

Received: 12 September 2025 • Accepted: 22 December 2025 • Published: 27 February 2026

Topic editor: Magalie Castelin • Desk editor: Fanny Herman

Research article

[urn:lsid:zoobank.org/pub:F0BAC580-B7B0-4EAA-A404-8B604C7F2748](https://zoobank.org/pub:F0BAC580-B7B0-4EAA-A404-8B604C7F2748)

A new species and a redescription of *Lepidocampa* Oudemans, 1890 (Diplura: Campodeidae) from the Eastern Himalayas, India

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Abstract. Diplura Börner, 1904 remains poorly documented in Asia, and despite India's status as a megadiverse country, it is currently represented by only 18 recognized species or subspecies. Many of them are poorly described, lacking key diagnostic features, which ultimately leads to taxonomic ambiguity, and impedes reliable taxonomic decisions. This study describes a new species of the genus *Lepidocampa* Oudemans, 1890, *Lepidocampa labiformis* sp. nov., and provides a comprehensive taxonomic account (re-description) of poorly described *Lepidocampa weberi nepalensis* Condé, 1993, collected from the Eastern Himalayan region of India.

Keywords. Arthropoda, chaetotaxy, Entognatha, Hexapoda, taxonomy.

Kar S., Mandal P., Mazumdar S. & Mandal G.P. 2026. A new species and a redescription of *Lepidocampa* Oudemans, 1890 (Diplura: Campodeidae) from the Eastern Himalayas, India. *European Journal of Taxonomy* 1043: 87–102. <https://doi.org/10.5852/ejt.2026.1043.3209>

Introduction

Diplura Börner, 1904 is a non-insect primitive hexapod occupying a vast array of trophic levels with cosmopolitan distribution (Sendra *et al.* 2021a; Potapov *et al.* 2022). Diplura, known as “two pronged bristle tails”, are a diverse group of animals, classified into 10 families comprising more than 1000 species (Paclt 1957; Pagés 1959; Sendra *et al.* 2021a). Photo-negatively adapted diplurans are recorded in numerous habitats, including various soil types, decomposed leaf litter, under stones, caves and even polar regions (Condé 1956; Sendra *et al.* 2021a). Limited studies bottlenecked the knowledge regarding one of these ancient evolutionary groups (Du *et al.* 2024). Campodeidae Lubbock, 1873 is the most diverse family that comprises almost half of the species described to date (Sendra *et al.* 2025). Further, this family is classified into five subfamilies viz., Campodeinae Condé, 1956; Lepidocampinae Condé, 1956; Hemicampinae Condé, 1956; Syncampinae Paclt, 1957; and Plusiocampinae Paclt, 1957 (Condé 1956; Paclt 1957; Sendra *et al.* 2020). Among them,

Lepidocampinae are primarily found in tropical and subtropical regions, and it is thought that, due to the presence of thoracic and abdominal scales, they can withstand a wide range of temperatures, from sea level to high mountains (Condé & Jacquemin-Naguyen 1968; Sendra *et al.* 2017). A relatively small number of species are recorded from the Lepidocampinae and Hemicampinae ($n=4$) subfamilies. A total of only 19 species/subspecies belonging to the subfamily Lepidocampinae have been recorded from different parts of the world (Sendra *et al.* 2017; Sánchez-García *et al.* 2024). Five were recorded from India (Kar & Mandal 2025), with two, *Lepidocampa webri* Oudemans, 1890 and *Lepidocampa weberi nepalensis* Condé, 1993, recorded from the Himalayan regions (Condé 1958; Condé & Jacquemin-Naguyen 1968). Limited information exists on the true diversity of Himalayan diplurans. Early surveys, including the Yale North Indian expedition, reported that Diplura were absent from high altitudes (Silvestri 1936). Later work disproved this assumption, documenting *L. weberi* at elevations up to 4800 m (Condé & Jacquemin-Nguyen 1968). Condé (1958) examined material from Nepal (2134 m) and multiple Indian states, including Sikkim (1829 m), Assam (1524 m), and Manipur (1291 m), and noted that these specimens differed morphologically from the already described subspecies of *L. weberi* Oudemans, 1890. Additional remarks by Condé and Jacquemin-Nguyen (1968) supported these differences, and similar material from Sumatra was later assigned to *L. weberi nepalensis* (Condé 1993). However, the scattered and incomplete nature of these accounts means that no study has provided a full and coherent description of the species. The available descriptions are limited to certain morphological characters, leaving several key diagnostic features unaddressed and creating persistent taxonomic uncertainty. This lack of comprehensive detail can lead to misinterpretation and makes it difficult for taxonomists to assign new species without error. Moreover, Indian Diplura research is limited and hindered by a lack of taxonomic expertise and



Fig. 1. A–B. Collection site (type locality) of *Lepidocampa labiformis* sp. nov. C. Collection site of *Lepidocampa weberi nepalensis* Condé, 1993.

by difficulties in accessing older bibliographic references (Condé 1956; Paclt 1957; Silvestri 1931a, 1931b; Condé 1993). The Indian Diplura fauna comprises only 18 known species/subspecies belonging to five families, namely Anajapygidae Bagnall, 1918; Japygidae Haliday, 1864; Projapygidae Cook, 1896; Campodeidae Meinert, 1865 (Kar & Mandal 2025); and Parajapygidae Womersley, 1939 (Silvestri 1913), among which many are poorly described. The last work on Indian Diplura taxonomy dates back to Rani & Mitra (1977) described a new subspecies, *Lepidocampa juradii bengalensis*.

This study aims at describing one new species of *Lepidocampa* and rediscussing *Lepidocampa weberi nepalensis* Condé, 1993 in the view of current taxonomic knowledge, collected from the Eastern Himalayan region, India.

Material and methods

Specimens were collected from leaf litter using a mouth-operated aspirator (Fig. 1 A–C). Collected specimens were washed in distilled water, then the entire specimens were mounted on a glass slide using Marc Andre II solution under a dissecting microscope (Leica EZ4). Slides were then dried on a hot plate for 3–5 days, observed, and photographed under a compound microscope (Leica DM2500) equipped with a camera (Leica DFC 295). Morphometric measurements were done using an ocular meter. For scanning electron microscopy (SEM), the last 5th abdominal segments and a metathoracic leg of one paratype (*Lepidocampa labiformis* sp. nov.) were coated with palladium-gold and photographed (Zeiss EVO 18 Special Edition). However, as the number of specimens for the species *L. weberi nepalensis* was limited to two, SEM was not attempted. To provide a more accurate interpretation of morphological characters and chaetotaxy, some illustrations were digitally drawn using CorelDRAW software.

Morphological abbreviations

Morphological description and abbreviation used here follow Condé (1956).

<i>ma</i>	=	medial-anterior
<i>la</i>	=	lateral-anterior
<i>lp</i>	=	lateral posterior
<i>post</i>	=	posterior
Th	=	thorax

Repositories

NZC	=	National Zoological Collection
ZSI	=	Zoological Survey of India

Results

Taxonomy

Class Hexapoda Blainville, 1816
 Order Diplura Börner, 1904
 Superfamily Campodeoidea Ewing, 1942
 Family Campodeidae Lubbock, 1873
 Subfamily Lepidocampinae Condé, 1956
 Genus *Lepidocampa* Oudemans, 1890

Lepidocampa labiformis sp. nov.

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Figs 2–6

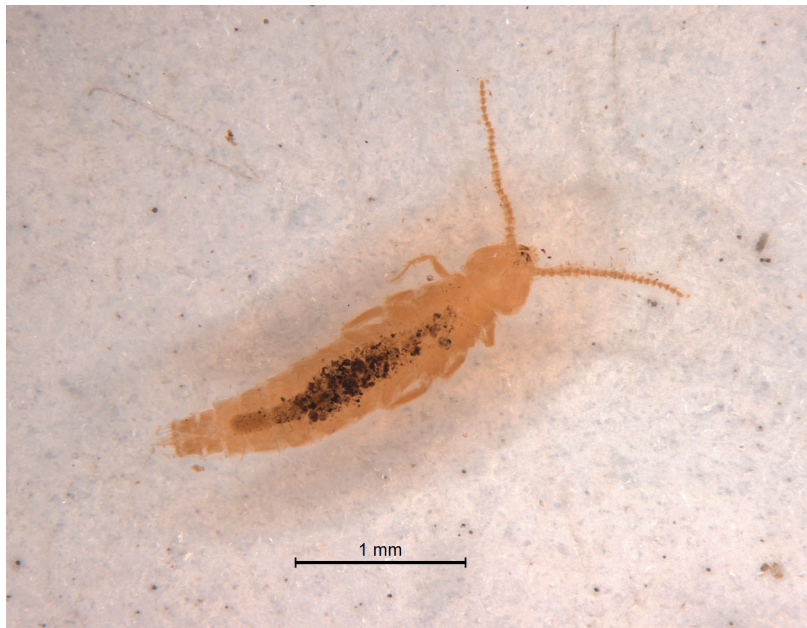


Fig. 2. Habitus of *Lepidocampa labiformis* sp. nov., holotype, ♀ (reg no. 3854/H14, NZC, ZSI).

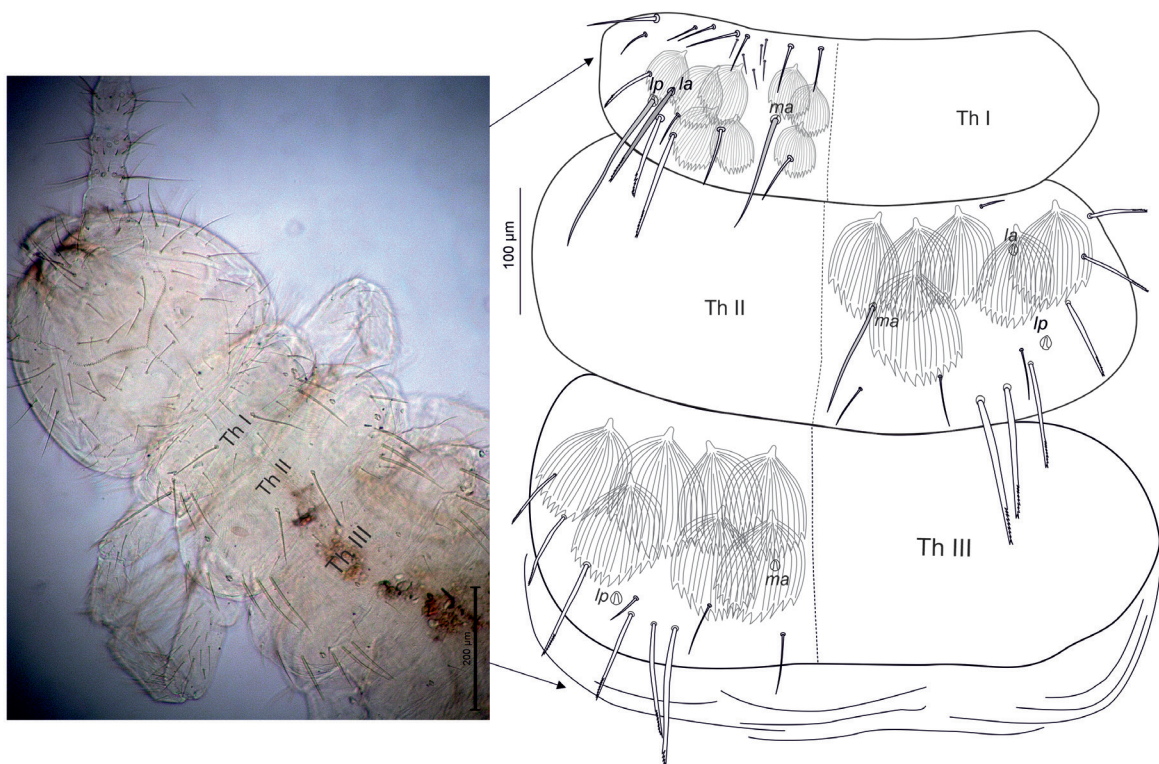


Fig. 3. Pro, meso and metanotum of *Lepidocampa labiformis* sp. nov., paratype, ♀ (reg no. 3855/H14, NZC, ZSI).

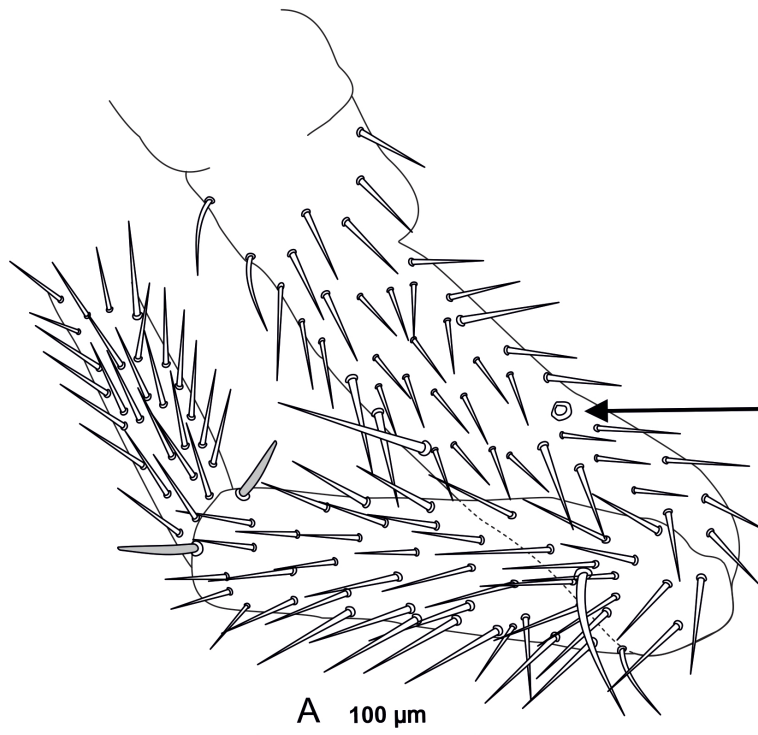


Fig. 4. *Lepidocampa labiformis* sp. nov., paratype, ♀ (reg no. 3855/H14, NZC, ZSI). **A.** Metathoracic leg (femur) (arrow indicates setae socket of dorsal macroseta). **B.** Telotarsus (metathoracic leg).

Diagnosis

Unpigmented smooth cuticle. Scales of different shapes cover thoracic and abdominal sclerites. Female antennae with 17–24 antennomeres, with presence of cupuliform organ on the distal antennomere (size of the cupuliform organ is one-twelfth of the apical antennomere). A baciliform sensilla present on antennomere 3. Notal macrosetae: Pronotum with 1+1 *ma*, 1+1 *lp* and 1+1 *la*; mesonotum with 1+1 *ma*, 1+1 *lp* and 1+1 *la*; and metanotum with 1+1 *ma* and 1+1 *lp*. Mesonotal *ma* is well developed and length exceeds bases of corresponding *ma*, also the apex of the *ma* exceeds corresponding marginal setae. Along with *ma*, *lp* and *la* (*la* absent in metanotum), meso and meta notum contains 6+6 unilateral barbed (distally) marginal setae. Hind femur bears a single dorsal macro seta. Urotergal macrosetae: II–III: 1+1 *post*; IV–VIII: 3+3 *post*; IX: 2+2 *post*. Urosternite macrosetae: I–VII and IX with 3+3, VIII with 1+1. Subequal curved claws with fine striate along with a median unpaired unguiculus present between them; presence of laminar lateral process with foliate long barbs. The posterior margin of female urosternite I is without glandular setae, subcylindrical appendages of urosternite I bear 5–9 glandular setae at their apex. A “lip shaped” genital papillae found in female urosternum VIII with presence of 17–20 C smooth setae and 2 B setae inserted between most lateral C setae. A second row of setae present above C setae forming a conical shape.

Etymology

The species epithet is taken from the Latin “labium”, meaning “lip” and “formis”, meaning “shaped like” of female genital papillae on urosternum VIII.

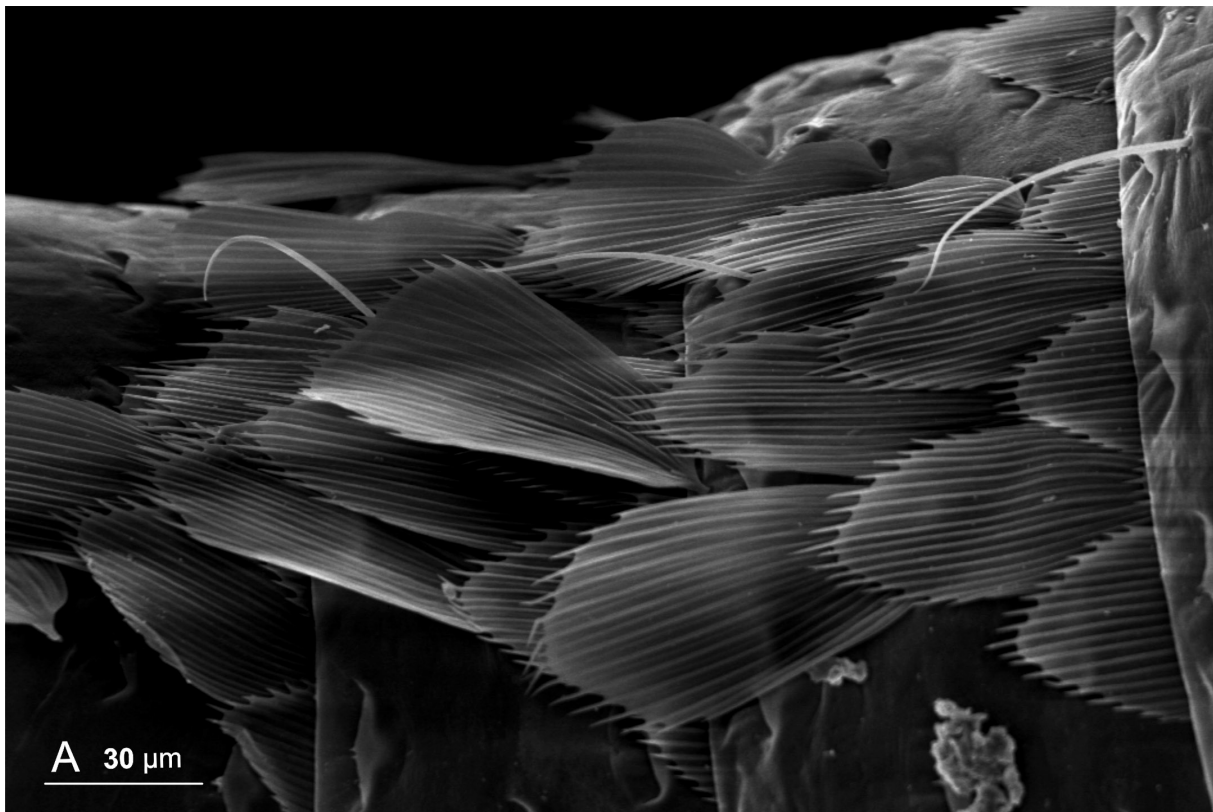


Fig. 5. Abdominal scales of *Lepidocampa labiformis* sp. nov., paratype, ♀ (reg no. 3855/H14, NZC, ZSI).

Type material

Holotype

INDIA • ♀ (on slide); West Bengal, Darjeeling, Kurseong BSF camp; 26°53'09.6" N, 88°17'14.8" E; 10 Nov. 2023; K.K. Bhattacharya & party leg.; in leaf litter; reg. no. 3854/H14; NZC in ZSI.

Paratypes

INDIA • 4 ♀ (juveniles, on slides); same collection data as for holotype; reg. no. 3855/H14; NZC in ZSI.

Description

BODY. Body length (excluding antennae and cerci): 2.74 mm (adult, holotype) (Fig. 2), 1.86–2.08 mm (juveniles), unpigmented plain cuticle.

HEAD. Head with short clothing setae, length: 0.37–0.43 mm; width: 0.42–0.51 mm. Antennae with 17–24 intact antennomeres (adult: 24; juveniles: 17–20), with the presence of a dorsal rod-shaped baciliform sensillum on antennal segment 3. Length of the proximal antennomere half its width (0.04 mm; 0.09 mm), length and width of middle antennomere are subequal (0.07; 0.06); length of the apical antennomere double its width (0.08; 0.04). Cupuliform organ distinct, occupying one-twelfth of the apical antennomere. Antennomeres III–VI bear Trichobothrium, 2 on III, 3 on IV and V and 2 on VI. Frontal process distinct, non-protuding. Labial palp with a lateral sensillum similar to the maxillary palp and 3rd antennomere. Labial palp bears 60–65 neuroglandular setae in adult female and 40–45 in juveniles.

THORAX. Pronotum with 1+1 *ma*, 1+1 *lp* and 1+1 *la*; mesonotum with 1+1 *ma*, 1+1 *lp* and 1+1 *la*; and metanotum with 1+1 *ma* and 1+1 *lp* (Fig. 3). Distal half of the *ma*, *la* and *lp* barbed. Mesonotum with well-developed *ma* (0.08 mm, paratype) exceeding the base of the corresponding *ma* and marginal setae. Metanotal *ma* lost for all specimens examined. 6+6 marginal setae (one sample with 6+7 on mesonotum) and 3+3 smooth microsetae present on both meso and metanotum, among them 1+1 present near *lp*. All thoracic sclerites with scales instead of clothing setae. Metathoracic legs reach the 6th abdominal segment (0.87 mm, holotype). Femur with apico-ventral 5–6 setae arranged in a line, with hind femur bearing a single dorsal macroseta (setae lost for all specimens) (Fig. 4A). Tibia with 2 small and stout ventral macrosetae. Curved subequal claws with fine striate with presence of median unpaired unguiculus between them; laminar lateral process with foliate long barbs (Fig. 4B).

ABDOMEN. Macrosetae on abdominal tergites II–III with 1+1 *post*, IV–VIII with 3+3 *post*, and 2+2 *post* on IX, most of the setae lost. Urosternite I–VII and IX with 3+3 macrosetae, urosternite VIII with 1+1, most of the setae lost, those present distally barbed. All abdominal segments with scales (Fig. 5). Styli with two (one apical and subapical) strong, smooth setae.

SECONDARY SEX CHARACTERS. Posterior margin of female urosternite I without any glandular setae, subcylindrical appendages of urosternite I with 5–9 glandular setae at their apex. Urosternite VIII of adult female with 17–20 C setae, 2 B setae; and 2A setae (setae lost), B setae inserted between the most lateral C setae. All B and C setae smooth. A second row of setae above the C setae are also present in a conical shape, overall forming a “lip shaped” structure (Fig. 6). Juveniles with 4–5 smooth C setae and 2 B setae. Cerci broken for all samples.

Remarks

Only two previously described subspecies, *L. weberi nepalensis* and *Lepidocampa weberi ceylonica* Silvestri, 1933, have well-developed mesonotal *ma* which exceed the length of the corresponding marginal setae (Silvestri 1933; Condé 1993). Our newly described species differs from them by having relatively less developed mesonotal *ma* (*ma* not passing the total length of the marginal setae). Moreover, the structure of female genital papillae and setae arrangement around the papillae are completely different

from *L. weberi nepalensis* (Fig. 11B) and *L. weberi ceylonica* (Silvestri 1933). On the other hand, the described species can also be distinguished from *L. weberi ceylonica* by the number of antennal articles; *L. weberi ceylonica* bears more articles, 33–36, whereas the *L. labiformis* sp. nov. bears 17–24. Furthermore, the number of urotergal macrosetae also differs between species (*Lepidocampa labiformis* sp. nov.: urotergite II–III: 1+1 *post*; IV–VIII: 3+3 *post*; IX: 2+2 *post*; *L. weberi ceylonica*: urotergite II–IV: 2+2 *post*; V–IX: 3+3 *post*) (Silvestri 1933). Urotergal macrosetae pattern of *L. labiformis* sp. nov. are similar to *Lepidocampa weberi* Oudemans, 1890 (except VIII: 3+3 vs. 4+4 *post* for *L. weberi*, IX: setae pattern absent for *L. weberi*) (Silvestri 1931b; Sendra *et al.* 2025) however, other characters such as number of antennal articles for adult *L. weberi* varies between 28–33 (Sendra *et al.* 2025), whereas for adult *Lepidocampa labiformis* sp. nov. bears 24; number of C setae (female *L. weberi*: 14, lateral C setae branched vs. female *Lepidocampa labiformis* sp. nov.: 17–20, lateral C setae smooth); and position of

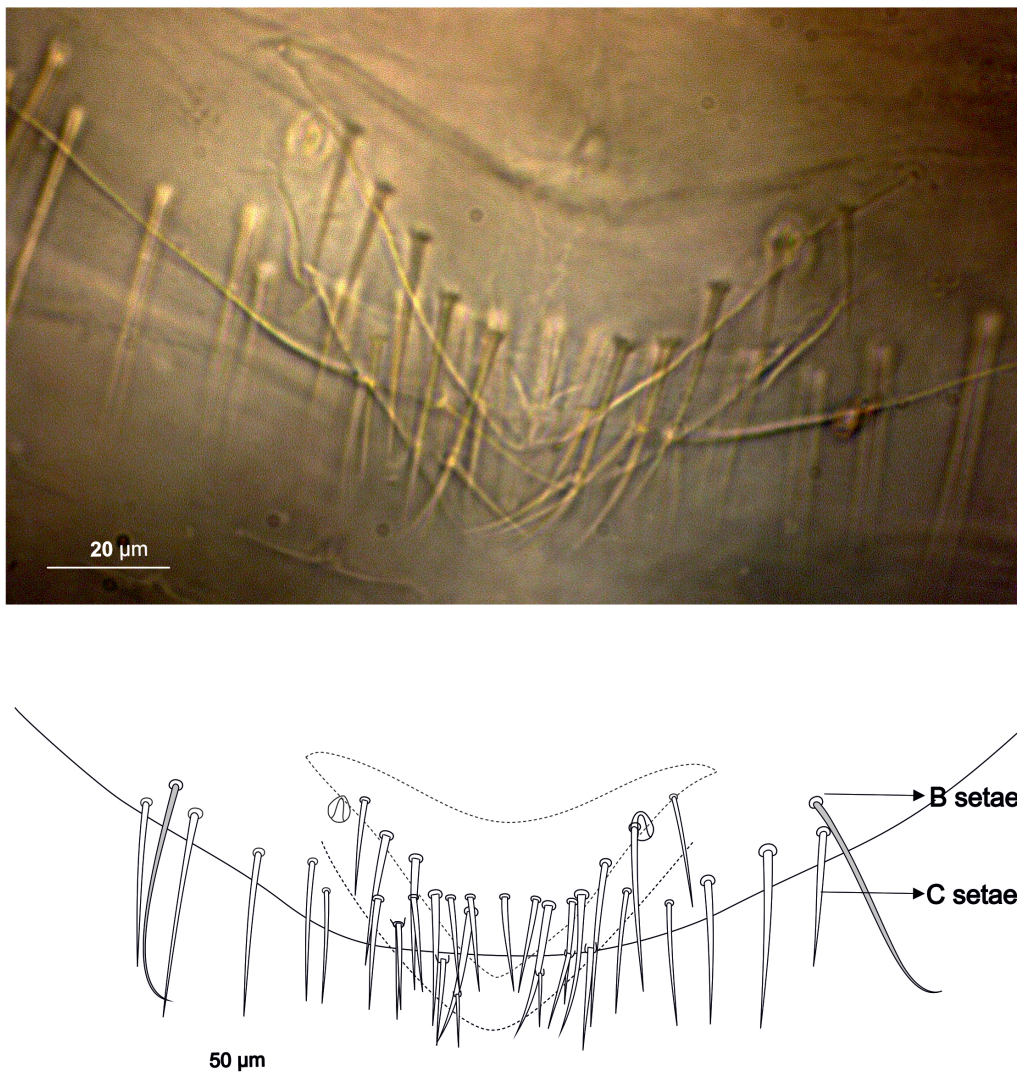


Fig. 6. Urosternum VIII of *Lepidocampa labiformis* sp. nov., paratype, ♀ (reg no. 3855/H14, NZC, ZSI).

meso and metanotal *lp* relative to other marginal setae (Silvestri, 1931b). Additionally, the “lip-shaped” female genital papillae on urosternum VIII (Fig. 6) of *L. labiformis* sp. nov., is unique among all species.

Lepidocampa weberi nepalensis Condé, 1993

Figs 7–11

Lepidocampa weberi nepalensis Condé, 1993: 951–954.

Lepidocampa weberi Oudemans, 1890, ? ssp. – Condé 1958: 192–193.

Diploures Campodéidés – Condé & Jacquemin-Nguyen 1968: 6–8.

Diagnosis

Specimens with soft and unpigmented cuticle. Scales of different shapes are found in the thorax and abdomens. Female antennae with 26–27 antennomeres and the third antennomere of male and female bear a rod-shaped bacilliform sensillum. An apical cupuliform organ distinctly occupying one-sixth of its apical antennomere. Notal macrosetae: Pronotum with 1+1 *ma*, 1+1 *lp* and 1+1 *la*; mesonotum with 1+1 *ma*, 1+1 *lp*, and 1+1 *la*; and metanotum with 1+1 *ma* and 1+1 *lp*. Mesonotal *ma* is well-developed (0.2 mm), and the length exceeds the bases of the corresponding *ma*, also passes the total length of corresponding marginal setae. Hind femur bearing a single dorsal macroseta. Urotergites: II–III with 1+1 *post*, IV–VIII with 3+3 *post*, and 2+2 *post* on IX. Urosternite macrosetae: I–VII and IX with 3+3, VIII with 1+1.

Material examined

INDIA • 1 ♂, 1 ♀ (on slide); Sikkim, Gangtok, near Baba Harvajan Singh Mandir; 27°21'54" N, 88°50'20" E; 3831 m a.s.l.; 18 Feb. 2025; K.K. Suman & party leg.; in leaf litter covered with ice bed; reg. no. 3869/H14; NZC of ZSI.



Fig. 7. Habitus of *Lepidocampa weberi nepalensis* Condé, 1993 ♂ (reg no. 3869/H14, NZC, ZSI).

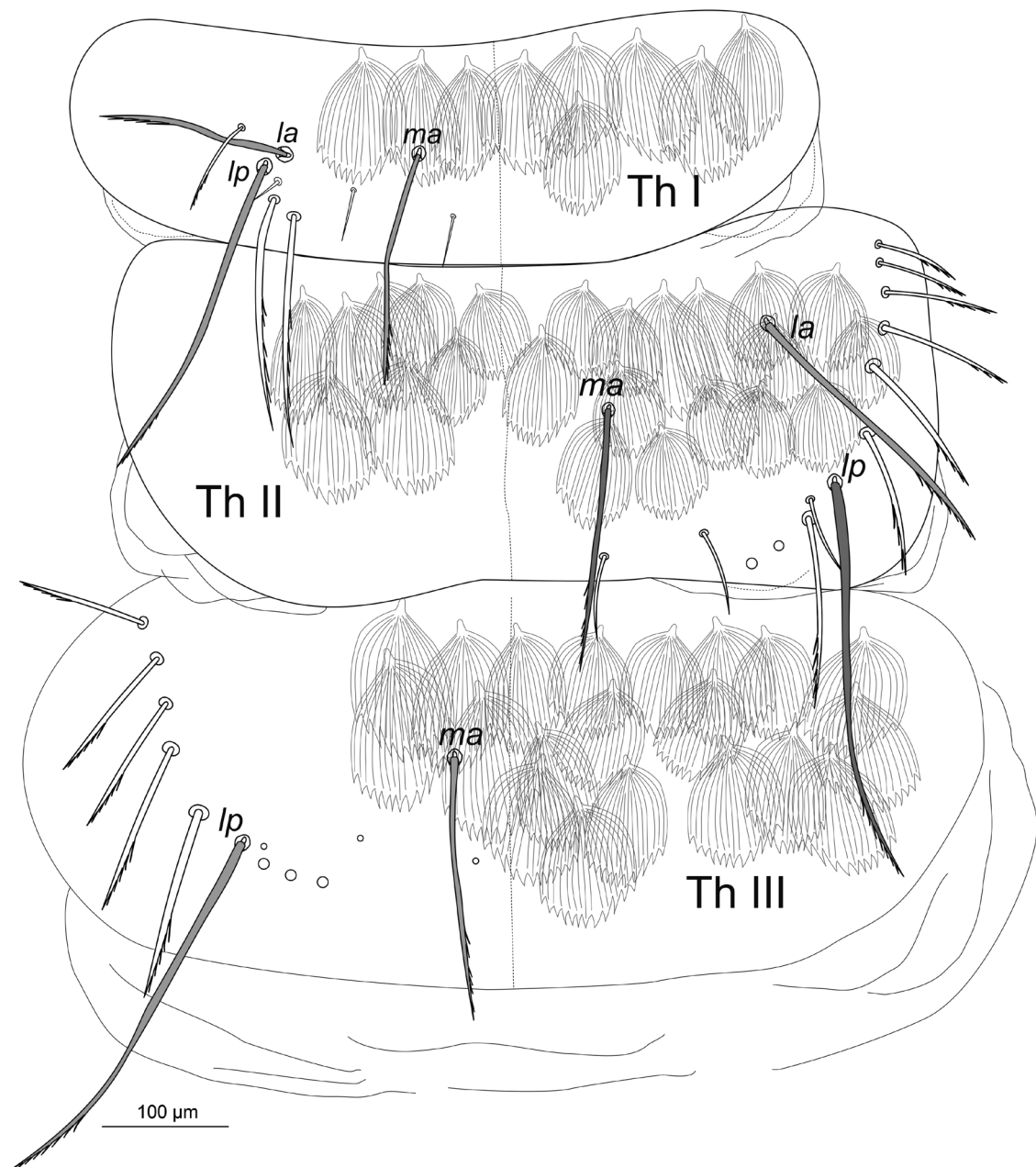


Fig. 8. Pro, meso and metanotum of *Lepidocampa weberi nepalensis* Condé, 1993, ♂ (reg no. 3869/H14, NZC, ZSI).

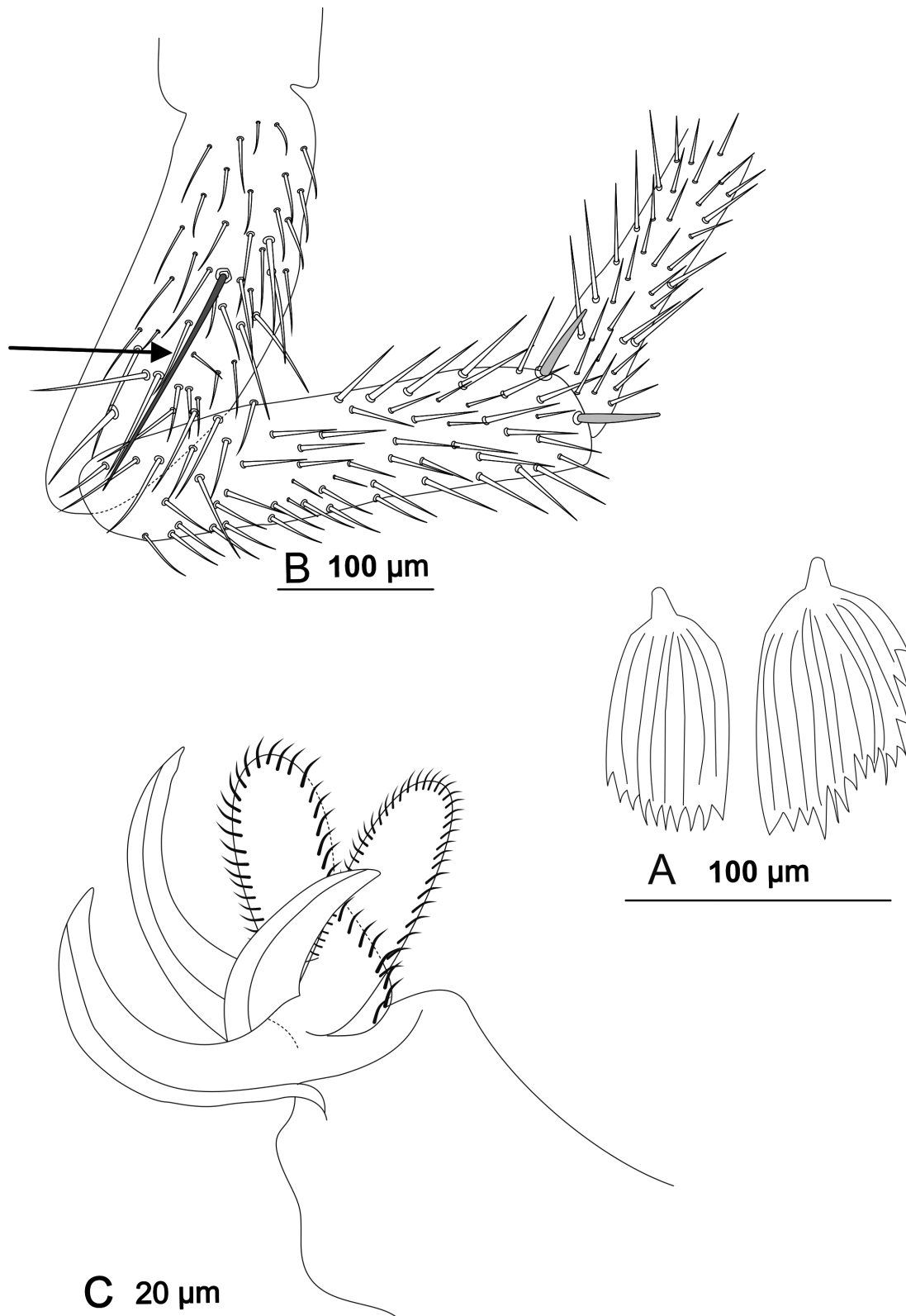


Fig. 9. *Lepidocampa weberi nepalensis* Condé, 1993, ♂ (reg no. 3869/H14, NZC, ZSI). **A.** Scales on thoracic and abdominal sclerites. **B.** Metathoracic leg (femur) (arrow indicates dorsal macroseta). **C.** Telotarsus.

Description

BODY. Body length (excluding antennae and cerci): 6.06 mm (adult female), 4.28 mm (adult male) (Fig. 7), unpigmented plain cuticle.

HEAD. Head with sparsely distributed short clothing setae, length: 0.53–0.62 mm; width: 0.62–0.63 mm. Female antennae with 26 intact antennomeres, male with 27, in both sexes 3rd antennomere with the presence of a dorsal rod-shaped baciliform sensillum. Length of the proximal antennomere almost 1/2 times its width (0.03 mm, 0.07 mm), length and width of middle antennomere are subequal (0.084 mm, 0.078 mm); length of the apical antennomere almost double its width (0.097 mm, 0.056 mm). Cupuliform organ distinct, occupying one-sixth of the apical antennomere. Antennomeres III–VI bear Trichobothrium, 2 on III, 3 on IV and V and 2 on VI. Frontal process distinct, non-protuding. Labial palp with a lateral sensillum similar to maxillary palp and 3rd antennomere. Labial palp bears 49–55 neuroglandular setae in both sexes.

THORAX. Pronotum with 1+1 *ma*, 1+1 *lp* and 1+1 *la*; mesonotum with 1+1 *ma*, 1+1 *lp* and 1+1 *la*; and metanotum with 1+1 *ma* and 1+1 *lp* (Fig. 8). Distal half of the *ma*, *la* and *lp* slightly barbed. Mesonotum with robust and well-developed *ma* (0.2 mm) exceeding the base of the corresponding *ma* and passes the total length of corresponding marginal setae (Fig. 8). Mesonotal and metanotal *lp* highly developed (0.33 mm). Mesonotum and metanotum with 9+9 (one with 8+8) and 8+8 (one with 9+9) marginal setae, respectively and 3+3 microsetae present on both meso and metanotum, among them 1+1 present near *lp*. All thoracic sclerites with scales instead of clothing setae (Fig. 9A). Metathoracic legs reach the middle of the 6th abdominal segment (1.46 mm, holotype).

Femur with apico-ventral 5–6 setae arranged in a line, with hind femur bearing a single dorsal macroseta (Fig. 9B). All tibia with 2 small and stout ventral macrosetae. Curved subequal claws with presence of a median unpaired unguiculus between them; laminar lateral process with foliate long barbs (Fig. 9C).

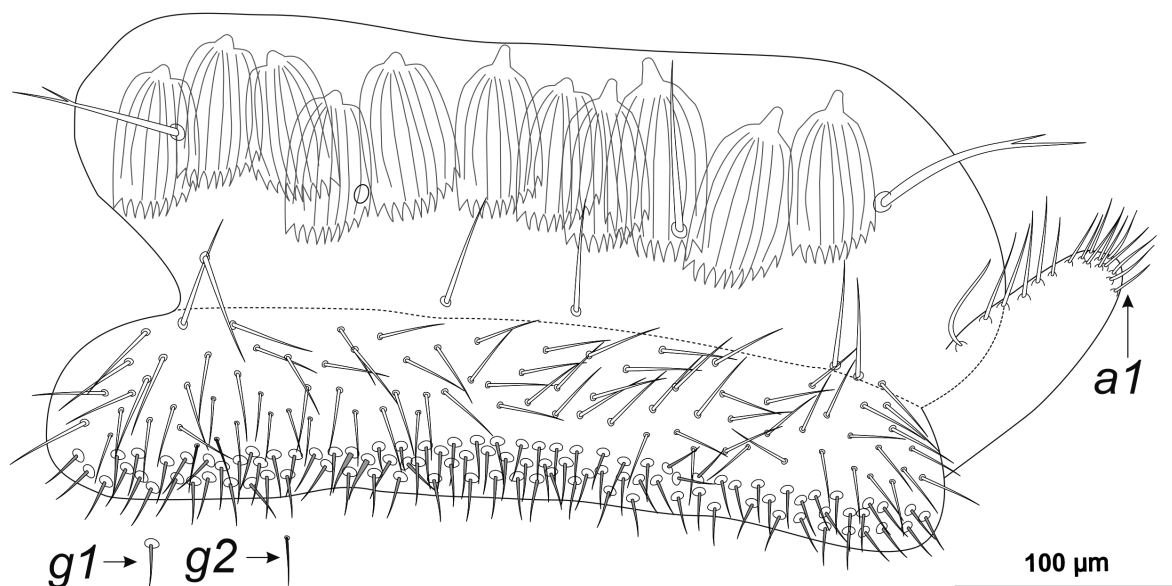


Fig. 10. Urosternite I (with glandular setae) of male *Lepidocampa weberi nepalensis* Condé, 1993 (reg no. 3869/H14, NZC, ZSI).

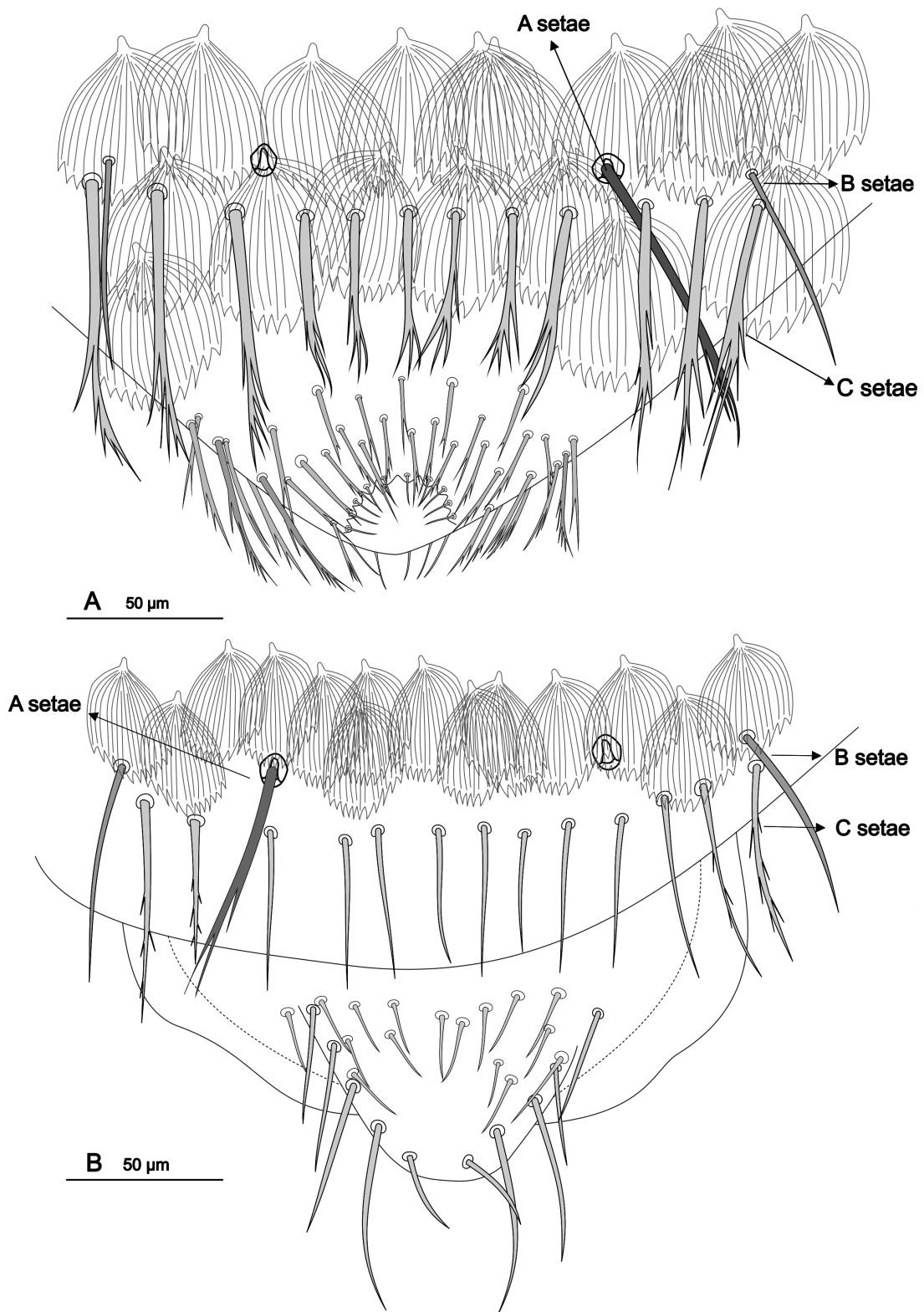


Fig. 11. *Lepidocampa weberi nepalensis* Condé, 1993. **A.** Urosternum VIII, ♂ (reg no. 3869/H14, NZC, ZSI). **B.** Urosternum VIII, ♀ (reg no. 3869/H14, NZC, ZSI).

ABDOMEN. Macrosetae on abdominal tergites II–III with 1+1 *post*, IV–VIII with 3+3 *post*, and 2+2 *post* on IX, all setae lost. Urosternite I–VII and IX with 3+3 macrosetae, urosternite VIII with 1+1, setae distally barbed. All abdominal segments with scales (Fig. 9A). Styli with six smooth setae, among them one apical and subapical strong.

CERCI. Non-intact cerci present in male and female with 4–5 segments (1.41 mm). Proximal segment with two whorls, with succeeding articles bearing 5–6 whorls of setae: first with short and smooth, 2nd and 3rd with long and smooth, 4th with short and smooth, 5th with long smooth.

SECONDARY SEX CHARACTERS. Posterior margin of male urosternite I bearing approximately 110 glandular setae (*g1*) in two to three rows, with 2 *g2* setae (Fig. 10), without any spiny setae. Subcylindrical appendages of male urosternite I bearing 11 *a1* glandular setae at the apex (Fig. 10). Urosternite VIII with 12 barbed C setae, 2 B setae inserted to the last lateral C setae (Fig. 11A). Some smooth and a few barbed setae form a circular rosette around the gonopore.

Subcylindrical appendages of female urosternite I bear 14 *a1* glandular setae. Posterior margin of the urosternite I without any glandular setae. Urosternite VIII with 2 barbed A setae, 13 C setae (2 lateral C setae slightly branched) and 2 B setae, one parallel and the other slightly exterior to the most lateral C setae (Fig. 11B).

Remarks

After several unsuccessful attempts to establish the subspecies status (Condé 1958; Condé & Jacquemin-Nguyen 1968), *Lepidocampa weberi nepalensis* was later described by Condé (1993) from material collected in Sumatra and Nepal. The original account was incomplete by current taxonomic standards, omitting several key diagnostic characters. It focused mainly on meso- and metanotal chaetotaxy and the male genitalia, with brief remarks on secondary sexual features. Earlier authors reported a well-developed mesonotal macroseta (*ma*) that exceeds the length of the corresponding microseta, and our observations confirm this. However, the number of *g2* setae in our material is lower, although Condé (1993) noted variability in this trait. The present study provides a detailed description, adding new information on additional morphological features and chaetotaxy for the first time.

Discussion

Campodeids represent a highly diverse family within the basal Diplura, as noted by Sendra *et al.* (2025). Members of this group have a nearly global distribution, occurring on every continent except Antarctica, with approximately half of the known species recorded from the West Palearctic region. Notably, of the 491 campodeid species documented worldwide, about 50 are found in East Asia, highlighting a significant gap in systematic surveys in that region (Sendra *et al.* 2021b). Sendra *et al.* (2021b) emphasized the biogeographical importance of Asian dipluran biodiversity and pointed out that many new species remain to be discovered. In addition, inadequate taxonomic information for previously described species impedes reliable taxonomic decisions concerning newly collected material. Therefore, a comprehensive re-examination and detailed documentation of existing and newly described taxa are urgently required to clarify the taxonomy of the group.

After a long interval, the present study describes one new species of *Lepidocampa* from West Bengal and re-describe *Lepidocampa weberi nepalensis* from Sikkim, the Eastern Himalayan region of India. Earlier, *L. weberi nepalensis* was recorded from various altitudinal zones (Condé 1958). The specimens of this study were recorded at a high elevation (3831 m), under leaf litters covered by ice bed as observed for samples collected from Nepal (3500–3600 m) (Condé 1993). This study also highlights the importance of systematic surveys of neglected but evolutionary significant groups in these regions. Moreover, a molecular approach to identify the specimens is recommended when possible. However, Diplura

is largely hindered by the cryptic nature of their habitat and the difficulty of collecting sufficient numbers of specimens. Condé & Jacquemin-Naguyen (1968) previously observed a pronounced development of the mesonotal macrosetae (*ma*) in species from higher elevations. Our findings, which also reveal well-developed mesonotal *ma*, reinforce this earlier observation.

Acknowledgments

We sincerely express our gratitude to the Director of the Zoological Survey of India for providing comprehensive laboratory facilities and granting permission to conduct surveys essential for this study. We also extend our appreciation to all the staff of the Apterygota section, ZSI, for their valuable support. Our thanks are due to the SEM technical staff for their assistance. We are deeply indebted to Prof. Alberto Sendra, Colecciones Entomológicas Torres-Sala, Servei de Patrimoni Històric, Ajuntament de València, València, Spain, for generously providing the necessary literature for this work.

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