Zootaxa 0000 (0): 000–000
https://www.mapress.com/j/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.0000.0.0
http://zoobank.org/urn:lsid:zoobank.org:pub:00000000-0000-0000-0000-00000000000

The millipede genus *Klimakodesmus* Carl, 1932, with the description of a new species from Kerala state, southern India (Diplopoda, Polydesmida, Pyrgodesmidae)

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Abstract

Klimakodesmus Carl, 1932 is briefly redescribed, rediagnosed, and shown to be an oligotypic genus endemic to southern India and distinct from the particularly similar genus *Pyrgodesmus* Pocock, 1892, monobasic and endemic to Sri Lanka, by several important features of peripheral and, especially, gonopodal structure. A new species, *Klimakodesmus bilobocaudatus* **sp. nov.**, is described from Kerala state, India, differing from the sole accepted, and type species *K. gravelyi* Carl, 1932, from Tamil Nadu state, primarily by the laterally trilobate paraterga, the caudally more deeply bilobate mid-dorsal keel on ring 19, and certain minor details of the gonopodal structure.

Key words: *Klimakodesmus*, *Pyrgodesmus*, taxonomy, new species, India, Sri Lanka

Introduction

At present, the millipede fauna of India, however insufficiently studied, comprises 270+ nominate species or subspecies in at least 90 genera, 25 families and 11 orders (Golovatch & Wesener 2016). Of them, the large and mostly tropical family Pyrgodesmidae contains some 14 species in seven genera, including *Klimakodesmus* Carl, 1932.

The taxonomy of Pyrgodesmidae is long known to be particularly badly confused and chaotic globally, with more than 170 genera, largely monotypic, and nearly 400 species all over the tropics, marginally in Southern Europe, North Africa, southern U.S.A., Japan, Taiwan and central China (Enghoff *et al.* 2015). Progress is strongly hampered by the small size of the animals (typically 3–16 mm long), as well as the outstandingly diverse and often complex structures, both peripheral and gonopodal, which are often difficult to see, let alone describe and depict. Numerous pyrgodesmid genera remain monotypic, often based only on female or even juvenile material, and delimited using solely such somatic features as the number of body segments/rings, the shape, distribution and location of ozopores and tergal ornamentations, the structure of the paraterga etc.

Klimakodesmus was originally described based on a single, and type species, *K. gravelyi* Carl, 1932, originating from near Coonoor and Mudumalai, both in Tamil Nadu state, Western Ghats, southern India (Carl 1932). Verhoeff (1939) promoted *Klimakodesmus* to the rank of a monobasic subfamily, Klimakodesminae Verhoeff, 1939, but presently it is considered as a strict junior subjective synonym of Pyrgodesmidae (Hoffman 1980; https://www.fieldmuseum.org/sites/default/files/taxon_table_5.pdf).

Carl (1932), when erecting his *Klimakodesmus*, compared it to *Pyrgodesmus* Pocock, 1892, the type genus of Pyrgodesmidae and also monobasic (Pocock 1892), because both genera shared numerous somatic features. He paid special attention to the identity of *Pyrgodesmus obscurus* Pocock, 1892, the type species of *Pyrgodesmus*, described from two male syntypes from Pundaluoya, Sri Lanka. Carl (1932) compared the original, rather superficial description and few schematic drawings of *P. obscurus* as given by Pocock (1892) to the excellent and richly illustrated

Accepted by T. Wesener: 28 Apr. 2021; published: xx xxx. 2021

redescription of that species as presented by Silvestri (1920), based on a male syntype from Pundaluoya and two additional males from Paradenyia, Sri Lanka. Carl noted differences between both descriptions in tergal ornamentation, antennae, leg thickness, and gonopodal conformation. In particular, the gonopods of *P. obscurus* were verbally described as showing unusually hypertrophied coxites and blade-like telopodites (Pocock 1892), *vs.* moderately enlarged and squarish coxites with strongly curved and ribbon-shaped telopodites as depicted by Silvestri (1920). As a result, Carl (1932) considered Silvestri's (1920) record and most detailed redescription of *P. obscurus* as a misidentification, suggesting to give it a new name different from *P. obscurus*, and emphasizing that neither species belonged to *Klimakodesmus*. He also expressed the need for a new revision of the *P. obscurus* syntypes, both presumably kept in the London Museum (Pocock 1892).

On the other hand, according to Silvestri (1920), the tegument of at least some of the *Pyrgodesmus obscurus* samples he studied was so heavily coated with earth that only after it had been thoroughly cleansed did it show the necessary details of the underlying, real tergal structure and sculpture. Moreover, both bodies, one coated with earth and the other clean, were very beautifully and artistically illustrated, albeit neither was properly labeled as to its provenance! So we can only adhere to Carl's (1932) appeal to revise at least one of the male syntypes of *P. obscurus*, since the task is to simply check the gonopodal structure and to compare it to Silvestri's (1920) account and illustrations. Only this could finally reveal the species' identity.

It was Attems (1940) who took action following Carl's (1932) investigation and suggestions. He proposed *Klimakodesmus permutatus* Attems, 1940 as a replacement name for *Pyrgodesmus obscurus* in the sense of Silvestri (1920), but, contrary to Carl's opinion, he assigned it to *Klimakodesmus*. It is since then that formally the genus *Klimakodesmus* has hitherto contained two species: *K. gravelyi* Carl, 1932, from southern India (Golovatch & Wesener 2016), and *K. permutatus* Attems, 1940, from Sri Lanka (De Zoysa *et al.* 2016). Moreover, strangely enough, Attems (1940: 271) retypified *Klimakodesmus* through selecting *K. permutatus* Attems, 1940 as the type species, a completely invalid action (Jeekel 1971).

The present paper puts on record a second, new species of *Klimakodesmus*, also clarifying the similarities to and differences from *Pyrgodesmus*. We follow Carl (1932) in treating both these genera as distinct and, pending a revision of *P. obscurus*, we remove *K. permutatus* from the scope of *Klimakodesmus* (see the reasons in Carl (1932) and below).

Materials and methods

The material underlying the present contribution was hand-collected in a sacred grove of Kannur district, Kerala, India. The local name of the grove is Thekkumbadu Koolom—Thazhekkavu, located on an inland island bordered by thick mangroves. The samples were collected in January 2021 (winter season) and preserved in absolute ethanol.
The holotype and most of the paratypes are deposited in the collection of the Centre for Animal Taxonomy and Ecology, Christ College, Irinjalakuda, Kerala, India (CATE), with the holotype ID–CATE-5302, and paratypes ID–CATE-5302B–CATE-5302I. A few paratypes have been lent for further studies to the Zoological Museum, State University of Moscow (ZMUM), Russia, as indicated below.

Photographs in the field were taken with a Canon EOS 5D Mark-III camera using a Canon EF 100 mm f/2.8 Macro USM Lens and a Canon MT-24EX Macro Twin Lite Flash. Multifocal photographs of specimens were taken in the lab with a Leica DMC4500 digital camera mounted on a Leica M205 C stereo microscope. Photographs were stacked, and the measurements (in mm) taken, using Leica Application Suite (LAS) version 4.3.0 software. The final images were processed with Adobe Photoshop CC software. The map was executed using both Google Earth and Simple Mappr software.

In the following morphological accounts, we use Hoffman's (1976) formula for describing the most typical ornamentation pattern of the metaterga in Pyrgodesmidae, in which:

PM stands for paramedian,
DL for dorsolateral tubercles/lobes,
i for intercalary series of grains,
Am for anteromarginal,
Cm for caudomarginal lobulations.

Taxonomic part

Order Polydesmida Latreille, 1802/03

Family Pyrgodesmidae Silvestri, 1896

Genus *Klimakodesmus* Carl, 1932

Type-species: *Klimakodesmus gravelyi* Carl, 1932, by monotypy.

Other species included: *Klimakodesmus bilobocaudatus* **sp. nov.**

Brief description. This genus shows a body shape and an ornamentation pattern typical of Pyrgodesmidae, characterized by 20 segments/rings (19+T) both in the male and female; a flabellate collum is strongly domed and tuberculate, completely covering the head from above, with 5+5 distinct, equal, clearly incised and rounded lobulations at a subhorizontal anterior margin; the antennae are short, two basal antennomeres of each antenna being sunken inside a distinct transverse groove, and antennomere 5 being much longer and thicker than the 6th; a cerotegument crust with microvilli covers most of the dorsal surface of the collum and following metaterga, the limbus being microlobulate and microspiculate caudally; body rings are strongly arched dorsally, each with 2+2 longitudinal rows of basically 2+2 or 3+3 larger and fused tubercles/lobes (paramedian, PM, and dorsolateral, DL), both rows largely representing higher bilobed keels mostly slightly inclined either forward or caudad, but PM always being higher than DL. PM of only ring 19 is abruptly and unusually strongly elongate and more or less clearly bilobate caudally, conspicuously overhanging and concealing a short epiproct from above (Figs 2–4, 8–10). Neither intercalary (i) series of grains nor antero- (Am), nor truly caudomarginal lobulations (Cm) are distinguished. The pore formula is normal: ozopores 5, 7, 9, 10, 12, 13, 15 and 16 are borne on distinct porosteles, *vs.* 17, 18 and 19 which open flush on the surface. The paraterga are set low (at about half the height of midbody metazonae), slightly declivous to subhorizontal, leaving the dorsum very convex, moderately bi- or trilobate laterally regardless of a cylindrical porostele or ozopore located just before or upon the ultimate lobulation, respectively. The legs are short and stout, rather sparsely setose, the prefemur bearing a particularly strong seta distomesally, the tibia a distodorsal one.

The gonopods are fairly simple, *in situ* either slightly diverging or distally crossing each other; each coxite is moderately enlarged, hemispherical or squarish, microgranulate and microsetose laterally, and concave medially, the gonocoel thus being moderately deep; the cannula is as usual, simple, moderately long and strongly unciform. The telopodite is simple, slender, unipartite, represented by a very strong, moderately long, but mostly exposed, gradually attenuating and acuminate solenomere.

Diagnosis. *Klimakodesmus* seems to be particularly similar to *Pyrgodesmus* in most somatic characters, as correctly noted by Carl (1932), but both genera are distinct primarily in gonopodal structure: clearly hypertrophied gonocoxites and "blade-like" telopodites (Pocock 1892) *vs.* moderately incrassate, apparently smaller, subspherical or squarish gonocoxites, each of which supports a strong and unipartite telopodite represented solely by a slender, strongly exposed, increasingly attenuating and acuminate solenomere. In addition, PM crests, including the one on the penultimate ring that overhangs and fully conceals the epiproct from above, are much higher and stronger, whereas DL reduced, in *Pyrgodesmus* compared to *Klimakodesmus* species.

A similar, remarkably strong, massive and largely exposed solenomere taking up most of the gonopod telopodite is also observed in the genus *Pseudocatapyrgodesmus* Miyosi, 1957, with *P. glaucus* Miyosi, 1957, the type species from Honshu, Japan (Miyosi 1957), and *P. pulcher* Golovatch, Semenyuk, VandenSpiegel & Anichkin. 2011, from southern Vietnam (Golovatch *et al.* 2011). Yet their gonopods are considerably more elaborate and clearly branched, *vs.* relatively very simple and unipartite in *Klimakodesmus*. They are the gonopods of *P. pulcher* that seem to be especially similar to those of *Klimakodesmus* (Golovatch *et al.* 2011).

The strong, flattened, dorsal crest PM on the penultimate ring that overhangs and conceals the epiproct from above, however conspicuous, is unique to neither *Klimakodesmus* nor *Pyrgodesmus* species. For instance, several, but not all of the Afrotropical species of the genera *Monachodesmus* Silvestri, 1927 or *Udodesmus* Cook, 1896 show the same or very similar conditions (Golovatch *et al.* 2015, 2017).

Species description

***Klimakodesmus bilobocaudatus* sp. nov.**
Figs 1–15

Material examined. Adult male holotype (CATE-5302), 2 adult male and 6 subadult female paratypes (CATE-5302B–CATE-5302I), 1 adult male and 2 subadult female paratypes (ZMUM), India, Kerala state, Kannur district, N11°58'2.5", E75°17'46.6", 5 m a.s.l., 27/01/2021, M.D. Aswathy leg.

Name. To emphasize a caudally relatively deeply bilobed dorsal keel (PM) on ring 19 in the new species; adjective.

Diagnosis. The new species differs clearly from *K. gravelyi*, the only other congener to be accepted (Carl 1932), by the more regularly tuberculate collum (cf. Figs 5 and 16), the lower PM and DL which are mostly inclined caudad (*vs.* inclined forward until ring 16, cf. Figs 7, 8 and 17), the caudally more deeply bilobed dorsal keel (PM) on ring 19 (*vs.* indistinctly bilobulate, cf. Figs 9, 10 and 18), the laterally bi- (rings 3 and 4) or trilobate (remaining postcollum rings) paraterga (*vs*. mostly bilobate, trilobate only on ring 2, cf. Figs 5, 8, 9 and 17–19), and the gonopods showing subspherical coxites (*vs.* squarish) and subcontiguous, apically subunciform and crossing each other (*vs.* divergent and suberect) telopodites, each of the latter additionally reinforced with a mesobasally thickened wall (*vs.* a laterobasal lobe, cf. Figs 12–15 and 20 & 21).

Description. Length ca. 3.68 mm, width of midbody segments 0.10 and 0.14 mm on pro- and metazonae, respectively (holotype). Length of adult male paratypes ca. 3.0–3.8 mm, that of subadult female paratypes 3.2–3.5 mm. Width of adult male paratypes ca. 0.40–0.45 mm, that of subadult female paratypes 0.44–0.48 mm. Live colouration generally pink; antennae, legs and venter translucent, lighter than dorsum (Figs 1, 7 & 9). Colouration in alcohol after 2 months of preservation pale brown to pinkish brown, legs and antennae faded to translucent (Figs 2–6, 8 & 10). No earth crust visible on body.

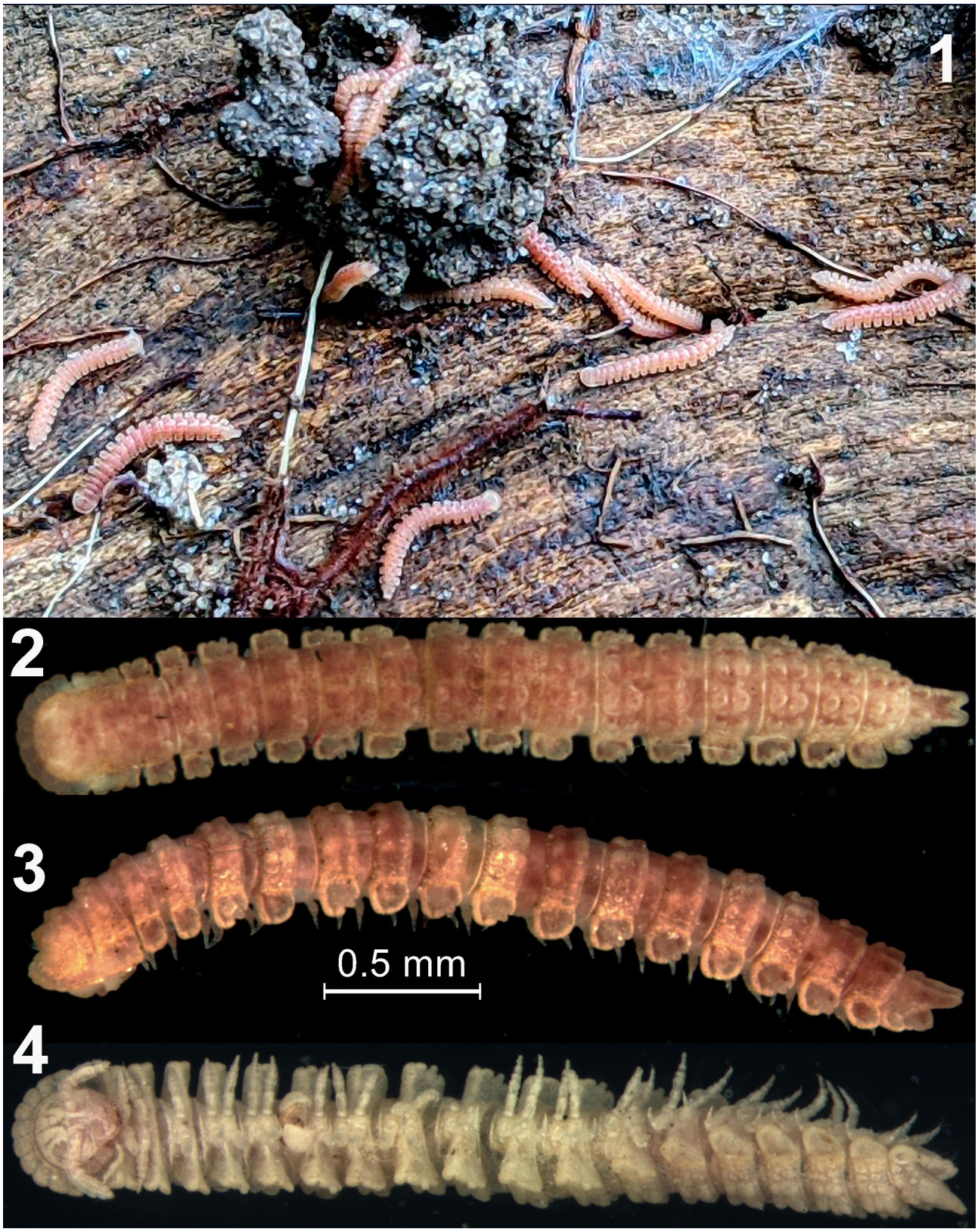
Most characters as in the generic description above, except as follows.

Body with 20 segments (likely in both sexes, see below) (Figs 2 & 4). In width, head << collum < segment 2=3 < 4–6 < 7–9 < 10–15, body gradually tapering towards telson thereafter. Head circular, labral region moderately setose, epicranial suture rather deep, vertex microgranulate (Fig. 6). Interantennal isthmus nearly as wide as diameter of antennal socket. Antennae short, weakly clavate, *in situ* reaching body segment/ring 3 when stretched ventrolaterally. In length, antennomere 7<3<1<6<4<2<<5; antennomeres 5–7 each with a more or less compact apicodorsal group of bacilliform sensilla (Figs 6 & 7). Collum flabellate, completely covering the head from above; anterior margin with 5+5 distinct, equal, moderately incised and rounded lobulations; central part domed, with 2+2 and 3+3 prominent and rounded tubercles arranged in two transverse rows (Figs 2–7). Paraterga set low (at about half of midbody height), subhorizontal to faintly declivous. Dorsum strongly arched, its outline smoothly extending onto paraterga (Figs 3 & 7). Prozonae, as well as deep and thin strictures between pro- and metazonae finely alveolate. Postcollum metaterga with strongly differentiated dorsal tuberculations: 2+2 longitudinal crests/rows of mostly 2+2 fused tubercles, those before ring 19 slightly inclined caudad, but PM on ring 19 abruptly modified into a mid-dorsal, strongly elongate, conspicuous and caudally clearly bilobate ridge overhanging and concealing a short epiproct (Figs 2–4, 8–10). Paraterga broad, thin, rather irregularly tuberculate near bases and clearly lobulated laterally, with three rounded and moderately incised lobulations on rings 2–19, regardless of cylindrical porosteles located between the 2nd and 3rd lobulations on rings 5, 7, 9, 10, 12, 13, 15 and 16 (Figs 2–10); only paraterga 3 and 4 with last lobulation in a clearly caudolateral position (Figs 5–7). Epiproct (Fig. 10) finger-shaped, tip bent down and divided into two round bulbs. Hypoproct (Fig. 10) semi-circular, with 1+1 strong setae borne on minute, caudal, paramedian knobs.

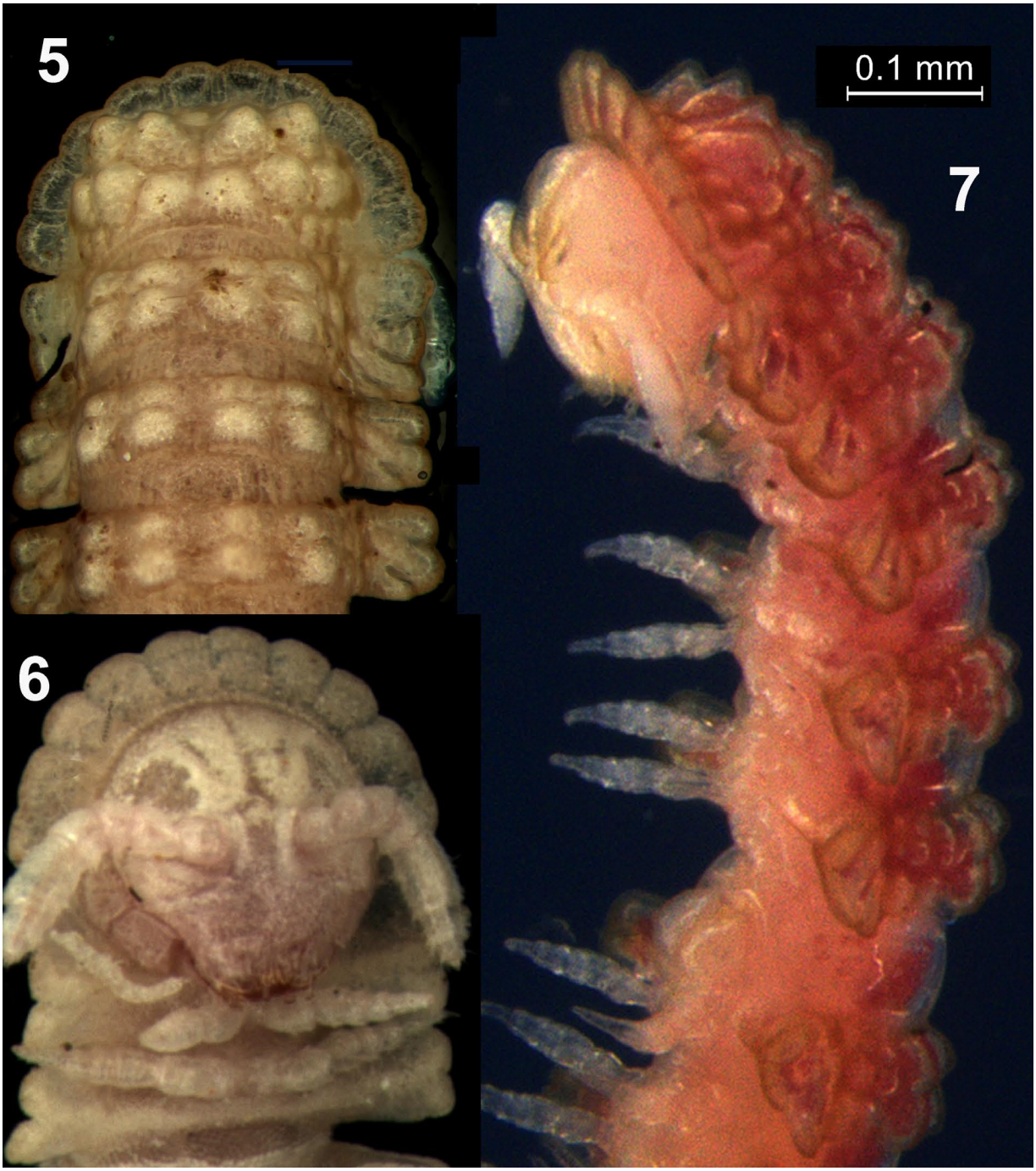
Legs with neither adenostyles nor tarsal brushes (Fig. 11). In length, tarsi > femora > prefemora > tibiae > coxae > postfemora; claws simple, slightly curved ventrally.

Gonopods (Figs 12–15) relatively simple, placed inside a transversely oblong-oval gonopodal aperture, the latter with thin and slightly elevated caudal and lateral margins; *in situ*, both gonopods strongly exposed, held mostly parallel to one another, with only tips crossing each other. Coxites (**cx**) voluminous, but moderately enlarged, gonocoel thus being relatively shallow; cannulae simple. Telopodites directed caudally, each unipartite and subtriangular, long and slender, gradually attenuating distad and acuminate apically, each represented solely by a solenomere (**sl**) and supporting a seminal groove running along lateral margin to the end of a laterally directed and unciform apical

part, and additionally reinforced basally through a distinctly thickened caudomesal wall of a prominent, membranous, mesal lobe (**lo**); prefemorite as usual, relatively short, densely and strongly setose.



FIGURES 1–4. *Klimakodesmus bilobocaudatus* **sp. nov. 1**. Natural microhabitat (rotting wood with a colony on the surface, photographed not to scale). **2**. Adult male paratype, dorsal view. **3**. Subadult female paratype, lateral view. **4**. Adult male paratype, ventral view.

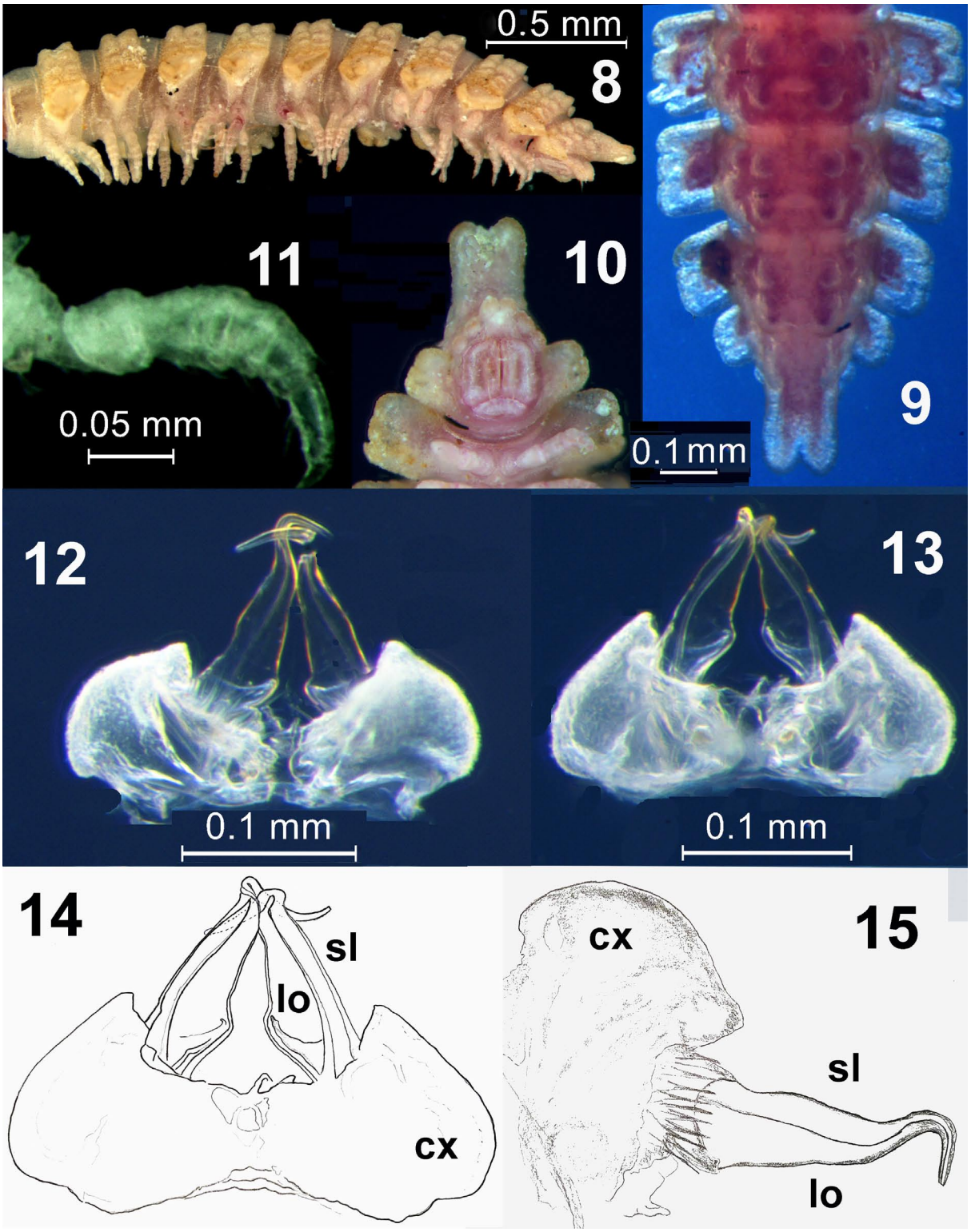


FIGURES 5–7. *Klimakodesmus bilobocaudatus* **sp. nov.** Anterior parts of body, dorsal, ventral and lateral views, respectively.

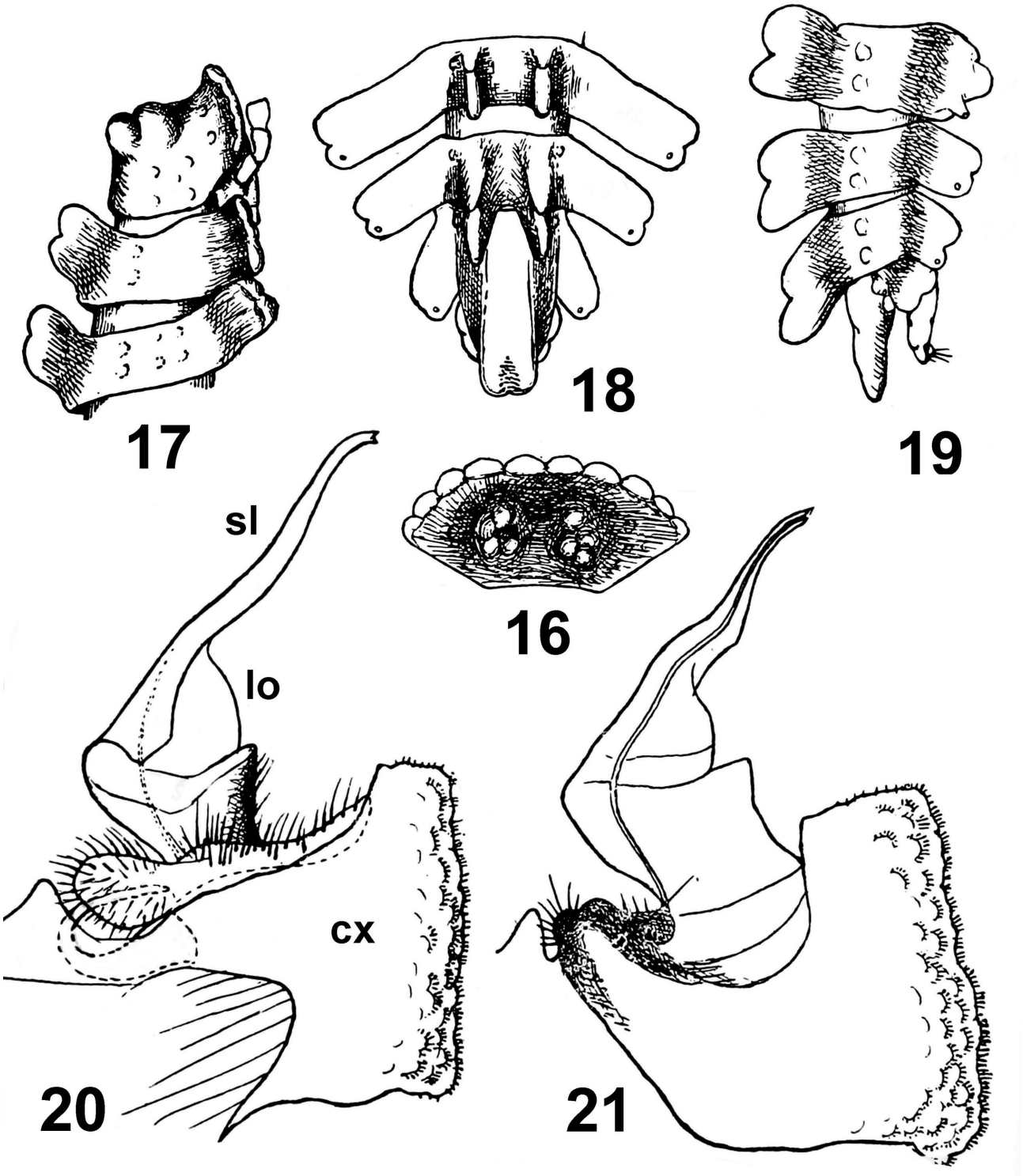
Ecological notes. This new species was found under rotting wood near a lowland swamp overgrown with *Myristica* forest in the Kannur district, northern Kerala, India. The habitat area of approximately 20 ha is a sacred grove protected by local people. In contrast, *K. gravelyi* came from high-altitude areas (1000–1600 m a.s.l.) in the state of Tamil Nadu (Carl 1932), Western Ghats, southern India (Fig. 22).

It seems noteworthy that all females collected at the type locality in January appear to be subadults, each with 19 body segments. This has been proven by dissecting the vulvae which have always been found underdeveloped (amorphous ovoid clods devoid of setae), and an anterior, ventral, transverse, marginal ridge on ring 3 missing. This agrees well with the common wisdom that only adult males in Polydesmida, but never adult females, can be composed of a lesser number of body rings. Usually, in the course of teloanamorphosis characteristic of the order Polydesmida, both the males and females of Polydesmida show the same number of body rings, either 20 or 19,

more rarely 18, exceptionally up to 40 (Shear *et al.* 2016). When there is a difference in polydesmidan body segment counts, the adult males typically have one segment less and nearly always remain stable per sex (Enghoff *et al.* 2015). Only exceptionally, as is the case of *Ammodesmus granum* Cook, 1896 and *A. congoensis* VandenSpiegel & Golovatch, 2015 (Ammodesmidae), from western or central Africa, respectively, can both sexes vary in the number (18 or 19) of body rings (VandenSpiegel & Golovatch 2012, 2015).



FIGURES 8–15. *Klimakodesmus bilobocaudatus* **sp. nov. 8**. Posterior half of body (subadult female paratype), lateral view. **9 & 10**. Posterior part of body (adult male paratype), dorsal and ventral views, respectively. **11**. Midbody leg (adult male paratype), lateral view. **12–14**. Both gonopods (adult male paratype), caudal, oral and caudal views, respectively. **15**. Right gonopod, caudal view. **Abbreviations**: **cx**, coxite; **lo**, mesal lobe; **sl**, solenomere. **NB:** Figures **14 & 15** drawn not to scale.



FIGURES 16–21. *Klimakodesmus gravelyi* Carl, 1932, male holotype, after Carl (1932). **16**. Collum, dorsal view. **17**. Anterior part of body, lateral view. **18 & 19**. Posterior part of body, dorsal and lateral views, respectively. **20 & 21**. Left and right gonopods, caudal and oral views, respectively. **Abbreviations**: **cx**, coxite; **lo**, lateral lobe; **sl**, solenomere. Drawn not to scale.

In *Klimakodesmus* species, however, the situation is ordinary, as both sexes (must) equally have 20 body segments. The absence of adult females in the type series seems best to be accounted for by seasonal factors alone.

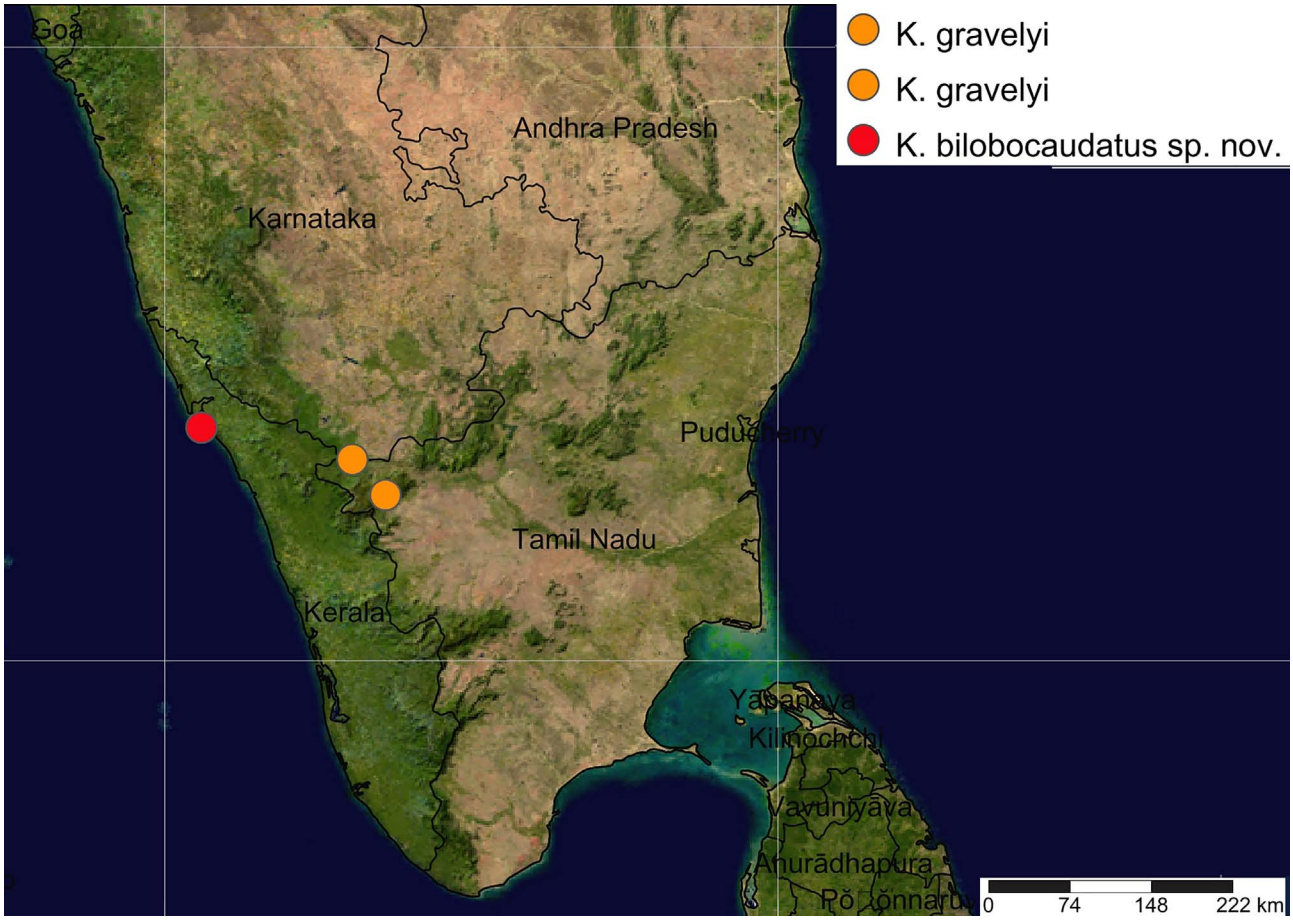


FIGURE 22. Distribution of the genus *Klimakodesmus*: *K. gravelyi* in Tamil Nadu state (orange dots), and *K. bilobocaudatus* **sp. nov.** in Kerala state (red dot).

Acknowledgements

The authors are grateful to the Principal, Christ College (Autonomous), Irinjalakuda, Kerala, for providing us with the facilities necessary for undertaking this study. The first author is thankful to UGC-JRF for the financial support to conduct this study. The authors also acknowledge the funding rendered by Science & Engineering Research Board (SERB), DST for the facilities used in this study (Major Research Project EMR/2016/006401). The second author was partly supported by the Presidium of the Russian Academy of Sciences, Program No. 41 "Biodiversity of Natural Systems and Biological Resources of Russia". We are also grateful to Mr. Santhosh, Devaswom staff, and Mr. Chandran, care taker of the sacred grove, for their hospitality and support in the field. We are greatly obliged to Nesrine Akkari (Vienna, Austria), Didier VandenSpiegel (Tervuren, Belgium) and Pooja A. Anilkumar (Bonn, Germany)**,** the three reviewers whose critiques and valuable suggestions have allowed us to considerably improve the paper.

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