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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)

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Abstract. Two new species of land-dwelling sesarmid crabs of the genus *Geosesarma* De Man, 1892, are described from central Java, Indonesia. These species have been in the aquarium trade for many years and go by the popular name of "vampire crabs". The two species, here named *Geosesarma dennerle* and *G. hagen*, are formally described and compared with their closest congeners in Java, *G. noduliferum* (De Man, 1892) and *G. bicolor* Ng & Davie, 1995. The identities of *G. noduliferum*, the type species of the genus, and *G. confertum* (Ortmann, 1894) are also clarified.

Key words. Crustacea, Brachyura, Sesarmidae, *Geosesarma*, new species, taxonomy, Java, Indonesia

INTRODUCTION

Over the last decade, there has been an increasing number of colourful land-dwelling (or 'entirely inland' according to the definition by Schubart et al., 2000) sesarmid crabs sold for the ornamental fish trade in Europe and Asia going under the name "vampire crabs" (see Rademacher & Mengedoht, 2011). These have been exported to many countries in Europe, East Asia and America. The two most common and popular colour forms are: (1) a bicoloured cream and violet morph; and (2) a bicoloured dark brown - bright orange one. While they are clearly species of *Geosesarma* De Man, 1892, a large genus of terrestrial crabs occurring in Southeast Asia, their exact provenances could not be ascertained, with dealers claiming they came from Sulawesi, Java, Krakatau or Riau Islands. In this paper, we describe these two species as new to science and establish that they are in fact native to central Java, Indonesia.

Four species of *Geosesarma* were previously known from Java: *G. noduliferum* (De Man, 1892) [Bogor, west Java], *G. confertum* (Ortmann, 1894) [Gunung Gede, west Java], *G. rouxi* (Serène, 1968b) [Poedjon, central Java], and *G. bicolor* Ng & Davie, 1995 [Ujung Kulon, west Java]. *Geosesarma confertum* is poorly known and was synonymised with *G. noduliferum* without comment by Serène (1968a) but was treated as a valid species by Ng et al. (2008). *Geosesarma rouxi* is very characteristic, with its lateral carapace margins distinctly diverging posteriorly and its male first gonopod being very short and stout, with the distal pectinated part short and rounded (cf. Serène, 1968b: figs. 15, 16).

The present paper describes the two new species from central Java and redescribes *G. noduliferum* on the basis of the types. The taxonomy of these three species, and the allied *G. bicolor*, is discussed. The abbreviations G1 and G2 are used for the male first and second gonopods, respectively. Measurements provided in millimetres are of the carapace width and length, respectively. The terminology used follows that in Ng (1988). The synonymy is restricted to the formal scientific literature, and we have excluded citations from aquarium publications or popular literature, as we are not certain of the identities or provenances of the specimens discussed. Specimens examined are deposited in the Museum Zoologicum Bogoriense (MZB), Cibinong, Bogor, Indonesia; Forschungsinstitut und Museum Senckenberg (SMF), Frankfurt, Germany; Naturalis Museum (ex Rijksmuseum van Natuurlijke Histories, RMNH), Leiden, The Netherlands; and the Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum (ex Raffles Museum of Biodiversity Research), National University of Singapore.

TAXONOMY

Family Sesarmidae Dana, 1851

Geosesarma De Man, 1892

Geosesarma noduliferum (De Man, 1892)

(Figs. 1A, B, 2A–E, 5A, B)

Sesarma (*Geosesarma*) *nodulifera* De Man, 1892: 342, pl. 20, fig. 16; Nobili, 1900: 512 (part).
Sesarma nodulifera – Ortmann, 1894: 56.
Sesarma (*Geosesarma*) *noduliferum* – Rathbun, 1910: 309; Serène, 1968a: 106.

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Sesarma (*Sesarma*) *nodulifera* – De Man, 1902: 519; Tesch, 1917: 178.
Geosesarma noduliferum – Serène & Soh, 1970: 402, 407; Ng, 1988: 119; Ng et al., 2008: 221.
(not *Sesarma* (*Geosesarma*) *noduliferum* – Serène 1968b: 1094, figs. 19, 20 = *Geosesarma confertum* (Ortmann, 1892)).

Material examined. Lectotype (here designated): male (11.4 × 10.9 mm) (RMNH 1246a), Tjiparidi River, near Kg. Baruh, near Buitenzorg (= Bogor), coll. M. Weber, July–September 1888. Paralectotypes: 1 male (10.6 × 9.5 mm), 1 female (11.9 × 10.8 mm) (RMNH 1246b), same data as lectotype; 4 males (11.4 × 10.3 mm, 11.8 × 10.4 mm, 11.2 × 10.3 mm, 11.7 × 10.4 mm), 1 female (10.5 × 10.1 mm) (RMNH 2611), same data as lectotype. Other material: 5 females (largest 11.5 × 10.5 mm) (ZRC 1989.2076–2080), rice field behind BIOTROP research station, Bogor, west Java, Indonesia, coll. P.K.L. Ng, 1986; 1 female (11.4 × 10.0 mm) (ZRC 1990.9166), on bank of stream, under rock, Botanical Gardens, Bogor, west Java, coll. P.K.L. Ng, 8 August 1985.

Diagnosis. Carapace squarish, slightly wider than long, lateral margins subparallel (Fig. 1A, B); dorsal surface with well-defined regions, anterior regions covered with numerous

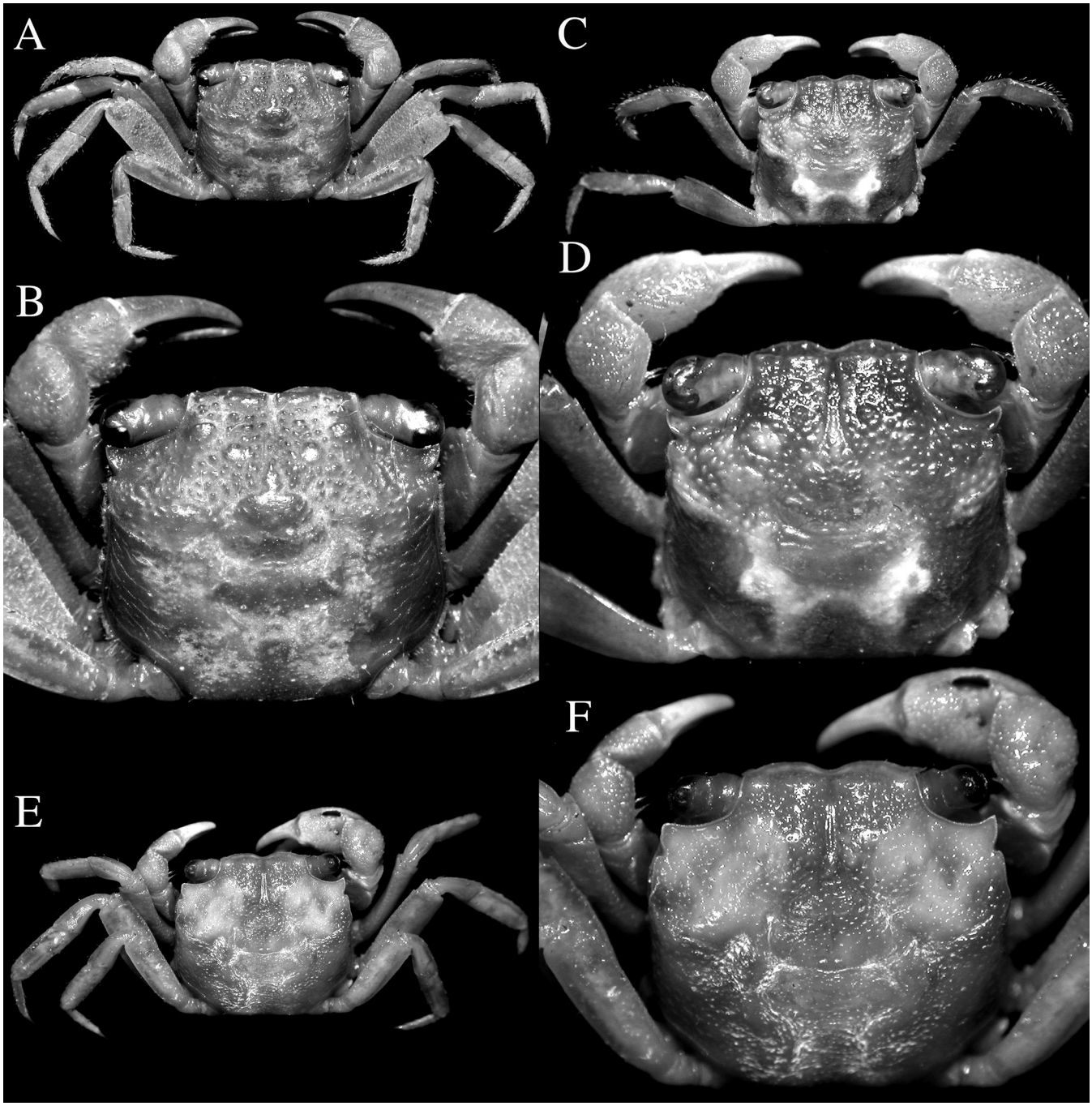

Fig. 1. A, B, *Geosesarma noduliferum* (De Man, 1892), lectotype male (11.4 × 10.9 mm) (RMNH 1246a), Bogor, Java; C, D, *G. bicolor* Ng & Davie, 1995, holotype male (11.0 × 10.5 mm) (ZRC 1995.279), Ujung Kulon, Java; E, F, *G. confertum* (Ortmann, 1894), male (10.7 × 9.7 mm) (ZRC 1970.3.7.11), Tjibodas, Java. A, C, E, overall view; B, D, F, dorsal view of carapace.

small rounded granules (Fig. 1A, B); front deflexed, frontal lobes very broad with convex margins; postfrontal cristae prominent (Fig. 1A, B); external orbital tooth triangular, directed obliquely outwards, tip level with lateral carapace margin (Fig. 1B). Exopod of third maxilliped relatively slender, with long flagellum that extends beyond merus width. Outer surface of palm of adult male chela granulated; dorsal margin of dactylus with 11–13 tubercles, each tubercle with pectinated tip (Fig. 5B). Ambulatory legs with relatively broad meri, with sharp subdistal spine on dorsal margin, surfaces rugose (Fig. 1A). Male abdomen relatively slender; telson triangular with rounded tip, longer than broad; somite 6 with gently convex lateral margins (Figs. 2E, 5A). G1 slender, proximal part gently curved, distal part pectinated, bent, elongate, spatuliform, tip with shallow indentation when viewed dorsally (Fig. 2A–C).

Colour. Adult coloration in life not known.

Remarks. The identity of *G. noduliferum* needs to be clarified. The species was described as *Sesarma* (*Geosesarma*) *nodulifera* from 61 specimens from Tjiparidi River in Kampung Baruh in Bogor, Java. Although De Man (1892: pl. 20 fig. 16) provided very good figures of the carapace, chelipeds and male abdomen, the diagnostic G1 structure was not illustrated. The significance of the G1 for the taxonomy of *Geosesarma* only became apparent much later, when Serène (1968b) demonstrated that many taxa have characteristic species-diagnostic structures. De Man (1892: 345) commented that he had many specimens from Tjipanas (= present day Cipanas) and Tjibodas (= present day Gunung Gede) in west Java that he could not identify with confidence with *G. noduliferum* because of their small size and having more tubercles on the movable dactylus of the chela. Ortmann (1894: 56) had several specimens from Tjibodas and also noted that his specimens had more closely packed tubercles on the dactylar finger. As such, he established a new taxon, *Sesarma nodulifera* var. *conferta* for them, probably alluding to the greater density of dactylar tubercles. No figures or detailed descriptions were provided. Serène (1968a: 106) synonymised *Sesarma nodulifera* var. *conferta* Ortmann, 1894, with *G. noduliferum* without comment; and did not use the name again in his later works. Ng et al. (2008: 220) resurrected the name as *Geosesarma confertum*, but did not elaborate on the reasons why.

Serène (1968b: 1094, figs. 19, 20) provided a figure of the G1 of what he identified as *G. noduliferum* (as *Sesarma* (*Geosesarma*)) from Tjibodas in West Java. The specimens he examined are in the ZRC [2 males (9.4 × 8.5 mm, 10.7 × 9.7 mm) (ZRC 1970.3.7.11–12), Tjibodas, west Java, don. Bogor Museum, 1960s]. The G1 figured by Serène (1968b: figs. 19, 20) is relatively short and stout with a cylindrical distal part and a rounded tip, and is very different from that of the types of *G. noduliferum* s. str. in RMNH (Fig. 2A–C) from Bogor. As noted by De Man (1892) and Ortmann

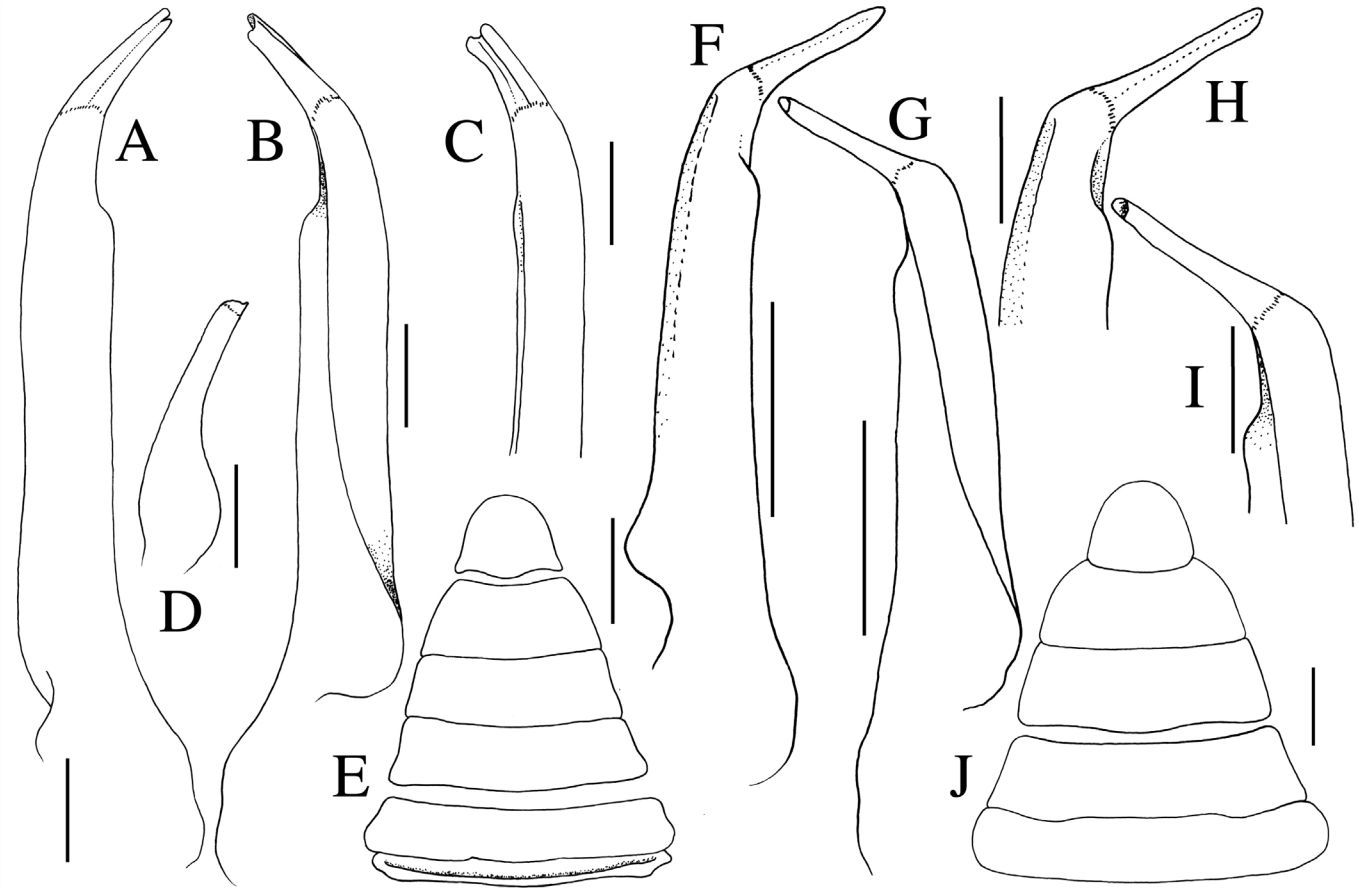

Fig. 2. A–E, *Geosesarma noduliferum* (De Man, 1892), lectotype male (11.4 × 10.9 mm) (RMNH 1246a), Bogor, Java; F–J, *G. bicolor* Ng & Davie, 1995, holotype male (11.0 × 10.5 mm) (ZRC 1995.279), Ujung Kulon, Java. A–C, F–I, left G1 (drawn from different angles); D, left G2; E, male abdominal somites 2–6 and telson; J, male abdominal somites 3–6 and telson. All structures denuded. Scale bars = 1.0 mm.

(1894), the tubercles on the dactylar fingers of the chelae of the Tjibodas males are more numerous (15 or 16) and closely packed on the proximal part (Fig. 5I) than those of *G. noduliferum* s. str. from Bogor (with 11–13 more widely spaced ones, Fig. 5B). In addition, the carapaces of the Tjibodas' specimens have a different shape from the Bogor ones, with the lateral margins almost parallel (Fig. 1E, F) rather than gently divergent (Fig. 1A, B), and the male abdomen (notably somites 5 and 6) being proportionately broader (Figs. 5H) (versus narrower, Figs. 2E, 5A). It is clear that the Tjibodas and Bogor specimens belong to separate species, and *G. confertum* (Ortmann, 1894) is a good species and not synonymous with *G. noduliferum* (De Man, 1892) s. str., as proposed by Serène (1968a). Tjibodas lies at a much higher altitude than Bogor (2500 m against 300 m above sea level), and species of *Geosesarma* from highlands and lower altitudes usually belong to separate species (see Ng, 1988; Schubart & Ng, 2014). The identity of De Man's (1892) material from Tjipanas, which is located in the lowlands east of Tjibodas, will need to be checked; they are probably not *G. confertum*. Nobili's (1900) and Rathbun's (1910) records included material from Bogor and Tjibodas, so both *G. noduliferum* and *G. confertum* are represented. The taxonomy of *G. confertum*, *G. rouxi* and other highland species from Java is now being studied by the first author and Daisy Wowor (MZB).

In the RMNH are two lots of type specimens of *Sesarma* (*Geosesarma*) *nodulifera* De Man, 1892, with the same collection data. A male measuring 11.4 × 10.9 mm (RMNH 1246a) is here selected as the lectotype of the species (Fig. 1A, B).

For differences between *G. noduliferum* and the two new species described from central Java, see general discussion.

Geosesarma bicolor Ng & Davie, 1995
(Figs. 1C, D, 2F–J, 5C)

Geosesarma bicolor Ng & Davie, 1995: 31, figs. 1, 2; Ng et al., 2008: 220.

Material examined. Holotype: male (11.0 × 10.5 mm) (ZRC 1995.279), Citerjun, in creeks, under stones, Ujung Kulon, West Java, coll. C. Stewart, July 1993. Paratypes: 1 male (10.5 × 9.9 mm), 2 nonovigerous females (10.0 × 9.7 mm, 13.9 × 12.7 mm) (both mature) (ZRC 1995.280), same data as holotype.

Diagnosis. Carapace squarish, slightly wider than long, lateral margins subparallel (Fig. 1C, D); dorsal surface with well-defined regions, anterior regions covered with numerous small rounded granules (Fig. 1C, D); front deflexed, frontal lobes very broad with convex margins; postfrontal cristae prominent (Fig. 1C, D); external orbital tooth triangular, directed obliquely outwards, tip level with lateral carapace margin (Fig. 1C). Exopod of third maxilliped relatively slender, with long flagellum that extends beyond merus width. Outer surface of palm of adult male chelae granulated; dorsal margin of dactylus with 10 or 11 tubercles, each with pectinated tip (Fig. 5C). Ambulatory legs with relatively broad meri, with sharp subdistal spine on dorsal margin, surfaces rugose (Fig. 1C). Male abdomen relatively broad; telson triangular with rounded tip, longer than broad; somite 6 with convex lateral margins (Fig. 2J). G1 slender, proximal part gently curved, distal part pectinated, bent, elongate, subspatuliform; tip entire, subtruncate when viewed dorsally (Fig. 2F–I).

Colour. In life, the species is bright purple on the anterior third of the carapace and ambulatory legs; with the posterior parts of the carapace bluish-grey; the chelae red and eyes bright yellow [cf. Ng & Davie, 1995: 32].

Remarks. The species is re-diagnosed here and the important G1 and male abdominal structures refigured to allow for more accurate comparisons with the two new species (see general discussion).

Geosesarma dennerle, new species
(Figs. 3A, B, 4A–G, 5D, F, 6A–C, 7C)

Material examined. Holotype: male (14.4 × 14.0 mm) (MZB 4061), station R605–6, north of Cilacap town, Cilacap Regency, central Java, 7°25′59″S, 108°55′50″E, Indonesia, coll. C. Lukhaup, 5 October 2011. Paratypes: 1 male (11.5 × 10.6 mm), 1 female (13.1 × 11.8 mm) (ZRC 2014.0270), same data as holotype; 5 males (largest 11.0 × 10.5 mm), 2 females (larger 11.3 × 10.2 mm) (SMF 46286), 4 males (largest 11.5 × 10.6 mm), 2 females (larger 13.5 × 11.8 mm) (ZRC 2014.0266), same data as holotype. Others: 9 males (largest 13.1 × 11.7 mm), 1 ovigerous female (12.0 × 10.6 mm, eyed eggs 1.5 mm) (ZRC 2014.0271), from aquarium dealer in Cilacap town, Java, 5 May 2009; 2 males (14.4 × 13.2 mm, 12.5 × 12.0 mm) (ZRC 2014. 0274), from aquarium dealer in Cilacap town, Java, 12 April 2011; 4 males, 1 female (ZRC 2014.0277), from aquarium dealer in Cilacap town, Java, May 2011; 1 male (11.8 × 10.8 mm) (ZRC 2014.0273), from aquarium trade, ostensibly from Cilacap, Java, from O. Mengedoht, 9 June 2010.

Description. Carapace squarish, slightly wider than long, lateral margins subparallel (Fig. 3A, B); dorsal surface with well-defined regions, anterior regions very densely covered with small rounded granules (Fig. 3A, B); front deflexed, frontal lobes broad with convex margins; postfrontal cristae prominent (Fig. 3A, B); external orbital tooth large, triangular, curving obliquely outwards, tip beyond level of lateral carapace margin (Fig. 3B). Exopod of third maxilliped relatively slender, with long flagellum extending beyond merus width (Fig. 4A). Outer surface of palm of adult male chelae granulated; dorsal margin of dactylus with 7–9 tubercles (distal one may be very low), each with pectinated tip (Fig. 5D). Ambulatory legs with relatively broad meri, with sharp subdistal spine on dorsal margin, surfaces rugose (Figs. 3A, 5F). Male abdomen relatively broad; telson semicircular; somite 6 with strongly convex lateral margins (Fig. 4B). G1 slender, proximal part straight, distal part pectinated, bent, elongate, spatuliform; tip entire, subtruncate when viewed dorsally (Fig. 4C–G).

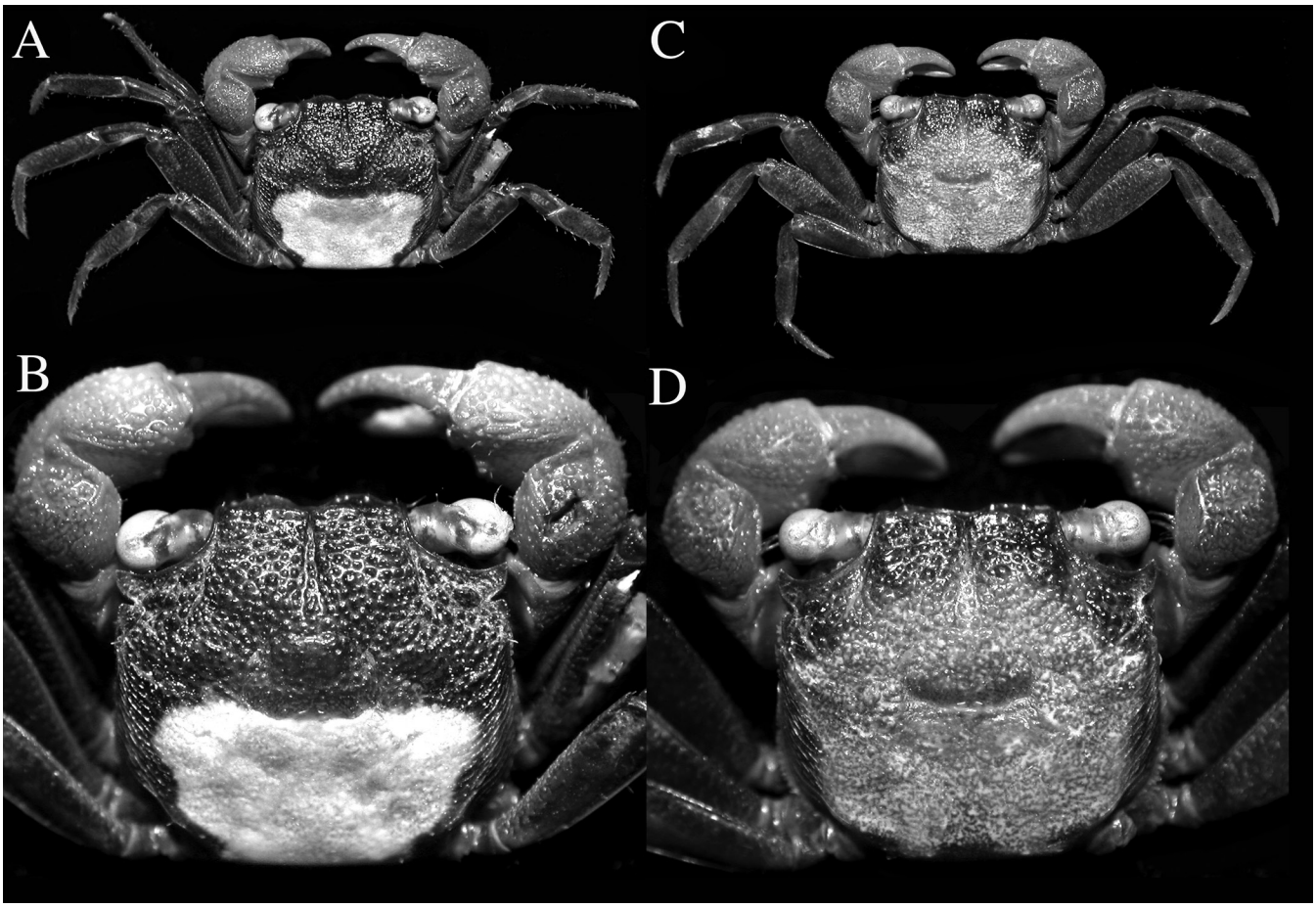

Fig. 3. A, B, *Geosesarma dennerle*, new species, holotype male (14.4 × 14.0 mm) (MZB 4061), Cilacap, Java; C, D, *G. hagen*, new species, holotype male (13.9 × 13.3 mm) (MZB 4062), Cilacap, Java. A, C, overall view; B, D, dorsal view of carapace.

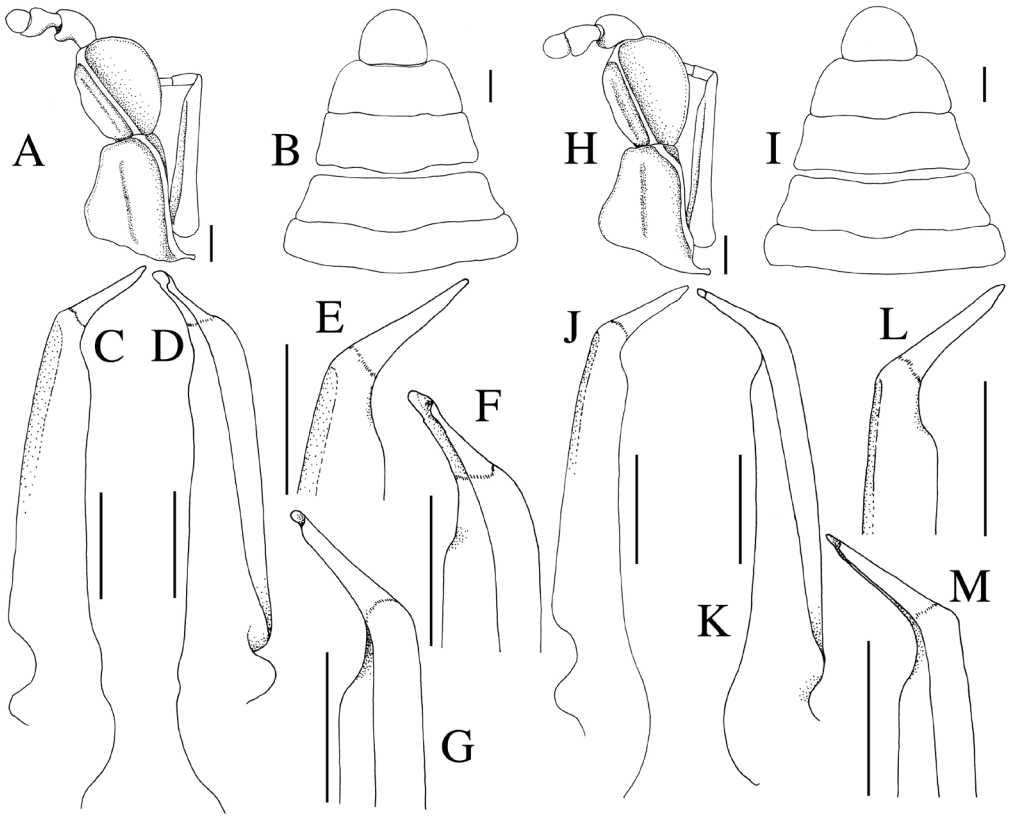

Fig. 4. A–G, *Geosesarma dennerle*, new species, holotype male (14.4 × 14.0 mm) (MZB 4061), Cilacap, Java; H–M, *G. hagen*, new species, holotype male (13.9 × 13.3 mm) (MZB 4062), Cilacap, Java. A, H, left third maxilliped; B, I, male abdominal somites 3–6 and telson; C–G, J–M, left G1 (drawn from different angles). All structures denuded. Scale bars = 1.0 mm.

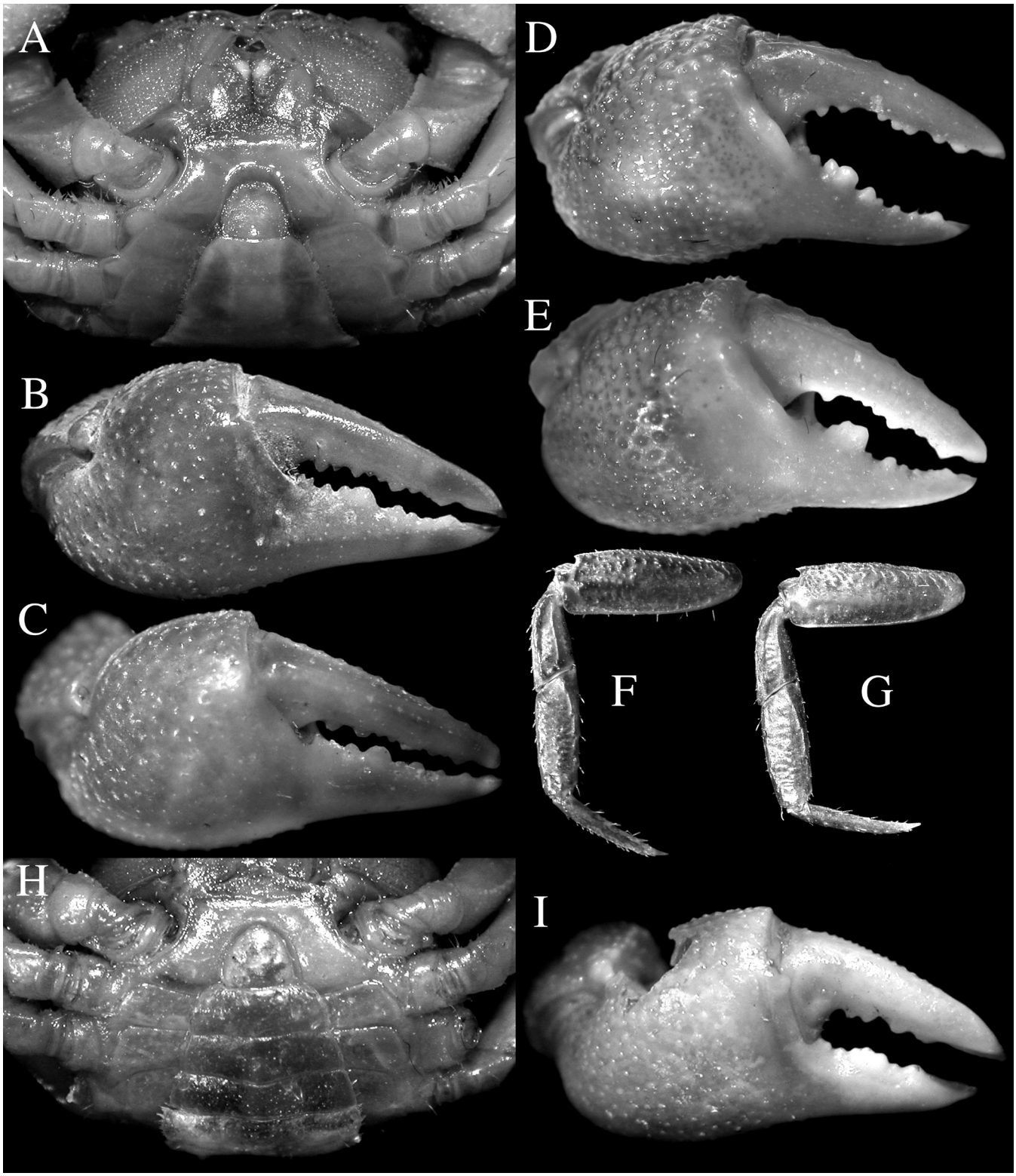

Fig. 5. A, B, *Geosesarma noduliferum* (De Man, 1892), lectotype male (11.4 × 10.9 mm) (RMNH 1246a), Bogor, Java; C, *G. bicolor* Ng & Davie, 1995, holotype male (11.0 × 10.5 mm) (ZRC 1995.279), Ujung Kulon, Java; D, F, *G. dennerle*, new species, holotype male (14.4 × 14.0 mm) (MZB 4061), Cilacap, Java; E, G, *G. hagen*, new species, holotype male (13.9 × 13.3 mm) (MZB 4062), Cilacap, Java; H, I, *G. confertum* (Ortmann, 1894), male (10.7 × 9.7 mm) (ZRC 1970.3.7.11), Tjibodas, Java. A, H, anterior male thoracic sternum and abdomen; B–E, I, outer surface of right chela; F, G, left last ambulatory leg

Colour. Adult coloration in life: violet purple to purplish-brown on anterior half of carapace and ambulatory legs; posterior half of carapace cream to yellowish-white; thoracic sternum greyish-white with grey specks in smaller specimens, but pale purple in larger specimens; abdomen dark grey to purplish grey with small spots; chelae bright purple; eyes bright yellow (Fig. 6A–C). While the typical colour pattern has the dorsal surface clearly demarcated into two zones, some specimens have most of the carapace cream with only the anterior edge purple. Juvenile specimens tend to have purplish-brown carapaces, with patches of yellow or brown on the anterior part (Fig. 7C). The bright purple chelae are present in larger adults (Fig. 6A–C), and occasionally in juveniles (Fig. 7C). In general, smaller specimens (e.g., males 9.1 × 8.5 mm, ZRC 2014.0266) possess greyish–purple to pale purple chelae, sometimes appearing almost white. Some larger males (e.g., 11.1 × 10.8 mm, ZRC 2014.0266), however, also have white chelae.

Etymology. The new species is named after the German company Dennerle, who kindly supported the third author's study in Java. The name is used as a noun in apposition.

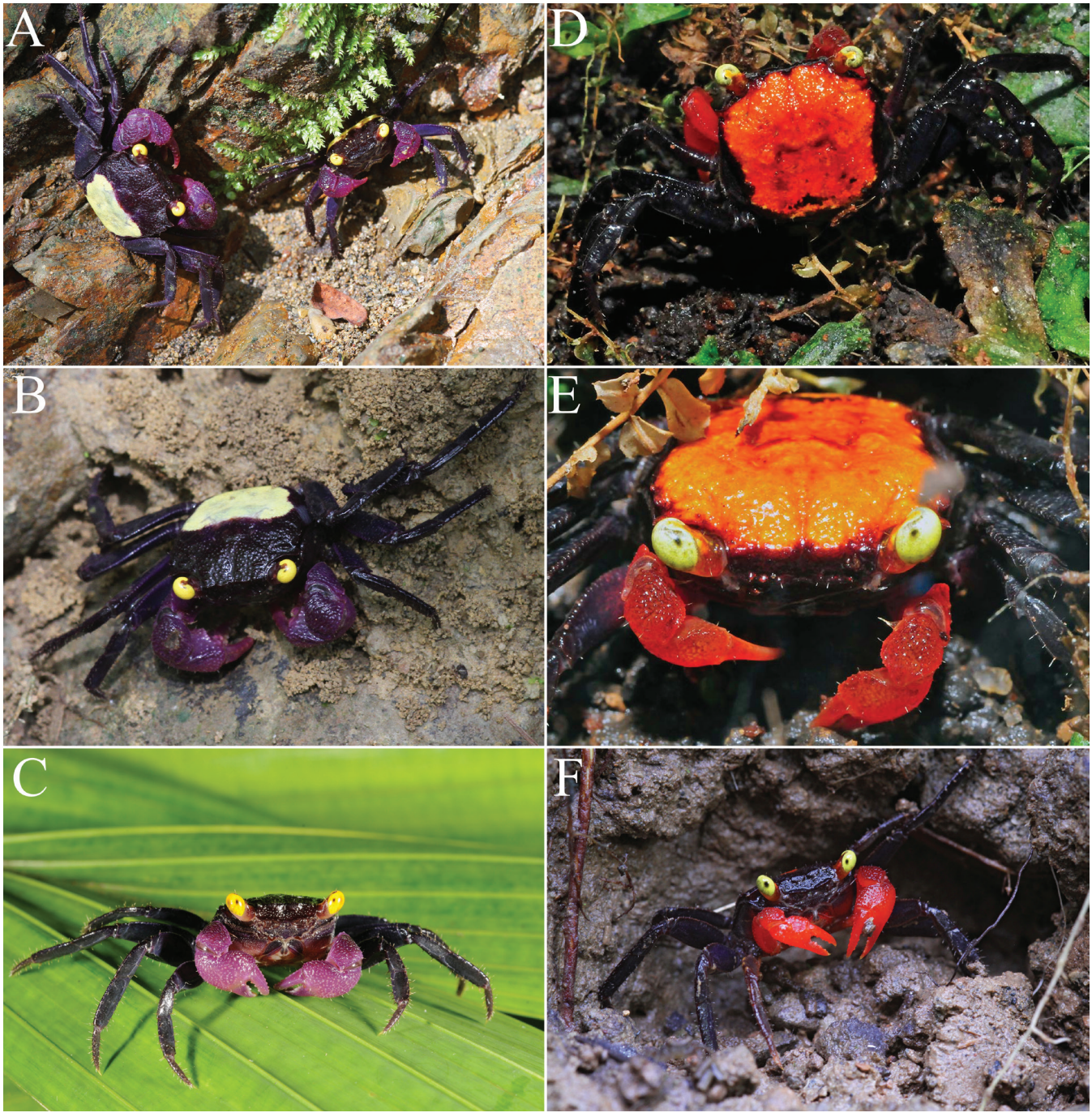

Fig. 6. Colours in life. A–C, *Geosesarma dennerle*, new species, Cilacap, Java; D–F, *G. hagen*, new species, Cilacap, Java. A, B, specimens from type series; C, male (13.1 × 11.7 mm) (ZRC 2014.0271). A, B: 7°25'59"S, 108°55'50"E, Cilacap, Java; F, 7°27'50"S, 108°50'16"E, Cilacap, Java; C–E, from aquarium trade, from Cilacap, Java (Photographs: Chris Lukhaup [A, B, F]; Tan Heok Hui [C]; Oliver Mengedoht (specimens not preserved) [D, E]).

Ecology. These terrestrial crabs inhabit the slopes of a small valley, living under and between rocks, among the dense vegetation (Fig. 7A). They sometimes excavate burrows in the loose ground at the edge of the creek that runs through the valley (Fig. 7B). Juveniles are often observed close to the waterline on land (Fig. 7C). Their diet consists mainly of small terrestrial insects such as grasshoppers, and probably also chironomid larvae and plant detritus.

Remarks. Specimens obtained from the aquarium trade by Rademacher & Mengedoht (2011) identified as "*Geosesarma* "Vampir" Vampirkrabbe" (p. 40) and "*Geosesarma* sp. "Blue" Blaue Vampirkrabbe" (p. 41), belong to *Geosesarma dennerle*, new species, at least on the basis of some of their specimens examined and the distinctive colour pattern figured (with due consideration of the colour variation noted above). Their specimens of "*Geosesarma bicolor* Krakatau-Vampirkrabbe" (Rademacher & Mengedoht, 2011: 45) probably also belong to the new species. The locality for these specimens (not examined) given by the aquarium is dubious, as the island of Krakatau is an active volcano and has no permanent freshwater source.

For comparisons with closest congeners, see general discussion.

Fig. 7. A, type locality of *Geosesarma dennerle*, new species; B, burrows by the side of a stream bank dug by of *G. dennerle*, new species; C, a young female *G. dennerle*, new species, on the stream bank; D, type locality of *G. hagen*, new species; E, adult *G. hagen*, new species, on bank of stream; F, an adult male of *G. hagen*, new species, on moss covered stream bank. A–C: 7°25'59"S, 108°55'50"E, Cilacap, Java; D–F, 7°27'50"S, 108°50'16"E, Cilacap, Java. Specimens not preserved (Photographs: Chris Lukhaup).

***Geosesarma hagen*, new species**
(Figs. 3C, D, 4H–M, 5E, G, 6D–F, 7E, F)

Material examined. Holotype: male (13.9 × 13.3 mm) (MZB 4062), station R605–1, north of Cilacap town, Cilacap Regency, central Java, 7°27'50"S, 108°50'16"E, Indonesia, coll. C. Lukhaup, 5 October 2011. Paratypes: 1 male (13.2 × 12.2 mm), 1 female (14.5 × 13.4 mm) (ZRC 2014.0269), same data as holotype; 2 males (larger 12.5 × 12.2 mm), 2 females (larger 11.6 × 10.9 mm) (SMF 46287), 2 males (larger 12.2 × 11.6 mm), 1 female (11.3 × 10.7 mm) (ZRC 2014.0268), same data as holotype. Others: 1 male (12.9 × 11.8 mm) (ZRC 2014.0272), from aquarium dealer in Cilacap town, Java, 12 April 2011; 2 males (larger 12.6 × 11.6 mm) (ZRC 2014.0267), from aquarium trade, ostensibly from Cilacap, Java, from O. Mengedoht, 9 June 2010.

Description. Carapace squarish, slightly wider than long, lateral margins subparallel (Fig. 3C, D); dorsal surface with well-defined regions, anterior regions very densely covered with small rounded granules (Fig. 3C, D); front deflexed, frontal lobes broad with convex margins; postfrontal cristae prominent (Fig. 3C, D); external orbital tooth large, triangular, curving obliquely outwards, tip protruding beyond level of lateral carapace margin (Fig. 3D). Exopod of third maxilliped relatively slender, with long flagellum extending beyond merus width (Fig. 4H). Outer surface of palm of adult male chelae granulated; dorsal margin of dactylus with 7–9 tubercles (distal one may be very low), each with pectinated tip (Fig. 5E). Ambulatory legs with relatively broad meri, with sharp subdistal spine on dorsal margin, surfaces rugose (Figs. 3C, 5G). Male abdomen relatively broad; telson semicircular; somite 6 with strongly convex lateral margins (Fig. 4I). G1 slender, proximal part straight, distal part pectinated, bent, elongate, spatuliform; tip entire, subtruncate when viewed dorsally (Fig. 4J–M).

Colour. Adult coloration in life: dark brown on anterior half or third of carapace and ambulatory legs; posterior half or two thirds of carapace orange or yellow; thoracic sternum greyish-white to grey with numerous grey specks; abdomen dark grey with small white spots; chelae bright orange; eyes bright yellow (Figs. 6D–F, 7E, F). The extent of bright orange on the dorsal surface of the carapace varies considerably, with some specimens being almost completely orange (Fig. 6D, E). The chelae in adults are bright or reddish-orange (Figs. 6E, 7E, F), but those from smaller specimens are generally more reddish (Fig. 6F).

Etymology. *Geosesarma hagen* is named after the Rolf C. Hagen Group of Companies, a major pet supplies company in Germany. They kindly supported the third author's projects in Java and subsequent work by the second author. The name is used as a noun in apposition.

Ecology. The crabs were found on a banana and rubber plantation on the side of a small hill, around 300 m from the road (Fig 7D). There are many trickles of water and a somewhat larger rivulet in the small area where they occur. Adult crabs are terrestrial, hiding under the dense bottom vegetation, usually under and between rocks, but they also sometimes excavate burrows at the edge of the water bodies (Fig. 7E). They seem to be carnivorous, feeding at least partially on insects inhabiting the ground. While adult crabs are seldom found in the water and mostly live on the moist banks (Fig. 7F), juveniles are often in the water or very close to the waterline, and are much less frequently seen on the drier forest ground.

Remarks. Material obtained from the aquarium trade by Rademacher & Mengedoht (2011) identified as "*Geosesarma* "Rot" Vampirkrabbe" (p. 44) are *Geosesarma hagen*, new species, on the basis of their colour photographs and specimens examined.

For comparisons with closest congeners, see general discussion.

GENERAL DISCUSSION

With the recent description of two new species of *Geosesarma* from Bintan (Riau Archipelago, Indonesia) by Schubart & Ng (2014), the current addition of two more species to the genus raises the count of species of *Geosesarma* to 53 (see Ng et al., 2008). Other than the very distinctive and different colours, the two new species described here are very similar morphologically. Both are also superficially close to *G. noduliferum* (De Man, 1892) and *G. bicolor* Ng & Davie, 1995.

Geosesarma noduliferum, *G. bicolor*, *G. dennerle*, new species, and *G. hagen*, new species, occur in relatively low elevations, and all of them have slender G1s with a well-developed flagellum on the exopod of the third maxilliped. They can be subdivided into two major groups. One group contains *G. noduliferum* and *G. bicolor*; its members have relatively wider frontal margin lobes (Fig. 1B, D), the anterior half of the dorsal surface of the carapace is less densely granulated (Fig. 1B, D), the external orbital tooth relatively smaller, with the tip levelling with the lateral carapace margin and being gently curved (Fig. 1B, D); the cheliped dactylus is armed with 10–13 tubercles on its dorsal margin (Fig. 5B, C). The second group contains *G. dennerle* and *G. hagen* that have narrower frontal margin lobes (Fig. 3B, D), a very densely granulated anterior half of the dorsal surface of the carapace (Fig. 3B, D), a larger external orbital tooth, with the tip extending beyond the lateral carapace margin and are more prominently curved (Fig. 3B, D); and a cheliped dactylus with 7–9 tubercles on its dorsal margin (Fig. 5D, E).

The number of tubercles on the dorsal margin of the dactylus of the male chela is a useful character to separate these two main groups of lowland species of *Geosesarma*. In *G. noduliferum* and *G. bicolor*, the larger number of tubercles is the consequence of being more closely spaced, with each tubercle being relatively smaller (Fig. 5B, C). In *G. dennerle* and *G. hagen*, the dactylar tubercles are relatively larger and more widely spaced (Fig. 5D, E).

The adult male abdomens of *G. noduliferum* and *G. bicolor* are proportionately narrower longitudinally, and this is partly the result of somite 6 having the lateral margins gently convex, and therefore appearing less broad transversely and the telson less broad (Figs. 2E, J, 5A). The adult male abdomens of *G. dennerle* and *G. hagen* are distinctly wider, and this is partly due to the more strongly convex and arched lateral margins of somite 6, resulting in a deeper depression on the distal margin for the more rounded telson (Fig. 4B, I). The series of specimens of *G. dennerle* and *G. hagen*, however, show some variation, with smaller male specimens sometimes possessing slightly more triangular and less broad male abdomens.

The type localities of the *G. dennerle* and *G. hagen* are relatively close, although they are in separate valleys. *Geosesarma hagen* was found about 10.5 km southwest of the type locality of *G. dennerle*. Their habitats are essentially hillstreams, from which two other freshwater crabs are known. One, the potamid *Malayopotamon lipkei*, was recently described by Wowor & Tan (2010); while another is an undescribed gecarcinucid species of *Terrathelphusa* Ng, 1989 (D Wowor & PKL Ng, in preparation).

While the colours in life of *Geosesarma dennerle* and *G. hagen* are very different, allowing even juveniles to be distinguished, they can also be separated by the degree of granulation on the anterior half of the carapace and usually by the form of the external orbital tooth. The anterior dorsal surface of the carapace of *G. hagen* is distinctly more granular and uneven (Fig. 3B) in contrast to that of *G. dennerle* that has lower and more flattened granules (Fig. 3A), which gives the surface a smoother texture. In *G. dennerle*, the external orbital tooth is also usually proportionately larger, more broadly triangular in shape, with the posterior margin more strongly convex (Fig. 3B) than in *G. hagen* that has a relatively narrower tooth with a gently convex posterior margin (Fig. 3D). Although the G1s of *G. dennerle* and *G. hagen* are superficially similar, that of *G. dennerle* (Fig. 4C–G) is consistently slightly stouter than in *G. hagen* (Fig. 4J–M). This is most apparent when similar-sized male specimens are compared. Compared to the G1s of *G. noduliferum* and *G. bicolor*, those of *G. dennerle* and *G. hagen* are slightly straighter. In addition, the part of the G1 in *G. dennerle* and *G. hagen* (Fig. 4C–G, J–M) just proximal to the pectinated distal part is relatively more slender in *G. noduliferum* and *G. bicolor* (Fig. 2A–C, F–I).

The colour pattern of *G. dennerle* is similar to the one of *G. bicolor* that has been described by Ng & Davie (1995: 32): "In the holotype male and larger female, the anterior one-third of the carapace is bright purple, the posterior two-thirds being bluish-grey. In the smaller paratypes, the anterior one-third is also clearly defined, but the purple color is paler. The corneas of all four specimens are bright yellow." Their chelipeds, male abdominal and G1 structures, however, argue against them being the same species.

It is also necessary to briefly comment on the possible threats faced by the two species. Since *G. dennerle* and *G. hagen* are collected in large numbers for the global aquarium trade, their populations will invariably be impacted. According to local collectors in Java, the populations of both species have been decreasing over the years. Clearly, the continued collection of these crabs for the trade is not a sustainable practice, and if the popularity of the species continues, a conservation management plan will have to be developed, probably including a captive breeding program. While the conservation status of primary freshwater crabs have been assessed under the IUCN Red List guidelines (see Cumberlidge et al., 2009), the same has not been conducted for *Geosesarma* and other sesarmid species. This will need to be done in the future in view of the increasing popularity of these species in the aquarium trade.

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