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A new species and record of *Labiobaetis* Novikova and Kluge, 1987 (Ephemeroptera: Baetidae) from India

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ABSTRACT

A new species of *Labiobaetis* Novikova and Kluge, 1987 is described based on the larval material from Tamil Nadu, southern India. The total number of *Labiobaetis* species in India is thereby increased to eight. *Labiobaetis davamanii* sp. n. is assigned to the *L. sumigarensis* group of species and it is compared with its other representatives as well as with other *Labiobaetis* species from the Indian subcontinent. *Labiobaetis operosus* Müller-Liebenau, 1984 from the *L. operosus* group is recorded for the first time from India.

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Eastern Ghats; Labiobaetini; mayflies; morphology; new species; Tamil Nadu

Introduction

The genus *Labiobaetis* Novikova and Kluge, 1987 is one of the richest genera of mayflies with 147 species (Kaltenbach et al. 2021). The distribution of *Labiobaetis* is nearly worldwide, except for the Neotropical Region, New Zealand, and some remote islands. The generic status of *Labiobaetis* was debated for a long period but is now widely accepted as a separate genus. The history and concept of the genus *Labiobaetis* were recently summarised in detail (Shi and Tong 2014; Kaltenbach and Gattolliat 2018). The larvae of *Labiobaetis* are characterised by a number of features, some of which are not found in other taxa (Kluge and Novikova 2014): (1) scape with or without a distolateral process; (2) maxillary palp two segmented; segment II with excavation at the inner distolateral margin, excavation may be poorly developed or absent; (3) paraglossae widened and glossae diminished; (4) labial palp segment II with distomedial protuberance. All these characters vary and may be secondarily lost (Kluge and Novikova 2014). Additional characters of *Labiobaetis* are summarised and discussed in Kaltenbach and Gattolliat (2018, 2019).

Studies on *Labiobaetis* in India are incomplete. Apart from four species described much earlier as imagines only: *L. dipsicus* (Gillies, 1949), *L. inopinum* (Gillies, 1949),

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L. palmyrae (Gillies, 1949) and *L. rubellum* (Navás, 1931), only two species were discovered in India recently and both in the Western Ghats: *L. soldani* Kubendran, Rathinakumar, Balasubramanian, Selvakumar, and Sivaramakrishnan, 2014 and *L. jacobusi* Kubendran and Balasubramanian, 2015 (in Kubendran, Balasubramanian, Selvakumar, Gattolliat, and Sivaramakrishnan 2015). In this article, we describe a new species of *Labiobaetis* from southern India.

Material and methods

The nymphs were collected by handpicking method in Tamil Nadu, Southern India (Figures 10 and 11). The collected specimens were then preserved in 80% ethanol. Larval morphological characters were studied using LABOMED Luzeo 6Z stereo zoom microscope and LABOMED Lx400 microscope and photos were taken with the help of AR 6 Pro digital camera and editing of photographs using Adobe Photoshop 7.0. Specimens studied under scanning electron microscope were first dehydrated using ethanol and dried by critical point drying and examined with an EVO-18 scanning electron microscope at 10k. Digital SEM photographs were made and edited by Adobe Photoshop 7.0. Type specimens are deposited in The American College Museum (AMC), Madurai, Tamil Nadu, India.

Results

Labiobaetis davamanii sp. n.

(Figures 1A, 2–5, and 10)

Materials examined

Holotype. ♀ mature larva, 'South India, Tamil Nadu, Natham District, Manikyan kada falls, 10°29.83'N, 78°23.40'E, ca.386 m, 30.06.2021, leg. Srinivasan and Isack' (AMC ZN 186).

Paratypes. 2 ♂ larvae, 6 ♀ larvae, with same label data as holotype (AMC ZN 187).

Mature larva description

Measurements. Body length 3.3–3.5 mm; paracercus length 1.61–1.68 mm, terminal filament length 1.45–1.50 mm.

Colouration. Head, thorax and abdomen dorsally light brownish in immature larvae (Figure 2A) and reddish brown in larvae ready to hatch (Figure 2B); head, thorax, and abdomen ventrally light brownish; paracercus light brownish and cerci translucent.

Head. Scape and pedicel subcylindrical; scape with poorly developed distolateral process (Figure 2C). Each segment of antenna with lanceolate spines and fine, simple setae on the apex of each segment. Labrum (Figure 2D): Sub-rectangular, length 0.7× maximum width; medial emargination with notched margin; dorsal surface with scattered fine, simple setae all over the surface; 16–18 clavate setae (Figure 2E) present

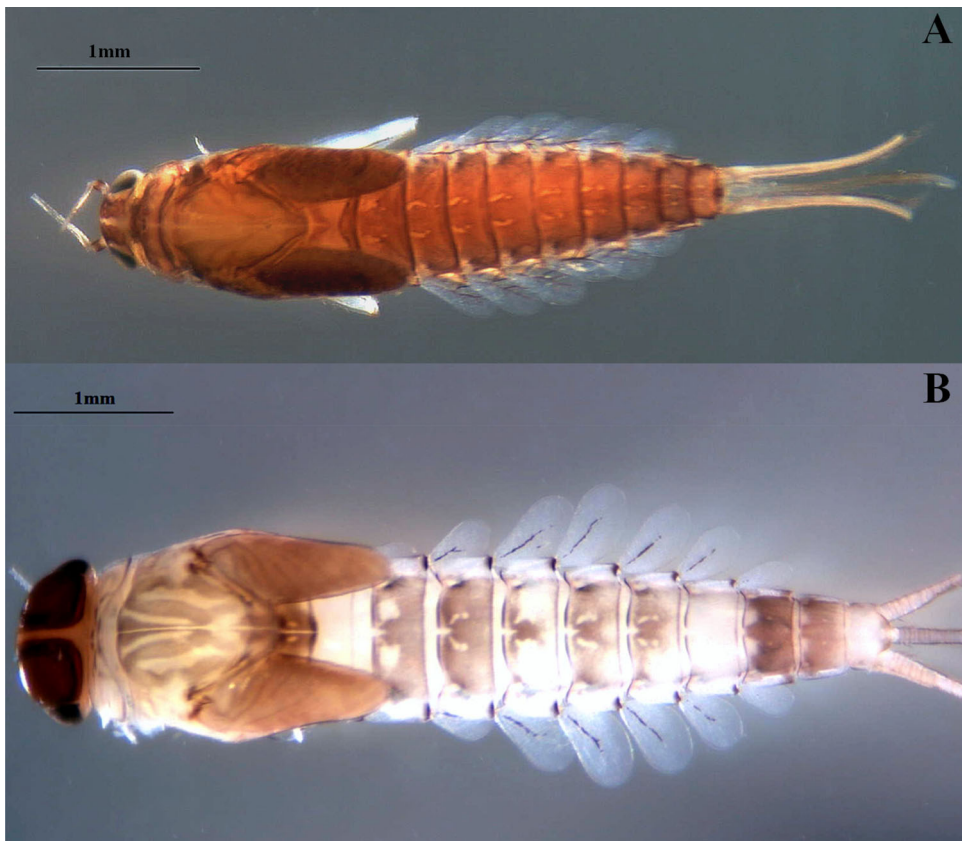


Figure 1. Habitus of larvae, dorsal view: (A) *Labiobaetis davamanii* sp. n.; (B) *L. operosus* Müller-Liebenau, 1984.

on the submarginal arc; ventral surface with 4–5 short, spine-like setae laterally. Hypopharynx (Figure 2F): Lingua longer than superlinguae; medial tuft of stout setae well developed. Right mandible (Figure 3A): Incisors fused; outer and inner incisor with 4 + 3 denticles and a minute intermediate denticle; inner margin of inner incisor with a row of thin setae; prostheca robust and apically denticulate (Figure 3A); margin between prostheca and molar region slightly convex, with minute denticles (Figure 3B); molar apex with a tuft of fine setae. Left mandible (Figure 3C): Incisors fused; outer and inner incisor with 4 + 3 denticles and a minute intermediate denticle; prostheca robust and comb-shaped with small denticles apically; margin straight with minute denticles; molar apex without setae. Maxilla (Figure 3D): Galea-lacinia with two simple setae under crown; medially with a long simple seta dorso-laterally and two small simple setae ventro-laterally. Maxillary palp ca. 1.4 × length of lacinia; two segmented, segment II 1.1 × length of segment I; fine, simple, scattered setae over the surface of maxillary palp; apex of segment II rounded, with a slight excavation at the inner distolateral margin. Labium (Figure 3E): Glossa shorter than paraglossa; inner margin of glossa with five spine-like setae increasing in length distally; apex with three long setae; outer margin with six long, spine-like setae increasing in length distally. Paraglossa with three rows of long, robust, pectinate setae on the apex

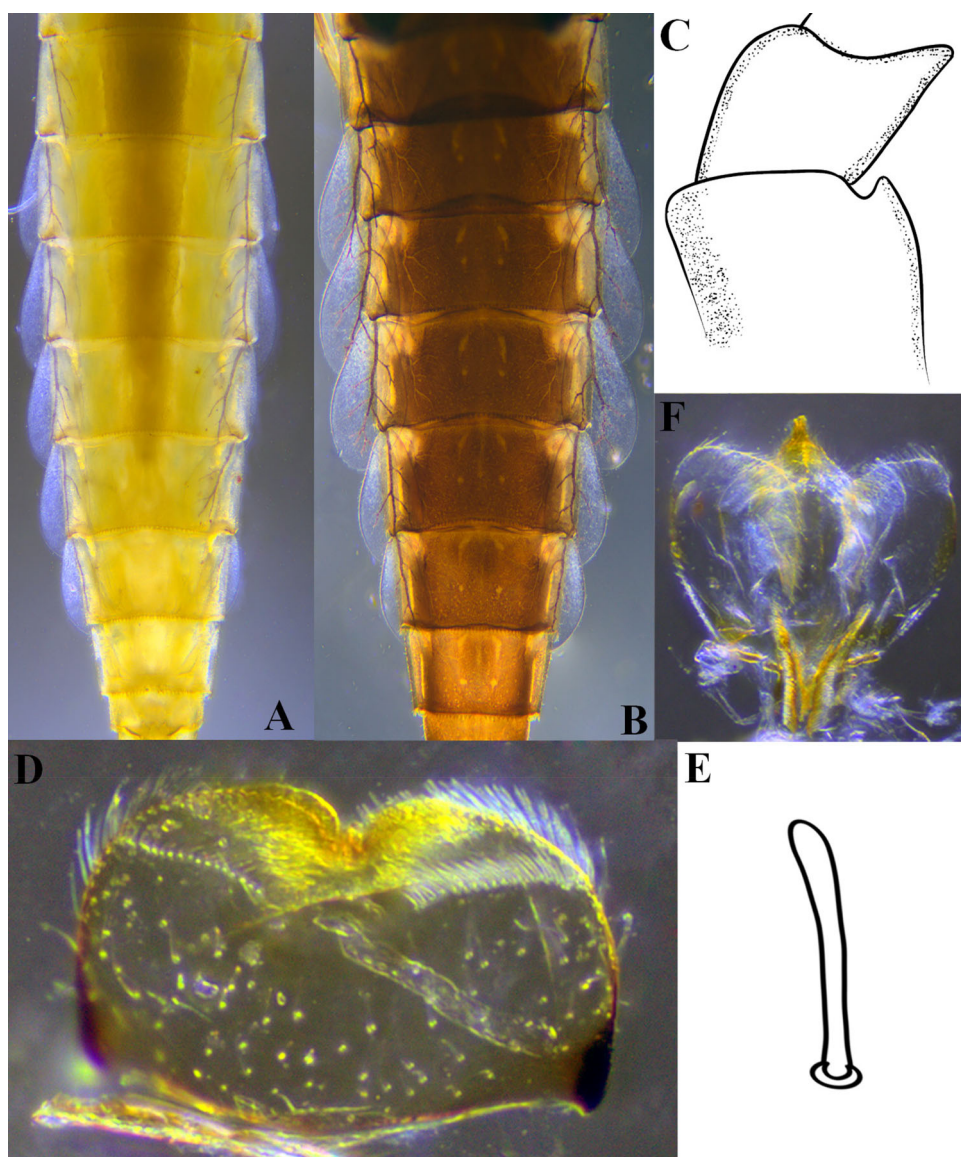


Figure 2. *Labiobaetis davamanii* sp. n.: (A) tergal colouration of immature larva; (B) tergal colouration of mature larva; (C) distolateral process at scape; (D) labrum; (E) shape of sub-marginal arc of setae in labrum; (F) hyopharynx.

and ventro-median row consists of 2 simple setae and dorsal surface with a row of 3–4 robust spines near inner margin. Labial palp three segmented; segment I $0.7\times$ length of segments II and III combined. Segment I with small micropores dorsally and fine, simple setae ventrally; segment II with an elongated, thumb-like distomedial protuberance; $0.6\times$ width of the base of segment III; both inner and outer margin with fine, simple setae; dorsal surface with a long, spine-like seta near the outer margin; segment III slightly pentagonal; apex truncate; length $0.9\times$ width; ventrally covered with spine-like, simple setae.

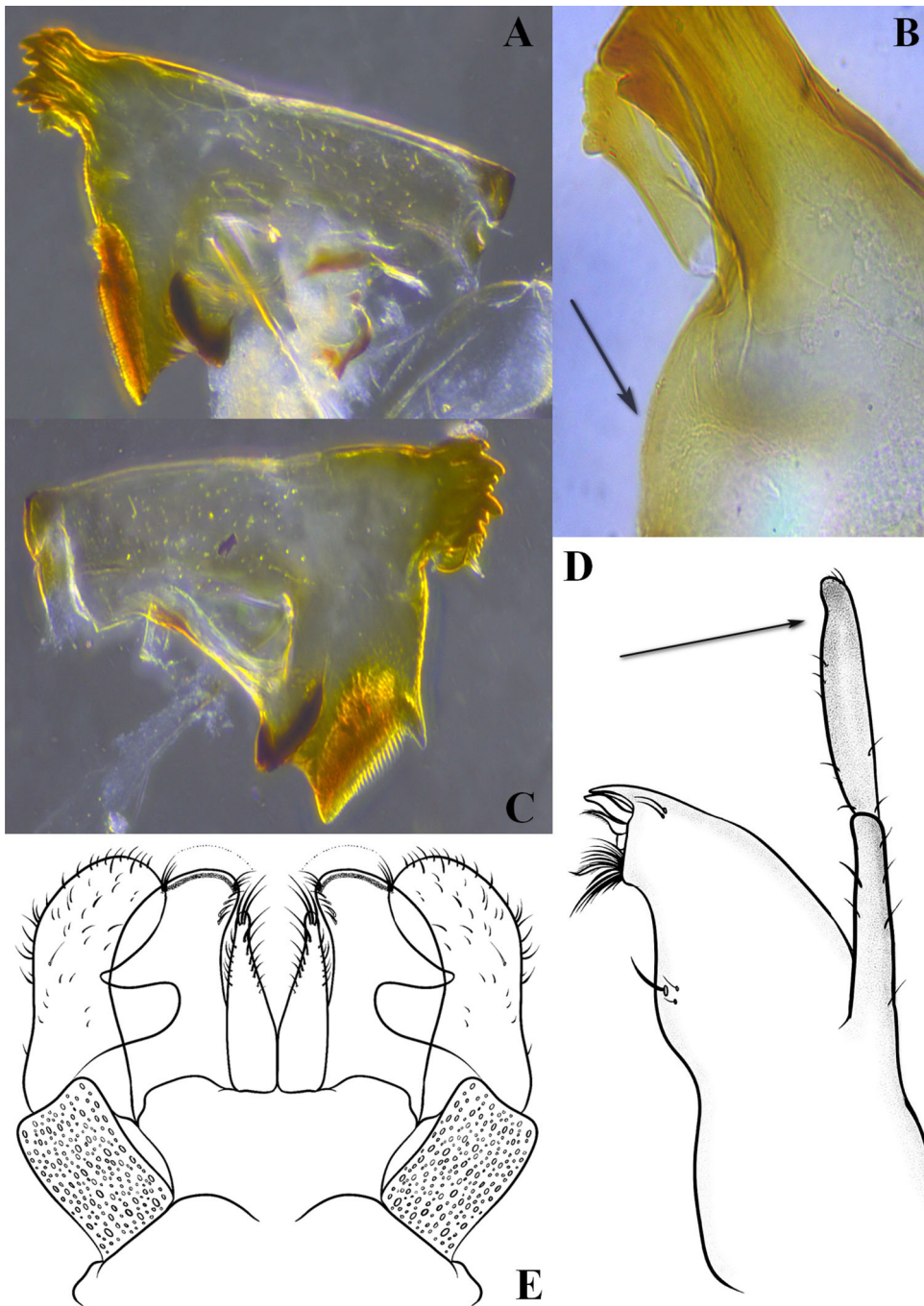


Figure 3. *Labiobaetis davamanii* sp. n.: (A) right mandible; (B) right prostheca; (C) left mandible; (D) maxilla; (E) labium.

Thorax. Hind wing pads absent. Foreleg (Figure 4A): ratio of length of femur/tibia/tarsus/claw 1.1:1.0:0.4:0.2. Femur. Length ca. $4\times$ maximum width; outer margin with a row of ca. 15 curved, spine-like setae (Figure 4D); length of setae $0.17\text{--}0.20\times$

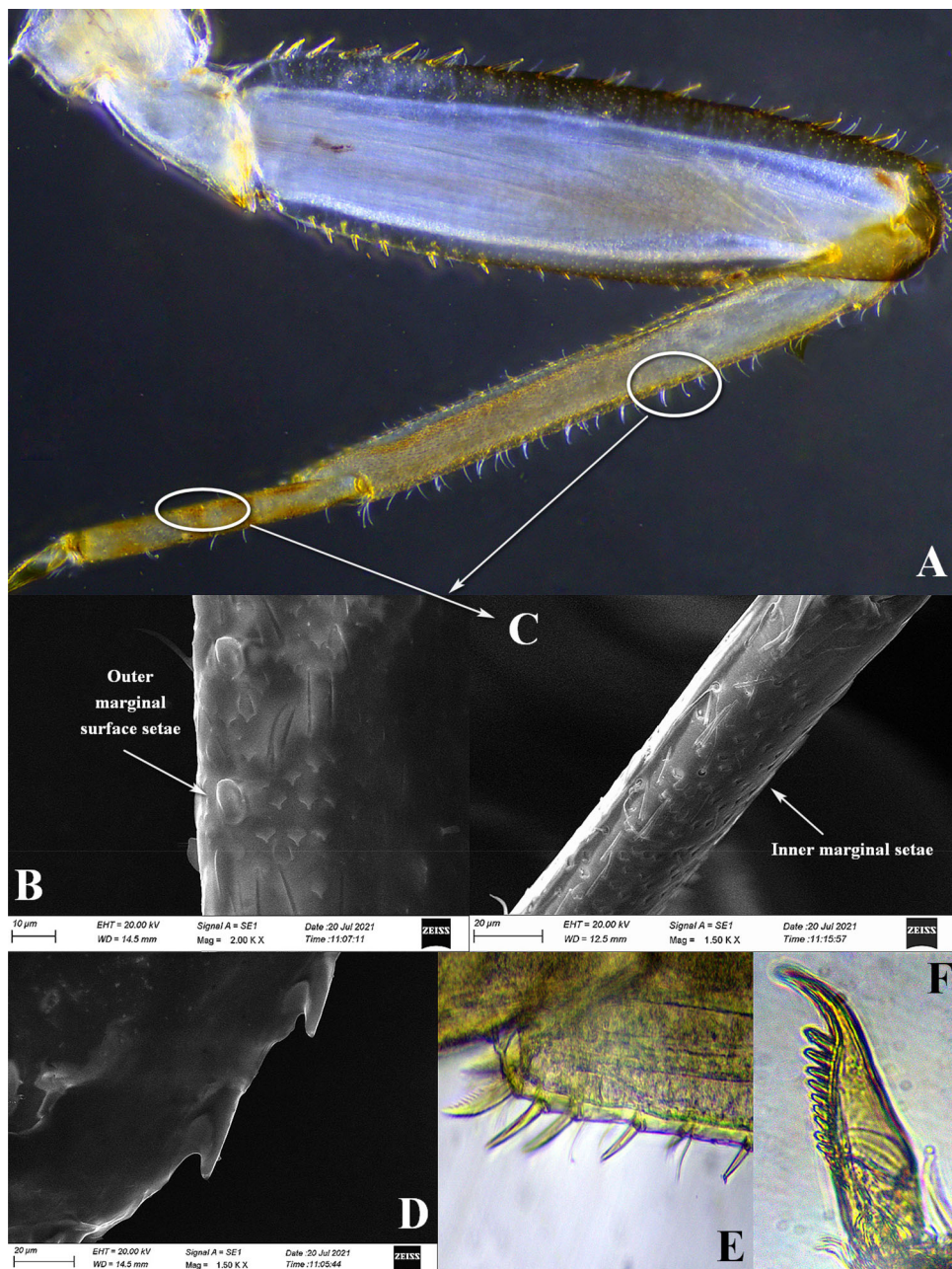


Figure 4. *Labiobaetis davamanii* sp. n.: (A) foreleg; (B) SEM view of outer marginal surface setae in foretibia; (C) SEM view of inner marginal setae in foretarsi; (D) SEM view of outer marginal setae in forefemur; (E) inner marginal setae in apex of foretibia; (F) foreclaw.

maximum width of femur; femora with rounded apex and with a pair of curved, spine-like setae; stout, lanceolate setae scattered along the inner margin; femoral patch rudimentary. Tibia. Outer margin with a row of stout, apically rounded setae (Figure 4B); inner margin with a row of short, curved, spine-like setae, apex with two

pectinate setae (Figure 4E) and a tuft of fine, simple setae; patellotibial suture present on the basal 1/3 area. Tarsus. Outer margin almost bare; inner margin with a row of curved, spine-like setae (Figure 4C). Claw with a row of 11–12 denticles; distally pointed, subapical setae absent (Figure 4F).

Abdomen. Tergum (Figure 5A). Surface with irregular rows of U-shaped scale bases and micropores. Posterior margin of tergum IV with triangular spines, wider than long. Tergalii (Figure 5B): Present on segments II–VII; margin with small denticles and intercalating fine, simple setae; tracheae extending from main trunk to both margins; tergalium IV as long as length of segments V and 2/3 VI combined; tergalium VII as long as length of segments VIII and 1/2 IX combined. Paraproct (Figure 5E): Distally not expanded, with ca. 32 stout marginal spines and with two larger spines proximally (Figure 5D); surface scattered with U-shaped scale bases, micropores and long, fine setae (Figure 5C); cercotractor with medium marginal spines.

Imago

Unknown.

Distribution

India (Eastern Ghats).

Diagnosis

Larval diagnostic characters of *Labiobaetis davamanii* sp. n. are as follows: (A) sub-marginal arc of labrum with 16–18 clavate setae; (B) labial palp segment II with a large, lobed distomedial protuberance, segment III slightly pentagonal; (C) dorsal surface of paraglossa with a row of 3–4 robust spines near inner margin; (D) fore femur rather slender, length ca. 4× maximum width, outer margin with a row of ca. 15 curved, spine-like setae; (E) tarsus with curved, spine-like setae at inner margin, claw with ca. eleven denticles; (F) paraproct distally not expanded, with ca. 32 stout marginal spines and with two larger spines at the proximal margin; (G) distolateral process at scape poorly developed.

Etymology

This new species is named in honour of Dr M. Davamani Christofer, the Principal and Secretary of The American College, Madurai for his constant support to carry out our research work. The species name is a noun in the genitive case.

***Labiobaetis operosus* Müller-Liebenau, 1984**

(Figures 1B, 6–9, and 11)

Materials examined

♂ mature larva, 2 ♂ larvae and 3 ♀ larvae, south India, Tamil Nadu, Madurai District, Vaigai River, 9°55.52'N, 78°06.59'E, ca.144 m, 12.VI.2021, leg. Srinivasan and Isack (AMC ZN 207, 208).

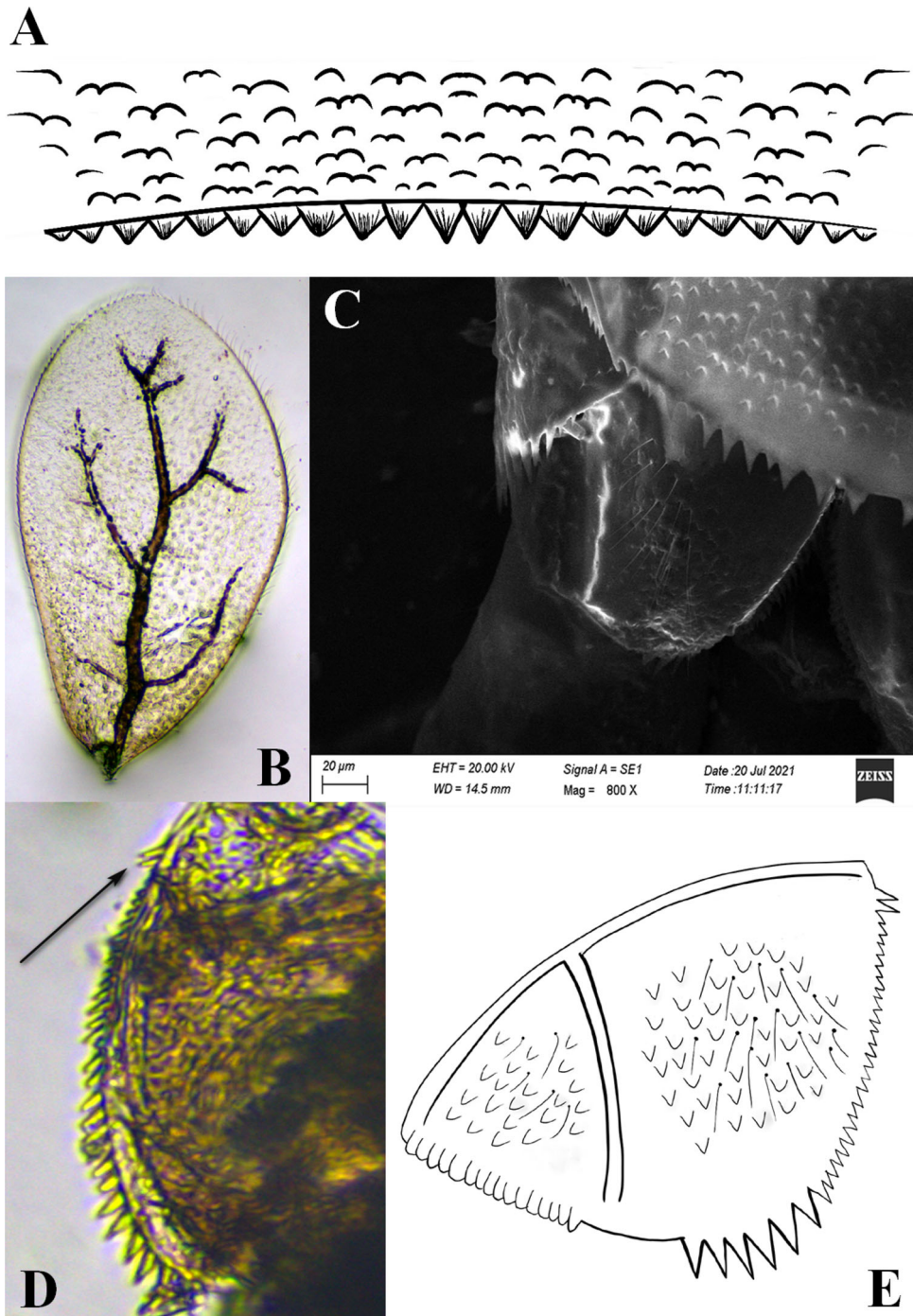


Figure 5. *Labiobaetis davamanii* sp. n.: (A) postero-tergal spines of segment IV; (B) tergite IV; (C) SEM of paraproct; (D) image of paraproct showing two apical spines in the proximal margin; (E) schematic diagram of paraproct.

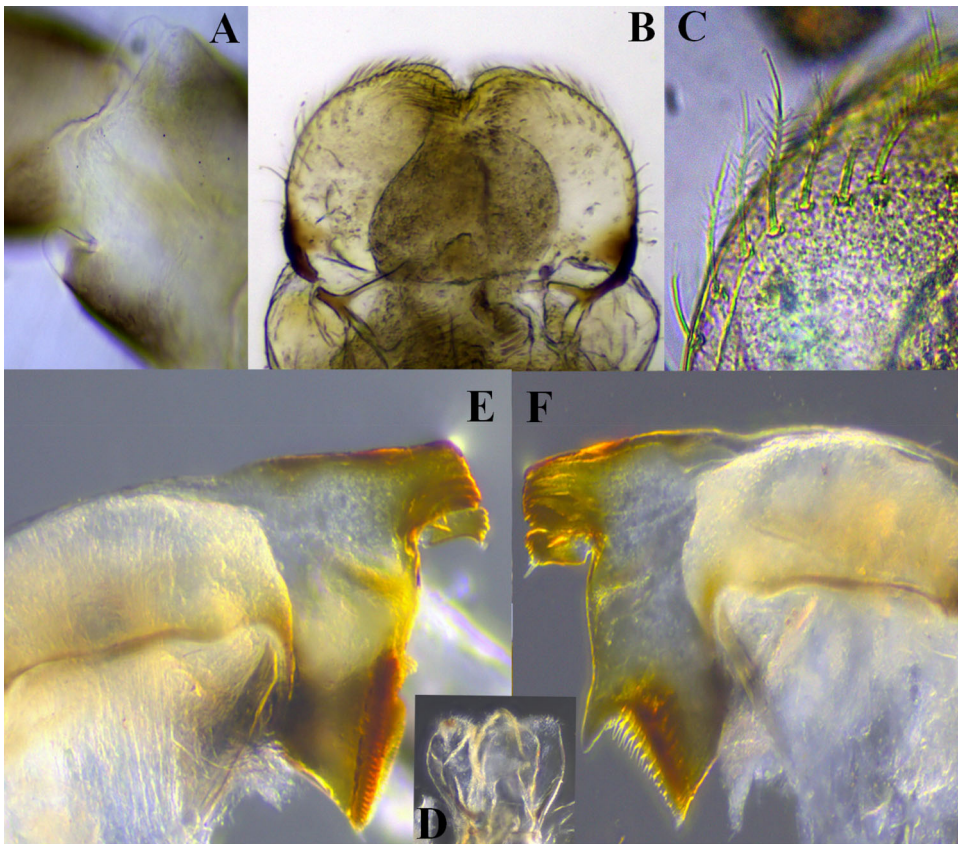


Figure 6. *Labiobaetis operosus* Müller-Liebenau, 1984: (A) distolateral process at scape; (B) labrum; (C) sub-marginal arc of feathered setae in labrum; (D) hyopharynx; (E) right mandible; (F) left mandible.

Mature larva description

Measurements. Body length 5.3 mm; paracercus length 2.2 mm, terminal filament length 1.5 mm. antenna: $2.1\times$ as long as length of head capsule.

Colouration. Head, thorax and abdomen dorsally greyish brown (Figure 1B); abdominal segment I, VII and X whitish, II–VI light brownish and VIII–IX dark brownish; head ventrally light brown; thorax ventrally pale and sternite I–VII pale; sternum VIII–IX light brown, legs transparent with brown spots distomedially on the femur and proximally on tibia and tarsus; paracercus greyish brown and cerci translucent.

Head. Scape and pedicel sub-cylindrical; scape with well-developed distolateral process (Figure 6A). Each segment of antenna with blunt triangular spines on the apex. Labrum (Figure 6B): Subrectangular, length $0.7\times$ maximum width; medial emargination with a notched margin; $1+6$ feathered setae present on the submarginal arc (Figure 6C); ventral surface with 5 short, spine-like setae laterally. Hypopharynx (Figure 6D): Lingua as long as superlinguae; medial tuft of stout setae well developed. Right mandible (Figure 6E): Incisors fused; outer and inner incisors combined with 6–7 denticles; prosthema robust and apically denticulate (Figure 7B); margin almost

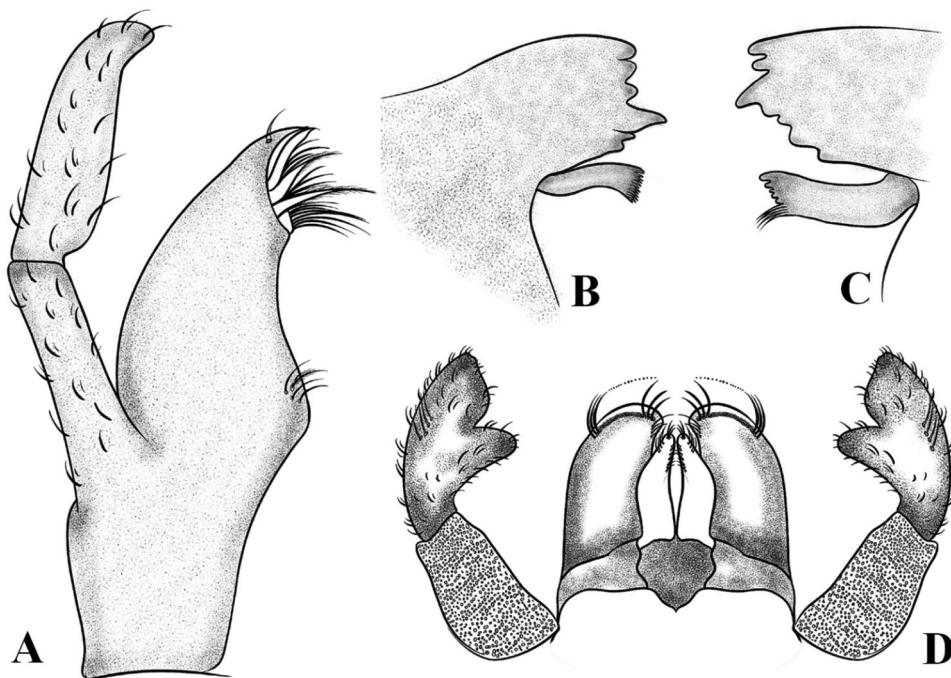


Figure 7. *Labiobaetis operosus* Müller-Liebenau, 1984: (A) maxilla; (B) right prosthema; (C) left prosthema; (D) labium.

straight; molar apex with a tuft of fine setae. Left mandible (Figure 6F): Incisors fused; outer incisor with 4 denticles and inner incisor with 3 denticles; prosthema robust and comb-shaped with small denticles apically (Figure 7C); margin straight; molar apex with a tuft of fine setae. Maxilla (Figure 7A): Galea-lacinia with a simple, seta under crown; medially with a long feathery seta dorso-laterally and three long, simple setae ventro-laterally. Maxillary palp slightly longer than length of galea-lacinia; two segmented, segment II $1.1\times$ length of segment I; fine, simple, scattered over the surface of maxillary palp; apex of segment II constricted, with excavation at the inner distolateral margin. Labium (Figure 7D): Glossa shorter than paraglossa; inner margin with seven spine-like setae; apex with two long and a medium simple setae; outer margin with 4 long simple setae; ventral surface with short, fine, simple, scattered setae. Paraglossa sub-rectangular with three rows of long, robust, pectinate setae on the apex and ventro-median row consists of a simple seta and dorso-median row of three or four long, spine-like setae near inner margin. Labial palp three segmented; segment I $0.84\times$ length of segments II and III combined; segment I with small micropores dorsally and fine, simple setae ventrally; segment II with elongated thumb-like distomedial protuberance; $0.9\times$ width of the base of segment III; both inner and outer margin with fine, simple setae; dorsal surface with four long, spine-like setae medially; segment III slightly pentagonal and apex truncated; length $1.1\times$ width; ventrally covered with spine-like, simple setae.

Thorax. Hind wing pads well developed. Foreleg (Figure 8A): ratio of length of femur/tibia/tarsus/claw $1.4:1.0:0.6:0.3$. Femur (Figure 8B). Length ca. $3\times$ maximum width; outer margin with a row of ca. 22 curved, spine-like setae (Figure 8C); length

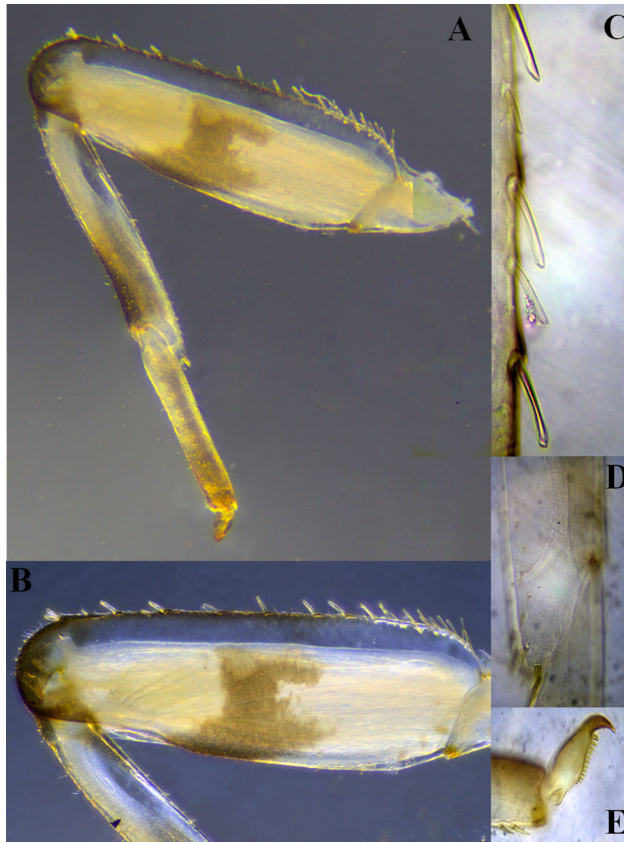


Figure 8. *Labiobaetis operosus* Müller-Liebenau, 1984: (A) foreleg; (B) forefemur; (C) outer marginal setae in forefemur; (D) inner marginal setae in apex of foretibia; (E) foreclaw.

of setae $0.16\times$ maximum width of femur; femora with rounded apex and with two pairs of curved, spine-like setae; pointed, lanceolate setae scattered along the inner margin; femoral patch well developed. Tibia. Outer margin with a row of stout, lanceolate setae and simple setae; inner margin with a row of curved, spine-like setae; apex with a stout, lanceolate seta (Figure 8D) and a tuft of long simple setae; patello-tibial suture present on basal 1/2 area. Tarsus. Outer margin with a row of short, curved, spine-like setae; inner margin with a row of curved, spine-like setae. Claw with a row of 12 denticles, subapical setae absent (Figure 8E).

Abdomen. Tergum (Figure 9A): Surface with irregular rows of U-shaped scale bases and micropores. Posterior margin of tergum IV with triangular spines, wider than long. Tergalii (Figure 9B): Present on segments I–VII; margin with small denticles intercalating fine, simple setae; tracheae extending from main trunk to both the margins. Tergalius I as long as length of segment II (Figure 9C); Tergalius IV as long as length of segments V and 2/3 VI combined; Tergalius VII as long as length of segments VIII and 1/4 IX combined. Paraproct (Figure 9D, E): Distally not expanded, with ca. 12 marginal, sharp stout spines; surface scattered with U-shaped scale bases and fine, simple setae (Figure 9E); cercotractor with small marginal spines.

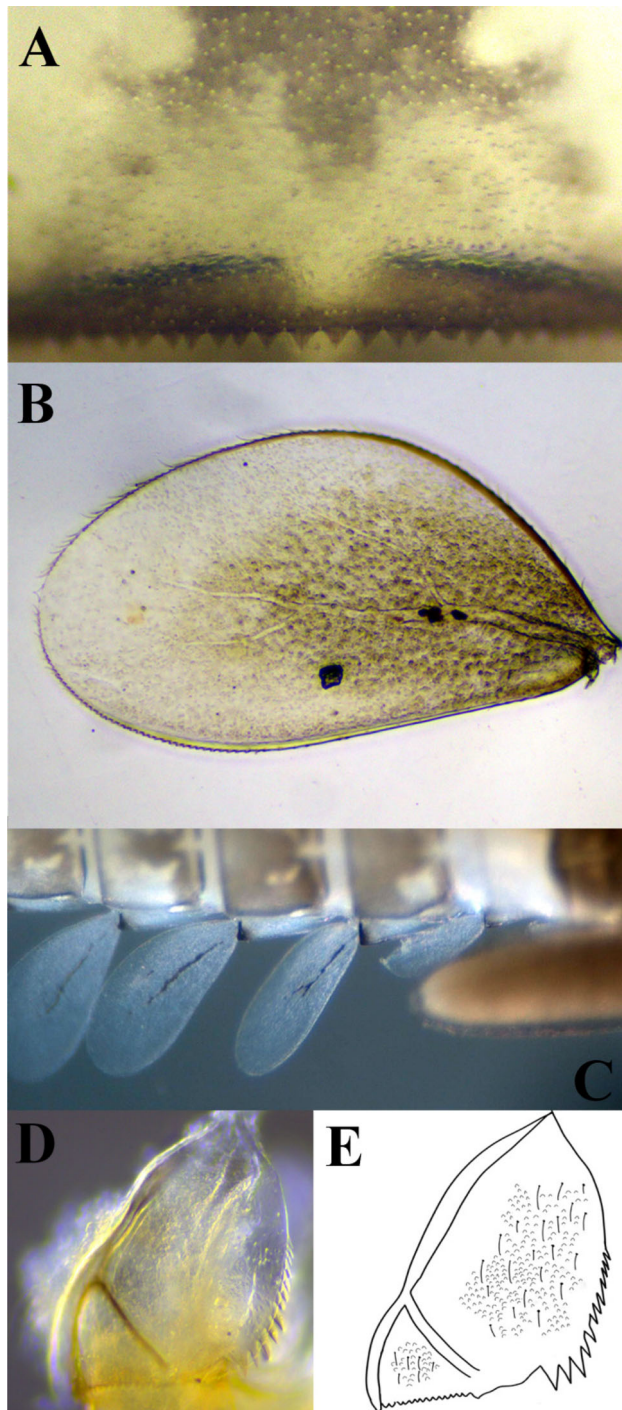


Figure 9. *Labiobaetis operosus* Müller-Liebenau, 1984: (A) postero-tergal spines of segment IV; (B) tergalium IV; (C) tergalium I; (D) paraproct; (E) schematic diagram of paraproct.



Figure 10. Habitat of *Labiobaetis davamanii* sp. n.



Figure 11. Habitat of *Labiobaetis operosus* Müller-Liebenau, 1984.

Imago

Unknown.

Distribution

India (first record): Tamil Nadu, Malaysia, Thailand.

Diagnosis

Larval diagnostic characters of *Labiobaetis operosus* are as follows: (A) dorsal surface of labrum with submarginal arc of 1 + 6 feathered setae; (B) labial palp segment II with a thumb-like distomedial protuberance, segment III slightly pentagonal and apically truncated; (C) maxillary palp with distolateral excavation on segment II; (D) fore femur rather broad, length ca. 3 × maximum width, outer margin with a row of ca. 22 curved, spine-like setae; (E) seven pairs of tergalii; (F) hindwing pads well developed; (G) distolateral process at scape well developed; (H) paraproct distally not expanded, with ca. 12 sharp stout marginal spines.

Discussion

Labiobaetis davamanii sp. n. is assigned to *L. sumigarensis* group of species (Kaltenbach and Gattolliat 2019) based on the following combination of characters: (1) dorsal surface of the labrum with submarginal arc of clavate, apically smooth setae; (2) labial palp segment II with large, lobed or thumb-like distomedial protuberance; (3) left mandible without setae at the apex of mola, with minute denticles between prosthema and mola; (4) six pairs of tergalii; (5) hindwing pads absent; (6) larval colour pattern uniform brown dorsally. The new species is compared with other closely related species as detailed in Table 1.

Table 1. Comparison of *Labiobaetis davamanii* sp. n. with other closely related species of the *L. sumigarensis* group.

Character	<i>L. davamanii</i> sp. n.	<i>L. diffundus</i> Müller-Liebenau, 1984	<i>L. jacobusi</i> Kubendran and Balasubramanian, 2015	<i>L. geminatus</i> Müller-Liebenau and Hubbard, 1985
Length of maxillary palp: galea lacinia	1.4 ×	Slightly longer	1.2 ×	?
Paraproct spines	ca. 32 spines with two larger spines proximally	ca. 35 spines without any larger spines proximally	ca. 38 spines without any larger spines proximally	ca. 38 spines without any larger spines proximally
Femoral patch	Rudimentary	Well developed	Rudimentary	?
Tergum IV spines	Bluntly pointed in the apex	Sharply pointed in the apex	Bluntly pointed in the apex	Sharply pointed in the apex
Distolateral process at scape	Poorly developed	Poorly developed	Absent	Poorly developed
Number of outer marginal setae in forefemur	ca. 15	10–13	ca. 7	ca. 12
Number of submarginal arc of clavate setae in the labrum	16–18	ca. 16	ca. 12	ca. 12
Reference	Present study	Müller-Liebenau (1984) and Kaltenbach and Gattolliat (2019)	Kubendran et al. (2015)	Müller-Liebenau and Hubbard (1985)

Labiobaetis operosus from the *L. operosus* group (Kaltenbach and Gattolliat 2019) is recorded for the first time from India. The main characteristics of the group are: (1) dorsal surface of labrum with submarginal arc of feathered setae; (2) segment II of labial palp with thumb-like or lobed distomedial protuberance; (3) seven pairs of tergites; (4) hind wing pad well developed; (5) distolateral process at scape well developed (Kaltenbach, Garces, and Gattolliat 2020). Though, some morphological variations occur in the Indian population such as in the tergal pattern, ratio of forefemora, and number of setae in the outer margin of forefemora. We considered them as *L. operosus* due to the absence of nominal morphological characters to differentiate from the Malaysian population. Moreover, the adults of both species are not available now. So, further clarification is needed in the future based on the male genital characters along with the molecular taxonomical methods to sort out this kind of species complex in *Labiobaetis* (Kaltenbach et al. 2020).

From the species of *Labiobaetis* (or previously assigned to *Pseudocloeon*) only known at the imaginal stage, four were described from India (*L. dipsicus*, *L. inopinum*, *L. palmyrae* and *L. rubellum*). As the identification of the imaginal stage of *Labiobaetis* is generally very difficult, we consider it unrealistic to safely associate the larval stage with old type material at the imaginal stage. Furthermore, the generic assignment of the species remains questionable. Therefore, we did not take these species into account in our study and wait for an eventual clarification of their status in the future by using molecular methods.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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