

# Establishment of A New Bornean Genus of Gecarcinucidae (Crustacea: Brachyura), with Descriptions of Five New Species

Peter K. L. Ng<sup>1</sup> and Jongkar Grinang<sup>2,\*</sup> 

<sup>1</sup>Lee Kong Chian Natural History Museum, Faculty of Science, National University of Singapore, 2 Conservatory Drive, Singapore 117377, Republic of Singapore. E-mail: peterng@nus.edu.sg (Ng)

<sup>2</sup>Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.

\*Correspondence: E-mail: gjongkar@unimas.my (Grinang)

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The freshwater gecarcinucid species from Borneo previously referred to *Sundathelphusa* Bott, 1969, are transferred to a new genus. *Borneosa* gen. nov. can be diagnosed by the presence of a distinct frontal median triangle that is shorter than the frontal margin, a relatively longer male thoracic sternum in which the sternopleonal cavity reaches more anteriorly, and a male first gonopod that has the terminal segment prominently covered with long setae. The eight species recognised—*B. tenebrosa* (Holthuis, 1979), *B. aspera* (Ng & Stuebing, 1989), *B. brachyphallus* (Ng, 2015), and five new species, *B. niah*, *B. bario*, *B. kapit*, *B. sarawakensis* and *B. serrata*—can be distinguished by characters of the frontal median triangle, epibranchial tooth, anterolateral margin, third maxillipeds, ambulatory legs, male sternum, male pleon and male first gonopod.

**Key words:** Freshwater crab, Gecarcinucoidea, New species, New genus, Malaysia, Brunei, Indonesia, Taxonomy, Distribution, Key.

## BACKGROUND

The freshwater gecarcinucid genus *Sundathelphusa* Bott, 1969 (type species *Potamon* (*Geothelphusa*) *cassiope* De Man, 1902), occurs in the Philippines, Sulawesi, Moluccas and Borneo, and 44 species are now known (Ng et al. 2008; Husana et al. 2009; Ng 2010; Mendoza and Naruse 2010; Husana et al. 2014 2015; Ng 2015; Ng and Anker 2016; Mendoza and Sy 2017; Husana and Ng 2019; Husana 2020; Ng and Mendoza 2020). Of these, only three species, *S. tenebrosa* Holthuis, 1979, *S. aspera* Ng & Stuebing, 1989, and *S. brachyphallus* Ng, 2015, are known from Borneo, all reported from the eastern half of the island. Ng and Stuebing (1989) commented that *S. tenebrosa* and *S. aspera* were distinct from congeners in their carapace and adult cheliped morphology. In a genetic

study done on various gecarcinucids, Klaus et al. (2009) showed that the Bornean species emerged in a separate clade from all the other species of *Sundathelphusa*, suggesting they belong to a separate taxon. Ng (2015) elaborated on the affinities of three Bornean species, observing that in addition to carapace and cheliped differences, their G1 structures were also distinct, with the terminal segment more cylindrical in shape with the surface covered with numerous setae on the dorsal and ventral parts, and the tip is wide and rounded. Over the last decade, the authors have obtained and studied a large series of specimens of “*Sundathelphusa*” from various parts of Borneo, confirming the suggestions of Ng and Stuebing (1989), Klaus et al. (2009) and Ng (2015) that the Bornean species should be referred to as a new genus. In addition to the characters noted by Ng and Stuebing (1989) and Ng (2015), there are others

that help differentiate the two genera. In addition, we describe five new species and extend the range of the genus to western Borneo.

## MATERIALS AND METHODS

Specimens examined are in the Muzium Zoologicum Bogorensis (MZB) in Cibinong, Java, Indonesia; The Natural History Museum (NHM), London, United Kingdom; The Naturalis Biodiversity Centre (NNM) (previously the Rijksmuseum van Natuurlijke Historie), Leiden, The Netherlands; Senckenberg Museum (SMF), Frankfurt, Germany; zoological collections of the Universiti Malaysia Sarawak (UNIMAS), Malaysia; and the Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum (previously Raffles Museum of Biodiversity Research), National University of Singapore.

The terminology used follows Ng (1988) and Davie et al. (2015). Measurements provided, in millimetres, are of the carapace width and length, respectively. The following abbreviations are used: asl = above sea level; coll. = collected by; G1 = male first gonopod; G2 = male second gonopod. The Malay and Indonesian words Sungei and Gunong are used for rivers and mountains, respectively. Stream order was estimated based on the number of tributaries upstream on a topography map of 1:75000 scale. A drainage at the origin with no tributaries is classified as a first order stream, with two first order streams joining downstream to form a second order stream; and so on (Strahler 1957). Feeder streams are here defined as headwater tributaries that flow into Batang Ai reservoir.

## RESULTS

### SYSTEMATIC ACCOUNT

#### Superfamily Gecarcinucoidea Rathbun, 1904 Family Gecarcinucidae Rathbun, 1904

##### *Borneosa* gen. nov.

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*Type species: Sundathelphusa tenebrosa* Holthuis, 1979, by present designation.

*Diagnosis:* Carapace transversely ovate; dorsal surface gently granulated, striated, rugose or pitted, convex, not distinctly swollen or inflated; cervical grooves deep, relatively broad; epigastric cristae slightly

to distinctly anterior of postorbital cristae, never fused into single ridge; frontal median triangle distinct, with dorsal margin cristate, fused with lateral margins or separated only by small gap; epibranchial tooth low but distinct with shallow cleft to confluent with anterolateral margin; lateral striae on antero- and posterolateral margins strong, prominent; larger chela never inflated or prominently enlarged even in large specimens; male thoracic sternites 3 and 4 proportionately wide, tip of sternopleonal cavity reaches or almost reaches suture between sternites 3 and 4; male pleon distinctly T-shaped; adult male chelipeds symmetrical or only slightly asymmetrical; tubercle of male pleonal locking mechanism on anterior third of sternite 5; G1 terminal segment subcylindrical, tip rounded wide; dorsal and ventral surfaces with numerous long setae; G2 subequal or longer than G1, distal segment flagelliform, about half to one-third length of basal segment; vulvae on submedian part or anterior third of sternite 6 large, round, without sternal cover, posterior margin slightly rimmed.

*Etymology:* The name is derived from the name of the island the species are endemic to, Borneo; in arbitrary combination with the genus name *Thelphusa*. Gender feminine.

*Remarks:* The taxonomic concept of *Sundathelphusa* Bott, 1969, remains unsatisfactory and a revision is needed. Ng and Sket (1996) treated *Archipelothelphusa* Bott, 1969 (type species *Thelphusa grapsoides* H. Milne Edwards, 1853) as a junior subjective synonym because the characters used by Bott (1969 1970) to separate the two genera are not discrete and overlap. Ongoing studies suggest that *Sundathelphusa* is actually made up of several discrete species groups with well demarcated distributions, which should be recognised as separate genera in the future (see also Ng 1990; Klaus et al. 2009), and *Archipelothelphusa* may be a good genus after all. One of the groups which is endemic to Borneo is here described as a new genus, *Borneosa* gen. nov.

There are several key characters that distinguish *Sundathelphusa* sensu lato from *Borneosa*. Many species of *Sundathelphusa* lack a frontal median triangle of any sort, and those that possess it invariably have the dorsal margin wide, subcristate and spanning the entire frontal margin, but does not fuse with the lateral margins at all (Fig. 1A). In *Borneosa*, the structure of the frontal median triangle is different, being more distinct and occupies only the median part of the frontal margin, with the dorsal margin cristate and fuses with the lateral margins or nearly so (Fig. 1B). In *Sundathelphusa*, male thoracic sternites 3 and 4 are proportionately narrower transversely and the tip of the sternopleonal cavity reaches to midway between sternites 3 and 4,

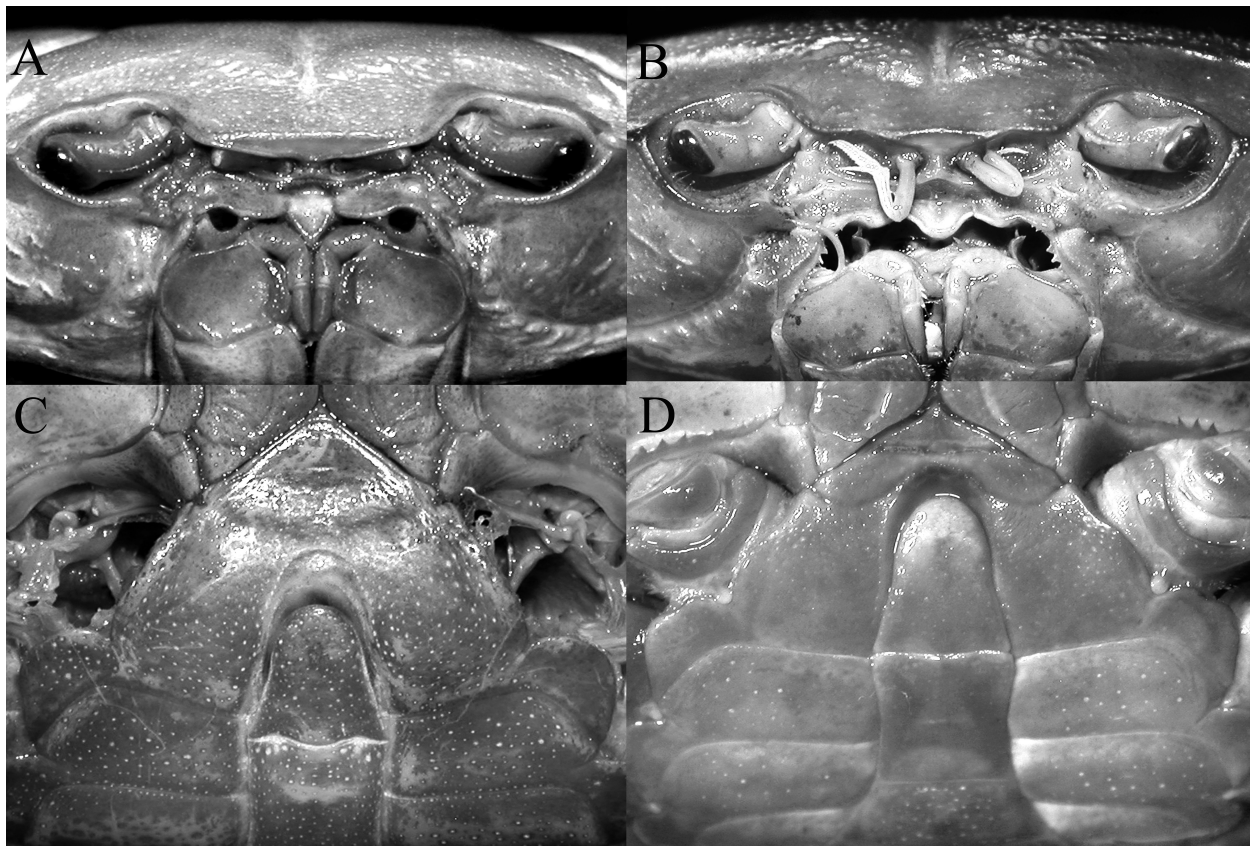
with a distinct gap visible between it and the suture between sternites 3 and 4 (Fig. 1C). In *Borneosa*, male thoracic sternites 3 and 4 are proportionately wider and the sternopleonal cavity reaches distinctly more anteriorly, with the tip of the cavity reaching the suture between sternites 3 and 4 (Fig. 1D). Although thoracic sternites 3 and 4 are fused in both genera, there remains a shallow groove or ridge that marks the boundaries of the two sternites. In addition, the G1 terminal segment of *Sundathelphusa* is cone-shaped with only the ventral margin distinctly lined with long setae and the tip is sharp with the opening small (cf. Chia and Ng 2006: figs. 40A–D, 41A–D, 43A–D; Ng and Anker 2016: fig. 4A–C; Schubart and Ng 2008: fig. 4A–D; Husana and Ng 2019: figs. 2A–D, H–M, J–S, 5A–D, I–L) whereas in *Borneosa*, it is subcylindrical to subconical in shape, with the overall surface covered with short and long setae and the tip is rounded with a relatively large opening (e.g., Fig. 20I–K). The dorsal carapace surface of *Sundathelphusa* species is relatively smooth, and striae, when present, are generally low and rounded (cf. Chia and Ng 2006: figs. 39, 42; Ng and Anker 2016: fig. 2; Schubart and Ng 2008: fig. 1A; Husana and Ng 2019:

figs. 1A–C, 3E, 4A, B, 7A); in *Borneosa* the surface is always prominently rugose, with the striae on the lateral margins strong (e.g., Figs. 2B, 4B, 6B, 8B, 10B, 12B, 15B, 17B). The same is true for the outer surface of the chelae; being relatively smooth or at most uneven in *Sundathelphusa* species (cf. Ng and Anker 2016: fig. 3C; Schubart and Ng 2008: fig. 2; Husana and Ng 2019: figs. 1F, 4F, 7E, F) but prominently granulated and rugose in *Borneosa* (e.g., Figs. 5D, E, 13D, E, 16D). In large males of *Sundathelphusa*, one of the chelae is always prominently enlarged and swollen, often at least twice the size of the minor one (cf. Chia and Ng 2006: fig. 42A; Ng and Anker 2016: figs. 2, 3C; Schubart and Ng 2008: fig. 1A; Husana and Ng 2019: fig. 7A, E, F). In *Borneosa*, even in large males, the major chela is only slightly larger than the minor one and never prominently swollen (e.g., Figs. 5D, E, 16D).

### ***Borneosa tenebrosa* (Holthuis, 1979)**

(Figs. 2, 3, 19A, 20A–L, 23A)

*Sundathelphusa tenebrosa* Holthuis, 1979: 39, pl. 7, text-fig. 8;  
Holthuis 1986: 594; Guinot 1988: 13; Guinot 1994: 171; Franssen



**Fig. 1.** A, B, frontal margin and median triangle; C, D, male anterior thoracic sternum and sternopleonal cavity. A, C, *Sundathelphusa philippina* (von Martens, 1868), paralectotype male (51.4 × 42.8 mm) (ZMB 1050), Samar, Philippines; B, D, *Borneosa aspera* (Ng & Stuebing), 1989, holotype male (42.6 × 32.8 mm) (ZRC 1989.2143), Sipitang, Sabah.

et al. 1997: 136; Ng 2004: 329; Ng and Yeo 2007: 12; Grinang and Nyanti 2007b: 2 (part); Ng et al. 2008: 73; Cumberlidge et al. 2009: unpaginated appendix; Klaus et al. 2009: 514; McFarlane et al. 2011: 12, figs. 2 (unnumbered), 4; Ng 2015: 494, figs. 3, 7F–H.

**Material examined:** Holotype male (23.5 × 19.1 mm) (NHM 1979.135), Camp 2, in 2 × 2 m pool, 10 cm deep, clear cold mountain stream with pebble and gravel bottom, hill dipterocarp forest, 4°03'N 114°53'E, 500 m asl, Gunong Mulu National Park, Sarawak, Malaysia, coll. J. Dring, 18 March 1978; paratype male (21.9 × 17.8 mm) (NHM 1979.136), same data as holotype; 1 paratype female (NNM D31972), Deer Cave, Gunong Mulu National stream near southwest entrance, under rock, Sarawak, Malaysia, coll. P. Chapman, 10 March 1978; 1 paratype female (NNM D31979), Deer Water Cave, Gunong Mulu National Park in stream about 100 m from entrance, Sarawak, Malaysia, coll. P. Chapman, 25 April 1978; 2 paratype females (NNM D31972), Clearwater Cave, Gunong Mulu National Park in main stream passage near river junction, coll. P. Chapman, 13 April 1978; 1 female (30.8 × 24.6 mm) (ZRC 1989.3420), Sungei Melinau, Merimau Gorge, Gunong Mulu National Park, Sarawak, Malaysia, coll. R.P. Lim & G. Liew, 16 April 1978; 1 juvenile (ZRC 1989.3682), Sungei Melinau, Merimau Gorge, Gunong Mulu National Park, Sarawak, Malaysia, coll. R.P. Lim, 17 April 1978; 1 male (16.1 × 13.0 mm) (ZRC 2013.1293), Mulu Summit trail at Camp 2, Gunong Mulu National Park, Sarawak, Malaysia, coll. A.D. Tranh, 4 November 2006.

**Diagnosis:** Adult carapace transversely subquadrate, width to length ratio 1.23–1.25 (Figs. 2A, B, 3E); striae on lateral parts of carapace distinct (Figs. 2B, 3E); branchial regions gently convex in frontal view (Fig. 2C); dorsal margin of frontal median triangle adjacent to but not contiguous with lateral margins, separated by a gap or connected by small flattened granules (Fig. 2C–F); exorbital tooth with outer margin almost entire (Figs. 2B, 3E); epibranchial tooth very low, just visible, separated from rest of margin by shallow low cleft (Figs. 2B, 3E); median lobe of posterior margin of epistome acutely triangular (Fig. 2C–F); ischium of third maxilliped subquadrate (Fig. 3A); fingers of adult male cheliped closing along entire cutting margins (Fig. 3D); P3 dactylus longer than P4 dactylus (Fig. 3G, H); male pleonal somite 6 rectangular, longer than broad (Fig. 3C); male sternopleonal cavity not prominently anterior, distance between tip of cavity and suture of thoracic sternites 2 and 3 subequal to length of thoracic sternite 2 (Fig. 3B); adult G1 subterminal segment relatively slender; terminal segment subcylindrical, distal half gently curved outwards, tapering gradually to truncate

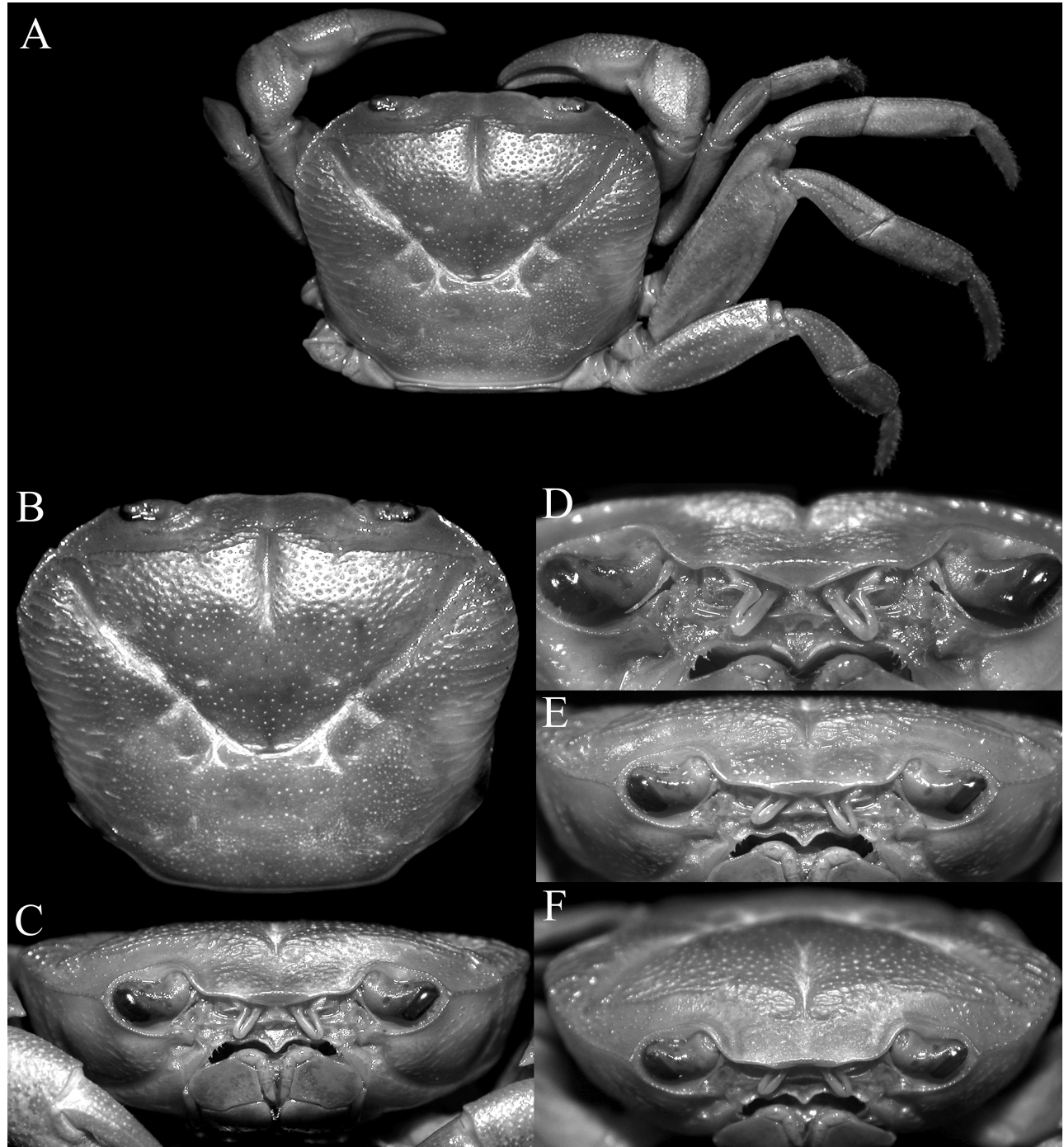
tip, 0.25–0.28 times length of subterminal segment, distal opening large, ovate (Fig. 20F, G, I–K); vulvae transversely subovate (Fig. 23A).

**Description:** Carapace transversely subquadrate, width to length ratio 1.23–1.25 (Figs. 2A, B, 3E); regions separated by distinct grooves; dorsal surface gently convex, glabrous, pitted, rugose, especially along margins and cristae, striae on lateral parts of carapace most distinct (Figs. 2B, 3E); frontal region with low granules and rugae especially nearer epigastric region, orbital regions finely pitted to smooth; cervical groove deep, broad, extending from lateral edge of postorbital cristae to deep H-shaped gastric groove; branchial regions gently convex, not distinctly inflated in frontal view (Figs. 2B, C, F, 3E); postorbital cristae relatively sharp, distinct, gradually becoming lower, less distinct towards cervical groove, with separate short, low rugose crista just before anterolateral margin; postorbital crista separated from epigastric crista by shallow oblique groove; epigastric cristae anterior of postorbital cristae, distinct, not sharp, prominently rugose, margins sloping anteriorly, separated medially by deep longitudinal groove which extends to just before mesogastric area (Figs. 2B, F, 3E). Frontal margin slightly sinuous to almost straight, slightly deflexed; frontal median triangle transversely narrow, median in position, edges of dorsal margin adjacent to but not contiguous with lateral margins, separated by a gap or connected by small flattened granules (Fig. 2C–F). Exorbital tooth low, broadly triangular, outer margin length ca. 4 times longer than inner margin, outer margin almost straight, lined with small granules, almost entire, curving to meet anterolateral margin, forming very small triangular notch (Figs. 2B, 3E). epibranchial tooth very low, just visible, separated from rest of margin by shallow low cleft (Figs. 2B, 3E); anterolateral margin gently convex, lined with small granules, adjacent surfaces covered with numerous rows of strong oblique striae; not clearly demarcated from posterolateral margin; posterolateral margin gently concave, adjacent surfaces lined with strong oblique striae, converging to almost straight or gently convex posterior carapace margin (Figs. 2B, 3E). Pterygostomial, suborbital, sub-hepatic and sub-branchial regions distinctly rugose or lined with oblique granules (Fig. 2C–F). Posterior margin of epistome with median lobe acutely triangular, tip sharp; lateral margin with low, broadly triangular lobe, separated by deep fissures (Fig. 2C–F). Third maxilliped quadrate; ischium subquadrate, longer than broad, sulcus deep, oblique, closer to inner margin; merus squarish, lateral and distal margins cristate, medially depressed; exopod slender, reaching to about half length of merus, with distinct triangular projection on inner margin of distal part, flagellum long, extending across width of merus (Fig.

3A). Terminal segment of mandibular palp bilobed, inner lobe twice length of outer lobe, flap-like.

Chelipeds subequal with one chela larger but not inflated; outer surfaces of articles rugose (Figs. 2A, 3D). Basis-ischium fused, with low tooth on anterior margin (Fig. 3B). Merus trigonal in cross-section, margins

uneven, covered with striae and low granules; anterior margin with low subterminal tooth. Upper surfaces of carpus with broad, shallow longitudinal depression, inner angle with prominent sharp spine, base with low tubercle (Fig. 2A). Fingers of chela longer than palm; cutting edges with numerous sharp teeth and denticles,



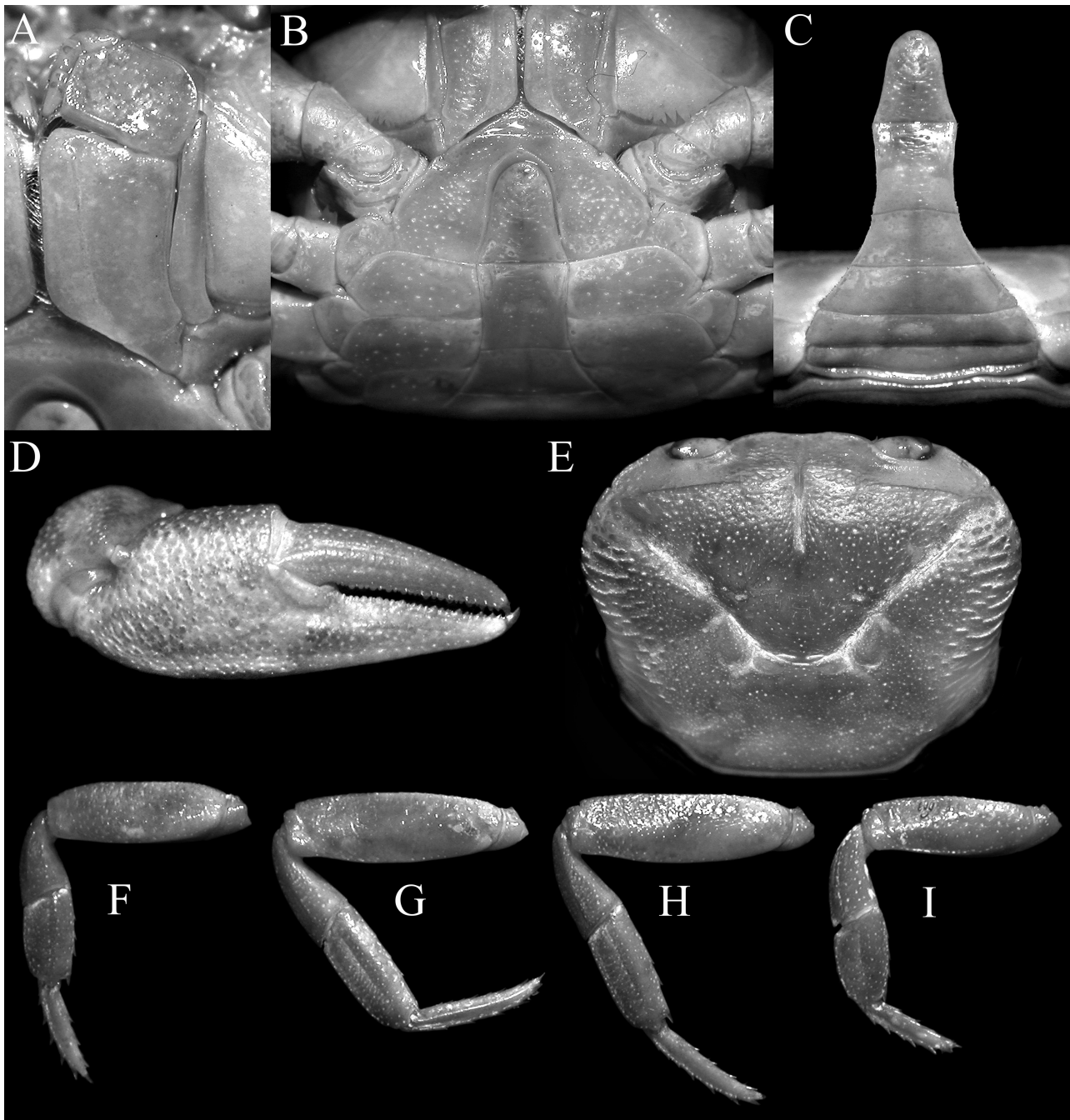
**Fig. 2.** *Borneosa tenebrosa* (Holthuis, 1979), holotype male (23.5 × 19.1 mm) (NHM 1979.135), Gunong Mulu National Park, Sarawak. A, overall dorsal view; B, dorsal view of carapace; C, frontal view of cephalothorax; D, frontal median triangle, eyes, epistome, antennae and antennules; E, F, different views of frontal part of cephalothorax.

tips of fingers strongly curved; fingers of adult male cheliped closing along entire cutting margins (Fig. 3D).

Ambulatory legs not elongated, P3 longest; outer surfaces gently rugose (Figs. 2A, 3F–I). Merus stout, anterior margin slightly crested, uneven, appears weakly serrated, dorsal subterminal angle just visible

but without spine or tooth; propodus with 2 rows of downward pointing spines on posterior margin; dactylus almost straight or gently curved, margins with numerous well developed spines pointing obliquely distally; P3 dactylus longer than P4 dactylus (Fig. 3F–I).

Surface of thoracic sternum punctate; sternites



**Fig. 3.** *Borneosa tenebrosa* (Holthuis, 1979). A–D, holotype male (23.5 × 19.1 mm) (NHM 1979.135), Gunong Mulu National Park, Sarawak; E, paratype male (21.9 × 17.8 mm) (NHM 1979.136), Gunong Mulu National Park, Sarawak; F–I, female (30.8 × 24.6 mm) (ZRC 1989.3420), Gunong Mulu National Park, Sarawak. A, left third maxilliped; B, anterior male thoracic sternum and pleon; C, male pleon; D, outer view of right chela; E, dorsal view of carapace; F–I, left P2–P5, respectively, all to same scale.

1 and 2 completely fused, forming triangular plate; separated from sternite 3 by gently concave suture; sternites 3 and 4 proportionately wide, completely fused except for lateral clefts and shallow median groove; sternopleonal cavity deep, almost reaching imaginary line connecting anterior edges of coxae of chelipeds, cavity not prominently anterior, distance between tip of cavity and suture of thoracic sternites 2 and 3 subequal to length of thoracic sternite 2 (Fig. 3B); pleonal locking mechanism composed of rounded tubercle on submedian part of sternite 5 (Fig. 19A).

Pleon distinctly T-shaped; all somites and telson free; somite 1 longitudinally narrow, extending across width of posterior carapace margin, reaching bases of coxae of P5; somite 2 as wide as somite 1; somite 3 subrectangular, with convex lateral margins; somites 4 and 5 trapezoidal with gently concave to straight lateral margins; male pleonal somite 6 rectangular, longer than broad, distal and proximal margins subequal; telson triangular with concave lateral margins, rounded tip (Fig. 3B, C).

Adult G1 directed obliquely outwards; subterminal segment relatively slender, tapering gradually from broad base, sinuous on proximal part of outer margin, rest of margin gently concave; terminal segment clearly demarcated from subterminal segment but grooves shallow; terminal segment subcylindrical, dorsal and ventral surfaces with numerous long setae, distal half gently curved outwards, tapering gradually to truncate tip, 0.25–0.28 times length of subterminal segment, groove for G2 marginal or slightly dorsal in position, dorsal and ventral folds slightly overlapping, distal opening large, ovate (Fig. 20F, G, I–K). G2 longer than G1, flagellum well developed, about one-third length of basal segment (Fig. 20H, L).

**Female:** Adult female chelipeds are relatively slenderer compared to those of males. The female pleon is ovate, has all the somites and telson free, and covers most of the thoracic sternal surface. The vulvae are large, transversely subovate, without a clear sternal cover with the posterior margin slightly rimmed, and are positioned on the submedian part or anterior third of sternite 6 (Fig. 23A).

**Colour:** Holthuis (1979: 42) described the colour as follows: “brown with orange-brown edges to the carapace... Dorsally dark brown with a slight purplish tinge. Venter pale brown, mouthparts dark and purple tinged.” This is similar to colour photographs of the species in McFarlane et al. (2011).

**Remarks:** The taxonomy of this species has been discussed at length by Ng (2015) and there is no need to elaborate further here.

**Biology:** The species was described from specimens collected in Deer Cave, Deer Water Cave

and Clearwater Cave in Gunong Mulu National Park, the highest altitude being 500 m but they are clearly not troglobites (Holthuis 1979) (see also McFarlane et al. 2011). It has also been found in streams outside caves (ZRC 2013.1293). Although most of the specimens have been found in caves, they should be considered as facultative cavernicoles at best as they have none of the adaptations associated with troglobites (cf. Holthuis 1986; Guinot 1988 1994).

### ***Borneosa aspera* (Ng & Stuebing, 1989)**

(Figs. 1B, D, 4, 5, 19B, 20M–P, 23B)

*Sundathelphusa aspera* Ng & Stuebing, 1989: 14, figs. 1, 2; Ng and Yeo 2007: 12; Ng et al. 2008: 72; Cumberlidge et al. 2009: unpaginated appendix; Ng 2015: 497, figs. 4–6, 7I–K.

**Material examined:** Holotype male (42.6 × 32.8 mm) (ZRC 1989.2143), clear, swift forest stream, Sungei Rabergan, tributary of Sungei Muaya, near Mendalong, 4°57'N 115°43'E, 750 m asl, Sipitang District, Sabah, Malaysia. Others: 1 male (32.3 × 25.4 mm), 1 female (44.1 × 33.1 mm) (ZRC 2014.845), Temburong, Amo, Batu Apoi Forest Reserve, Ulu Temburong National Park, Brunei, coll. Jangorun anak Eri, 7 August 2014; 1 female (44.5 × 33.7 mm) (ZRC 2013.746), Bukit Pagon, Temburong District, Brunei, 900 m asl, coll. S. Salam, 6 July 2012; 2 females (29.3 × 23.0 mm, 19.7 × 15.6 mm) (ZRC 2012.1225), in primary forest stream, in area near Sarawak border, Brunei, coll. H. Mohammad, October 2012.

**Diagnosis:** Adult carapace transversely ovate, width to length ratio 1.27–1.30 (Figs. 4A, B, 5F); striae on lateral parts of carapace strong (Figs. 4B, 5F); branchial regions gently convex in frontal view (Fig. 4C, F); dorsal margin of frontal median triangle contiguous with lateral margins (Fig. 4C–E); exorbital tooth with outer margin almost entire (Figs. 4B, 5F); epibranchial tooth low, separated from rest of margin by shallow low cleft (Figs. 4B, 5F); median lobe of posterior margin of epistome obtusely triangular (Fig. 4C–E); ischium of third maxilliped subquadrate (Fig. 5A); fingers of adult male cheliped closing along entire cutting margins (Fig. 5D, E); P3 dactylus longer than P4 dactylus (Fig. 5H, I); male pleonal somite 6 rectangular, longer than broad (Fig. 5C); male sternopleonal cavity not prominently anterior, distance between tip of cavity and suture of thoracic sternites 2 and 3 subequal to length of thoracic sternite 2 (Fig. 5B); adult G1 subterminal segment very slender; terminal segment cylindrical, distal half almost straight, tip wide, truncate, 0.35–0.37 times length of subterminal segment, distal opening very wide, ovate (Fig. 20M–O); vulvae transversely subovate (Fig. 23B).

**Colour:** In life, the carapace and pereopods of

the species are dark to dull brown, with the ventral and frontal surfaces light brown to yellow and pale yellow; the pleon being reddish-brown (Fig. 24A–G).

**Remarks:** Described on the basis of one large male by Ng and Stuebing (1989) from northern Sabah, the species was subsequently recorded and redescribed at length on the basis of a larger series of specimens from Brunei (Ng 2015). *Borneosa aspera* is the most distinctive member of the genus as it reaches the largest sizes (a female, 44.5 × 33.7 mm, ZRC 2013.746) and males also have proportionately, the longest G1 terminal

segment (Fig. 20M–O).

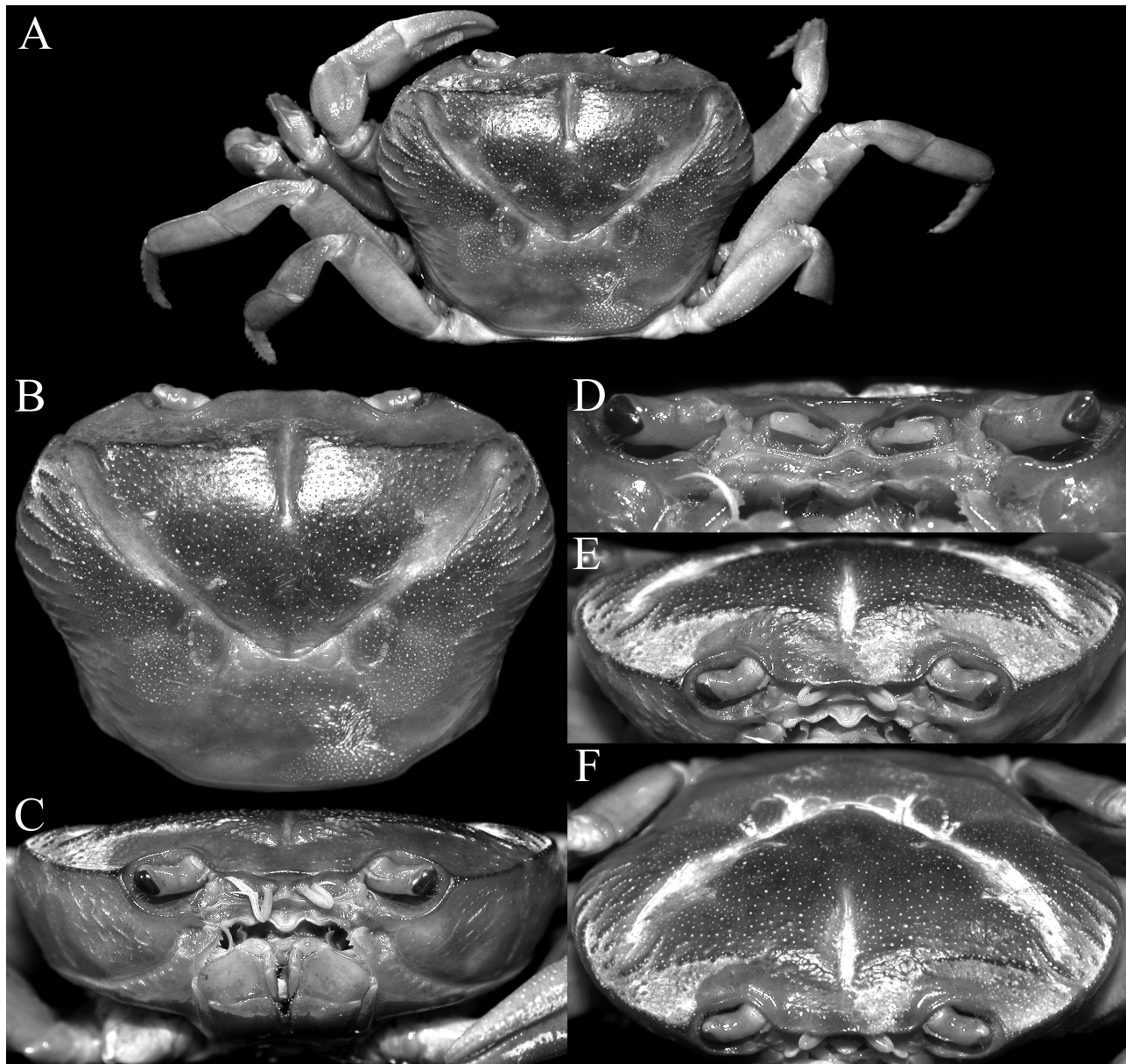
**Biology:** All the specimens were collected from primary highland rainforest streams.

***Borneosa brachyphallus* (Ng, 2015)**

(Figs. 6, 7, 19C, 22Q–T)

*Sundathelphusa brachyphallus* Ng, 2015: 494, figs. 1, 2, 7A–E.

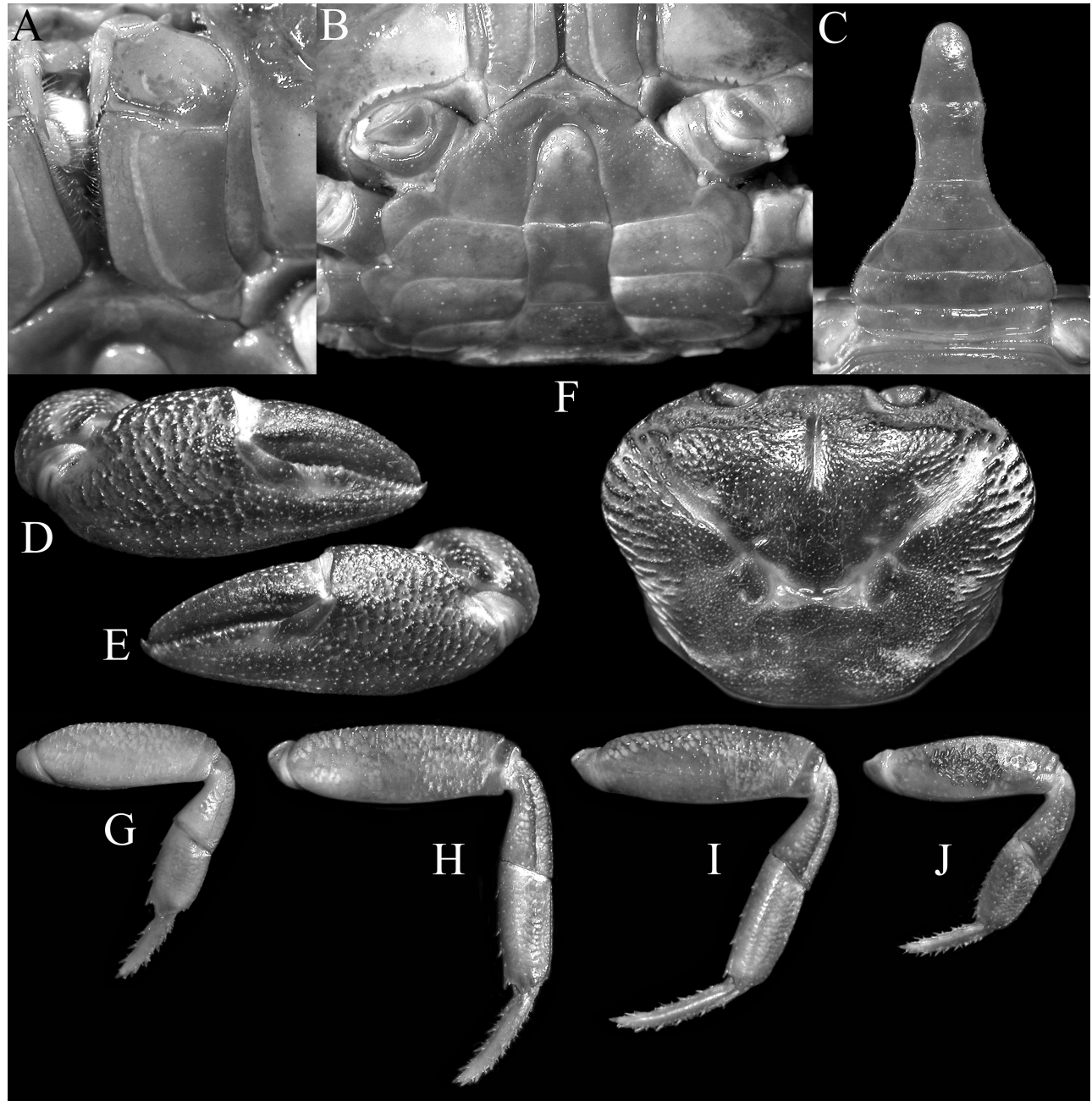
**Material examined:** Holotype: male (27.1 × 22.0 mm) (MZB Cru 4396), Liang Hintan, Hulu Sungei



**Fig. 4.** *Borneosa aspera* (Ng & Stuebing), 1989, holotype male (42.6 × 32.8 mm) (ZRC 1989.2143), Sipitang, Sabah. A, overall dorsal view; B, dorsal view of carapace; C, frontal view of cephalothorax; D, frontal median triangle, eyes, epistome, antennae and antennules; E, F, different views of frontal part of cephalothorax.

Barito, 0°27'33"N 115°01'1.0"E, 222–250 m asl, Kalimantan Tengah, Indonesia, coll. C. Rahmadi, 16 June 2004. Paratype: 1 male (29.3 × 23.4 mm, chelipeds missing) (ZRC 2015.0460), same data as holotype. Others: 1 male (26.1 × 21.8 mm), 2 females (39.8 × 31.2 mm, 35.2 × 27.6 mm) (ZRC 2021.0840), Liang Hintan, Tumbang Topus, Sumber Barito, Kalimantan Tengah, Indonesia, coll. C. Rahmadi, 14 June 2004.

**Diagnosis:** Adult carapace transversely subquadrate, width to length ratio 1.23–1.25 (Figs. 6A, B, 7I); striae on lateral parts of carapace distinct (Figs. 6B, 7I); branchial regions gently convex in frontal view (Fig. 6C, E); dorsal margin of frontal median triangle contiguous with lateral margins (Fig. 6C–E); exorbital tooth with outer margin almost entire (Figs. 6B, 7I); epibranchial tooth very low to absent, if visible,

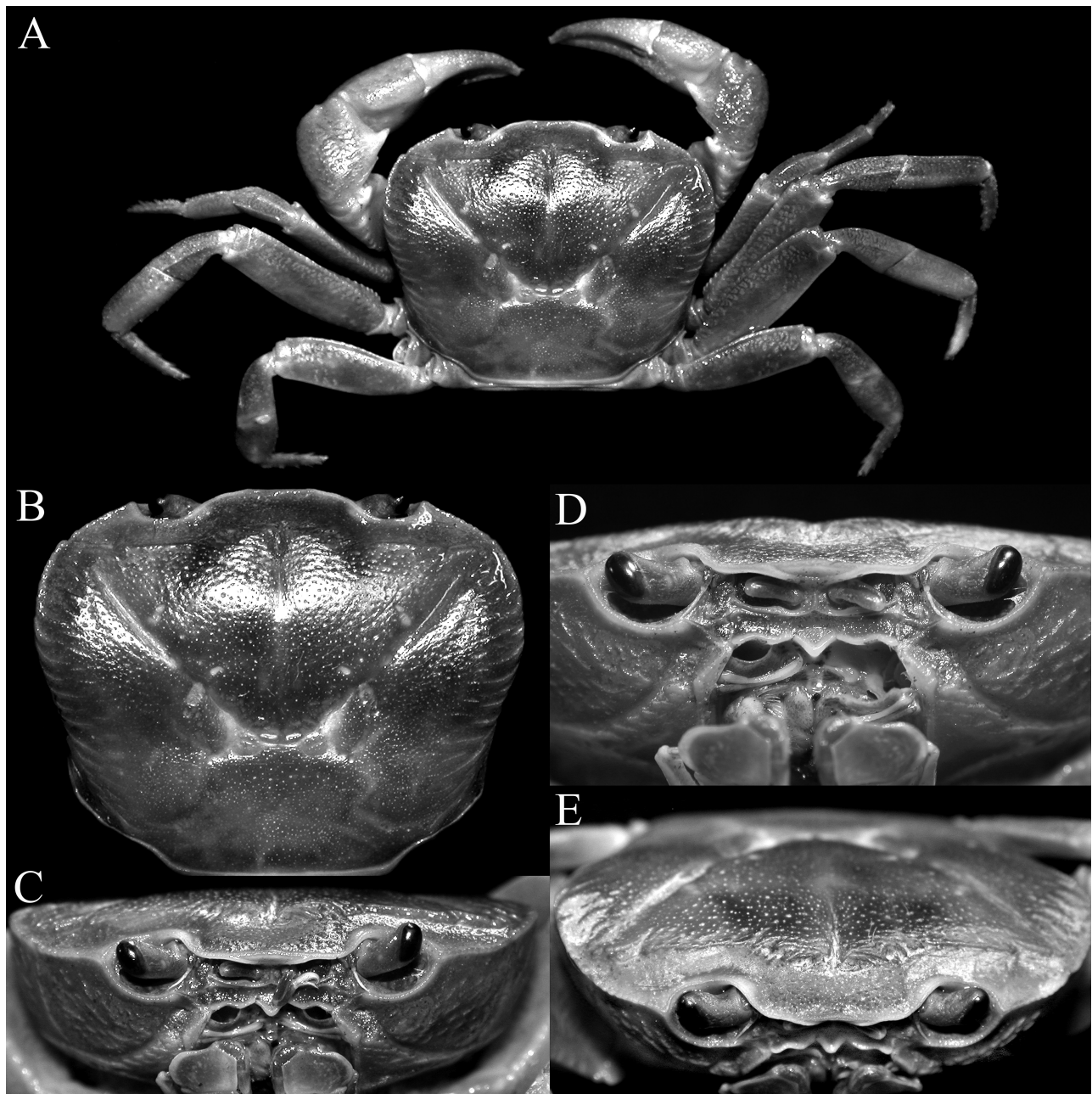


**Fig. 5.** *Borneosa aspera* (Ng & Stuebing, 1989). A–C, holotype male (42.6 × 32.8 mm) (ZRC 1989.2143), Sipitang, Sabah; D–J, male (32.3 × 25.4 mm) (ZRC 2014.845), Temburong, Brunei. A, left third maxilliped; B, anterior male thoracic sternum and pleon; C, male pleon; D, outer view of right chela; E, outer view of left chela; F, dorsal view of carapace; G–J, right P2–P5, respectively, all to same scale.

separated from rest of margin by shallow low cleft, anterolateral margin may appear entire (Figs. 6B, 7I); median lobe of posterior margin of epistome acutely triangular (Fig. 6C–E); ischium of third maxilliped subquadrate (Fig. 7A); fingers of adult male cheliped closing along entire cutting margins (Fig. 7D); P3 and P4 dactyli subequal in length (Fig. 7F, G); male pleonal somite 6 subquadrate, slightly longer than broad (Fig. 7C); male sternopleonal cavity not prominently anterior,

distance between tip of cavity and suture of thoracic sternites 2 and 3 longer than length of thoracic sternite 2 (Fig. 7B); adult G1 subterminal segment relatively stout; terminal segment subconical, distal half gently curved outwards, tapering gradually to subtruncate tip, 0.35 times length of subterminal segment, distal opening relatively smaller, subovate (Fig. 20Q–S); vulvae almost round (Fig. 23C).

*Colour:* Not known.

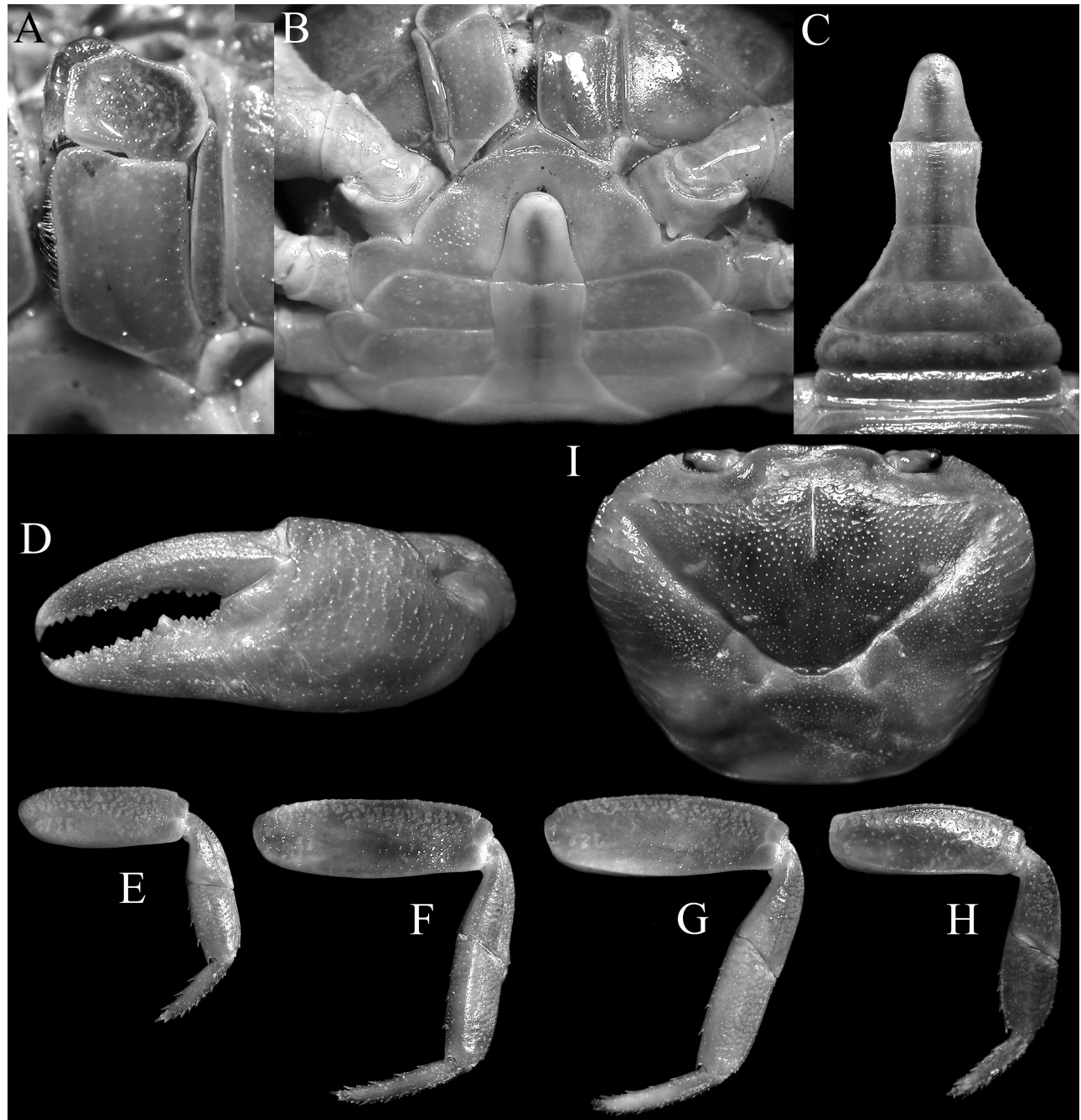


**Fig. 6.** *Borneosa brachyphallus* (Ng, 2015), holotype male (27.1 × 22.0 mm) (MZB Cru 4396), Barito, Kalimantan Tengah. A, overall dorsal view; B, dorsal view of carapace; C, frontal view of cephalothorax; D, frontal median triangle, eyes, epistome, antennae and antennules; E, different view of frontal part of cephalothorax.

**Remarks:** Of the various characters Ng (2015) used to distinguish this species from *B. tenebrosa* and *B. aspera*, perhaps the most obvious is that the carapace of *B. brachyphallus* is much smoother, with the striae near the lateral regions relatively lower and more rounded (Figs. 6A, B, E, 7I). The short G1 terminal segment is a character now also shared with *B. bario* sp.

nov., *B. sarawakensis* sp. nov. and *B. serrata* sp. nov., although the subterminal segment of *B. brachyphallus* is still proportionately the shortest and stoutest among congeners (Fig. 20Q–S).

**Biology:** *Borneosa brachyphallus* was collected from inside shallow streams in a horizontal cave in central Kalimantan, in the Barito Basin (Rahmadi and



**Fig. 7.** *Borneosa brachyphallus* (Ng, 2015). A–H, holotype male (27.1 × 22.0 mm) (MZB Cru 4396), Barito, Kalimantan Tengah; I, paratype male (29.3 × 23.4 mm, chelipeds missing) (ZRC 2015.0460), Barito, Kalimantan Tengah. A, left third maxilliped; B, anterior male thoracic sternum and pleon; C, male pleon; D, outer view of left chela; E–H, right P2–P5, respectively, all to same scale; I, dorsal view of carapace.

Suhardjono 2004), but it is clearly not a cavernicolous species as it has no the troglobitic adaptations (cf. Holthuis 1986; Guinot 1988 1994).

***Borneosa niah* sp. nov.**

(Figs. 8, 9, 21A–D)

urn:lsid:zoobank.org:act:5EB6A04C-E114-4F4E-ACA4-C9D76BC5F8A4

**Material examined:** 1 male (22.6 × 19.1 mm) (ZRC 2006.064), Bukit Kasut, in river along trail to jetty, in isolated hill some distance from Niah massif, Niah, ca. 3.80°N 113.77°E, Sarawak, Malaysia, coll. I. Das, November 2002.

**Diagnosis:** Adult carapace transversely subquadrate, width to length ratio 1.18 (Fig. 8A, B); striae on lateral parts of carapace distinct (Fig. 8B); branchial regions gently convex in frontal view (Fig. 8C, F); dorsal margin of frontal median triangle contiguous with lateral margins (Fig. 8C–E); exorbital tooth with outer margin almost entire (Fig. 8B); epibranchial tooth distinct, separated from rest of margin by low cleft (Fig. 8B); median lobe of posterior margin of epistome obtusely triangular (Fig. 8C–E); ischium of third maxilliped subquadrate (Fig. 9A); fingers of adult male cheliped closing along entire cutting margins (Fig. 9D, E); P3 and P4 dactyli subequal in length (Fig. 9G, H); male pleonal somite 6 subquadrate, slightly longer than broad (Fig. 9C); male sternopleonal cavity prominently anterior, distance between tip of cavity and suture of thoracic sternites 2 and 3 distinctly shorter than length of thoracic sternite 2 (Fig. 9B); adult G1 subterminal segment relatively slender; terminal segment subcylindrical, distal half gently curved outwards, tapering gradually to truncate tip, 0.30 times length of subterminal segment, distal opening large, subovate (Fig. 21A–C); females not known.

**Colour:** Not known.

**Etymology:** The species is named after its type locality in Niah. The name is used as a noun in apposition.

**Remarks:** *Borneosa niah* sp. nov. has a G1 that is similar to that of *B. tenebrosa* although the terminal segment is relatively longer (Fig. 21B, C) when compared to specimens of *B. tenebrosa* of similar sizes (Fig. 20F, G). In addition, the frontal median triangle of *B. niah* is complete, with the dorsal margin confluent with the lateral margins (Fig. 8C–E) (versus dorsal margin of frontal median triangle separated from lateral margins by a small gap or connected by small granules in *B. tenebrosa*; Fig. 2C–E); and the epibranchial tooth is relatively well-developed and strong (Fig. 8B) (versus low to almost confluent with anterolateral margin in *B. tenebrosa*; Figs. 2B, 3E). The two species are

adjacent to each other in their distribution, with that of *B. niah* in Niah only just west of the Mulu area where *B. tenebrosa* occurs. Both highlands, however, are separated by lowland rainforests and their drainages are not connected.

**Biology:** The only known specimen was collected from a stream with rocky substrates in the Niah limestone hills but not from a cave (I. Das, pers. comm.).

***Borneosa bario* sp. nov.**

(Figs. 10, 11, 21E–H, 23C)

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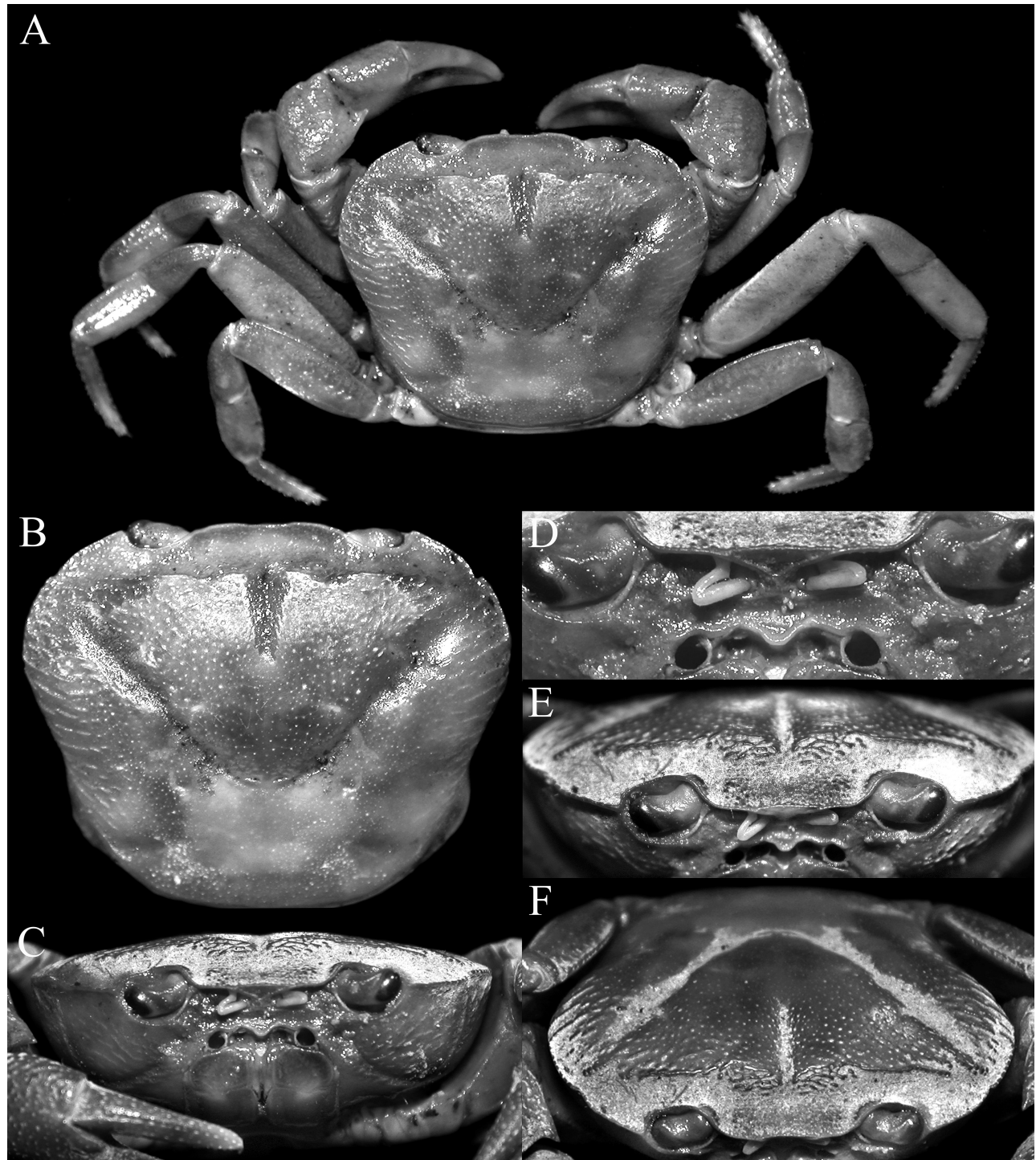
*Sundathelphusa tenebrosa* – Grinang and Nyanti 2007a: 14, pl. 5; Grinang and Nyanti 2007b: 2 (part) (not *Sundathelphusa tenebrosa* Holthuis, 1979).

**Material examined:** Holotype: male (29.6 × 23.1 mm) (ZRC 2021.0692), third order stream, downstream, primary forest, Sungei Menalio, Pulong Tau National Park, Bario, 3°34'07.2"N 115°24'22.9"E, 1020 m asl, Sarawak, Malaysia, coll. J. Grinang et al., 18 June 2005. Paratypes: 1 female (24.3 × 19.3 mm) (ZRC 2021.0693, ex UNIMAS.C.00009), same data as holotype; 1 young male (14.8 × 11.8 mm), 1 young female (19.0 × 15.3 mm) (ZRC 2021.0694, ex UNIMAS.C.00014), third order stream, downstream, primary forest, Sungei Bayuh, Bario, 3°36'36.3"N 115°24'52.9"E, 1070 m asl, Sarawak, Malaysia, coll. J. Grinang et al., 21 June 2005; 1 male (16.2 × 13.4 mm) (ZRC 2021.695), 1 female (15.4 × 13.0 mm) (UNIMAS.C.00026), first order stream, downstream, primary forest Sungei Selipor in Bario, Sarawak, Malaysia, coll. J. Grinang et al., 26 July 2005. 1 male (31.1 × 23.9 mm) (UNIMAS.C.00011), second order stream, downstream, primary forest Sungei Takang in Bario, 3°34'37.1"N 115°23'25.4"E, 1040 m asl, Sarawak, Malaysia, coll. J. Grinang et al., 26 June 2005.

**Diagnosis:** Adult carapace transversely subovate, width to length ratio 1.26–1.28 (Figs. 10A, B, 11F, H); striae on lateral parts of carapace distinct (Figs. 10B, 11F, H); branchial regions gently convex in frontal view (Fig. 10C); dorsal margin of frontal median triangle contiguous with lateral margins (Fig. 10C–F); exorbital tooth with outer margin almost entire (Figs. 10B, 11F, H); epibranchial tooth distinct, separated from rest of margin by distinct U-shaped cleft (Figs. 10B, 11F, H); median lobe of posterior margin of epistome obtusely triangular (Fig. 10C–E); ischium of third maxilliped subrectangular (Fig. 11A); fingers of adult male cheliped closing along entire cutting margins or with small basal gape (Figs. 11D, E, G); P3 and P4 dactyli subequal in

length (Fig. 11J, K); male pleonal somite 6 subquadrate, longer than broad (Fig. 11C); male sternopleonal cavity prominently anterior, distance between tip of cavity and suture of thoracic sternites 2 and 3 distinctly shorter

than length of thoracic sternite 2 (Fig. 11B); adult G1 subterminal segment relatively stout; terminal segment subcylindrical, distal half gently curved outwards, tip distinctly truncate, 0.34 times length of subterminal



**Fig. 8.** *Borneosa niah* sp. nov., holotype male (22.6 × 19.1 mm) (ZRC 2006.064), Niah, Sarawak. A, overall dorsal view; B, dorsal view of carapace; C, frontal view of cephalothorax; D, frontal median triangle, eyes, epistome, antennae and antennules; E, F, different views of frontal part of cephalothorax.

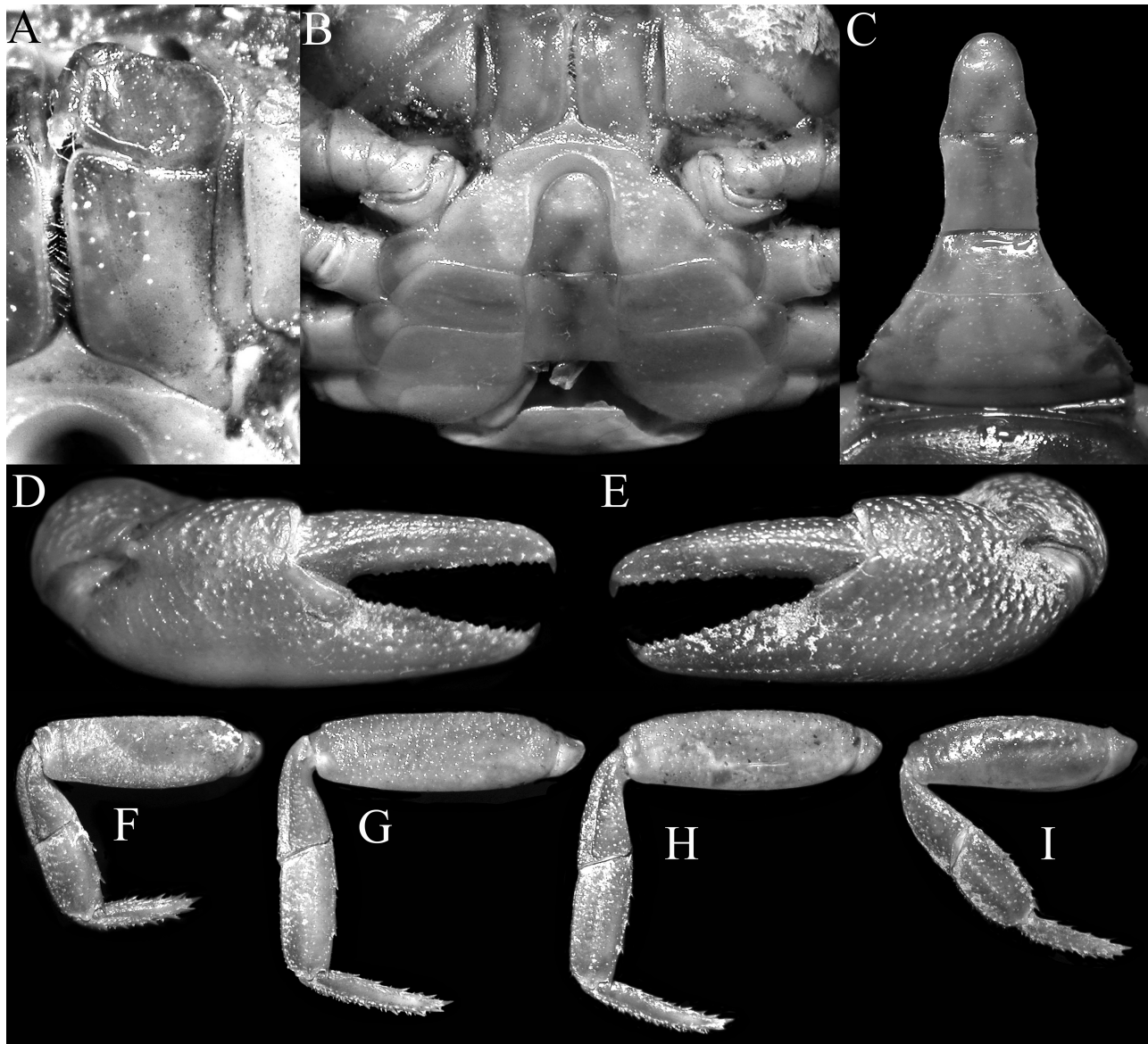
segment, distal opening large, subovate (Fig. 21E–G); vulvae transversely subovate (Fig. 23D).

**Colour:** In life, the carapace and pereopods are brown to olive brown, with the ambulatory merus grey to light brown; the ventral surfaces being dull yellow (Fig. 24H–J).

**Etymology:** The name is derived from the area where the crab was found, the Bario Highlands in Sarawak. The name is used as a noun in apposition.

**Remarks:** Although the Bario Highlands, the type locality of *B. bario* sp. nov., is inland to the Miri area and Gunong Mulu National Park where *B. tenebrosa* occurs, *B. bario* is easily distinguished in having the

epibranchial tooth large and well developed with a distinct U-shaped cleft separating it from the rest of the anterolateral margin, even in small individuals (Figs. 10B, 11F, H) (versus tooth very low to obscure, and separated by a shallow narrow cleft at most in *B. tenebrosa*; Fig. 2B); the dorsal margin of frontal median triangle is contiguous with lateral margins (Fig. 10C–F) (versus separated by a gap or connected by small flattened granules in *B. tenebrosa*; Fig. 2C–F); the P3 and P4 dactyli subequal in length (Fig. 11J, K) (versus P3 dactylus longer than P4 dactylus in *B. tenebrosa*; Fig. 2G, H); and the G1 terminal segment is proportionately stouter and shorter (Fig. 21E–G) (versus

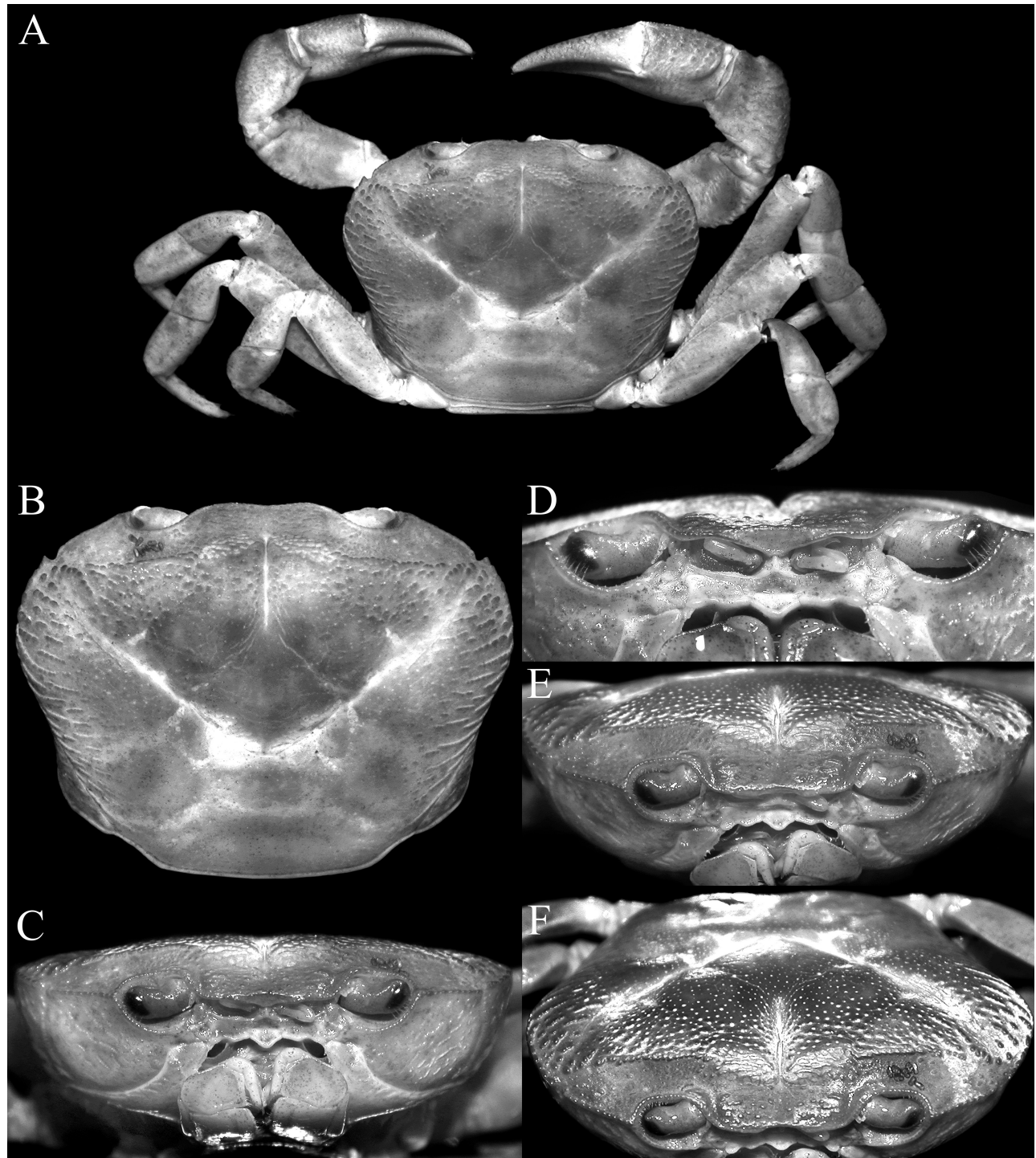


**Fig. 9.** *Borneosa niah* sp. nov., holotype male (22.6 × 19.1 mm) (ZRC 2006.064), Niah, Sarawak. A, left third maxilliped; B, anterior male thoracic sternum and pleon; C, male pleon; D, outer view of right chela; E, outer view of left chela; F–I, left P2–P5, respectively, all to same scale.

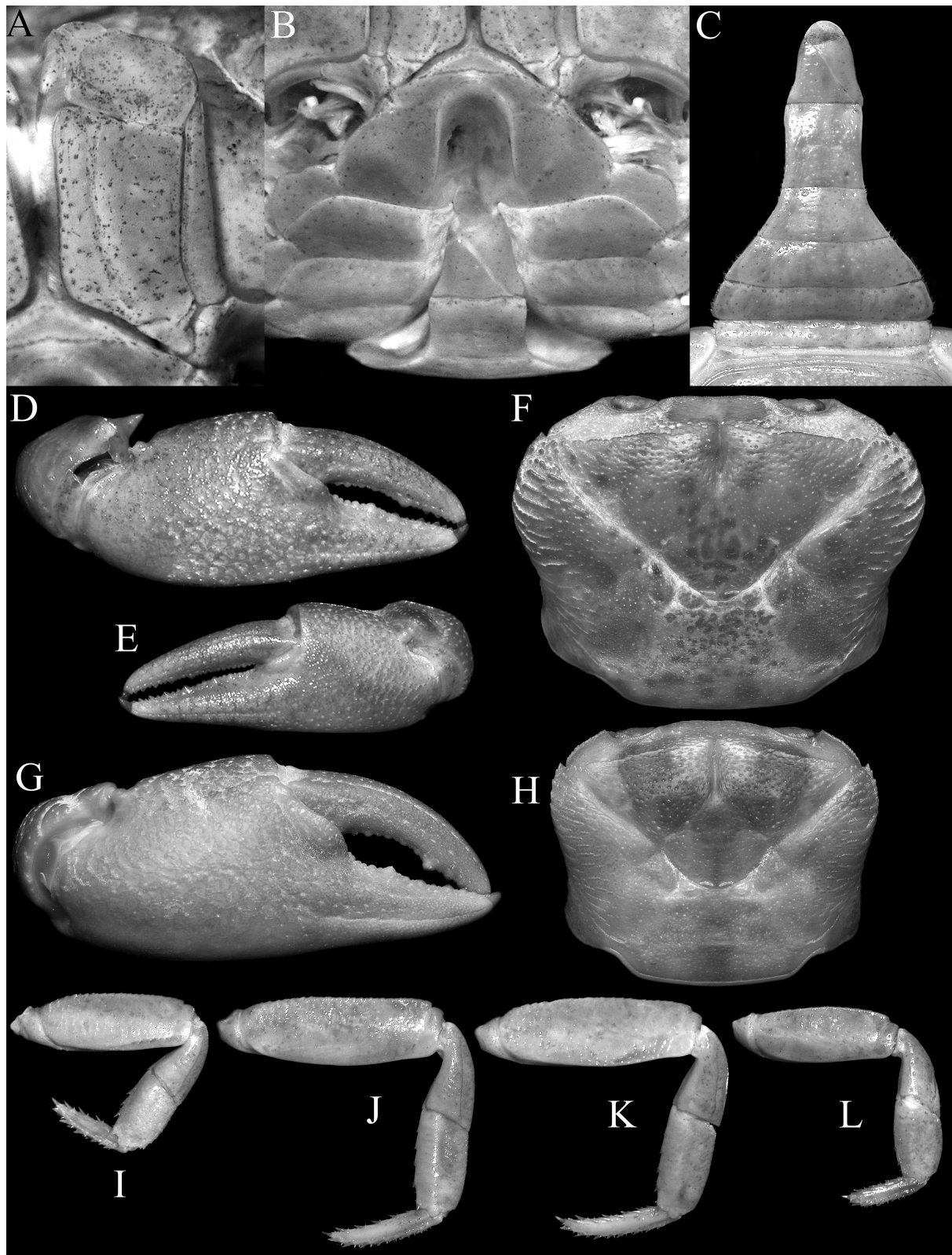
more elongate and slender in adult *B. tenebrosa*; Fig. 20I–K).

The epibranchial tooth of *B. bario* is well-developed, a character shared with *B. niah* sp. nov. and

*B. serrata* sp. nov. The tooth is distinct and cleft deep even in small subadult specimens of *B. bario*. From *B. niah*, *B. bario* can easily be separated by epibranchial tooth being more pronounced with the cleft deep (Fig.



**Fig. 10.** *Borneosa bario* sp. nov., holotype male (29.6 × 23.1 mm) (ZRC 2021.0692), Bario, Sarawak. A, overall dorsal view; B, dorsal view of carapace; C, frontal view of cephalothorax; D, frontal median triangle, eyes, epistome, antennae and antennules; E, F, different views of frontal part of cephalothorax.



**Fig. 11.** *Borneosa bario* sp. nov. A–E, I–L, holotype male (29.6 × 23.1 mm) (ZRC 2021.0692), Bario, Sarawak; F, paratype male (31.1 × 23.9 mm) (UNIMAS.C.00011), Bario, Sarawak; H, paratype male (16.2 × 13.4 mm) (UNIMAS.C.00011), Bario, Sarawak. A, left third maxilliped; B, anterior male thoracic sternum and pleon; C, male pleon; D, G, outer view of right chela; E, outer view of left chela (same scale as D); F, H, dorsal view of carapace; I–L, right P2–P5, respectively, all to same scale.

10B, 11F, H) (versus tooth smaller and cleft shallow in *B. niah*; Fig. 8B); the third maxilliped ischium being proportionately longer (Fig. 11A) (versus distinctly shorter in *B. niah*; Fig. 9A); and the G1 terminal segment is proportionately stouter and shorter in adult males (Fig. 21E–G) (versus terminal segment more slender and longer in *B. niah*; Fig. 21A–C). From *B. serrata*, *B. bario* can be distinguished in having the outer margin of the exorbital tooth entire (Fig. 10B) (versus gently serrated in *B. serrata*; Fig. 17B); the ischium of the third maxilliped is proportionately longer (Fig. 11A) (versus clearly shorter in *B. serrata*; Fig. 18A); and the G1 subterminal segment is relatively stouter (Fig. 21E–G) (versus slenderer in *B. serrata*; Fig. 22M–O).

The fingers of the major chela of the holotype male do not obviously gape when closed (Fig. 11D) but that of a slightly larger paratype male shows a distinct small gape (Fig. 11G). This indicates that the presence of a gape is likely size related.

**Biology:** All specimens were collected from small streams with waters tea-coloured or crystal clear, fast flowing (range: 0.35–1.34 m/s), cold (19.5–21.5°C), and acidic or slightly alkaline (pH 4.68–7.66) (see Grinang and Nyanti 2007a b). The crabs were found underneath rocky substrates under shaded canopy.

### ***Borneosa kapit* sp. nov.**

(Figs. 12–14, 19D, 22A–H, 23D)

urn:lsid:zoobank.org:act:432F792E-60B3-4AD8-9AF1-D00BD8D087E7

**Material examined:** Holotype: male (37.4 × 28.4 mm) (SMF 48750), Balui River, Rejang River, 2°44.616'N 114°4.565'E, Sarawak, Malaysia, coll. A. Leek, 11 November 1982. Paratypes: 2 males (20.6 × 16.9 mm, 12.8 × 9.9 mm) (UNIMAS.C.00039), first order stream, downstream, logged forest Sungei Pap in Belaga, 2°38'08.1"N 114°26'16.6"E, 535 m asl, Sarawak, Malaysia, coll. J. Grinang et al., 10 September 2007; 3 males (23.5 × 19.1 mm, 19.1 × 16.6 mm, 13.7 × 11.2 mm), 1 female (22.1 × 18.1 mm) (ZRC 2021.0518), second order stream, upstream, logged forest Sungei Belepu in Belaga, 2°37'22.4"N 114°24'55.3"E, 497 m asl, Sarawak, Malaysia, coll. J. Grinang et al., 11 September 2007; 1 male (12.0 × 11.0 mm), 1 juvenile (UNIMAS.C.00045), second order stream, midstream, logged forest Sungei Belepu in Belaga, 2°37'26.0"N 114°25'02.4"E, 450 m asl, Sarawak, Malaysia, coll. J. Grinang et al., 11 September 2007; 1 juvenile (UNIMAS.C.00051), first order stream, downstream, logged forest Sungei Sunan in Belaga, 2°39'30.8"N 114°11'11.0"E, 476 m asl, Sarawak, Malaysia, J coll. J. Grinang et al., 9 September 2007;

1 male (21.9 × 18.7 mm) (ZRC 2021.0519), 2 females (27.3 × 23.4 mm, 12.4 × 10.9 mm) (UNIMAS.C.00101), second order stream, logged over forest Sungei Simalajau, Kapit, Sarawak, Malaysia, bought from Teresang Market, Kapit, J. Grinang, 14 April 2016; 1 male (37.5 × 29.4 mm), 1 female (29.5 × 23.5 mm) (ZRC 2021.0690), first order stream, Nanga Benin, Pelagus, Kapit, Sarawak, Malaysia, coll. J. Grinang et al., 6 September 2016; 1 male (32.3 × 25.6 mm) (ZRC 2021.0520), first order stream, logged over forest Sungei Lebau, Pelagus, Kapit, Sarawak, Malaysia, coll. J. Grinang et al., 11 December 2015; 2 males (35.8 × 28.0 mm, 35.8 × 28.6 mm), 2 females (40.6 × 31.4 mm, 36.9 × 29.0 mm) (ZRC 2021.0521), 3 males (35.8 × 28.6 mm, 35.3 × 28.0 mm, 35.3 × 28.3 mm, 36.9 × 28.7 mm), 2 females (36.6 × 29.9 mm, 28.5 × 23.6 mm) (UNIMAS.C.00102), second order stream, Sungei Yong, Kapit, Sarawak, Malaysia, sent by M.B. Sadar, 8 February 2020.

**Diagnosis:** Adult carapace transversely subovate, width to length ratio 1.20–1.32 (Figs. 12A, B, 14); striae on lateral parts of carapace strong (Fig. 12B); branchial regions convex in frontal view (Fig. 12C, F); dorsal margin of frontal median triangle contiguous with lateral margins (Fig. 12C–E); exorbital tooth with outer margin almost entire (Fig. 12B); epibranchial tooth low to absent, separated from rest of margin by low cleft when present (Figs. 12B, 14); median lobe of posterior margin of epistome obtusely triangular (Fig. 12C–E); ischium of third maxilliped subrectangular (Fig. 13A); fingers of larger adult male cheliped with gape at base of when closed (Fig. 13E); P3 and P4 dactyli subequal in length (Fig. 13G, H); male pleonal somite 6 rectangular, longer than broad (Fig. 13C); male sternopleonal cavity not prominently anterior, distance between tip of cavity and suture of thoracic sternites 2 and 3 longer than length of thoracic sternite 2 (Fig. 13B); adult G1 subterminal segment relatively stout; terminal segment subconical, distal half slightly curved outwards, tapering gradually to rounded tip, 0.30–0.33 times length of subterminal segment, distal opening relatively small, round (Fig. 22A–C, E–G); vulvae almost round (Fig. 23E).

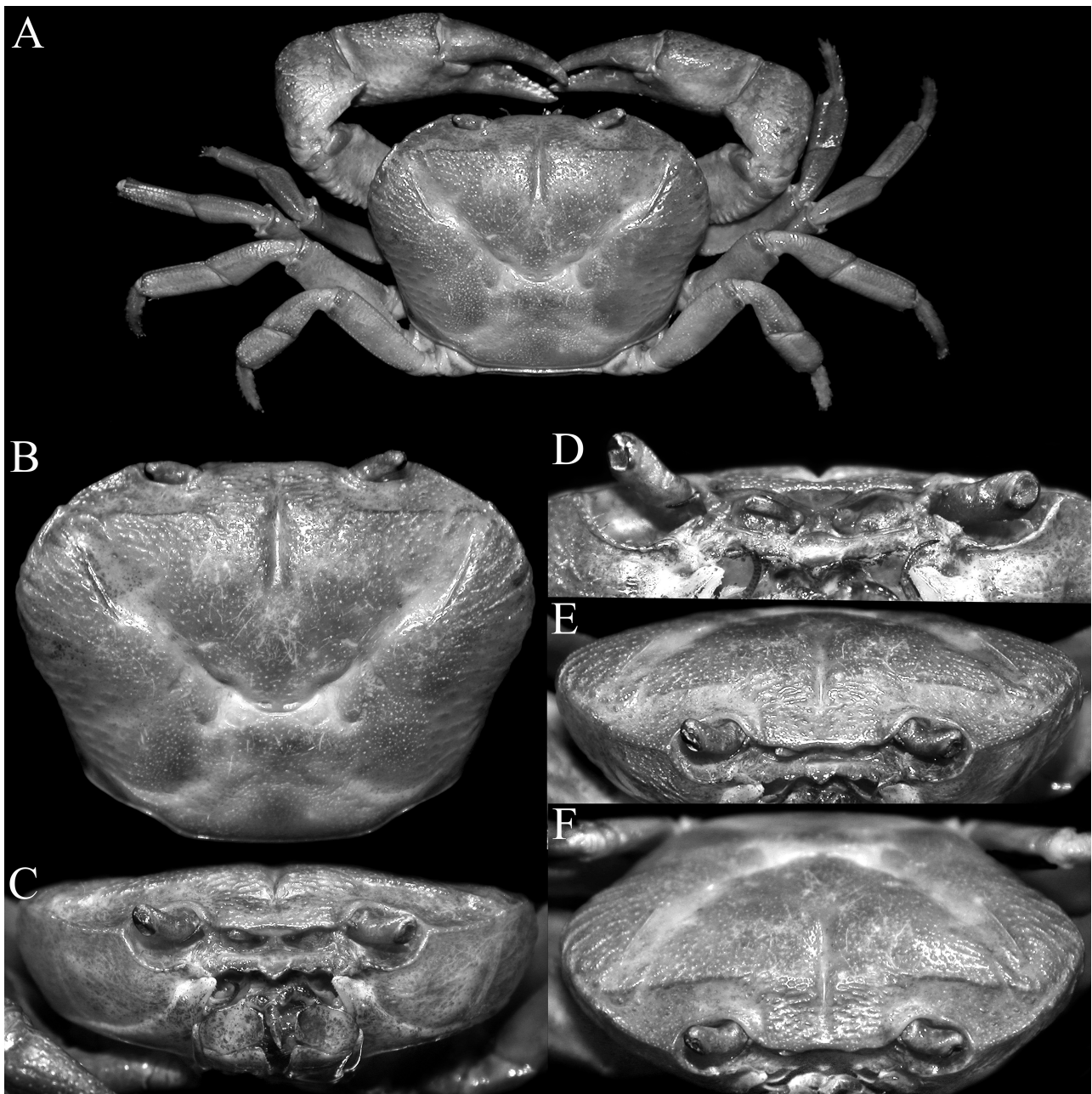
**Colour:** In live, carapace and pereopods orange to light brown, darker on centre of carapace; with ventral surface pale yellow (Fig. 25C).

**Etymology:** The name is derived from the town of Kapit in the upper part of the Rejang River, where the species occurs. The name is used as a noun in apposition.

**Remarks:** *Borneosa kapit* sp. nov. and *B. sarawakensis* sp. nov. bear a close resemblance, but can easily be separated by several characters. Adult *B. kapit* have a carapace which is usually wider in proportions (width to length ratio 1.20–1.32, Fig. 12B) (versus more

quadrate in *B. sarawakensis*, with the width to length ratio 1.18–1.26; Fig. 15A); the epibranchial tooth is small but still usually visible, and even when low, is with rare exceptions, demarcated from the anterolateral margin by a shallow cleft (Figs. 12B, 14) (versus epibranchial tooth not visible with the anterolateral margin appearing entire in *B. sarawakensis*; Fig. 15B); the branchial regions in adult males are relatively higher and appear more inflated in the frontal view (Fig.

12C) (versus with regions relatively lower and less convex in *B. sarawakensis*; Fig. 15C); the G1 terminal segment has the median part less distinctly bent, with the distal part more elongate with a more tapering tip and the opening proportionately smaller (Fig. 22A–C, E–G) (versus median part distinctly bent with the distal part ending in a rounded tip with a wide opening in *B. sarawakensis*; Fig. 22I–K). Significantly, while both species are from the Rejang drainage, *B. kapit* is



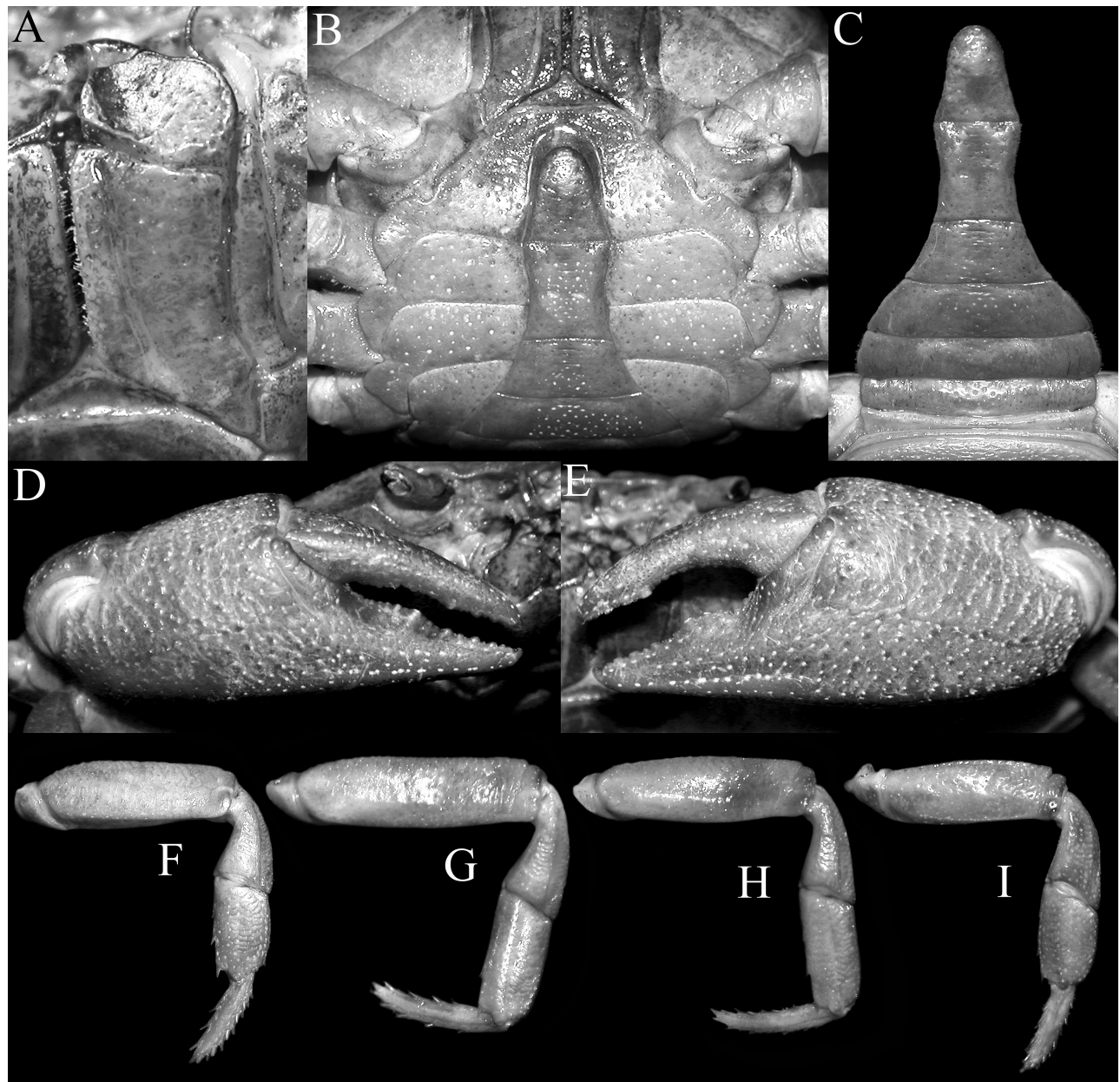
**Fig. 12.** *Borneosa kapit* sp. nov., holotype male (37.4 × 28.4 mm) (SMF 48750), Rajang River, Sarawak. A, overall dorsal view; B, dorsal view of carapace; C, frontal view of cephalothorax; D, frontal median triangle, eyes, epistome, antennae and antennules; E, F, different views of frontal part of cephalothorax.

from the headwaters of the river to the eastern part of Sarawak while *B. sarawakensis* is on the highlands on the western part of the drainage.

The good series of specimens of *B. kapit* shows that the degree of variation at the species level is not substantial. The carapace of smaller specimens is proportionately less wide, appearing more subquadrate and the convexity of the branchial regions also less pronounced. The size of the epibranchial tooth varies slightly, but it is always distinct (Fig. 14). As for the G1,

in smaller specimens, the terminal segment is slightly slenderer with a slightly larger distal opening (Fig. 22A–C) compared to the condition in larger adults (Fig. 22E–G).

**Biology:** The known habitat of the species are small streams flowing through secondary forests or logged over forest, under a partly shaded or complete canopy. The waters are clear, fast flowing, and cold, with the substrates mainly composed of pebbles and cobblestones. The species is occasionally sold at the



**Fig. 13.** *Borneosa kapit* sp. nov., holotype male (37.4 × 28.4 mm) (SMF 48750), Rajang River, Sarawak. A, left third maxilliped; B, anterior male thoracic sternum and pleon; C, male pleon; D, outer view of right chela; E, outer view of left chela (same scale as D); F–I, right P2–P5, respectively, all to same scale.

Teresang Market in Kapit which had been collected from Sungei Similajau (UNIMAS.C.00101), a stream which feeds the main Rejang river.

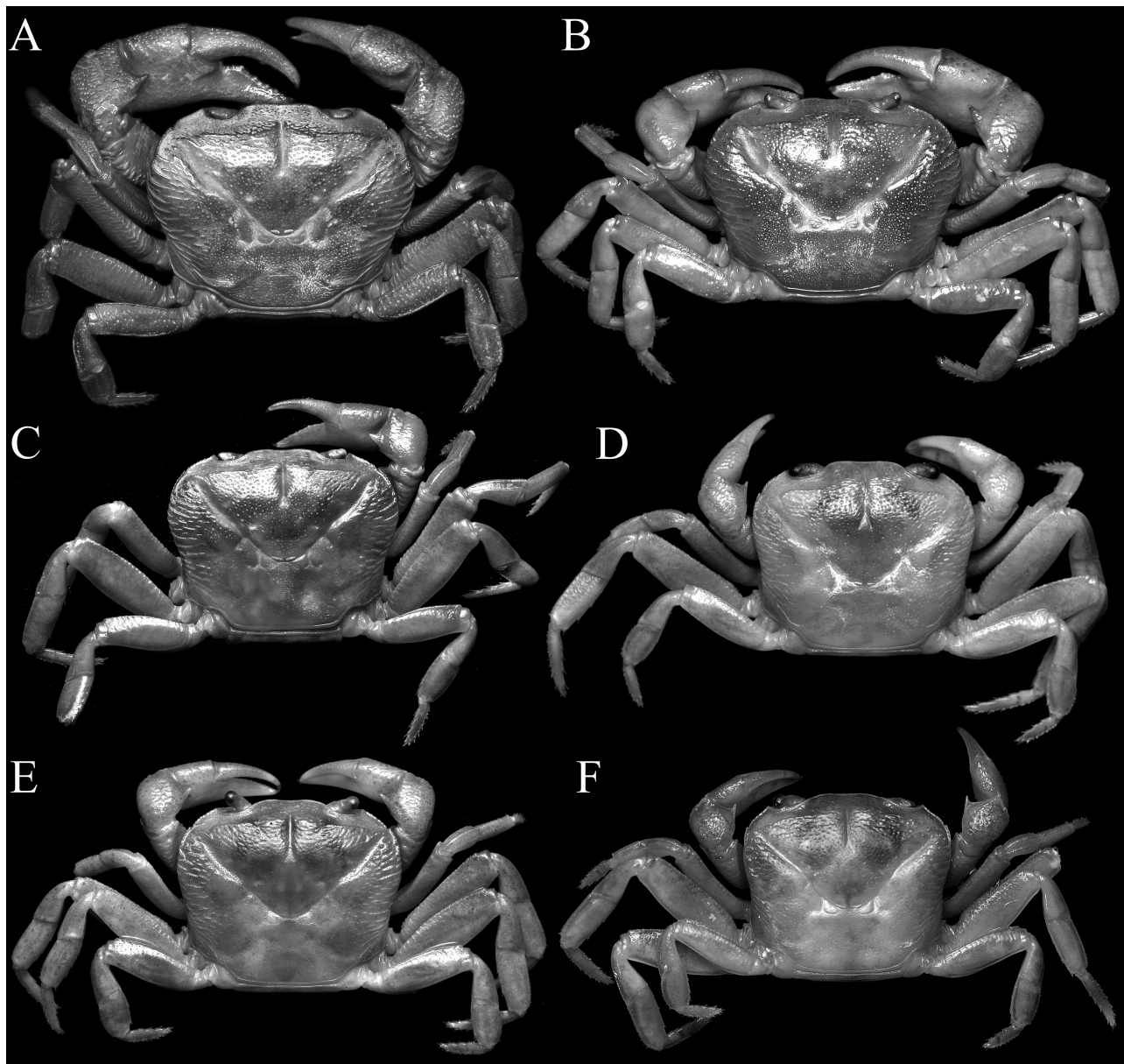
***Borneosa sarawakensis* sp. nov.**

(Figs. 15, 16, 22I–L, 23E)

urn:lsid:zoobank.org:act:1A80E5BF-EB74-42B0-AF74-98E5023A91FA

*Material examined:* Holotype: male ( $35.5 \times 28.1$  mm), 1 female ( $11.8 \times 10.3$  mm) (ZRC 2021.0516),

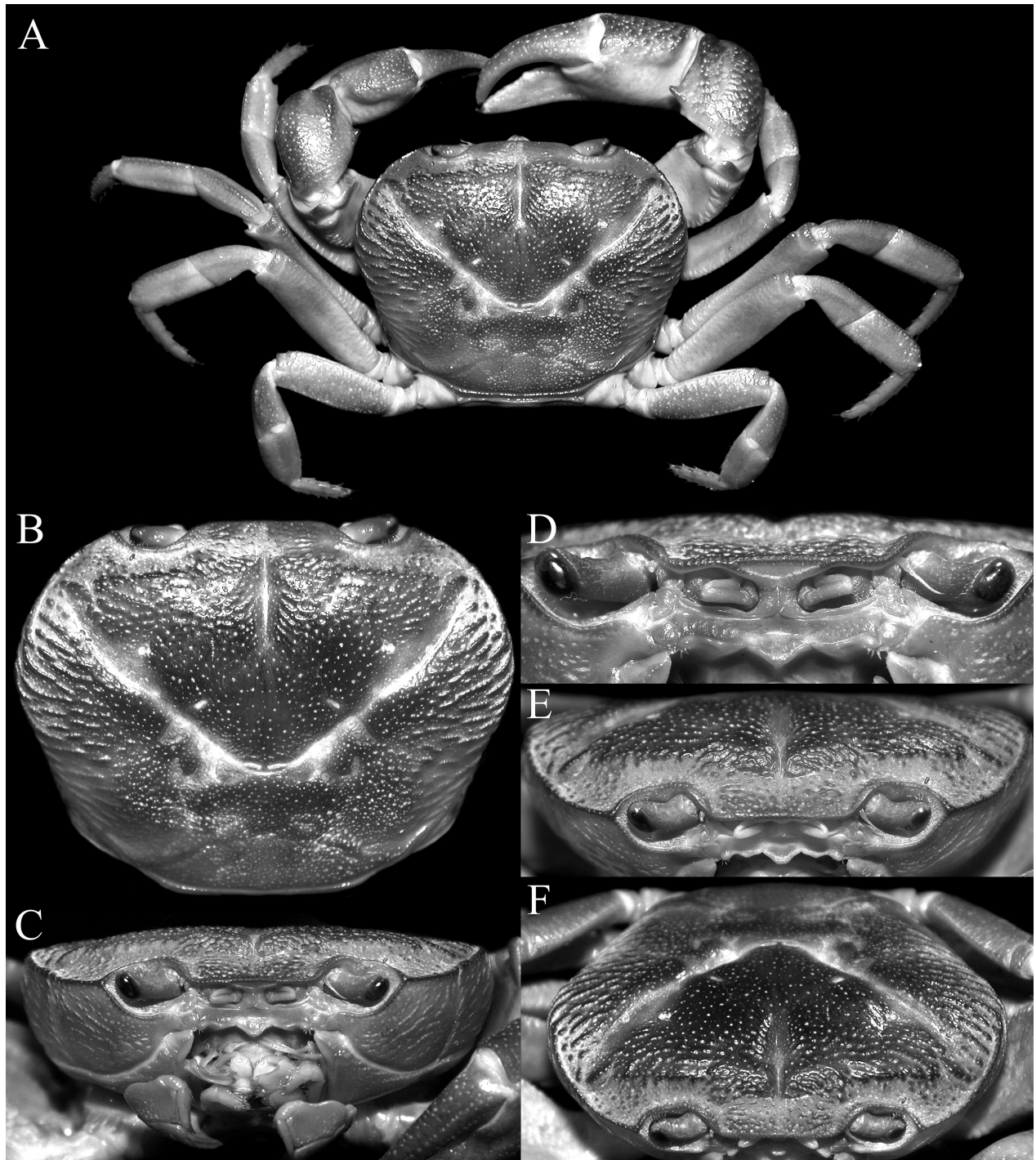
first order stream, primary forest, Sungei Musing, Batang Ai National Park, Sri Aman, Sarawak, Malaysia, coll. J. Grinang et al., 30 January 2015. Paratypes: 1 female ( $11.8 \times 10.3$  mm) (ZRC 2021.0517), same data as holotype. Others: 1 male ( $30.8 \times 24.6$  mm) (ZRC 2020.0338), station THH19-34, in fast flowing water over bedrock, rocks and gravel, feeder stream to Sungei Mujok, survey up to ca. 800 m upstream, Nanga Sepulau, Kanowit basin in Rejang Basin,  $1^{\circ}40.999'N$   $112^{\circ}09.908'E$ , Sarawak, Malaysia, electrofishing, coll. H.H. Tan et al., 15 October 2019; 3 females ( $24.6 \times$



**Fig. 14.** *Borneosa kapit* sp. nov., overall dorsal view. A, paratype male ( $35.8 \times 28.6$  mm) (UNIMAS.C.00102), Sungei Yong, Sarawak; B, paratype male ( $36.3 \times 27.6$  mm) (UNIMAS.C.00103), Benin, Kapit, Sarawak; C, paratype female ( $27.8 \times 22.3$  mm) (UNIMAS.C.00103), Benin, Kapit, Sarawak; D, paratype male ( $12.8 \times 9.9$  mm) (UNIMAS.C.00039), Belaga, Sarawak; E, paratype male ( $20.6 \times 16.9$  mm) (UNIMAS.C.00039), Belaga, Sarawak; F, paratype female ( $12.4 \times 10.9$  mm) (UNIMAS.C.00101), Kapit, Sarawak.

20.9 mm, 25.3 × 21.2 mm, 27.2 × 22.7 mm [with one juvenile crab under pleon]) (ZRC 2020.0336), station DZ-01, along first small stream on right side of Sungei Mujok, upstream from base camp, at night, Lanjak-Entimau National Park, Sarawak, Malaysia, coll. K.O.

Chan et al., 12 October 2019; 1 brooding female (30.0 × 24.0 mm) (ZRC 2020.0337), station THH19-33, in clear fast flowing water over bedrock, rocks, gravel, upstream from Nanga Sepulau (ca. 1 km) to Nanga Sepuna, Kanowit basin in Rejang Basin, 1°40.917'N

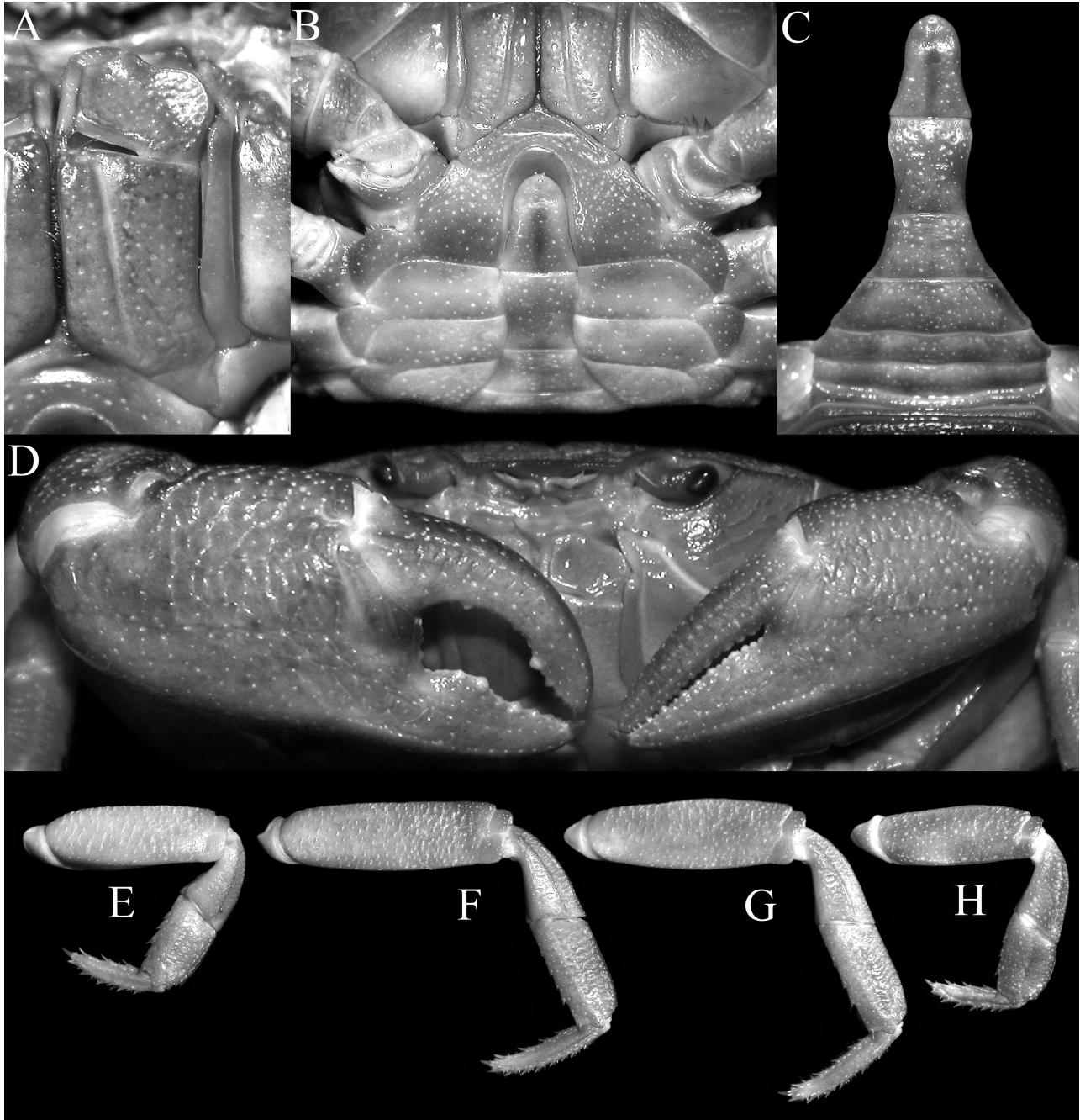


**Fig. 15.** *Borneosa sarawakensis* sp. nov., holotype male (35.5 × 28.1 mm) (ZRC 2021.0516), Batang Ai, Sarawak. A, overall dorsal view; B, dorsal view of carapace; C, frontal view of cephalothorax; D, frontal median triangle, eyes, epistome, antennae and antennules; E, F, different views of frontal part of cephalothorax.

112°10.162'E, 104 m asl, Sarawak, Malaysia, electrofishing, coll. H.H. Tan et al., 14 October 2019.

**Diagnosis:** Adult carapace transversely subquadrate, width to length ratio 1.18–1.26 (Fig. 15A, B); striae on lateral parts of carapace strong (Fig. 15B); branchial regions gently convex in frontal view (Fig. 15C, F); dorsal margin of frontal median triangle contiguous with lateral margins (Fig. 15C–E);

exorbital tooth with outer margin almost entire (Fig. 15B); epibranchial tooth very low to absent, separated from rest of margin by very low cleft when present (Fig. 15B), anterolateral margin almost entire (Fig. 15B); median lobe of posterior margin of epistome obtusely triangular (Fig. 15C–E); ischium of third maxilliped rectangular (Fig. 16A); fingers of larger adult male cheliped with gape at base of when closed (Fig. 16D);



**Fig. 16.** *Borneosa sarawakensis* sp. nov., holotype male (35.5 × 28.1 mm) (ZRC 2021.0516), Batang Ai, Sarawak. A, left third maxilliped; B, anterior male thoracic sternum and pleon; C, male pleon; D, outer view of chelae; E–H, right P2–P5, respectively, all to same scale.

P3 and P4 dactyli subequal in length (Fig. 16F, G); male pleonal somite 6 rectangular, longer than broad (Fig. 16C); male sternopleonal cavity not prominently anterior, distance between tip of cavity and suture of thoracic sternites 2 and 3 longer than length of thoracic sternite 2 (Fig. 16B); adult G1 subterminal segment relatively slender; terminal segment subcylindrical, distal half distinctly curved outwards, with distinct rounded tip, 0.30–0.32 times length of subterminal segment, distal opening large, subovate (Fig. 22I–K); vulvae almost round (Fig. 23F).

**Colour:** In life, the carapace is maroon to reddish brown, darker on the anterior parts; the ambulatory legs and chela are olive brown with the ventral surface pale yellow (Fig. 25B).

**Etymology:** The species is named after the state of Sarawak.

**Remarks:** For differences between *B. sarawakensis* sp. nov. and its closest species, *B. kapit* sp. nov., see remarks for latter taxon.

**Biology:** All the habitats in the type locality are feeder streams of the Batang Ai hydroelectric reservoir, on a relatively high gradient, with rocky substrates and fast flowing clear, cold water (Fig. 25A). The specimens from Lanjak-Entimau Wildlife Sanctuary, Kanowit, were collected from pristine forest streams with shallow water and a rocky substrate. These sites share the same drainage.

### ***Borneosa serrata* sp. nov.**

(Figs. 17, 18, 22M–P)

urn:lsid:zoobank.org:act:B65416DA-4501-43C1-A0FB-31C9D46816A0

**Material examined:** 1 male (25.5 × 22.0 mm) (ZRC 2006.57), Sungei Pangean (= Pengean), Long Yiu Hulu, Kabupaten Bulungan, Kalimantan Utara, ca. 2.7°N 116.7°E, Indonesia, coll. R. Diesel, 20 August 1995.

**Diagnosis:** Adult carapace transversely subquadrate, width to length ratio 1.16 (Fig. 17A, B); striae on lateral parts of carapace distinct (Fig. 17B); branchial regions gently convex in frontal view (Fig. 17C, F); dorsal margin of frontal median triangle contiguous with lateral margins (Fig. 17C–E); exorbital tooth with outer margin serrated (Fig. 17B); epibranchial tooth prominent, separated from rest of margin by distinct cleft (Fig. 17B); median lobe of posterior margin of epistome acutely triangular (Fig. 17C–E); ischium of third maxilliped subrectangular (Fig. 18A); fingers of adult male cheliped closing along entire cutting margins (Fig. 18E); P3 and P4 dactyli subequal in length (Fig. 18G, H); male pleonal somite 6 subquadrate, slightly longer than broad (Fig. 18C); male sternopleonal cavity prominently anterior, distance

between tip of cavity and suture of thoracic sternites 2 and 3 distinctly shorter than length of thoracic sternite 2 (Fig. 18B); adult G1 subterminal segment relatively slender; terminal segment subconical, distal half gently curved outwards, tapering gradually to subtruncate tip, 0.31 times length of subterminal segment, distal opening large, ovate (Fig. 22M–O); females not known.

**Colour:** When freshly collected, the specimen was a uniform dark brown on all the dorsal surfaces (R. Diesel, pers. comm.).

**Etymology:** The species is named for the serrated appearance of the anterolateral margin, with the epibranchial tooth prominent.

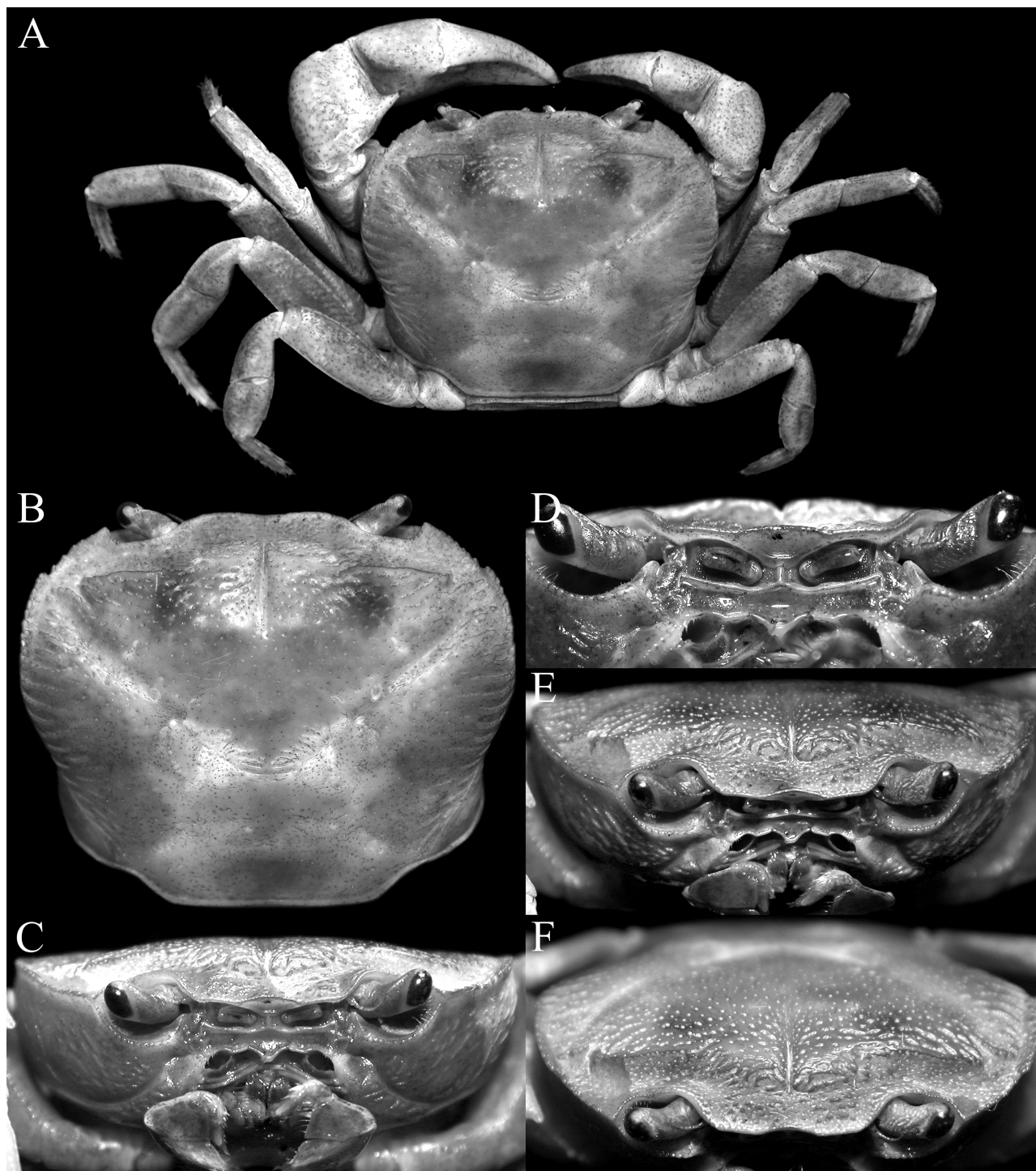
**Remarks:** Morphologically, *B. serrata* sp. nov. most closely resembles *B. niah* sp. nov., especially in the presence of a more well-developed epibranchial tooth separated from the anterolateral margin by a deep cleft; and the male sternopleonal cavity projects deeper into thoracic sternite 3 with only a narrow space present between the tip of the cavity and the suture between sternites 1 and 3. *Borneosa serrata*, however, can be distinguished in having the outer margin of the exorbital tooth serrated (Fig. 17A) (versus almost smooth in *B. niah*; Fig. 8B); the median tooth on the posterior margin of the epistome is sharply triangular in shape (Fig. 17C–E) (versus blunter in *B. niah*; Fig. 8C–E); the third maxilliped ischium is proportionately longer (Fig. 18A) (versus proportionately shorter in *B. niah*; Fig. 9A); the male pleon (notably somites 3–5) is relatively more narrow (Fig. 18C) (versus relatively wider in *B. niah*; Fig. 9C); and the G1 terminal segment is relatively longer (Fig. 22M–O) (versus relatively shorter in *B. niah*; Fig. 21A–C).

The G1 structure of *B. serrata* is very close to that of *B. brachyphallus*, but *B. serrata* can be separated in possessing a distinct epibranchial tooth (Fig. 17B) (versus tooth very low to almost absent in *B. brachyphallus* with the anterolateral margin appearing almost entire; Figs. 6B, 7I); the outer margin of the exorbital tooth is tuberculate and appears serrated (Fig. 17B) (versus almost smooth in *B. brachyphallus*; Figs. 6B, 7I); the third maxilliped ischium is proportionately longer (Fig. 18A) (versus shorter in *B. brachyphallus*; Fig. 7A); the male sternopleonal cavity projects deeper into thoracic sternite 3, with only a narrow space present between the cavity and the suture between sternites 1 and 3 (Fig. 18B) (versus there is a wider gap between the tip of the male sternopleonal cavity and the suture between sternites 2 and 3 in *B. brachyphallus*; Fig. 7B); male pleonal somite 6 is distinctly longer (Fig. 18C) (versus proportionately shorter and more quadrate in *B. brachyphallus*; Fig. 7C); and the G1 subterminal segment is slightly longer (Fig. 22M–O) (versus relatively shorter in *B. brachyphallus*; Fig. 20Q–S).

**Biology:** The specimen was collected in a small tributary with rock substrates and dense forest cover in the centre of Kalimantan Utara (R. Diesel, pers. comm.).

## DISCUSSION

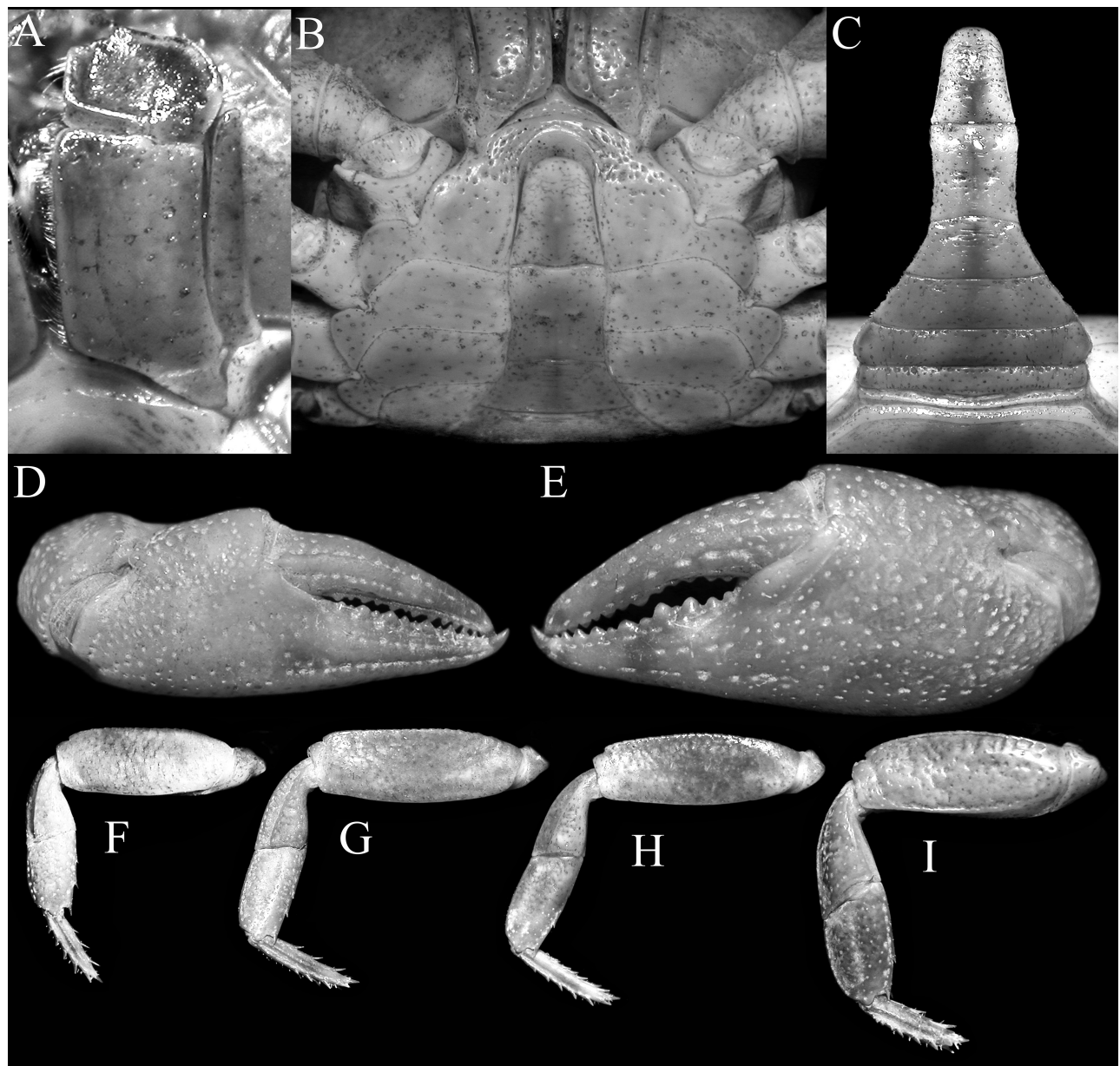
The eight taxa now recognised under *Borneosa* can be approximately placed into three species-



**Fig. 17.** *Borneosa serrata* sp. nov., holotype male (25.5 × 22.0 mm) (ZRC 2006.57), Sungei Pangean, Kalimantan Utara. A, overall dorsal view; B, dorsal view of carapace; C, frontal view of cephalothorax; D, frontal median triangle, eyes, epistome, antennae and antennules; E, F, different views of frontal part of cephalothorax.

groups. One group, with *B. tenebrosa* and *B. aspera*, is characterised by having the P4 dactylus being slender and distinctly longer than the P3 dactylus (Figs. 3G, H, 5H, I). This character is obvious even in smaller individuals, being most evident in large specimens. Both species also have relatively longer G1s with the terminal segment more elongate (Fig. 20F, G, I–K, M–O); that for *B. aspera* in particular, being the longest for all congeners. All the other *Borneosa* species have P3 and P4 dactyli which are subequal in length (e.g., Fig. 7F, G). A second group, with *B. niah* sp. nov., *B. bario*

sp. nov. and *B. serrata* sp. nov., has the epibranchial tooth more developed, forming a distinct cleft with the rest of the anterolateral margin (Figs. 8B, 10B, 11F, H, 17B), with the male sternopleonal cavity extending almost to the suture between sternites 2 and 3, with only a narrow gap in-between (Figs. 9B, 11B, 18B). The strength of the epibranchial tooth does vary slightly for other species so this character should be used carefully, especially since *B. niah* and *B. serrata* are represented by only one specimen each. In *B. kapit*, the epibranchial tooth is usually small but distinct (Figs. 12B, 14A, D–F)

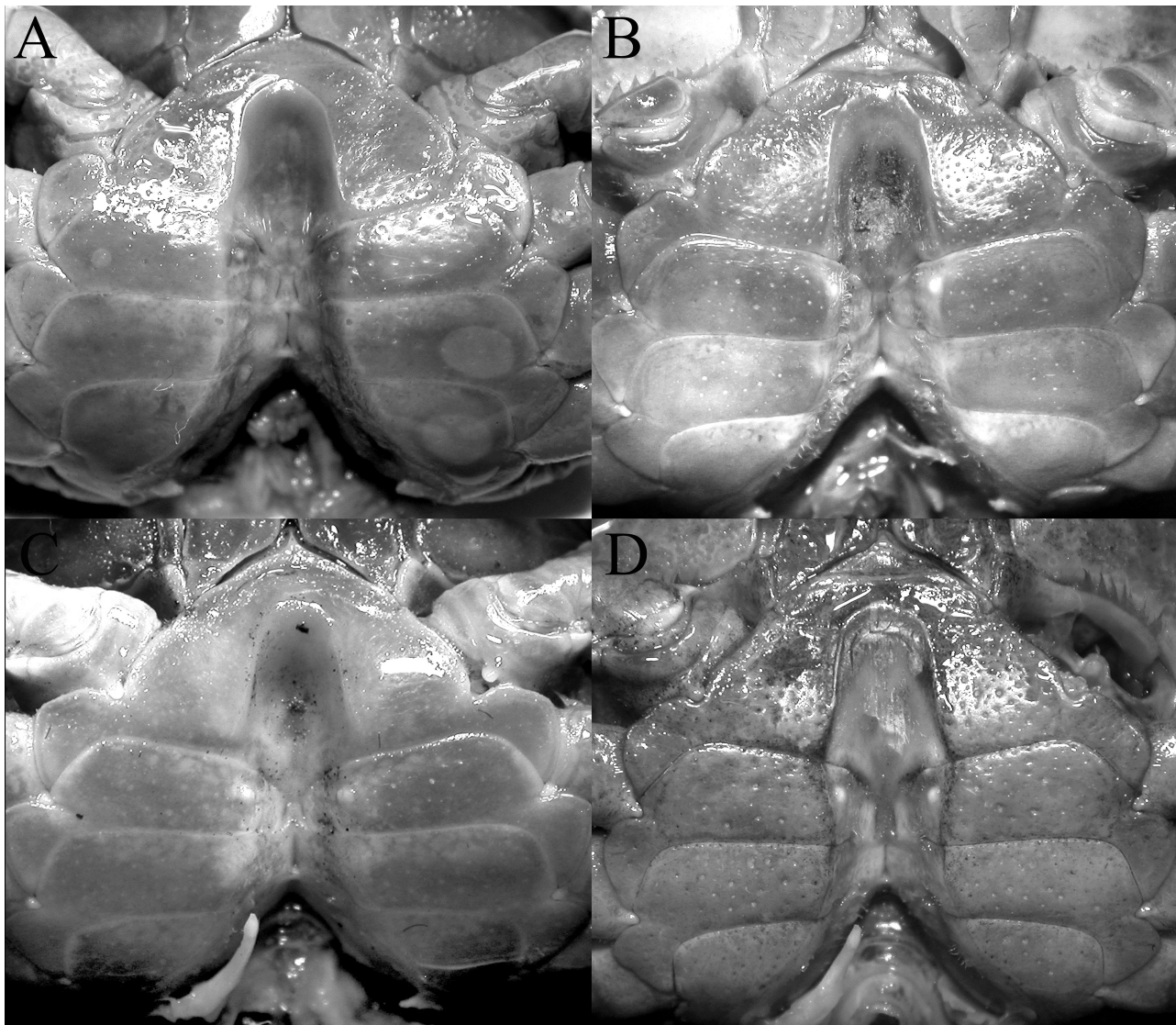


**Fig. 18.** *Borneosa serrata* sp. nov., holotype male (25.5 × 22.0 mm) (ZRC 2006.57), Sungei Pangean, Kalimantan Utara. A, left third maxilliped; B, anterior male thoracic sternum and pleon; C, male pleon; D, outer view of right chela; E, outer view of left chela; F–I, left P2–P5, respectively, all to same scale.

although in some, it can be very low (Fig. 14B, C). In *B. tenebrosa*, the epibranchial tooth is low to very low, with the anterolateral margin appearing almost entire as the notch is very shallow (Figs. 2B, 3E). The form of the anterior male thoracic sternum in *B. niah*, *B. bario* and *B. serrata*, however, is distinct; even in small specimens of other species groups, the sternopleonal cavity does not extend as far anteriorly. The third group, with *B. brachyphallus*, *B. kapit* sp. nov. and *B. sarawakensis* sp. nov. have the G1 terminal segment relatively short, and the distal part is narrower and slightly bent outwards (Figs. 20Q–S, 22A–C, E–G, I–K). The epibranchial tooth in these species is usually low to almost obscure,

and the anterolateral margin may be entire (Figs. 6B, 7I, 12B, 14, 15B).

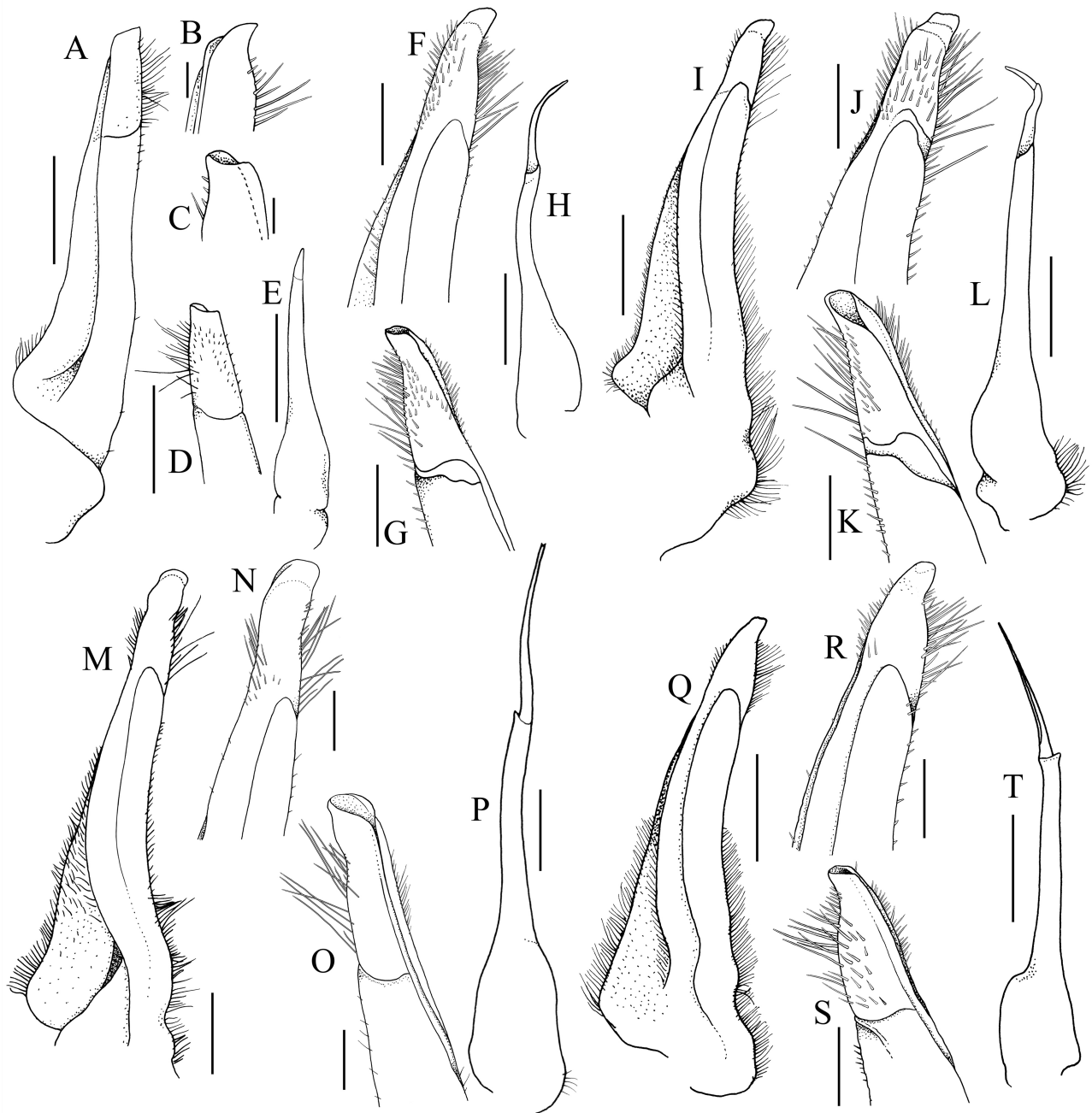
As for species-level characters, carapace proportions are hard to use as smaller specimens tend to be more quadrate with width to length ratios of 1.1–1.2. Larger specimens, especially males, are invariably proportionately wider, with width to length ratios of 1.25–1.32. Ng (2015: 501) discussed the usefulness of the male pleon shape and proportions of the somites in separating species, noting that in general, larger males have relatively slenderer pleons with somite 6 usually proportionately longer. In addition, the lateral margins of somite 6 in larger males tend to be more concave,



**Fig. 19.** Male sternopleonal cavity and pleonal locking tubercle on sternite 5. A, *Borneosa tenebrosa* (Holthuis, 1979), holotype male (23.5 × 19.1 mm) (NHM 1979.135), Gunong Mulu National Park, Sarawak; B, *B. aspera* (Ng & Stuebing), 1989, holotype male (42.6 × 32.8 mm) (ZRC 1989.2143), Sipitang, Sabah; C, *B. brachyphallus* (Ng, 2015), holotype male (27.1 × 22.0 mm) (MZB Cru 4396), Barito, Kalimantan Tengah; D, *B. kapit* sp. nov., holotype male (37.4 × 28.4 mm) (SMF 48750), Rajang River, Sarawak.

being straight or sinuous in smaller ones. As such, males of comparable sizes need to be compared when the male pleon is used as a character. The proportions of the G1 terminal and subterminal segments is also hard to use, mainly because in some species, both segments are proportionately shorter or longer. For

example, in *B. aspera*, it is clear that the G1 terminal segment is the longest among all congeners (Fig. 20M–O), but its subterminal segment is also slender and more elongate, resulting in the terminal segment being 0.37 times the length of the subterminal segment. In *B. brachyphallus*, the G1 terminal segment is very short,



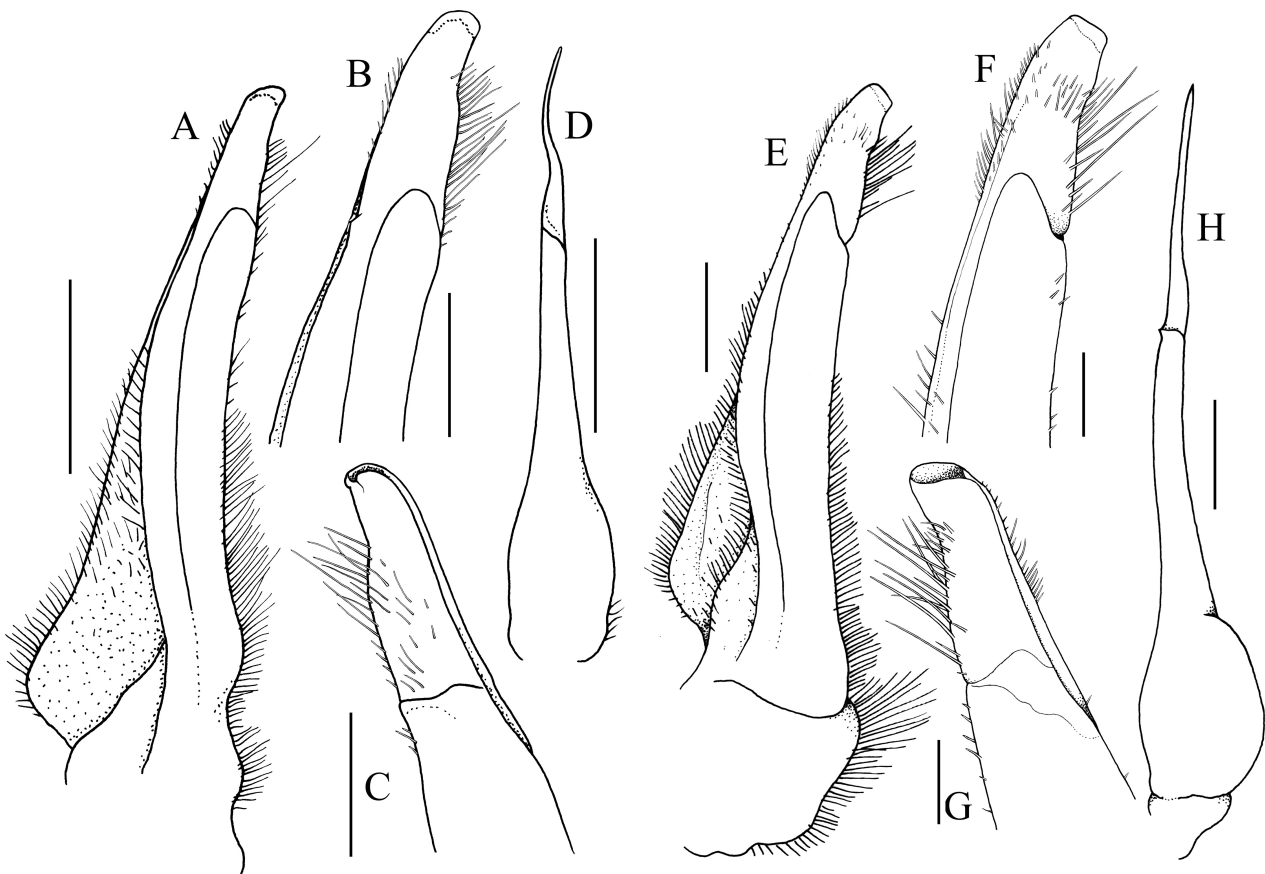
**Fig. 20.** A–E, *Borneosa tenebrosa* (Holthuis, 1979), male (16.1 × 13.0 mm) (ZRC 2013.1293), Gunong Mulu National Park, Sarawak; F–H, *B. tenebrosa* (Holthuis, 1979), paratype male (21.9 × 17.8 mm) (NHM 1979.136), Gunong Mulu National Park, Sarawak; I–L, *B. tenebrosa* (Holthuis, 1979), holotype male (23.5 × 19.1 mm) (NHM 1979.135), Gunong Mulu National Park, Sarawak (structures laterally inverted for comparative purposes); M–P, *B. aspera* (Ng & Stuebing, 1989), male (32.3 × 25.4 mm) (ZRC 2014.845), Temburong, Brunei; Q–T, *B. brachyphallus* (Ng, 2015), holotype male (27.1 × 22.0 mm) (MZB Cru 4396), Sungei Barito, central Kalimantan. Scale bars: A, D, E, F, G, J, K, N, O, R, S = 0.5 mm; B, C = 0.1 mm; H, I, L, M, P, Q, T = 1.0 mm

but the subterminal segment is also proportionately one of the shortest for any member of the genus (Fig. 20Q–S); and the terminal segment is 0.35 times the length of the subterminal segment. Despite their similar ratios, the G1 structures of *B. aspera* and *B. brachyphallus* are very different in appearance.

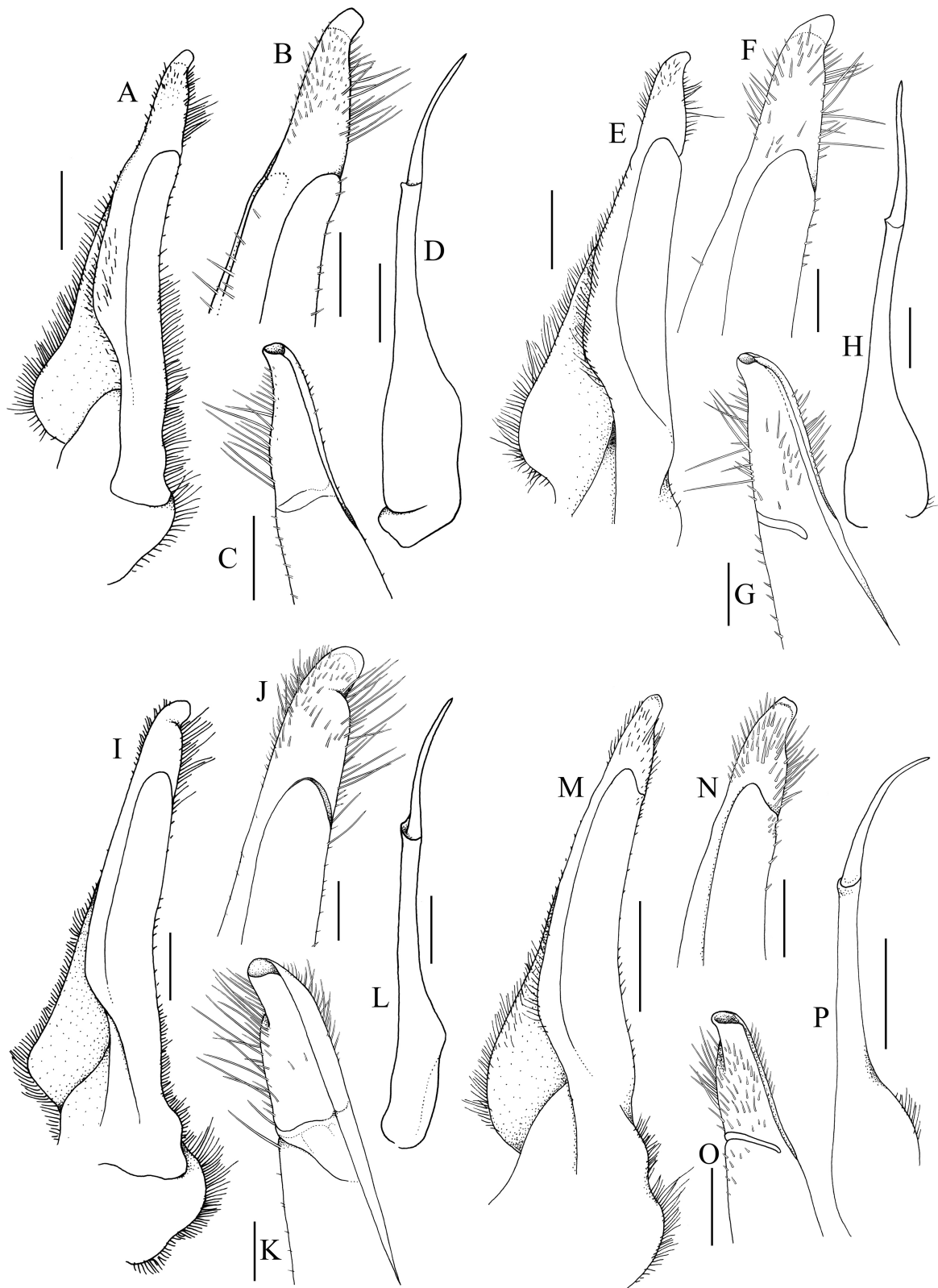
Noteworthy is that of the eight species now recognised, two of them, *B. tenebrosa* and *B. brachyphallus*, have been found mainly or only from inside caves and cave passages. Neither species, however, possess any of the morphological adaptations associated with true troglobites like reduced pigmentation, reduced eyes and elongate pereopods (cf. Holthuis 1979 1986; Guinot 1988 1994; Ng and Grinang 2014; Huang et al. 2017 2021), and are probably not even troglaphiles which still have well developed eyes (see Ng 2013; Grinang and Ng 2021). All the features of the two *Borneosa* species suggest they are facultative cavernicoles, using the cave habitat to shelter and search for food but the main population is in the open waters outside the cave system. All the other species have been found in small order streams of primary rainforest, being completely aquatic and preferring torrent waters.

In open forest habitats, *Borneosa* is usually found together with members of the potamid genus *Isolapotamon* Bott, 1968, and occasionally with the gecarcinucids *Thelphusula* Bott, 1969 or *Bakousa* Ng, 1995. The water conditions preferred by members of the genus appear to vary. Grinang and Nyanti (2007b) noted that in Sarawak, while the waters in Gunong Mulu National Park, where *B. tenebrosa* occurs, are alkaline due to the extensive limestone formations present, those in Pulong Tau National Park (type locality of *B. bario*) were acidic due to the Kerangas forest present. Similarly in Kalimantan, *B. brachyphallus* has been collected from cave systems with alkaline waters (Ng 2015). The habitat requirements of the other species are not known but the waters where *B. kapit* and *B. sarawakensis* occur in the Rejang Basin are generally not associated with limestone formations and are slightly acidic.

Biogeographically, the eight species of *Borneosa* are endemic to their respective basins. Two new species are present in the Rejang drainage, the largest in Sarawak: *B. kapit*, *B. sarawakensis*, but each occurs in separate sub-basins, all of which eventually drain into the lower Rejang. Interestingly, *B. sarawakensis*



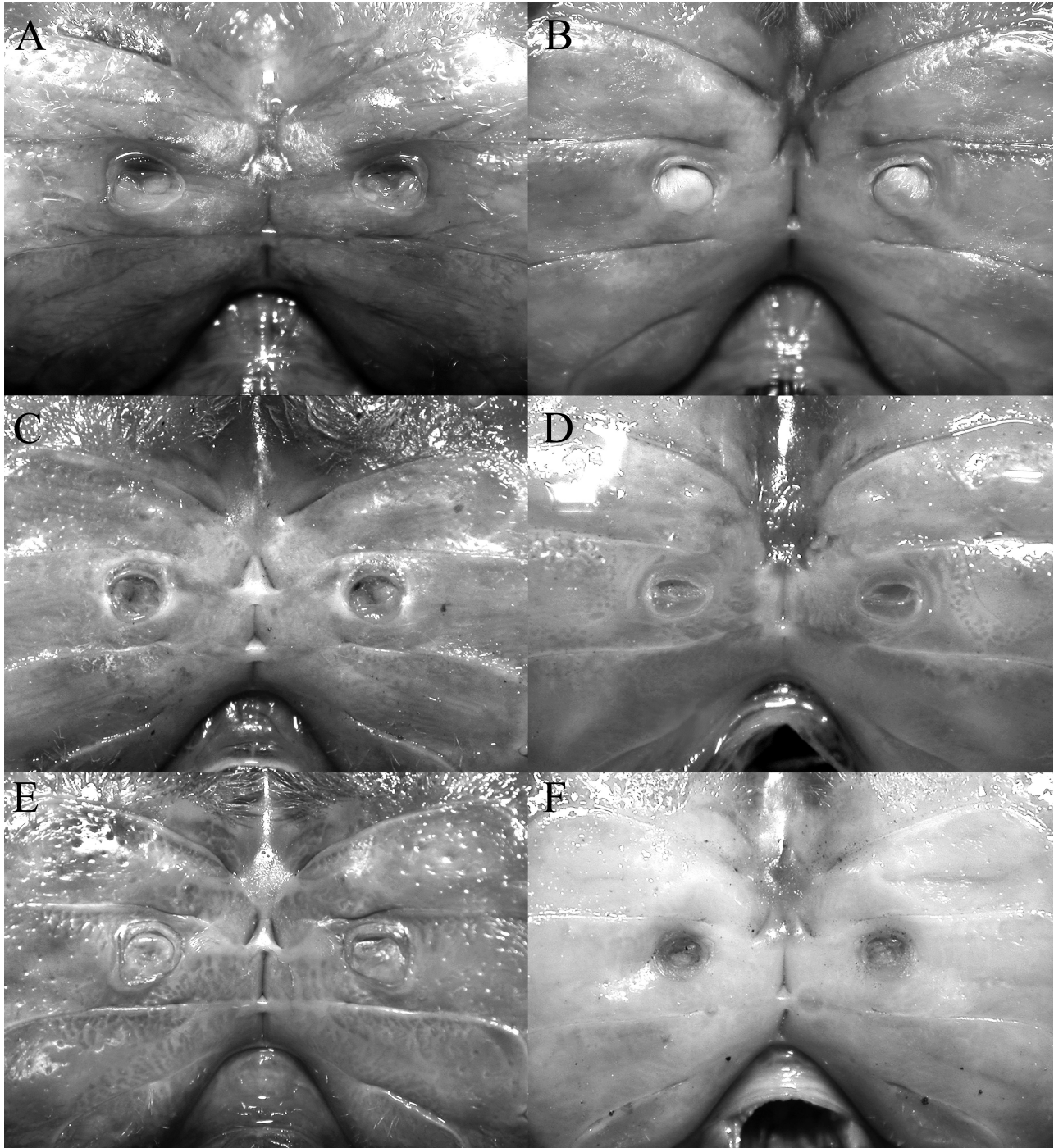
**Fig. 21.** A–D, *Borneosa niah* sp. nov., holotype male (22.6 × 19.1 mm) (ZRC 2006.064), Niah, Sarawak; E–G, *B. bario* sp. nov., holotype male (29.6 × 23.1 mm) (ZRC 2021.0692), Bario, Sarawak. Scale bars: A, D, E, H = 1.0 mm; B, C, F, G = 0.5 mm.



**Fig. 22.** A–D, *Borneosa kapit* sp. nov., paratype male (23.5 × 19.1 mm) (ZRC 2021.0518), Belaga, Sarawak; E–G, *B. kapit* sp. nov., holotype male (37.4 × 28.4 mm) (SMF 48750), Rajang River, Sarawak; H, *B. kapit* sp. nov., paratype male (35.8 × 28.0 mm) (ZRC 2021.0521), Kapit, Sarawak; I–L, *B. sarawakensis* sp. nov., holotype male (35.5 × 28.1 mm) (ZRC 2021.0516), Batang Ai, Sarawak; M–P, *S. serrata* sp. nov., holotype male (25.5 × 22.0 mm) (ZRC 2006.57), Sungei Pangean, Kalimantan Utara. Scale bars: A, D, E, H, I, L, M, P = 1.0 mm; B, C, F, G, J, K, N, O = 0.5 mm.

tend to have wider western Bornean distribution which extends to Sri Aman in southwestern Sarawak. Another three new species, *B. niah*, *B. bario* and *B. tenebrosa*, occur in northern Sarawak but in separate sub-basins.

*Borneosa tenebrosa* and *B. bario* occupy separate sub-basins within the main Baram basin while *B. niah* occurs in a more isolated sub-basin in Niah. The genus appears to essentially be a highland taxon, with



**Fig. 23.** Female thoracic sternum and vulvae. A, *Borneosa tenebrosa* (Holthuis, 1979), female (30.8 × 24.6 mm) (ZRC 1989.3420), Gunong Mulu National Park, Sarawak; B, *B. aspera* (Ng & Stuebing, 1989), female (44.1 × 33.1 mm) (ZRC 2014.845), Temburong, Brunei; C, female (39.8 × 31.2 mm) (ZRC 2021.0840), Barito, Kalimantan Tengah; D, *B. bario* sp. nov., paratype female (24.3 × 19.3 mm) (ZRC 2021.0693), Bario, Sarawak; E, *B. kapit* sp. nov., paratype female (40.6 × 31.4 mm) (ZRC 2021.0521), Kapit, Sarawak; F, *B. sarawakensis* sp. nov., female (27.2 × 22.7 mm) (ZRC 2020.336), Lanjak-Entimau, Sarawak.



**Fig. 24.** Colour in life. A–C, *Borneosa aspera* (Ng & Stuebing, 1989), female (44.5 × 33.7 mm (ZRC 2013.746), Temburong, Brunei; D, E, *B. aspera* (Ng & Stuebing, 1989), female (44.1 × 33.1 mm) (ZRC 2014.845), Temburong, Brunei; F, G, *B. aspera* (Ng & Stuebing, 1989), male (32.3 × 25.4 mm) (ZRC 2014.845), Temburong, Brunei; H, *B. bario* sp. nov., holotype male (29.6 × 23.1 mm) (ZRC 2021.0692), Bario, Sarawak; I, *B. bario* sp. nov., paratype male (31.1 × 23.9 mm) (UNIMAS.C.00011), Bario, Sarawak; J, *B. bario* sp. nov., Sungei Lawan, tributary of Sungei Tutoh, Baram basin, Miri, specimen not caught. Photographs: A, B, Mohd. Abdul Majid; C–F, Low Yee Wen.

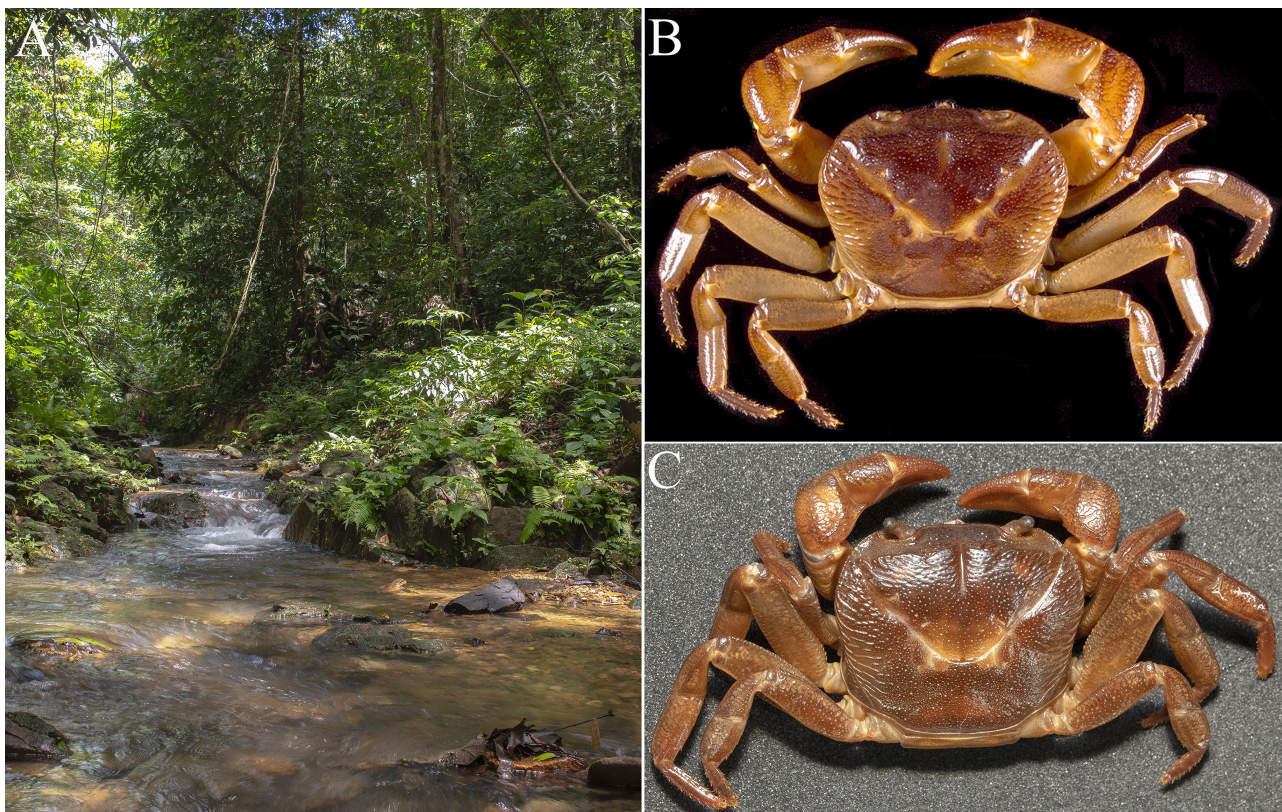
those present at lower elevations always associated with limestone caves. Of the eight species, *B. bario* is considered the most montane, occurring at altitudes above 1000 m above sea level. Until the discovery of the new species from Batang Ai and Lanjak-Entimau in Sarawak, members of *Borneosa* were thought to be a primarily eastern Borneo group, but their presence in central and eastern Borneo suggests that more *Borneosa* species will be discovered as more detailed surveys are done in western and southern Kalimantan. That being said, *Borneosa* species are not yet known west of Batang Ai in Sarawak, with Grinang and Nyanti (2007b) commenting that the genus has not been found in the Bau area west of Kuching despite extensive surveys there (see also Ng and Grinang 2004).

The current conservation challenges facing the various species cannot be ascertained accurately mainly due to their biology being largely unknown. Ng and Yeo (2007) regarded *B. tenebrosa* and *B. aspera* as endangered, but Cumberlidge et al. (2009) concluded that they should be treated as of Least Concern instead under the current guidelines for the IUCN (International Union for Conservation of Nature) Red List. *Borneosa tenebrosa*, *B. niah* and *B. bario* occur inside well-

established national parks in Sarawak (Gunong Mulu, Niah and Pulong Tau, respectively) and face no immediate threat, while *B. aspera* has a relatively wider range which includes the Temburong National Park in Brunei. *Borneosa sarawakensis* occurs inside the protected drainages of the Batang Ai National Park and Lanjak-Entimau Wildlife Sanctuary in Sarawak, so it should also be well protected. *Borneosa kapit* appears to have a wide distribution in central Sarawak but not all of its distribution range is protected. As such the threats facing these taxa are not known, and their conservation status should be treated as Data Deficient for now. The statuses of *B. brachyphallus* and *B. serrata* should also be regarded as Data Deficient as they are only known from their type localities which are not protected areas.

### Key to species of *Borneosa*

- 1a. Anterolateral margin with the epibranchial tooth distinct, sharp, separated from rest of anterolateral margin by clear cleft (e.g., Figs. 10B, 11F, H); male sternopleural cavity separated from suture between thoracic sternites 2 and 3 by narrow gap, less than combined length of thoracic sternites 1 and 2 (e.g., Fig. 18B) .. 2
- 1b. Anterolateral margin with the epibranchial tooth low to almost absent, cleft when visible, low, shallow, anterolateral margin may



**Fig. 25.** A, type locality of *B. sarawakensis* sp. nov., Sungei Musing, first order stream feeding Batang Ai reservoir, Sri Aman, Sarawak; B, *B. sarawakensis* sp. nov., holotype male (35.5 × 28.1 mm) (ZRC 2021.0516), Batang Ai, Sarawak (freshly preserved); C, *B. kapit* sp. nov., paratype male (32.3 × 25.6 mm) (ZRC 2021.0520), Sungei Lebau, Pelagus, Kapit, Sarawak (freshly preserved).

- appear entire (e.g., Fig. 2B); male sternopleural cavity separated from suture between thoracic sternites 2 and 3 by relatively wide gap, more than combined length of thoracic sternites 1 and 2 (e.g., Fig. 3B) ..... 4
- 2a. Outer margin of exorbital tooth distinctly serrated (Fig. 17B); Bulungan, Kalimantan Utara ..... *B. serrata* sp. nov.
- 2b. Outer margin of exorbital tooth entire or almost so (e.g., Fig. 8B); Sarawak ..... 3
- 3a. Epibranchial tooth low, separated from anterolateral margin by small cleft (Fig. 8B); third maxilliped ischium subquadrate (Fig. 9A); G1 terminal segment relatively slender, long (Fig. 21A–C); Niah, Sarawak ..... *B. niah* sp. nov.
- 3b. Epibranchial tooth strong, separated from anterolateral margin by prominent U-shaped cleft (Figs. 10B, 11F, H); third maxilliped ischium subrectangular (Fig. 11A); G1 terminal segment relatively stout, short (Fig. 21E–G); Bario Highlands, Sarawak ..  
..... *B. bario* sp. nov.
- 4a. P3 dactylus distinctly more slender and elongate compared to P4 dactylus (e.g., Fig. 5H, I) ..... 5
- 4b. P3 and P4 dactyli not elongate, subequal in length (e.g., Fig. 7F, G) ..... 6
- 5a. Frontal median triangle with dorsal margin separated from lateral margins by small gap (Fig. 2C–F); G1 terminal segment relatively short, subcylindrical (Fig. 20F, G, J, K); Gunong Mulu National Park, Sarawak ..... *B. tenebrosa* (Holthuis, 1979)
- 5b. Frontal median triangle with dorsal margin contiguous with lateral margins (Fig. 4C–E); G1 terminal segment very long, cylindrical (Fig. 20M–O); Brunei and northern Sabah .....  
..... *B. aspera* (Ng & Stuebing, 1989)
- 6a. Striae on lateral parts of dorsal surface of carapace relatively lower, rounded (Figs. 6B, 7I); median lobe of posterior margin of epistome acutely triangular (Fig. 6C–E) .....  
..... Barito, Kalimantan Tengah *B. brachyphallus* (Ng, 2015)
- 6b. Striae on lateral parts of dorsal surface of carapace strong, sharp (Fig. 15B); median lobe of posterior margin of epistome obtusely triangular (e.g., Fig. 15C–E) ..... 7
- 7a. Epibranchial tooth small but usually visible, and even when low, demarcated from the anterolateral margin by a shallow cleft (Figs. 12B, 14); G1 terminal segment with median part less distinctly bent, distal part more elongate with more tapering tip, opening small (Fig. 22A–C, E–G); Kapit area and upper Rejang, Sarawak .....  
..... *B. kapit* sp. nov.
- 7b. Epibranchial tooth not visible or very low, with the anterolateral margin appearing entire (Fig. 15B); G1 terminal segment with median part distinctly bent, distal part ending in rounded tip with wide opening (Fig. 22I–K); Batang Ai National Park and Lanjak-Entimau Wildlife Sanctuary, Kanowit Basin, Sarawak .....  
..... *B. sarawakensis* sp. nov.

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**Authors' contributions:** JG conducted most of the field work and collected the bulk of the specimens. PKLN and JG jointly processed the various samples, performed the morphological comparisons and drafted the manuscript. All authors read and approved the final manuscript.

**Competing interests:** The authors declare that they have no conflict of interests.

**Availability of data and materials:** All specimens are deposited in museum or institutional collections stated in the paper.

**Consent for publication:** Not applicable.

**Ethics approval consent to participate:** Not applicable.

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