

Ateneo de Manila University

Archium Ateneo

Biology Faculty Publications

Biology Department

2016

Two new species of *Geosesarma* De Man, 1892 (Crustacea: Brachyura: Sesarmidae) from Palawan, the Philippines

Hendrik Freitag
Ateneo de Manila University

Marivene Manuel-Santos

Peter K.L Ng

Follow this and additional works at: <https://archium.ateneo.edu/biology-faculty-pubs>



Part of the [Aquaculture and Fisheries Commons](#), [Biodiversity Commons](#), and the [Biology Commons](#)

Custom Citation

Manuel-Santos, Marivene R., Peter K. L. Ng & Hendrik Freitag. 2016. Two new species of *Geosesarma* De Man, 1892 (Crustacea: Brachyura: Sesarmidae) from Palawan, the Philippines. *Raffles Bulletin of Zoology* 64: 335-342.

This Article is brought to you for free and open access by the Biology Department at Archium Ateneo. It has been accepted for inclusion in Biology Faculty Publications by an authorized administrator of Archium Ateneo. For more information, please contact oadrcw.ls@ateneo.edu.

Two new species of *Geosesarma* De Man, 1892 (Crustacea: Brachyura: Sesarmidae) from Palawan, the Philippines

Marivene Manuel-Santos^{1*}, Peter K. L. Ng² & Hendrik Freitag³

Abstract. Two new and relatively large species of semi-terrestrial sesarmid crabs of the genus *Geosesarma* De Man, 1892, are described from Palawan Island, Philippines. They are distinguishable from congeners by the characteristic structure of their carapace, chelipeds, ambulatory legs and male first gonopods. Aspects of their ecology are briefly discussed.

Key words. Crustacea, Brachyura, Decapoda, Sesarmidae, *Geosesarma*, Palawan, Philippines, taxonomy, new species.

INTRODUCTION

In the early 1990s, an expedition was conducted by the National Museum of the Philippines and the Cincinnati Museum of Natural History to study the fauna of the Mount Victoria range in Palawan. Among the specimens collected was a relatively large species of semi-terrestrial sesarmid crab belonging to the genus *Geosesarma* De Man, 1892. About 15 years later, additional specimens of a similar *Geosesarma* were collected by Mr. Jojo V. Orcullo, Palawan artist and ethnographer, who kindly forwarded the specimens to the authors for study. Subsequently, more specimens of this genus were obtained by the third author from central parts of Palawan during samplings for the AQUA Palawana program, with most of the material collected from the primary forests around Mount Cleopatra Needle in 2015. This material proved to belong to two new allied species.

Geosesarma currently has 56 recognised species (Ng et al., 2015; Ng, 2015) from Southeast Asia, eastern Indian Ocean, and western Pacific. Five species are previously known from the Philippines: *G. hednon* Ng, Liu & Schubart, 2004 [Cebu, Philippines; Taiwan], *G. vicentense* (Rathbun, 1914) [Luzon], *G. rathbunae* (Serène, 1968) [Panay], *G. protos* Ng & Takeda, 1992 [Mindanao], and *G. lawrencei* Manuel-Santos & Yeo, 2007 [Palawan]. The two new species of *Geosesarma* from Palawan are here described, figured and compared with congeners.

Specimens are deposited in the Crustacean Reference Collection of the National Museum of the Philippines (NMCR), Manila; Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum (previously the Raffles Museum of Biodiversity Research); National University of Singapore; Palawan Council for Sustainable Development Reference Collection (PCSD), Puerto Princesa City; Senckenberg Collections of Natural History Dresden (SMTD), Germany; and collection of the third author currently in the Ateneo de Manila University, Philippines (CFM-ADMU). The abbreviations G1 and G2 are used for the male first and second gonopods, respectively. The measurements, in millimetres, are given as maximum carapace width by carapace length, including the frontal lobes. Most of the terminologies used are based on Ng et al. (2004). The images of the G1 and G2 were taken with a Leica M205C stereomicroscope. Photographs of various focus layers were combined stacked using CombineZP software (Hadley, 2010).

TAXONOMY

Family SESARMIDAE Dana, 1851

Geosesarma De Man, 1892

Type species. Type species *Sesarma* (*Geosesarma*) *nodulifera* De Man, 1892, subsequent designation by Serène & Soh (1970).

Remarks. *Geosesarma* was last revised in part by Serène (1968) and Serène & Soh (1970) but is still heterogeneous in regard to several important diagnostic characters: (1) the egg size and developmental pattern: representatives with large eggs that practice completely abbreviated development (e.g., *G. notophorum* Ng & Tan, 1995), reduced larval development (e.g., *G. peraccae* (Nobili, 1903) and species described in this study); as well as inland forms with small eggs that presumably return to the sea for larval release (e.g., *G. maculatum* (De Man, 1892); *G. hednon*; *G. ternatense*

¹Zoology Division, National Museum of the Philippines, P. Burgos Street, Ermita, Manila 1000 Philippines. Email: vinmanuel@yahoo.com (*corresponding author)

²Lee Kong Chian Natural History Museum, National University of Singapore, 2 Conservatory Drive, Singapore 117377. Email: peterng@nus.edu.sg

³Ateneo de Manila University, Biology Department, School of Science & Engineering, Loyola Heights, Quezon City 1101, Philippines & Senckenberg Museum of Zoology, Koenigsbrücker Landstrasse 159, 01109 Dresden, Germany. Email: hendrik.freitag@senckenberg.de

(Serène, 1968)); (2) the shape of the distal chitinous part of the G1, which can either be long and straight (e.g., *G. maculatum*; *G. hednon*); long and bent (e.g., *G. krathing* Ng & Naiyanetr, 1992, *G. peraccae* (Nobili, 1903)); or short, bent and sometimes flattened (e.g., *G. notophorum*, *G. sabanum* Ng, 1992); and (3) the presence of a long flagellum of the exopod of the third maxilliped (e.g., *G. krathing*; *G. rathbunae*; *G. lawrencei*); the flagellum is reduced (e.g., *G. hednon*); or is absent (*G. malayanum* group, e.g., *G. sabanum*; *G. protos*; *G. aurantium* Ng, 1995) (Serène, 1968; Serène & Soh, 1970; Ng & Takeda, 1992; Ng & Naiyanetr, 1992; Ng, 1992, 1995a; Ng et al., 2004; Manuel-Santos & Yeo, 2007). The dorsal margin of the adult male dactylar finger of the cheliped in many species is usually lined with a distinct row of prominent pectinate tubercles along most of the length (e.g., *G. malayanum* group, *G. peraccae*, *G. noduliferum*, *G. bicolor* Ng & Davie, 1995, *G. peraccae*, *G. hagen* Ng, Schubart & Lukhaup, 2015, *G. dennerlei* Ng, Schubart & Lukhaup, 2015) (see Ng, 1988; Ng & Lim, 1987; Ng et al., 2015), but in several species, such tubercles are absent. In some species (e.g., *G. maculatum*, *G. hednon*, *G. aurantium*, *G. sabanum*, *G. danumense*, *G. lawrencei*), the proximal part of the dactylar finger has some sharp tubercles but these are not arranged in a discrete row or pectinate at the tips, and they are reduced or absent towards the distal half of the finger (Ng, 1992, 1995a, 2002; Ng et al., 2004; Manuel-Santos & Yeo, 2007).

Geosesarma batak, new species, and *G. tagbanua*, new species, together with *G. lawrencei*, share the following unique combination of characters: a squarish carapace in which the external orbital tooth is triangular in shape; the postfrontal lobes are prominent, project distinctly anteriorly, and are separated by deep, wide grooves; the ambulatory legs are relatively longer; the exopod of the third maxilliped has a long flagellum; the proximal part of the dactylar finger of the cheliped has only scattered non-pectinate tubercles; the male abdominal somite is distinctly wide; and the G1 is slender with the chitinous distal part long and gently or distinctly bent. In this combination of features, they are easily distinguished from other congeners in the Philippines or Southeast Asia. In features like larger adult size, longer ambulatory legs and arboreal habits, *G. batak* and *G. tagbanua* are superficially similar to species of *Labuanium* Serène & Soh, 1970, or *Scandarma* Schubart, Liu & Cuesta, 2003. Unlike *Labuanium*, these Palawan species do not have a short ambulatory dactylus; and compared to *Scandarma*, they lack the distinct granulated crest on the dorsal margin of the adult chela, and there is also no transverse ridge on the inner surface of the chela (see Schubart et al., 2003; Naruse & Ng, 2007; Ng, 2012, 2013). Their G1 structures are very different. In species of *Labuanium* and *Scandarma*, the G1 is relatively stout with the distal chitinous part short and truncate. In the two Palawan species, the G1 is distinctly more slender and the distal chitinous part is elongate and spatulate in form. In this respect, their G1s are more like those of *G. krathing* and *G. peraccae* (see Ng, 1988; Ng & Naiyanetr, 1992; Schubart et al., 2003; Naruse & Ng, 2007; Ng, 2013).

Geosesarma batak and *G. tagbanua* are also distinct from all congeners by their comparatively large adult size (carapace dimensions at least 22.8 × 22.4 mm for *G. batak* and at least 21.8 × 21.8 mm for *G. tagbanua*). Other *Geosesarma* species are adults at sizes of 7–13 mm in carapace width (see Ng, 1988); and the largest species now known include *G. rathbunae* (13.0 × 12.0 mm, from Panay in the Philippines), *G. insulare* (Ng, 1986) (13.9 × 13.6 mm, from Anambas Islands, Indonesia), *G. katibas* Ng, 1995 (13.5 × 13.5 mm, from central Borneo), *G. danumense* (14.8 × 14.6 mm, from Sabah, Borneo) and *G. sabanum* (13.1 × 13.6 mm, from Sabah, Borneo) (cf. Serène, 1968; Ng, 1986, 1995a, b).

Some species of *Geosesarma* do appear to be related to *Labuanium* Serène & Soh, 1970, and *Scandarma* Schubart, Liu & Cuesta, 2003. As several taxonomic characters in the genera *Labuanium* and *Geosesarma*, are either overlapping (e.g., basal antennular segment subglobular and swollen), inconsistent (presence of salient postfrontal lobes; carapace shape) or might have been neglected in previous studies (e.g., type of larval development; shape of the G1; presence/absence of an exopod flagellum at third maxilliped), this group of genera needs revision. This is now in progress by T. Naruse and the second author.

Geosesarma batak, new species

(Figs. 1A–C, 4A–F, 5A, B)

Material examined. Holotype: male (22.8 × 22.4 mm) (NMCR-40105), Puerto Princesa, Concepcion, near Cleopatra Needle, c. 8.5 km upstream of highway, primary forest, phytothelmata, c. 600 m asl, 10°06'N 119°00'E, coll. H. Freitag, 31 January 2015. Paratypes: 1 female (20.6 × 20.1 mm), 2 juveniles (larger 9.1 × 8.5 mm) (NMCR-40106), same data as holotype; 1 male (11.7 × 11.4 mm) (PCSD), Puerto Princesa, Tagpaya, Camp Aga, Taranaban River, c. 7 km upstream of highway, disturbed primary forest, hydropetric rocks, c. 350 m asl, 10°05'08"N 119°00'33"E, coll. H. Freitag, 2 February 2015; 1 female (21.9 × 21.4 mm) (ZRC 2015.290), 1 male (14.5 × 14.1 mm), 7 juveniles (largest 9.6 × 9.4 mm) (CFM-ADMU), Puerto Princesa, Concepcion, Taranaban River, c. 4 km upstream highway, tree phytothelmata, c. 100 m asl, 10°02'00"N 119°01'00"E, coll. H. Freitag, 20 January 1994; 1 male (18.9 × 18.5 mm) (ZRC 2015.291), Puerto Princesa, 2 km SE Laptay/Napsan, Kalalagbong forest, Tagbanua rainforestation, 9°41'20"N, 118°27'15"E, coll. H. Freitag, 22 August 2008; 2 females (18.0 × 17.6 mm, 15.7 × 15.6 mm) (SMTD-S170, SMTD-S171), 2 females (18.3 × 18.0 mm, ovigerous), 1 male (20.2 × 19.8 mm, dried) (CFM-ADMU), Puerto Princesa, Langogan, side of small temporary tributary near National Highway km 83.9, c. 600 m asl, degraded primary forest, c. 10°01'50"N 119°08'31"E, coll. H. Freitag, 22 August 1994. All locations in Palawan Island, Philippines.

Diagnosis Carapace almost squarish, slightly wider than long; dorsal surfaces rough, gastric and branchial regions slightly swollen, frontal margin strongly deflexed at 90° from horizontal view; postfrontal crest separated into 4 unevenly shaped, dentiform granulated lobes; posterolateral regions

with fine granular striae. Outer surface of chela covered with low rounded granules, dorsal margin with incomplete granular ridge. Ambulatory legs relatively shorter, fourth merus 0.8 times as long as carapace width. Male abdominal somite 6 as long as telson; male telson relatively broader, 1.3 times wider than long. G1 relatively long, slender, shaft more or less evenly tapering, distal chitinous part gently bent laterad at 45°, chitinous part relatively broad, long, gently curved.

Description of holotype male. Carapace (Fig. 1A) sub-squarish, almost as long as wide; lateral margins subparallel; dorsal surfaces slightly convex, rough, with low granules; gastric and branchial regions swollen, hepatic region depressed; grooves moderately deep, regions well defined. Postfrontal crest straight to slightly concave, divided into 4 dentiform postfrontal lobes, reaching or extending slightly beyond frontal margin in dorsal view; anterior margins unevenly granulate; median cleft deep, moderately broad, leading to deep mesogastric groove; 2 distinct, sharp protogastric protuberances present behind lateral frontal lobes; front prominently deflexed from dorsal carapace at right angles, frontal margin sinuous, with broad median concavity; sublateral areas gently lobiform. Orbital carapace margin gently curved. External orbital tooth broadly triangular, directed antero-laterad, tip sharp, pointed; first anterolateral tooth distinctly smaller than external orbital angle, broadly triangular, pointing dorso-laterad, tip acute; second anterolateral tooth very low, inconspicuous; lateral margins finely granular, cristate. Posterolateral regions with fine oblique striae.

Third maxillipeds with rhomboidal gap when closed (Fig. 1B); merus and ischium subequal in size; combined length of carpus, propodus and dactylus (palp) slightly shorter than merus; merus longitudinally ovate, widest subdistally; median and anterior rims, and oblique crista with densely setose fringe; ischium elongately subtrapezoidal; sulcus shallow; entire rim with setose fringe; base with large patch of soft thick setae that extends to base of cheliped; exopod behind ischium, slender, apical median rim with dense setose fringe; flagellum long, reaching beyond width of merus.

Surfaces of thoracic sternites smooth (Fig. 1B), but with scattered bristles; sternites 1 and 2 completely fused; sternite 2 separated from sternite 3 by setose ridge; sternites 3 and 4 fused; sternoabdominal cavity reaching to midpoint of fused sternites 3 and 4. Telson relatively broader, ca. 1.2 times wider than long, lateral margins very gently convex on distal part, but almost straight proximally, tip rounded; somite 6 about as long as telson, distal part of lateral margin convex, proximal part almost straight; abdominal somites 3–5 increasingly trapezoidal; somites 1 and 2 transverse, narrow.

Left cheliped (Fig. 1C) large, distinctly longer than carapace; outer surfaces covered with distinct rounded granules and scattered setae; ischium short subcylindrical, with few prominent, conical granules at ventral and anterior margins, and several inconspicuous setiferous granules; merus approximately as long as palm, ventral margins with sharp granules, dorsal margin serrate, ventral and inner

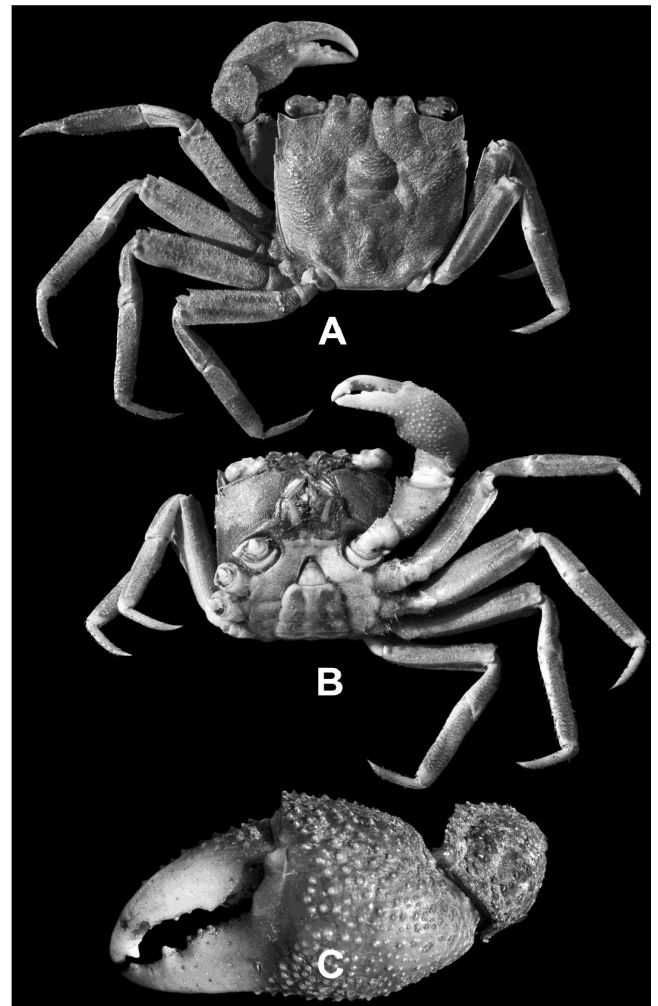


Fig. 1. *Geosesarma batak*, new species, holotype male (22.8 × 22.4 mm) (NMCR-40105), Concepcion, near Cleopatra Needle. A, overall habitus; B, ventral view of cephalothorax; C, left chela and carpus, outer view.

sides smooth, inner side with regularly arranged setae and 2 additional longitudinal rows of setae, lower (ventral) one much more distinct; carpus subovate, slightly longer than broad, subtrapezoidal in dorsal view, with short row of setae at basal inner margin near mero-carpal joint, without distinct inner tooth. Chela relatively stout, median upper (dorsal) margin and outer surface with conspicuous rounded granules; dorsal margin with incomplete granular ridge; lower (ventral) margin and inner surface with lower, smaller granules; fingers subequal to palm in length; dorsal margin of dactylar finger with small sharp tubercles on proximal half; cutting edges of both fingers with prominent teeth, distal half with small gap when closed (Fig. 1C); dorsal and ventral finger margins with conical granules.

Ambulatory legs (Fig. 1A, B) slender, very long; third ambulatory leg longest (combined length of merus, carpus, propodus and dactylus about 2 times of carapace width). Meri moderately slender, very long; second ambulatory merus slightly overreaching frontal carapace margin; fourth ambulatory merus about 0.8 times as long as carapace width; lateral margins almost straight, with distinct subdistal spine; dorsal surfaces with scattered micro-granules; ventral side

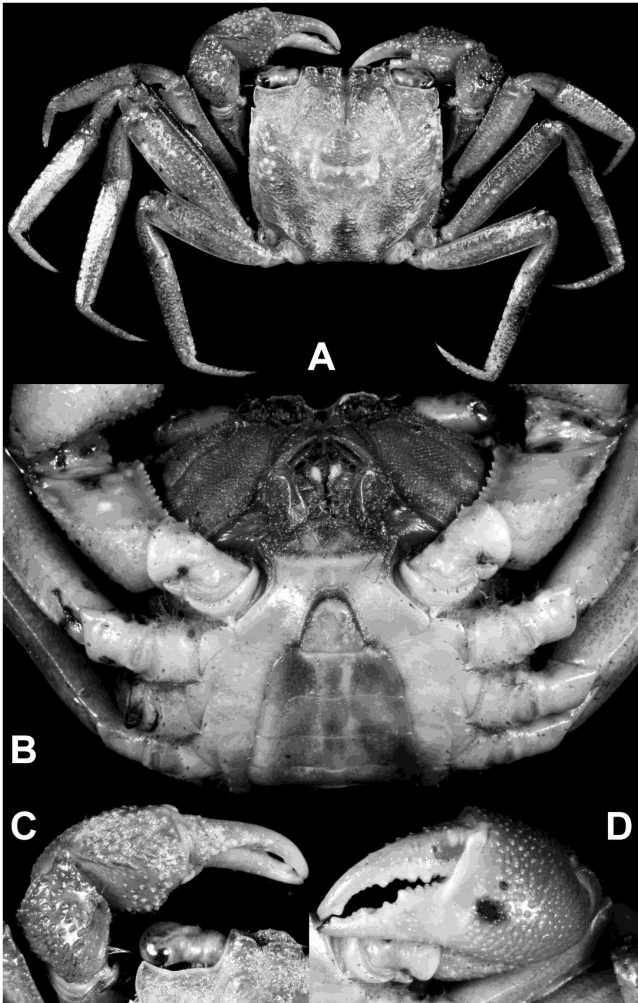


Fig. 2. *Geosesarma tagbanua*, new species, holotype male (21.8 × 21.8 mm) (NMCR-40107), Lipuun Point, Tabon Caves. A, overall habitus; B, ventral view of cephalothorax; C, left chela and carpus, dorsal view; D, left chela, outer view.

smooth; margins serrate, subcristate. Carpi slender; fourth ambulatory carpus ca. 0.5 times as long as fourth ambulatory merus, with subparallel dorsal ridge; surfaces smooth; margins partly granulose, not serrate. Propodus and dactylus slender; fourth ambulatory propodus ca. 0.8 times as long as fourth ambulatory merus; fourth ambulatory dactylus ca. 0.5 times as long as fourth ambulatory merus, surfaces smooth, margins with short dark amber-coloured spines and scattered bristles.

G1 (Fig. 4A–C) moderately long, slender, reaching half length of abdominal somite 6, straight; subdistal inner margin with long setae that do not overreach tip; base rounded, relatively less prominent (Fig. 4B); shaft more or less evenly tapering towards distal chitinous part in dorsal and ventral views (Fig. 4A, C); apically comparably gently bent laterad at 45° in ventral view (Fig. 4A); distal part slightly bent dorsad in lateral view (Fig. 4B), moderately broad, moderately long, entirely gently curved. G2 (Fig. 4D) very short; base subtriangular; distal part moderately slender, outer margin somewhat abruptly curved at half length.

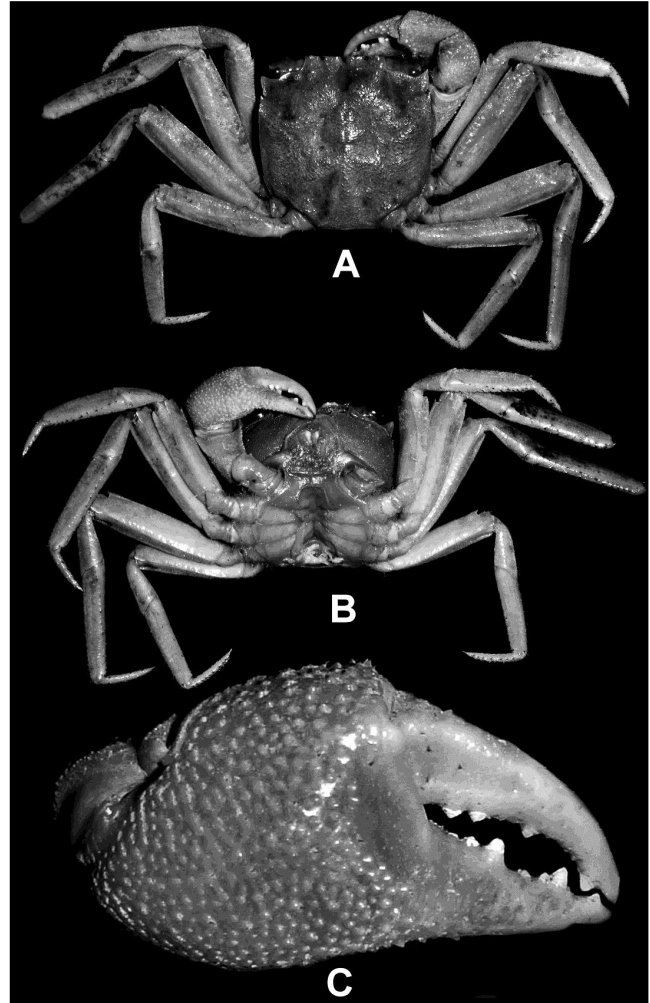


Fig. 3. *Geosesarma tagbanua*, new species, paratype male (21.2 × 21.7 mm) (NMCR-25052), Narra, Tuas, Estrella Creek. A, overall habitus; B, ventral view of cephalothorax; C, right chela, outer view.

Colour in life. Carapace and legs brown with yellowish crested margin of carapace with reddish tinge anteriorly, becoming yellowish posteriorly; tubercles and spinules of chelipeds reddish; abdomen and ventral surfaces pale yellow (Fig. 5).

Etymology. Named after the Bataks, the oldest indigenous tribe in the Philippines who reside in Puerto Princesa and the rest of Palawan. The name is used as a noun in apposition.

Remarks. As discussed earlier, the two new species share with *G. lawrencei* the same prominent four postfrontal lobes and wide male abdominal somite 6 (Manuel-Santos & Yeo, 2007: fig. 1A–C). The G1 is also similar in form, being slender but the chitinous distal part is only gently bent from the vertical (Manuel-Santos & Yeo, 2007: fig. 2A, B). In addition, the ambulatory legs are relatively shorter in *G. lawrencei* compared to the two new species (cf. Manuel-Santos & Yeo, 2007: fig. 1A). As discussed in Manuel-Santos & Yeo (2007), *G. lawrencei* is only known from three relatively small specimens collected from the southern part of Palawan (Brooke's Point) (all about 10 mm in carapace width), and they may not be fully adult as yet.

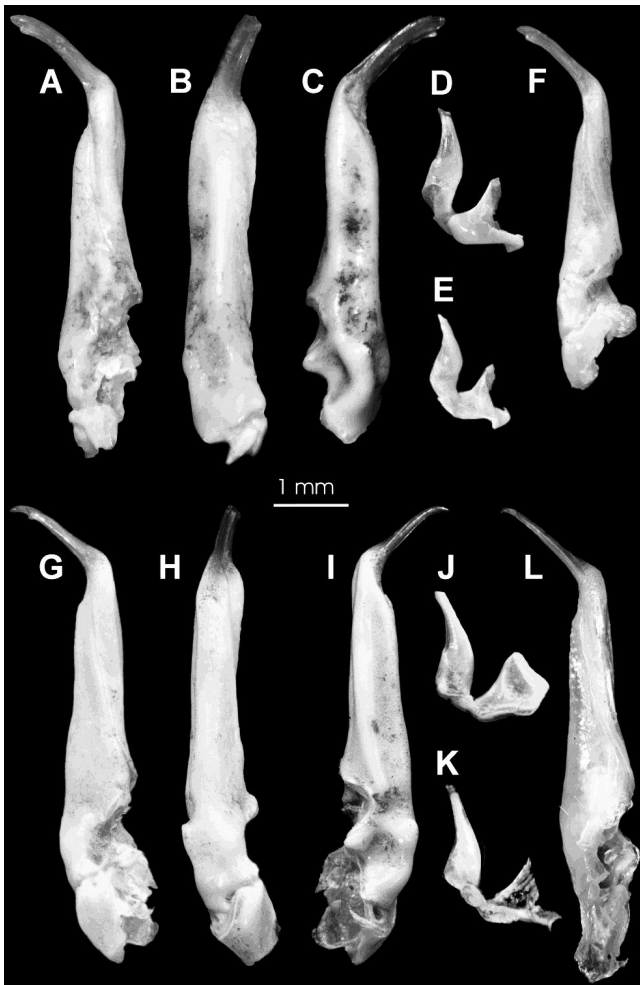


Fig. 4. A–D, *Geosesarma batak*, new species, holotype male (22.8 × 22.4 mm) (NMCR-40105), Concepcion, near Cleopatra Needle; E, F, *G. batak*, new species, paratype male (18.9 × 18.5 mm) (ZRC 2015.291), from Laptay/Napsan; G–J, *G. tagbanua*, new species, holotype male (21.8 × 21.8 mm) (NMCR-40107), Lipuun Point, Tabon Caves; K, L, *G. tagbanua*, new species, paratype male (21.2 × 21.7 mm) (NMCR-25052), Narra, Tuas, Estrella Creek. A–C, F, G–I, L, left G1 (from different angles); D, E, J, K, left G2.

Geosesarma batak is most closely related with *G. tagbanua*, new species (described below). However, their G1 structures are different. The G1 of *Geosesarma tagbanua* is proportionately more slender, abruptly tapering subapically (Fig. 4G–I, L) (versus evenly tapering towards distal chitinous part in *G. batak*, Fig. 4A–C, F), and its distal chitinous part is distinctly more slender, with only the apical area curved (Fig. 4G–I, L) (versus moderately wider and entirely curved in *G. batak*, Fig. 4A–C, F). In addition, *G. tagbanua* can be distinguished from *G. batak* by its relatively more slender male telson (Fig. 2B) (ca. 1.2 times versus 1.3 times wider than long in *G. batak*, Fig. 1B); and the shorter male abdominal somite 6 (Fig. 2B) (slightly shorter than telson versus as long as telson in *G. batak*, Fig. 1B). The ambulatory legs of *G. tagbanua* are also slightly longer (Fig. 2A) (fourth ambulatory merus about 0.9 times versus 0.8 times as long as carapace broad in *G. batak*, Fig. 1A).

With regards to the slender G1 with a long and slender chitinous distal part that is bent laterad at 45°, *G. batak*

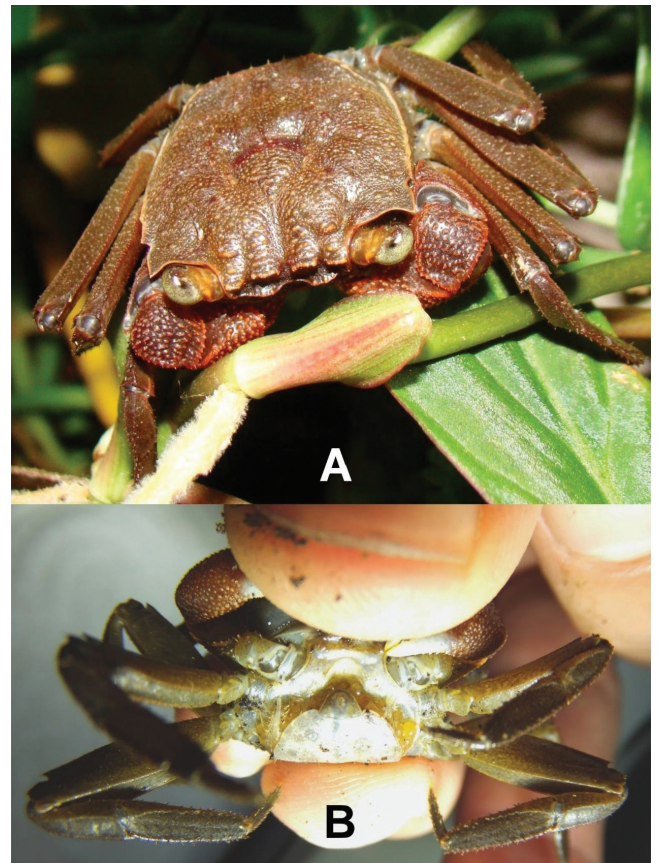


Fig. 5. *Geosesarma batak*, new species, in vivo. A, frontodorsal view of paratype female (20.6 × 20.1 mm) (NMCR-40106), Concepcion, Taranaban River; B, ventral view of an ovigerous female from Concepcion, Taranaban River (specimen not collected)

and *G. tagbanua* are most similar to *G. bicolor* [western Java], *G. dennerle* [central Java], *G. hagen* [central Java], *G. krathing* [eastern Thailand] and *G. peraccae* [southern Malaysia and Singapore]. However, both new species can easily be distinguished from these species by its relatively larger adult size (adults in excess of 20 mm in carapace width) and prominently longer ambulatory legs. In addition, the carapace of *G. peraccae* is distinctly trapezoidal (Ng, 1988: fig. 56A) whereas those of *G. batak* and *G. tagbanua* are squarish (Figs. 1A, 2A, 3A).

With regards to the squarish form of the carapace, general appearance of the external orbital tooth and lateral carapace margin, *G. batak* and *G. tagbanua* resemble *G. sabanum* and *G. danumense* from Sabah, Borneo (Ng, 1992: fig. 1A; Ng, 2002: figs. 1a, 3B, 4a, b). These two species also have longer ambulatory legs compared to most *Geosesarma*, although they are still relatively shorter than the two new species from Palawan (Ng, 1992: fig. 1c; Ng, 2002: figs. 1a, 3B, 4a). The two species from Sabah, however, have the postfrontal lobes less distinctly separated (Ng, 1992: fig. 1A; Ng, 2002: figs. 1a, 3B, 4a, b); have no flagellum on their third maxilliped exopod (cf. Ng, 1992: fig. 1B; Ng, 2002: 304); possess a male abdominal somite 6 which is proportionately less wide (cf. Ng, 1992: fig. 1L; Ng, 2002: figs. 2c, 3C); and have stout G1s in which the chitinous distal part is relatively short and spatuliform (cf. Ng, 1992: 1E–J; Ng, 2002: fig. 3D–H)

Geosesarma batak and *G. tagbanua*, like other *Geosesarma* species now known from the Philippines, do not have pectinate tubercles on the dorsal margin of the dactylus of their chela. While the condition of the carapace, third maxilliped, chela, male abdomen, and/or G1 are not known in *G. rathbunae* and *G. vicentense*, the second author has examined the types in the U.S. National Museum of Natural History, and that information is added in this discussion for completeness. *Geosesarma batak* and *G. tagbanua* resemble *G. rathbunae* in the squarish carapace. However, *G. rathbunae*, from Panay Island, has proportionately much shorter ambulatory legs (Serène, 1968: pl. 1 fig. 4). Its G1 superficially resembles those of *G. batak* and *G. tagbanua* in the general shape and angle but the distal chitinous part is relatively shorter (Serène, 1968: figs. 5, 6). *Geosesarma rathbunae* shares the same wide male abdominal somite 6 as *G. batak* and *G. tagbanua*; but the exopod of its third maxilliped has no flagellum (second author, unpublished data). *Geosesarma batak* and *G. tagbanua* differ distinctly from *G. hednon* (from Cebu, Visayas) and *G. protos* (from Mindanao) in the squarish carapace shape (Figs. 1A, 2A) (distinctly wider than long in *G. hednon*, trapezoidal in *G. protos*, cf. Ng et al., 2004: fig. 9A, B; Ng & Takeda, 1992: fig. 1A); longer ambulatory legs (Figs. 1A, 2A, 3A) (much shorter in *G. hednon* and *G. protos*, cf. Ng et al., 2004: fig. 9A; Ng & Takeda, 1992: fig. 1D); and the presence of a long flagellum of the exopod of the third maxilliped (short or absent in *G. hednon*, always absent in *G. protos*, cf. Ng et al., 2004: 241; Ng & Takeda, 1992: fig. 1B). In *G. protos*, the G1 is also short and stout (Ng & Takeda, 1992: fig. 1G–I), very different from that of *G. batak* and *G. tagbanua* (Fig. 4A–C, F, G–I, L). The poorly known *G. vicentense* belongs to same group of species as *G. hednon* and *G. maculatum*, with a squarish carapace and short ambulatory legs, the exopod of the third maxilliped has a distinct or short flagellum (sometimes missing), and the G1 is straight with the distal chitinous part directed vertically (Ng et al., 2004: figs. 4, 7B–E, 13C–G; unpublished data).

Distribution. Only known from Palawan Island, the Philippines.

Ecological notes. The species was only found in forested areas near streams. Specimens were rarely found at the ground, but more commonly on trees where they dwell in wet knot-holes (and other phytothelms). Some were detected on rocks where they hide in crevices when disturbed or when resting during daytime. The species is probably nocturnal.

One specimen from Puerto Princesa, Concepcion, Taranaban River, possessed relatively large eggs (diameter 1.12–1.39 mm, on average ca. 1.2 mm) (Fig. 5B); suggesting this species undergoes direct or semi-abbreviated development (Ng, 1988; Ng & Tan, 1995).

***Geosesarma tagbanua*, new species**
(Figs. 2A–D, 3A–C, 4G–L)

Material examined. Holotype: male (21.8 × 21.8 mm) (NMCR-40107), Quezon, Lipuun Point, Tabon Caves, c. 4

km NNW Quezon town, c. 9°16'N 117°59'E, coll. J. Orcullo, March 2003. Paratypes: 3 males (largest 20.0 × 20.1 mm) (ZRC, SMTD-S172), same data as holotype; 1 male (21.2 × 21.7 mm) (NMCR-25052), Narra, Tuas, Estrella Creek, ca 370 m asl, 9°19'N, 118°20'E, coll. M. R. Manuel-Santos, 24 May 1990. All locations in Palawan Island, Philippines.

Diagnosis. Carapace squarish; dorsal surfaces flat, rough, frontal margin strongly deflexed at 90° from horizontal view; postfrontal crest divided into 4 dentiform granulated lobes. Outer surface of chela densely covered with low rounded granules; dorsal margin with incomplete granular ridge. Ambulatory legs relatively longer, fourth merus 0.9 times as long as carapace width. Male abdominal somite 6 slightly shorter than telson; male telson relatively narrower, 1.2 times wider than long. G1 long, slender; shaft rather abruptly tapering subapically, forming angle, distal chitinous part bent laterad at 45°, moderately slender, long, broad, relatively straight except for curved apex.

Description of holotype male. Carapace (Fig. 2A) squarish, about as long as wide; lateral margins almost subparallel or slightly diverging towards posterior carapace margin; dorsal surfaces approximately flat, not convex, rough, with low granules; gastric and branchial regions swollen; hepatic region depressed; grooves deep, regions well defined. Postfrontal crest overall straight, with 4 dentiform postfrontal lobes, reaching or extending slightly beyond frontal margin in dorsal view; anterior margins granulate; median cleft connected with mediogastric groove; protogastric protuberances behind relatively inconspicuous lateral postfrontal lobes; front prominently deflexed from dorsal carapace at right angles; ventral front margin sinuous; sublateral areas distinctly lobiform. Orbital margin angularly bent abruptly, not sinuous. External orbital tooth broadly triangular, directed antero-laterad, entirely slightly upward directed; tip sharp, pointed; first anterolateral tooth smaller, broadly triangular, tip acute, pointing antero-laterad; second anterolateral tooth very low or inconspicuous; lateral margins finely granular, slightly cristate. Posterolateral regions with fine oblique striae.

Third maxillipeds (Fig. 2B) as in previous species.

Thoracic sternites (Fig. 2B) as in previous species. Abdomen (Fig. 2B) with telson ca. 1.15–1.25 wider than long, lateral margins gently convex on distal part, almost straight proximally, tip rounded; somite 6 slightly shorter than telson, distal part of lateral margin convex, proximal part almost straight; somites 3–5 increasingly trapezoidal; somites 1 and 2 transversely narrow.

Male chelipeds (Fig. 2A, C, D) as in previous species.

Ambulatory legs (Fig. 2A) slender, very long; fourth ambulatory merus about 0.9 times as long as carapace width, lateral margins of meri subparallel at least from basal 0.3 to 0.8. Otherwise similar to previous species.

G1 (Fig. 4G–I) long, slender, straight, reaching distal end of abdominal somite 6; subdistal inner margin with long setae

that do not overreach tip; basal part rounded, prominent (Fig. 4H); shaft rather abruptly tapering subapically near distal chitinous part, apically rather abruptly angled lateral at 45° in ventral view (Fig. 4G); distal part moderately slender, moderately long, slightly bent dorsad in lateral view (Fig. 4H), overall rather straight, but apex distinctly curved. G2 (Fig. 4J) moderately short; base subtriangular; distal part slender, outer margin gently curved.

Colour in life. Not known.

Etymology. Named after the Tagbanua, an indigenous tribe in Palawan, who like the Bataks, get their sustenance from the forests. The name is used as a noun in apposition.

Distribution. Only known from two sites in the Municipalities of Narra and Quezon of the Province of Palawan, the Philippines.

Ecological notes. Specimens were collected in a limestone cave and at a montane forest. One specimen (NMCR-25052) was collected across a creek at ca. 370 m elevation at Mt. Victoria. The site was surrounded by huge boulders of algae-covered rocks where dipterocarps, bamboos and thorny rattans dominated. The specimen was found there by the first author among the fallen barks of “almaciga” (*Agathis loranthifolia*) near the creek banks.

Remarks. The paratype male specimen of *G. tagbanua*, new species, from Narra (NMCR-25052) (Figs. 3A–C, 4K, L) differs slightly from the remaining type material in its carapace shape, which appears to be somewhat rounder and is 1.02 times longer than broad. The carapaces of the remaining specimens are distinctly more squarish and almost exactly as wide as long. Furthermore, its dorsal surface is slightly more concave, the external orbital teeth are more acute and pronounced (Fig. 3A right side; cf. Fig. 2C), and the dactylar finger of the chela is slightly stouter and lacks the dorsal row of granules (Fig. 3C; cf. Fig. 2D). The G1 of this specimen is also not as strongly chitinised as the other specimens. These observations suggest this specimen had recently moulted. However, all the other key diagnostic characters, notably that of the G1 and G2 (Fig. 4L, K; cf. Fig. 4G, J) is consistent with the other specimens and we regard them all as conspecific for now.

For comparisons with *G. batak*, new species, see remarks for that species.

GENERAL DISCUSSION

Both *Geosesarma* species treated here are semi-terrestrial and belong to the “entirely inland” ecological group following the terms of Schubart et al. (2000). For *G. batak*, it was observed that they probably reproduce in freshwater-filled cavities as an ovigerous female was found there (Fig. 5B). The holotype male of *G. batak* was collected along with an adult female and juveniles from the same knothole.

Among the known representatives of the genus, their comparably large size of more than 20 mm carapace length and width is interesting. However, both species lack the often diagnostic colour patterns that are seen in some *Geosesarma* species from Malaysia, Borneo and Java (e.g., see Ng et al., 2015).

Based on the available material, it appears that *G. batak* is distributed in the central-southern portion of Palawan Island, while *G. tagbanua* is confined to the central-northern portion. However, the two species occur on the eastern and western lowlands of the central-southern (Quezon-Aboabo Gap) and central-northern parts (Ulugan Gap), respectively. Neither are confined to higher altitudes. It is possible their ranges will be found to partially overlap when more collections are made. A separation of either part of the island, southern or northern, from central Palawan during the Holocene or Pleistocene by higher sea levels than today is unlikely based on current sea level reconstructions (Robles et al., 2015). Therefore we are uncertain if the two species are the result of an allopatric speciation event.

The two new species probably prefer pristine forests and caves. The fact that one specimen of *G. batak* (a paratype male, 18.9 × 18.5 mm, ZRC 2015.291) from Laptay/Napsan was unexpectedly obtained in a traditional “rainforestation” site of the Tagbanua community of Laptay suggests that areas with sustainable agroforestry farming systems can be supportive of the indigenous biodiversity. The numerous exemplars of *G. batak* near Mount Cleopatra Needle underlines once more the importance of these natural rainforests in the area of Puerto Princesa City. The present results will certainly provide supporting data to help endeavours by various research initiatives, NGOs, and government institutions (e.g., AQUA Palawana Program, Centre for Sustainability, Palawan Council for Sustainable Development) to conserve and protect the remaining natural habitats and unique biodiversity of Palawan Island.

ACKNOWLEDGEMENTS

The first author is very grateful to the Lee Kong Chian Natural History Museum for a fellowship and the research grant ARF R-154-000-334-112 from the Philippines. Many thanks are also due to Tohru Naruse (University of the Ryukyus, Okinawa) for some of the photography, as well as Angelito Felipe L. Puno (ABE International Business College, Cubao, Quezon City) for digitally improving the illustrations. Sincere thanks are due to Jojo Orcullo who donated material for this study. The AQUA Palawana collections in the territory of Puerto Princesa City were made possible by the long term collaboration with the Western Philippines University (Aquatic Biology Section, Puerto Princesa Campus, Palawan) and Gratuitous Permits (WGP 2014-15; GP 2008-03) and Transport Permits (WTP-15-37, WTP-08-17) kindly issued by the Palawan Council for Sustainable Development (PCSD). Prerequisite permissions were kindly given by the Barangay councils of Napsan, the City Council of Puerto Princesa City and by the indigenous

Tagbanua community in Napsan and the Batak community in Taranaban. We thank Southsea Exclusive Philippines Inc., Puerto Princessa City (Centre for Sustainability) for the kind cooperation during the 2015 field sampling. The authors are grateful to Tohru Naruse for his many helpful suggestions.

LITERATURE CITED

- Dana JD (1851) Conspectus Crustaceorum quæ in Orbis Terrarum circumnavigatione, Carolo Wilkes e Classe Reipublicæ Foederatæ Duce, lexit et descripsit. Proceedings of the Academy of Natural Sciences of Philadelphia, 5: 247–254.
- Hadley A (2010) CombineZP. Version of 6th June 2010. <http://hadleyweb.pwp.blueyonder.co.uk> (Accessed 8 November 2011)
- Man JG De (1892) Decapoden des Indischen Archipels. Zoologische Ergebnisse einer Reise in Niederlandisch OstIndien, 2: 265–527.
- Manuel-Santos MR & Yeo DCJ (2007) A new species of *Geosesarma* from Palawan, Philippines (Crustacea: Decapoda: Brachyura: Sesarmidae). Zootaxa, 1607: 63–67.
- Naruse T & Ng PKL (2007) *Scandarma splendidum*, a new species of tree-climbing crab (Decapoda: Brachyura: Sesarmidae) from Sarawak, Malaysia, Borneo. Raffles Bulletin of Zoology, 55(2): 337–341.
- Ng PKL (1986) Preliminary descriptions of 17 new freshwater crabs of the genera *Geosesarma*, *Parathelphusa*, *Johora* and *Stoliczia* (Crustacea Decapoda, Brachyura) from South East Asia. Journal of the Singapore National Academy of Science, 15: 36–44.
- Ng PKL (1988) The Freshwater Crabs of Peninsular Malaysia and Singapore. Department of Zoology, National University of Singapore, Shinglee Press, pp. i–viii, 1–156, figs. 1–63, 4 colour plates.
- Ng PKL (1992) *Geosesarma sabanus*, a new sesarmine crab (Decapoda, Brachyura, Grapsidae) from the forests of Sabah, East Malaysia, Borneo. Crustaceana, 63(2): 210–213.
- Ng PKL (1995a) *Geosesarma aurantium*, a new sesarmine land crab (Crustacea: Decapoda: Brachyura: Grapsidae) from Sabah. Malayan Nature Journal, 49: 65–70.
- Ng PKL (1995b) On one new genus and three new species of freshwater crabs (Crustacea: Decapoda: Brachyura: Potamidae and Grapsidae) from Lanjak Entimau, Sarawak, East Malaysia, Borneo. Zoologische Mededelingen, 69(5): 57–72.
- Ng PKL (2002) On a new species of terrestrial crab of the genus *Geosesarma* (Crustacea: Brachyura: Sesarmidae) from Sabah, Malaysia. Malayan Nature Journal, 56(3): 303–310.
- Ng PKL (2012) The identity of *Sesarma rotundata* Hess, 1865, and description of a new species of arboreal crab of the genus *Labuanium* Serène & Soh, 1970, from Guam, western Pacific (Crustacea: Decapoda: Brachyura: Sesarmidae). Raffles Bulletin of Zoology, Supplement 25: 265–277.
- Ng PKL (2013) A new species of *Scandarma* (Crustacea: Brachyura: Sesarmidae) from Sabah, Borneo, Malaysia. Zootaxa, 3652(2): 289–294.
- Ng PKL (2015) Semiterrestrial crabs of the genus *Geosesarma* De Man, 1892 (Crustacea, Brachyura, Sesarmidae) from western Borneo, Indonesia, with descriptions of three new species. Zootaxa, 4048(1): 37–56.
- Ng PKL & Davie PJF (1995) The terrestrial sesarmine crabs of the genera *Metasesarma* and *Geosesarma* (Crustacea: Decapoda: Brachyura: Grapsidae) of Ujung Kulon, West Java, Indonesia. Tropical Biodiversity, 3(1): 29–43, colour frontispiece.
- Ng PKL & Lim RP (1987) The taxonomy and biology of the nepenthophilous sesarmine freshwater crab, *Geosesarma malayanum* Ng and Lim, 1986 (Crustacea, Decapoda, Brachyura, Grapsidae) from Peninsular Malaysia. Malayan Nature Journal, 41: 393–402.
- Ng PKL, Liu H-C & Schubart CD (2004) *Geosesarma hednon*, a new species of terrestrial crab (Crustacea: Decapoda: Brachyura: Sesarmidae) from Taiwan and the Philippines. Raffles Bulletin of Zoology, 52(1): 239–249.
- Ng PKL & Naiyanetr P (1992) On a new species of *Geosesarma* de Man, 1892 (Crustacea: Decapoda: Brachyura: Grapsidae) from Chanthaburi Province, eastern Thailand. Zoologische Mededelingen, 66: 449–452.
- Ng PKL, Schubart CD & Lukhaup C (2015) New species of “vampire crabs” (*Geosesarma* De Man, 1892) from central Java, Indonesia, and the identity of *Sesarma* (*Geosesarma*) *nodulifera* De Man, 1892 (Crustacea, Brachyura, Thoracotremata, Sesarmidae). Raffles Bulletin of Zoology, 63(1): 3–13.
- Ng PKL & Takeda M (1992) A new freshwater crab of the genus *Geosesarma* de Man, 1892 from the Philippines (Crustacea, Brachyura, Grapsidae). Proceedings of the Japanese Society of Systematic Zoology, 47: 29–32.
- Ng PKL & Tan CGS (1995) *Geosesarma notophorum* sp. nov. (Decapoda, Brachyura, Grapsidae, Sesarminae), a terrestrial crab from Sumatra, with novel brooding behaviour. Crustaceana, 68(3): 390–395.
- Nobili G (1903) Crostacei di Singapore. Bollettino dei Musei di Zoologia ed Anatomia comparata della Regia, Università di Torino, 18(455): 1–39, 1 fig.
- Rathbun MJ (1914) New species of crabs of the families Grapsidae and Ocypodidae. Proceedings of the United States National Museum, 47: 69–85.
- Robles E, Piper P, Ochoa J, Lewis H, Paz V & Ronquillo W (2015) Late Quaternary Sea-Level Changes and the Palaeohistory of Palawan Island, Philippines. Journal of Island and Coastal Archaeology, 10(1): 76–96. DOI: 10.1080/15564894.2014.880758
- Schubart CD, Cuesta JA, Diesel R & Felder DL (2000) Molecular phylogeny, taxonomy, and evolution of nonmarine lineages within the American grapsoid crabs (Crustacea: Brachyura). Molecular Phylogenetics and Evolution, 15(2): 179–190.
- Schubart CD, Liu H-C & Cuesta JA (2003) A new genus and species of tree-climbing crab (Crustacea: Brachyura: Sesarmidae) from Taiwan with notes on its ecology and larval morphology. Raffles Bulletin of Zoology, 51(1): 49–59.
- Serène R (1968) Note préliminaire sur de nouvelles espèces de *Sesarma* (Decapoda Brachyura). Bulletin du Muséum national d’Histoire naturelle, Paris, 39(5): 1084–1095.
- Serène R & Soh CL (1970) New Indo-Pacific genera allied to *Sesarma* Say, 1877 (Brachyura, Decapoda, Crustacea). Treubia, 27(4): 387–416.