

## Taxonomy of the semiterrestrial crab *Lepidothelphusa cognettii* (Nobili, 1903) (Crustacea: Decapoda: Brachyura: Gecarcinucidae), with descriptions of five new species from Sarawak, Malaysia, Borneo

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**Abstract.** The taxonomy of the semiterrestrial gecarcinucid crab *Lepidothelphusa cognettii* (Nobili, 1903) from Borneo is revised. The identity of *L. cognettii* s. str. is clarified and five new species: *L. flavochela*, *L. limau*, *L. loi*, *L. padawan* and *L. sangon*, are described from southwestern Sarawak, Malaysia. The species are characterised by their diagnostic live colours, structures of their carapaces, chelae, male abdomens and male first gonopods. They also occupy geographically discrete ranges, sometimes with different habitats.

**Key words.** Decapoda, Gecarcinucidae, *Lepidothelphusa*, taxonomy, revision, mudstone, sandstone, Sarawak

### INTRODUCTION

In studying the crustacean specimens of Borneo sent to him by Robert Shelford, curator of the Sarawak Museum from 1897 to 1904, Nobili (1903) recognised an unusual freshwater crab collected from 3000 feet high in Mount Penrissen which he identified as a new species, *Potamon* (*Geotelphusa*) *cognettii*. He remarked that the species can be distinguished from known Bornean freshwater crabs by its square carapace, the presence of a toothed projection on the chelipeds, and the disproportionately large adult male cheliped (Nobili, 1903: 18). Colosi (1920) later established a new genus, *Lepidothelphusa*, for the species. Bott (1970) highlighted the unusual-scissor blade like fingers of the chelipeds, and commented the species has relationships with the gecarcinucid genus *Phricotelphusa* Alcock, 1909, from Myanmar, Thailand and northern Peninsular Malaysia. He also added Bidi in Sarawak to the list of localities for the species. In discussing *Lepidothelphusa cognettii* (Nobili, 1903), Ng & Grinang (2004) noted that current records may involve more than two species, but they did not elaborate. Ng et al. (2008: 68) commented that the specimens from Bau (includes Bidi) was an undescribed species differing from the type species by the colour in life and form of the third maxillipeds and G1s. They also provided a photograph of a specimen from there.

Extensive collections in recent years from Kuching Division, Sarawak, have resolved the taxonomy of the species. Detailed descriptions and figures of *L. cognettii* s. str. and the five new species are provided. The habitat preferences and distributions of the species are also documented.

### MATERIAL AND METHODS

The terminology essentially follows Ng (1988), with the abbreviations G1 and G2 used for the male first and second gonopods, respectively. Measurements provided (in millimetres) are of the carapace width and length, respectively. The Malay words “Kampung” and “Gunung” are used for village and mountain, respectively. Specimens examined are deposited in the Sarawak Museum (SM), Kuching, Sarawak; Sarawak Biodiversity Centre (SBC), Kuching, Sarawak; and the Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum (ex Raffles Museum of Biodiversity Research), National University of Singapore.

The G1 is a valuable character in separating the various species but has to be compared at the same orientation to make comparisons useful. In this paper, the G1s and G2s have been drawn from a standardised plane to ensure comparisons are accurate. The G1s of all *Lepidothelphusa* species are gently twisted so how they appear from dorsal and ventral views can be quite different in appearance. For example in *L. flavochela*, new species, the G1 appears almost straight from the dorsal view (Fig. 4A) but is gently curved from the ventral view (Fig. 4D).

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## TAXONOMY

## Family Gecarcinucidae Rathbun, 1904

*Lepidothelphusa* Colosi, 1920

*Parathelphusa* (*Lepidothelphusa*) Colosi, 1920: 24.  
*Para-Lepidothelphusa cognettii* – Balss, 1937: 174.  
*Lepidothelphusa* – Bott, 1970: 55.

**Type species.** *Potamon* (*Geotelphusa*) *cognettii* Nobili, 1903; by original designation; gender of genus feminine.

**Diagnosis.** Carapace quadrate, slightly wider than long, dorsal surface relatively flat, smooth to rugose; cervical and H-grooves visible, shallow to deep; anterolateral margins not clearly demarcated from posterolateral margins, lateral margins subparallel; epibranchial tooth undiscernible; frontal median triangle absent; epigastric and postorbital cristae distinct, margins gently serrated; lateral margins of posterior epistome gently concave, entire; ischium of third maxilliped rhomboidal without discernible sulcus, exopod flagellum very short; adult male major cheliped prominently enlarged, chela swollen, large, fingers slightly to strongly gaping, cutting edges with prominent teeth; inner margin of merus of cheliped with expanded projection with serrated margin; ambulatory legs relatively long, slender; anterior male thoracic sternum (sternites 1–4) longitudinally compressed, sterno-abdominal cavity reaching to base of buccal cavity; male abdomen triangular, somite 6 trapezoidal, telson elongate; G1 relatively stout; terminal segment subcylindrical, straight to curving outwards, gradually tapering to rounded tip, about half of length of subterminal segment; G2 with long distal segment about half of length of basal segment.

**Remarks.** In examining specimens of *Potamon* (*Geotelphusa*) *cognettii* Nobili, 1903, Colosi (1920) suggested that the species must be removed from the genus *Potamon* and referred to *Parathelphusa*. He established a new subgenus, *Lepidothelphusa*, for the species and gave a brief description, indicating for the first time that it had bilobed mandibular palps. This character clearly shows that the species belongs to the family Gecarcinucidae (see Ng, 1988; Ng et al., 2008). *Lepidothelphusa* can be distinguished from almost all other freshwater gecarcinucids from Southeast Asia by its squarish carapace (with the width just longer than the length and the lateral margins subparallel) with the dorsal surfaces smooth or slightly rugose; there is no epibranchial tooth; there is no frontal median triangle; the lateral margins of the posterior margin of the epistome are almost entire; the ischium of the third maxillipeds does not have a visible sulcus and the flagellum on the exopod is poorly developed; the distinctive asymmetrical adult male chelipeds with gaping fingers (very strong in some species); the presence of a well-developed serrated projection on the merus of the chelipeds; the male sterno-abdominal cavity reaching all the way to the buccal cavity; the G1 is relatively stout; and the G2 is shorter than the G1 (see also Nobili, 1903; Bott, 1970; Ng, 2004). *Lepidothelphusa cognettii* s. str. and five new species described herein all have the typical generic characters.

There is some variation in some of the diagnostic characters is quite consistent among the species. The serrated projection on the inner margin of the merus of the chelipeds is relatively more prominent in larger males and is less well-developed in juveniles and female specimens. The chelipeds are also more prominently asymmetrical in larger male specimens.

*Lepidothelphusa cognettii* (Nobili, 1903)

(Figs. 1A–I, 2A–E, 13A, B)

*Potamon* (*Geotelphusa*) *cognettii* Nobili, 1903: 15.  
*Potamon* (*Geotelphusa*) *cognettii* – Rathbun, 1905: 214.  
*Parathelphusa* (*Lepidothelphusa*) *cognettii* – Colosi, 1920: 24 (part).  
*Para-Lepidothelphusa cognettii* (sic) – Balss, 1937: 174 (list).  
*Lepidothelphusa cognettii* – Bott, 1970: 55 (part); Ng & Grinang, 2004: 309 (part).  
*Lepidothelphusa cognettii* (sic) – Ng, 2004: 319 (part); Ng & Yeo, 2007: 108 (part); Ng et al., 2008: 67; Cumberlidge et al., 2009: appendix 1 (part).

**Material examined.** 3 males (largest 12.2 × 10.2 mm) (ZRC 2015.0601), 2 females (larger 10.7 × 8.9 mm) (ZRC 2015.0602), 4 males (largest 11.6 × 10.0 mm) (SBC.C.00378–81), Batu Panggah Trail, Gunung Penrissen, Kuching, Sarawak, coll. J Grinang et al., 3 April 2013; 9 males (largest 12.0 × 10.2 mm), 1 ovigerous female (10.2 × 8.6 mm) (SBC.C.00382–90), Batu Panggah Trail, Gunung Penrissen, Kuching, Sarawak, coll. J Grinang et al., 7 July 2014; 1 male (11.2 × 9.1 mm) (SBC.C.00391), Batu Panggah Trail, Gunung Penrissen, Kuching, Sarawak, coll. WC Lou, 28 July 2012; 1 female (10.0 × 8.9 mm) (ZRC 2015.0603), road to Borneo Highland Resort, Gunung Penrissen, Kuching, Sarawak, coll. PKL Ng, 16 September 2013; 7 males (largest 10.5 × 9.6 mm) (SBC.C.00448–54); 5 females (largest 10.4 × 9.2 mm) (SBC.C.00455–59), 7 juveniles (SBC.C.0060–66), Kalimantan Trail, Gunung Penrissen, Kuching, Sarawak, coll. J Grinang et al., 10 September 2015.

**Diagnosis.** Carapace quadrate, surface relatively flat, smooth, anterolateral margins smooth; antero- and posterolateral regions slightly rugose; epibranchial tooth undiscernible; external orbital tooth with outer margin concave, smooth; epigastric and postorbital cristae distinct, margins serrated; cervical and H-grooves shallow, not confluent (Fig. 1A, B, D); ischium of third maxilliped rhomboidal, much longer than broad, sulcus undiscernible (Fig. 1F); inner margin of merus of chelipeds with large, expanded serrated projection, projection prominent in large male (Fig. 1G); carpus of chelipeds smooth, inner angle with broadly triangular tooth (Fig. 1A); fingers of adult major male chela strongly gaping (Fig. 1H, I); ambulatory legs relatively long, merus of fourth ambulatory legs subequal to length of carapace (Fig. 1A, E); male abdomen triangular, somite 6 width and length subequal, subequal to length of telson (Fig. 1C); G1 relatively stout, sinuous, gently curving outwards; terminal segment gently curving outwards (Fig. 2A, B, D, E); G2 with relatively long distal segment, about half length of basal segment (Fig. 2C).

**Colour.** In life, the species is almost cream-white, light yellow anterior regions and chelipeds, light blue posterior regions. Females are generally duller in coloration (Fig. 13A, B).

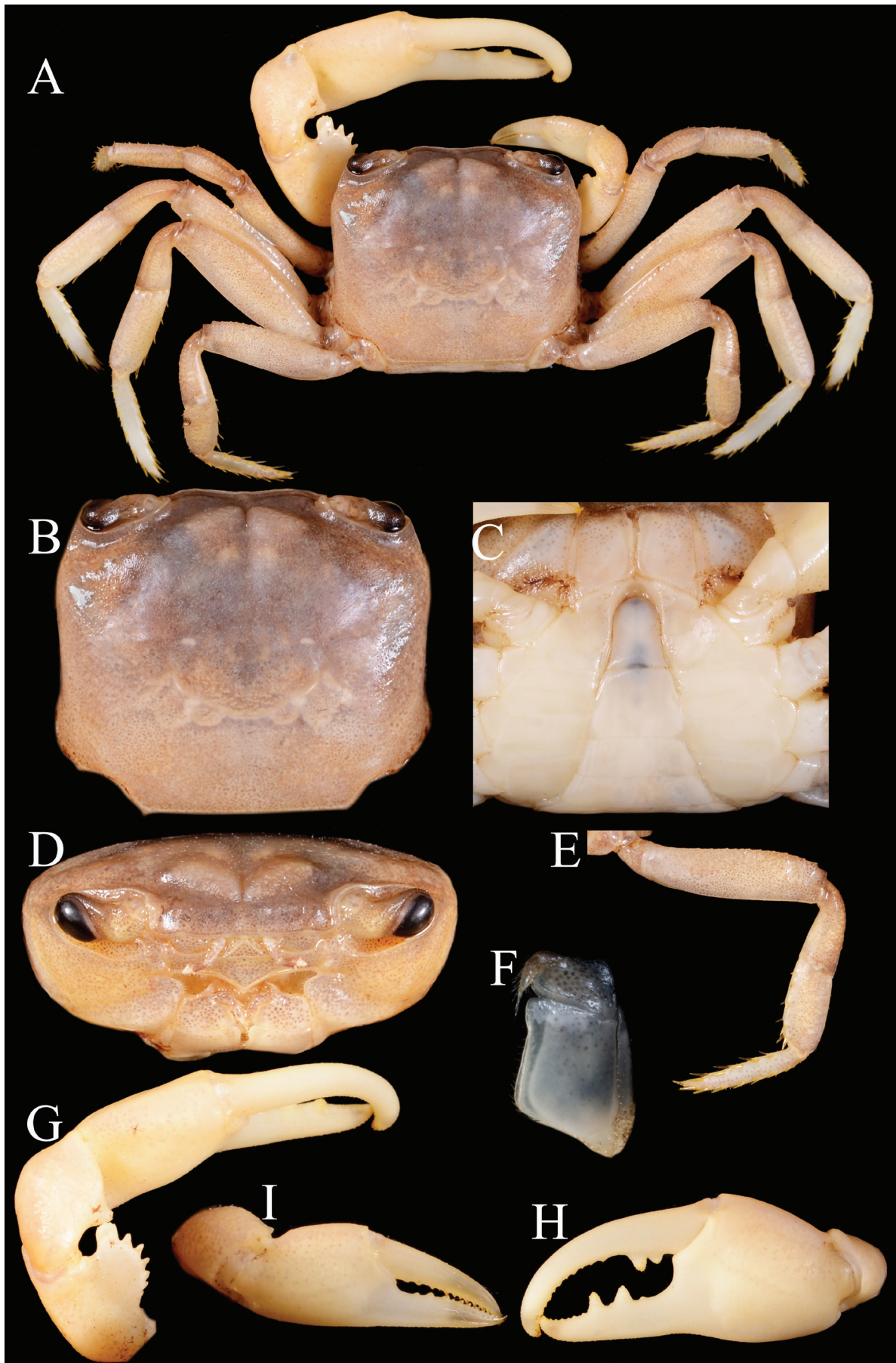


Fig. 1. *Lepidothelphusa cognettii* (Nobili, 1903), male (12.2 × 10.2 mm) (ZRC 2015.0601), Batu Panggah Trail, Gunung Penrissen, Kuching, Sarawak. A, overall dorsal view of habitus; B, dorsal view of carapace; C, ventral view showing anterior thoracic sternum and male abdomen; D, frontal view of carapace; E, outer view of right fourth ambulatory leg; F, left third maxilliped showing exopod; G, left cheliped showing serrated inner margin of merus; H, outer view of left chela; I, outer view of right chela.

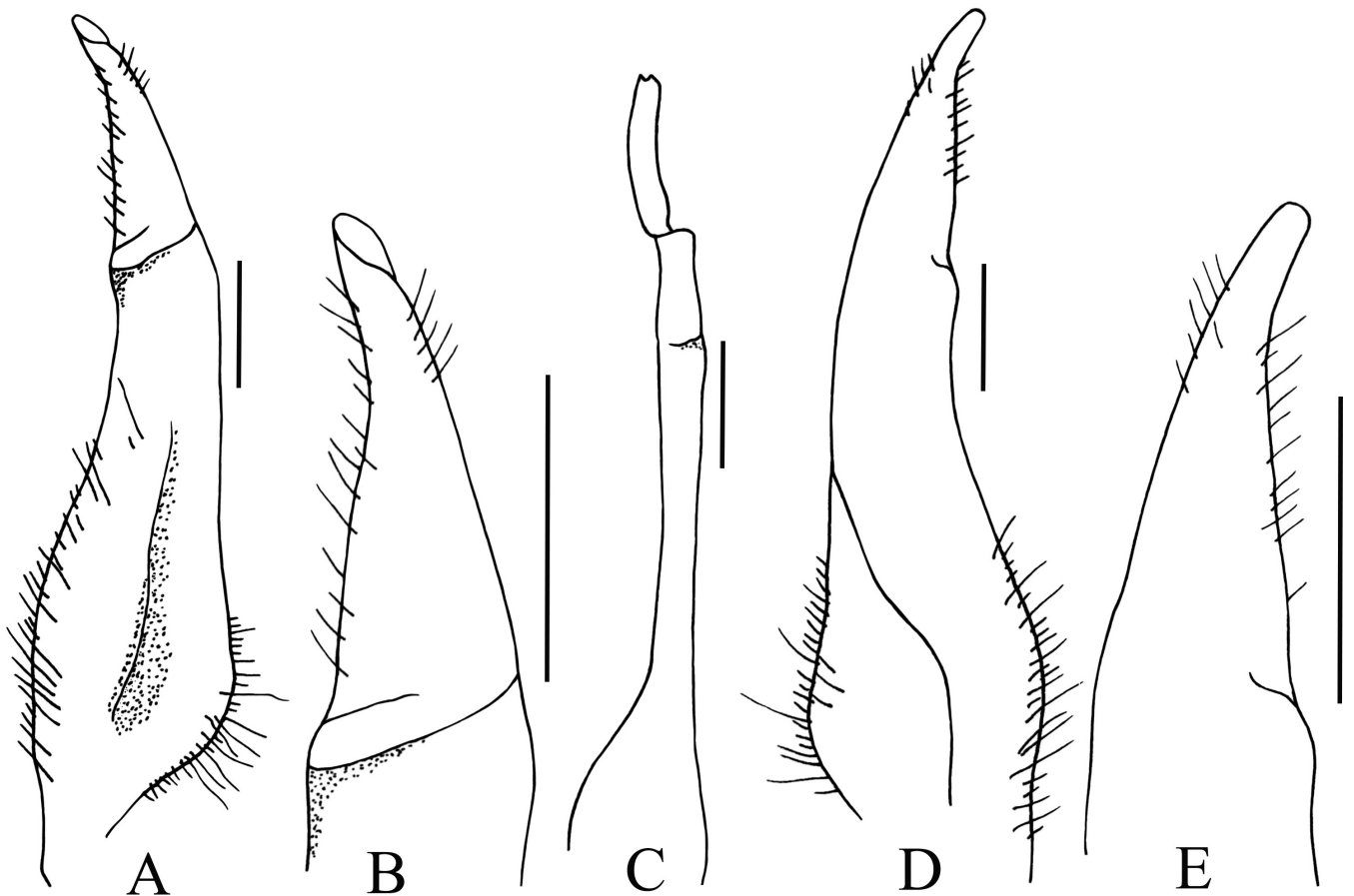


Fig. 2. *Lepidothelphusa cognettii* (Nobili, 1903), male (12.2 × 10.2 mm) (ZRC 2015.0601), Batu Panggah Trail, Gunung Penrissen, Kuching, Sarawak. A, dorsal view of left G1; B, dorsal view of distal part of left G1; C, dorsal view of left G2 (distal segment damaged at proximal half); D, ventral view of left G1; E, ventral view of distal part of left G1. Scale bars = 0.5 mm.

**Remarks.** Bott (1970: 56) noted that he had one “paratype” male from Bidi (Museum Turin catalogue number 1943), and he figured this specimen (Bott, 1970: pl. 7 figs. 69–72, pl. 27 fig. 31). However, this specimen is not a paratype. Nobili (1903: 15) had described this species from two males and one female collected by Robert Shelford from Mount Penrissen and made no mention of any material from Bidi. Colosi (1920: 24) listed specimens from Penrissen as well as pair of specimens from Bidi, so the latter material must have been sent to the Turin Museum after Nobili (1903) described the species. The second author has tried to contact the curators and management of the Turin Museum on several occasions to obtain the types. In the early part of this century, the material was being moved but as of today, the museum has suspended all research activities and the collection is no longer accessible (Franco Andreone, in letter, March 2015). Although we have not managed to obtain the type material for this study, considering the restricted distributions of the species now studied, and the material we have obtained from Mount Penrissen is from the type locality, in areas Shelford himself would have collected, we are confident our specimens represent the true *Lepidothelphusa cognettii*. They agree in all respects with the descriptions by Nobili (1903) and Colosi (1920). The authors also have additional specimens from Bidi collected at the same time as the Colosi material – they are clearly referable to *L. limau*, new species, instead (see later). Examining the figures of Bott (1970: pl. 7 figs. 69–72, pl. 27 fig. 31), they also agree well with what

is described here as *L. limau*, notably in the carapace shape and structure of the G1. As the reports of this species by Ng (2004), Ng & Grinang (2004), Ng & Yeo (2007), Ng et al. (2008) and Cumberlidge et al. (2009) and Klaus et al. (2009) include or use the Bidi location, all these records also include *L. limau*. Although there is a second species known from Bau (*L. flavochela*, new species), this taxon is easily distinguished by the structure of its carapace and gonopods (see discussion for this species).

*Lepidothelphusa cognettii* s. str. can be distinguished from its congeners by a combination of characters: carapace distinctly square and flat (Fig. 1A, B) (versus carapace relatively less square and rugose in *L. limau*, new species (Fig. 5A, B); *L. loi*, new species (Fig. 7A, B); and *L. padawan*, new species (Fig. 9A, B)), the gap between fingers of adult major chela is conspicuously wide (Fig. 1H) (versus gap between fingers of major chela is relatively narrow in *L. flavochela*, new species (Fig. 3G); and *L. sangon*, new species (Fig. 11H)), and the G1 is relatively slender (Fig. 2A, D) (versus G1 stout in *L. flavochela* (Fig. 4A, D); *L. limau* (Fig. 6A, D); *L. loi* (Fig. 8A, D); *L. sangon* (Fig. 12A, D)). In the form and shape of the G1, notably in the curving terminal segment, *L. cognettii* s. str. is similar to *L. flavochela* and *L. padawan*. In *L. cognettii* s. str., the G1 is gently curving outwards (Fig. 2A, B, D, E) but in *L. padawan*, it is more curving outwards (Fig. 10A, B, D, E). The G1 of *L. cognettii* s. str. is relatively slender (Fig. 2A, B, D, E) while in *L.*

*flavocheila* it is distinctly stouter (Fig. 4A, B, D, E). Other differences between *L. cognettii* s. str. and congeners are treated in the general discussion.

All fresh specimens of both species were collected from sandstone outcrops and non-cave systems. This indicates that the Bidi specimens examined by the previous authors might also have been collected from Kampung Peros in Krokong, Bau (type locality of *L. limau*), which is only about 2 km from the limestone area of Bidi (see discussion for *L. limau*). Certainly, they are not known from limestone formations or inside the Bidi caves (see also Ng, 1989; Ng & Yussof, 1990; Ng & Grinang, 2014).

**Habitat.** The habitat of the species is moist rock crevices and leaf litter in shaded springs. The habitat is a primary dipterocarp forest with sandstone substrate and the elevation ranges from 200 m to 1200 m above sea level. The habitat appears to be highly localised. Of the known *Lepidothelphusa* species, *L. cognettii* s. str., is the only one known from such high altitudes.

***Lepidothelphusa flavocheila*, new species**

(Figs. 3A–I, 4A–E, 13C, D)

**Material examined.** Holotype: male (8.1 × 7.2 mm) (ZRC 2015.0604), 194 m above sea level, Pagar Besi, Kampung Gumbang, Bau, Sarawak, coll. J Grinang et al., 15 February 2013. Paratypes: 4 males (largest 8.5 × 7.5 mm), 5 females (largest 9.9 × 8.8 mm) (SBC.C.00392–401), data same as holotype.

**Diagnosis.** Carapace quadrate, surface relatively flat, rugose, anterolateral margins smooth; antero- and posterolateral regions slightly rugose; epibranchial tooth undiscernible; infra-, supra-orbital margins confluent gradually, external orbital tooth with outer margin concave, smooth; serrated projection on frontal region distinct; epigastric and postorbital cristae distinct, relatively low, margins serrated; cervical and H-grooves relatively shallow, not confluent (Fig. 3A, B, D); ischium of third maxilliped rhomboidal, much longer than broad, sulcus undiscernible (Fig. 3F); inner margin of merus of chelipeds with relatively lower serrated projection (Fig. 3I); carpus of chelipeds smooth, inner angle with broad, low triangular tooth (Fig. 3A); fingers of adult major male chela gaping (Fig. 3G, H); ambulatory legs relatively long, merus of fourth ambulatory legs subequal to length of carapace (Fig. 3A, E); male abdomen triangular, somite 6 width and length subequal, subequal to length of telson (Fig. 3C); G1 stout, sinuous in ventral view, straight in dorsal view; terminal segment straight in dorsal view, curved in ventral view (Fig. 4A, B, D, E); G2 with relatively long distal segment, about half length of basal segment (Fig. 4C).

**Colour.** In life, males have uniformly yellow chela, cream-white ambulatory legs and the anterior part of the carapace is yellowish-orange with the posterior part pale orange to yellowish-white. Females are dark brown overall (Fig. 13C, D).

**Etymology.** The name is derived from the Latin “flavo” combined with chela, alluding to the entire yellowish chela. The name is used as a noun in apposition.

**Remarks.** *Lepidothelphusa flavocheila*, new species, is most easily distinguished from *L. cognettii* s. str. and congeners in having poorly developed epigastric and postorbital cristae (Fig. 3B, D versus Figs. 1B, D, 5B, D, 7B, D, 9B, D, 11B, D). Its coloration in life is closest to *L. limau*, new species, especially with the dorsal surface of adults having the anterior half orange and posterior part lighter; and the legs cream-white. The chelae are also similar in colour except that in *L. flavocheila*, even the fingers are yellow (Fig. 13C) while in *L. limau*, the fingers are white (Fig. 13E). The yellow chela of *L. flavocheila* (Fig. 13C, D) is a character shared by *L. loi* and *L. sangon* but these species have the carapace a more uniform reddish-brown to orange and the legs are reddish-brown (Figs. 14A, B, E, F). The G1s of these species are quite different. The terminal segment of the G1 of *L. flavocheila* (Fig. 4A, B, D, E) is proportionately longer than that of *L. limau* (Fig. 6A, B, D, E) and *L. loi* (Fig. 8A, B, D, E), while in *L. sangon*, it is much straighter with the distal opening more flared and the lateral margins of the subterminal segment sinuous (Fig. 12A, B, D, E).

**Habitat.** The habitat is similar to that of *L. cognettii* s. str. except that it is less than 200 m above sea level.

***Lepidothelphusa limau*, new species**

(Figs. 5A–I, 6A–E, 13E, F)

*Parathelphusa* (*Lepidothelphusa*) *cognettii* – Colosi, 1920: 24 (part). (not *Potamon* (*Geotelphusa*) *cognettii* Nobili, 1903)

*Lepidothelphusa cognettii* – Bott, 1970: 55 (part), pl. 7 figs. 69–72, pl. 27 fig. 31; Ng & Grinang, 2004: 309 (part); Ng et al., 2008: 67 (part), 68, fig. 55; Klaus et al., 2009: 513, 521. (not *Potamon* (*Geotelphusa*) *cognettii* Nobili, 1903)

*Lepidothelphusa cognetti* – Ng, 2004: 319 (part); Ng & Yeo, 2007: 108 (part); Ng et al., 2008: 67; Cumberlidge et al., 2009: appendix 1 (part). (not *Potamon* (*Geotelphusa*) *cognettii* Nobili, 1903)

**Material examined.** Holotype: male (12.1 × 10.8 mm) (ZRC 2015.0605), forested area behind village, 189 m above sea level, Kampung Peros, Krokong, Bau, Sarawak, coll. PKL Ng et al., 14 September 2013. Paratypes: 28 males (largest 11.6 × 10.4 mm), 1 ovigerous female, 12 females (largest 11.5 × 9.8 mm), 3 juveniles (ZRC 2015.0606), data as holotype; 4 males (largest 11.5 × 9.7 mm) (SBC.C.00402–05), data as holotype; 1 male (10.0 × 9.0 mm) (SBC.C.00406), Kampung Peros, Krokong, Bau, Sarawak, coll. J Grinang & M Dingol, 10 June 2012; 1 female (12.5 × 10.2 mm) (ZRC 1985.4414–4415), Bidi Caves, Sarawak, coll. CJ Brooks, June 1903.

**Diagnosis.** Carapace relatively quadrate, surface relatively flat, smooth, anterolateral margins smooth; antero- and posterolateral regions slightly rugose; epibranchial tooth undiscernible; external orbital tooth with outer margin concave, smooth; serrated projection on frontal region distinct; epigastric and postorbital cristae distinct, margins

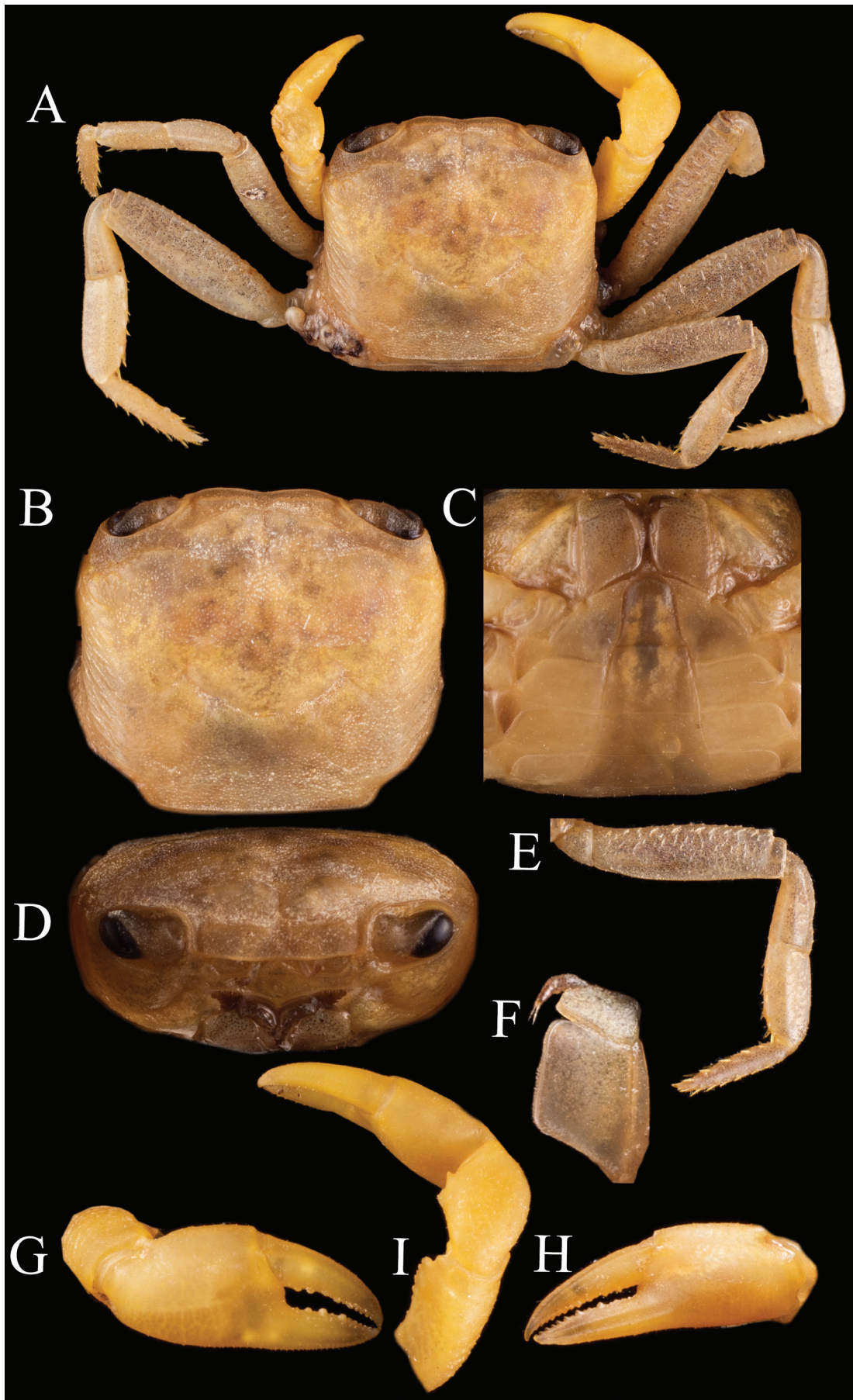


Fig. 3. *Lepidothelphusa flavochela*, new species, holotype male (8.1 × 7.2 mm) (ZRC 2015.0604), Pagar Besi, Kampung Gumbang, Bau, Sarawak. A, overall dorsal view of habitus; B, dorsal view of carapace; C, ventral view showing anterior thoracic sternum and male abdomen; D, frontal view of carapace; E, outer view of right fourth ambulatory leg; F, left third maxilliped showing exopod; G, outer view of right chela; H, outer view of left chela; I, left cheliped showing serrated inner margin of merus.

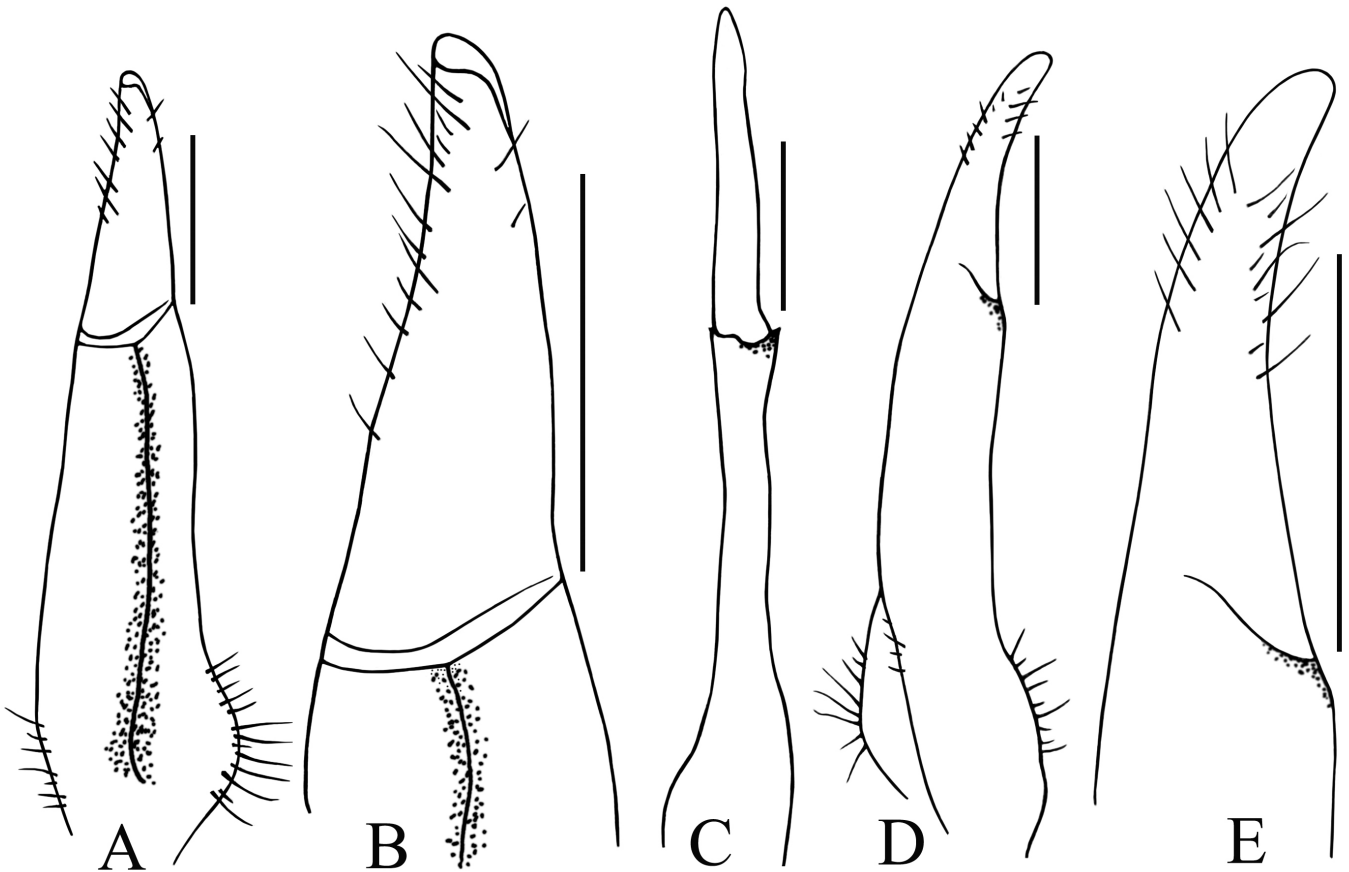


Fig. 4. *Lepidothelphusa flavochela*, new species, holotype male (8.1 × 7.2 mm) (ZRC 2015.0604), Pagar Besi, Kampung Gumbang, Bau, Sarawak. A, dorsal view of left G1; B, dorsal view of distal part of left G1; C, dorsal view of right G2; D, ventral view of left G1; E, ventral view of distal part of left G1. Scale bars = 0.5 mm.

serrated; cervical and H-grooves relatively deep, not confluent (Fig. 5A, B, D); ischium of third maxilliped rhomboidal, much longer than broad, sulcus undiscernible (Fig. 5F); inner margin of merus of chelipeds with large, prominently expanded serrated projection (Fig. 5G); carpus of chelipeds smooth, inner angle with broadly triangular tooth (Fig. 5A); fingers of adult major male chela narrowly gaping (Fig. 5H, I); ambulatory legs relatively long, merus of fourth ambulatory legs subequal to length of carapace (Fig. 5A, E); male abdomen triangular, somite 6 wider than long, subequal to length of telson (Fig. 5C); G1 stout, straight; terminal segment almost straight in dorsal view, slightly curved outwards in ventral view (Fig. 6A, B, D, E); G2 with relatively long distal segment, about half length of basal segment (Fig. 6C).

**Colour.** In life, males are yellowish-orange carapace with light blue on posterior regions, yellowish-white chelipeds and cream-white ambulatory legs. Females are dark brown overall (Fig. 13C, D).

**Etymology.** The name is derived from the Iban word “limau” for a plant species popularly called calamansi, *Citrofortunella microcarpa* (Bunge, 1833), alluding to the yellowish carapace that similar to a ripe fruit of the plant species. The name is used as a noun in apposition.

**Remarks.** *Lepidothelphusa limau*, new species, can be easily distinguished from *L. cagnettii* s. str. and *L. padawan*, new

species, in having relatively less strongly developed major male cheliped (Fig. 5A, H, I versus Figs. 1A, H, I, 9A, H, I). It differs from *L. flavochela*, new species, and *L. sangon*, new species, in having a less square and rugose carapace than the latter (Fig. 5A, B versus Figs. 3A, B, 11A, B). It differs from *L. loi*, new species, in having a less square carapace and relatively longer ambulatory legs than the latter (Fig. 5A, B, E versus Fig. 7A, B, E). The third maxilliped ischium of *L. limau* is relatively longer and less rhomboidal compared to the other five species (Fig. 5F versus Figs. 1F, 3F, 7F, 9F, 11F). The G1 of *L. limau* is stout (Fig. 6A, B, D, E) versus more slender in *L. cagnettii* s. str. (Fig. 2A, B, D, E) and *L. padawan* (Fig. 10A, B, D, E); the tip of the terminal segment of G1 of *L. limau* is more pointed (Fig. 6B, E) but is relatively blunt in *L. flavochela* (Fig. 4B, E), *L. loi* (Fig. 8B, E) and *L. sangon* (Fig. 12B, E).

As discussed under *L. flavochela*, the colour of the carapace, chela and legs of *L. limau* are most similar to that species, but they differ in the structure of the carapace and G1s.

Ng et al. (2008: 68, fig. 55) discussed and figured a specimen from Bau which they argued was different from *L. cagnettii* s. str. The specimen in their photograph (not collected) was from somewhere in Krokong (which is in the district of Bau and near Bidi), and all the present material from this area belongs to *L. limau*. The older material collected by C. J. Brooks from “Bidi” agrees very well with the types of *L. limau*.

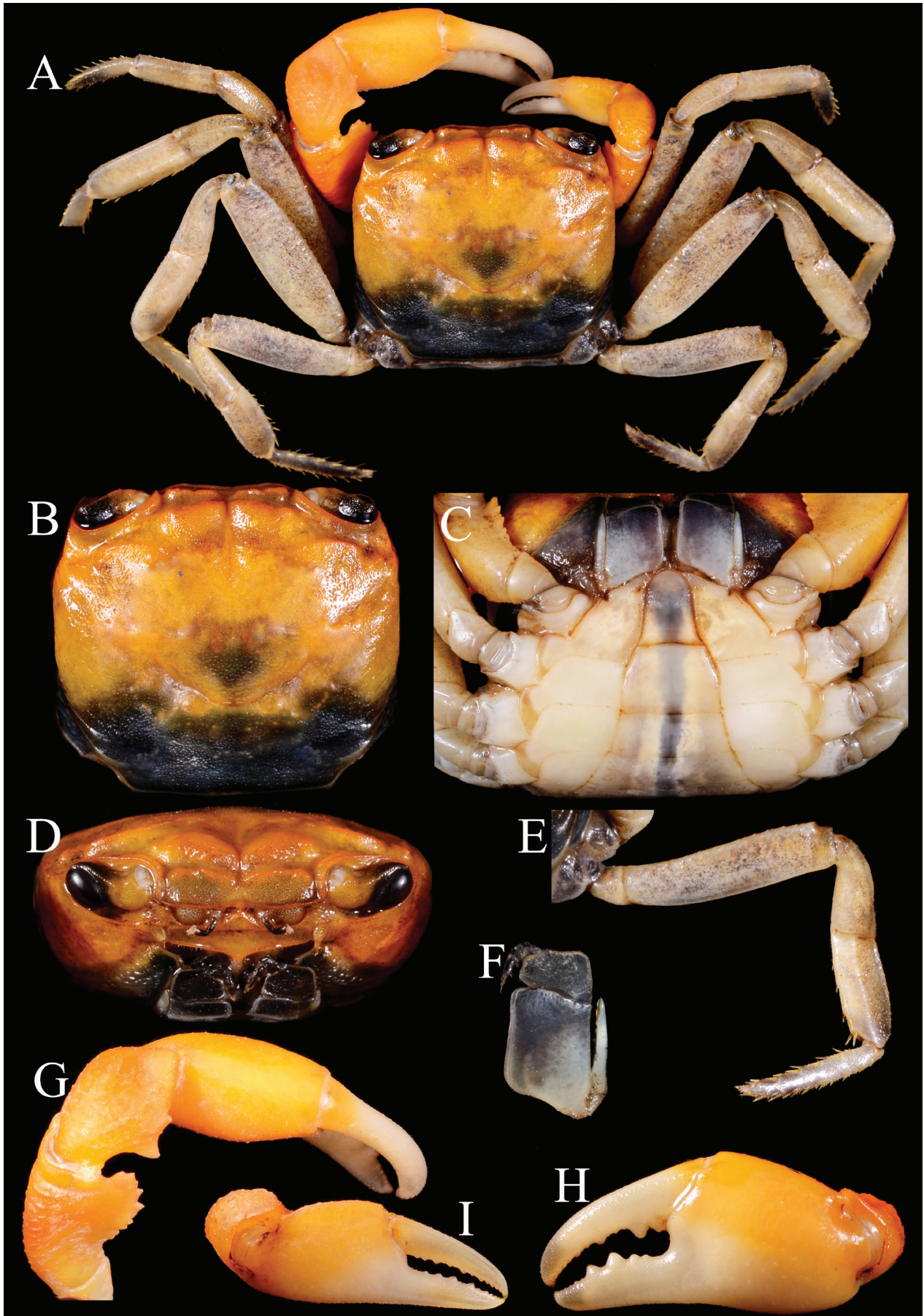


Fig. 5. *Lepidothelphusa limau*, new species, holotype male (12.1 × 10.8 mm) (ZRC 2015.0605), Kampung Peros, Krokong, Bau, Sarawak. A, overall dorsal view of habitus; B, dorsal view of carapace; C, ventral view showing anterior thoracic sternum and male abdomen; D, frontal view of carapace; E, outer view of right fourth ambulatory leg; F, left third maxilliped showing exopod; G, left cheliped showing serrated inner margin of merus; H, outer view of left chela; I, outer view of right chela.



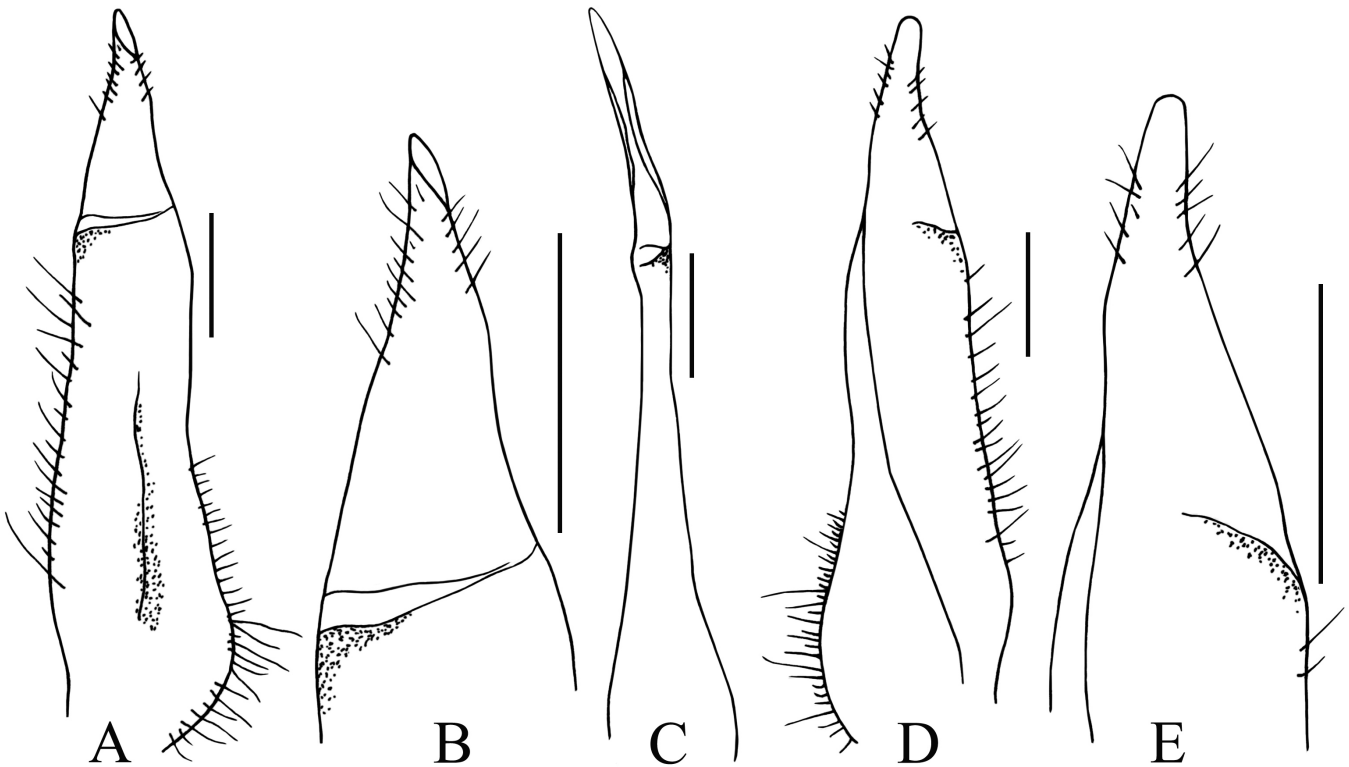


Fig. 6. *Lepidothelphusa limau*, new species, holotype male (12.1 × 10.8 mm) (ZRC 2015.0605), Kampung Peros, Krokong, Bau, Sarawak. A, dorsal view of left G1; B, dorsal view of distal part of left G1; C, dorsal view of right G2; D, ventral view of left G1; E, ventral view of distal part of left G1. Scale bars = 0.5 mm.

**Habitat.** The habitat is relatively flat primary dipterocarp forest and is less than 200 m above sea level. The substrate is moist and consists of sandstone, moist sand with leaf litter.

***Lepidothelphusa loi*, new species**

(Figs. 7A–I, 8A–E, 14A, B)

**Material examined.** Holotype: male (10.3 × 9.6 mm) (ZRC 2015.0607), Gunung Ampungan, Sadong River Basin, Serian, Sarawak, coll. J Grinang et al., 8 February 2015. Paratypes: 2 females (larger 9.8 × 9.2 mm), 2 ovigerous females (larger 10.3 × 9.8 mm) (SBC.C.00435–39), data same as holotype; 14 males (largest 11.3 × 10.6 mm, 10.5 × 9.6 mm, 11.8 × 10.9 mm), 8 females (largest 11.2 × 9.8 mm) (ZRC 2015.0292), on sides of small stream, mudstone and rocks substrate, densely forest covered slope of hill Gunung Ampungan, Sadong River Basin, Serian, Sarawak, coll. PKL Ng, J Grinang & PYC Ng, 18 and 20 June 2015.

**Diagnosis.** Carapace quadrate, surface relatively flat, smooth, anterolateral margins smooth; antero- and posterolateral regions rugose; epibranchial tooth undiscernible; external orbital tooth with outer margin concave, smooth; serrated projection on frontal region distinct; epigastric and postorbital cristae distinct, high, margins serrated; cervical and H-grooves relatively deep, not confluent (Fig. 7A, B, D); ischium of third maxilliped rhomboidal, much longer than broad, with incomplete median sulcus (Fig. 7F); inner margin of merus of chelipeds with relatively lower serrated projection (Fig. 7G); carpus of chelipeds rugose, inner angle with broad, low triangular tooth (Fig. 7A); fingers of adult major male chela narrowly gaping (Fig. 7H, I); ambulatory

legs short, merus of fourth ambulatory legs about half of length of carapace (Fig. 7A, E); male abdomen triangular, somite 6 width and length subequal, subequal to length of telson (Fig. 7C); G1 stout, sinuous in ventral view, straight in dorsal view; terminal segment straight in dorsal view, gently curving outwards in ventral view (Fig. 8A, B, D, E); G2 with long distal segment, about three-quarters length of basal segment (Fig. 8C).

**Colour.** In life, males are yellowish-red carapace, reddish-brown ambulatory legs and yellowish chelipeds. Females are light brown overall (Fig. 14A, B).

**Etymology.** The name is after Michael Lo in recognition of his kind help in helping us search for these interesting animals.

**Remarks.** *Lepidothelphusa loi*, new species, can be easily distinguished from *L. cognettii* s. str., *L. flavochela*, new species, *L. limau*, new species, and *L. padawan*, new species, in having relatively shorter ambulatory legs (Fig. 7A, E versus Figs. 1A, E, 3A, E, 5A, E, 9A, E, 11A, E). The distal segment of the G2 of *L. loi* is relatively longer than congeners (Fig. 8C versus Figs. 2C, 4C, 6C, 10C, 12C). See also discussion for *L. flavochela* and *L. limau*.

**Habitat.** The habitat is a gentle slope, with the substrate composed of moist mud and sand, with leaf litter. The site is shaded, has a spring, and is part of a disturbed dipterocarp forest. The base substrate is sandstone, and the site is more than 500 m above sea level.

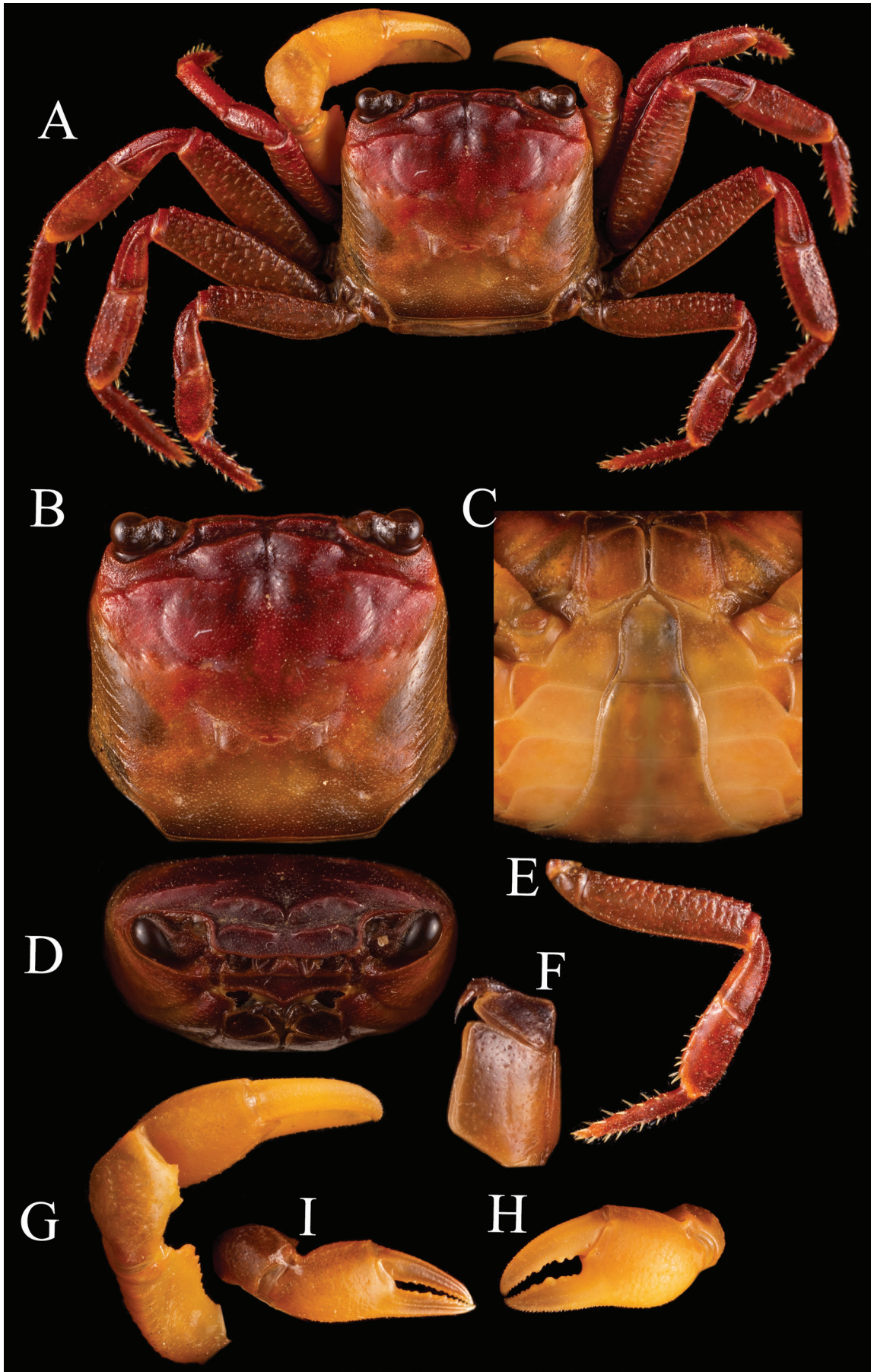


Fig. 7. *Lepidothelphusa loi*, new species, holotype male (10.3 × 9.6 mm) (ZRC 2015.0607), Gunung Ampungan, Sadong River Basin, Serian, Sarawak. A, overall dorsal view of habitus; B, dorsal view of carapace; C, ventral view showing anterior thoracic sternum and male abdomen; D, frontal view of carapace; E, outer view of right fourth ambulatory leg; F, left third maxilliped showing exopod; G, left cheliped showing serrated inner margin of merus; H, outer view of left chela; I, outer view of right chela.

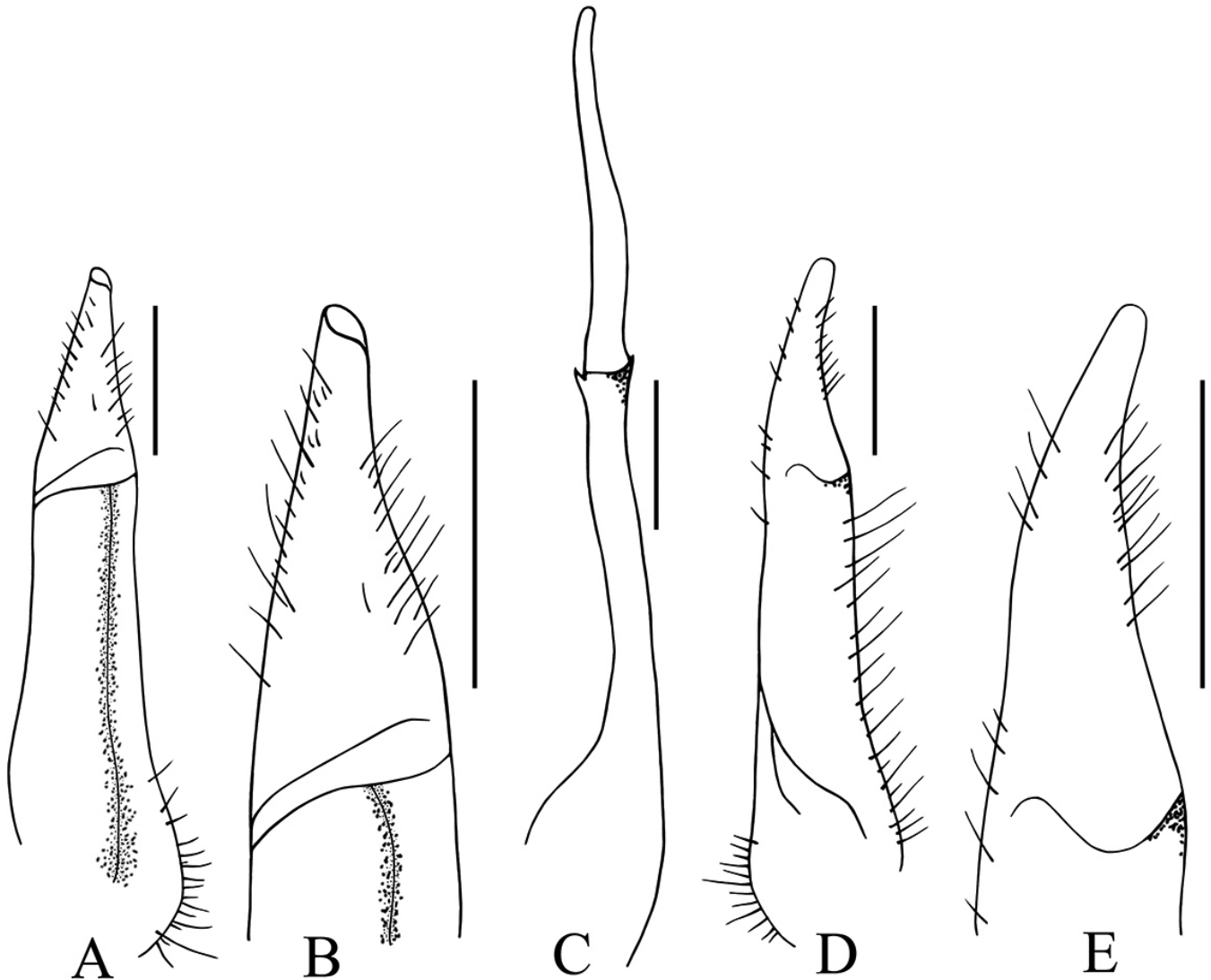


Fig. 8. *Lepidothelphusa loi*, new species, holotype male (10.3 × 9.6 mm) (ZRC 2015.0607), Gunung Ampungan, Sadong River Basin, Serian, Sarawak. A, dorsal view of left G1; B, dorsal view of distal part of left G1; C, dorsal view of right G2; D, ventral view of left G1; E, ventral view of distal part of left G1. Scale bars = 0.5 mm.

***Lepidothelphusa padawan*, new species**

(Figs. 9A–I, 10A–E, 14C, D, 15A–F)

**Material examined.** Holotype: male (13.6 × 12.5 mm) (ZRC 2015.0608), Kampung Sentah, Padawan, Sarawak, coll. J Grinang & HH Tan, 5 November 2013. Paratypes: 5 males (largest 14.2 × 12.1 mm), 2 females (larger 12.6 × 10.7 mm) (SBC.C.00407–13), location as holotype, coll. J Grinang, 12 January 2014; 7 males (largest 10.7 × 10.1 mm), 3 juveniles (SBC.C.00414–23), Sebarau, Kampung Bidak, Padawan, Sarawak, coll. J Grinang & A Alek, 12 January 2014; 5 males (largest 9.6 × 8.6 mm), 2 females (larger 9.3 × 8.2 mm) (SBC.C.00424–30), Kampung Petag, Padawan, Sarawak, coll. J Grinang, 14 January 2014; 12 males, 3 females (ZRC 2015.0609), Kampung Sentah, Padawan, Sarawak, coll. HH Tan & J Grinang, 5 November 2013; 3 males, 3 females (ZRC 2015.0610), Sarawak, from aquarium trade, obtained HH Tan, 4 December 2013; 5 males (largest 15.8 × 13.2 mm), 2 females (larger 10.8 × 9.1 mm) (SBC.C.00440–46), Bung Brungu, Padawan, Sarawak, coll. J Grinang, 8 March 2015.

**Diagnosis.** Carapace relatively quadrate, surface relatively flat, smooth, anterolateral margins serrated; antero- and posterolateral regions slightly rugose; epibranchial tooth undiscernible; external orbital tooth with outer margin slightly concave, smooth; serrated projection on frontal region distinct; epigastric and postorbital cristae distinct, margins serrated; cervical and H-grooves relatively deep, not confluent (Fig. 9A, B, D); ischium of third maxilliped rhomboidal, slightly longer than broad, sulcus undiscernible (Fig. 9F); inner margin of merus of chelipeds with large, prominently expanded serrated projection (Fig. 9G); carpus of chelipeds smooth, inner angle with broadly triangular tooth (Fig. 9A); fingers of adult major male chela strongly gaping (Fig. 9H, I); ambulatory legs relatively long, merus of fourth ambulatory legs subequal to length of carapace (Fig. 9A, E); male abdomen triangular, somite 6 slightly longer than wide, subequal to length of telson (Fig. 9C); G1 cylindrical, sinuous, gently curving outwards; terminal segment distinctly curving outwards (Fig. 10A, B, D, E); G2 with relatively long distal segment, about half length of basal segment (Fig. 10C).

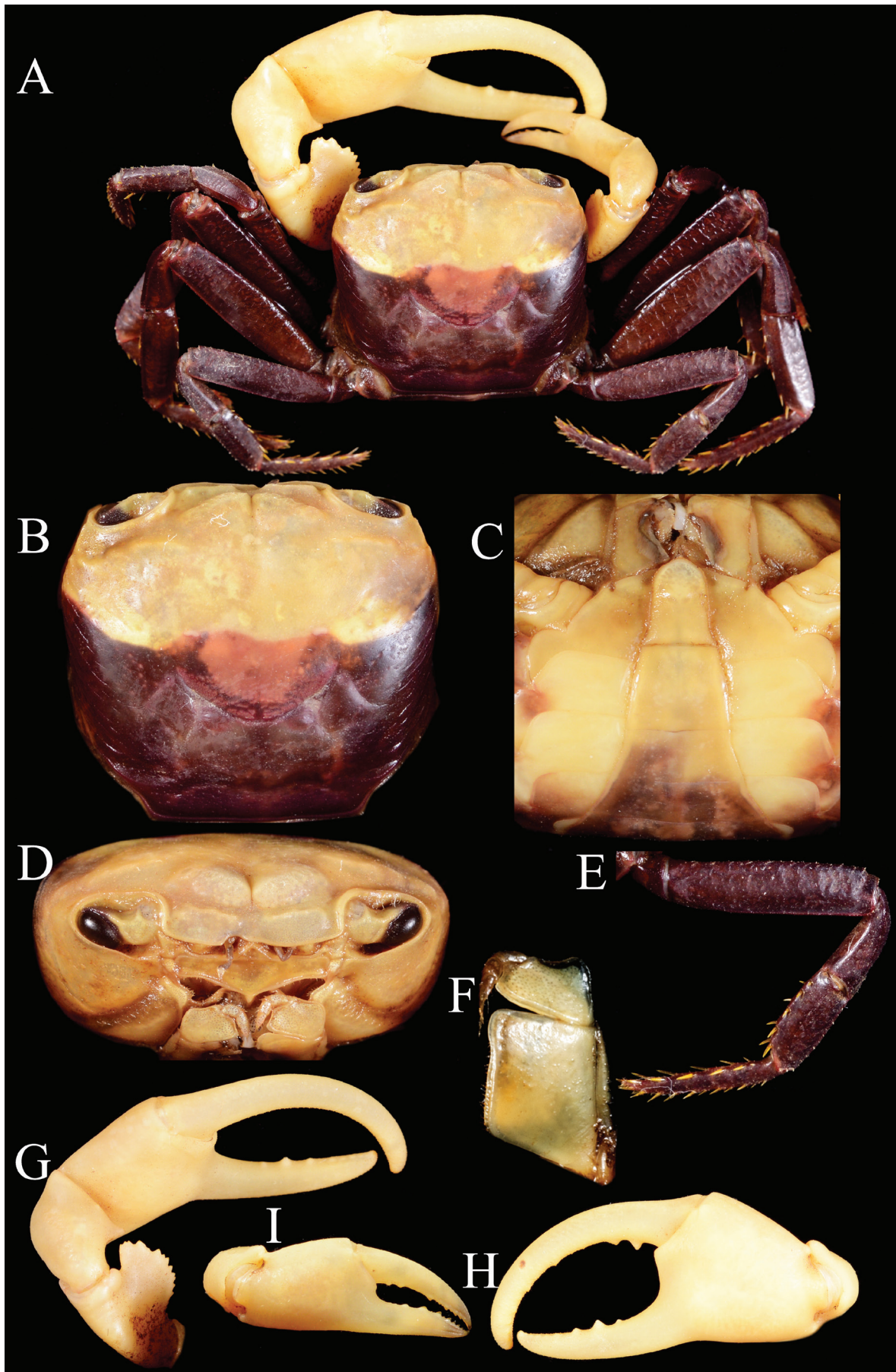


Fig. 9. *Lepidothelphusa padawan*, new species, holotype male (13.6 × 12.5 mm) (ZRC 2015.0608), Kampung Sentah, Padawan, Sarawak. A, overall dorsal view of habitus; B, dorsal view of carapace; C, ventral view showing anterior thoracic sternum and male abdomen; D, frontal view of carapace; E, outer view of right fourth ambulatory leg; F, left third maxilliped showing exopod; G, left cheliped showing serrated inner margin of merus; H, outer view of left chela; I, outer view of right chela.

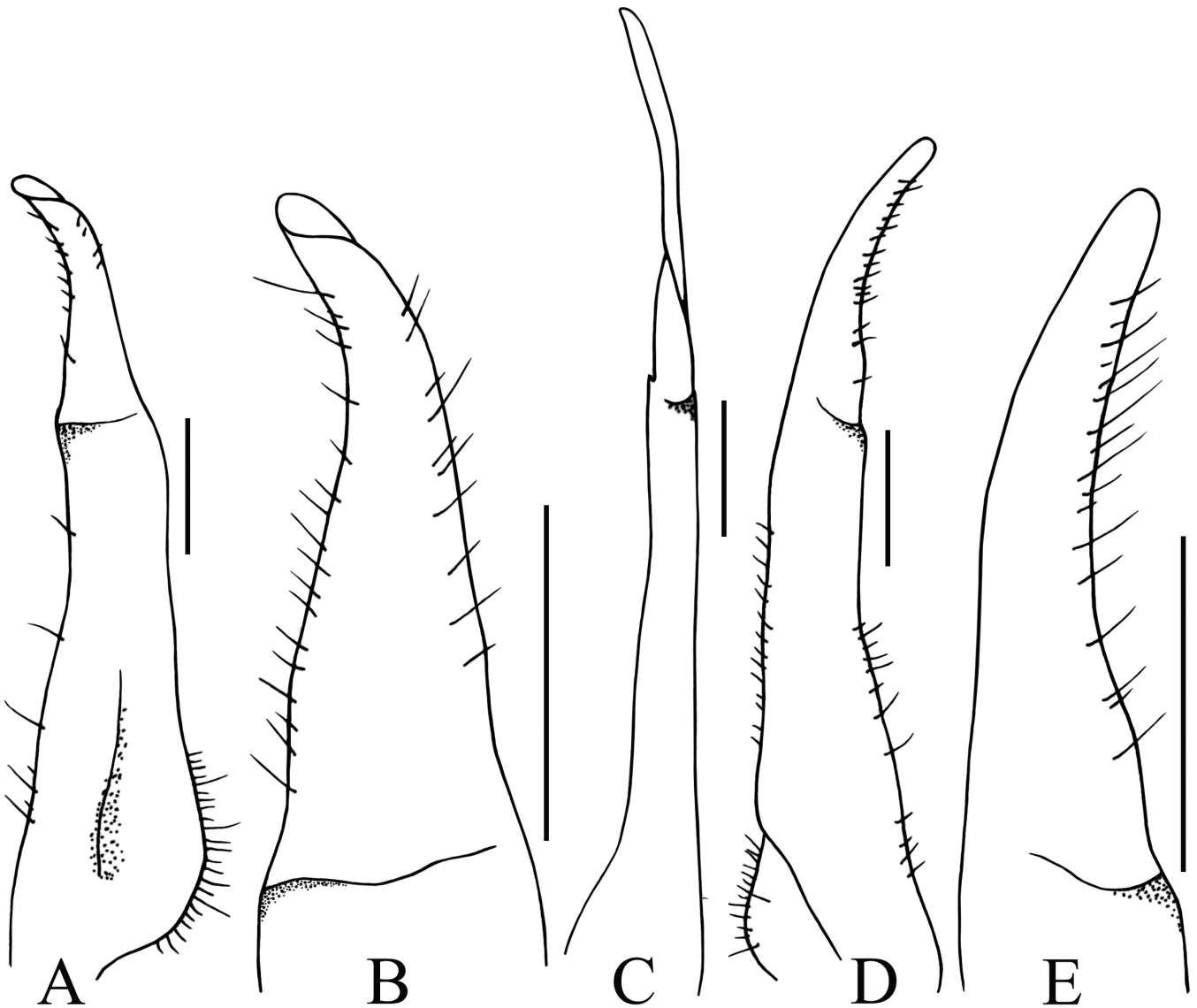


Fig. 10. *Lepidothelphusa padawan*, new species, holotype male (13.6 × 12.5 mm) (ZRC 2015.0608), Kampung Sentah, Padawan, Sarawak. A, dorsal view of left G1; B, dorsal view of distal part of left G1; C, dorsal view of left G2; D, ventral view of left G1; E, ventral view of distal part of left G1. Scale bars = 0.5 mm.

**Colour.** In life, the males have dark purple (almost black) ambulatory legs, white chelipeds, and at least three distinctive white-dark purple/black patterns on the carapace: i) carapace white or cream-white (anterior) and dark purple to black (posterior) equally or about equally horizontally (Figs. 14C, D, 15A, B); ii) carapace white-dark purple to black broad “V” shaped (Fig. 15C, D); and iii) carapace almost or entirely white (Fig. 15E). Female crabs are usually a uniform dark brown to purplish-brown to black, with cream-white chelipeds (Fig. 15F).

**Etymology.** The species is named after Padawan, the area where it was collected. The name is used as a noun in apposition.

**Remarks.** *Lepidothelphusa padawan*, new species, can be easily distinguished from *L. cognettii* s. str. and congeners in having a distinctive white-dark purple to black body in life. This contrasting colour pattern is unique among known *Lepidothelphusa* species. It also differs from other species

in having proportionately the widest gape of fingers of the adult major male chela (Fig. 9H versus Figs. 1H, 3H, 5H, 7H, 11H). The G1 of *L. padawan* is diagnostic among congeners in being the most slender and having the terminal segment the most strongly curved (Fig. 10A, B, D, E).

**Habitat.** The habitat is moist rocks and leaf litter, in partially open or shaded forest springs. The area is old primary dipterocarp forest with a mudstone substrate, and elevation is between 100 to 300 m above sea level.

***Lepidothelphusa sangon*, new species**

(Figs. 11A–I, 12A–E, 14E, F)

**Material examined.** Holotype: male (8.4 × 7.6 mm) (ZRC 2015.0611), Nawang Waterfall, 187 m above sea level, Bung Bratak, Bau, Sarawak, coll. PKL Ng et al., 14 September 2013. Paratypes: 14 males (largest 8.0 × 7.1 mm), 7 females, 2 ovigerous females (largest 7.4 × 6.0 mm), 1 juvenile (ZRC 2015.0612), data same as holotype; 4 males (largest 9.0 ×

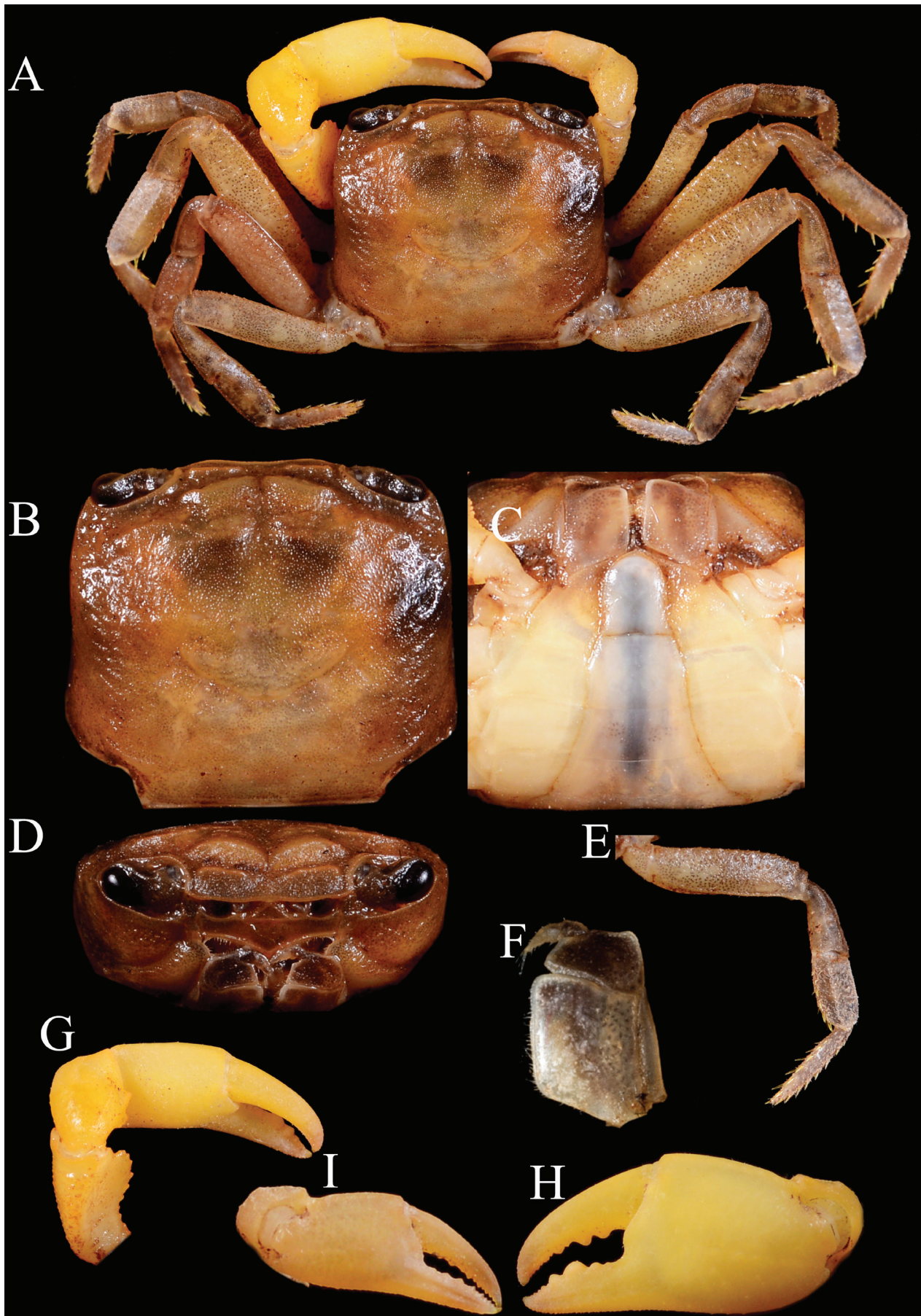


Fig. 11. *Lepidothelphusa sangon*, new species, holotype male (8.4 × 7.6 mm) (ZRC 2015.0611), Nawang Waterfall, Bung Bratak, Bau, Sarawak. A, overall dorsal view of habitus; B, dorsal view of carapace; C, ventral view showing anterior thoracic sternum and male abdomen; D, frontal view of carapace; E, outer view of right fourth ambulatory leg; F, left third maxilliped showing exopod; G, left cheliped showing serrated inner margin of merus; H, outer view of left chela; I, outer view of right chela.

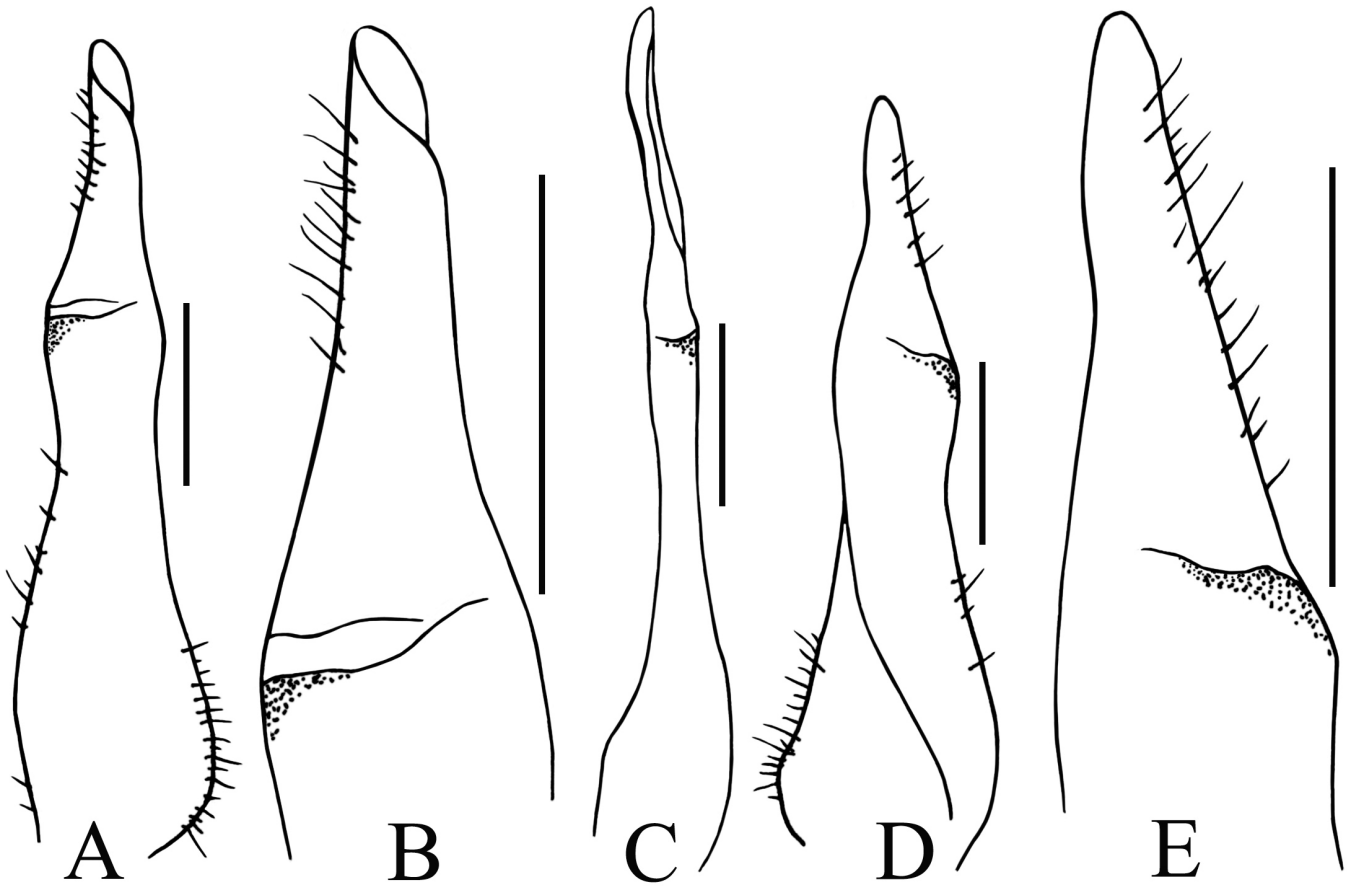


Fig. 12. *Lepidothelphusa sangon*, new species, holotype male (8.4 × 7.6 mm) (ZRC 2015.0611), Nawang Waterfall, Bung Bratak, Bau, Sarawak. A, dorsal view of left G1; B, dorsal view of distal part of left G1; C, dorsal view of left G2; D, ventral view of left G1; E, ventral view of distal part of left G1. Scale bars = 0.5 mm.

7.9 mm) (SBC.00431–34), location same as holotype, coll. J Grinang et al., 14 September 2013; 1 male (8.0 × 7.0 mm) (SBC.C.00476), location same as holotype, J Grinang, 1 May 2013.

**Diagnosis.** Carapace quadrate, surface relatively flat, rugose, anterolateral margins smooth; antero- and posterolateral regions rugose; epibranchial tooth undiscernible; external orbital tooth with outer margin concave, smooth; serrated projection on frontal region distinct; epigastric and postorbital cristae distinct, margins serrated; cervical and H-grooves shallow, not confluent (Fig. 11A, B, D); ischium of third maxilliped rhomboidal, slightly longer than broad sulcus undiscernible (Fig. 11F); inner margin of merus of chelipeds with relatively lower serrated projection (Fig. 11G); carpus of chelipeds rugose, inner angle with broad, low triangular tooth (Fig. 11A); fingers of adult major male chela gaping (Fig. 11H, I); ambulatory legs short, merus of fourth ambulatory legs about half of length of carapace (Fig. 11A, E); male abdomen triangular, somite 6 width and length subequal, subequal to length of telson (Fig. 11C); G1 stout, slightly sinuous, basal segment weakly constricted on distal third; terminal segment slightly curving outwards in dorsal view, almost straight in ventral view (Fig. 12A, B, D, E); G2 with relatively long distal segment, about half length of basal segment (Fig. 12C).

**Colour.** In life, both sexes are red to reddish-brown with yellow chelipeds (Fig. 14E, F). The colour in females is slightly less striking.

**Etymology.** The name is derived from the Bidayuh word “sangan” for beautiful, alluding to the striking colour of the crab. The name is used as a noun in apposition.

**Remarks.** *Lepidothelphusa sangon*, new species, can be easily distinguished from *L. cognettii* s. str., *L. limau*, new species, and *L. padawan*, new species, by its relatively small adult size (males and females are already fully mature at 8.0 mm carapace width). Its size range is similar to *L. flavochela*, new species, and *L. loi*, new species, but distinguishable from the latter by its striking reddish carapace and ambulatory legs (Fig. 14E, F versus Figs. 13C, D, 14A, B). It is close to *L. limau*, but can be distinguished by its more squarish and flat carapace (Fig. 11B versus Fig. 5B), relatively smaller projection on the merus of the cheliped (Fig. 11G versus Fig. 5G), narrower gap of the fingers of chela (Fig. 11H versus Fig. 5H) and relatively shorter G1 (Fig. 12A, D versus Fig. 6A, D).

**Habitat.** The habitat is moist rocks and leaf litter, in partially exposed or shaded, small streams in old primary dipterocarp forests. The substrate is mudstone and the site is less than 200 m above sea level.



Fig. 13. Live colours of three *Lepidothelphusa* species from Kuching Division, southwestern Sarawak. A, B, *Lepidothelphusa cognettii* (Nobili, 1903), male (12.0 × 10.2 mm) (SBC.C.00382–90), Batu Panggah Trail, Gunung Penrissen, Sarawak; C, D, *Lepidothelphusa flavochela*, new species, paratype male (8.5 × 7.5 mm) (SBC.C.00392–401), Pagar Besi, Kampung Gumbang, Bau, Sarawak; E, F, *Lepidothelphusa limau*, new species, paratype male (10.5 × 9.7 mm) (SBC.C.00402–05), Kampung Peros, Bau, Sarawak.

### GENERAL DISCUSSION

The new species of *Lepidothelphusa* recognised here are interesting because until recently, only one species was known; and almost nothing known about its ecology. However, about a decade ago, specimens of *Lepidothelphusa* started to appear in the aquarium trade (Rademacher & Mengedoht, 2011). These were ostensibly from Borneo but without precise data. The various colour forms indicated there were several species (including what is here described as *L. padawan* and *L. limau*) but because their provenance was not known, nothing could be done. The identity of *L. cognettii* s. str. was also not known as the types could not be re-examined and fresh material from the type locality was not available. There are clearly still more species to be discovered.

The six species of *Lepidothelphusa* recognised can be separated into several groups depending on the character states used. In terms of colour, *L. cognettii* s. str. is distinct

because of its pale adult coloration; while *L. padawan* has a sharply contrasting white and dark purple/black pattern. Two species, *L. flavochela* and *L. limau* have similar colours, with a bi-coloured carapace, cream legs and yellow-orange chela. Two other species, *L. loi* and *L. sangon* are striking in their reddish-brown carapaces and legs and orange chela. With regards to their carapaces, *L. loi* is distinctive among the species in having the smoothest carapace, with the epigastric and postorbital cristae low (Fig. 7A, B). In the other species, these cristae are sharper and stronger, being most strongly developed in *L. cognettii* s. str. and *L. flavochela* (Figs. 1A, B, 3A, B, 5A, B, 9A, B, 11A, B). In the form of the ischium of the third maxillipeds, that of *L. cognettii* s. str. and *L. limau* is relatively more elongate (Figs. 1F, 5F) whereas that of *L. flavochela*, *L. loi*, *L. padawan* and *L. sangon* is more quadrate (Figs. 3F, 7F, 9F, 11F). The adult male abdominal somite 6 of *L. limau* is distinctive in that it is distinctly wider than long (Fig. 5C); in the other species, it is more squarish or slightly longer than wide (Figs. 1C, 3C, 7C, 9C, 11C). In terms of their G1 structures, that of





Fig. 14. Live colours of three *Lepidothelphusa* species from Kuching Division, southwestern Sarawak. A, B, *Lepidothelphusa loi*, holotype male (10.3 × 9.6 mm) (ZRC 2015.0607), Gunung Ampungan, Sadong River Basin, Serian, Sarawak; C, D, *Lepidothelphusa padawan*, new species, paratype male (15.8 × 13.2 mm) (SBC.C.00440–4), Bung Brungu, Padawan, Sarawak; E, F, *Lepidothelphusa sangon*, new species, paratype male (8.0 × 7.0 mm) (SBC.C.00476), Nawang Waterfall, Bung Bratak, Bau, Sarawak.

*L. sangon* stands out in that both terminal and subterminal terminals are almost straight from both dorsal and ventral views, with the margins of the subterminal segment sinuous and the tip of the terminal segment flared (Fig. 12A, B, D, E). The G1 of *L. cognettii* s. str. and *L. padawan* both have relatively slender subterminal segments with the terminal segment curved from both dorsal and ventral views (Figs. 2A, B, D, E, 10A, B, D, E); although that of *L. padawan* is distinctly more curved. In *L. flavochela*, *L. limau* and *L. loi*, the G1 subterminal segment is relatively stout, and the terminal segment appears almost straight from the dorsal view (Figs. 4A, B, 6A, B, 8A, B) but gently curved from the ventral view (Figs. 4D, E, 6D, E, 8D, E). The G2 structures of the species are generally constant, being slightly longer than the G1 and the distal segment shorter or slightly shorter than the basal segment (Figs. 2C, 4C, 6C, 10C, 12C). Only the G2 of *L. loi* is unusual in that the G2 is some 50% longer than the G1 (Fig. 8C). The serrated projection on the merus of the cheliped of *L. cognettii* s. str., *L. limau* and *L. padawan* are large and very prominent, being almost

wing-like (Figs. 1G, 5G, 9G). In *L. flavochela*, *L. loi* and *L. sangon*, the structure is proportionately lower and less prominent, and more reminiscent of the condition of juveniles (Figs. 3I, 7G, 11G). The fingers of their chelae also do not gape significantly (Figs. 3G, 7H, 11H). However, these species do not appear to grow large (we have a good series in particular of *L. sangon*), with the G1s fully developed and females the size of the males (or smaller) already bearing eggs. It therefore appears that species are naturally small.

The habitat of *Lepidothelphusa* species is interesting as it is invariably in habitats with a bedrock of mudstone or sandstone. The habitats are invariably localised, fed by small streams or springs, or if part of a major stream or waterfall, there are many small crevices in the associated rock faces. The well shaded habitats with springs and small streams appear ephemeral, and are almost dried at times; although there is clearly ground water or moist mud still present below the usually extensive leaf litter. In these habitats, we do not find adults of any large freshwater crabs like *Isolapotamon*



Fig. 15. Live colours of *Lepidothelphusa padawan*, new species, paratypes (ZRC 2015.0609), showing variation. A, male (ca. 11.0 mm carapace width); B, male (ca. 11.0 mm carapace width); C, male (ca. 12.0 mm carapace width); D, male (ca. 12.0 mm carapace width); E, male (ca. 12.0 mm carapace width); F, female (ca. 9.0 mm carapace width). Kampung Sentah, Padawan, Sarawak

Bott, 1968 (Potamidae) or *Parathelphusa* H. Milne Edwards, 1853 (Gecarcinucidae) species. In the case of *L. limau*, we found only juvenile specimens of the potamids *Isolapotamon bauense* Ng, 1987, and some adult *Ibanum pilimanus* Ng & Grinang, 2004. Adult *Ibanum* species are small and are similar in size to *Lepidothelphusa* species; and unlike *Isolapotamon*, are not very aggressive with other taxa. The same situation is true of *L. sangon*, with only specimens of *Ibanum* sp. found and the palaemonid *Macrobrachium pilimanus* (De Man, 1879). *Lepidothelphusa flavochela* was also found only with *Ibanum pilimanus* while *L. loi* was sympatric with an unidentified gecarcinucid of the genus *Bakousa* Ng, 1995. The specimens of *L. limau* were most common in the upper parts of the stream. In the case of *L. sangon*, while specimens were collected from under loose rocks at the base, we observed many more specimens hiding in the

small crevices on the vertical face of the waterfall adjacent to the main body of water. These could not be collected. This particular habitat is not accessible to the less nimble *Ibanum* and certainly too small to enter for any *Isolapotamon* species. For *L. padawan*, it shared with *Ibanum* sp. in the flat and moist spring, but the latter absent in the drier and steep habitats. For *L. cognettii* s. str., no other crab or shrimp species were found with them. *Lepidothelphusa* species thus seem to survive in these more extreme sites where there is too little permanent water or with microhabitats, where larger crustacean species are unable to thrive. Certainly there are no fish in any of these habitats.

In their molecular analysis, Klaus et al. (2009: 521) noted that the genera *Phricotelphusa* Alcock, 1909 (northern Myanmar to northern Peninsular Malaysia), *Liotelphusa* Alcock, 1909

(India and Himalayas), *Thaksintheiphusa* Ng & Naiyanter, 1993 (southern Thailand), and *Lepidotherphusa* (Borneo) formed a monophyletic group which was basal to all other gecarcinucids. The age of the group may help explain the unusual distribution of these genera, especially if they are to be regarded as relicts.

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