lateral spine; merus 6.45–6.63 times as long as wide, armed with 2 lateral spines. Ratio length of third pereiopod dactylus with longest apical spine/length of propodus 0.42–0.46; ratio length of third pereiopod dactylus with longest apical spine/length of carpus 0.86–0.92; ratio length of dactylus without spines/breadth of dactylus without spines 2.86–2.93; ratio length of dactylus with longest spines/breadth of dactylus without spines 4.35–4.43; ratio length of longest spine of dactylus/breadth of dactylus without spines 1.50–1.55; ratio length of longest spine of dactylus/length of dactylus without spines 0.53–0.58.

Third pereiopod of male specimen with propodus and dactylus forming a prehensile apparatus (Fig. 9G,H). Fourth and fifth pereiopods (Fig. 9I,J) similar in shape to third pereiopod of female specimen, but slightly decreasing in size. Merus of fourth pereiopod armed with 0–1 lateral spine, merus of fifth pereiopod without lateral spine.

First pleopod (Fig. 9K) of female specimen normal, endopod about 0.72–0.78 times as long as exopod. First pleopod (Fig. 9L) of male specimen with endopod about 0.25–0.29 times as long as exopod. Second pleopod (Fig. 9M) of male specimen with endopod about 0.79–0.86 times as long as exopod; appendix masculina with 8 apical setae, about 0.41–0.47 times as long as appendix interna (Fig. 9N).

Coloration and Biotopes. Specimens collected from different biotopes manifested different body colors. Specimens (Fig. 5B,C) captured among Galaxaura sp. were generally pink over body, with numerous white spots; specimens (Fig. 5D,E) captured among Halimeda sp. were generally light green over body, with white or pink stains on the carapace, abdomen, and telson. All specimens were captured from 1 to 3 m depth.

Distribution. Xisha Islands, South China Sea. Presumably, this species also occurs in Taiwan Island (see discussion).

Etymology. ‘Nanhai’ means the South China Sea; the new species is named after its type locality.

Hippolyte cf. ventricosa H. Milne Edwards, 1837 (Figs. 5F–G)

Material examined. MBM189209, ovigerous female, 4.9 mm CL, Houhai bay, Hainan Island, northern South China Sea, 1–3 m, Coll. Z B, Gan, 22 November 2014 (GenBank accession number of 16S rRNA gene: MK231003). MBM189208, 19 male, 1.6–2.8 mm CL, 25 female, 1.8–4.7 mm CL, 36 ovigerous female, 2.6–5.0 mm CL, 11 juvenile 0.6–1.1 mm CL, same collection data as MBM189209; MBM189207, 1 ovigerous female, 3.8 mm CL, Hongtang bay,
Hainan Island, northern South China Sea, 1–2 m, Coll. Z B. Gan, 22 March 2018 (GenBank accession number of 16S rRNA gene: MK231004); MBM189208, 3 male, 1.3–2.6 mm CL, 3 female, 1.5–3.9 mm CL, 6 ovigerous female, 2.5–4.7 mm CL, same collection data as MBM189207; MBM189206, 1 female, 3.5 mm CL, Luhuitou bay, Hainan Island, northern South China Sea, 1–2 m, Coll. Z B. Gan, 8 May 2015 (GenBank accession number of 16S rRNA gene: MK231009); MBM189205, 2 male, 2.0–2.6 mm CL, 1 female, 3.2 mm CL, 4 ovigerous female, 2.8–3.9 mm CL, same collection data as MBM189206; MBM189204, 5 male, 1.4–2.8 mm CL, 7 female, 1.4–4.0 mm CL, 9 ovigerous female, 2.2–4.5 mm CL, Dadonghai bay, Hainan Island, northern South China Sea, 2–3 m, Coll. Z B. Gan, 25 April 2016; MBM189203, 4 male, 1.1–2.9 mm CL, 9 female, 1.3–3.8 mm CL, 15 ovigerous female, 2.3–4.4 mm CL, 2 juvenile 0.6–0.9 mm CL, Yalong bay, Hainan Island, northern South China Sea, 1–3 m, Coll. Z B. Gan, 18 September 2017.

Remarks. These specimens had the following features: (1) first article of the antennular peduncle with one distolateral tooth, and fifth pleonite no dorsolateral tooth; (2) carapace length of mature females among 1.8–3.3 mm, and total length among 13–24 mm; (3) rostrum distinctly overreaching the end of the antennular peduncle but falling short of scaphocerite apex, superior border with 1–2 teeth and inferior border with 1–5 teeth; (4) incisor process of mandible with 5–6 teeth; (5) scaphocerite 2.79–3.38 times as long as wide; (6) dactylus of the third to fifth pereiopods with 2 large apical spines, but the longest apical spine never exceeding the half-length of dactyli properly, the ratio of the longest spine of dactylus/length of dactylus without spines among 0.33–0.41; (7) specimens displaying various colorations (Fig. 5F–G).

These features differ from those described for *H. acuta*, *H. australiensis*, *H. ngi*, *H. singaporensis*, and *H. nanhaiensis* sp. nov., but are similar to the morphological characters of *H. ventricosa* (referring to the redescription of D’Udekem d’Acoz, 1999). More than four cryptic or pseudocryptic species were recently detected using molecular markers, which were also morphologically very similar to *H. ventricosa* (De Grave et al., 2014; Terossi et al., 2017). Therefore, it is not clear which specimens represent the true *H. ventricosa*; 16S rRNA or other genetic data derived from the *H. ventricosa* topotype are expected to resolve this issue.

Coloration and Biotopes. Specimens captured among *Thalassia* sp. were generally bright green over body (Fig. 5F), or green over body with pink or brown stains on carapace, abdomen, and telson (Fig. 5J); specimens (Fig. 5G–I) captured among *Sargassum* sp. are generally sandy brown or reddish brown over body, with or without white stains on carapace, abdomen, and telson. All specimens were captured at depths of 1–3 m.

Discussion

*Hippolyte chacei* sp. nov. is distinguished from all other valid *Hippolyte* species by the unique dactylus of the third to fifth pereiopods. This type of dactylus has previously reported only for specimens attributed to *H. ventricosa*, such as those reported from the Malayan Archipelago (Holthuis, 1947), Madagascar (Ledoyer, 1970), and Hawai (Hayashi, 1981), which D’Udekem d’Acoz (1996) considered represented undescribed species. Our work, based on molecular data,
confirms this suspicion. In the 16S rRNA phylogenetic tree (Fig. 10), *H. chacei* sp. nov. (two specimens) form an isolated branch clustered in the subbasal position of the Indo-West Pacific clade (Terossi et al., 2017). Additionally, the average genetic divergence between *H. chacei* sp. nov. and other *Hippolyte* species is 20.8%, which is slightly greater than the average interspecific genetic divergence of 20.5% (calculated from the 30 *Hippolyte* species in our study).

Specimens attributed to *H. ventricosa* from the Malayan Archipelago and Madagascar by Holthuis (1947) and Ledoyer (1970) respectively, are very similar to *H. chacei* sp. nov. in morphology. We speculate that they are conspecific, but this speculation requires a detailed examination of their specimens. Hayashi (1981) stated that the mouthparts of Hawaiian specimens were similar to those of *H. edmondsoni* and *H. jarvisensis*, of which distinctly differ from those of *H. chacei* sp. nov.; moreover, difference is also apparent in the position of hepatic spine. Those specimens reported by Hayashi (1981) may represent a different species from *H. chacei* sp. nov.

Morphologically, *H. nanhaiensis* sp. nov. is similar to *H. acuta*, *H. australiensis*, *H. ngi*, *H. singaporensis*, and *H. ventricosa* (referring to the redescription of D’Udekem d’Acoz, 1999). They all have the first article of the antennular peduncle with one distolateral tooth, fifth pleonite without dorsolateral teeth, and third to fifth pereiopods with normal dactyli. *H. nanhaiensis* sp. nov. differs from *H. acuta*, *H. australiensis*, and *H. ngi* by its shorter rostrum (reaching to or only slightly overreaching the end of the antennular peduncle vs. distinctly overreaching the end of the antennular peduncle). *H. acuta* is further distinguished from *H. nanhaiensis* sp. nov. by its particularly long eyestalk (Stimpson, 1860; Hayashi & Miyake, 1968; Yanagawa & Watanabe, 1988; D’Udekem d’Acoz, 1996). *H. australiensis* is further distinguished from *H. nanhaiensis* sp. nov. by its rostrum, which has a sharp lateral carina, and also by the dactylus of the third to fifth pereiopods, which have four large apical spines (D’Udekem d’Acoz, 2001). *H. ngi* differs from *H. nanhaiensis* sp. nov. by its hepatic, which overreaches the anterior edge of carapace by distal half length, and also by the dactylus of the third to fifth pereiopods, which have three large apical spines (Gan & Li, 2017b).

According to D’Udekem d’Acoz (1999), *H. ventricosa* also has two large apical spines on the dactylus of the third to fifth pereiopods, although the apical spines of *H. nanhaiensis* sp. nov. are proportionally longer. The ratio of the longest spine of the dactylus/length of the dactylus without spines is 0.53–0.58 in *H. nanhaiensis* sp. nov., but it is only 0.35 in *H. ventricosa*. The rostrum of *H. ventricosa* distinctly overreaches the end of the antennular peduncle, but it only reaches to or slightly overreaches the end of the antennular peduncle in *H. nanhaiensis* sp. nov. The scaphocerite of *H. ventricosa* is 3.10 times as long as wide, but it is 2.19–2.38 times as long as wide in *H. nanhaiensis* sp. nov. The total length of the *H. ventricosa* syntypes reaches 17 mm (D’Udekem d’Acoz, 1999), nearly two times longer than the largest *H. nanhaiensis* sp. nov. Furthermore, the two species inhabit different ecological niches. *H. ventricosa* lives among *Zostera* sp. or *Padina* sp., and may also be found among *Sargassum* sp., but *H. nanhaiensis* sp. nov. was found only among *Galaxaura* sp. or *Halimeda* sp., and no other congeners were found in these biotopes.
In the 16S rRNA phylogenetic tree (Fig. 10), *H. nanhaiensis* sp. nov. (two specimens) form a clade with *H. ventricosa* group-sp. 4 (Terossi et al., 2017), with this clade being a sister to *H. australiensis*. The average genetic divergence between *H. nanhaiensis* sp. nov. and other *Hippolyte* species is 22.5%, which is greater than the average interspecific genetic divergence (20.5%). 16S rRNA sequence alignment reveals *H. nanhaiensis* sp. nov. to be identical to, or to have a single nucleotide base difference from specimen of *H. ventricosa* group-sp. 4 (KX588916). Therefore, the specimen attributed to *H. ventricosa* group-sp. 4 and *H. nanhaiensis* sp. nov. might ultimately prove to be conspecific.

**Conclusions**

As noted by D’Udekem d’Acoz (1999; 2001), the systematics of Indo-West Pacific *Hippolyte* is extremely complicated, even though this region is considered the origin center of the genus (Terossi et al., 2017). Much of this taxonomic confusion stems from a lack of knowledge of several species, such as *H. proteus*, *H. kraussiana*, and *H. acuta*, and the plasticity in morphological characters of deemed taxonomic importance. Our study demonstrate the length of the rostrum relative to the antennular peduncle, the ratio of width to height of the scaphocerite, the position of the hepatic spine, and the features of the dactylus of the third to fifth pereiopods to be taxonomic value. A preliminary key for the indentification of mature female of the genus *Hippolyte* occurring in the Indo-West Pacific and neighboring seas is provided. This key only contains valid species listed in WoRMS (http://www.marinespecies.org); the cryptic or pseudocryptic *H. ventricosa* species are temporarily pooled as ‘*H. ventricosa*’ sensu lato.

Key to mature female of *Hippolyte* for the Indo-West Pacific and neighboring seas

1a-First segment of antennular peduncle without distolateral tooth .................................2
1b-First segment of antennular peduncle with one distolateral tooth .................................3
2a-Merus of third pereiopod with no more than one lateral spine, scaphocerite about 2.8 times as long as wide .................................................................................................................................*H. proteus*
2b-Merus of third pereiopod with 3–5 lateral spines, scaphocerite about 3.5 times as long as wide .................................................................................................................................*H. kraussiana*
3a-Dactyli of third to fifth pereiopods slender, simple, with elongate curved unguis, without ventral spines, mainly associated with Alcyonacean corals ........................................................................4
3b-Dactyli of third to fifth pereiopods with obvious ventral or subdorsal spines, mainly inhabited among seaweeds ........................................................................................................5
4a-Carapace with dorsal surface strongly gibbous, fingers of first pereiopod about half as long as palm .................................................................................................................................*H. dossena*
4b-Carapace with dorsal surface flat, non-gibbous, fingers of first pereiopod subequal to palm .................................................................................................................................*H. commensalis*
5a-Rostrum not overreaching the end of antennular penduncle ..................................................6
5b-Rostrum distinctly overreaching the end of antennular penduncle ...........................................10
6a-Rostrum less than half length of carapace, reaching to the end of first segment of antennular peduncle at most..............................................................H. edmondsoni
6b-Rostrum longer than the half length of carapace, reaching to the end of antennular peduncle..............................................................
7a-Rostrum without dorsal tooth, base of hepatic spine nearly situating at anterior edge of carapace..............................................................H. singaporensis
7b-Rostrum with 1–2 dorsal teeth, base of hepatic spine situating at posterior to the anterior edge of carapace..............................................................H. jarvinensis
8a-Distal spine of dactylus of third pereiopod longer than the half length of dactylus proper (excluding spines)..............................................................H. caradina
8b-Distal spine of dactylus of third pereiopod shorter than the half length of dactylus proper (excluding spines)..............................................................H. nanhaiensis sp. nov.
9a-Rostrum with postrostral spine, situating at just above the orbit..............................H. acuta
9b-Rostrum without postrostral spine, all dorsal spines situating at prior to the orbit..............................................................H. ventricosa sensu lato
10a-Incisor process of mandible with no more than 8 acute teeth..............................................................H. multicolorata
10b-Incisor process of mandible with 15–17 acute teeth, dactyls of third to fifth pereiopods with 2–3 subdorsal spines..............................................................H. australiensis
11a-Unpigmented part of eyestalk 3 times as long as cornea......................................................H. ngi
11b-Unpigmented part of eyestalk no more than 3 times as long as cornea..............................H. ventricosa
12a-Rostrum without dorsal spine..............................................................................................H. bifidirostris
12b-Rostrum with dorsal spine..............................................................................................H. ventricosa sensu lato
13a-Apex of the rostrum trifid..............................................................................................H. ventricosa sensu lato
13b-Apex of rostrum simple..............................................................................................H. ventricosa sensu lato
14a-Apex of the Rostrum bifid..............................................................................................H. ventricosa sensu lato
14b-Apex of rostrum simple..............................................................................................H. ventricosa sensu lato

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References
Castresana J. 2000. Selection of conserved blocks from multiple alignments for their use in phylogenetic analysis. *Molecular Biology and Evolution* **17**(4): 540–552.

Crandall KA, Fitzpatrick JF Jr. 1996. Crayfish molecular systematics: using a combination of procedures to estimate phylogeny. *Systematic Biology* **45**(1): 1–26.

De Grave S, Li CP, Tsang LM Chu KH, Chan T-Y. 2014. Unweaving hippolytoid systematics (Crustacea, Decapoda, Hippolytidae): resurrection of several families. *Zoologica Scripta* **43**(5): 496–507.

Duarte C, Flores AA. 2017. Morph-specific habitat and sex distribution in the caridean shrimp *Hippolyte obliquimanus*. *Journal of the Marine Biological Association of the United Kingdom* **97**(2): 235–242.

Duarte RC, Flores AA, Vinagre C, Leal MC. 2017. Habitat-dependent niche partitioning between colour morphs of the algal-dwelling shrimp *Hippolyte obliquimanus*. *Marine Biology* **164**(11): 235–242.

D'Udekem d'Acoz C. 1996. The genus *Hippolyte* Leach, 1814 (Crustacea: Decapoda: Caridea: Hippolytidae) in the East Atlantic Ocean and the Mediterranean Sea, with a checklist of all species in the genus. *Zoologische Verhandelingen* **303**: 1–133.

D'Udekem d'Acoz C. 1999. Redescription of *Hippolyte ventricosa* H. Milne Edwards, 1837 based on syntypes, with remarks on *Hippolyte orientalis* Heller, 1862 (Crustacea, Decapoda, Caridea). *Zoosystema* **21**(1): 65–76.

D'Udekem d'Acoz C. 2001. Redescription of *Hippolyte australiensis* (Stimpson, 1860) (Crustacea, Decapoda, Caridea). *Biologie* **71**: 37–44.

D'Udekem d'Acoz C. 2007. New records of Atlantic *Hippolyte*, with the description of two new species, and a key to all Atlantic and Mediterranean species (Crustacea, Decapoda, Caridea). *Zoosystema* **29**(1): 183–207.

Edgar RC. 2004. MUSCLE: multiple sequence alignment with high accuracy and high throughput. *Nucleic Acids Research* **32**(5): 1792–1797.

Gan ZB, Li XZ. 2017a. A new species of the genus *Hippolyte* (Decapoda: Caridea: Hippolytidae) from South China Sea and Singapore. *Zootaxa* **4258**(1): 34–42.

Gan ZB, Li XZ. 2017b. A new species of the genus *Hippolyte* (Decapoda: Caridea: Hippolytidae) from Singapore. *Raffles bulletin of zoology* **65**: 207–212.

Guindon S, Gascuel O. 2003. A simple, fast, and accurate algorithm to estimate large phylogenies by maximum likelihood. *Systematic Biology* **52**(5): 696–704.

Hayashi KI. 1981. The Central Pacific shrimps of the genus *Hippolyte*, with a description of two new species (Decapoda, Caridea, Hippolytidae). *Pacific Science* **35**(3): 185–196.

Hayashi KI, Miyake S. 1968. Studies on the hippolytid shrimps from Japan, V. Hippolytidae fauna of the sea around the Amakusa Marine Biological Laboratory. *Ohmu [Occasional papers of Zoological Faculty of Agriculture, Kyushu University, Fukuoka, Japan]* **1**(6): 121–163.
Holthuis LB. 1947. The Hippolytidae and Rhynchocinetidae collected by the Siboga and Snellius Expedition with remarks on other species. *Siboga Expeditie Monographie* 39a: 1–100.

Huelsenbeck JP, Ronquist F. 2001. MRBAYES: Bayesian inference of phylogeny. *Biometrics* 17: 754–755.

Kumar S, Stecher G, Tamura K. 2016. MEGA7: molecular evolutionary genetics analysis version 7.0 for bigger datasets. *Molecular biology and evolution* 33(7): 1870–1874.

Ledoyer M. 1970. Étude systématique et remarques écologiques sur les Caridea recueillis principalement dans les biotopes de substrat meuble régions de Tuléar et de Nosy-Bé. *Annales de l’Université de Madagascar série Sciences de la nature et Mathématiques* 7: 121–157.

Liasko R, Anastasiadou C, Ntakis A. 2018. Eco-morphological consequences of the ‘rostral loss’ in the intertidal marine shrimp *Hippolyte sapphica* morphotypes. *Journal of the Marine Biological Association of the United Kingdom* 98(7): 1667–1673.

Liasko R, Anastasiadou C, Ntakis A, Leonardos ID. 2015. How a sharp rostral dimorphism affects the life history, population structure and adaptability of a small shrimp: the case study of *Hippolyte sapphica*. *Marine Ecology* 36(3): 400–407.

Manjón-Cabeza ME, Cobos V, Raso JEG. 2011. The reproductive system of *Hippolyte niezabitowskii* (Decapoda, Caridea). *Zoology* 114(3), 140–149.

Marin I, Okuno J, Chan T-Y. 2011. On the “Hippolyte commensalis Kemp, 1925” species complex (Decapoda, Caridea, Hippolytidae), with the designation of a new genus and description of two new species from the Indo-West Pacific. *Zootaxa* 2768: 32–54.

Posada D, Crandall KA. 1998. Modeltest: testing the model of DNA substitution. *Bioinformatics* 14(9): 817–818.

Stimpson W. 1860. Prodromus descriptionis animalium evertebratorum, quae in Expeditione ad Oceanum Pacificum Septentrionalem, a Republica Federate missa, Cadwaladaro Ring-gold et Johanne Rodgers Ducibus, observavit et descripsit. Pars V. Crustacea Ocypodoidea. *Proceedings of the Academy of Natural Sciences of Philadelphia* 12: 22–47.

Terossi M, De Grave S, Mantelatto FL. 2017. Global biogeography, cryptic species and systematic issues in the shrimp genus *Hippolyte* Leach, 1814 (Decapoda: Caridea: Hippolytidae) by multimarker analyses. *Scientific reports* 7(1): 6697.

Terossi M, Mantelatto FL. 2012. Morphological and genetic variability in *Hippolyte obliquimanus* Dana, 1852 (Decapoda, Caridea, Hippolytidae) from Brazil and the Caribbean Sea. *Crustaceana* 85(6): 685–712.

Yanagawa SL, Watanabe S. 1988. Life history and morphology of the hippolytid shrimp *Hippolyte ventricosa* in Kominato bay. *Bulletin of the Japanese Society of Scientific Fisheries* 54(4): 613–618.
Figure 1

_Hippolyte chacei_ sp. nov. female, holotype.

_Hippolyte chacei_ sp. nov. female, holotype, MBM285015, lateral view. Scale: 1.0 mm.
Figure 2

Cephalon and telson of *Hippolyte chacei* sp. nov.

*Hippolyte chacei* sp. nov. A, B, D–H, female, holotype, MBM285015; C, male, paratype, MBM285016. A, cephalon, dorsal; B, carapace and rostrum, lateral; C rostrum, lateral; D, inferior orbital angle, dorsal; E, telson and uropods, dorsal; F, right antennula, dorsal; G, first segment of right antennule, ventral; H, right scaphocerite, dorsal. Scales: 1.0 mm.
Figure 3

Mouthparts of *Hippolyte chacei* sp. nov.

*Hippolyte chacei* sp. nov. female, holotype, MBM285015. A, B, left mandible; C, left maxillule; D, left maxilla; E, left first maxilliped; F, left second maxilliped; G, left third maxilliped. Scale: 1.0 mm.
Figure 4

Pereiopods and pleopods of *Hippolyte chacei* sp. nov.

*Hippolyte chacei* sp. nov. A–F, I–M, female, holotype, MBM285015; G, H, N–P, male, paratype, MBM285016. A, left first pereiopod, lateral; B, tip of the left first pereiopod, mesial (setae not shown); C, left second pereiopod, lateral; D, tip of the left second pereiopod, mesial (setae not shown); E, left third pereiopod, lateral; F, dactylus of left third pereiopod, lateral; G, H, propodus and dactylus of left third pereiopod, lateral; I, left fourth pereiopod, lateral; J, dactylus of left fourth pereiopod, lateral; K, left fifth pereiopod, lateral; L, dactylus of left fifth pereiopod, lateral; M, N, left first pleopod; O, left second pleopod; P, appendix masculina. Scales: A, C, E, G, I, K, M–O, 1 mm; B, D, 100 μm.
Figure 5

Photos of *Hippolyte* spp. collected from Hainan Island and the Xisha Islands.

Photos of *Hippolyte* spp. collected from Hainan Island and the Xisha Islands. A, *Hippolyte chacei* sp. nov.; B–E, *Hippolyte nanhaiensis* sp. nov.; F–G, *Hippolyte* cf. *ventricosa*. Scale: 1.0 mm.
Figure 6

*Hippolyte nanhaiensis* sp. nov. ovigerous female, holotype.

*Hippolyte nanhaiensis* sp. nov. ovigerous female, holotype, MBM285018, lateral view. Scale: 1.0 mm.
Figure 7

Cephalon and telson of Hippolyte nanhaiensis sp. nov.

*Hippolyte nanhaiensis* sp. nov. A–C, E–H, ovigerous female, holotype, MBM285018; D, male, paratype, MBM285019. A, cephalon, dorsal; B, anterior of rostrum, dorsal; C, carapace and rostrum, lateral; D, rostrum, lateral; E, telson and uropods, dorsal; F, right antennula, dorsal; G, first segment of right antennule, ventral; H, right scaphocerite, dorsal. Scales: 1.0 mm.
Figure 8

Mouthparts of *Hippolyte nanhaiensis* sp. nov.

*Hippolyte nanhaiensis* sp. nov. ovigerous female, holotype, MBM285018. A, left mandible; B, left maxillule; C, left maxilla; D, left first maxilliped; E, left second maxilliped; F, left third maxilliped. Scale: 1.0 mm.
Figure 9

Pereiopod and pleopods of *Hippolyte nanhaiensis* sp. nov.

*Hippolyte nanhaiensis* sp. nov. A–F, I–K, female, holotype, MBM285018; G, H, L–N, male, paratype, MBM285019. A, right first pereiopod, lateral; B, tip of the left right pereiopod, mesial (setae not shown); C, right second pereiopod, lateral; D, tip of the right second pereiopod, mesial (setae not shown); E, right third pereiopod, lateral; F, dactylus of right third pereiopod, lateral; G, H, propodus and dactylus of right third pereiopod, lateral; I, right fourth pereiopod, lateral; J, right fifth pereiopod, lateral; K, L, left first pleopod; M, right second pleopod; N, appendix masculina. Scales: A, C, E, G, I–M, 1 mm; B, D, 100 μm.
Figure 10

16S rRNA phylogenetic tree.

Maximum likelihood tree based on 16S rRNA sequence data. Numbers at nodes represent posterior probabilities/bootstrap values (BI/ML), numbers less than 50 or 0.50 are not shown.
Table 1 (on next page)

Information on biodiversity

The information on biodiversity surveys
| Sampling locality | Investigation date          | Botopes                  |
|-------------------|-----------------------------|--------------------------|
| Hainan island     | 20 Nov 2014–01 Dec 2014     | *Sargassum* sp. and *Zostera* sp. |
| Hainan island     | 04 May 2015–10 May 2015     | *Sargassum* sp. and *Zostera* sp. |
| Hainan island     | 22 Apr 2016–27 Apr 2016     | *Sargassum* sp. and *Zostera* sp. |
| Hainan island     | 16 Sep 2017–22 Sep 2017     | *Sargassum* sp. and *Zostera* sp. |
| Hainan island     | 20 Mar 2018–28 Mar 2018     | *Sargassum* sp. and *Zostera* sp. |
| Xisha islands     | 12 May 2015–19 May 2015     | *Galaxaura* sp. and *Halimeda* sp. |
| Xisha islands     | 10 Jul 2016–20 Jul 2016     | *Galaxaura* sp. and *Halimeda* sp. |
**Table 2** (on next page)

Specimens information.

Specimens collected in this study with reference to their locality, Voucher ID, and GenBank accession numbers.
| Species                        | Sampling locality | Voucher ID | GenBank accession numbers |
|-------------------------------|-------------------|------------|---------------------------|
| Hippolyte cf. ventricosa      | Hainan island     | MBM285012  | MK231003                  |
| Hippolyte cf. ventricosa      | Hainan island     | MBM285013  | MK231004                  |
| Hippolyte cf. ventricosa      | Hainan island     | MBM285014  | MK231009                  |
| Hippolyte chacei sp. nov.     | Hainan island     | MBM285015  | MK231007                  |
| Hippolyte chacei sp. nov.     | Hainan island     | MBM285016  | MK231008                  |
| Hippolyte nanhaiensis sp. nov.| Xisha islands     | MBM285018  | MK231005                  |
| Hippolyte nanhaiensis sp. nov.| Xisha islands     | MBM285019  | MK231006                  |