

## *Aiyunamon*, a new genus for southern Chinese potamid species previously placed in *Eosamon* Yeo & Ng, 2007 (Decapoda: Brachyura: Potamidae)

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**Abstract.** Four species of Chinese potamid freshwater crabs currently placed in *Eosamon* Yeo & Ng, 2007 are assigned to a new genus, *Aiyunamon*. While the new genus is morphologically close to *Eosamon*, *Indochinamon* Yeo & Ng, 2007, and *Doimon* Yeo & Ng, 2007, it possesses a distinctive combination of carapace, male pleon, male first gonopod, and vulva characters that easily distinguishes it. This distinction is supported by genetic data. The new genus is described and compared with allied genera. *Eosamon* species are now restricted to Indochina.

**Key words.** Potamoidea, Potamiscinae, taxonomy, Yunnan, freshwater crab

### INTRODUCTION

The freshwater crab genus *Eosamon* Yeo & Ng, 2007, was established for a group of species earlier attributed to *Potamon* sensu lato (Yeo & Ng, 2007). It currently contains 12 recognised species with a disjunct distribution (Yeo & Ng, 2007; Yeo, 2010; Zhang et al., 2020). Eight species, *E. boonyaratae* (Naiyanetr, 1987), *E. brousmichei* (Rathbun, 1904), *E. hafniense* (Bott, 1966), *E. nominathuis* Yeo, 2010, *E. paludosum* (Rathbun, 1904), *E. phuphanense* (Naiyanetr, 1992), *E. smithianum* (Kemp, 1923) (type species), and *E. yotdomense* (Naiyanetr, 1984), are distributed in eastern-northeastern Thailand and southern Vietnam, while the other four species, *E. daiae* Zhang & Sun, 2020, *E. lushuiense* (Dai & Chen, 1985), *E. tengchongense* (Dai & Chen, 1985), and *E. tumidum* (Wood-Mason, 1871), are found primarily in southwestern China.

Even as they established *Eosamon*, Yeo & Ng (2007) highlighted that the type specimens of three species from China were not well studied and their inclusion in the genus was provisional. Studies by Zhang et al. (2020: fig. 12) and Pan et al. (2022: fig. 4) have confirmed their concerns, showing that *Eosamon* species from China are genetically distinct. In this study, the four Chinese *Eosamon* species are formally transferred to their own genus, *Aiyunamon* (Fig. 1).

### MATERIAL AND METHODS

The specimens that were examined are deposited in the Nanjing Normal University, Jiangsu, China (NNU); National Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences, Beijing, China (IZCAS); and Zoological Reference Collection, Lee Kong Chian Natural History Museum, National University of Singapore, Singapore (ZRC). The terminology used follows Ng (1988) and Davie et al. (2015). The following abbreviations are used: G1, male first gonopod; G2, male second gonopod. Measurements provided are of the maximum carapace width and length, respectively.

Genomic DNA of *Aiyunamon tumidum* was extracted from gill tissue using the Cell and Tissue DNA Extraction Kit (Generay Biotech). Partial sequence of 16S rRNA gene was amplified following Ji et al. (2016) and deposited under the GenBank accession number: OL853518 (voucher number: NNU 319301), OL853819 (voucher number: NNU 324401), and OL853520 (voucher number: NNU 314101). After combining with publicly available sequences downloaded from GenBank, sequences were aligned using MAFFT 7.310 (Katoh & Standley, 2013). Maximum Likelihood (ML) analysis was performed using IQ-TREE 1.6.12 (Nguyen et al., 2015). Bootstrap values (BS) were obtained through 1,000 ultra-fast bootstrap replicates (Minh et al., 2013). Best substitution model was estimated with the ‘-m TEST’ option (Kalyaanamoorthy et al., 2017). Phylogenetic tree was visualised using iTOL 5 (Letunic & Bork, 2021).

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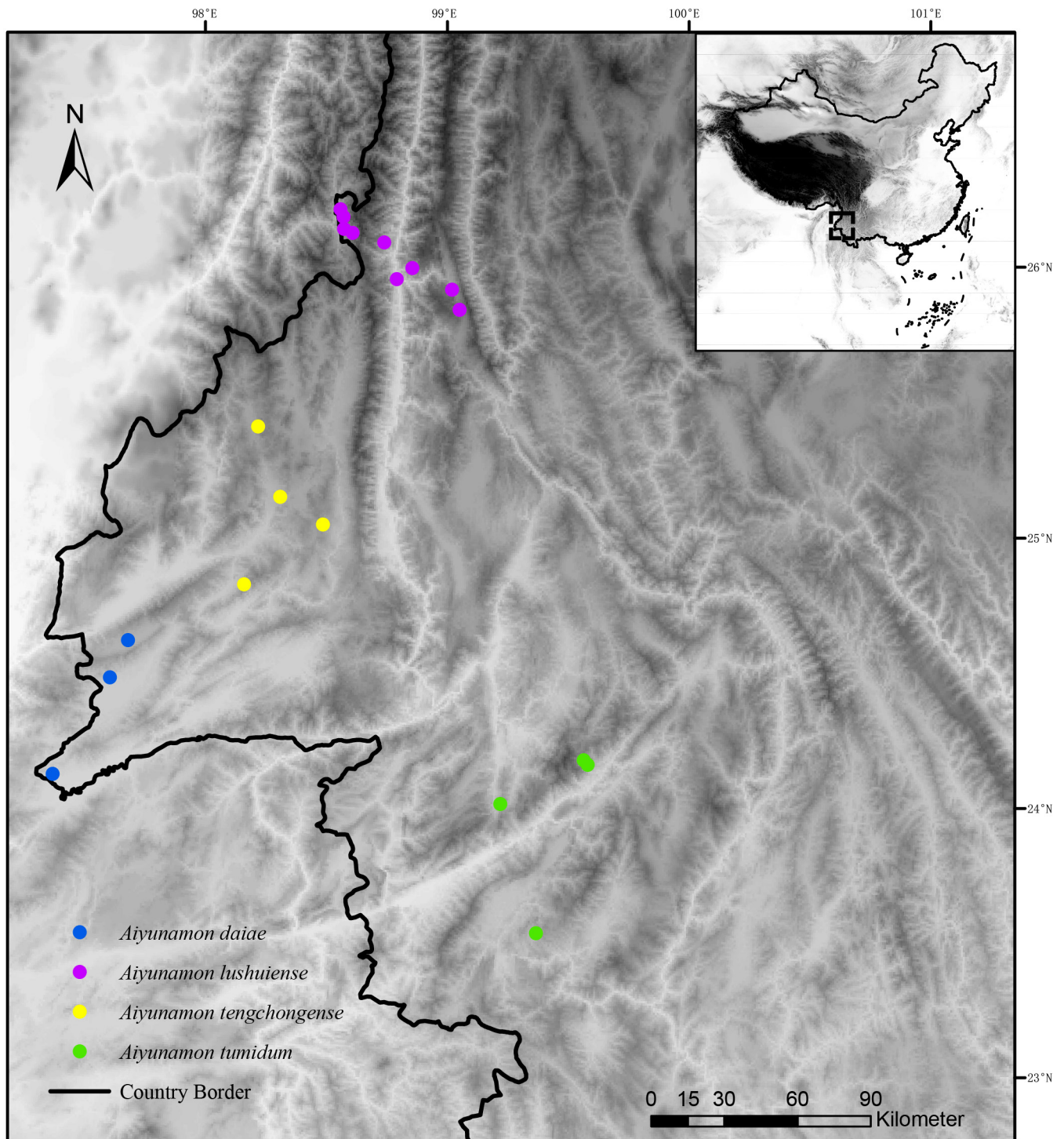


Fig. 1. Distribution of *Aiyunamon* species. Species occurrence records were obtained through long-term field surveys by the Chinese authors.

## SYSTEMATICS

Family Potamidae Ortmann, 1896

Subfamily Potamiscinae Bott, 1970

*Aiyunamon*, new genus

**Type species.** *Eosamon daiae* Zhang & Sun, 2020, by present designation.

**Material examined.** *Aiyunamon daiae* (Zhang & Sun, 2020): 1 male (26.6 × 22.2 mm, NNU 190503) (holotype), Bangyang Village, Longba Town, Longchuan County, Dehong Prefecture, Yunnan Province, China, coll. X. Hao & Z. Zhang, 5 May 2019; 1 female (20.1 × 16.5 mm, NNU 190505) (paratype), same data as holotype. *Aiyunamon lushuiense* (Dai & Chen, 1985): 1 male (26.5 × 22.1 mm, NNU 148401), Wagu Village, Liuku Town, Lushui City, Yunnan Province, China, coll. K. Chu, P. Wang & H. Sun, 4 May 2016; 1 female (21.4 × 18.3 mm, NNU 282103), Shuishan Village, Lushui City, Yunnan Province, China,



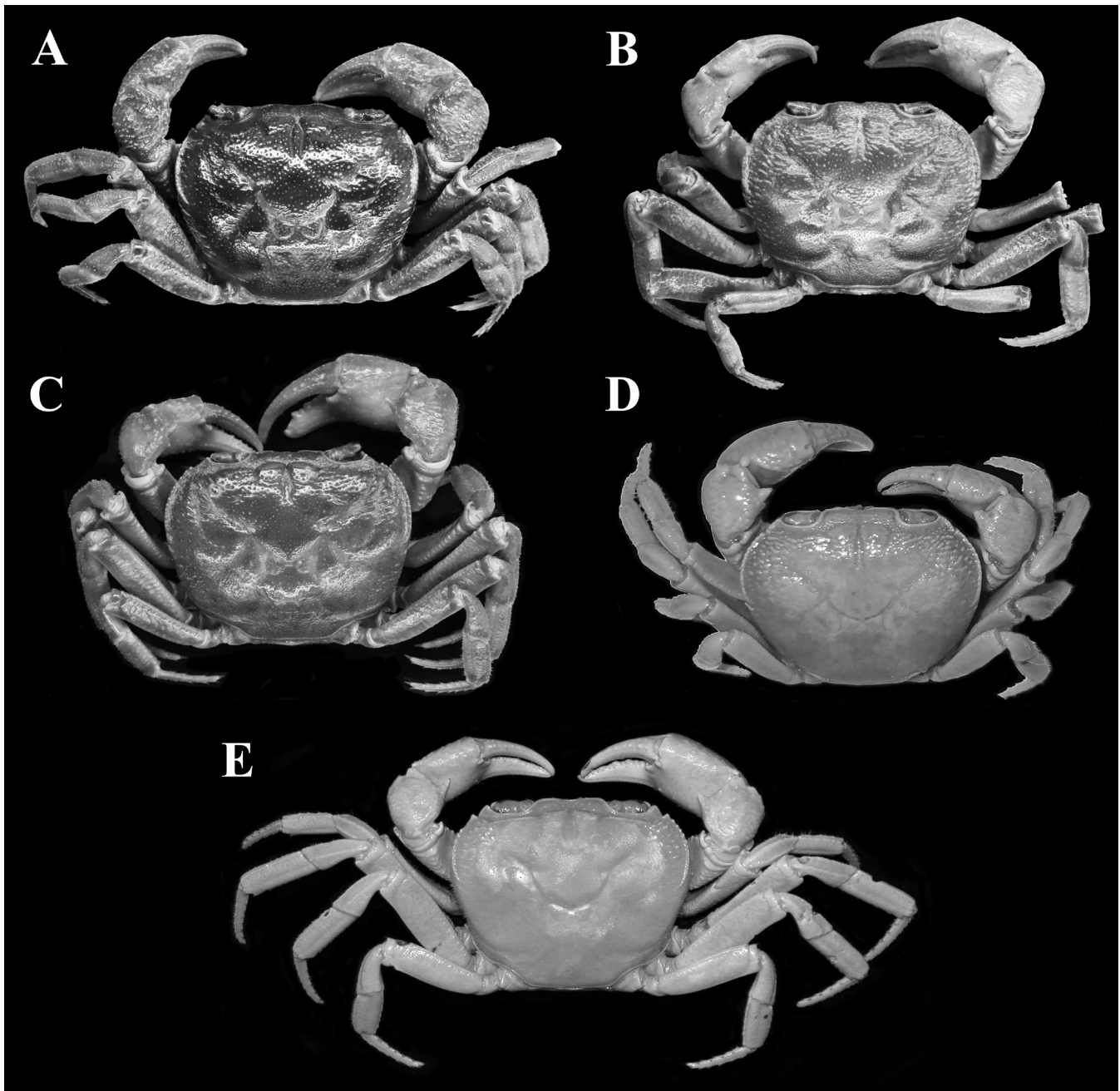


Fig. 2. Overall habitus of species of *Aiyunamon*, new genus, and *Eosamon smithianum* (Kemp, 1923). A, *A. daiae* (Zhang & Sun, 2020), NNU 190503; B, *A. lushuiense* (Dai & Chen, 1985), NNU 148401; C, *A. tengchongense* (Dai & Chen, 1985), NNU 193261; D, *A. tumidum* (Wood-Mason, 1871), IZCAS CB11382; E, *E. smithianum*, ZRC 1990.498.

coll. K. Chu, P. Wang & H. Sun, 4 May 2016. *Aiyunamon tengchongense* (Dai & Chen, 1985): 1 male ( $37.9 \times 30.1$  mm, NNU 193261), Lianghe County, Yunnan Province, China, coll. X. Hao & Z. Zhang, 9 May 2019; 1 female ( $25.5 \times 20.5$  mm, NNU 282202), Hongdoushu Village, Menglian County, Tengchong City, Yunnan Province, China, coll. K. Chu, P. Wang & H. Sun, 5 May 2016. *Aiyunamon tumidum* (Wood-Mason, 1871): 1 male ( $23.2 \times 18.7$  mm, IZCAS CB11382), Sipai Mountain, Yunnan Province, China, coll. 1964; 1 female ( $23.6 \times 18.4$  mm, IZCAS CB11383), Sipai Mountain, Yunnan Province, China, coll. 1964. *Eosamon smithianum* (Kemp, 1923): 1 male ( $49.6 \times 39.1$  mm, ZRC 1990.498–514), 1 female ( $39.5 \times 33.4$  mm, ZRC 1990.498–514), Krating Waterfall area, near Kitchagood National Park,

eastern Thailand, fast flowing water with smooth rocks, sand substrate, coll. P. K. L. Ng, December 1988.

**Diagnosis.** Carapace slightly broader than long, dorsal surface slightly convex, regions distinctly defined; epigastric cristae distinct, rugose, separated from postorbital cristae by shallow groove; postorbital cristae distinct, rugose; H-shaped groove distinct (Figs. 2A–D, 3A–D). Frontal margin slightly sinuous, gently concave medially, placed anterior to level of external orbital angles; external orbital angle low, separated from rest of margin by small or shallow cleft; epibranchial tooth low, not prominent; anterolateral margins slightly convex, cristate, lined with distinct granules; posterolateral margins gently converging posteriorly (Fig. 2A–D). Third maxilliped

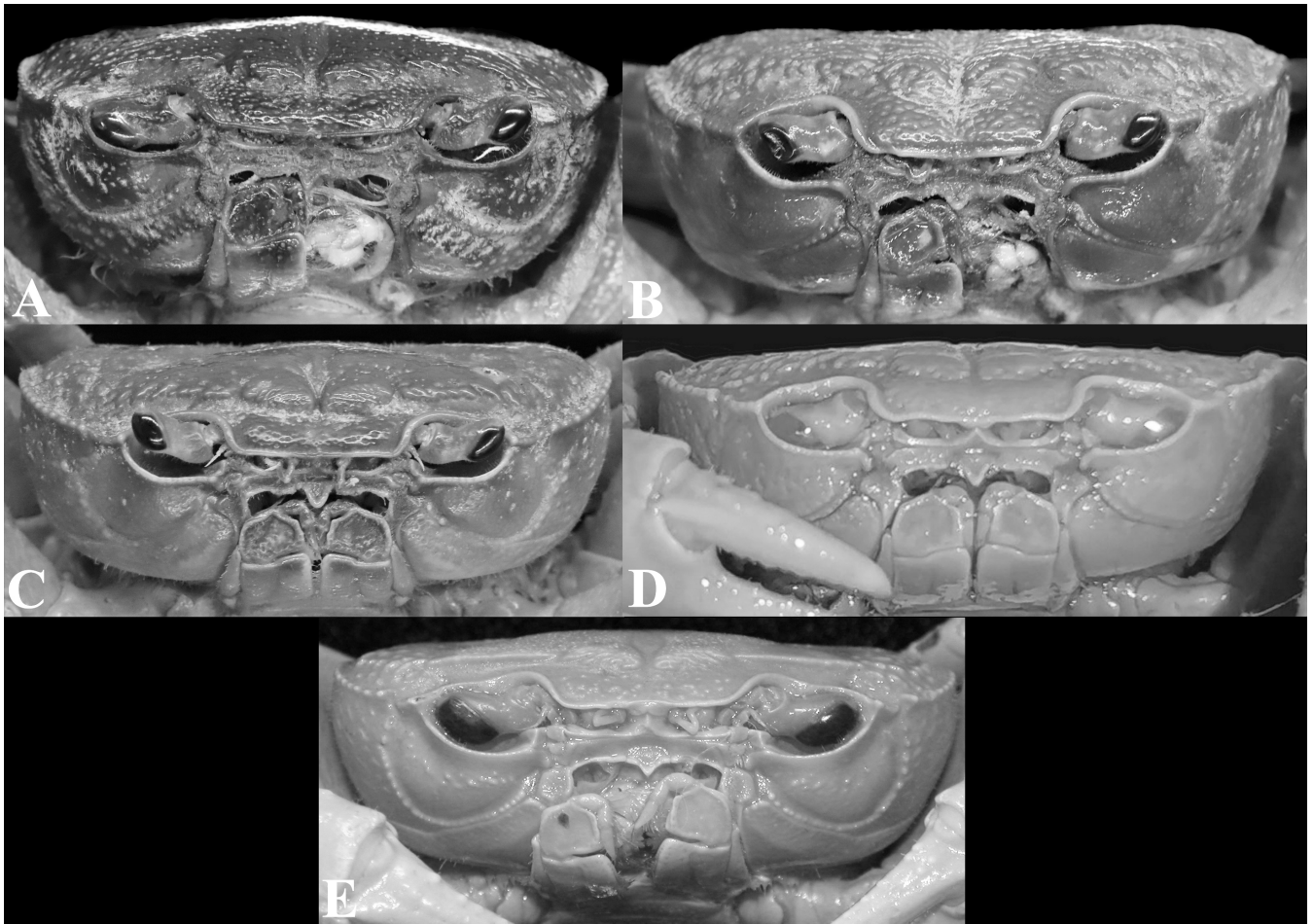


Fig. 3. Frontal view of carapace of species of *Aiyunamon*, new genus, and *Eosamon smithianum* (Kemp, 1923). A, *A. daiae* (Zhang & Sun, 2020), NNU 190503; B, *A. lushuiense* (Dai & Chen, 1985), NNU 148401; C, *A. tengchongense* (Dai & Chen, 1985), NNU 193261; D, *A. tumidum* (Wood-Mason, 1871), IZCAS CB11382; E, *E. smithianum*, ZRC 1990.498.

exopod with long flagellum. Male pleon triangular, lateral margins almost straight (Fig. 4A–D). G1 curved outwards; distal part of outer margin of subterminal segment at junction with terminal segment deeply concave; terminal segment conical, straight to slightly curved, without dorsal flap (Fig. 5A–D, F–I); G2 slender. Female vulvae with anterior margin appressed against suture of thoracic sternites 5/6, ovate, without operculum (Fig. 6A–D).

**Etymology.** The genus is named after the late Prof. Aiyun Dai, in honour of her immense contributions to Chinese freshwater crab taxonomy. Gender of genus neuter.

**Remarks.** This new genus currently contains four species, *Aiyunamon daiae* (Zhang & Sun, 2020) (type species), *A. lushuiense* (Dai & Chen, 1985), *A. tengchongense* (Dai & Chen, 1985), and *A. tumidum* (Wood-Mason, 1871).

Morphologically, *Aiyunamon* is most similar to *Eosamon* but can be separated by the following characters: postorbital cristae rugose (Figs. 2A–D, 3A–D) (versus postorbital cristae sharp in *Eosamon*; Figs. 2E, 3E; cf. Yeo & Ng, 2007: fig. 5); external orbital angle low, separated from the lateral margin by shallow cleft (Figs. 2A–D, 3A–D) (versus external orbital angle prominent, separated from lateral margin by deep cleft in *Eosamon*; Figs. 2E, 3E; cf. Yeo & Ng, 2007:

fig. 5); epibranchial tooth indistinct (Fig. 2A–D) (versus epibranchial tooth distinct, sharp in *Eosamon*; Fig. 2E; cf. Yeo & Ng, 2007: fig. 5); male pleon lateral margins straight (Fig. 4A–D) (versus male pleon lateral margins slightly concave in *Eosamon*; Fig. 4E; cf. Yeo & Ng, 2007: fig. 5); G1 subterminal segment with distal part of outer margin, at junction with terminal segment, deeply concave (Fig. 5A–D, F–I) (versus G1 outer margin of subterminal segment gradually tapering to junction with terminal segment, margin appearing gently concave in *Eosamon*; Fig. 5E, J; cf. Yeo & Ng, 2007: fig. 5); G1 terminal segment without any trace of dorsal flap (Fig. 5A–D, F–I) (versus G1 terminal segment with low, broad dorsal flap in *Eosamon*; Fig. 5E, J; cf. Yeo & Ng, 2007: fig. 5); and anterior margin of female vulvae appressed on suture of thoracic sternites 5/6, without operculum (Fig. 6A–D) (versus only anterior edge of female vulvae touching suture of thoracic sternites 5/6, with distinct lateral operculum present in *Eosamon*; Fig. 6E).

*Aiyunamon* is also superficially similar to *Indochinamon* Yeo & Ng, 2007 which is also present in southwestern China. *Aiyunamon* can easily be distinguished by its proportionately less transverse carapace (Fig. 2A–D) (versus more transverse carapace in *Indochinamon*; cf. Yeo & Ng, 1998: fig. 7D); the epigastric cristae being separated from postorbital cristae by shallow groove (Fig. 2A–D) (versus epigastric



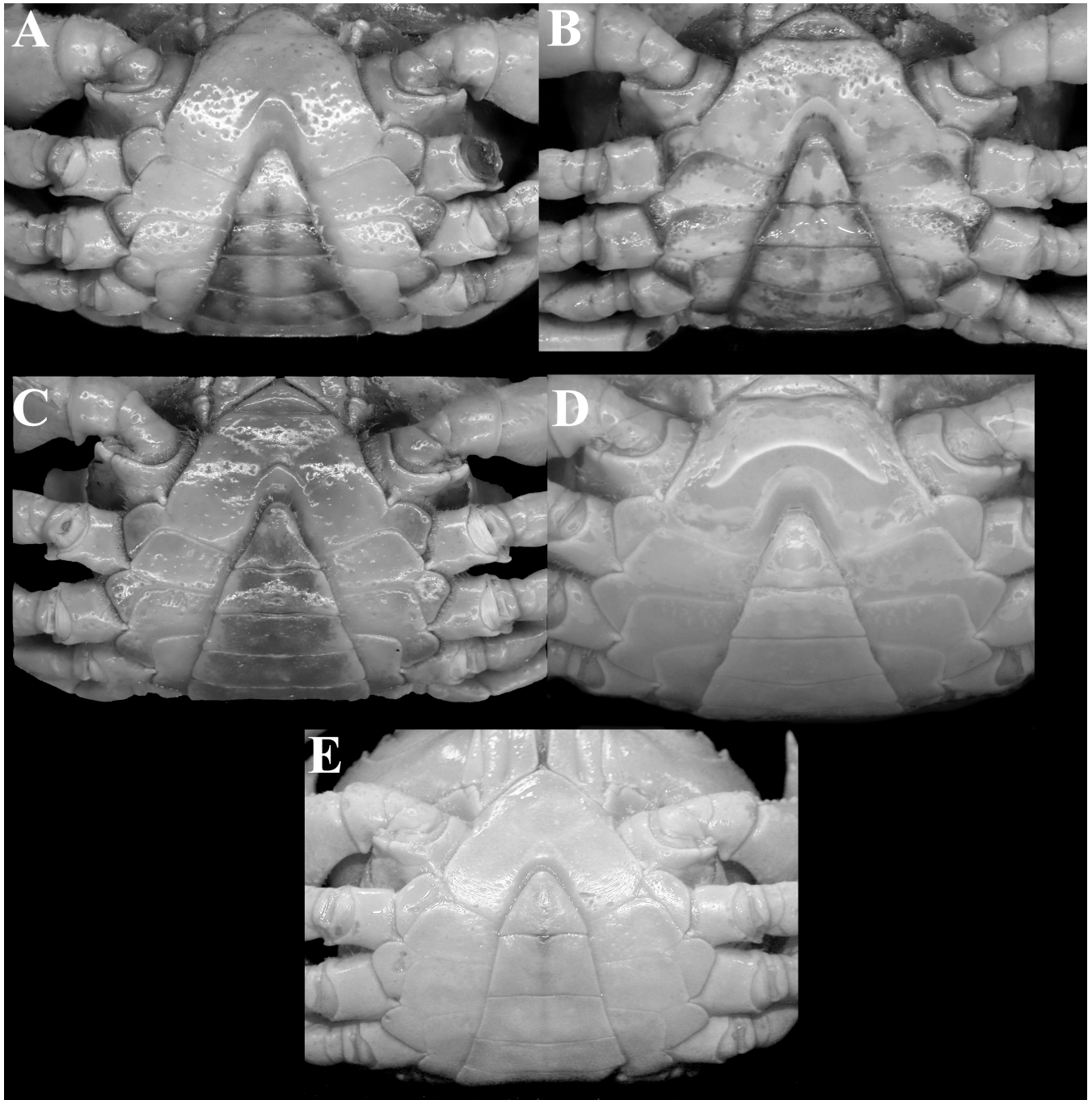


Fig. 4. Male pleon of species of *Aiyunamon*, new genus, and *Eosamon smithianum* (Kemp, 1923). A, *A. daiae* (Zhang & Sun, 2020), NNU 190503; B, *A. lushuiense* (Dai & Chen, 1985), NNU 148401; C, *A. tengchongense* (Dai & Chen, 1985), NNU 193261; D, *A. tumidum* (Wood-Mason, 1871), IZCAS CB11382; E, *E. smithianum*, ZRC 1990.498.

cristae being separated from postorbital cristae by distinct groove in *Indochinamon*; cf. Yeo & Ng, 1998: fig. 7D; the external orbital angle is low and separated from the rest of the margin only by a shallow cleft (Figs. 2A–D, 3A–D) (versus well-developed external orbital angle separated from rest of margin by a deep cleft in *Indochinamon*; cf. Yeo & Ng, 1998: fig. 7D); the low epibranchial teeth (Fig. 2A–D) (versus more distinct, sharp epibranchial teeth in *Indochinamon*; cf. Yeo & Ng, 1998: fig. 7D) and relatively more slender G1 terminal segment (Fig. 5A–D, F–I) (versus relatively stouter terminal segment in *Indochinamon*; cf. Yeo & Ng, 1998: fig. 5I, J). The carapace of *Aiyunamon* can be distinguished from *Doimon* Yeo & Ng, 2007 by the same

suite of features as in *Indochinamon* (cf. Naiyanetr & Ng, 1990: fig. 4); and the G1 terminal segment is gently curved to straight and without any dorsal flap (Fig. 5A–D, F–I) (versus more curved terminal segment with a clear dorsal flap in *Doimon*; cf. Naiyanetr & Ng, 1990: fig. 5A–C). *Aiyunamon* differs from *Iomon* Yeo & Ng, 2007 in having the external orbital angle low and separated from the rest of the margin only by a shallow cleft (Fig. 2A–D) (versus external orbital angle relatively large, broadly triangular in *Iomon*; cf. Ng & Naiyanetr, 1993: fig. 13), and the G1 slightly bent outwards (Fig. 5A–D, F–I) (versus G1 distinctly bent outwards in *Iomon*; cf. Ng & Naiyanetr, 1993: fig. 48).

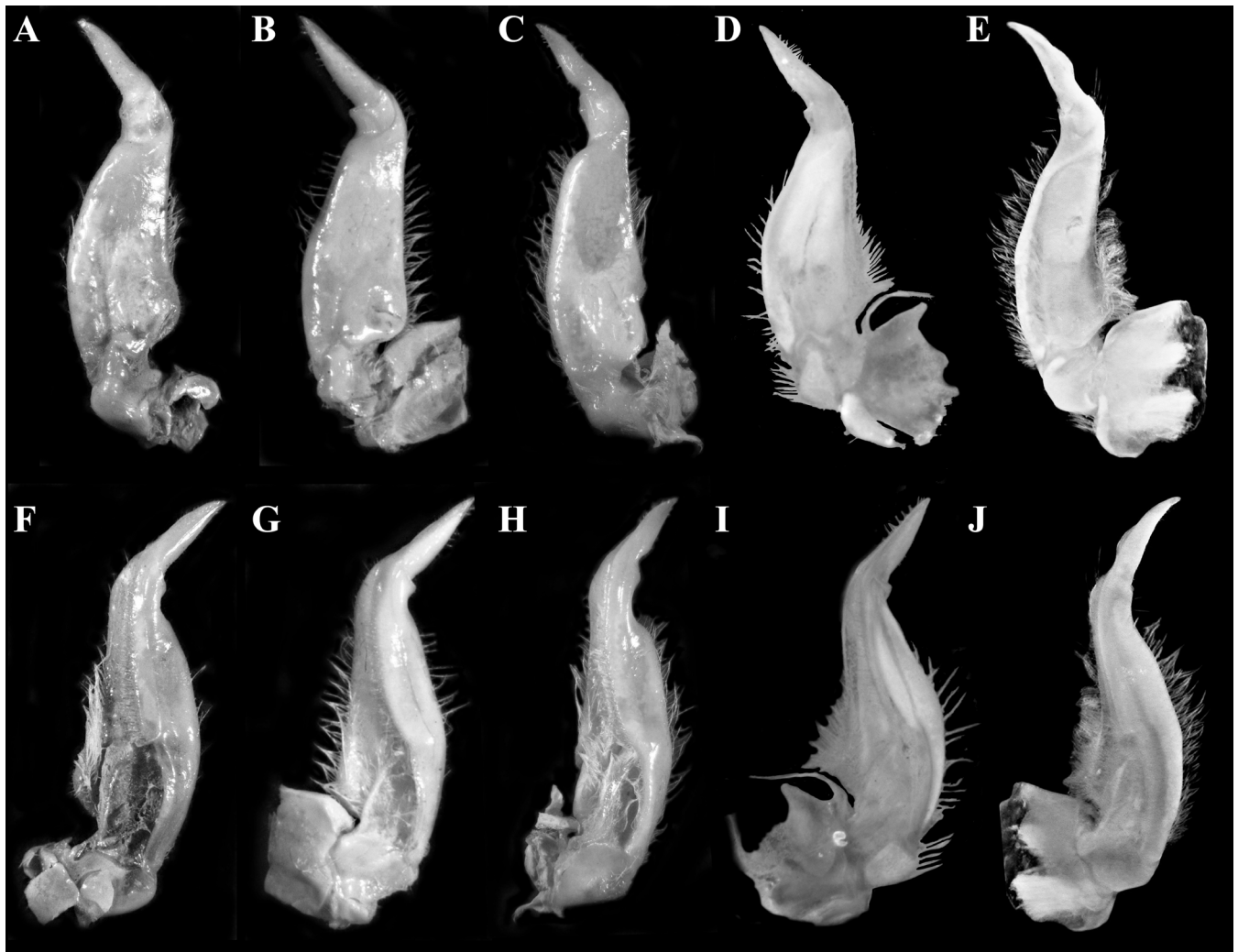


Fig. 5. Male first gonopod (G1) of species of *Aiyunamon*, new genus, and *Eosamon smithianum* (Kemp, 1923). A, F, *A. daiae* (Zhang & Sun, 2020), NNU 190503; B, G, *A. lushuiense* (Dai & Chen, 1985), NNU 148401; C, H, *A. tengchongense* (Dai & Chen, 1985), NNU 193261; D, I, *A. tumidum* (Wood-Mason, 1871), IZCAS CB11382; E, J, *E. smithianum*, ZRC 1990.498. A–D, right G1, dorsal view; F–I, right G1, ventral view; E, J, left G1, dorsal and ventral views, respectively (laterally transposed for comparisons).

In its external features, *Aiyunamon* is also superficially similar to *Potamiscus montosus* Dai, Song, He, Cao, Xu & Zhong, 1975, and *P. yiwuensis* Dai & Cai, 1998. The new genus, however, is easily separated by possessing a distinct flagellum on the third maxilliped exopod (cf. Dai, 1999: figs. 91, 92, 93; Zhang et al., 2020: fig. 4) (versus absent or vestigial flagellum in *Potamiscus*; cf. Dai & Cai, 1998: fig. 2; Dai, 1999: fig. 99) and the relatively slender G1 terminal segment (Fig. 5A–D, F–I) (versus relatively stouter G1 terminal segment in *Potamiscus*; cf. Dai & Cai, 1998: figs. 5, 6; Dai, 1999: fig. 99).

The confirmed distribution of *Aiyunamon* is southwestern Yunnan (Fig. 1), about 1,300–1,700 m above sea level. *Aiyunamon tumidum* was described from Yunnan and upper Myanmar (Wood-Mason, 1871: 454) but we are not certain if all his specimens belong to the same species; they will need to be re-examined. Yeo & Ng (2007: 304) recorded one syntype male and seven non-type specimens of *A. tumidum* in their revision of the Potamidae, but all were from Yunnan. *Aiyunamon* species are usually found hiding under stones and/or burrowing on the banks of shallow

hilly streams, and they have also been found in holes on the ridges of rice fields. The burrows in the rice fields are about 30–50 cm deep.

The dispersal abilities and fecundity of freshwater crabs are relatively low. As such, genera usually do not have disjunct distributions, especially for highland taxa. Therefore, as exemplified by this study, genera with disjunct distributions should be restudied to see if the taxa are monophyletic. Another case is *Tenuipotamon* Dai, 1990, which also has a disjunct distribution, but studies have since shown that the genus is not monophyletic (cf. Pan et al., 2022: figs. 2, 3).

## MOLECULAR RESULTS & DISCUSSION

All four *Aiyunamon* species as well as three *Eosamon* species, including the type species of the genus, *E. smithianum* (Kemp, 1923), were included in our phylogenetic analysis. While all *Aiyunamon* species were clustered together with moderate support value (bootstrap value = 70), *Aiyunamon* and *Eosamon* species segregated to different clades with the



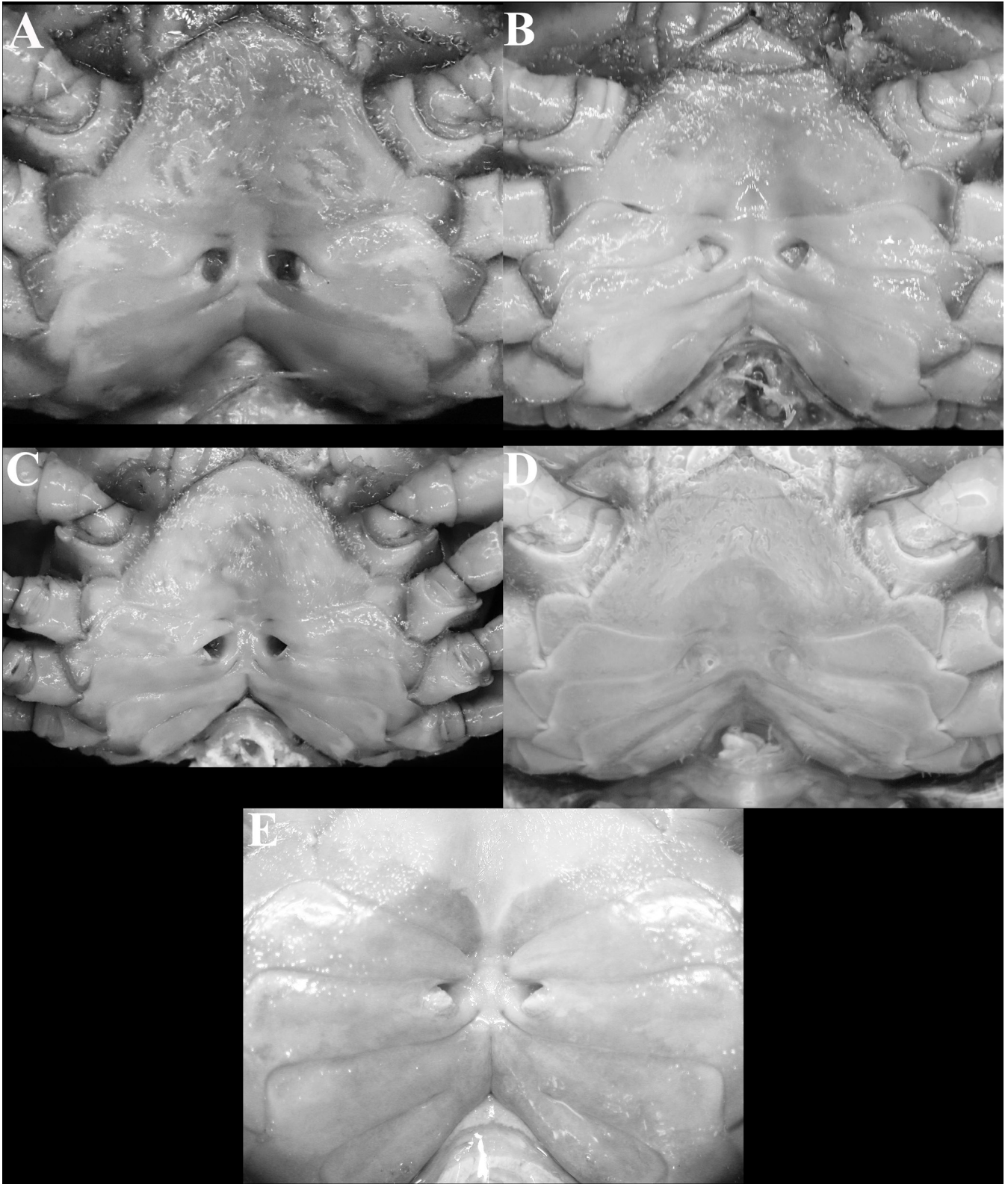


Fig. 6. Vulvae of species of *Aiyunamon*, new genus, and *Eosamon smithianum* (Kemp, 1923). A, *A. daiae* (Zhang & Sun, 2020), NNU 190505; B, *A. lushuiense* (Dai & Chen, 1985), NNU 282103; C, *A. tengchongense* (Dai & Chen, 1985), NNU 282202; D, *A. tumidum* (Wood-Mason, 1871), IZCAS CB11383; E, *E. smithianum*, ZRC 1990.498.

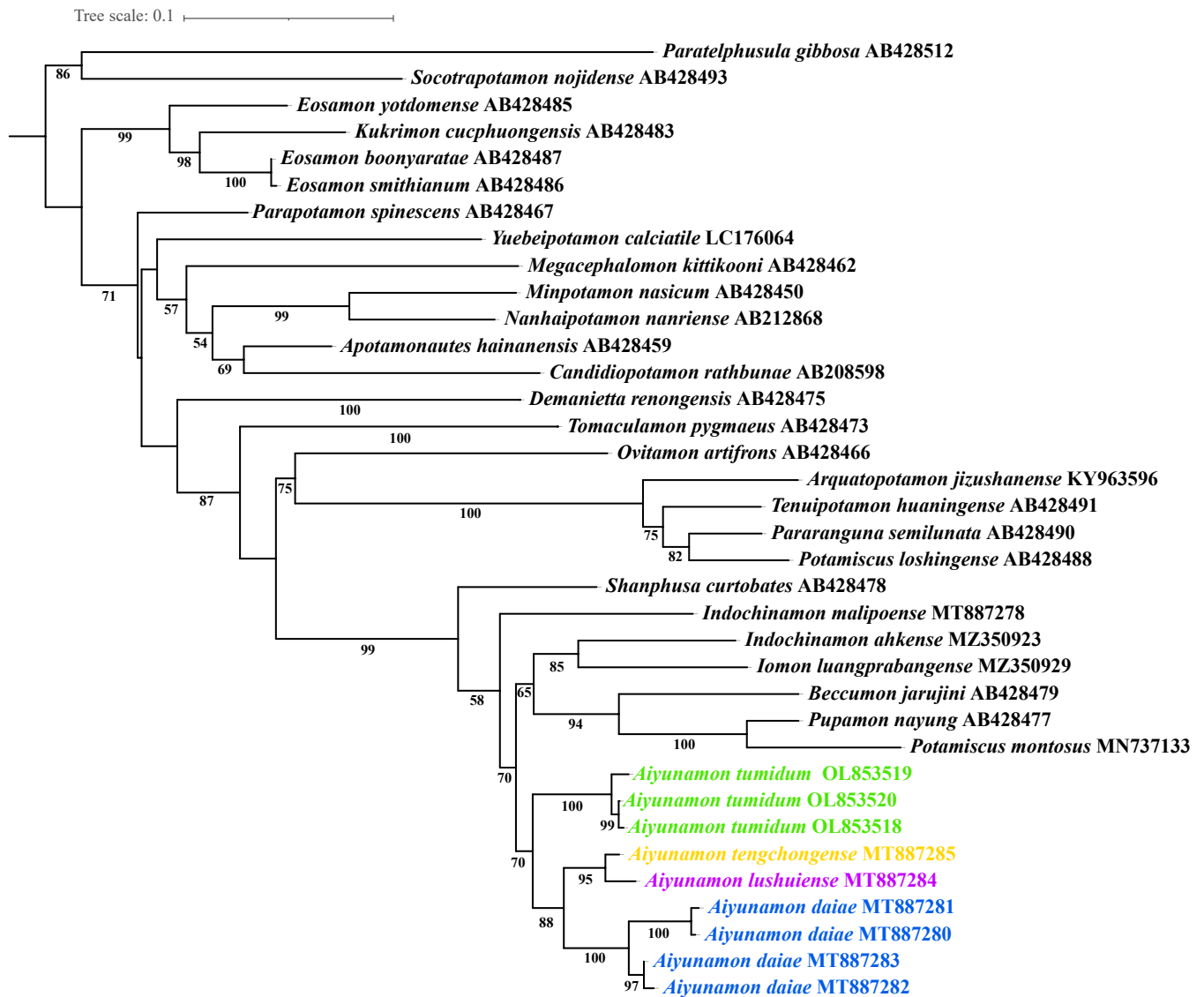


Fig. 7. Maximum Likelihood phylogenetic tree based on 16S rRNA gene sequences of potamid crabs including *Aiyunamon*, new genus, and *Eosamon* Yeo & Ng, 2007. Bootstrap values over 50 are shown on branches. The accession numbers are provided along with species names.

divergence being quite major (Fig. 7). The result confirmed the genetic distinctiveness between *Aiyunamon* and *Eosamon* (cf. Pan et al., 2022: fig. 4). Our phylogenetic analysis, based on 16S rRNA gene sequences, supports the establishment of the new genus, *Aiyunamon*.

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