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Mongolodiaptomus mekongensis, a new species of copepod (Copepoda, Calanoida, Diaptomidae) from temporary waters in the floodplain of the lower Mekong River Basin

La-orsri Sanoamuang[1,2] & Santi Watiroyram[3*]

Abstract. Freshwater copepods in the genus *Mongolodiaptomus* Kiefer, 1938 are known to occur in Asia. Of the thirteen species of this genus reported, ten are recorded from the lower Mekong River Basin (Thailand, Cambodia, Laos, and Vietnam). Collections from several temporary waters in the floodplain of lower Mekong River Basin resulted in the identification of a new species of *Mongolodiaptomus*. We describe the new species collected from several habitats in Ubon Ratchathani province of Thailand, Champasak province of Laos, Binh Phuoc province of Vietnam, and five provinces of Cambodia (Steung Treng, Kratié, Kampong Thom, Siem Reap, and Battambang). It is similar to *Mongolodiaptomus loeiensis* Watiroyram & Sanoamuang, 2017 in regards to the male 5th leg and the antepenultimate segment of the male right antennule. In this study, we propose three species groups of *Mongolodiaptomus*; *mariadvigae*, *gladiolus*, and *mephistopheles* groups, based on similarities of their morphological characteristics.

Key words. biodiversity, Southeast Asia, Cambodia, Laos, Thailand, Vietnam

INTRODUCTION

The Mekong is the longest river in Southeast Asia (SE Asia) and the 12th longest river in the world, and is one of Asia's major river systems which flows 4,350 km from the Tibetan Plateau to the Mekong Delta into the South China Sea. The river runs through six countries including China, Myanmar, Laos, Thailand, Cambodia, and Vietnam, and drains more than 810,000 square km of land (White et al., 2017). The flood monsoon season in the Mekong River Basin lasts from June to November and accounts for about 80% of the total annual flow. The source of the river's great productivity is its seasonal variation in water level and the range of flooded wetland habitats. The Mekong sub-region is home to at least 430 mammal, 1,200 bird, 800 reptile, 20,000 plant, and 850 fish species (White et al., 2017).

The ornamentation on the right second exopod of the male fifth legs is considered as a good generic characters for identification of diaptomid copepods, especially the three closely related genera, *Neodiaptomus* Kiefer, 1932, *Allodiaptomus* Kiefer, 1936, and *Mongolodiaptomus* Kiefer, 1938 (Ranga Reddy et al., 2000). Regarding to the generic revision made by Ranga Reddy et al. (2000), *Mongolodiaptomus* is differentiated from its allied genera by having at least two lateral spines and processes on the right second exopod; one principal spine on middle of segment, and 1–2 spinous processes proximally or/and distally. To date, thirteen and ten species of the genus *Mongolodiaptomus* have been reported from Asia and the lower Mekong River Basin (Thailand, Cambodia, Laos, and Vietnam), respectively (Ranga Reddy, 1994; Ranga Reddy et al., 1998, 2000; Sanoamuang, 2001b, 2002; Sanoamuang & Sivongxay, 2004; Tran et al., 2016; Watiroyram & Sanoamuang, 2017).

The biodiversity study of freshwater calanoid copepods from Southeast Asia has been intensively documented in Thailand since 1994 (Dumont & Ranga Reddy, 1994; Dumont et al., 1996; Ranga Reddy et al., 1998, 2000; Sanoamuang, 2001a, 2001b, 2001c, 2002; 2004; Sanoamuang & Yindee, 2001; Sanoamuang & Athibai, 2002; Sanoamuang & Teeramaethee, 2006; Proongkiat & Sanoamuang, 2008; Watiroyram & Sanoamuang, 2017). However, the investigations in the neighboring countries including Cambodia, Laos, and Vietnam are poorly studied (Brehm, 1951; Sanoamuang & Sivongxay, 2004; Tran et al., 2016). During our ongoing study of freshwater copepods in the lower Mekong River Basin, a new calanoid copepod belonging to the genus *Mongolodiaptomus* was found. This contribution provides an illustrated description of the new species of *Mongolodiaptomus*, and a morphological comparison of the new species to its congeners.

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MATERIAL & METHODS

Samples were collected using a plankton net with a mesh size of 60 μm from the lower Mekong River Basin including Thailand (198 samples from Ubon Ratchathani Province Thailand), Laos (91 samples from Champasak Province), Cambodia (252 samples from Banteay Meanchey, Battambong, Siem Reap, Kampong Thom, Pursat, Kratie, and Stung Treng provinces), and Vietnam (85 samples from Ho Chi Minh City, Ba Ria-Vung Tau, Binh Duong, Binh Phuoc, Dong Nai, Tay Ninh, Long An, and Tien Giang provinces). All samples were preserved in 70% ethanol immediately after collection. Specimens were placed in a mixture of glycerol and 70% ethanol (ratio ~ 1:10 v/v) and pure glycerol, respectively. Specimens were dissected and mounted at 40–100× magnification under an Olympus SZ51 stereomicroscope. All appendages and body ornamentation were examined at 1,000× magnification under an Olympus compound microscope (CX31). All the drawings were made at 100× magnification under a compound microscope with a drawing tube (Olympus U-DA). The final versions of the drawings were made using the CORELDRAW® 12.0 graphic program. Specimens for a scanning electron microscopy (SEM) were dehydrated in an ethanol series (50%, 70%, 80%, 90%, 95%, 100%, 100%, 50: 50 v/v of absolute ethanol: amyl acetate, and 100% amyl acetate) for 15 min each concentration. Specimens were dried in a critical point dryer and were coated with gold in a sputter-coater. The SEM photographs were carried out using a scanning electron microscope (LEO, 1450VP).

The following abbreviations are used throughout the text and figures: Pdg 1–5, pedigerous segments 1–5; P1–P5, swimming legs 1–5; Enp, endopod; Exp, exopod; Exp/Enp-n, exopodal segment n/endopodal segment n. The nomenclature and descriptive terminology follow Huys & Boxshall (1991), including analysis of caudal setae (I–VII). Specimens were deposited at the Natural History Museum, London, United Kingdom (NHMUK), the Nakhon Phanom University, Faculty of Science, Thailand (NPU), and the Applied Taxonomic Research Center, Khon Kaen University (KKU).

TAXONOMY

Order Calanoida Sars, 1903

Family Diaptomidae Baird, 1850

Genus *Mongolodiaptomus* Kiefer, 1938

Mongolodiaptomus mekongensis, new species (Figs. 1–7)

Material examined. Holotype, one adult male (NHMUK 2018.1464), dissected and mounted in glycerol on one slide: Allotype, one adult female (NHMUK 2018.1465), dissected and mounted in glycerol on one slide: Paratypes, three adult females and males (NHMUK 2018.1466–1475), three adult females and males (NPU 2018–005), three adult females and males (KKU-COP-2018S-01), undissected and preserved in 70% ethanol in 1.5 mL microtubes. All specimens collected on June 9, 2002 by L. Sanoamuang.

Type locality. A roadside canal near Kilometer Post 28, National Highway no. 2134, Na Kham Subdistrict, Sri Muang Mai District, northeastern Thailand, Ubon Ratchathani Province; 15°22′42″N; 105°12′42″E.

Common features of both sexes. Left antennule (Fig. 1G) 25-segmented, reaching beyond the caudal setae. Setal formula [number of setae + aesthetasc (a) + spine (s)] of each segment as follows: 1+a, 3+a, 1+a, 1, 1+a, 1, 1+a, 1+s, 2+a, 1, 1, 1+a+s, 1, 1+a, 1, 1+a, 1, 1, 1+a, 1, 1, 2, 2, 2, 4+a.

Antenna (Fig. 3A) coxa small, with 1 inner seta. Basis with 2 smaller medial setae on distal corner. Exp 7-segmented, with 1, 3, 1, 1, 1, 1, and 4 (one inner and 3 apical) inner setae respectively. Enp 2-segmented, Enp-1 with 2 medial setae. Enp-2 with 9 inner and 7 apical setae.

Mandible (Fig. 3B) coxa with 2 cuspidate and 5 blunt teeth on gnathobase plus one small dorsal seta on distolateral corner. Basis with 4 inner setae. Enp 2-segmented, Enp-1 with 4 inner setae and Enp-2 with 9 apical setae. Exp 4-segmented, with 1, 1, 1, and 3 setae, respectively.

Maxillule (Fig. 3C) praecoxal arthrite with 7 strong and 4 fine setae. Coxal endite with 3 fine setae and coxal epipodite with 9 strong setae. Basis with 2 endites, each with 4 fine setae; basal exite with 1 small seta. Enp reduced, represented by 8 apical setae. Exp with 6 setae.

Maxilla (Fig. 3D) proximal and distal praecoxal endite, each with 3 setae. Two coxal endites with 3 setae each. Allobasis with 3 setae on basal endite. Enp reduced to 2 segmented, each with 3 setae.

Maxilliped (Fig. 3E) praecoxa completely fused to coxa, represented by 4 endites with 1, 2, 3, 4 setae each. Basis with 3 setae distally plus row of strong spinules along inner margin. Enp 6-segmented, with 2, 3, 2, 2, 2, and 4 setae, respectively.

P1–P4 (Figs. 4A–D) biramous. Coxa with pinnate seta at distal inner corner. Basis of P4 with small seta at outer distal margin. Exp longer than Enp. P1 with 3-segmented Exp and 2-segmented Enp, P2–P4 with 3-segmented Exp and Enp. Exp-1 with one outer spine and inner pinnate seta. Exp-2 as same as Exp-1 except P1 lacking outer spine. Exp-3 with 3 inner and 3 apical pinnate setae, and one outer spine except P1 with 2 inner setae. Enp-1 with one inner pinnate seta. P1 Enp-2 with 3 inner, 2 apical, and one outer pinnate setae; P2–P4 Enp-2 with 2 inner pinnate setae. P2–P4 Enp-3 with 3 inner, 2 apical, and 2 outer pinnate setae.

Description. *Adult female*. Total body length excluding caudal setae 1.32–1.41 mm (mean ± SD = 0 1.38 ± 0.01, N = 20) (Figs. 1A, 2A). Antennules (Fig. 1G) symmetrical. Rostrum (Figs. 1B, 2B) with pair of teeth-like process on anterior margin. Cephalosome and Pdg 1 completely fused,

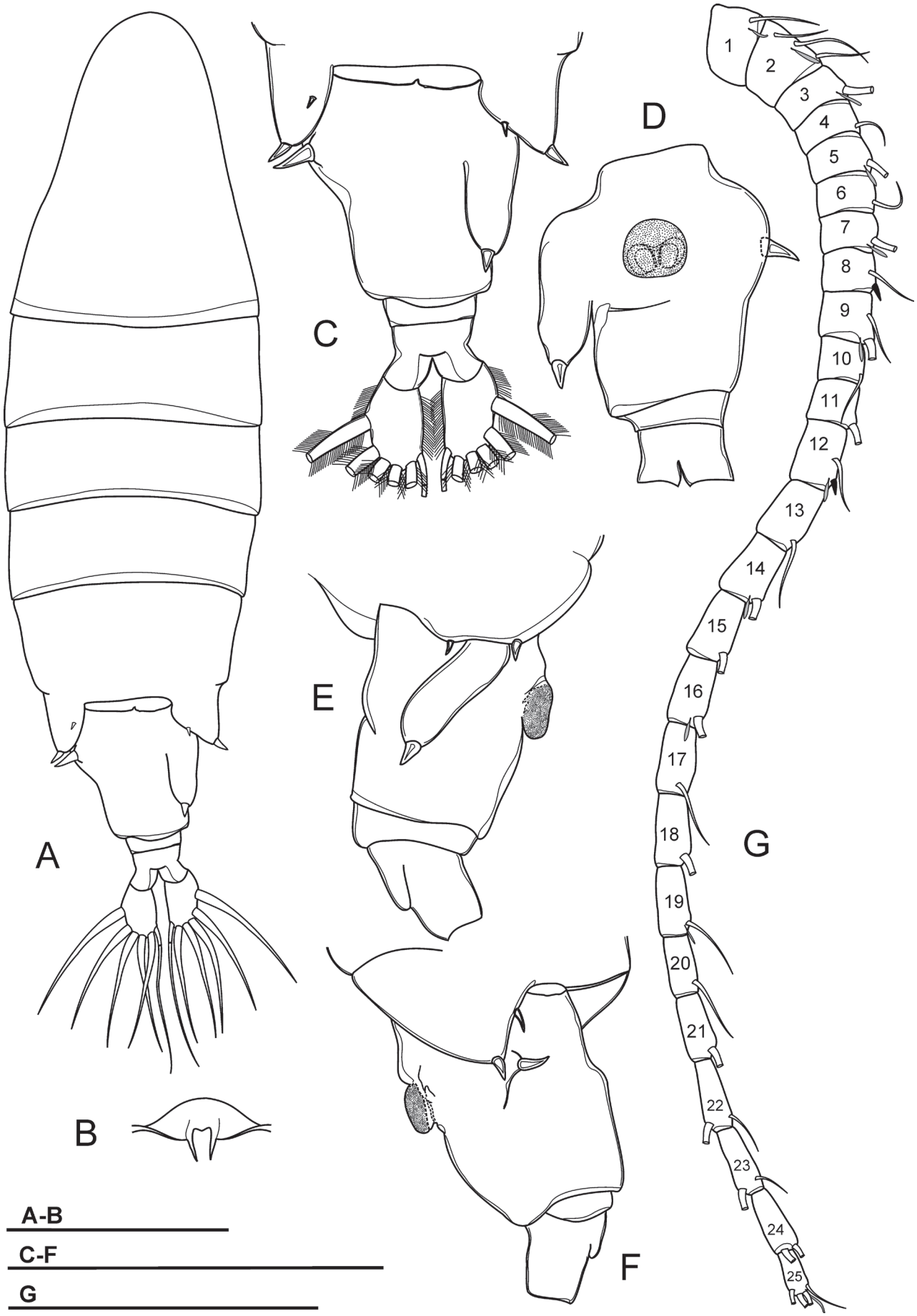

Fig. 1. *Mongolodiaptomus mekongensis*, new species, female. A, habitus, dorsal view; B, rostrum anterior view; C, pediger 5 and urosome, dorsal view; D, urosome, ventral view (without caudal rami); E, pediger 5 and urosome, right lateral view (without caudal rami); F, pediger 5 and urosome, left lateral view (without caudal rami); G, antennule. Scale bar = 200 µm.

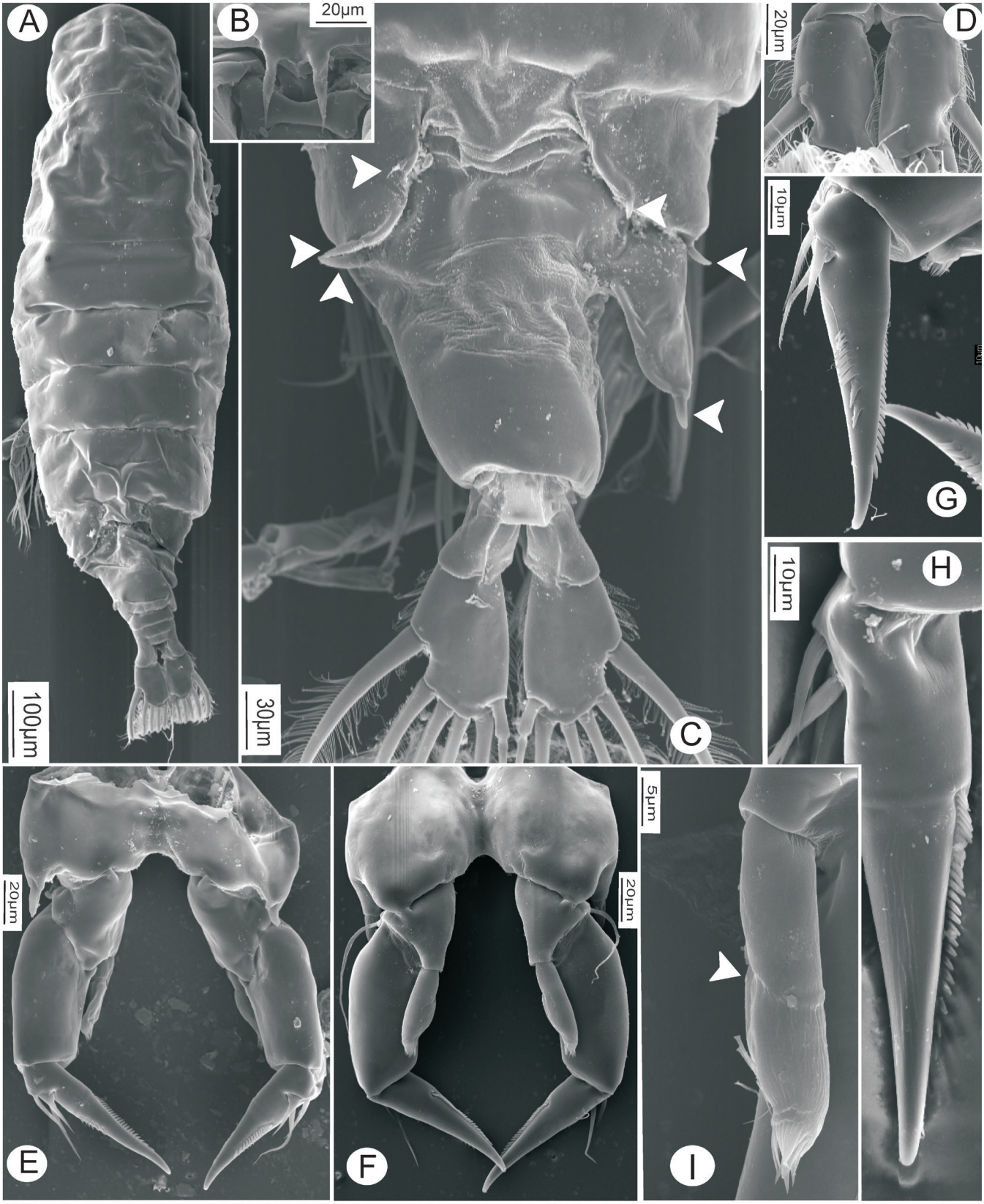

Fig. 2. *Mongolodiaptomus mekongensis*, new species, SEM photographs of female (A–I). A, habitus, dorsal view; B, rostrum, frontal view; C, pediger 5 and urosome, dorsal view (white arrow pointed to spines); D, caudal rami, ventral view; E, P5 in anterior view; F, P5 in posterior view; G, P5 Exp-2–3 in anterior view; H, P5 Exp-2–3 in posterior view; I, Enp-1–2 in anterior view, white arrow indicates the segmented Enp.

Pdg 4 and 5 incompletely fused. Pdg 5 (Figs. 1C, 2C) produced into slightly asymmetrical posterolateral wings (right wing somewhat larger than left), each ending with short, posterior spine; smaller dorsal spine located on inner margin of each wing. Urosome 3-segmented, genital double-somite more longer than two later urosomites and caudal rami combined. Genital double-somite (Figs. 1C–F, 2C) asymmetrical, right posterolateral process well-developed, extended beyond haft of segment; with strong, blunt spine on respective process. Left side with strong dorsolateral spine on small prominence proximally, larger than other genital spines. Posterior margin slightly produced in dorsal and right lateral view. Urosomite 2 symmetrical, shorter than wide, partly covered by posterior end of genital double-somite. Anal somite (Figs. 1C, 2C) symmetrical, divergent distally, slightly shorter than later somite; anal operculum small, with slightly posterior margin concave or nearly straight.

Caudal rami (Figs. 1C, 2A, C, D) symmetrical, each ramus expanded on distal end, with setules along inner and outer margins. Each ramus with 6 setae (seta II–VII): seta II–VI plumose, anterolateral (II) seta with smooth region on outer margin proximally; terminal setae (seta IV and V) without fracture plane; dorsal seta (VII) articulated, bare, and longest.

P5 (Figs. 2E–I, 4E, F) symmetrical. Coxa with stout spine on protuberance at distolateral corner in posterior view; coxal spine prolonged to Exp-1. Basis with a thin seta on distolateral margin, reaching beyond middle of Exp-1. Exp 3-segmented and Enp 2-segmented. Exp-1 enlarged rectangular-like, more than 2.0 times as long as wide. Exp-2 sub-triangular, with a row of strong spinules along both margins; with small outer spine proximally. Exp-3 reduced into small prominence on Exp-2, with short spine and long seta apically. Enp subconical, about half as long as Exp-1. Enp-1 cylindrical, shorter than Enp-2. Enp-2 with a circular row of spinules on narrowed end apically.

Adult male. Body length excluding caudal setae 1.19–1.30 mm (mean ± SD = 0 1.24 ± 0.02, N = 20) (Figs. 5A, 6A), smaller than female. Pdg 4 and 5 incompletely fused. Lateral wing (Figs. 5C, 6A) less developed, slightly asymmetrical, left wing prolonged into downward direction and tipped with thinner spine than those on opposite wing. Urosome (Figs. 5A, 6A–C) 5-segmented and asymmetrical, oriented obliquely posteriad to right side. Genital somite (Figs. 5B, C, 6A–C) shortest, asymmetrical, right side dilated posterolaterally and with small seta on outer distal margin. Urosomites 2–3 (Figs. 6A–C) symmetrical, former somite longer than later one, both with long hairs ventrally. Urosomite 4 (Figs. 6A, C) with right posterolateral dilated; dorsoposterior margin expanded reaching to anal operculum. Anal somite (Figs. 5A, 6A, C) similar to female but asymmetrical posteriorly end. Caudal rami (Figs. 5D, 6B, C) asymmetrical and cylindrical, about 2.5 times as long as wide, with hairy inner margin. Right ramus with two ventral chitinous processes: strong spiniform process on prominence proximally and two semi-circular ridges located at base of seta IV and V. Their setation as in female.

Right antennule (Fig. 6D) transformed and geniculated, with 22 segments. Setal formula (a = aesthetasc, s = spine): 1+a, 3+a, 1+a, 1, 1+a, 1, 1+a, 1+s, 2+a, 1+s, 1+s, 1+a+s, 1+a+s, 2+a+s, 2+a+s, 2+a+s, 1+s, 1+s, 2+s, 3+s, 2, 4+a. Segments 13 to 20 enlarged and elongated; segments 18 and 19 geniculated; segment 20 (antepenultimate) with comb-like process (4 teeth).

P5 (Figs. 5E–M, 7) asymmetrical, right leg highly enlarged. Intercoxal plate with strong finger-like projection on distal margin, its tip bent inward. Right P5: coxa with strong spine inserted on posterior lobe (present spinous process on distal inner corner of posterior lobe, see Fig. 5F), almost reaching distal end of basis. Basis quadrangular, about twice as long as wide; with small hyaline lamella at inner margin (Fig. 5G); with small chitinous prominence on posterior view mid-distally; with small seta located at distal outer margin on anterior view. Exp 3-segmented: Exp-1 quadrangular, distal outer corner produced (Fig. 5I); with 2 chitinous prominences on posterior view. Exp-2 slightly incurved, proximal and distal parts enlarged, about 2.5 times as long as wide; with two small processes proximally and distally, and principal spine located slightly posterior to mid-outer margin. Lateral spine strong, cylindrical, slightly longer than 1/2 of segment, about one third of spine length bent or twist to posterolateral direction distally on posterior view; with pointed tip. Exp-3 modified into end claw with sickle-shaped, thickness, long beyond 1.5 times as long as Exp-2; with inner serrate margin. Enp 1-segmented, conical, gradually tapering to distal end, reaching to quarter of Exp-2; with spinulated tip.

Left P5: coxa with thin seta inserted on posterior lobe at distal inner margin, reaching beyond mid-half of basis. Basis with long inner hyaline lamella; with short, thin posterolateral seta on posterior surface; with obviously longitudinal chitinous ridge, extending almost entire segment (Fig. 5J). Exp 3-segmented (Fig. 5K, M): Exp-1 longer than wide, gradually tapering in posterior end; with inner strongly serrate margin at distal half. Exp-2 oval, smaller than Exp-1; with inner robust seta, longer than Exp-2; with inner strongly serrate margin margin. Exp-3 reduced to bare apical process, stretched into somewhat spearhead-like. Enp 1-segmented, slightly longer than Exp-1, with spinulated tip.

Etymology. The specific name "*mekongensis*" is named after the place "the Great Mekong sub-region" where the new species was found.

Remarks. *Mongolodiaptomus mekongensis*, new species, fits well with the generic diagnosis of the genus *Mongolodiaptomus* as described in the amended delimitation by Ranga Reddy et al. (2000) in that the male right P5 Exp-2 with a principal spine on approximately mid-outer margin and two small spinous processes proximally and distally. According to the identification key given by Watiroyram & Sanoamuang (2017), the new species is similar to *M. loeiensis* Watiroyram & Sanoamuang, 2017 by shared morphological characteristics in both sexes. In the males, the segment 20 of right antennule with a comb-like process, the intercoxal plate of P5 with outgrowth on distal margin, and the uniqueness of P5 by

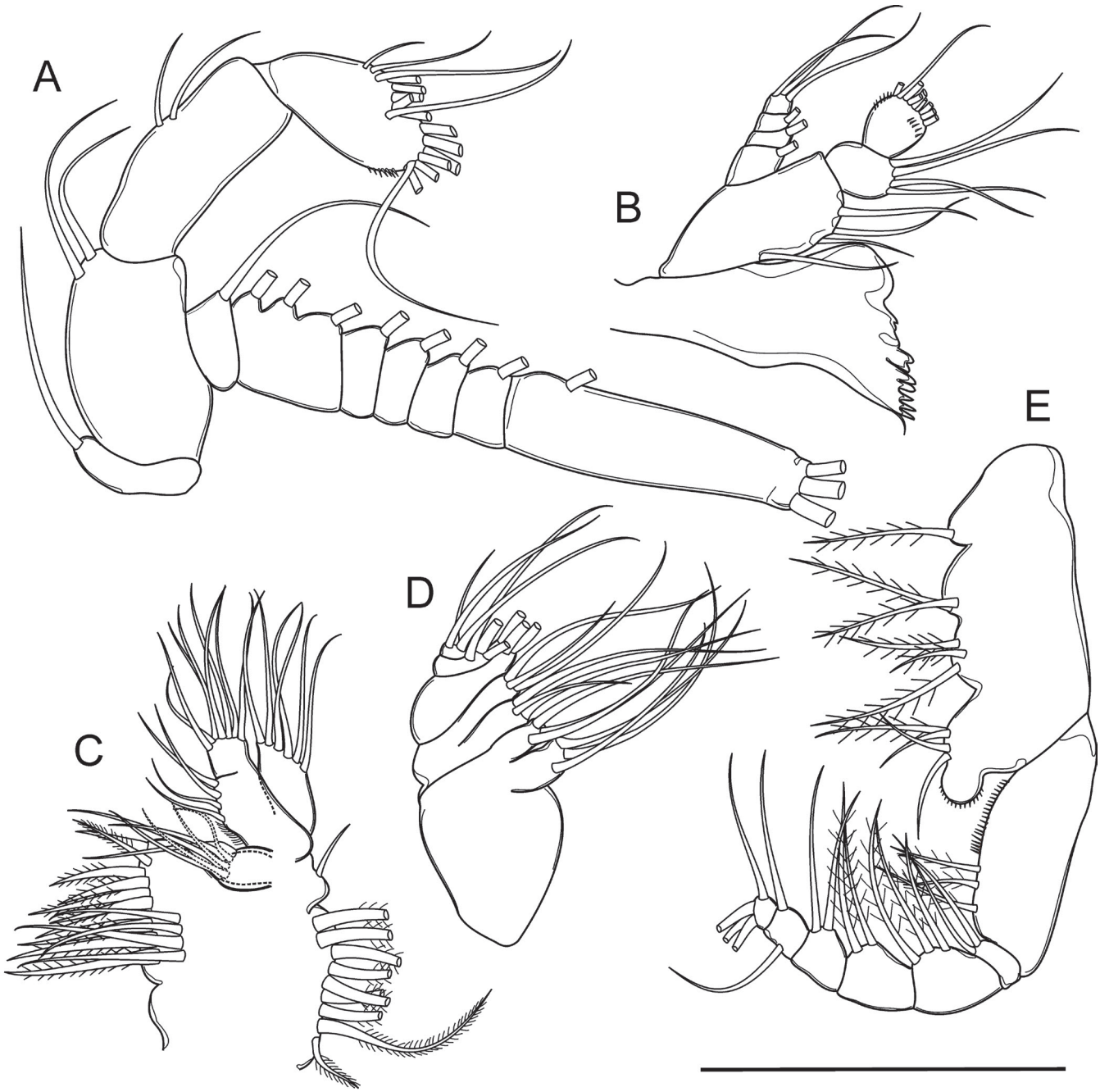

Fig. 3. *Mongolodiaptomus mekongensis*, new species, female. A, antenna; B, mandible; C, maxillule; D, maxilla; E, maxilliped. Scale bar = 100 μm.

shared similarities that is the right leg with (1) a strong coxal spine on prominent lobe, (2) an hyaline membrane on inner margin of basis, (3) Exp-1 distolateral corner produced, (4) a strong and bent principal lateral spine; on left leg with (1) an hyaline membrane on inner margin of basis, and (2) strong spinules along inner margin of Exp-2. The female shares with *M. loeiensis* the following characters: (1) the spine on Pdg 5 and genital double-somite with similar shape and size, (2) the genital double-somite with the right posterolateral outgrowth, and (3) the structure of fifth leg. The new species can be differentiated from *M. loeiensis* by the characteristics of the male caudal rami, and fifth leg: the right caudal ramus with two ventral chitinous processes (proximal spine-like and distal semi-circular process) while *M. loeiensis* with two spine-like processes proximally and semi-circular one distally; intercoxal plate of the new species with one spine-like outgrowth on its distal margin but present two spine-like outgrowths in *M. loeiensis*; the new species with acute projection at the base of the right coxal spine (Fig. 5F) but this apparatus is absent and having the shorter and stronger coxal spine in *M. loeiensis*. The right leg: the principal spine of Exp-2 with acute tip in *M. mekongensis*, new species, but blunt in *M. loeiensis*; the Exp-2 end claw of the new species is somewhat shorter and thicker than that in *M. loeiensis*: the left leg; the basis with obviously longitudinal chitinous ridge on posterior view, and Exp-3 with long apical process in the new species but with short and blunt process in *M. loeiensis*. The female Pdg 5 of the new species with asymmetrical posterolateral wings but it is symmetrical in *M. loeiensis*. The genital double-somite of

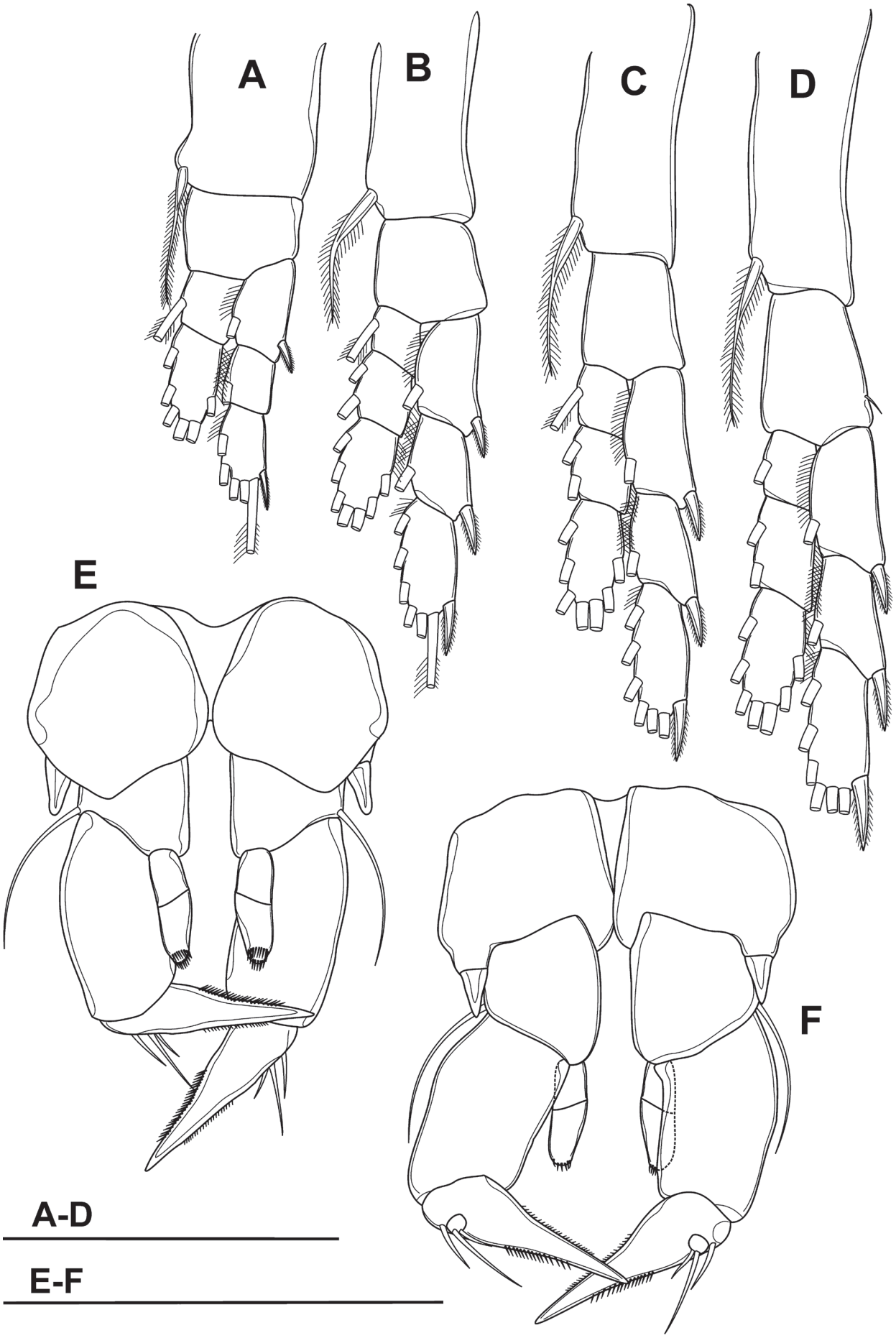

Fig. 4. *Mongolodiaptomus mekongensis*, new species, female. A, P1; B, P2; C, P3; D, P4; E, P5 (A–E in posterior view); F, P5 in anterior view. Scale bar = 100 μm.

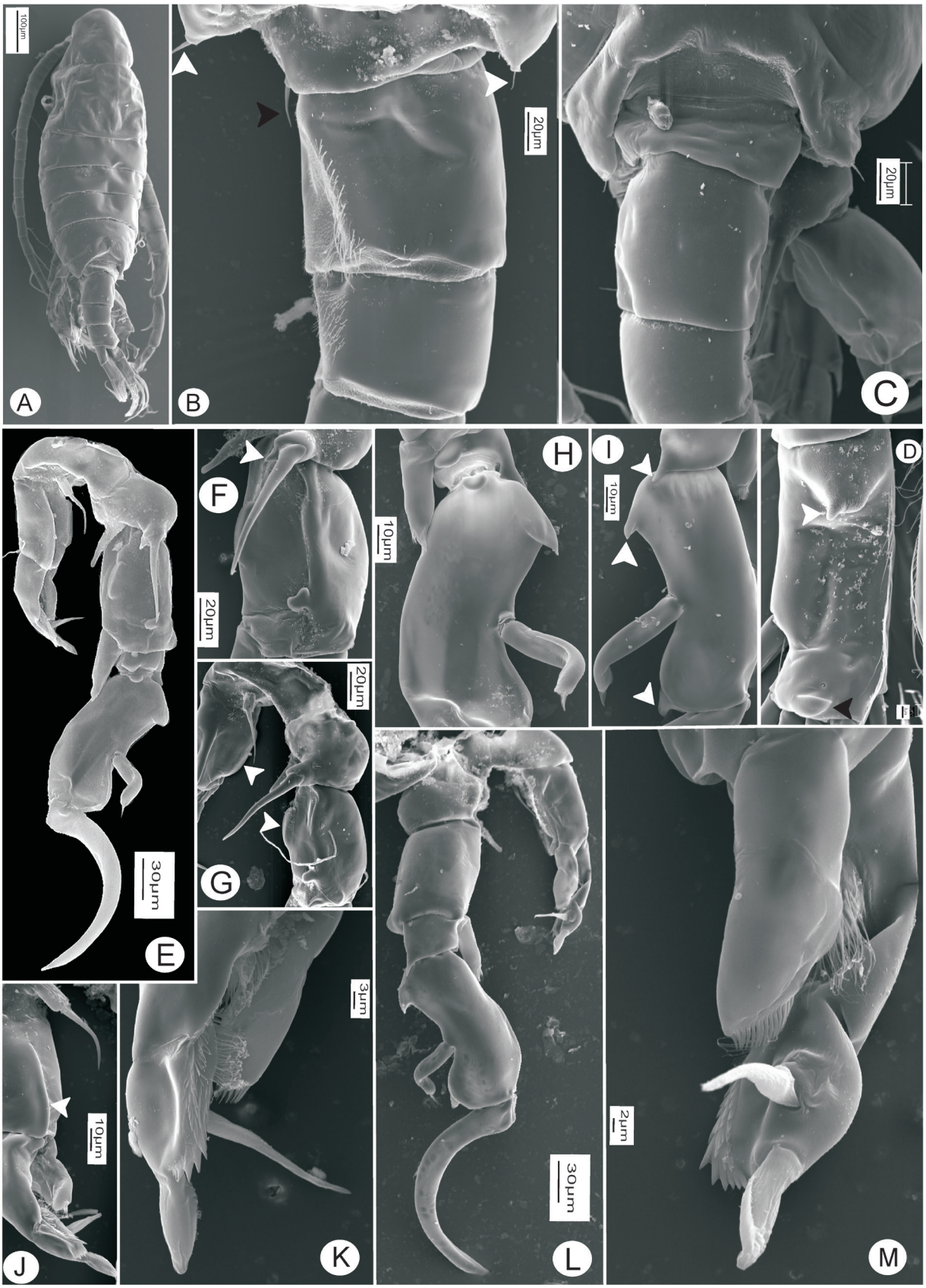

Fig. 5. *Mongolodiaptomus mekongensis*, new species, SEM photographs, male (A–M). A, habitus, dorsal view; B, lateral wings, genital somite, and urosomites 2–3, dorsolateral view (white arrow pointed to spines and black one pointed to seta); C, pediger 5, genital somite, and urosomites 2–3, dorsal view; D, right caudal ramus, ventral view (white arrow pointed spiniform process); E, P5 in posterior view; F, the right coxal spine, and basis of P5 in posterior view (white arrow pointed to spiniform process on posterior lobe); G, intercoxal plate, and basis of P5 in posterior view (white arrow pointed to hyaline membranes); H, the right P5 Exp-1–2 and Enp in posterior view; I, the right P5 Exp-1–2 in anterior view (white arrow pointed to spiniform processes); J, the left P5 basis, Exp and Enp in posterior view (white arrow pointed to longitudinal chitinous ridge); K, the left P5 Exp-1–3 and Enp in posterior view; L, P5 in anterior view; M, the left P5 Exp and Enp in anterior view.

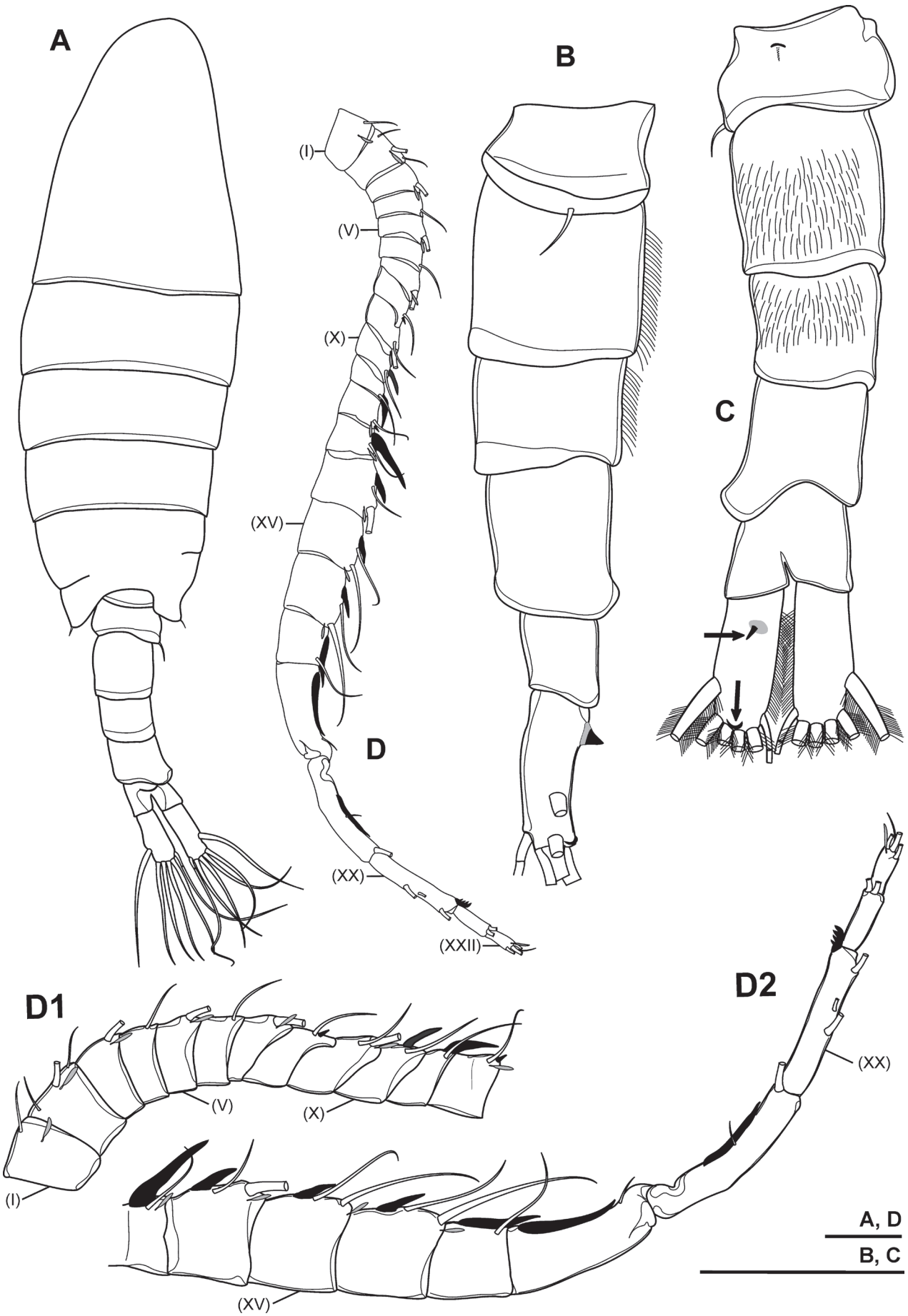

Fig. 6. *Mongolodiaptomus mekongensis*, new species, male. A, habitus, dorsal view; B, urosome, right lateral view; C, urosome, ventral view (black arrows indicate chitinous spines and ridge on right caudal ramus); D, the right antennule: D1, segment 1–12; D2, segment 13–22. Scale bar = 100 μm.

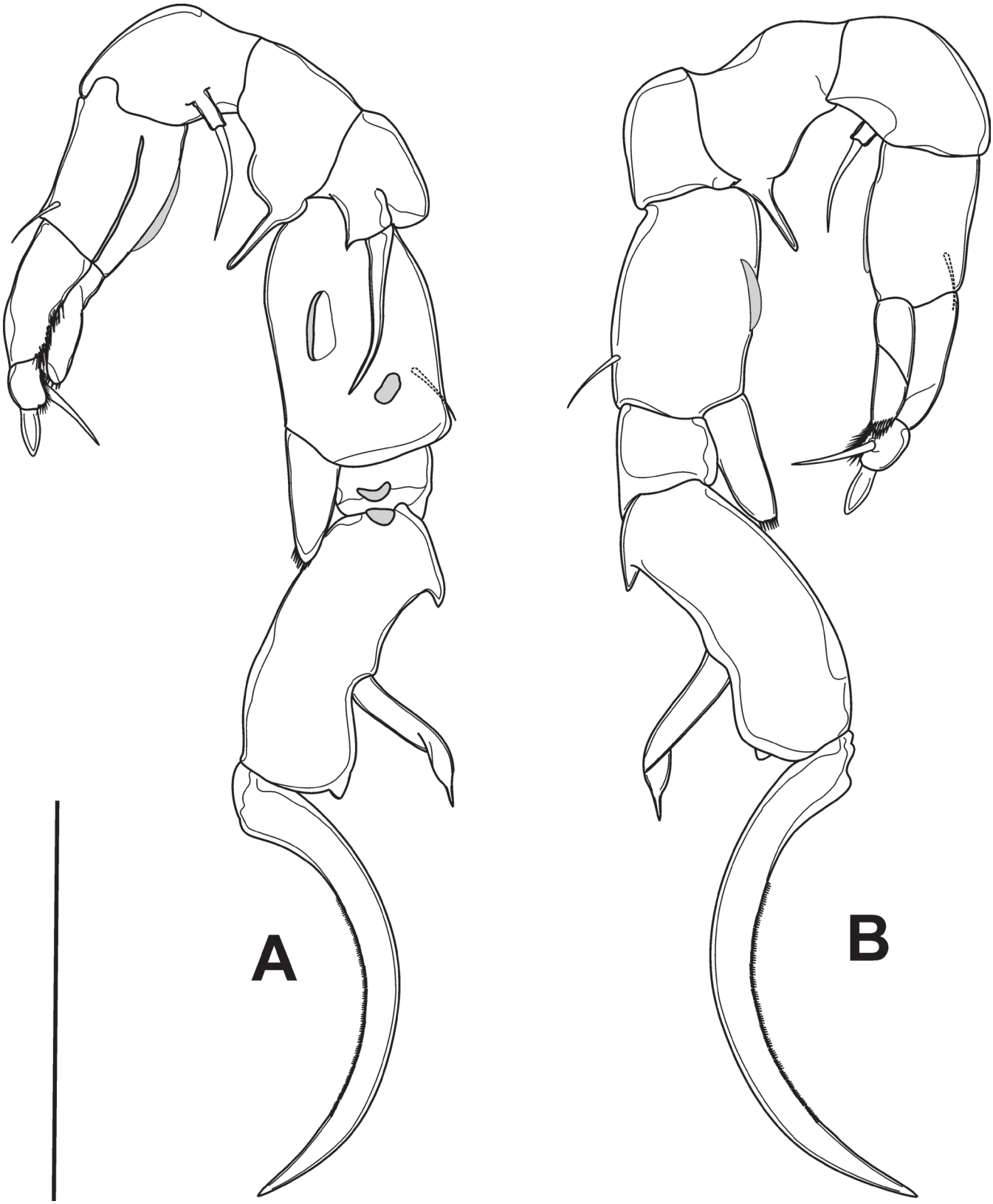

Fig. 7. *Mongolodiaptomus mekongensis*, new species, male. A, P5 in posterior view; B, P5 in anterior view. Scale bar = 100 μm.

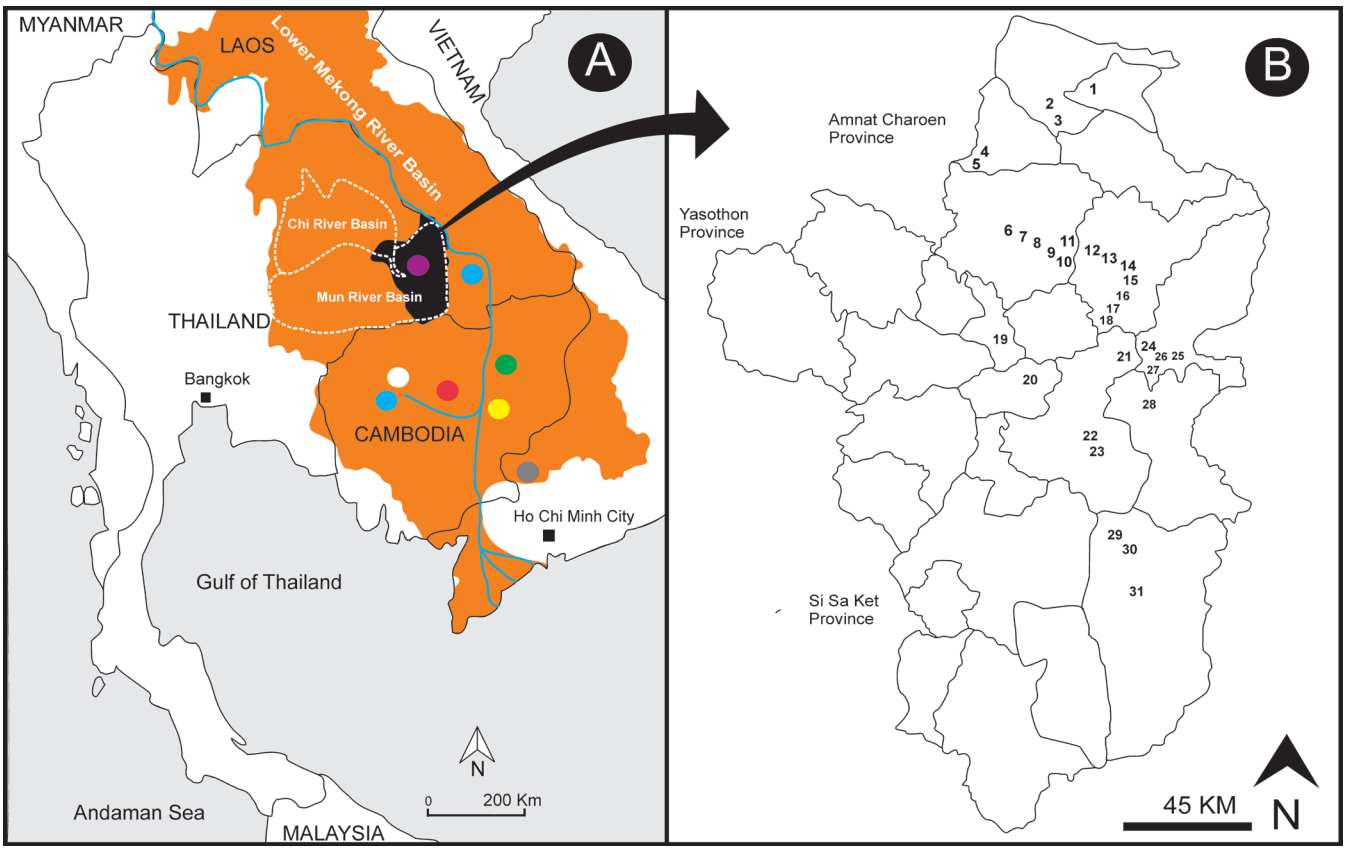

Fig. 8. Distribution map of *Mongolodiaptomus mekongensis*, new species, in the lower Mekong River Basin. A, species distribution in southeast Asia indicates with different coloured circles (Thailand: violet = Ubon Ratchathani Province; Laos: blue = Champasak Province; Cambodia: green = Steung Treng Province, yellow = Kratié Province, red = Kampong Thom Province, white = Siem Reap Province, black = Battambang Province; Vietnam: grey = Binh Phuoc Province); B, species distribution in Ubon Ratchathani Province from Thailand (an area of Ubon Ratchathani indicated with shaded black in A), 1–31 = sampling site.

the new species with only proximal bulge on the right outer margin but that in *M. loeiensis* with three bulges beginning from proximal to middle region (see Table 1).

The females of the new species can be distinguished from the *M. dumonti* Sanoamuang, 2001 by (1) the lateral wings are asymmetrical versus symmetrical in the later species, (2) the genital double-somite with a posterolateral process on right margin but it is absent in *M. dumonti*. In the males, (1) the right caudal ramus on the ventral side with a large, chitinous tooth and semi-circular ridge in *M. mekongensis*, new species but with only two chitinous teeth in *M. dumonti*, (2) the P5 intercoxal plate produced into triangular process on inner distal margin in the new species but non-produced in *M. dumonti*, (3) the right P5 coxa with acute inner process on posterior lobe in the new species but it is absent in *M. dumonti,* (4) the right P5 basis with inner hyaline lamella in the new species but it is absent in *M. dumonti,* (5) the right P5 Exp-1 with acute process on distal outer margin in the new species but it is round in *M. dumonti,* and (6) the principal spine on the right P5 Exp-2 bent in the new species but it is straight in *M. dumonti* (see Table 1).

DISCUSSION

Mongolodiaptomus mekongensis, new species, was widely distributed downward from Ubon Ratchathani Province (Thailand) to Champasak Province (Laos), Steung Treng, Kratié, Kampong Thom, Siem Reap and Battambang Provinces (Cambodia), and Binh Phuoc Province (Vietnam) as shown in Fig. 8A. According to this study, the new species is distributed widely in the Mun River Basin, a tributary of the Mekong River (31 out of 198 samples in Ubon Ratchathani Province, Thailand) and the downstream of the lower Mekong River Basin in Laos (6 out of 91 samples), Cambodia (74 out of 252 samples), and Vietnam (3 out of 85 samples). In the case of 31 temporary waters in Ubon Ratchathani Province (Fig. 8B), they were mainly collected from roadside canals with 84 % of the sampled sites, following by temporary ponds (10%), and rice fields (6%). The new species occurred with ten diaptomid species namely, *M. botulifer* (Kiefer, 1974), *M. malaindosinensis* (Lai & Fernando, 1978), *M. uenoi* (Kikuchi, 1936), *Eodiaptomus phuphanensis* Sanoamuang, 2001, *E. phuvongi* Sanoamuang & Sivongxay, 2004, *Dentodiaptomus javanus* (Grochmalicki, 1915), *Neodiaptomus laii* Kiefer, 1974, *N. yangtsekiangensis* Mashiko, 1951, *Phyllodiaptomus christineae* Dumont, Ranga Reddy & Sanoamuang, 1996, and *Vietodiaptomus blachei* (Brehm, 1951). It was found in rainy season (May until October) over a water temperature range of 26.5–35°C (mean = 32.4°C), conductivity 16–174 µS/cm (mean = 57.1 µS/cm), and pH 6.9–7.9 (mean = 7.3). Most of their habitats are small, shallow, with flooded water bodies. These flooded habitats may result in their abundance throughout the Ubon Ratchathani Province, which is the catchment area of the Mekong River Basin. Frisch et al. (2005) pointed that the

Table 1. Comparison of morphological characters among the three regional *Mongolodiaptomus* species.

Species Characters	*M. dumonti*	*M. loeiensis*	*M. mekongensis* new species
FEMALE			
Lateral wings on Pdg 5 (left : right)	Symmetrical	Symmetrical	Asymmetrical
Genital somite with posterolateral process	No	Yes	Yes
P5 Enp length (compare to P5 Exp length)	>2/3 of Exp-1	≈Exp-1	>2/3 of Exp-1
MALE			
Chitinous teeth on the right caudal ramus	two	two	one
Chitinous (semicircular) ridge on the right caudal ramus	Absence	one	one
P5 intercoxal plate produced (shape)	No	Yes (2 spine-like processes)	Yes (1 spine-like process)
Right P5 coxal (posterior) lobe	Without spiniform process	Without spiniform process	With spiniform process
Right P5 basis with inner hyaline lamella	No	Yes	Yes
Right P5 Exp-1 with distal outer corner produced	No	Yes	Yes
Principal spine on the right P5 Exp-2	Strong, straight	Strong, bent	Strong, bent

hydrological connection in inland waters may have an effect on dispersion, gene flows, and species composition, more than those in isolated habitats. For example, *M. loeiensis* has abundance of population and is currently restricted to a single locality, which was probably a result of being inhabited in isolated water from river system and flood plains and lack of species competition (i.e., only single diaptomid species was found in their habitats).

The male P5 is one of the most reliable characters compared to the corresponding appendage in females, particularly characterised armature of coxa, basis and Exp-2 of the right side (Ranga Reddy, 1987). In addition, the antepenultimate segment of the male right antennule and the right caudal ramus are used to distinguish species of this genus. Amongst the unique characteristics of these certain appendages, the 14 known species are divided into three species groups based on male only as follows:

1. The *mariadvigae* species group [*M. mariadvigae* (Brehm, 1921), *M. birulai* (Rylov, 1922), *M. botulifer*, *M. malaindosinensis*, and *M. formosanus* Kiefer, 1937], the following features can be observed in this group: (1) the spinous process on the antepenultimate segment of the right antennule is long and slender; (2) the right P5 basis has hyaline lamella but without chitinous prominence; (3) the inner distal margin of P5 intercoxal plate is produced; and (4) the right caudal ramus has ventral chitinous prominences.

2. The *gladiolus* species group [*M. gladiolus* (Shen & Lee, 1963), *M. calcarus* (Shen & Tai, 1965), *M. rarus* (Ranga Reddy, Sanoamuang & Dumont, 1998), and *M. dumonti*], the following features can be observed in this group: (1) the spinous process on the antepenultimate segment is comb-like; (2) the right P5 basis has no inner hyaline membrane; (3) the inner distal margin of P5 intercoxal plate is not produced; and (4) the P5 Exp-1 has no acute process on outer distal margin.

3. The *mephistopheles* species group [*M. mephistopheles* (Brehm, 1933), *M. uenoi*, *M. pectinidactylus* (Shen & Tai, 1964), *M. loeiensis*, and *M. mekongensis*, new species], the following features can be observed in this group: (1) the spinous process on the antepenultimate segment is comb-like; and (2) the right and left P5 basis has inner hyaline lamella.

Ranga Reddy et al. (2000) considered the species of the genus *Mongolodiaptomus* as a more or less homogeneous group. We also agree with this point of view, because its members share many important characters across different parts of the world on their morphology and distribution. Therefore, the species group can be classified, based on their morphological features rather than their zoogeographical distributions. Sanoamuang (2001) grouped *M. gladiolus*, *M. calcarus*, *M. rarus*, and *M. dumonti* as the *gladiolus* group, which is the first morphological species group for the genus *Mongolodiaptomus*.

Table 2. Distributions of the species in the genus *Mongolodiaptomus* Kiefer, 1938. Abbreviations and symbols used in table: Th = Thailand, La = Laos, Ca = Cambodia, Vi = Vietnam, Ma = Malaysia, Si = Singapore, In = Indonesia, Ph = Philippines, Ch = China, Ta = Taiwan, SE Asia = Southeast Asia, E Asia = East Asia.

	Th	La	Ca	Vi	Ma	Si	In	Ph	Ch	Ta	Zoographical distribution
***mariadvigae* group**											
*M. mariadvigae**									+		South China
M. birulai				+				+	+	+	SE Asia, E Asia
*M. formosanus***										+	Taiwan endemic
*M. malaindosinensis****	+	+	+		+						SE Asia
M. botulifer	+	+	+	+	+	+					SE Asia
***gladiolus* group**											
M. gladiolus				+					+		South China, Vietnam
M. calcarus	+	+	+	+	+		+		+		South China, Mekong region, Malay Archipelago
M. rarus	+										Thailand endemic
M. dumonti	+		+								Mekong region
***mephistopheles* group**											
M. mephistopheles	?				+		+				Malay Archipelago
M. pectinidactylus	+			+					+		South China, Mekong region
M. uenoi	+			+	+		+		+	+	SE Asia, E Asia
M. loeiensis	+										Thailand endemic
M. mekongensis, new species	+	+	+	+							Mekong region
Total	9	4	5	7	5	1	3	1	6	3	

+ = presence
* = *Diaptomus mariadvigae* Brehm, 1921 was transferred into the genus *Mongolodiaptomus* by Shen & Tai (1964b) but treated as *Neutrodiaptomus mariadvigae* (Brehm, 1921) by Li et al. (2018).
** = Ranga Reddy et al. (2000) and Watiroyram & Sanoamuang (2017) counted *M. formosanus* as a different species from *M. birulai* while Young & Shih (2011) and Tran et al. (2016) considered as junior synonym of *M. birulai*.
*** = *M. malaindosinensis* is considered as a synonym of *M. botulifer* by Ranga Reddy et al. (2000) while the present study followed the identification of Sanoamuang (2002) and Watiroyram & Sanoamuang (2017) which is considered it as a distinct species.
? = doubtful record; Ranga Reddy et al. (1998) assigned *M. mephistopheles* in sense of Bricker et al. (1978) and Boonsom (1984) as *M. calcarus.*

The genus *Mongolodiaptomus* is confined in distribution from northeastmost Asia (Heilongjiang, China) south to the southeastmost Asia (Indonesia). Most species are currently restricted to SE Asia, only five species have also been recorded outside the area including *M. birulai*, *M. uenoi*, *M. pectinidactylus*, *M. calcarus*, and *M. gladiolus*. Two species, *M. malaindosinensis* and *M. botulifer*, have been found only in SE Asia (Boonmak et al., 2018), while two species (*M. mekongensis* and *M. dumonti*), and one species (*M. mephistopheles*), are confined in distribution in the Mekong region, and Malay Archipelago, respectively. Three endemic species are occurring in Thailand (*M. loeiensis* and *M. rarus*) and Taiwan (*M. formosanus*). Only *M. birulai* has the widest distribution occurring from Vietnam upwards to north China (it was also found in a cave from Hainan, southern China), while others are defined in SE Asia to south China, for more details see Table 2 (Bricker at al., 1978; Boonsom, 1984; Ranga Reddy et al., 1998, 2000; Sanoamuang, 2001b; Alekseev et al., 2013, 2016; Young & Shih, 2011; Tran et al., 2016; Lopez et al., 2017; Watiroyram & Sanoamuang, 2017; Li et al., 2018).

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