Zoological Studies **57:** 49 (2018)
doi:10.6620/ZS.2018.57-49

Zoological Studies

Open Access

From an Old Eroded Carapace: Rediscovery of the Majid Crab *Leptomithrax sinensis* Rathbun, 1916 (Crustacea, Brachyura, Majidae) from Taiwan and Japan

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(Received 9 August 2018; Accepted 16 September 2018; Published 19 October 2018; Communicated by Benny K.K. Chan)

Citation: Wong KJH, Ng PKL, Jeng MS. 2018. From an old eroded carapace: rediscovery of the majid crab *Leptomithrax sinensis* Rathbun, 1916 (Crustacea, Brachyura, Majidae) from Taiwan and Japan. Zool Stud **57:**49. doi:10.6620/ZS.2018.57-49.

Kingsley J. H. Wong, Peter K. L. Ng, and Ming-Shiou Jeng (2018) The majid crab *Leptomithrax sinensis* Rathbun, 1916 was previously only known from the holotype, a detached and partially eroded carapace collected during the *Albatross* Philippine Expedition in 1908 from the northern part of the South China Sea. Recent collections of fresh material from precious coral harvest sites off northeastern Taiwan, and Shikoku, Japan made verifying this poorly known species possible. The species is considered to be valid and is here redescribed, illustrated, and compared with its closest East Asian congener, *L. bifidus* (Ortmann, 1893).

Key words: *Leptomithrax sinensis*, Spider crab, Majoidea, Precious red coral, Taxonomy, East Asia, *Leptomithrax bifidus*.

BACKGROUND

Spider crabs of the genus *Leptomithrax* Miers, 1876 (Majidae Samouelle, 1819) are represented by 15 extant species (Ng et al. 2008; Ng and Richer de Forges 2015; Richer de Forges and Ng 2015), many with relatively restricted distributions (see Griffin 1966a b; Griffin and Tranter 1986), with 11 being reported from the temperate waters of Australia and New Zealand. Of the four species found in the northwest Pacific, *L. edwardsii* (De Haan, 1835) and *L. bifidus* (Ortmann, 1893) were described from Japan, whereas the other two are from the northern part of the South China Sea: *L. sinensis* Rathbun, 1916 from "near southern Luzon" and *L. eldredgei* Richer de Forges & Ng, 2015 from off Hong Kong. One Japanese species, *L. kiiensis* Sakai, 1969 (cf. Sakai 1969 1976), has been transferred to *Rathbunaja* Ng and Richer de Forges, 2015 (cf. Ng and Richer de Forges 2015).

Leptomithrax sinensis Rathbun, 1916 was collected during the *Albatross* Philippine Expedition (1907-1910) and relatively well described from a dried and eroded carapace of unknown sex, but no illustrations were published and further material has never been reported. The holotype deposited in the National Museum of Natural History of the Smithsonian Institution was examined by T. Sakai (1965), who distinguished it from the Japanese *L. bifidus* using several features. However, no figures were provided. Later Richer de Forges and Ng (2015) illustrated the type specimen as part of their comparisons with *L. eldredgei*. They also commented that *L. bifidus* and *L. sinensis* may be

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synonyms. *Leptomithrax bifidus* has been cited and/or figured in various Japanese and Korean texts since its original description (*e.g.*, Terasaki 1903; Parisi 1915; Balss 1924; Yokoya 1933; Sakai 1938 1965 1976; Kim 1973; Muraoka 1998; Ko and Lee 2015). Aside from possessing a diagnostic bilobed tip of postorbital spine, other characters are seldom illustrated, although the male first gonopod was figured by Takeda and Kurata (1976).

Brachyuran material obtained from waters off Yilan, northeastern Taiwan, at harvesting sites of precious red coral ("Zone B": see Huang and Ou 2010) was recently examined. Other crabs have previously been reported from near this location by Shih et al. (2017) and Ng and Jeng (2017). Among this material were two specimens of *Leptomithrax* that superficially resembled *L. bifidus*. Comparisons of this material with those of *L. bifidus* in other museums showed that the two Taiwan specimens are actually *L. sinensis*, and can be separated from *L. bifidus* s. str. by many characters. A specimen of *L. sinensis* was also found from Japan. Consequently, *L. sinensis* is redescribed and figured in this paper, and fully compared with *L. bifidus*. The identification of *L. sinensis* here represents a new record for Taiwan and Japan.

MATERIALS AND METHODS

The terminology of morphological features used follows Ng and Richer de Forges (2015) and the measurements listed, in millimeters (mm), are of the post-pseudorostral carapace length (CL) and width (CW) between bases of the spines. The abbreviations G1 and G2 are used for the male first and second pleopods, respectively. Specimens examined are deposited in the collections of the Biodiversity Research Museum, Academia Sinica, Nankang (ASIZCR), Taiwan; Kanagawa Prefectural Museum of Natural History (KPM), Kanagawa, Japan; Museum of Zoology, Strasbourg (MZS), France; The Natural History Museum (NHM), London, U.K.; U.S. National Museum of Natural History, Smithsonian Institution (USNM), Washington D.C.; and Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum, National University of Singapore.

RESULTS

TAXONOMY

Family Majidae Samouelle, 1819
Genus *Leptomithrax* Miers, 1876

Leptomithrax sinensis Rathbun, 1916
(Figs. 1A; 2A-E; 3A-F; 4A-J)

Leptomithrax sinensis Rathbun, 1916: 555. - Bennett 1964: 46 [list]. - Sakai 1965: 86. - Griffin 1976: 199. - Griffin and Tranter 1986: 208 [key], 209. - McLay et al. 1995: tab. 1 [list]. - Ng et al. 2008: 117 [list]. - Ng and Richer de Forges 2015: 206 [list]. - Richer de Forges and Ng 2015: 127, fig. 3A-C.

Material examined: Holotype (25.3 × 32.0 mm, carapace only) (USNM 48219), station 5311, South China Sea, "near southern Luzon", 21°33'N 116°15'E, 88 fathoms, Philippines, coll. RV *Albatross*, 4 November 1908.

Others: 1 male (32.1 × 40.6 mm) (ZRC 2018.0726), Cape Muroto, Shikoku, Japan, 8 July 1988; 1 female (32.4 × 41.2 mm) (ASIZCR 101304), off Kueishan Island, 24°43.608'N 122°12.199'E, 134 m, coll. Fishing Vessel De-Cheng 136, M.-L. Chang, 23 Sep 2016; 1 male (35.2 × 43.1 mm) (ASIZCR 101305), off Kueishan Island, 24°43.309'N, 122°11.625'E, 149 m, coll. Fishing Vessel De-Cheng 136, M.-L. Chang, 23 May 2018.

Comparative material examined: *Leptomithrax bifidus* (Ortmann, 1893): Lectotype (here designated): 1 male (25.8 × 32.3 mm) (MZS Cru3193) (= larger male of MZS 755 recorded in Komai 1999), Sagami Bay, coll. L. Döderlein, 1881. Paralectotypes (here designated): 1 male (17.9 × 22.0 mm) (MZS Cru0755), details same as lectotype; 1 female (11.8 × 15.2 mm) (MZS Cru4246), details same as lectotype; 1 male (30.0 × 36.0 mm) (MZS Cru2406), details same as lectotype; 1 female (26.8 × 32.4 mm) (MZS Cru4326), details same as lectotype. Others: 1 male (27.5 × 32.5 mm) (NHM 1961.11.13.28-29), Seto, Japan, coll. Gordon, I. & Harada, 1950s; 1 male (29.4 × 36.5 mm; dried) (KPM NH4024), Kii, Nagashima, Japan, T. Sakai Collection, coll. March 1969; 1 male (18.0 × 22.6 mm) (ZRC 2014.0354), Cape Muroto, Shikoku, Japan, 8 July 1988.

Description: Carapace pyriform, regions well defined, distinctly elevated along median line, surface covered with rugose tubercles, larger ones with granular surface. Pseudorostral spines slender, elongated (from 0.24-0.37 CL),

cross-section rounded, moderately diverging, lateral margin slightly concave (Figs. 1A; 2A-D; 4A). Supraocular eave broad, posterior lobe triangular, with acute tip, leaving distinct gap from acutely triangular intercalated spine with sharp tip. Postorbital lobe closely appressed to intercalated spine, broad, anteriorly produced, tapering, tip appearing truncated (type) or weakly bifid, posterior portion crested, produced laterally as faint convex lobe. Gastric region with 2 prominent granulated tubercles, never spiniform (Fig. 3A, B); cardiac region with 2 distinct tubercles, directed obliquely laterally, with 2 shorter ones on posterior margin. Hepatic lobe as 2 stout, robust conical spines, anterior one more distinct. Lateral margin with 3 spines, branchial region with 1 robust, acute spine (Figs. 1A; 2A-D; 3A-B; 4A).

Basal antennal article broad, completely fused with carapace, mesial distal spine more produced than interantennular spine, external one more produced, acute, directed anterolaterally, visible in dorsal view, followed posteriorly by strongly convex lobe (margin of orbit), basal part forming a narrow U-shaped hiatus against ventral margin of postorbital lobe (Figs. 3C; 4B). Antennal peduncle positioned far from orbit (Fig. 2E). Epistome broad rectangular, smooth; posterior margin forming median triangular lobe with shallow median cleft (Figs. 3C; 4B).

Third maxilliped elongated, swollen portions glabrous, prominently sculptured, suture between ischium and merus distinctly sinuous, forming a boss-like elevation; ischium longer than broad, surface with deep, distinct Y-shaped groove covered with setae, lateral margin with triangular tooth, inner margin with 7-9 distinct rounded teeth; merus broader than long, swollen along strongly concave proximal margin, subparallel with slightly produced anteroexternal margin, anterior extremity with distinct tooth. Exopod relatively broad with longitudinal median sulcus (Figs. 3D; 4C).

Male chelipeds robust, sub-symmetrical, about as long as carapace (Fig. 2A); merus and carpus dorsally irregularly decorated by low granulated tubercles, forming rugose surface, merus with distinct curved spine distally along dorsal margin, ventral margin with 3 low tubercles, carpus with 1 conical tubercle on proximal margin (Figs. 2A; 4D). Chela slightly inflated, without granules or tubercles, surfaces minutely pitted, palm distinctly longer than fingers, ventral margin of pollex confluent with that of palm (Fig. 4E). Cheliped of female proportionately more slender, surfaces of merus and carpus likewise granular, palm not inflated (Fig. 2C).

Thoracic sternites of male distinctly excavated medially: third and fourth sternites medially divided by a well-defined longitudinal carina, each portion subdivided into 2 by faint oblique ridge, that proximal to base of cheliped shallower; fifth to seventh sternites prominently excavated on anterior half, with posterior part distinctly raised, surfaces granular (Fig. 3F). Pleon of both sexes with 6 articulated somites and telson (Figs. 3F; 4F-G); male pleon relatively broad transversely, heavily sculptured, elevated along the median, telson broad, rounded trapezoidal, third somite broadest, with a distinct glabrous ovoid elevation on each side (Figs. 3F; 4F); that of female broad, subcircular, entirely covering thoracic sternum, somites and telson moderately sculptured, elevated along median, fifth somite broadest (Fig. 4G). G1 slender, tapering, external margin lined with setae, curving laterally on distal quarter (Fig. 4H), subdistal portion armed with minute conical spines on mesial surface, tip extended, rounded, directed anterolaterally (Figs. 3E; 4H-J). G2 about 0.3 length of G1, basal segment relatively elongate, distal part spatuliform without flagellum (Fig. 4K).

Life coloration: Dorsal surface of carapace and ambulatory legs overall dull orange, chela and ambulatory dactyli amber, chelae fingers cream (Fig. 2D).

Habitat: The holotype carapace was collected from a substrate of coarse sand and shells (US Bureau of Fisheries 1910; Rathbun 1916). The collection sites of both Taiwanese specimens are located in the seas off Yilan, northeastern Taiwan, some 13 km approximately east of Kueishan Island, within the “Zone B” legally designated for precious coral harvesting (Huang and Ou 2010; Ministry of Justice, Taiwan 2014), where depths are greater than 130 m with the bottoms typically rocky with low sedimentation. Weighted fishing nets are dragged across the rugged hard substrate, and organisms, such as pieces of targeted precious coral (Family Corallidae), and “by-catch” including corals of fan-shaped octocorallians, occasionally some scleractinians, athecate hydroids, or antipatharians, and crustaceans are entangled within (see Jeng 2014). For the Japanese specimen from Shikoku in Japan (probably collected by tangle nets), the same lot also contained a smaller male specimen of *L. bifidus* (ZRC 2014.0354), indicating that the two species may occur sympatrically.

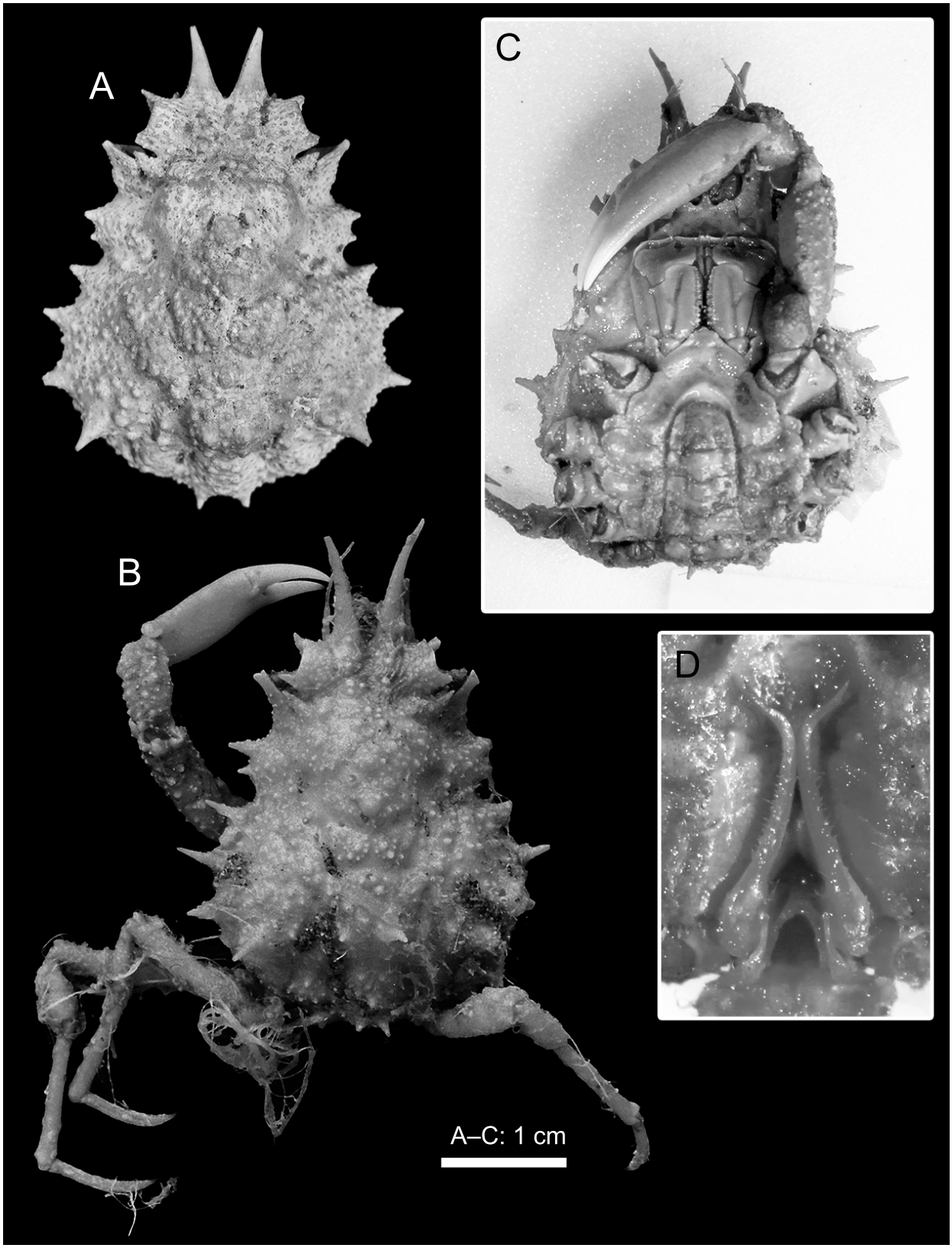

Fig. 1. *Leptomithrax sinensis*: A, overall habitus. *L. bifidus*: B, overall habitus; C: thoracic sternum and pleon; D: G1, in-situ. A, *L. sinensis*, holotype male (25.3 × 32.0 mm) (USNM 48219), northern South China Sea; B-D, *L. bifidus*, lectotype male (25.8 × 32.3 mm) (MZS Cru3193), Sagami Bay, Japan. Photo credits: B by T. Komai; C, D by M. Meister.

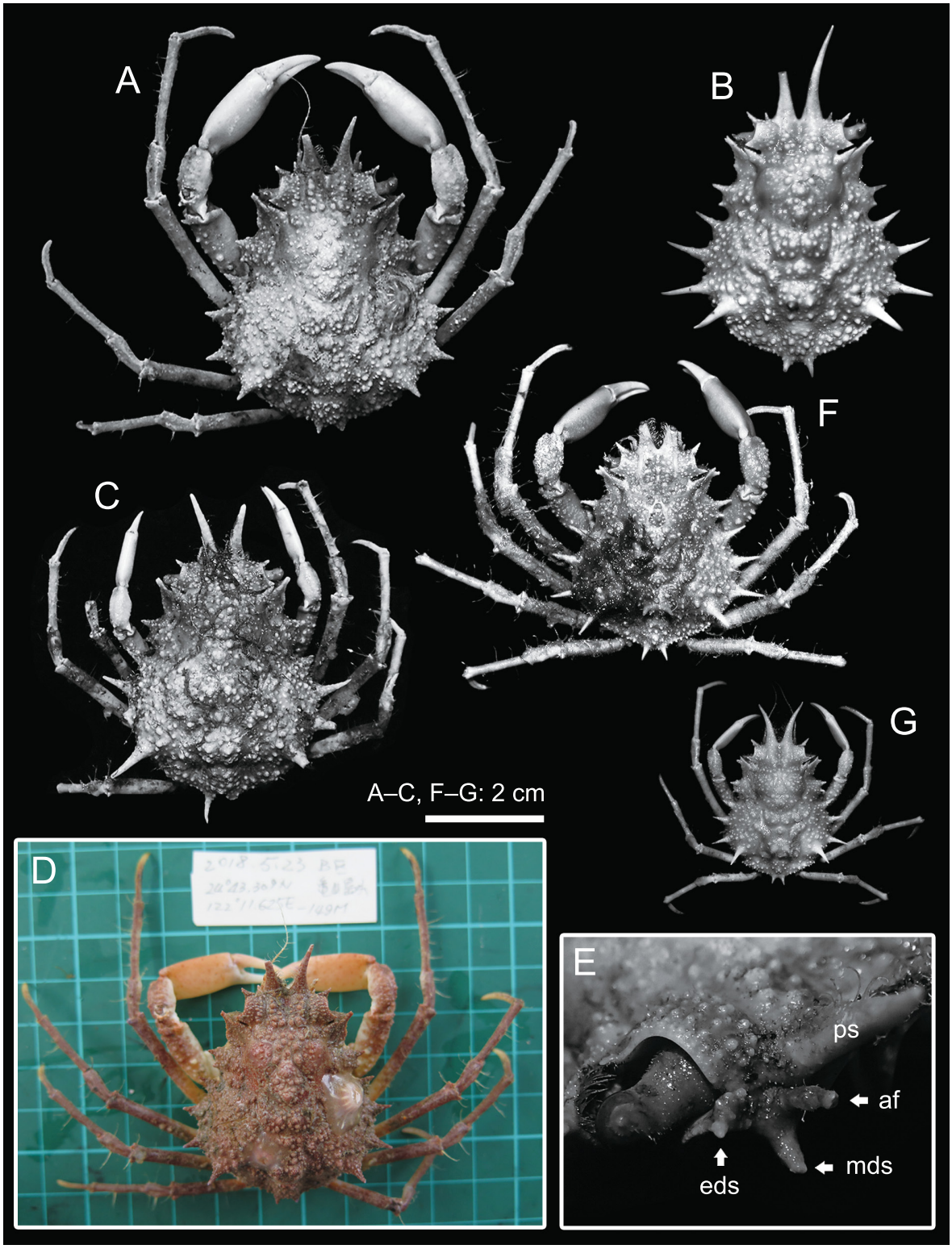

Fig. 2. *Leptomithrax sinensis*: A, C: overall habitus; B: carapace, appendages omitted; D: overall habitus, live coloration; E: right basal antennal articles and position of flagellum: ps, pseudorostral spine; af, antennal flagellum; mds and eds, mesial and external distal spines of antennal article. *L. bifidus*: F, G: overall habitus. A, D, E, *L. sinensis*, male (35.2 × 43.1 mm) (ASIZCR 101305), off NE Taiwan; B, *L. sinensis*, male (32.1 × 40.6 mm) (ZRC 2018.0726), Cape Muroto, Shikoku, Japan; C, *L. sinensis*, female (32.4 × 42.1 mm) (ASIZCR 101304), off NE Taiwan; F, *L. bifidus*, male (27.5 × 32.5 mm) (NHM 1961.11.13.28-29), Seto, Japan; G, *L. bifidus*, male (18.0 × 22.6 mm) (ZRC 2014.0354), Cape Muroto, Shikoku, Japan.

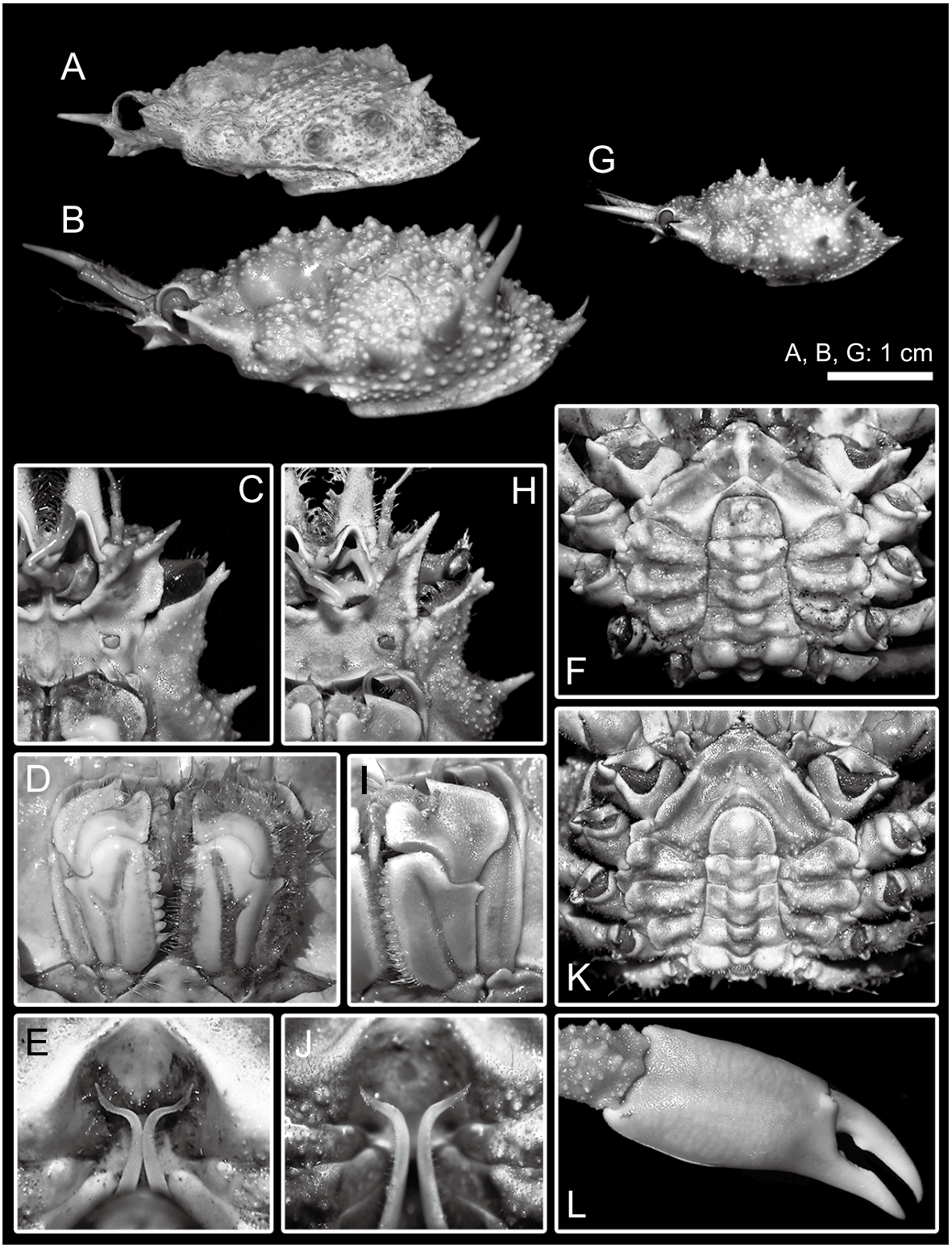

Fig. 3. *Leptomithrax sinensis*: A, B: lateral view of carapace; C: basal antennal article and orbit, ventral view; D: third maxillipeds, right denuded; E: G1, in-situ; F: male thoracic sternite and pleon. *L. bifidus*: G: lateral view of carapace; H: basal antennal article and orbit, ventral view; I: left third maxilliped; J: G1, in-situ; K: male thoracic sternite and pleon; L: right chela. A, *L. sinensis*, holotype (25.3 × 32.0 mm) (USNM 48219), northern South China Sea; B, C, *L. sinensis*, male (32.1 × 40.6 mm) (ZRC 2018.0726); D-F, *L. sinensis*, male (35.2 × 43.1 mm) (ASIZCR 101305); *L. bifidus*, G: male (18.0 × 22.6 mm) (ZRC 2014.0354), Cape Muroto, Shikoku, Japan; H-L, *L. bifidus*, male (27.5 × 32.5 mm) (NHM 1961.11.13.28-29), Seto, Japan.

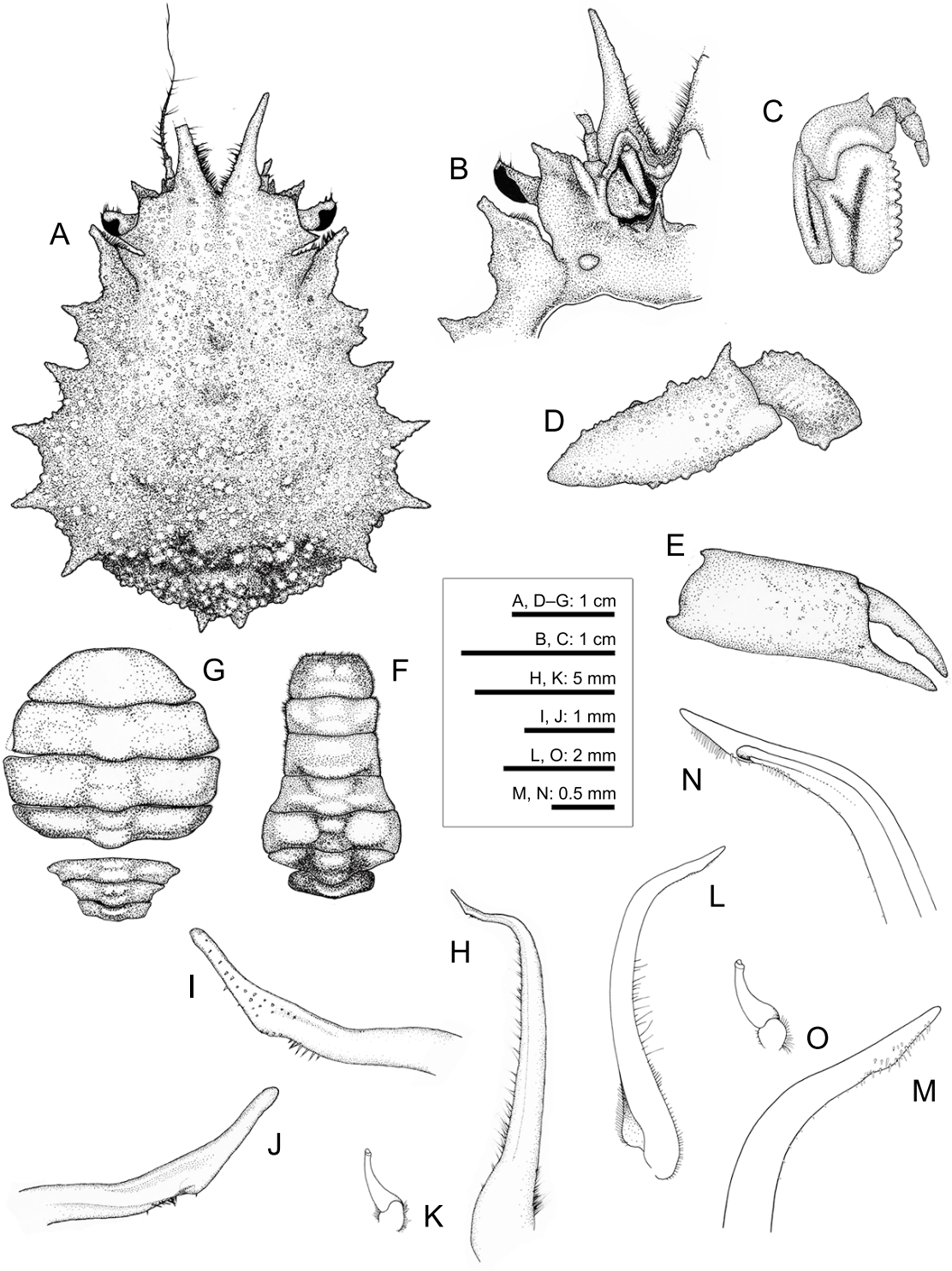

Fig. 4. *Leptomithrax sinensis*: A: carapace; B: basal antennal article and orbit, ventral view; C: right third maxilliped; D: right cheliped merus and carpus, lateral view; E: right chela; F: male pleon; G: female pleon; H: right G1, mesial view; I: tip of right G1, mesial view; J: tip of right G1, lateral view; K: left G2, ventral view. *L. bifidus*: L: left G1, mesial view; M: tip of left G1, mesial view; N: tip of left G1, lateral view; O: left G2, ventral view. A-F, H-J, *L. sinensis*, male (35.2 × 43.1 mm) (ASIZCR 101305), off NE Taiwan; G, *L. sinensis*, female (32.4 × 42.1 mm) (ASIZCR 101304), off NE Taiwan; K, *L. sinensis*, male (32.1 × 40.6 mm) (ZRC 2018.0726), Cape Muroto, Shikoku, Japan; L-O, *L. bifidus*, male (18.0 × 22.6 mm) (ZRC 2014.0354), Cape Muroto, Shikoku, Japan. Structures A, C, F, G denuded.

DISCUSSION

In the original description of *L. sinensis*, the collection site of the holotype was listed as "China Sea, near southern Luzon: lat. 21°33'N.; long. 116°15'E.; 88 fathoms ... station 5311, *Albatross*." These co-ordinates, however, place the location about 240 km southeast off Hong Kong in the northern portion of the South China Sea, rather than near southern Luzon. Station 5311 was sampled during the sail northwards from the Philippines to Hong Kong in November, 1908 (US Bureau of Fisheries 1910).

In addition to the *L. bifidus* material on hand, photographs of the types of *Paramithrax* (*Leptomithrax*) *bifidus* Ortmann, 1893 deposited in the Museum of Zoology in Strasbourg (MZS) were also examined. Ortmann (1893: 53) stated that he had three males and two females from Sagami Bay in Japan collected from 50-100 fathoms by Döderlein in 1881, and all are still extant (Komai 1999). All are syntypes, as Ortmann (1893) did not select a holotype. Given the superficial resemblance of the two *Leptomithrax* species, one of these syntypes, a male specimen measuring 25.8 × 32.3 mm (MZS Cru3193: Fig. 1B-D) is here designated as the lectotype of *Paramithrax* (*Leptomithrax*) *bifidus* Ortmann, 1893, and the other four become paralectotypes.

Comparing only characters of an eroded carapace of *L. sinensis* with the closely resembling *L. bifidus*, Richer de Forges and Ng (2015) suggested that both species may be synonymous, but they nevertheless kept them as distinct species. Tune Sakai (1965), on comparing Japanese *L. bifidus* to the type of *L. sinensis*, noted that, for the latter, the gastric and cardiac spines are weaker, the external orbital tooth has the tip subtruncate (versus not distinctly bifid as in *L. bifidus*) and there is a U-shaped sinus between the external orbital tooth and the basal antennal article. Taking into consideration the present description of fresh material, *L. sinensis* actually differs markedly from *L. bifidus* in many other characters.

Sakai (1965) noted that the postorbital spine of *L. sinensis* tapers into a "sub-truncate" tip (as Figs. 1A; 2A, C; 4A). The tip, however, appears to be slightly variable, from truncate (Figs. 2A; 4A, B) to weakly bifid (Figs. 2B; 3C), in contrast to being distinctly bilobed in *L. bifidus* (Figs. 1B; 2F, G; 3H). The condition of this structure in the holotype carapace of *L. sinensis* in any case has almost certainly been affected by erosion. The two species can be most readily distinguished by the shape of the lateral margin of the postorbital spine: that of *L. sinensis* is markedly convex (Figs. 1A; 2A-C; 3C; 4A) but gently concave in *L. bifidus* (Figs. 1B, 2F, G, 3H). Along the median line of the dorsal carapace surface, *L. sinensis* has two conical tubercles on the gastric region, and another two on the cardiac region, and are relatively low even in larger individuals (Fig. 3A, B). The gastric and cardiac spines in *L. bifidus*, on the other hand, are very pronounced, acute and elongate, even in small specimens (Fig. 3G). In ventral view, the lateral margin of the basal antennal article of *L. sinensis* is markedly convex and forms a constricted keyhole-shaped hiatus with the ventral margin of the postorbital lobe (Figs. 3C; 4B); the same margin of *L. bifidus* is gently concave, with the resultant hiatus broad and not constricted (Fig. 3H).

The third maxilliped of *L. sinensis* is strongly sculptured, with the swollen portions of the ischium and proximal part of the merus glabrous, forming a boss-like structure, the ischium is proportionately more elongate with the Y-shaped groove deep, and the anteroexternal margin of the merus is convex but not distinctly produced (Figs. 3D; 4C). In *L. bifidus*, however, the ischium and merus are only gently swollen, not boss-like, the ischium is proportionately shorter, the Y-shaped groove is distinctly more shallow, and the anteroexteral angle of the merus is conspicuously produced (Fig. 3I). The cheliped carpus of large males of *L. bifidus* is distinctly tubercular (Fig. 2F) while that of *L. sinensis* relatively less tuberculate and just rugose (Figs. 2A, D; 4D).

With regards to the male thoracic sternum of *L. sinensis*, the transverse depressions are prominently much deeper, with the margins and median parts of the third and fourth sternites appearing carinate and the anterior surfaces of sternites 5-7 distinctly concave (Fig. 3F). In *L. bifidus*, the overall surfaces are less excavated: the margins and median parts of the third and fourth sternites are low and not distinctly carinate, and the anterior surfaces of sternites 5-7 are gently concave (Fig. 3K). The male pleon of *L. sinensis* is relatively wider than *L. bifidus*, with the telson very broad, the distally margin gently concave and appearing somewhat trapezoidal (Figs. 3F; 4F) (male pleon relatively narrower with the telson slightly broader than long and sub-semicircular in *L. bifidus*; Fig. 3K). The gonopods of the two species are very different. The G1 of *L. sinensis* is strongly curved laterally along the distal quarter at an angle of nearly 90° with the tip produced into a rounded,

slightly expanded structure and directed somewhat anteriorly (Figs. 3E; 4H-J), whereas in *L. bifidus*, the G1 is less strongly curved and tapers gently into a fine tip that is directed anterolaterally (Figs. 3J; 4L-N). The condition of the G1 does not vary with the size of the specimens, similarly structured in both small and large males (Figs. 3J; 4L-N).

In reporting Japanese species, Sakai (1938 1976) indicated individuals of *L. edwardsii* carrying sea anemones on carapaces, whereas none thus far have been observed for *L. bifidus*. It is interesting to note the male specimen of *L. sinensis* from northeastern Taiwan carried two sea anemones (Fig. 2A, D), but this behavior was not observed in the Japanese specimen. The ecological significance of this is not known.

The distinctions between *L. sinensis* and the two northwestern Pacific congeners have been discussed by Rathbun (1916) and Richer de Forges and Ng (2015) based on carapace features alone. The above comparisons supplement these studies in considerable detail. *Leptomithrax edwardsii* reaches a much larger size than *L. sinensis*, growing to carapace widths of over 50 mm, and its carapace is more evenly ovate, with the postorbital spine extending into an acute tip anteriorly, and the lateral margin of the basal antennal article is concave and entire (cf. Sakai 1976; unpublished data) (versus hepatic regions somewhat constricted, giving carapace a more pyriform appearance, the distal part of the postorbital spine is more slender with the tip subtruncate to bifid, and the lateral margin of the basal antennal article is markedly convex in *L. sinensis*; Figs. 1A; 2A-D; 3C; 4A, B). Pseudorostral spines of *Leptomithrax eldredgei* are straight, narrowly triangular, and directed anteriorly; the postorbital lobe is broad and foliaceous, anteriorly forming two flattened lobes and the G1 is also proportionately shorter with the distal part not elongate and sinuous (Richer de Forges and Ng 2015; versus the pseudorostral spines elongate and gently curving laterally, the postorbital lobe more narrow and triangular, and the G1 proportionately longer with the distal part elongate in *L. sinensis*; Figs. 1A; 2A-D; 3C; 4A, H-J).

The morphology of *L. sinensis* and *L. bifidus*, as well as the other two northwestern Pacific congeners (*L. edwardsii* and *L. eldredgei*), corresponds to the concept of the subgenus *Austromithrax* Bennett, 1964 (together with seven Australasian species) in the form of basal antennal article (Figs. 3C, H; 4B) in which the external distal spine is prominently elongated and visible in dorsal view, and the flagellum is clearly separated from the orbit (Fig. 2E); the posterior margin of carapace armed with two spines (Figs. 1A, B; 2; 4A); the ischium of the third maxilliped subrectangular with the external margin possessing a distal spine (Figs. 3D, I; 4C); and the male thoracic sternum distinctly excavated (Figs. 3F, K) (see Ng and Richer de Forges 2015). Griffin (1966a) and Griffin and Tranter (1986) discussed the subgeneric issues but did not use a subgeneric arrangement for *Leptomithrax*. The structure of these subgenera (or genera) will need to be addressed when all the taxa are examined and considered.

The diversity of Majidae s. str. in Taiwan is not high, and only 17 species have recorded thus far (Ng et al. 2017); the only *Leptomithrax* species known thus far had been *L. edwardsii* (De Haan, 1835) (see also Wang et al. 2017). The addition of *L. sinensis* to the Taiwanese fauna is thus of considerable interest.

Acknowledgments: The authors thank Tomoyuki Komai (Natural History Museum and Institute, Chiba, Japan), Marie Meister and Dominique Wandhammer (MZS), Paul Clark (NHM), Takehiru Sato (KPM), and Rafael Lemaitre and Karen Reed (USNM) for giving access to their material. We are especially grateful to T. Komai for his help with the types. KJHW thanks Benny K. K. Chan (ASIZCR) for allowing use of laboratory facilities, and Anyi Cheng (ASIZCR) for help with the specimens and manuscript. We also thank the anonymous reviewers for their very helpful suggestions and comments. This study was partially sponsored by the Fisheries Agency, Council of Agriculture, Executive Yuan, Taiwan. (107AS-9.2.1-FA-F1).

Author's contributions: MSJ provided Taiwanese specimens of *L. sinensis*. KJHW compiled morphological descriptions and drafted the manuscript. PKLN examined other relevant material from various institutes, and substantially modified the manuscript. All authors read and approved the final manuscript.

Competing interests: KJHW, PKLN and MSJ declare no conflicts of interest.

Availability of data and materials: Material examined in this study have been deposited in the following institutes: Biodiversity Research Museum, Academia Sinica, Nankang (ASIZCR), Taiwan; Kanagawa Prefectural Museum of Natural History (KPM), Kanagawa, Japan; Museum of

Zoology, Strasbourg (MZS), France; The Natural History Museum (NHM), London, U.K.; U.S. National Museum of Natural History, Smithsonian Institution (USNM), Washington D.C.; and Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum, National University of Singapore.

Consent for publication: Not applicable.

Ethics approval consent to participate: Not applicable.

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