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new taxa paper

The deep-sea commercial caridean shrimp, *Heterocarpus woodmasoni* (Crustacea: Decapoda: Panalidae), with description of a new species from the western Pacific Ocean

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ABSTRACT.—The availability of fresh specimens of the commercial, deep-sea pandalid shrimp, *Heterocarpus woodmasoni* Alcock, 1901, from India revealed that material referred to this species from India and the western Pacific Ocean have distinct differences in coloration, morphology, and genetic divergence. Although the syntypes of *H. woodmasoni* cannot be located now, a color photograph of a typotypic specimen from the Andaman Sea allowed the determination of the Indian form as the true *H. woodmasoni*. To stabilize the taxonomy in the *"H. woodmasoni"* species group, a neotype is selected for *H. woodmasoni* from an Indian specimen with both coloration and molecular barcoding information. The western Pacific form is described as a new species, *Heterocarpus fascirostratus* sp. nov., which differs from *H. woodmasoni* in having a banded rostrum, eggs reddish brown instead of greenish brown, lacking rostral crest, armed usually with fewer dorsolateral spines on the telson, the overhanging spine on the abdominal somite III not markedly recurved downwards, and a rather straight postantennal carina.

The deep-sea pandalid shrimp, *Heterocarpus woodmasoni* Alcock, 1901, was previously thought to be widely distributed in the Indo-West Pacific region, and fished commercially or considered as of fishery potential in many areas (e.g., Holthuis 1980, 1984, Wadley and Evans 1991, De Bruin et al. 1995, Rajan et al. 2001, Rajool Shanis et al. 2014, Everett et al. 2015). This taxon, however, has been separated into three species by Crosnier (1988, 1999). It has been believed that *H. woodmasoni* is characterized by having four pairs of dorsolateral spines on the telson and distributed in the northern Indian Ocean to the western Pacific Ocean, as far as Japan and northern Australia (Crosnier 1999). The two other species have only two pairs of dorsolateral spines on the telson, but differ in coloration and height of the rostral crest, with *Heterocarpus calmani* Crosnier, 1988 occurring in the southwestern Indian Ocean and off eastern Australia, and *Heterocarpus intermedius* Crosnier, 1999 occurring in the South Pacific Ocean and off eastern Australia (Crosnier 1999). The type locality of *H. woodmasoni* is in the Andaman Sea in northeastern Indian Ocean (Alcock

1901). As remarked by Crosnier (1999), the exact number of dorsolateral spines on the telson in the syntypes of *H. woodmansoni* is actually unclear because of the difficulties in accessing specimens now deposited in the Zoological Survey of India. *Heterocarpus woodmasoni* is now a target species in recent development of deep-sea fisheries off southern India (e.g., Rajan et al. 2001, Rajasree and Kurup 2011, Rajool Shanis et al. 2014). Recently, we managed to obtain a good series of fresh specimens of *H. woodmasoni* from an Indian deep-sea fishing port. It was found that Indian *H. woodmasoni* specimens differ from western Pacific material (see de Man 1920, Chace 1985, Chan and Yu 1987, Crosnier 1988, Li and Chan 2013) in having more numerous telson spines (see also George and Rao 1967) and different coloration. Molecular genetic analysis confirms the distinct specific status of the Indian and western Pacific (including the South China Sea) forms. Although the syntypes of *H. woodmasoni* cannot be located now, a color photograph on the topotypic material in the Andaman Sea from recent FAO survey in Myanmar reveals that the material from southern India is the true *H. woodmasoni*. The western Pacific and South China Sea form, though generally treated as the "typical" form of *H. woodmasoni* (Crosnier 1988, 1999, Hanamura and Evans 1996, Li 2006a,b, Li and Chan 2013), is actually an unnamed species and is herein described as new. To stabilize the taxonomy in the "*H. woodmasoni*" group (i.e., abdomen only armed with an overhanging spine at tergite III), a neotype is selected for *H. woodmasoni* from an Indian specimen in the present study with both coloration and molecular barcoding information.

Material and Methods

The materials examined are deposited in the National Taiwan Ocean University (NTOU), Department of Aquatic Biology and Fisheries, University of Kerala (DABFUK), Zoological Survey of India, Western Ghats Research Centre, Kerala (ZSI/WGRC), National Museum of the Philippines (NMCR), and Muséum national d'Histoire naturelle, Paris (MNHN). The measurements given are carapace length (cl) measured dorsally from the postorbital margin to the posterior margin of the carapace. Since *H. woodmasoni* is a commercial species with many reports related to this name, the synonymy provided are restricted to important taxonomic works on the species. Partial sequences of mitochondrial cytochrome c oxidase I (COI) gene barcoding data (Hebert et al. 2003, Hajibabaei et al. 2007) were generated by following the methods given in Yang et al. (2010). Comparative material of the other species of the "*H. woodmasoni*" group are:

Heterocarpus calmani.—Madagascar, 22°18.7′S, 43°4.5′E, 400 m, 7 January, 1986, 1 male cl 29.3 mm, 1 ovig. female cl 23.8 mm (NTOU M02058, exchanged from MNHN-Na 10484); Mozambique, MAINBAZA, stn CC3152, 19°34′S, 36°45′E, 443–445 m, 13 April, 2009, 1 ovig. female cl 28.5 mm (MNHN IU-2008-14588).

H. intermedius.—Fiji, BORDAU 1, stn CP1419, 17°5′S 178°55′W, 654–656 m, 28 Feb 1999, 1 ovig. female cl 28.1 mm, 1 female cl 25.1 mm (NTOU M02059, exchanged from MNHN); 1 male 29.0 mm (MNHN).

Taxonomic Account

Genus *Heterocarpus* A. Milne-Edwards, 1881
Heterocarpus woodmasoni Alcock, 1901
(Figs. 1A–C, 2)

Heterocarpus Wood-masoni Alcock 1901: 108 (type locality: Andaman Sea; now changed to southwestern India by neotype designation).

Heterocarpus wood-masoni.—Alcock and McArdle 1901: p. 51-fig. 2; George and Rao 1967: 331.

not *Heterocarpus Wood-masoni.*—De Man 1920: 156, pl. 13-fig. 36. (= *Heterocarpus fascirostratus* sp. nov.).

? not *Heterocarpus Wood-Masoni.*—Balss 1925: 70 (p.p.). (= *Heterocarpus fascirostratus* sp. nov.).

not *Heterocarpus Wood-Masoni.*—Balss 1925: 70 (p.p.); Calman 1939: 204. (= *Heterocarpus calmani* Crosnier, 1988).

not *Heterocarpus woodmasoni.*—Kensley 1969: 170, fig. 12; 1972: 50, fig. 23d; Holthuis 1980: 137 (p.p.). (= *Heterocarpus calmani* Crosnier, 1988).

Heterocarpus woodmasoni.—Holthuis 1980: 137 (p.p.).

not *Heterocarpus woodmasoni.*—Holthuis 1980: 137 (p.p.); Chace 1985: 42, fig. 13q; Chan and Yu 1987: 55, pl. 1D; Crosnier 1988: fig. 1i-l; 1999: 349; Hanamura and Evans 1996: 10; Li 2006a: 1284; 2006b: 368; Hayashi 2007: 471, fig. 553i-l; Li and Chan 2013: 136, fig. 1G. (= *Heterocarpus fascirostratus* sp. nov.).

? not *Heterocarpus woodmasoni.*—Hanamura and Takeda 1987: 108; Kensley et al. 1987: 313; Wadley and Evans 1991: 29, 2 unnumbered figs; Jones and Morgan 2001: 71, unnumbered fig. (= *Heterocarpus fascirostratus* sp. nov.).

Material Examined.— Neotype, Sakthikulangara fishing harbor, Kollam district, Kerala, India, 20 March, 2017, ovig. female cl 28.4 mm (ZSI/WGRC/IR-INV).

Other material: Sakthikulangara fishing harbor, Kollam district, Kerala, India, 20 March 2017, 1 female cl 23.2 mm (DABFUK); 4 male cl 20.8–27.8 mm, 7 ovig. females cl 24.3–27.8 mm, 4 females cl 20.2–23.3 mm (DABFUK); 1 male cl 23.4 mm, 1 ovig. female cl 26.5 mm, 1 female cl 18.6 mm (DABFUK); 1 male cl 23.4 mm, 1 ovig. female cl 24.1 mm, 1 female cl 19.8 mm (DABFUK); 1 male cl 24.1 mm, 1 ovig. female cl 24.3 mm, 1 female cl 20.1 mm (DABFUK).

Diagnosis.—Rostrum far overreaching scaphocerite, armed dorsally with 9 or 10 teeth (including 1 or 2 postrostral teeth) and ventrally with 7–9 teeth, decreasing in size distally. Carapace with postrostral ridge extending near to posterodorsal margin, slightly elevated at base of rostrum, forming low crest; lateral surface with two strong longitudinal carinae, originating from antennal and branchiostegal spines and extending to >80% of carapace length; posterior 1/3 of postantennal carina distinctly curved with dorsally convex outline (Fig. 2A); branchiostegal spine shorter or as long as antennal spine. Scaphocerite 2.9–3.6 times as long as maximum width, with blade overreaching distolateral spine. Abdomen only with somite III bearing large overhanging spine at mid-dorsal part, tip of overhanging spine distinctly recurved downwards (Fig. 2B), only pleuron V bearing acute posteroventral tooth. Telson bearing 2 rows of dorsolateral spines, each row usually with 5–6 and rarely 4 or 7 spines (excluding subterminal spine, Fig. 2C). Pereiopod II unequal; carpus of shorter one

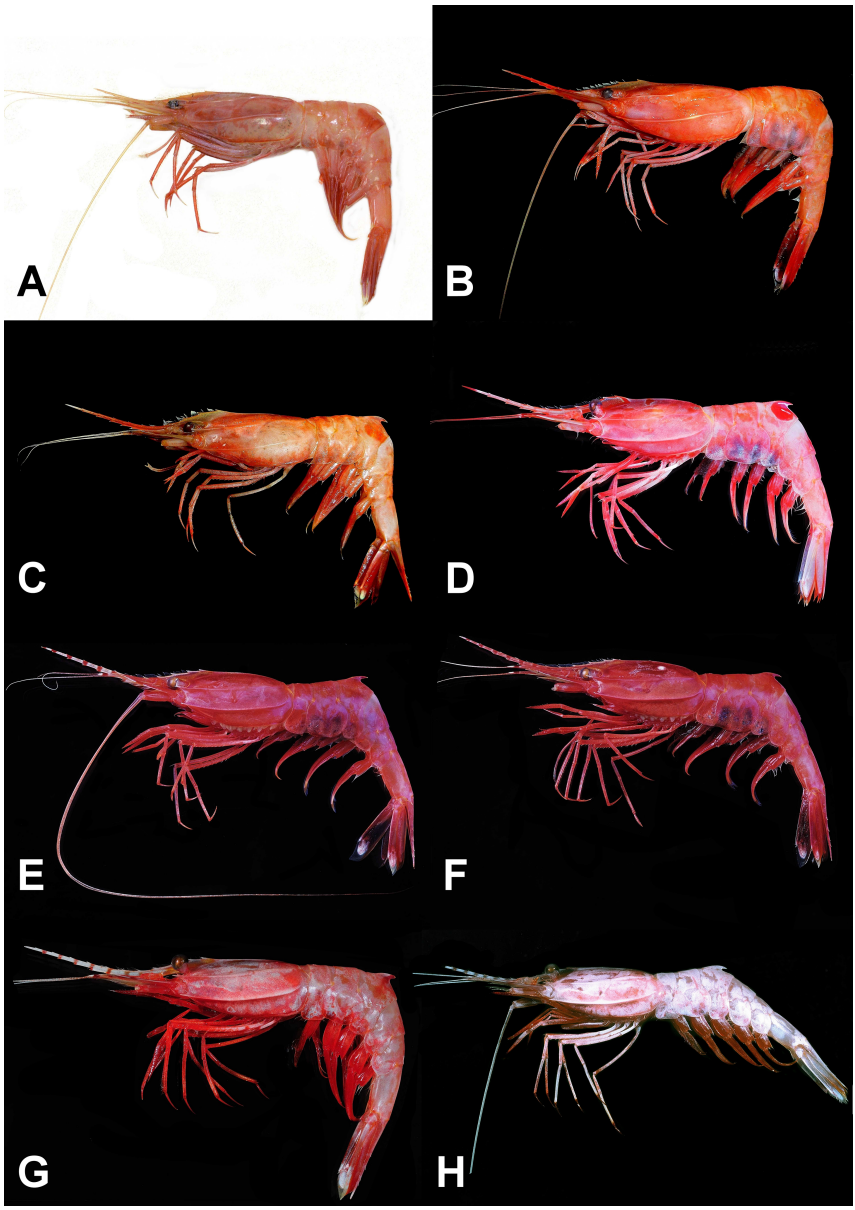

Figure 1. (A) *Heterocarpus woodmasoni*, Myanmar, NANSEN 2013, stn 127, 11°44.13′N, 96°46.87′E, 318–319 m, 10 December, 2013 (photographed by O Alhveim), (B) *H. woodmasoni*, Sakthikulangara fishing harbor, Kerala, India, ovig. female neotype cl 28.4 mm (ZSI/WGRC/IR-INV), (C) *H. woodmasoni*, Sakthikulangara fishing harbor, Kerala, India, female cl 28.5 mm (DABFUK), (D) *Heterocarpus calmani*, Mozambique, MAINBAZA, stn CC3152, ovig. female cl 28.5 mm (MNHN IU-2008-14588), (E) *Heterocarpus fascirostratus* sp. nov., Philippines, AURORA, stn CP2734, ovig. female holotype cl 24.3 mm (NMCR), (F) *H. fascirostratus* sp. nov., Philippines, AURORA, stn CP2734, ovig. female paratype cl 28.5 mm (NTOU M02066), (G) *H. fascirostratus* sp. nov., Papua New Guinea, BIOPAPUA, stn DW3734, male cl 21.5 mm (MNHN IU-2011-5267), (H) *Heterocarpus intermedius*, Fiji, BORDAU, 1 stn CP1419, male cl 29.0 mm (MNHN).

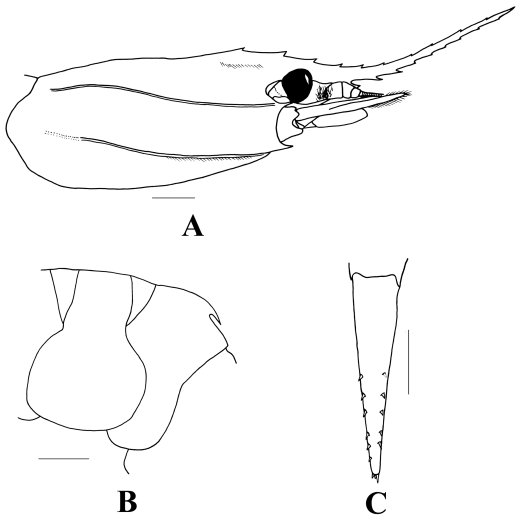

Figure 2. *Heterocarpus woodmasoni*, Sakthikulangara fishing harbor, Kerala, India, ovig. female neotype cl 28.4 mm (ZSI/WGRC/IR-INV). (A) Carapace and cephalic appendages, lateral view. (B) Abdominal somites II and III, lateral view. (C) Telson, dorsal view. Scales = 5 mm.

(generally right) divided into 9–11 articles, that of longer one with 22–25 articles. Pereiopod III with 4–6 (rarely 7) spines on carpus; merus with 2 rows of spines, 8–13 spines on distal row and 1–4 spines at proximal row; 2–3 (rarely 4) spines on ischium; dactylus about half as long as propodus and bearing 4–6 proximo-ventral spinules. Pereiopod IV with 3–5 (rarely 6) spines on carpus, 11–15 (rarely 10) spines on merus and 2–3 (rarely 4 or 5) spines on ischium. Pereiopod V bears 1–3 (rarely 5) spines on carpus, 9–11 (rarely 7) spines on merus while ischium without any spine.

Color.—Body generally orange-red (Fig. 1A–C). Rostrum sometimes paler in color with tip whitish, but never banded; base of postrostral crest somewhat yellowish. Antennular and antennal flagella also sometimes paler in color. Eyes dark brown. Abdominal tergite III often with a thick dark red longitudinal strip on lateral surface, but overhanging spine always similar in color with other parts of abdomen. Uropods with tips whitish. Eggs (uneyed) greenish brown.

Distribution.—North Indian Ocean and known with certainty from India and the Andaman Sea. At depths of 318–485 m (perhaps 251–600 m, Kurup et al. 2008).

Remarks.—The Indian specimens differ from the western Pacific material of *H. woodmasoni* (sensu Crosnier 1988, 1999) in generally having more numerous dorsolateral spines on the telson (Fig. 2C, also see George and Rao 1967). Of the 23 Indian specimens with a complete telson, all except one individual have at least one side of the two dorsolateral rows bearing 5–7 spines. The remaining specimen has 4 pairs of dorsolateral spines on the telson. The coloration of the Indian material (Fig. 1B, C) also distinctly differs from the western Pacific material from Taiwan (Chan and Yu 1987: pl. 1D), the Philippines (Fig. 1E, F; Li and Chan 2013: fig. 1G) and Papua New Guinea (Fig. 1G) in the rostrum not distinctly banded with red and white, the abdominal tergite III often with a thick longitudinal stripe lateral to the overhanging spine, and greenish brown instead of reddish brown uneyed eggs. Close examination

Table 1. Uncorrected pairwise distance (*P*-distance) among the species of the "*Heterocarpus woodmasoni*" species group based on mitochondrial cytochrome c oxidase I partial sequences (324–657 bp). All species are of genus *Heterocarpus*.

	H. fascirostratus sp. nov.	*H. woodmasoni*	*H. calmani*	*H. intermedius*
H. fascirostratus sp. nov.	0.000–0.010			
H. woodmasoni	0.078–0.082	0.000		
H. calmani	0.079–0.083	0.070–0.071	0.000	
H. intermedius	0.095–0.100	0.097	0.092	–

revealed that the Indian form has a low rostral crest (Fig. 2A) which is completely lacking in the western Pacific form (Fig. 3A, also see Crosnier 1988: fig. 1i). The overhanging spine on the abdominal tergite III markedly recurves downwards in the Indian material (Fig. 2B) but only slightly curves downwards in the western Pacific form (Fig. 3C). Moreover, the postantennal carina is distinctly curved in posterior 1/3 in the Indian form (Fig. 2A) but rather straight in the western Pacific form (Fig. 3A, also see Crosnier 1988: fig. 1i). Molecular genetic analysis on the DNA barcoding gene COI showed 7.8-8.2% sequence divergence between the Indian and Western Pacific forms. Such large genetic difference is generally considered as specific in crustaceans (Shih et al. 2007, Malay and Paulay 2010, Yang and Chan 2012) and similar to the divergences amongst the different species in the "*H. woodmasoni*" group (Table 1, Fig. 4).

Although the present study shows that the Indian and western Pacific material examined belongs to different species, the actual identity of *H. woodmasoni* s.s. is still unclear. The original description of Alcock (1901: 108) did not mention any of the distinguishing characters discussed above. The illustration of one of the two young syntypes provided by Alcock and McArdle (1901: p. 51-fig. 2) also does not show any telson spine, the overhanging spine at the abdominal somite III appeared to have a broken tip and it is unclear if there is a rostral crest present. Only the posterior part of the postantennal carina is shown as clearly curved in Alcock and McArdle's (1901) figure. *Heterocarpus woodmasoni* was originally described from two "Investigator" syntypes from the Andaman Sea (Alcock, 1901) and the material has never been examined since (see Crosnier 1999). It appears to be lost, and we have not been able to find it in the Zoological Survey of India (ex Indian Museum) in Calcutta or the Natural History Museum in London (S Mitra, Zoological Survey of India in Calcutta, pers comm; P Clark, the Natural History in London, pers comm; respectively). The authors were fortunate to examine a photograph of a topotypic specimen of *H. woodmasoni* from the Andaman Sea (Fig. 1A) collected from the recent 2013 Nansen Myanmar survey by the FAO. Although the specimen was not retained, the photograph of the Myanmar specimen clearly depicts the same coloration as the present Indian form from southern India (Fig. 1B, C), has a low rostral crest, possesses five spines on the left dorsolateral row of the telson, has a posteriorly curved postantennal carina and has a markedly recurved overhanging spine at the abdominal somite III. We are thus confident that our Indian material is conspecific with the Myanmarese specimen and all represent true *H. woodmasoni*. As discussed earlier, *H. woodmasoni* is now known to be a species complex consisting of at least four similar species, with one of the species, *H. calmani*, also known from Madagascar and southeastern Africa in the Indian Ocean. In the context of *H. woodmasoni* being the oldest name in this species group, a second closely allied

species present in the Indian Ocean, and that a new species is here described from the western Pacific Ocean, which has long been confused with *H. woodmasoni*. It is perhaps best to here select a neotype for *H. woodmasoni* as well. This will ensure that there is no doubt about the identity of *H. woodmasoni* s.s. and the taxonomy of the species treated here remains stable. The present Indian specimen (ovig. female cl 28.4 mm, ZSI/WGRC/IR-INV) illustrated (Fig. 2) which has a color photograph (Fig. 1B), as well as COI sequence data (MF681719) is here selected as the neotype of *Heterocarpus woodmasoni*.

Heterocarpus fascirostratus **new species**

(Figs. 1E–G, 3)

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Heterocarpus Wood-masoni.—De Man 1920: 156, pl. 13-fig. 36. (non Alcock, 1901).

? *Heterocarpus Wood-Masoni.*—Balss 1925: 70 (p.p.). (non Alcock, 1901).

Heterocarpus woodmasoni.—Holthuis 1980: 137 (p.p.); Chace 1985: 42, fig. 13q; Chan and Yu 1987: 55, pl. 1D; Crosnier 1988: fig. 1i-l; 1999: 349; Hanamura and Evans 1996: 10; Li 2006a: 1284; 2006b: 36; Hayashi 2007: 471, fig. 553i-l; Li and Chan 2013: 136, fig. 1G. (non Alcock, 1901).

? *Heterocarpus woodmasoni.*—Hanamura and Takeda 1987: 108; Kensley et al. 1987: 313; Wadley and Evans 1991: 29, 2 unnumbered figs; Jones and Morgan 2001: 71, unnumbered fig. (non Alcock, 1901).

Material Examined.—Holotype: Philippines, eastern of Luzon, AURORA, stn CP2734, 15°56′N, 121°49′E, 453–460 m, 01 June, 2007, ovig. female cl 24.3 mm (NMCR).

Paratypes: Philippines, eastern of Luzon, AURORA, stn CP2656, 16°02′N, 121°53′E, 262–278 m, 20 May, 2007, 1 female cl 19.5 mm (NTOU M02060); stn CP2657, 16°01′N, 121°53′E, 342–358 m, 20 May, 2007, 1 ovig. female cl 26.1 mm (NTOU M2061), 28 males cl 15.0–29.3 mm, 6 ovig. females cl 23.4–28.1 mm, 29 females cl 13.8–19.3 mm, 26 juveniles cl 11.7–14.7 mm (NTOU M02062); stn CP2658, 15°59′N, 121°51′E, 422-431 m, 20 May, 2007, 1 male cl 23.9 mm, 1 ovig. female cl 29.9 mm, 3 females cl 17.7–19.4 mm (NTOU M02063); stn CP2708, 15°07′N, 121°38′E, 307–309 m, 28 May, 2007, 4 males cl 25.3–29.1 mm, 1 female cl 27.5 mm (NTOU M02064); stn CP2727, 15°20′N, 121°34′E, 300–318 m, 31 May, 2007, 1 female cl 25.3 mm (NTOU M02065); stn CP2734, 15°56′N, 121°49′E, 453–460 m, 01 June, 2007, 1 ovig. female cl 28.5 mm (NTOU M02066); stn CP2736, 16°01′N, 121°53′E, 344–347 m, 01 June, 2007, 1 male cl 16.4 mm, 1 juvenile cl 13.8 mm (NTOU M02067).

Non-types: Philippines, southeastern Luzon, R/V Fisheries Researcher 1, stn FR1-PH1-14-95, 14°41.07′N, 123°24.12′E, 435–451 m, 27 September, 1995, 1 male cl 26.0 mm, 1 ovig. female cl 22.4 mm (NTOU M02068); Sulu Sea, PANGLAO 2005, stn CP2381, 8°43.3′N, 123°19.0′E, 275–280 m, 28 May, 2005, 1 juvenile cl 10.8 mm (NTOU M01595).—Papua New Guinea, BIOPAPUA, stn DW3734, 08°16′S, 150°30′E, 389 m, 09 October, 2010, 1 male cl 21.5 mm (MNHN IU-2011-5267).—MADEEP, stn CP4255, 2°28′S, 150°42′E, 333–420 m, 24 April, 2014, 1 male cl 15.0 mm (MNHN IU-2013-2316).—Solomon Islands, SALOMON 1, stn CP1786, 9°21′S, 160°25′E, 387 m, 30 September, 2001, 2 males cl 17.4 and 25.4 mm, 1 juvenile cl 10.5 mm (NTOU

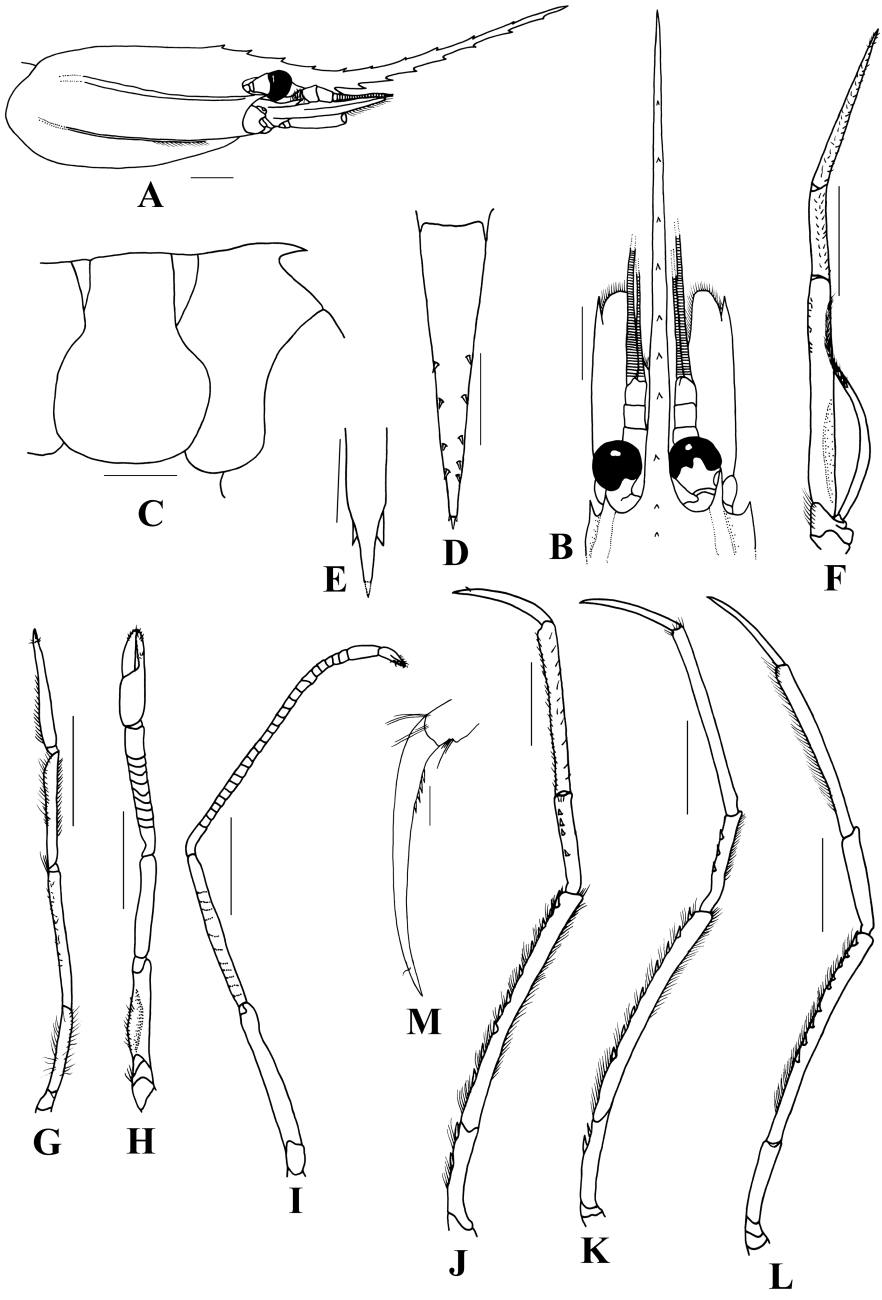

Figure 3. *Heterocarpus fascirostratus* sp. nov., Philippines, AURORA, stn CP2734, (A–I, K, L) ovig. female holotype cl 24.3 mm (NMCR), (J, M) ovig. female paratype cl 28.5 mm (NTOU M02066). (A) Carapace and cephalic appendages, lateral view. (B) Anterior carapace and cephalic appendages, dorsal view. (C) Abdominal somites II and III, lateral view. (D) Telson, dorsal view. (E) Tip of telson, dorsal view. (F) Left maxilliped III. (G) Right pereiopod I. (H) Right pereiopod II. (I) Left pereiopod II. (J) Left pereiopod III. (K) Left pereiopod IV. (L) Left pereiopod V. (M) Dactylus of left pereiopod III. Scales: A–D, F–L = 5 mm, E, M = 1 mm.

M02069, exchanged from MNHN); stn CP1794, 9°16′S, 160°08′E, 494–504 m, 30 September, 2001, 1 ovig. female cl 26.2 mm (NTOU M02070, exchanged from MNHN); stn CP1795, 9°19′S, 160°23′E, 442–451 m, 01 October, 2001, 1 male cl 24.5 mm, 1 female cl 12.3 mm (NTOU M2071, exchanged from MNHN); stn CP1796, 9°19′S, 160°25′E, 469–481 m, 01 October, 2001, 1 female cl 24.4 mm (NTOU M02072, exchanged from MNHN). —Taiwan, Donggang fishing port, Pingtung County, 6 November 2000, 2 juveniles cl 11.3 and 12.8 mm (NTOU M02073); TAIWAN 2000, stn CP27, 22°13.3′N, 121°23.4′E, 329–377 m, 30 June, 2000, 1 juvenile cl 10.6 mm (NTOU M02074).—South China Sea, Dongsha (Pratas), purchased at Badouzi fishing market, Keelung, Taiwan, 3 June, 1992, 1 male cl 25.5 mm (NTOU M02075); commercial trawler, May 1999, 2 males cl 27.9 and 30.0 mm, 3 ovig. females cl 28.5–31.8 mm (NTOU M02076); purchased at Nanfanou fishing market, Yilan County, Taiwan, 6 November, 2000, 17 males cl 25.2-33.7 mm, 29 ovig. females cl 28.5–35.3 mm, 2 females cl 24.2 and 24.4 mm (NTOU M02077); R/V Ocean Researcher 1, 01 May, 2014, 1 ovig. female cl 24.0 mm (NTOU M02078).

Diagnosis.—Rostrum far overreaching scaphocerite, armed dorsally with 9–12 teeth (including 1 or 2 postrostral teeth) and ventrally with 8 or 9 teeth, decreasing in size distally. Carapace with postrostral ridge extending near to posterodorsal margin, not elevated at base of rostrum; lateral surface with two strong and more or less straight longitudinal carinae, originating from antennal and branchiostegal spines and extending to near posterior margin (Fig. 3A); branchiostegal spine shorter or as long as antennal spine. Scaphocerite 3.0–3.7 times as long as maximum width, with blade overreaching distolateral spine (Fig. 3B). Abdomen only with somite III bearing large overhanging spine at mid-dorsal part, tip of overhanding spine slightly recurved downwards (Fig. 3C), only pleuron V bearing acute posteroventral tooth. Telson bearing 2 rows of dorsolateral spines, each row usually with 4 and rarely 2–7 spines (excluding subterminal spine, Fig. 3D). Pereiopod II unequal; carpus of shorter one (Fig. 3H, generally right) divided into 8–11 articles, that of longer one (Fig. 3I) with 22–26 articles. Pereiopod III with 3–6 spines on carpus; merus with 2 rows of spines, 8-12 spines on distal row and 1–3 spines at proximal row; 2–3 spines on ischium (Fig. 3J); dactylus 0.5–0.7 times as long as propodus and bearing 4–6 proximo-ventral spinules (Fig. 3M). Pereiopod IV with 3–5 (rarely 6) spines on carpus, 10–14 (rarely 15) spines on merus and 2–3 (rarely 4 or 5) spines on ischium (Fig. 3K). Pereiopod V bears 2–5 (rarely 6) spines on carpus, 9–11 spines on merus while ischium without any spine (Fig. 3L).

Description.—Rostrum extending far beyond scaphocerite, 1.1–1.65 times longer than carapace, straight and directed anterodorsally after passing antennal peduncle; dorsally armed with 9–12 teeth including 1 or more often 2 teeth on carapace posterior to orbital margin; ventrally bearing 8–9 teeth almost along entire length; rostral teeth progressively smaller anteriorly, distal 2 or 3 teeth very small and obscure. Rostral crest absent while postrostral carina slightly elevated and extending to near posterior margin of carapace (Fig. 3A). Carapace with 2 strong and more or less straight lateral carinae across almost entire carapace length, with postantennal carina continuous with antennal spine while branchiostegal carina continuous with branchiostegal spine; branchiostegal carina generally sharper than postantennal carina (Fig. 3A). Eye subpyriform and without ocellus (Fig. 3B). Antennal spine nearly reaching distal end of eyestalk. Branchiostegal spine shorter or as long as antennal

spine (Fig. 3A). Antennular peduncle with stylocerite sharply acute and reaching distal end of basal segment (Fig. 3A). Outer flagellum long. Scaphocerite, about 0.6 times as long as carapace and 3.0–3.7 times as long as wide, with distolateral spine overreached by lamella (Fig. 3B).

Maxilliped III stouter than pereiopods and overreaching scaphocerite, exopod slightly shorter to more or less as long as antepenultimate segment (Fig. 3F). Pereiopod I slightly overreaching scaphocerite, with microscopic chela (Fig. 3G). Pereiopods II markedly unequal, shorter one (about 80% at right side) with carpus subdivided into 8–11 articles, distal and proximal articles long but other articles short; carpus 1.2–1.6 times as long as chela, ischium ventrally compressed and protruded (Fig. 3H); longer one (80% at left side) with carpus subdivided into 22–26 articles and merus somewhat subdivided into 8–12 articles (Fig. 3I). Pereiopod III overreaching scaphocerite by about dactylus; dactylus 0.5–0.7 times as long as propodus, bearing 4-6 proximo-ventral spinules (Fig. 3M); propodus scattered with setae; carpus 0.6–0.7 times as long as propodus, with 3–6 spines; merus armed with 1–3 mesial and 8–12 lateral spines along flexor margin, ischium with 2–3 spines (Fig. 3J). Pereiopods IV and V similar to pereiopod III. Pereiopod IV with propodus lacking setae, carpus armed with 3–5 (rarely 6) spines, merus with 10–14 (rarely 15) spines and ischium with 2–3 spines (Fig. 3K). Pereiopod V with propodus bearing long setae, carpus with 2–5 (rarely 6) spines and merus with 9–11 spines (Fig. 3L).

Abdomen only with somite III armed dorsally at median part a strong overhanging spine, directed posterodorsally and slightly recurved downwards (Fig. 3C). All other somites without spine or dorsal boss. Only pleuron V armed with sharp posteroventral tooth. Somite VI 2.1–2.3 times as long as maximum height, bearing dorsolaterally a pair of well-defined longitudinal carinae. Telson distally pointed (Fig. 3E), 1.5–1.7 times longer than somite VI, usually bearing 4 pairs, infrequently 3 pairs and very rarely 5 pairs, of dorsolateral spines (excluding subterminal spines), sometimes number of dorsolateral spines asymmetrical in two sides with each side having 2–7 spines (Fig. 3D). Uropods nearly as long as telson.

Color.—Body generally reddish to pinkish red (Fig. 1E). Rostrum distinctly alternated with red and white or pink bands, rostral teeth often whitish. Antennal and antennular flagella somewhat paler in color. Area below postrostral teeth sometimes yellowish and occasionally a pair of dorsal white spots present at posterior 1/3 of carapace (Fig. 1F). Eyes dark brown. Pereiopods sometimes with some segments whitish pink. Abdomen somite III generally uniform in color, but in material from Papua New Guinea distal half of overhanging tooth more reddish and with reddish color extending downwards onto tergite as a red transverse stripe (Fig. 1G). Tips of uropods whitish. Eggs (uneyed) reddish brown.

Distribution.—Western Pacific, South China Sea and Northern Australia, known with certainty from Japan, East China Sea, Taiwan, the Philippines, South China Sea, Indonesia, Papua New Guinea, Solomon Islands and Northern Australia from the North West Shelf to Cape York, at depths of 262–655 m.

Etymology.—The name "*fascirostratus*", meaning banded rostrum, refers the rostrum of this species differing from the true *H. woodmasoni* in distinctly alternated with red and white bands.

Remarks.—As discussed under the "Remarks" of *H. woodmasoni*, the western Pacific material previously considered to be the typical form of *H. woodmasoni* (sensu Crosnier 1988, 1999) is actually an undescribed species. Therefore, the western Pacific form is here assigned to a new species. Apart from the Western Pacific, this species is rather abundant off Dongsha in the South China Sea and sometimes caught commercially by Taiwanese trawlers and sold in the fish markets of Taiwan. The specimens examined from the various localities in the western Pacific and South China Sea are essentially similar except those from Papua New Guinea sometimes bear a red transverse stripe on the abdominal tergite III extending onto the overhanging spine (Fig. 1G). Nevertheless, COI sequence divergence is 1% or less amongst the present material from far distant areas (Table 1, Fig. 4).

Of the four species now known in the "*H. woodmasoni*" group, *H. woodmasoni* and *H. calmani* have a rostral crest while *H. intermedius* and *H. fascirostratus* sp. nov. lack a rostral crest (Fig. 3A, Crosnier 1988: fig. 1i, 1999: fig. 1a, d). The rostral crest is high in *H. calmani* (Crosnier 1988: fig. 1a) but low in *H. woodmasoni* (Fig. 2A). Both *H. calmani* and *H. intermedius* have only two pairs of dorsolateral spines on the telson (Crosnier 1988: fig. 1c, 1999: fig. 1c), while *H. fascirostratus* sp. nov. generally has four pairs (Fig. 3D, Crosnier 1988: fig. 1k) and *H. woodmasoni* has usually five to six pairs (Fig. 2C). Of the 172 *H. fascirostratus* sp. nov. specimens examined, 132 have a complete telson. However, a Philippines specimen (NTOU M02062) abnormally bears only one pair of dorsolateral spines on the telson. The telson of this specimen is likely regenerated as its right subterminal spines is situated rather far away from the tip. Amongst the 131 specimens with intact normal telson, 90 (68.7%) have four pairs, seven (5.3%) has three pairs and only two (1.5%) have five pairs of dorsolateral spines. The remaining 32 specimens (24.4%) have asymmetrical dorsolateral spines on the two sides, all except one specimen with two to five spines on each side. Amongst them only 17 (13.0%) have one side of the telson bearing five and the other side having four dorsolateral spines. The exceptional specimen from Paupa New Guinea (MNHN IU-2013-2316) has six and seven dorsolateral spines on the either side of the telson. Of the 23 *H. woodmasoni* specimens examined with intact telson, only one (4.3%) has four pairs of dorsolateral spines while five (21.7%) have one side bearing four and the other side bearing five dorsolateral spines. Although there is still 16.9% (26/154) of overlapping in the dorsolateral spine counts between *H. woodmasoni* and *H. fascirostratus* sp. nov., *H. woodmasoni* is unique in the posterior part of the postantennal carina and the overhanging spine at abdominal somite III distinctly curved (Fig. 2A, B). The other three species have the postantennal carina more or less straight (Fig. 3A, Crosnier 1988: fig. 1a, i, 1999: fig. 1a), and the overhanging spine of the abdominal somite III not markedly recurved downwards (Fig. 3C, Crosnier 1988: fig. 1b, 1999: fig. 1b). The number of spines on the posterior pereiopods appears to be similar amongst *H. woodmasoni*, *H. intermedius,* and *H. fascirostratus* sp. nov., but generally fewer at the meri in *H. calmani* (see Crosnier 1999: table 1). The spine counts given in the "Description" for the present new species are based on the material examined. There are larger variations in the spine counts provided by Chace (1985, as "*H. woodmasoni*") and Crosnier (1988, 1999, as "*H. woodmasoni*").

The coloration of *H. calmani* is unique in having the abdominal tergite III with a large rounded red patch (with some white longitudinal lines) covering the overhanging spine and its basal part (Fig. 1D) and bright blue eggs. The rostrum of *H. calmani* is not banded. The body of *H. woodmasoni* is rather uniform in color and

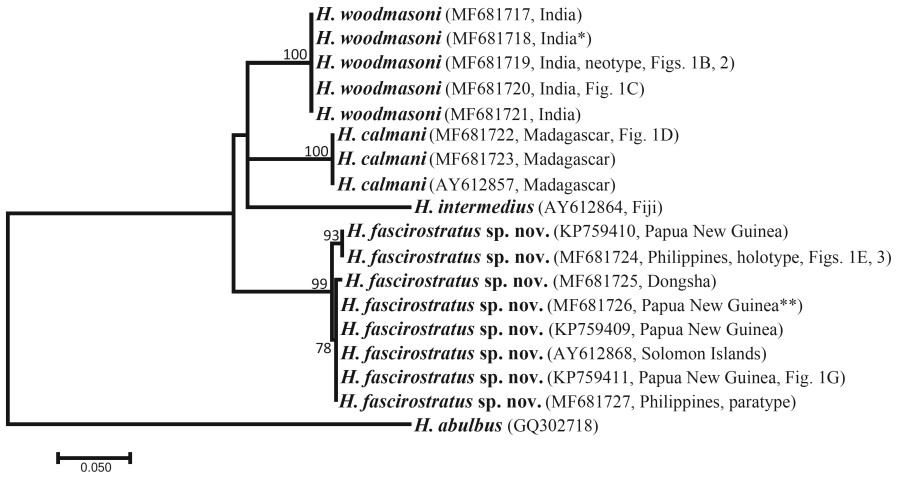

Figure 4. Maximum-likelihood (ML) tree from partial sequences of mitochondrial COI gene (324–657 bp) of "*Heterocarpus woodmasoni*" species group and outgroup based on TIM2+I+G model (I = 0.225, G = 0.284). Numbers at nodes are bootstrap values and only values >50 are shown. * telson with 4 pairs of dorsolateral spines. ** telson with 6 and 7 dorsolateral spines on two sides.

only with the abdominal somite III sometimes bearing a longitudinal red stripe below the overhanging spine (Fig. 1A–C). Moreover, the uneyed eggs of *H. woodmasoni* are greenish brown. *Heterocarpus fascirostratus* sp. nov. has the rostrum distinctly banded and bearing reddish brown uneyed eggs. The abdominal somite III of *H. fascirostratus* sp. nov. is generally uniform in color and only sometimes bearing a transverse red stripe extending from the overhanging spine down to lateral tergite (Fig. 1E–G). The coloration of *H. intermedius* appears to be very similar to *H. fascirostratus* sp. nov. according to the color description given by Crosnier (1999). Some photographs of *H. intermedius* collected from New Caledonia to Fiji deposited at MNHN also showed a similar coloration as *H. fascirostratus* sp. nov. except the body is generally more whitish (Fig. 1H). Thus, *H. fascirostratus* sp. nov. seems still can only be clearly separated from *H. intermedius* by the number of dorsolateral spines on the telson (see also Crosnier 1999) even though there are large genetic differences between these two species (the partial sequence divergence on COI gene is 9.5%–10.0%, Table 1, Fig. 4). Since both *H. fascirostratus* sp. nov. (as *H. woodmasoni* in Crosnier 1999) and *H. intermedius* occur in Australia, only those reported by Hanamura and Evans (1996) and Crosnier (1999) can be determined to be the present new species. The exact identities of the material from various Australian localities in Wadley and Evans (1991), Jones and Morgan (2001), Hanamura and Takeda (1987) and Kensley et al. (1987) will need to be verified. On the other hand, Balss' (1925) station 199 specimen from northwestern Sumatra south to the Andaman Sea also need to be re-examined to determine if it is truly *H. woodmasoni* or actually *H. fascirostratus* sp. nov.

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Literature Cited

Alcock A. 1901. A descriptive catalogue of the Indian deep-sea Crustacea Decapoda Macrura and Anomala, in the Indian Museum. Being a revised account of the deep-sea species collected by the Royal Indian Marine Survey Ship Investigator. Calcutta: Trustees of the Indian Museum. iv. 286 p, plates 1–3.

Alcock A, McArdle AF. 1901. Crustacea, Part IX. *In*: Illustrations of the zoology of the Royal Indian Marine Survey Ship Investigator, under the command of Commander T.H. Heming, R.N., plates 49–55. Calcutta.

Balss H. 1925. Macrura der deutschen Tiefsee-Expedition. 1. Palinura, Astacura und Thalassinidea. *In:* Chun C, editor. Wissenschaftliche Ergebnisse der deutschen Tiefsee-Expedition auf dem Dampfer "Valdivia" 1898–1899. Vol. 20(4–5). p. 189–216.

Calman WT. 1939. Crustacea: Caridea. The John Murray Expedition 1933-34. Sci Rep. 6(4):183–224.

Chace FA Jr. 1985. The caridean shrimps (Crustacea: Decapoda) of the *Albatross* Philippine Expedition, 1907–1910, Part 3: Families Thalassocarididae and Pandalidae. Smithson Contrib Zool. 411:1–143. https://doi.org/10.5479/si.00810282.411

Chan T-Y, Yu H-P. 1987. On the *Heterocarpus* shrimps (Crustacea: Decapoda: Pandalidae) from Taiwan. Bull Inst Zool Acad Sin. 26(1):53–60.

Crosnier A. 1988. Sur les *Heterocarpus* (Crustacea, Decapoda, Pandalidae) du sud-ouest de l'océan Indien. Remarques sur d'autres espèces ouest-pacifiques du genre et description de quatre taxa nouveaux. Bull Mus natn Hist nat, Paris 4(10):57–103, pls.1–4.

Crosnier A. 1999. Un *Heterocarpus* nouveau (Crustacea, Decapoda, Pandalidae) du Pacifique Sud-Ouest. Zoosystema. 2(2):345–351.

De Bruin GHP, Russell BC, Bogusch A. 1995. FAO Species Identification Field Guide for Fishery Purposes. The Marine Fishery Resources of Sri Lanka. FAO, Rome, 400 p. plates I-XXXII.

de Man JG. 1920. The Decapoda of the Siboga Expedition. IV: Families Pasiphaeidae, Stylodactylidae, Hoplophoridae, Nematocarcinidae, Thalassocaridae, Pandalidae,

Psalidopodidae, Gnathophyllidae, Processidae, Glyphocrangonidae and Crangonidae. Siboga-Expeditie. 39a(3):1–318, pls. 1–25.

Everett BI, Groeneveld JC, Fennessy ST, Dias N, Filipe O, Zacarias L, Igulu M, Kuguru B, Kimani E, Munga CN, et al. 2015. Composition and abundance of deep-water crustaceans in the Southwest Indian Ocean: enough to support trawl fisheries? Ocean Coast Manage. 111:50–61. https://doi.org/10.1016/j.ocecoaman.2015.04.003

George MJ, Rao PV. 1967. On some decapod crustaceans from the south-west coast of India. *In:* Symposium Series of the Marine Biological Association of India. No. 2. Proc Symp Crust. 1:327–336.

Hajibabaei M, Singer GAC, Hebert PDN, Hickey DA. 2007. DNA barcoding: how it complements taxonomy, molecular phylogenetics and population genetics. Trends Genet. 23(4):167–172. https://doi.org/10.1016/j.tig.2007.02.001

Hanamura Y, Evans DR. 1996. Deepwater caridean shrimps of the families Nematocarcinidae, Stylodactylidae, Pandalidae and Crangonidae (Crustacea: Decapoda) from Western Australia. Bull Nansei Natl Fish Res Inst. 29:1–18.

Hanamura Y, Takeda M. 1987. Family Pandalidae (Crustacea, Decapoda, Caridea) collected by the RV "SOELA" from the Northwest Australian Shelf. Bull Natl Sci Mus Ser A (Zool). 13(3):103–121.

Hayashi K-I. 2007. Prawns, shrimps and lobsters from Japan (155). Family Pandalidae—genus *Heterocarpus* (3). Kaiyo To Seibutsu. 29(5):466–472.

Hebert PDN, Cywinska A, Ball SL, deWaard JR. 2003. Biological identifications through DNA barcodes. Proc Biol Sci. 270:313–321. https://doi.org/10.1098/rspb.2002.2218

Holthuis LB. 1980. FAO species catalogue, Vol.1. Shrimps and prawns of the world. An annotated catalogue of species of interest to fisheries. FAO, Rome. 261 p.

Holthuis LB. 1984. Shrimps and prawns. FAO species identification sheets for fishery purposes, western Indian Ocean (Fishery Area 51). FAO, Rome. 132 p.

Jones DS, Morgan GJ. 2002. A field guide to crustaceans to crustaceans of Australian waters. Western Australian Museum/Reed New Holland Publication, Frenchs Forest. 224 p.

Kensley BF. 1969. Decapod Crustacea from the South-West Indian Ocean. Ann S Afr Mus. 52(7):149–181.

Kensley BF. 1972. *Shrimps and prawns of southern Africa.* South African Museum, Cape Town. 65 p.

Kensley BF, Tranter HA, Griffin DJG. 1987. Deepwater decapod Crustacea from eastern Australia (Penaeidea and Caridea). Rec Aust Mus. 39:263–331.

Kurup BM, Rajasree R, Venu S. 2008. Distribution of deep sea prawns off Kerala. J Mar Biol Assoc India. 50(2):122–126.

Li X. 2006a. Report on some pandalid shrimps from the East China Sea (Decapoda, Caridea). Crustaceana. 79(11):1281–1296. https://doi.org/10.1163/156854006779277303

Li X. 2006b. Additional pandaloid shrimps from the South China Sea (Crustacea: Decapoda: Caridea), with description of new species. Raffles Bull Zool. 54(2):361–372.

Li X, Chan T-Y. 2013. Pandalid shrimps (Crustacea, Decapoda, Caridea) collected from the Philippines PANGLAO 2005 deep-sea expedition. *In:* Ahyong ST, Chan TY, Corbari L, Ng PKL, editors. Tropical Deep-Sea Benthos 27. Mém Mus nat Hist nat. 204:129–154.

Malay MCD, Paulay G. 2010. Peripatric speciation drives diversification and distributional pattern of reef hermit crabs (Decapoda: Diogenidae: *Calcinus*). Evolution. 64:634–662. https://doi.org/10.1111/j.1558-5646.2009.00848.x

Rajan KN, Nandakumar G, Chellappan K. 2001. Innovative exploitation of deepsea Crustacean along the Kerala coast. *In:* Marine Fisheries Information Service, Technical and Extension. Central Marine Fisheries Research Institute, Kochi. 168:1–11.

Rajasree SRR, Kurup BM. 2011. Food and feeding habits of deepsea pandalid prawns *Heterocarpus gibbosus* Bate, 1888 and *Heterocarpus woodmasoni* Alcock, 1901 off Kerala, south India. Indian J Fish. 58(3):45–50.

Rajool Shanis CP, Salim SS, Manjebrayakath H, Ganga U, Manjusha U, Pillai NGK. 2014. Deep-sea shrimp fishery operations in Kerala coast: problems and prospects. Int J Fish Aquat Stud. 1(6):237–242.

Shih H-T, Ng PKL, Schubart CD, Chang H-W. 2007. Phylogeny and phylogeography of the genus *Geothelphusa* (Crustacea: Decapoda, Brachyura, Potamidae) in southwestern Taiwan based on two mitochondrial genes. Zool Sci. 24:57–66. https://doi.org/10.2108/zsj.24.57

Wadley V, Evans D. 1991. Crustaceans from the deepwater trawl fisheries of Western Australia. Western Australia: CSIRO. 44 p.

Yang C-H, Chan T-Y. 2012. On the taxonomy of the slipper lobster *Chelarctus cultrifer* (Ortmann, 1897) (Crustacea: Decapoda: Scyllaridae), with description of a new species. Raffles Bull Zool. 60(2):449–460.

Yang C-H, Chan T-Y, Chu KH. 2010. Two new species of the "*Heterocarpus gibbosus* Bate, 1888" species group (Crustacea: Decapoda: Pandalidae) from the western Pacific and north-western Australia. Zootaxa. 2372:206–220.