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Research Article

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Description of two new species of the genus *Potamanthellus* Lestage, 1931 (Ephemeroptera: Neoephemeridae) from India

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Abstract. Two new species of the genus *Potamanthellus* Lestage viz., *P. diversprimus* **sp. nov.** and *P. sineiugis* **sp. nov.,** were collected from the Eastern and Western Himalayan regions of India. This represents the first record of the family from these biogeographic regions. The two new species are described herein based on the larval stage from our recent exploration of mayflies in the streams and rivers of the Eastern and Western Himalayas of India.

Keywords: Mayfly, taxonomy, new species, Himalaya, India

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Introduction

The family Neoephemeridae (Ephemeroptera) is widespread in Oriental and Holarctic regions and comprises 16 described species, most of which are described from both larval and imaginal stages (Ma & Zhou, 2021). This family encompass five genera: *Neoephemera* McDunnough, 1925, *Ochernova* Bae & McCafferty, 1998, *Leucorhoenanthus* Lestage, 1931, *Potamanthellus* Lestage, 1931, and *Pulchephemera* Zhou, 2021. Recently, *Neoephemera projecta* (Zhou & Zheng, 2001) was reassigned to the genus *Pulchephemera* (Ma & Zhou, 2021). Bae & McCafferty (1998) provided the phylogenetic systematics and biogeographic status of three genera (*Neoephemera, Ochernova,* and *Potamanthellus*) under the family Neoephemeridae, and synonymized the genus *Neoephemeropsis* with *Potamanthellus*. The larvae of *Potamanthellus* are prominent among the benthic macroinvertebrate population in fast-flowing streams and rivers within freshwater ecosystems, where they can be found clinging to erosional substrates or sprawling on sediment areas.

The genus *Potamanthellus* Lestage, 1931 comprises eight species: *P. amabilis* (Eaton, 1892), described from Burma and transferred from the genus *Rhoenanthus*, also recorded in China, Vietnam, and Thailand (Nguyen & Bae, 2004); *P. caenoides* (Ulmer, 1939), described from Sumatra and also found in Malaysia, the Philippines, Thailand (Bae, 1998), and Vietnam (Nguyen and Bae, 2003), with a report from India by Selvakumar *et al.* (2015); *P. edmundsi* (Bae & McCafferty, 1998), described from Thailand, Malaysia, and Vietnam; *P. ganges* (Bae & McCafferty, 1998), described from India; *P. chinensis* (Hsu, 1936), from China, Korea, and Russia; *P. shaowuensis* Gui, Zhou & Su, 1999; *P. unicutibius* Nguyen & Bae, 2004 from China; and *P. panayensis* Garces & Sartori, 2022, described from Vietnam. Among these, only three species viz., *P. amabilis*, *P. caenoides*, and *P. chinensis* are known from both larval and adult stages. Five species are known from the larval stage viz., *P. edmundsi*, *P. ganges*, *P. unicutibius*, *P. panayensis* and *P. shaowuensis* is known from the adult stage only. As part of our ongoing efforts to explore the Ephemeroptera fauna in the streams and rivers of the Eastern and Western Himalayas of India, two new species, *P. diversprimus* **sp. nov.** and *P. sineiugis* **sp. nov.** are described herein based on freshly collected larval materials.

Materials and methods

Larval materials were collected from streams and rivers in the Eastern and Western Himalayan regions of India

during an expedition conducted by the Zoological Survey of India. The larvae were collected using a combination of methods, including kick-net sampling, hand-picking, and the use of a fine brush. To ensure their preservation, all materials were stored in 95% ethanol. Permanent mounts were then prepared in Hoyer's medium and sealed with Canada Balsam, allowing for detailed microscopic observations. These materials were thoroughly examined, and photographs were captured using a Leica M205A stereo zoom microscope and Leica D3000 microscope. Type specimens are deposited in the National Zoological Collection (NZC) of the Southern Regional Centre (SRC), Zoological Survey of India (ZSI), Chennai, India.

Results

Potamanthellus diversprimus sp. nov. (Fig. 1–5)

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Material examined

Holotype: ♀ mature larva, INDIA, Himachal Pradesh, Hamirpur, Beas River, Nadaun, 31°46'53.2'' N, 76°20'12.9'' E, 468 m a.s.l., 23 March 2021, leg. T. Kubendran (Reg. No. I/E/762). Paratypes: 2 larvae, same data as holotype (Reg. No. I/E/763).

Description

Mature larva (Fig. 1A–2B): Length: body 10.5–11 mm; head width 2.1–2.3 mm; antennae 1.5–2 mm; cerci 6.8–7mm (Fig. 5K), median filament 6–6.5 mm.

Head

Generally brownish black. Anterior margin slightly to moderately concave; Genae small (Fig. 2B). Dorsal surface of head with simple setae; head even with small simple setae (Fig. 2B). Antennae with dark brown basally, flagellum pale yellowish, 3× longer than head width, articulations with numerous small setae (Fig. 5K); Labrum: anterior margin of median emargination concave with serration (Fig. 3A), lateral margin with long plumose setae; dorsal surface densely covered with long plumose, small stout plumose and bifid setae (Fig. 3B); ventral surface densely covered with long and hair-like plumose setae. Mandibles: right mandible of lateral margin densely covered with small bifurcate setae; outer incisor with two teeth, inner incisor with a single tooth; prostheca with tuft of fine setae, and inner margin near the mola with a row of dense fine setae (Fig. 3D); left mandible of lateral margin densely covered with bifurcate setae; outer incisor with three teeth, and inner incisor teeth are joined with the outer teeth, with one long and other one small mola with 6–7 fine setae (Fig. 3E). Hypopharynx: anterior margin of lingua medially concave with cover dense fine setae; superlinguae rectangular with long hair-like setae apically and laterally slightly concave (Fig. 3C). Maxilla: galea-lacinia with 3 canines and 2 long distinct dentisetae, both inner and outer margins with row of long hair-like plumose setae; palp three segmented, length of segment in mm (0.42/0.32/0.46), segment I broader and longer than segments II, segment III longer than segment I and II with long setae along with inner and outer margins, segment II with long hair-like setae on outer margin and surface with few stout setae, inner margin of segment III with long plumose setae and dorsal surface with stout setae, long hair-like setae apically (Fig. 3F–G). Labium: glossae laterally round, apically pointed, dense hair-like stout setae; dorsum of paraglossae with dense long hair-like setae, laterally round with long hair-like setae, ventral surface with dense hair-like setae; labial palps three-segmented, segment I broader, segment II smaller than segment III; length of segment I subequal to segment II and III; inner and outer margin of segment I with hair-like and dense stout bifid setae, inner margin of segment II with small hair-like setae, long hair-like setae near outer margin; segment III with numerous subapical stout setae and covered with dense long hair-like setae on outer margin; dorsal surface of mentum and submentum with stout setae and plumose setae on laterally (Fig. 4A–B).

Thorax

Brownish black; margins with dense stout setae, pronotum brown with pale yellow maculae medially and small stout setae and black maculae laterally; mesonotum black, with brown color anterior part and small stout setae laterally, metanotum brown (Fig. 1A). Legs brown mixed with pale yellow, fore leg broad, dorsal surface of femur

with numerous bifid stout setae on proximal part, distally with transverse row of five long bifurcate setae; tibia and tarsi with brown band, dorsal surface with few stout setae and inner margin with hair-like setae (Fig. 4C–E); middle and hindlegs similar, femora with scattered stout small and long bifurcate setae, both legs with patella tibial suture distinctly exposed; outer margin of hind tibia with three long setae and inner margin with small stout setae (Fig. 4F–G). Claw of all legs long without denticles and apically hooked (Fig. 4H).

Abdomen

Brownish black; terga I–X with stout bifurcate setae on dorsal surface and posterior margins (Fig. 1A, 2A, 5A–C); posterolateral spines on terga IV–IX well developed, progressively larger posteriorly, tergum III slightly expanded (Fig. 1A); terga III–VIII with distinct median tubercle (Fig. 1A); sterna I–VI medially yellowish, sterna VII–IX medially brownish, sterna I–IX laterally brown along with dark brown band (Fig. 1B). Gill I–VI present; gill I unilamella, with 2 segments, apical one longer than basal one and covered with long plumose setae and scattered fine setae (Fig. 5D); gill II subquadrate operculate, meet medially with somewhat rudimentary diagonal ridge and covered with small scattered stout bifurcate setae (Fig. 5F), ventral lamella small with numerous long fringes (Fig. 5E). Gill III V bilamella, well developed tracheae; gill III–V similar in shape with a row of long fringes on lateral margin (Fig 5G–J); Gill VI unilamella, smaller in size (Fig. 5J). Caudal filaments subequal in length, with whorls of spine-like setae on each segment (Fig. 1A).

Adult

Unknown.

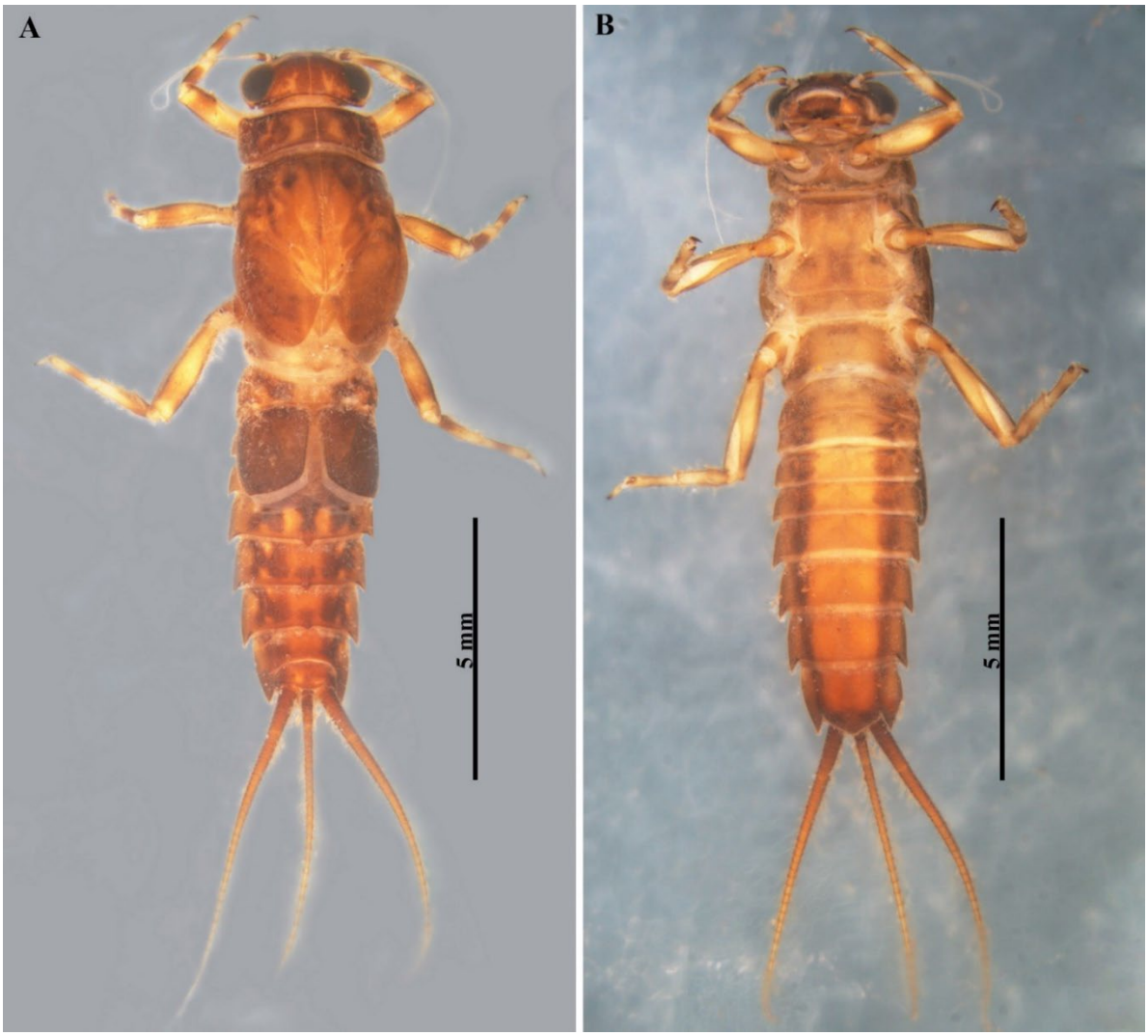

Fig. 1. Holotype Larva of *Potamanthellus diversprimus* **sp. nov.** A. Dorsal view; B. Ventral view.

Etymology

The species name "*diversprimus*" is derived from the Latin words "diversitas" meaning "diversity," and "primus," meaning "first." This name highlights the species significance as a representation of the diversity found in Himachal Pradesh, India.

Distribution

Himachal Pradesh (India) (Fig. 13).

Diagnosis

The new species *Potamanthellus diversprimus* **sp. nov.** can be distinguished from all known species of the genus *Potamanthellus* by the following combination of characters: (i) dorsal surface of the forefemora features numerous bifid stout setae in proximal part and five distinct bifurcate setae distally on brown band (Fig. 4C–E); (ii) gill II operculate with somewhat rudimentary diagonal ridge (Fig. 5E–F); (iii) abdominal terga III –VIII possess median tubercles (Fig. 2A, 5C); (iv) posterolateral spines present on terga IV–IX, and tergum III slightly developed (Fig. 2E); (v) maxilla contains two long dentisetae and three canines (Fig. 3F); (vi) segment III of the maxillary palp longer than others (Fig. 3F–G); (vii) claw without denticles, and apically narrow (Fig. 4H).

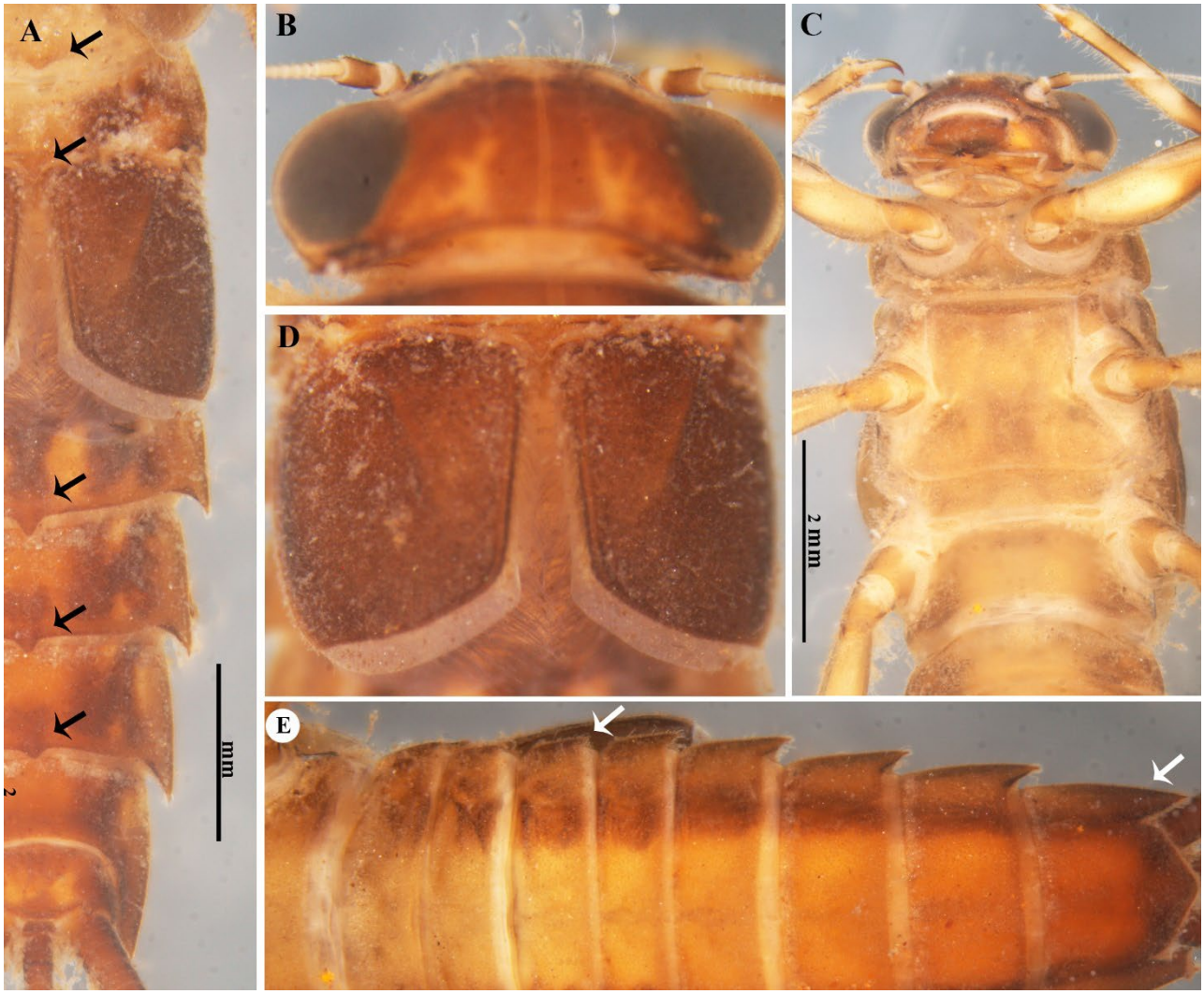

Fig. 2. Larva of *Potamanthellus diversprimus* **sp. nov.** A. Abdomen dorsal view (arrow indicated abdomen median tubercles); B. Head; C. Thorax ventral view; D. Gill II; E. Abdomen ventral view (arrow indicated sternum posterolateral margin IV, VIII).

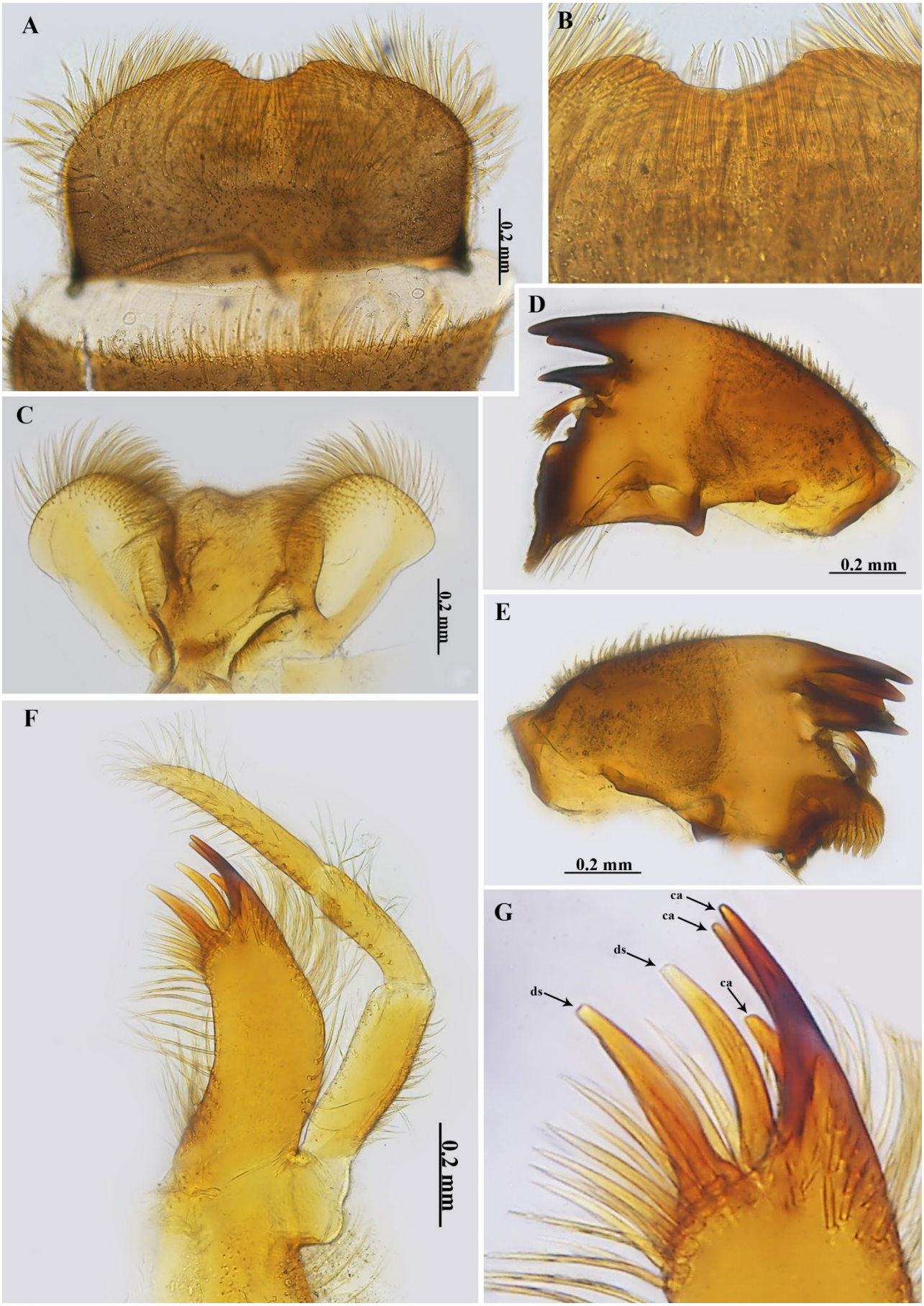

Fig. 3. Larva of *Potamanthellus diversprimus* **sp. nov.** A. Labrum; B. Labrum closer view; C. Hypopharynx; D. Right mandible; E. Left mandible; F. Maxilla; G. Maxilla closer view (arrow indicated ca- canines, ds- dentidetae).

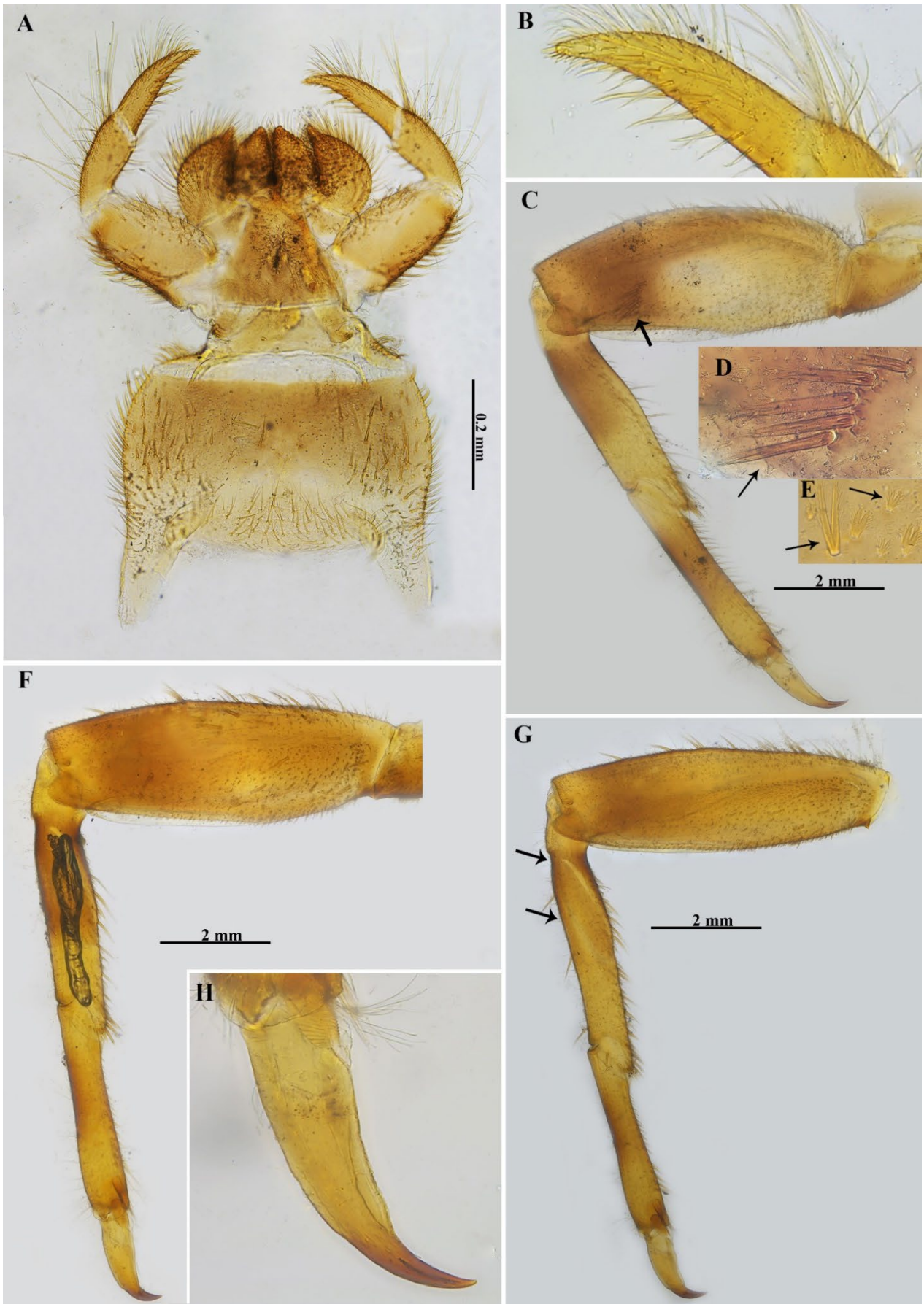

Fig. 4. Larva of *Potamanthellus diversprimus* **sp. nov.** A. Labium; B. Labial palp III closer view; C. Foreleg; D. Foreleg bifid setae closer view; E. Foreleg dorsal surface setae; F. Midleg; G. Hindleg; H. Claw.

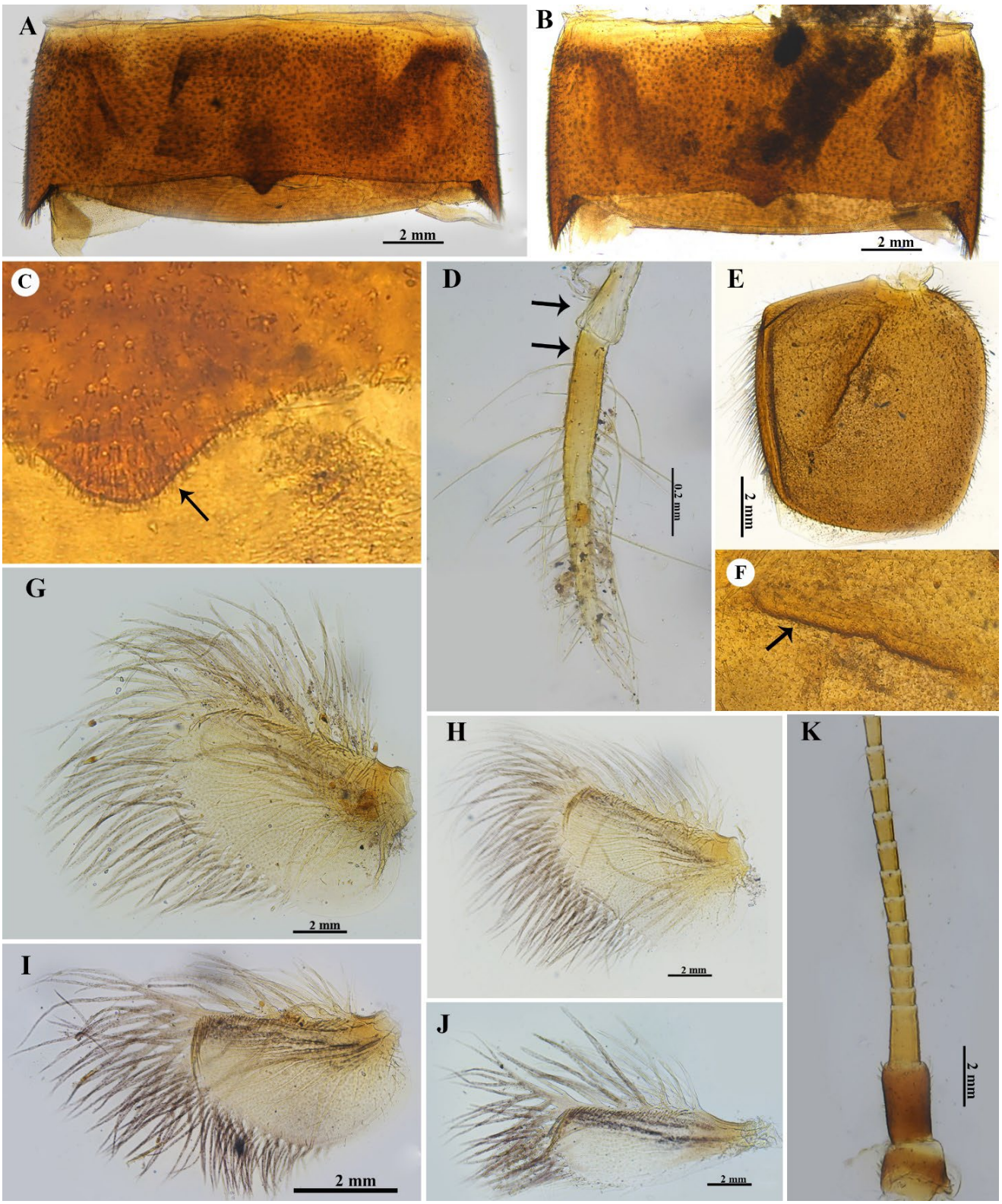

Fig. 5. Larva of *Potamanthellus diversprimus* **sp. nov.** A. Tergum VII; B. Tergum VIII; C. Tergum VIII arrow closer view on tubercle; D. Gill I (arrow indicated segment I & II); E. Gill II operculate; F. Gill II (arrow indicated diagonal ridge); G. Gill III; H. Gill IV; I. Gill V; J. Gill VI; K. Antennae.

Potamanthellus sineiugis sp. nov. (Fig. 6–12)

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Material examined

Holotype: mature larva, INDIA, Arunachal Pradesh, Dibang Valley, Aalo River (away from 10 km from Aalo

town) 28°11'49.6'' N, 94°42'06.1'' E, 209 m a.s.l., 28 February 2024, leg. T. Kubendran (Reg. No. I/E/838). Paratypes: 5 larvae, same data as holotype (Reg. No. I/E/839).

Description

Mature larva (Fig. 6A–C): Length: male body 9.5–10.5 mm; head length 0.7–0.9 mm, width 2.2–2.5 mm; antennae 1.2–1.5 mm; cerci 5.2–5.5, median filament 4.8–5 mm. female body 11.5–12 mm; head width 2.3–2.5 mm; antennae 1.5– 2 mm (Fig. 12B); cerci 6–6.5, median filament 5.8–6 mm.

Head

Generally, brown with black. Anterior margin moderately concave; Genae moderately small. Dorsal surface of head with small stout setae (Fig. 7A). Antennae with pale brown basally, flagellum pale white, above 3× longer than head width, articulations with few small setae (Fig. 6A); Labrum: anterior margin of median emargination shallowly cleft and laterally rectangular (Fig. 8A) and lateral margin with strong setae; dorsal surface densely covered with long plumose, small stout plumose and bifid setae (Fig. 8A–B); ventral surface densely covered with long and hair-like plumose setae. Mandibles: right mandible of lateral margin densely covered with small bifurcate setae; outer incisor with broad two teeth, inner incisor with two teeth; prostheca with tuft of setae, and inner margin near the mola with a row of dense fine setae (Fig. 9A–B); left mandible of lateral margin densely covered with bifurcate setae; outer incisor with three or four teeth, and inner incisor with two teeth, with one long and other one small apically blunt, mola with 10–11 fine setae (Fig. 9C–D). Hypopharynx: anterior margin of lingua medially rounded with cover dense fine setae; superlinguae broad, rectangular with long hair-like setae apically and laterally slightly concave (Fig. 8C). Maxilla: galea-lacinea slightly lean differentiated with *P. diversprimus* sp. nov. (Fig. 8D), with 3 blunt canines and 2 long serrated dentisetae, both inner and outer margins with row of long hair-like plumose setae; palp three segmented, length of segment in mm (0.4/0.3/0.42), segment I somewhat broad and longer than segments II, segment III longer than segment I and II with long setae along inner and outer margins, segment II with long hair-like setae on outer margin and surface with few stout setae, inner margin of segment III with long plumose setae and dorsal surface with stout setae, long hair-like setae apically (Fig. 8E–F). Labium: glossae laterally somewhat rounded, apically pointed, dense hair-like stout setae; dorsum of paraglossae with dense long hair-like setae, laterally round with long hair-like setae, ventral surface with dense hair-like setae; labial palps three-segmented, segment I broader, segment II smaller than segment III; length of segment I longer than segment II and segment III long and apically sharp; inner and outer margin of segment I with hair-like and dense stout bifid setae, inner margin of segment II with small hair-like setae, long hair-like setae near outer margin; segment III with numerous subapical stout setae and covered with dense long hair-like setae on outer margin; dorsal surface of mentum and submentum with stout setae and plumose setae on laterally (Fig. 9E–G).

Thorax

Brownish with diffuse black; margins with small stout setae, pronotum brown with pale black spots laterally; mesonotum brown with yellowish anterior part, black spots laterally, metanotum brown with yellowish (Fig. 6A, 7A–B). Legs yellowish, femur with dark brown band on distal region (Fig. 10A–C); terga and tarsi with dark brown band on medially (Fig. 11A–C); fore leg broad, dorsal surface of femur with small bifurcate stout setae, forefemora dorsal surface of distal region with four short bifid stout setae (Fig. 10A); middle and hindlegs similar, femora with scattered small stout and long bifurcate setae, both legs with patella tibial suture distinctly exposed and terga and tarsi with present dark brown band on medially (Fig. 10B–C). Claw without denticles and apically slightly hooked (Fig. 12A).

Abdomen

Brownish yellow diffuse with black; terga I–X with small stout bifurcate setae on dorsal surface and posterior margins (Fig. 6A, C); posterolateral expansions on terga II IX, and tergum II–IV slightly developed and tergum V–IX well developed (Fig. 6B, 7C); abdominal terga VI–VIII dorsal and ventral ornamentation differentiated with other species (Fig. 7B, D). Terga II–VIII with distinct median tubercle (Fig. 6A, 7B, 7D–E); sterna I–V medially yellowish and laterally brownish, sterna VI–VIII medially dark yellowish mixed with orange and laterally brownish, sternum IX dark brownish (Fig. 6B); sterna VI–IX with lateral spines and medially brown band (Fig. 6B, 7C); Gill present I–VI; gill I unilamella with long hair-like setae (Fig. 12C); gill II subquadrate operculate,

meet medially (Fig. 12D), without diagonal ridge on operculate and covered with small scattered stout, bifurcate setae, ventral lamella small with numerous long fringes. Gill III–V bilamella; slightly developed trachea; gill III–V similar in shape and structure with row of long fringes on lateral margin (Fig. 12E–H); Gill VI unilamella, smaller in size (Fig. 12H). Caudal filaments subequal in length, with whorls of spine-like setae on each segment (Fig. 6A).

Adult

Unknown.

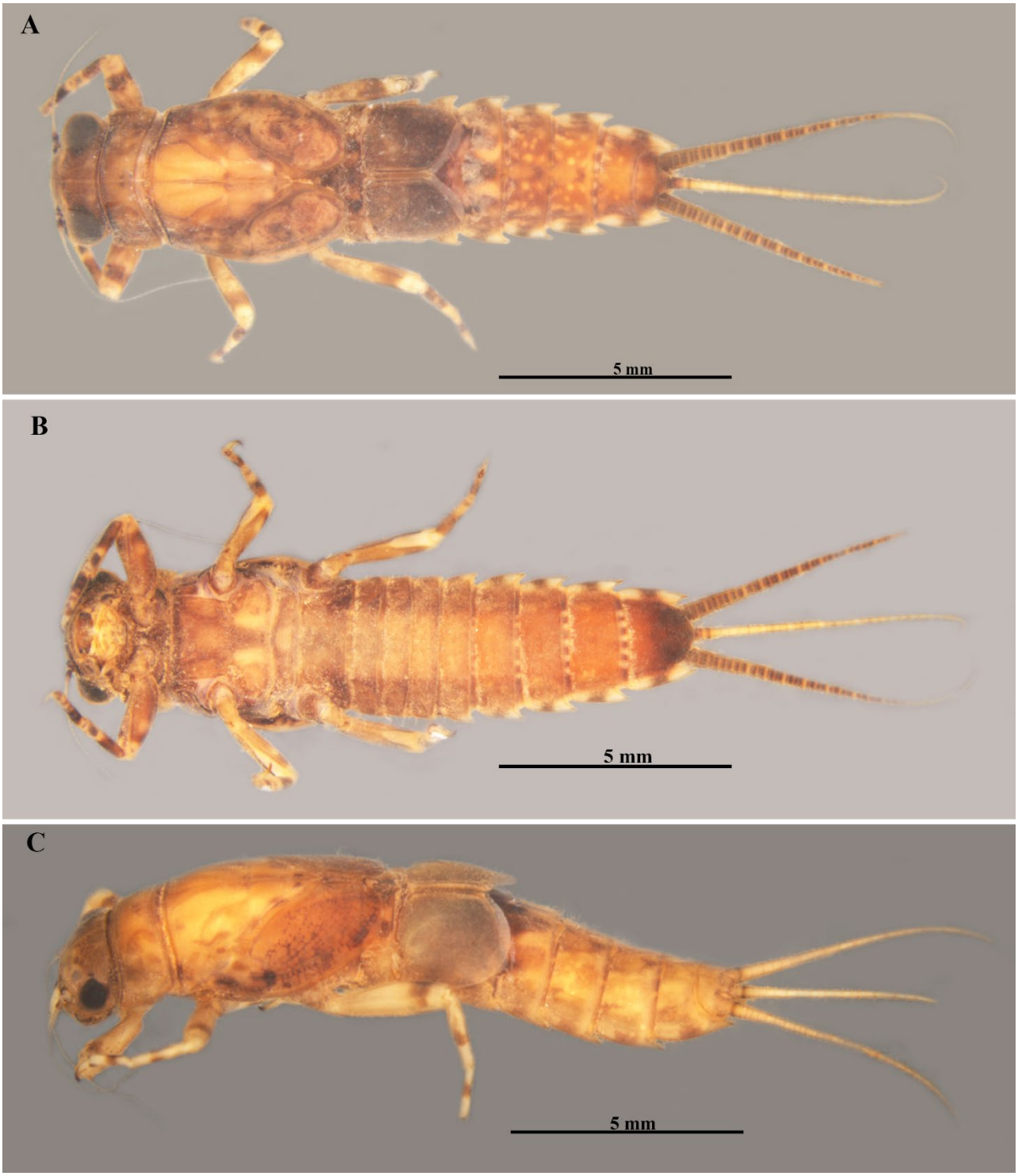

Fig. 6. Larva of *Potamanthellus sineiugis* **sp. nov.** A. Dorsal view; B. Ventral view; C. Lateral view.

Fig. 7. Larva of *Potamanthellus sineiugis* **sp. nov.** A. Dorsal view (middle instar); B. Abdomen dorsal (arrow indicated gill place); C. Abdomen ventral (arrow indicated segment VIII–IX ornamentation); E. Abdomen median tubercles; D. Abdomen dorsal (arrow indicated middle instar median tubercles).

Etymology

The species is named after the absence of diagonal ridge on the surface of operculate gill II. The name "sineiugis" is derived from Latin meaning "without ridge".

Distribution

Arunachal Pradesh (India) (Fig. 13).

Diagnosis

The new species *Potamanthellus sineiugis* **sp. nov.** can be distinguished by the following combination of characters: (i) femur of all legs a dark brown band on distal region, with similar band in terga and tarsi medially

(Fig. 10–11); (ii) dorsal surface of forefemora distal region with four short bifid stout setae (Fig. 10A); (iii) operculate gills lack of diagonal ridge (Fig. 12D); (iv) abdominal terga II–VIII with median tubercles (Fig. 7D–E) and posterolateral expansions are slightly developed on terga II–IV and well developed on terga V–IX (Fig. 6A, 7A–B); (v) abdominal terga VI–VIII distinct dorsal and ventral ornamentation (Fig. 7B–D); (vii) maxilla with three blunt canines and two long serrated dentisetae (Fig. 8D); (viii) galea-lacinea slightly slender with few hair-like setae (Fig. 8E); (x) mandibles strongly developed inner and outer canines (Fig. 9A–D); (xi) claw lack of denticles and slightly hooked at apex (Fig. 12A).

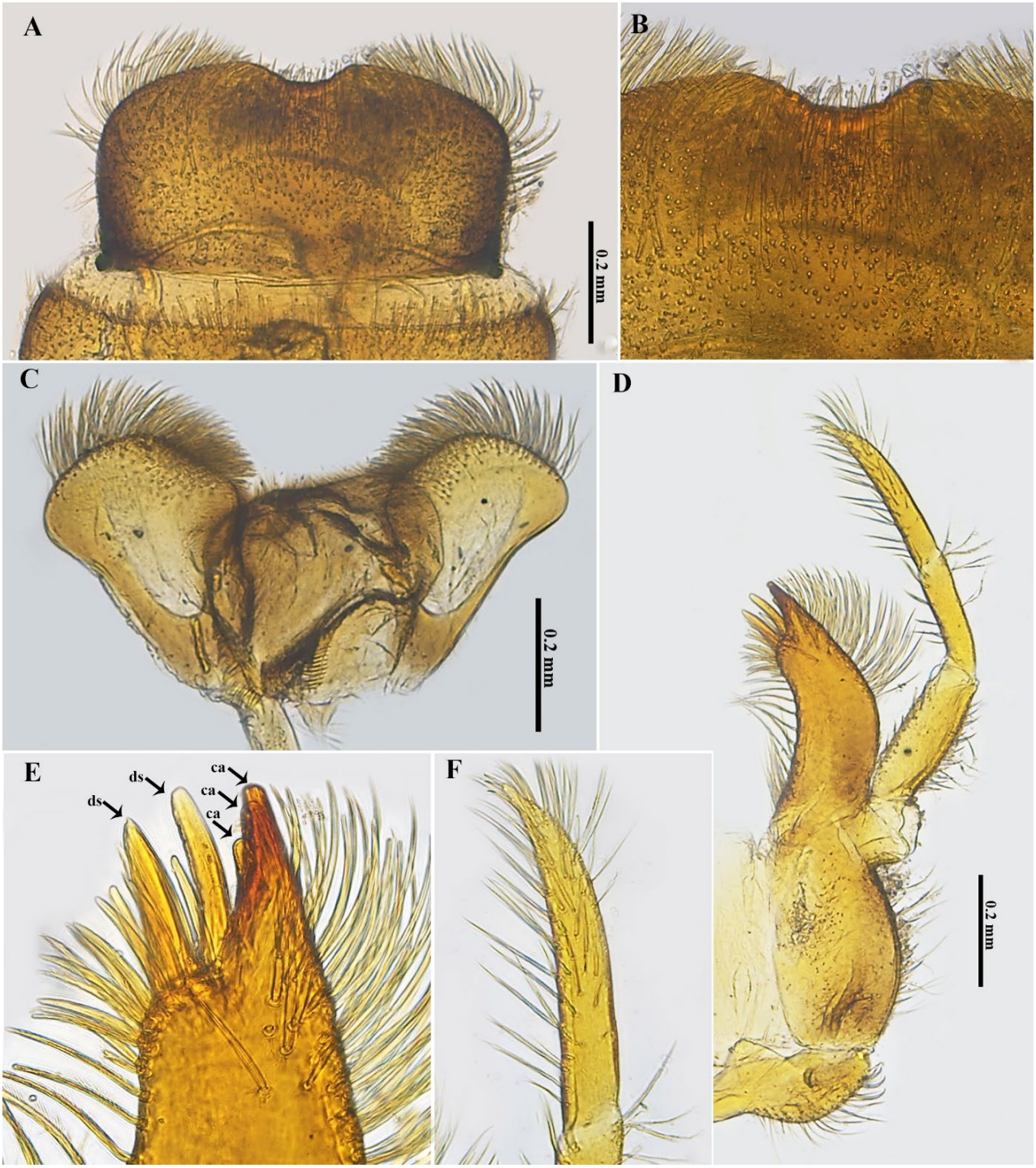

Fig. 8. Larva of *Potamanthellus sineiugis* **sp. nov.** A. Labrum; B. Labrum closer view; C. Hypopharynx; D. Maxilla; E. Maxillary palp closer view; F. Galea-lacinea (arrow indicated ca- canines, ds- dentidetae).

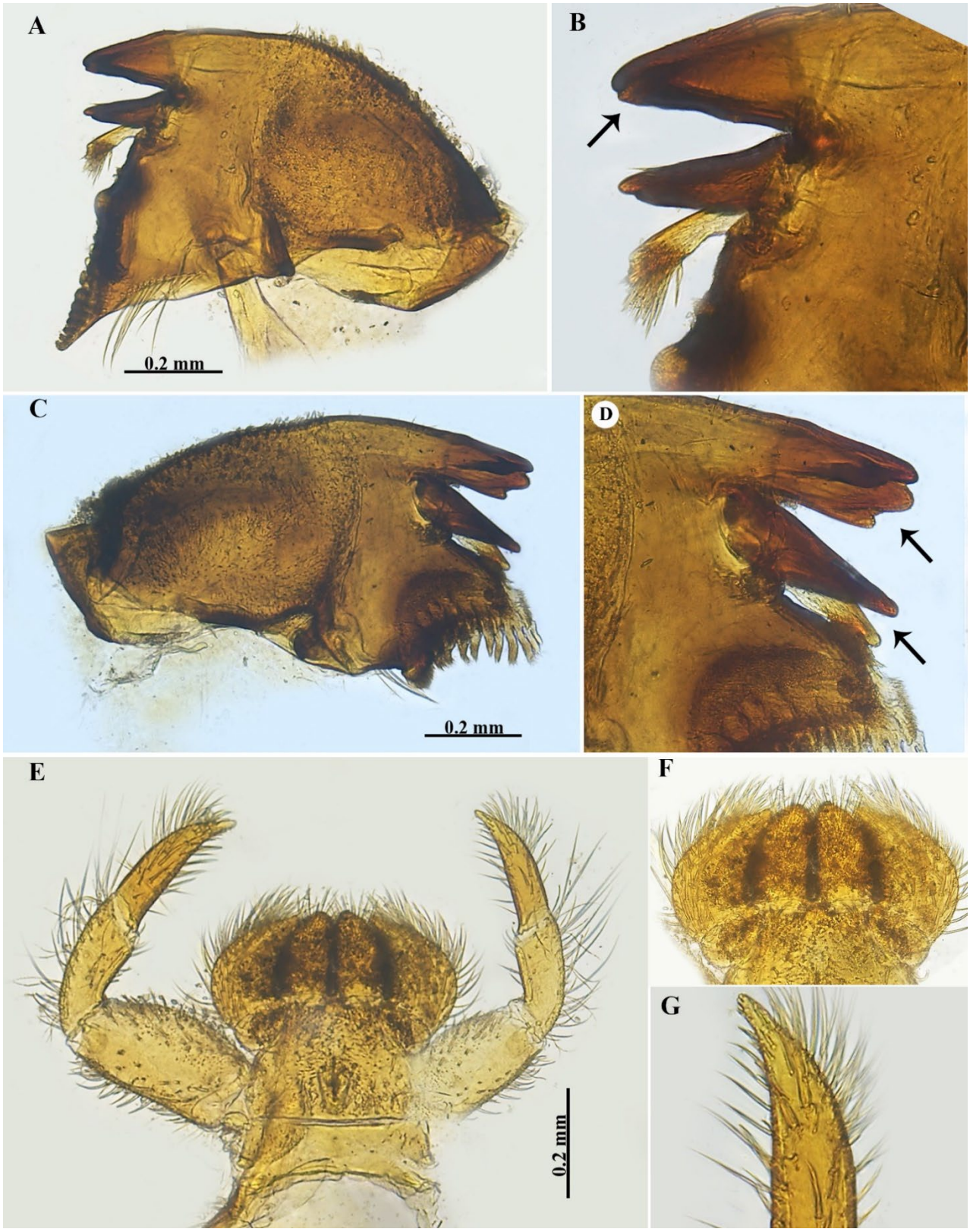

Fig. 9. Larva of *Potamanthellus sineiugis* **sp. nov.** A. Right mandible; B. Right mandible closer view; C. Left mandible; D. Left mandible closer view; E. Labium; F. Labium closer view; G. Labial palp III closer view.

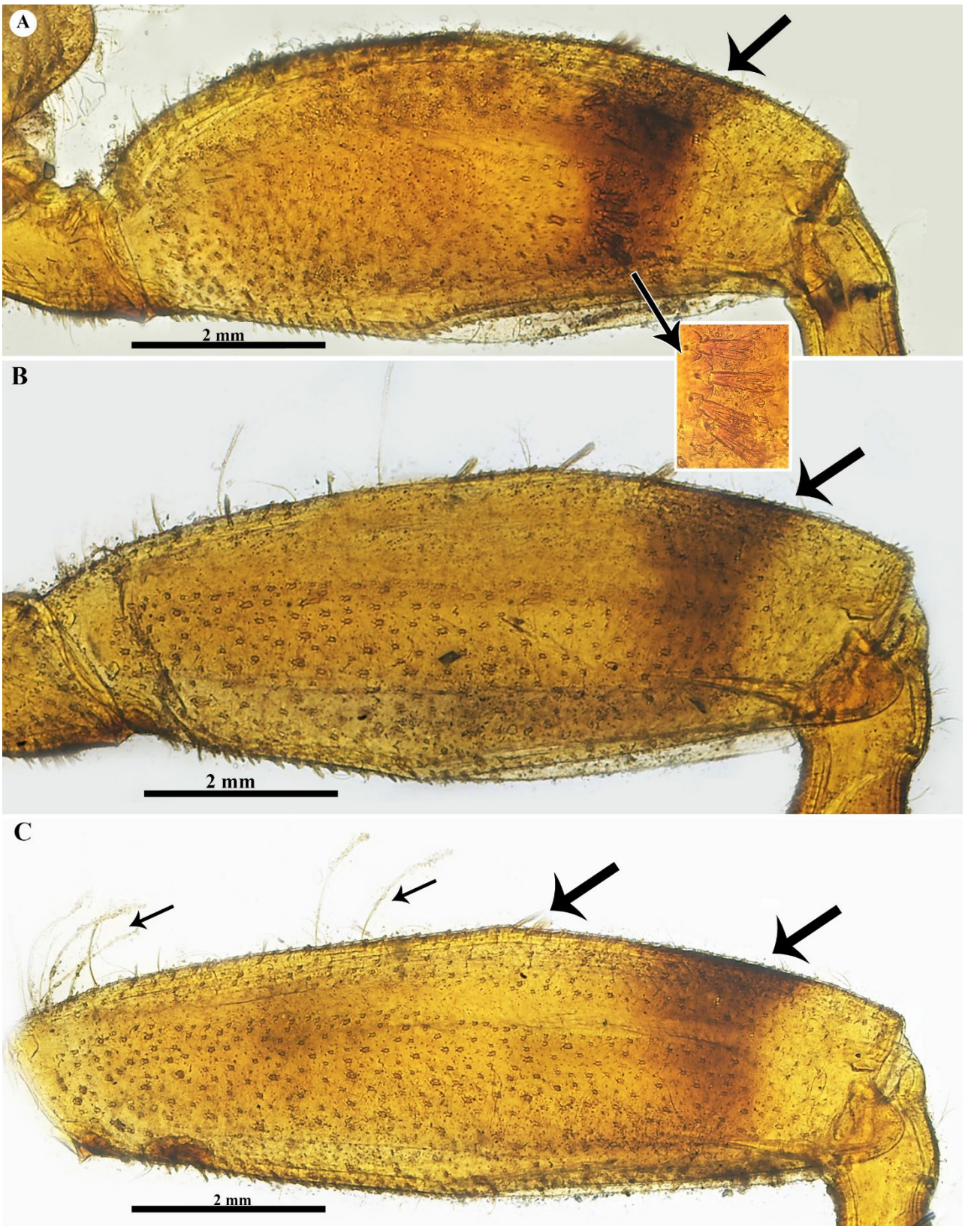

Fig. 10. Larva of *Potamanthellus sineiugis* **sp. nov.** A. Forefemur (arrow indicated transverse setae); B. Midfemur (arrow indicated anterior marginal stout setae); D. Hindfemur (arrow indicated anterior marginal long setae).

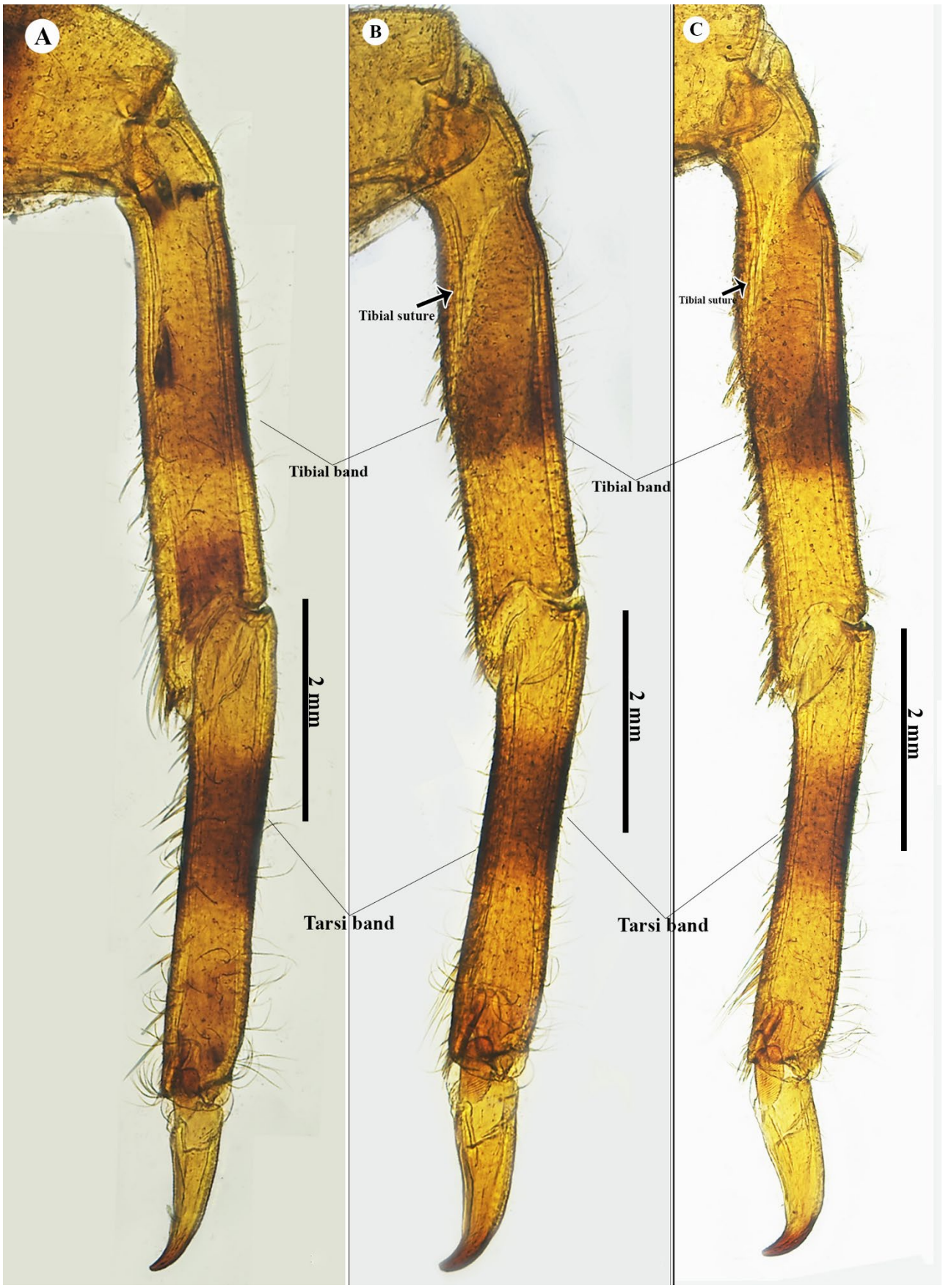

Fig. 11. Larva of *Potamanthellus sineiugis* **sp. nov.** A–C. Fore-mid-hind tibia and tarsi (arrow indicated mid-hind tarsal patella suture and brown band).

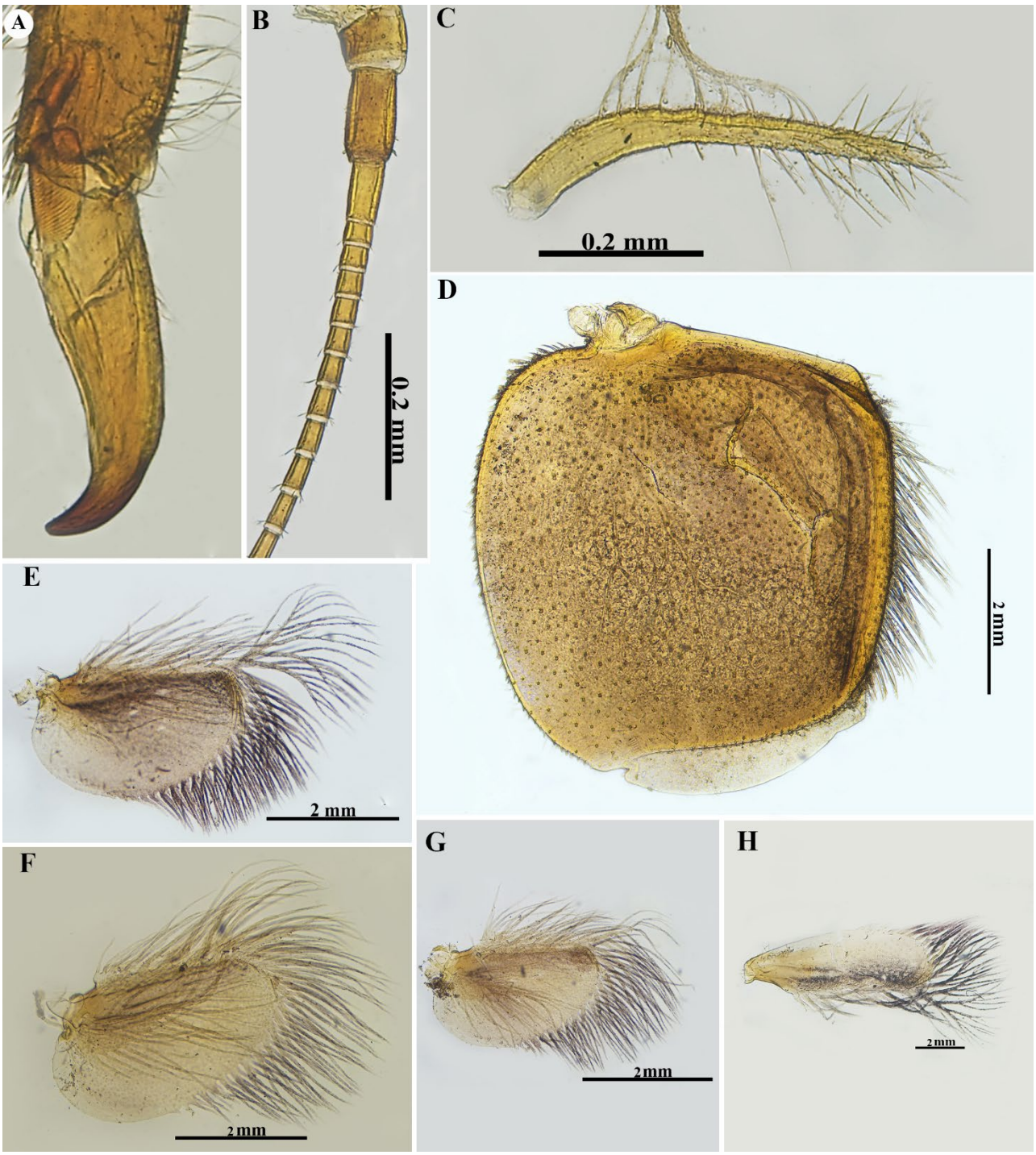

Fig. 12: Larva of *Potamanthellus sineiugis* **sp. nov.** A. Claw; B. Antennae; C. Gill I; D. Gill II operculate; E. Gill III; F. Gill IV; G. Gill V; H. Gill VI.

Discussion

The genus *Potamanthellus* Lestage, 1931 recorded in the Oriental and eastern Palearctic regions. There are eight species described globally under this genus, all of which share similar characteristics with this new species *P. diversprimus* **sp. nov.**, by the diagonal ridge on the operculate gills (except for *P. edmundsi*), whereas gill II operculate, with the diagonal ridge somewhat rudimentary. The distinctive character i.e., dorsal surface of forefemora with numerous bifid, stout setae on the anterior proximal part, and five distinct bifurcate setae situated distally were observed in *P. diversprimus* **sp. nov.**, whereas, the dorsal surface of forefemoral setae absent in closely related to species of *P. caenoides*, and *P. ganges*.

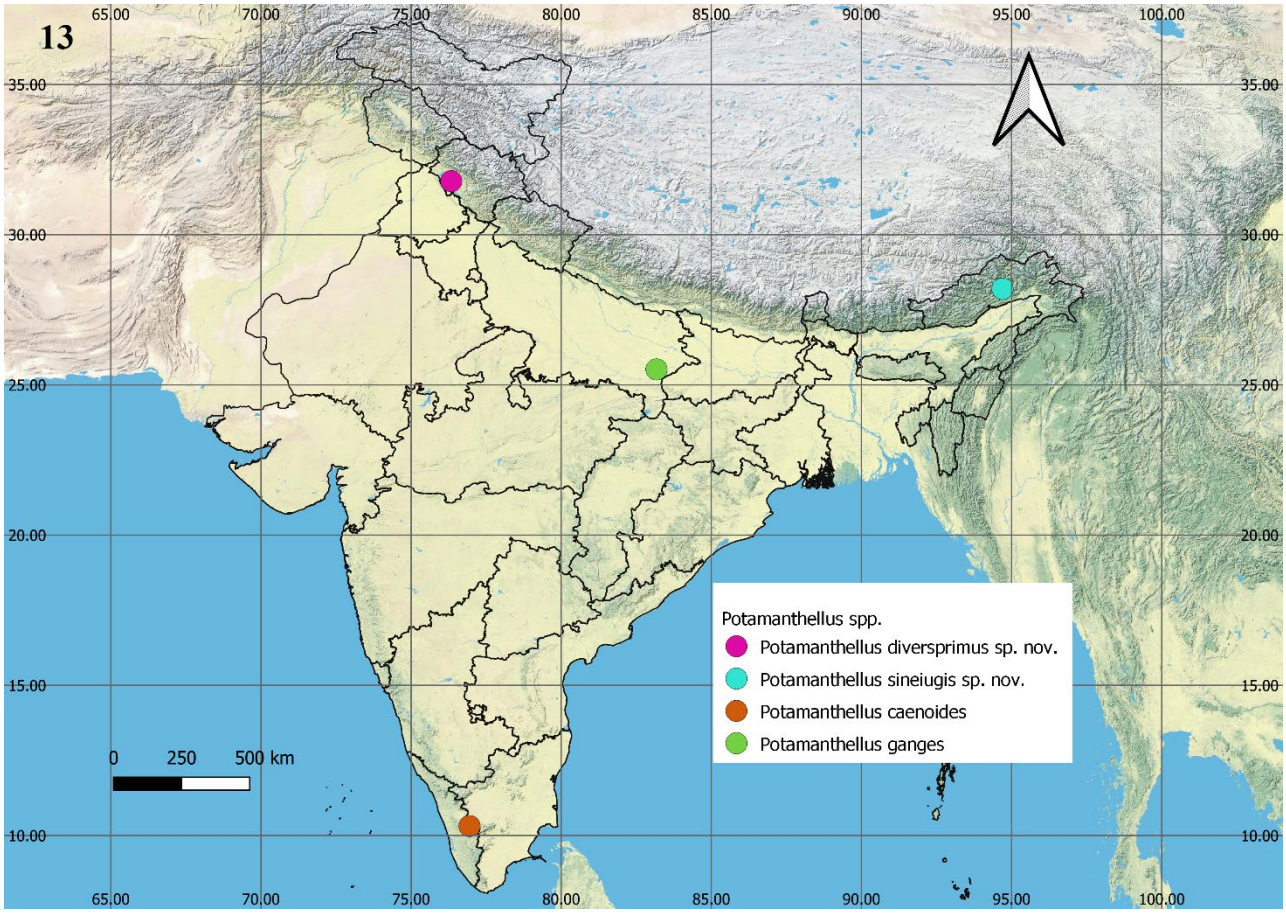

Fig. 13: Distribution of the genus *Potamanthellus* in India.

Potamanthellus panayensis is absence of brown band on the femur whereas the present new species is present brown band on all femora. The present new species *P. diversprimus* **sp. nov.**, with the distinct abdominal tergum with median tubercles on terga II–VIII, whereas it differs in *P. caenoides* and *P. ganges*.

The newly discovered species *P. sineiugis* **sp. nov.** is closely related to *P. diversprimus sp. nov.* but can be distinguished from Oriental species based on several key characteristics. Specifically, *P. sineiugis* **sp. nov.** features a dark brown band on the distal region of the femur, as well as medial dark brown bands on the terga and tarsi. Additionally, *P. sineiugis* **sp. nov.** can be differentiated from *P. caenoides* and *P. panayensis* by the presence of four short bifid stout setae on the distal region of the dorsal surface of the forefemora, whereas *P. diversprimus* **sp. nov.** possesses five stout setae, showcasing significant variation in these features across species. Moreover, *P. sineiugis* **sp. nov.** lacks a diagonal ridge on operculate gill II, a characteristic present in known species of this genus.

Future research should focus on extensive surveys and collections of larval and adult specimens in all of India's biogeographic regions. This approach has the potential to greatly enhance our understanding of the distribution patterns of the genus *Potamanthellus* and contribute to the broader knowledge of these species.

Author's Contributions

Malaisamy Vasanth: conceptualization, methodology, formal analysis, investigation, draft preparation, visualization; **Thangavel Kubendran:** conceptualization, methodology, final review and edit, visualization; **Kumarapuram Apadodharanan Subramanian:** conceptualization, methodology, final review and edit, supervision, project administration and funding acquisition.

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Data Availability Statement

All data supporting the findings of this study are available Southern Regional Centre (SRC), Zoological Survey of India (ZSI).

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Ethics Approval

Insects (Ephemeroptera) were used in this study. All applicable international, national, and institutional guidelines for the care and use of animals were followed. This article does not contain any studies with human participants performed by the authors.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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توصیف دو گونه جدید از جنس *Potamanthellus* Lestage 1931 (Ephemeroptera: Neoephemeridae)، از هند

مالازامی وازانس [۱]، تانگاول کوبندران [۲] و کومارام پوران سوبرامانیان [۱]

۱ –موسسه جانورشناسی هند، مرکز منطقه‌ای جنوبی، بزرگراه سانتوم، چنای 028 600، تامیل نادو، هند

۲– بخش حشرات متفرقه، موسسه جانورشناسی هند، پرانی ویگیان باوان، ام بلوک، نیو آلیپور، کلکته– ۷۰۰ ۰۵۳، بنگال غربی، هند

چکیده: دو گونه جدید از جنس *Potamanthellus* Lestage شامل *P. diversprimus* sp **nov.** و *P. sineiugis* sp **nov.**، از مناطق شرقی و غربی هیمالیای هند جمع آوری شدند. این اولین گزارش ثبت خانواده Neoephemeridae از این مناطق جغرافیایی است. در اینجا دو گونه جدید حاصل بررسی در این تحقیق روی یک روزه‌های نهرها و رودخانه‌های هیمالیای شرقی و غربی هند بر اساس مرحله لاروی توصیف شده‌اند.

کلمات کلیدی: یک‌روزه‌ها، طبقه بندی، گونه های جدید، هیمالیا، هند

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