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Rediscovery of synanthropic silverfish *Ctenolepisma calvum* (Ritter, 1910) (Insecta: Zygentoma: Lepismatidae: Ctenolepismatinae) from Kerala, India and assignation of European *C. calvum* to a new species

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Ctenolepisma calvum (Ritter, 1910) from Kerala, India, ventral view of head.

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ABSTRACT

Ctenolepisma calvum (Ritter, 1910) (Zygentoma: Lepismatidae: Ctenolepismatinae) was first described with two pairs of styli by Ritter on the basis of specimens from Sri Lanka found in houses. Recent records of synanthropic populations of *Ctenolepisma* Escherich, 1905 with similar habitus were attributed to this species and redescribed as bearing only one pair of styli, interpreting Ritter's reference to the number of styli as erroneous. However, a species of silverfish from Kerala, India, has been found that matches Ritter's description of *C. calvum* in terms of morphological characters and is genetically different from the lineages of European *Ctenolepisma* previously attributed to *C. calvum*. Thus, the specimens from Europe studied by Molero-Baltanás *et al.* (2024a) as *C. calvum* are assigned to a new species, *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. *Ctenolepisma calvum* is the tenth species in the genus *Ctenolepisma* reported from India. A detailed morphological redescription of this species is presented in this paper, together with its differences from *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. recorded in Europe and Japan, and molecular sequences of the authentic *C. calvum*.

KEY WORDS
Ctenolepisma, *Ctenolepisma phantasma*, Lepismatidae, Ctenolepismatinae, Kerala, India, COI, morphology, new species.

RÉSUMÉ
Redécouverte du lépisme synanthrope Ctenolepisma calvum *(Ritter, 1910) (Insecta : Zygentoma : Lepismatidae : Ctenolepismatinae) de Kerala, Inde et assignation de* C. calvum *européen à une nouvelle espèce.*
Ctenolepisma calvum (Ritter, 1910) (Zygentoma: Lepismatidae: Ctenolepismatinae) a été décrit pour la première fois avec deux paires de styles par Ritter sur la base de spécimens du Sri Lanka trouvés dans des maisons. Des signalements récents de populations synanthropiques de *Ctenolepisma* Escherich, 1905 avec un habitus similaire ont été attribués à cette espèce et redécrits comme ne portant qu'une seule paire de styles, interprétant la référence de Ritter sur le nombre de styles comme erronée. Cependant, une espèce de lépisme du Kerala, en Inde, correspond à la description de *C. calvum* par Ritter en termes de caractères morphologiques et est génétiquement différente des lignées de *Ctenolepisma* européens précédemment attribuées à *C. calvum*. Ainsi, les spécimens européens étudiés par Molero-Baltanás *et al.* (2024a), sous le nom de *C. calvum* sont attribués à une nouvelle espèce, *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. *Ctenolepisma calvum* est la dixième espèce du genre *Ctenolepisma* signalée en Inde. Cet article présente une redescription morphologique détaillée de cette espèce, ainsi que ses différences avec *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. retrouvés en Europe et au Japon, avec les séquences moléculaires de l'authentique *C. calvum*.

MOTS CLÉS
Ctenolepisma,
Ctenolepisma phantasma,
Lepismatidae,
Ctenolepismatinae,
Kerala,
Inde,
COI,
morphologie,
espèce nouvelle.

INTRODUCTION

The silverfish family Lepismatidae Latreille, 1802 (Insecta: Zygentoma) includes six subfamilies, around 46 genera and over 340 described species, with the subfamily Ctenolepismatinae Mendes, 1991, the most diverse among all, comprising 21 genera and about 190 species (Molero-Baltanás *et al.* 2024b). Among these, 119 species belong to the genus *Ctenolepisma* Escherich, 1905 (Smith 2018). In 1955, Wygodzinsky split the genus into two subgenera: *Ctenolepisma s. str.* for species bearing 1 + 1 bristle combs on the urotergite I, and *Sceletolepisma* Wygodzinsky, 1955 for species with 2 + 2 bristle combs on this urotergite. Based on the presence (*Ctenolepisma*) or absence (*Sceletolepisma*) of medial combs on the urosternites, Irish (1987) reclassified these two subgenera, that have been recently raised to generic level by Molero-Baltanás *et al.* (2024b).

The poorly known Indian fauna of Lepismatidae is currently represented by 17 species; of these, nine species belong to the genus *Ctenolepisma s. str.*, i.e., lacking medial combs on urosternites (Jana & Hazra 2023): *C. alticola* Silvestri, 1935, *C. amrabadense* Hazra, Jana & Mandal, 2022a, *C. boettgerianum* Paclt, 1961, *C. kawalense* Hazra, Jana, Mandal & Molero-Baltanás, 2023*, C. longicaudatum* Escherich, 1905, *C. nigrum* (Oudemans, 1890), *C. tripurense* Hazra, Biswas & Mitra, 2000, *C. udumalpetense* Hazra, Jana, Mandal & Molero-Baltanás, 2022, and *C. venkataramani* Hazra, Jana, Mandal & Molero-Baltanás, 2022.

The species *C. calvum* (Ritter, 1910) was described as *Peliolepisma calva* by Ritter (1910) on the basis of specimens from Sri Lanka (Fig. 1). In recent works this species has been treated as a member of the genus *Ctenolepisma* since the characters distinguishing *Peliolepisma* Ritter, 1910 are not relevant and based on an error of Ritter overlooking the abdominal chaetotaxy of this silverfish (Molero-Baltanás *et al.* 2024a). Another early record of *C. calvum* was also from Sri Lanka (Crusz 1957). It was then reported from Guyana and Cuba by Wygodzinsky (1972). The initial reports of this species from Europe came from Chemnitz, Germany by Landsberger & Querner (2018) and Norway (Aak *et al.* 2019; Hage *et al.* 2020; Querner *et al.* 2022). Kulma *et al.* (2022) reported the species from Czech Republic and also reported unverified reports from Spain, Italy, Switzerland, Austria, Croatia, Montenegro, Finland and Russia. Querner *et al.* (2022) provided a key and a table comparing major characteristics of *C. calvum* they observed, with some other synanthropic species, although some of the characters were incorrectly presented and later amended by Molero-Baltanás *et al.* (2024a), who gave an updated redescription of the species.

The *Ctenolepisma* specimens from Prague and Spain showed close similarity with the original description of *C. calvum* from Sri Lanka (see Kulma *et al.* 2022; Molero-Baltanás *et al.* 2024a) but some significant differences with the description of Ritter (1910) were detected. These differences related to the number of pairs of styli (one instead of two in topotype from Sri Lanka according to Ritter's description) and the relative length of the ovipositor compared to the styli, but European authors assumed that the description made by Ritter (1910) was outdated and partially incorrect, keeping the name *C. calvum* for European specimens. Molero-Baltanás *et al.* (2024a) presented a detailed and updated description of this synanthropic silverfish recorded in Europe.

During samplings of households and institutions in Kerala (India), many specimens of *Ctenolepisma* showing remarkable difference from other previously known species of this genus reported from India, were observed and collected. The presence of two styli and some other characters showed similarity with Ritter's description of *C. calvum*. They also showed much similarity to *C. calvum* described from Europe except for the major dissimilarity in the number of styli.

FIG. 1. — Location of *Ctenolepisma calvum* (Ritter, 1910) from Kerala (**red dot**) with respect to original description by Ritter (1910) (**red star**).

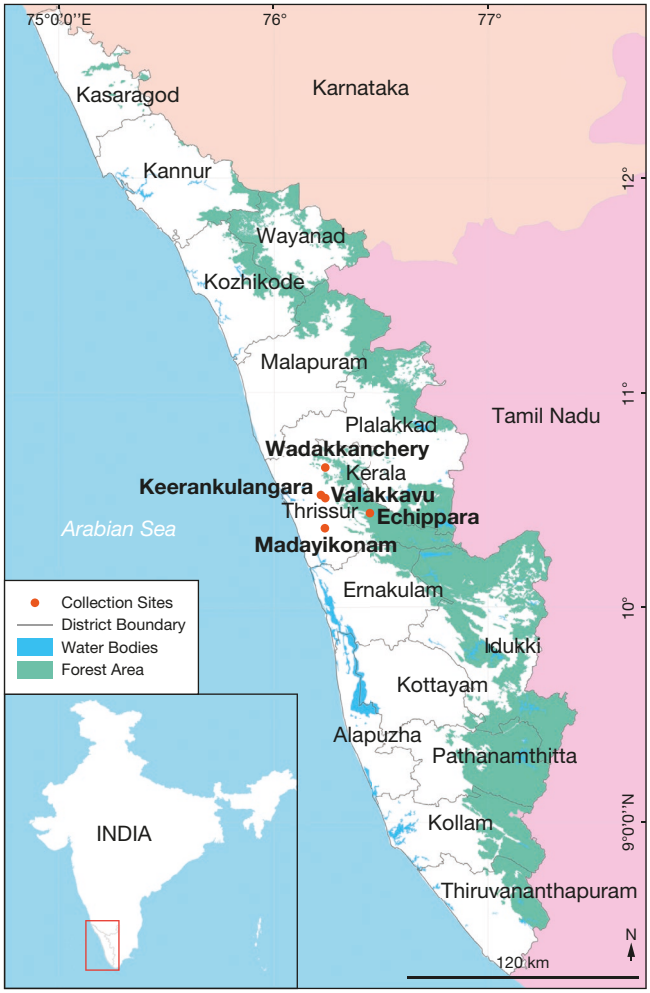

FIG. 2. — Collection sites of *Ctenolepisma calvum* (Ritter, 1910) in Kerala, India.

We endeavour to compare both populations, the European ones and those from Kerala, morphologically and using molecular tools to test their specific identity or to establish them as different species and independent lineages.

MATERIAL AND METHODS

Specimens were collected from different localities in Central Kerala during 2021 and 2022 (Table 1; Fig. 2). Live silverfish were collected following Thomsen *et al.* (2019) and "paper strip method". The containers with live insects were carried to the laboratory, sorted and some samples were preserved in plastic vials with 99% alcohol for further studies. Other specimens were transferred to culture boxes. Some specimens were dissected in alcohol, treated with fuchsin stain. Morphometric measurements were taken following Smith (2013) and available descriptions and dichotomic keys were used as a reference for morphological identification, especially those of Kulma *et al.* (2022), Bednár *et al.* (2023) and Molero-Baltanás *et al.* (2024a). Silverfish habitus was imaged with LEICA MC170 HD stereomicroscope and measurements were taken with LAS software. Imaging was also done with LABOMED Lx 300 compound microscope and SEM-EDAX: (Jeol 639oLA/ OXFORD XMX N) at STIC, CUSAT. Drawings were made using a microscope and a camera lucida and the GIMP2 software (version 2.10.12) was used for improving some figures. Some images published in Molero-Baltanás *et al.* (2024a) were reused with permission. Currently relevant characters used in the taxonomy of Lepismatidae (Smith *et al.* 2019) were considered for identification.

TABLE 1. — Geo coordinates of collection sites of *Ctenolepisma calvum* (Ritter, 1910) in Kerala (India).

Location	No. of insects collected	Longitude	Latitude
Keerankulangara (neotype)	6	76.21942°E	10.52301°N
Echippara	11	76.450389°E	10.438078°N
Wadakkanchery	9	76.2397°E	10.6521°N
Valarkkavu	11	76.239295°E	10.5095°N
Madayikkonam	4	76.238183°E	10.368145°N

TABLE 2. — Primers used for COI sequencing of *Ctenolepisma calvum* (Ritter, 1910) from Kerala.

Target	Primer Name	Direction	Sequence (5' → 3')
COI	LCO1490	Forward	GGTCAACAAATCATAAAGATATTGG
	HCO2198	Reverse	TAAACTTCAGGGTGACCAAAAAATCA

For the study of European specimens previously identified as *C. calvum*, those used for the updated description presented by Molero-Baltanás *et al.* (2024a) were re-examined using light and electronic microscopy, together with a thorough revision of the available literature on this species and all the related taxa of the genus *Ctenolepisma*.

COI GENE SEQUENCING

DNA was extracted from four insects. Sequencing of the cytochrome oxidase I gene was done at the RGCB, Trivandrum and Mediomix Diagnosis & Bioresearch Lab, Bengaluru, using the forward and reverse primers, LCO1490 and HCO2198 respectively (Folmer *et al.* 1994) (Table 2). Forward and reverse direction sequence trace files for two samples were assembled using Geneious Prime 2022.2.1 (Kearse *et al.* 2012) and consensus sequences, sequence trace files, and specimen collection data were uploaded to BOLD (www.boldsystems.org) and submitted to GenBank.

PHYLOGENY

We downloaded ten "DNA barcode" (i.e., mitochondrial COI gene) sequences from GenBank for *Ctenolepisma* species, with accession numbers OR732091-OR732793, OR732095-OR732797, OR732102-OR732105 (Molero-Baltanás *et al.* 2024a), NC046478 (Chen *et al.* 2019), MK185702 (Smith *et al.* 2019), LC19153-LC19156 (Shimada *et al.* 2022), and OP028702-OP028703 (Querner *et al.* 2022). All ten of these publicly available sequences were determined in a recent review of the world fauna of synanthropic silverfish (Molero-Baltanás *et al.* 2024a) to be correctly identified. These sequences were added to the four new sequences we produced (with accession numbers PV633791-PV633794) to make a dataset of 14 sequences.

The 14 sequences were aligned in Geneious using Muscle (Edgar 2004). The DNA sequence alignment was trimmed to 646 base pairs to minimize missing data. MEGA v.11.0.13 (Tamura *et al.* 2021) was used to calculate uncorrected DNA distances ("p-distances") and to test models of sequence evolution for phylogenetic analysis. The General Time Reversible model with Gamma-distributed rates (GTR+G) had both the lowest Bayesian Information Criterion (BIC) score and the lowest Akaike Information Criterion, corrected (AICc) score, and was selected for the analysis.

Phylogenetic analyses were performed using Maximum Likelihood (ML) as implemented in RAxML 8.2.11 (Stamatakis 2014) and Bayesian Inference (BI) in MrBayes v.3.2.6 (Ronquist *et al.* 2012) using the plugins available in Geneious. RAxML analyses used the ML search convergence criterion and performed 1 000 fast bootstrap replicates. MrBayes analyses used four heated chains with chain temperature of 0.2, a chain length of 1 000 000 generations, subsampling every 500 generations, and a burnin length of 500 samples (25%).

ABBREVIATIONS

Institutions

CUSAT	Cochin University of Science and Technology, Kerala, Cochin;
MNCN_Ent	Entomology collection of the Museo Nacional de Ciencias Naturales (MNCN), Madrid;
MNHN	Muséum national d'Histoire naturelle, Paris;
RGCB	Rajiv Gandhi Centre for Biotechnology, Kerala, Trivandrum;
STIC	Sophisticated Test and Instrumentation Centre, Kerala, Cochin;
UCO	Department of Zoology, University of Córdoba;
WGRC	Western Ghat Research Center, Kerala, Calicut;
ZSI	Zoological Survey of India collection, Kolkata.

Morphology

L/W	ratio length/width.

RESULTS

COI SEQUENCE OF *C. CALVUM* FROM KERALA AND COMPARISON WITH OTHER PREVIOUSLY SEQUENCED SPECIMENS IDENTIFIED AS *C. CALVUM*

The COI sequences of the Kerala specimens were compared with the COI sequences of Japanese and European specimens previously identified as *C. calvum,* uploaded in GenBank (LC719153, LC719154, LC719155, LC719156-Japan, OP028702, OP028703-Poland) listed in Molero-Baltanás *et al.* (2024a). We found that all the sequences from Japan were 100% similar to each other and the sequences from Poland were similar to each other too. There was negligible difference between the sequences from Japanese and European specimens, and the single specimen from Spain that was included in our dataset (sample ID gbs006285). The Kerala specimens showed only 82.83% and 82.87% similarity with the Japanese and European specimens respectively and lower similarity when compared to other *Ctenolepisma* species. We found that they were closest to the '*C. calvum*' from Europe and Japan, thereby confirming that it is indeed a different species from both the *C. calvum* identified from Europe and Japan and other synanthropic species of *Ctenolepisma* with available sequences (Fig. 3).

So, if our Indian specimens identified a priori as *C. calvum* and those previously identified with the same name belong to different species, this name should be retained by only one of them. Our morphological study (see below) finds that the specimens from Kerala are more similar to the original description of *C. calvum* (Ritter 1910) than to the specimens from Europe, so the Kerala specimens should retain the name *C. calvum* and those from Europe are designated here as a new species, and the name *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. is given to this synanthropic form.

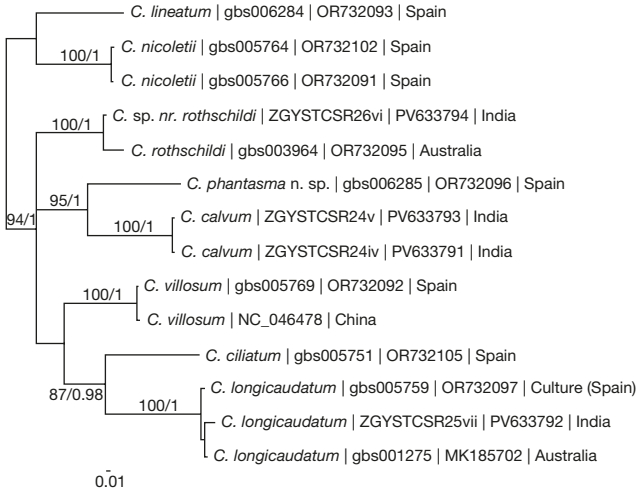

Fig. 3. — Bayesian tree of COI sequences. Numbers above branches are ML bootstrap values/Bayesian posterior probabilities, shown only if ≥70 and ≥90 respectively.

Fig. 4. — *Ctenolepisma calvum* (Ritter, 1910) from Kerala, India, dorsal view. Scale bar: 1 mm.

SYSTEMATICS

Order ZYGENTOMA Börner, 1904
Family Lepismatidae Latreille, 1802
Subfamily Ctenolepismatinae Mendes, 1991
Genus *Ctenolepisma* Escherich, 1905

Ctenolepisma calvum (Ritter, 1910)
(Figs 4-11)

Peliolepisma calva Ritter, 1910: 380.

Ctenolepisma calvum – Paclt 1967: 39.

Peliolepisma calvum – Paclt 1979: 223.

Material studied. — **Neotype. India** • 1 ♀; Kerala, Thrissur District, Valarkkavu, bookcase in a house; 22.IX.2022; S. Raphel leg., specimen in alcohol; ZSI/WGRC, I.R.-INV.26922.

Other material studied. — **India** • 1 ♀; same locality as neotype; 12.IV.2023; specimen in alcohol; ZSI/WGRC, I.R.-INV.26923.

Diagnosis. — Body length up to 9.75 mm. Macrosetae plumose. Epidermic pigment whitish to light yellowish. Dorsal scales transparent, light yellowish, heterogeneous in shape and in the spacing of their ribs, but more uniform than those of *C. rothschildi* Silvestri, 1907. Appendages lacking scales except for coxae and femora; coxal scales similar to those covering the body and femoral scales present only on the inner side, their shape subtriangular

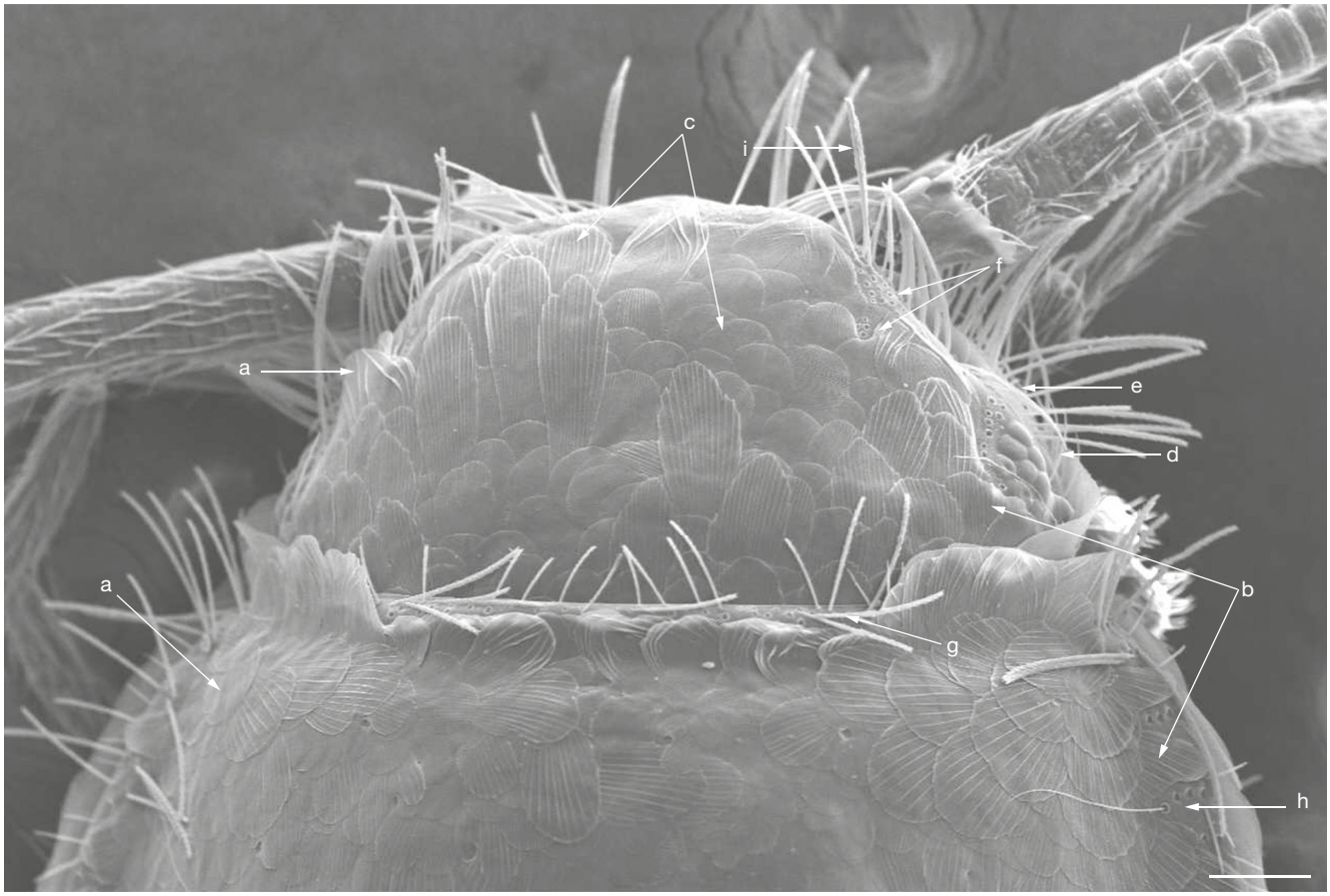

FIG. 5. — *Ctenolepisma calvum* (Ritter, 1910) from Kerala, India, head and part of pronotum: **a**, arrangement of scales; **b**, narrow and broad ribbed scales; **c**, elongated and rounded scales; **d**, ommatidia (right side); **e**, periocular bristle comb sockets (right side); **f**, bristle sockets of frontal bush (right side); **g**, pronotal collar; **h**, trichobothrium at N-5; **i**, feathered macrosetae. Scale bar: 100 µm.

with truncated or bifid apical margin. Antennae shorter than body length. Cephalic chaetotaxy typical of *Ctenolepisma*. Last article of labial palp with five sensory papillae arranged in a single row. Setal collar of pronotum with two rows of macrosetae on its median part. Lateral margins of pronotum and mesonotum bearing 8-10 pairs of lateral bristle-combs; metanotum with 5-7 lateral combs on each side. Posterior margins of thoracic nota with 1 + 1 posterior small combs of 2-3 macrosetae each. Anterior trichobothrial areas of pronotum associated to the N-4 or N-5 lateral combs; those of mesonotum and metanotum associated to the penultimate (N-1) comb. Posterior trichobothria inserted on the last lateral comb of each notum. All thoracic sterna with 1 + 1 antedistal bristle-combs bearing 5-10 macrosetae, frequently arranged in two irregular rows. Abdominal tergite I with 1 + 1 infralateral combs of two macrosetae. Urotergites II-V with 3 + 3 combs, urotergites VI-VIII with 2 + 2 combs and urotergite IX glabrous; infralateral combs consisting of 2-5 macrosetae; remaining dorsal combs of abdomen with 2-3 macrosetae. Urotergite X trapezoidal, short and with a slightly concave posterior margin. Urosternites I and II lacking setae; urosternites III-VIII with 1 + 1 lateral combs of 10-13 macrosetae. Two pairs of styli inserted on abdominal segments VIII and IX. Inner process of coxite IX about 1-1.6 times longer than wide at its base and about 2-2.4 times longer than the outer process. Ovipositor moderately long, with about 30-33 divisions; its apex surpassing the tip of styli IX by about 0.5 times the latter's length. Maximum length preserved of caudal filaments up to 5.25 mm. Male unknown. *Ctenolepisma calvum* is close to *C. rothschildi*, but the dorsal scales are more uniform (big pauciradiate scales occurring in *C. rothschildi* are absent), the colour of scales and epidermic pigment is lighter (in *C. rothschildi* the colour pattern seems to be variable but the pigment is always darker), the number of macrosetae on sternites is greater (in *C. rothschildi*, the combs of thoracic sternites have less than 8 macrosetae, not arranged in two rows, and the combs of abdominal sternites have less than 10 macrosetae) and the ovipositor is shorter (in *C. rothschildi*, its apex exceeds the tip of the last pair of styli by 1-2 times their length).

REDESCRIPTION

Male unknown. Body of female elongated, more or less parallel sided, slightly tapering towards the posterior end (Fig. 4). Maximum body length: 9.75 mm, excluding terminal filaments. Macrosetae pectinate (Figs 5; 6). Epidermic pigment whitish dorsally, with slightly grey pigmentation; under artificial light colour appearing light straw, covered with dull golden scales. Maximum length of cerci up to 4.5 mm and that of paracercus up to 5.25 mm.

Scales

Dorsal and ventral surface of the body covered with heterogeneous scales; based on shape, sometimes be oval, globular and sub-triangular; based on size, sometimes be large (more than 100 µm) and small (less than or equal to 30 µm). Based on rays, two types distinguished: one with 30-40 fine rays and the other with 10-16 widely spaced thicker rays. The three

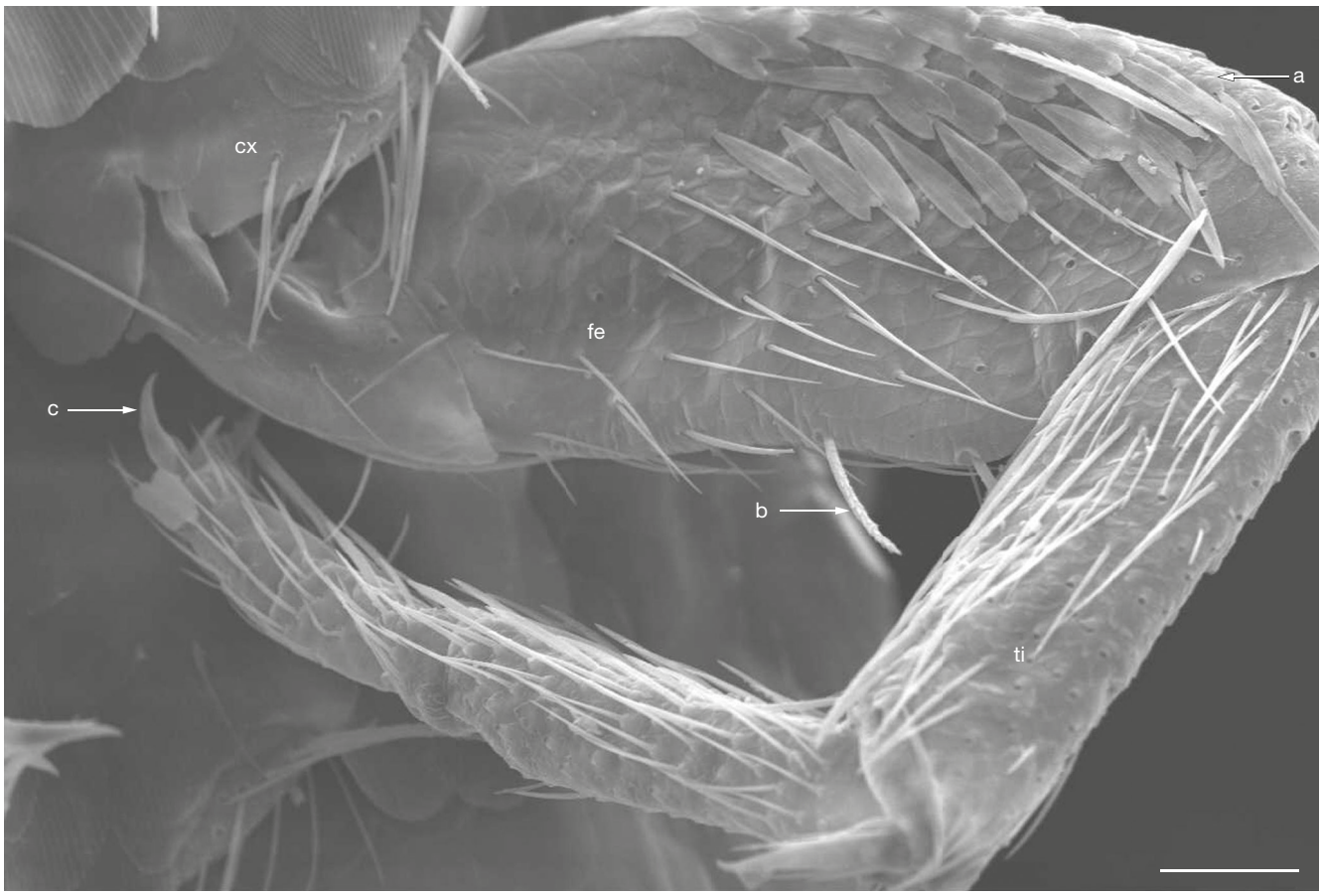

FIG. 6. — *Ctenolepisma calvum* (Ritter, 1910) from Kerala, India, part of a leg showing the inner side of the femur (**fe**) with elongated bifid scales on its dorsal part (**a**) different to those of the coxa (**cx**), and pectinate macroseta (**b**). The tibia (**ti**) lack scales. The pretarsus is also shown (**c**). Scale bar: 50 µm.

different shaped scales of both small and large sizes, with either wide spaced or narrow spaced rays (Fig. 5). Appendages lacking scales except for coxae and femora; femoral scales are different in shape, elongated, with bifid apex (Fig. 6).

Head

Head wider (maximum 1.1 mm) than long (maximum 0.70 mm). Setation similar to other species of the genus, with both clypeus and labrum having setal bushes of bifid and pectinate macrosetae (Fig. 7). Antennae up to 6 mm long. Maxillary palp 5-segmented; apical article 4.2-6.5 times longer than wide and 0.74-1.00 times as long as the penultimate article. Four segmented labial palps, their apical article being slightly longer than wide (L/W: 1.1-1.2) with five sensory papillae arranged in single row (Figs 7; 8A).

Thorax

Thorax wider than abdomen. Maximum thorax width: 2.12 mm; maximum thorax length: 3.1mm. Pronotal collar with two rows of bristle combs in the centre and single row towards the anterolateral corner. Pronotum (Figs 5; 8B) with (8-9) + (8-10) bristle combs on lateral margins, each one with 2-5 macrosetae; posterior trichobothria of pronotum on inner side of the last lateral comb (N) and anterior trichobothria on inner side of N-4 or N-5 combs. Mesonotum (Fig. 8C) with (8-9) + (8-9) lateral combs of 2-3 macrosetae; posterior trichobothria on the inner side of the last lateral comb (N) and anterior on the outer side of the penultimate lateral comb (N-1). Metanotum (Fig. 8D) with (5-6) + (5-7) bristle combs of 1-3 macrosetae each on its lateral margins; arrangement of trichobothria similar to that of mesonotum. All nota with 1 + 1 posterior submarginal combs with 2-3 macrosetae.

Thoracic sterna as in Figure 9. Prosternum and mesosternum longer than wide; ratio L/W of the prosternum: 1.16-1.20, and ratio L/W of the mesosternum: 1.20-1.26. Metasternum as long as wide or slightly shorter (ratio L/W:0.92-1.00). All thoracic sterna with one pair of oblique antedistal combs; those of prosternum and metasternum with 7-10 macrosetae, and those of mesosternum consisting of 5-8 macrosetae. In all sterna, macrosetae of the combs arranged in two irregular rows, and few submarginal setae also present between the comb and the margin.

Legs

Legs stout; femora shorter than tibiae and tarsi. Tarsi of hind legs moderately longer than that of other two legs. Protibiae 3.0-3.5 times longer than wide; mesotibiae 3.0-3.8 times longer than wide and about 1.14-1.19 times longer than the protibiae; metatibiae 3.6-5.2 times longer than wide and 1.5-1.6 times longer than the protibiae.

FIG. 7. — *Ctenolepisma calvum* (Ritter, 1910) from Kerala, India, ventral view of head showing: **a**, setae on clypeus; **b**, setae on labrum; **c**, five segmented maxillary palp; **d**, four segmented labial palp. Scale bar: 100 µm.

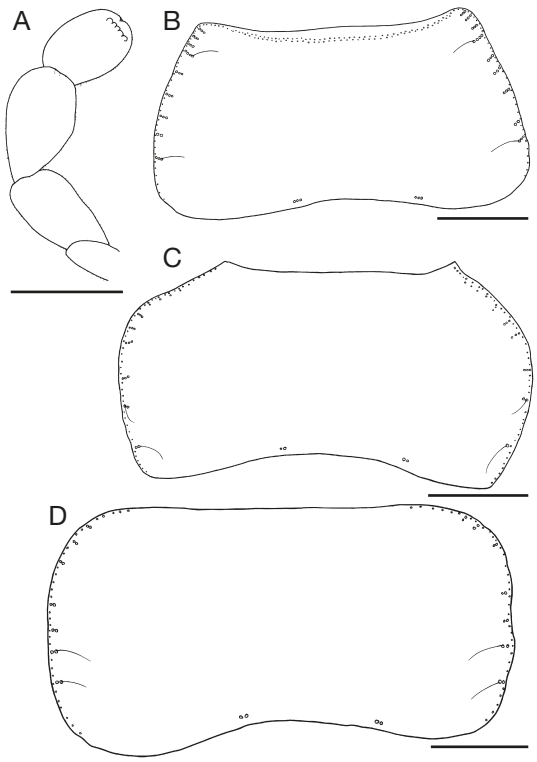

FIG. 8. — *Ctenolepisma calvum* (Ritter, 1910) from Kerala, India, diagnostic characters: **A**, labial palp with five sensory papillae; **B**, pronotum; **C**, mesonotum; **D**, metanotum. The arrangement of trichobothria is shown in all thoracic nota. Scale bars: A, 0.2 mm; B-D, 0.5 mm.

In the tarsi of the first legs, tarsomere 1 (T1) 3.5-5.5 times longer than tarsomere 2 (T2), 3.7-4.8 times longer than tarsomere 3 (T3) and 3.2-5.6 times longer than tarsomere 4 (T4). In the mesotarsus, tarsomere 1 5.3-6.0 times longer than T2, 4.0-6.4 times longer than T3 and 4.6-4.8 times longer than T4. In the metatarsus, T1 5.30-6.65 times longer than T2, 6.5-9.0 times longer than T3 and 4.0-5.6 times longer than T4. Femur with subtriangular elongated bifid scales (Fig. 6) on their inner side. Pretarsus with 3 claws, two lateral and one median.

Abdomen

Urotergite I with 1 + 1 infralateral combs of 2-3 macrosetae, urotergites II-V with 3 + 3 bristle combs, urotergites VI and VIII with 2 + 2 combs and urotergite IX bare. Urotergite X trapezoidal in shape (Fig. 10), wider than long (in the neotype, length: 0.56 mm and base width: 1.4 mm), with 1 + 1 subapical bristle combs consisting of 2-3 macrosetae; scattered setae arranged as in Figure 10. Urosternites I and II glabrous, urosternites III-VII with 1 + 1 lateral combs of 10-13 macrosetae. Number of macrosetae on abdominal bristle combs, see Table 3.

Two pairs of styli inserted on abdominal segments VIII and IX (Fig. 11), apically with several spines. Styli IX longer than styli VIII; ratio of length of styli IX/ length of styli VIII: 1.06-2.08. Inner process of the coxite IX long, triangular and pointed at tip, about 1.00-1.66 times longer than wide at its base and 2.0-2.4 times longer than the outer process.

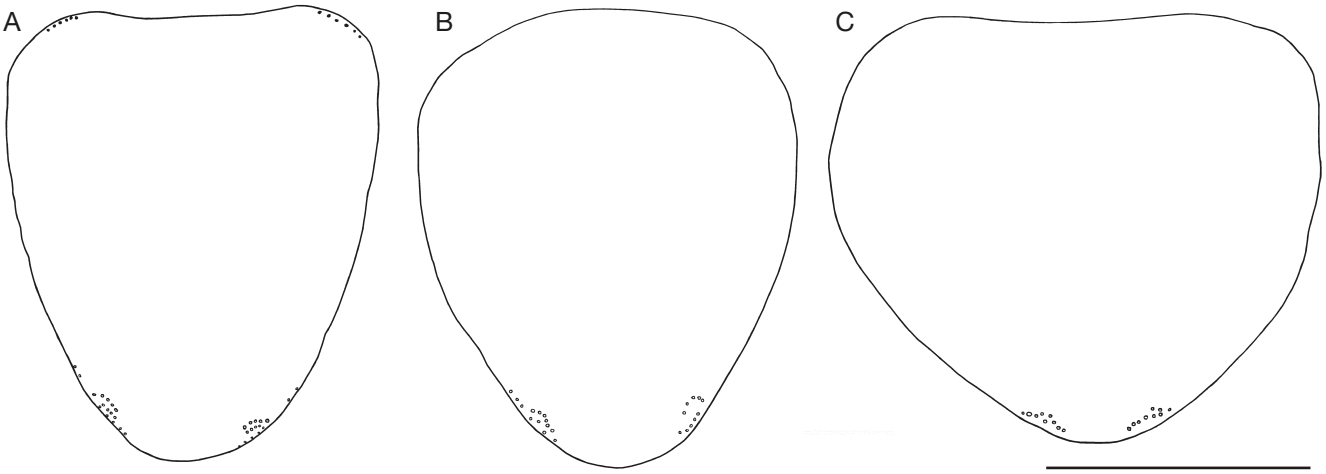

Fig. 9. — *Ctenolepisma calvum* (Ritter, 1910) from Kerala, India, thoracic sternites: **A**, prosternum; **B**, mesosternum; **C**, metasternum. Scale bar: 0.5 mm.

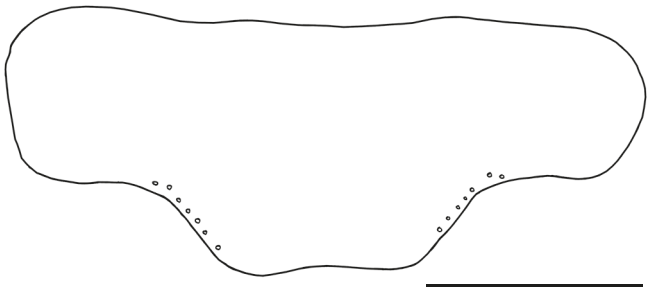

Fig. 10. — *Ctenolepisma calvum* (Ritter, 1910) from Kerala, India, urotergite X. Scale bar: 0.5 mm.

Table 3. — Number of macrosetae per bristle comb on urotergites and urosternites of *Ctenolepisma calvum* (Ritter, 1910) from Kerala.

	Urotergites			Urosternites
Segment	**Infra lateral**	**Sublateral**	**Submedian**	**Lateral**
I	2-3	–	–	–
II	3-4	2	2	–
III	3-4	2	2	8-12
IV	3-4	2	2	10-13
V	3-4	2	2-3	10-13
VI	4-5	2	–	10-12
VII	4-5	–	2-3	10-11
VIII	4-5	–	2	4-6
IX	–	–	–	–

Ovipositor with 30-33 divisions; 1.36-1.76 mm in length from base of urosternite VIII, surpassing the apex of the inner processes of coxites IX by 2-4 times its length.

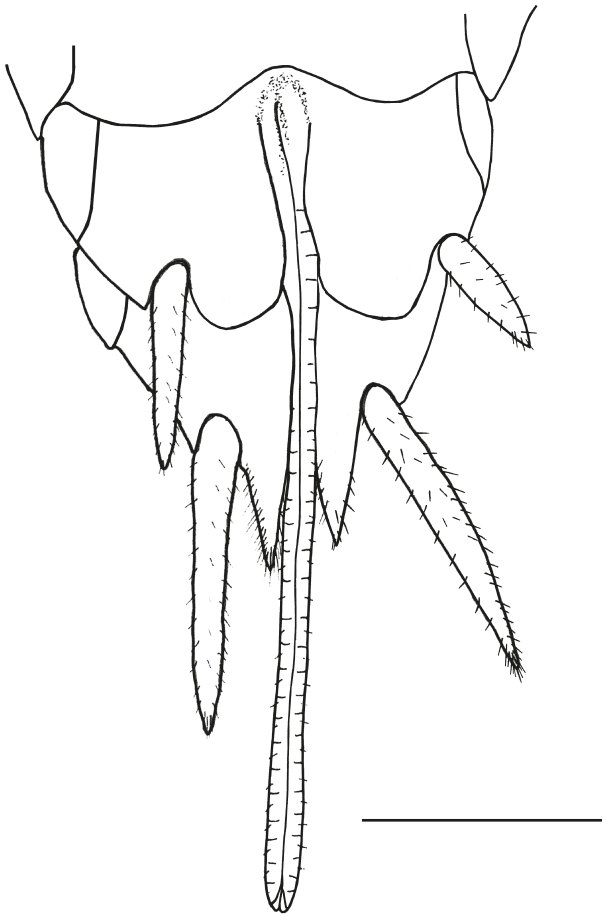

Fig. 11. — *Ctenolepisma calvum* (Ritter, 1910) from Kerala, India, ventral view of abdominal segments VIII and IX showing the two pairs of styli and the ovipositor. Scale bar: 0.5 mm.

Remark

The status and whereabouts of the types of *C. calvum* are unknown. Ritter (1910) mentioned that the Sri Lankan specimens he studied were deposited in the k.k.k. Naturhistorisches Museum; we guess this is the Natural History Museum of Vienna (Austria), but it seems that the specimens are lost or damaged (perhaps during the World War II). Querner *et al.* (2022) provided some descriptive details of this species but did not use the type of the species in spite of these authors working at this Austrian Museum.

FIG. 12. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., habitus of a living specimen (paratype: MNHN-EA-EA110321). Scale bar: 2 mm.

So we designed here a neotype to fix the taxonomy of the species, even though the specimen comes from Kerala (S. India) and not Sri Lanka.

Ctenolepisma phantasma
Molero-Baltanás, Raphel, Mitchell & Jose, n. sp.
(Figs 12-22)

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Ctenolepisma calvum (non *C. calvum* Ritter, 1910) – Querner *et al.* 2022: 5. — Kulma *et al.* 2022: 112. — Shimada *et al.* 2023: 4. — Bednár *et al.* 2023: 3. — Molero-Baltanás *et al.* 2024a: 14.

TYPE MATERIAL. — **Holotype**. **Spain** • 1 ♀; Córdoba, basement of a house in the city of Córdoba; 7.XI.2021; M. Gaju leg.; mounted on slide; MNCN_Ent 283578.
Paratypes. **Spain** • 1 ♀; same locality as for the holotype; 31.X.2023; mounted on slide; UCO, Ref. Z2764b • 2 ♀; same locality and date than the first paratype; preserved in alcohol; UCO, Refs. Z2764c and Z2764d • 2 ♀; preserved in alcohol; MNHN-EA-EA110321; same locality as for the holotype, resulting from parthenogenetic reproduction of one of the aforementioned paratypes.

OTHER MATERIAL STUDIED. — **Spain** • 3 ♀; Córdoba, basement of a house in the city of Córdoba; 31.XI.2023; M. Gaju leg., UCO Ref. Z2764. **Czechia** • 6 ♀; Prage; 2021; M. Kulma leg., UCO, Ref. 2868). These specimens were referenced in Molero-Baltanás *et al.* (2024a); the Czechian specimens were previously examined for the descriptive remarks given in Kulma *et al.* (2022). Additional specimens have been reared in the laboratory of the Department of Zoology of UCO (Córdoba, Spain) and some of them will be deposited in the near future in the collection of MNCN, Madrid, Spain.

DIAGNOSIS. — Body length up to 12 mm. Macrosetae pectinate plumose. Epidermic pigment whitish to light yellowish. Dorsal scales transparent or light grey, heterogeneous but the most abundant widely spaced ribs. Coxae with scales similar to those covering the body. Inner side of femora with subtriangular elongated scales, with apex truncated or bifid; all the remaining articles of legs and appendages without scales. Antennae slightly shorter than body length. Cephalic chaetotaxy typical of *Ctenolepisma*, with a gap without macrosetae on the frontal margin and 1 + 1 tufts on clypeus and labrum. Last article of labial palp with three sensory papillae. Setal collar of pronotum with 2-3 rows of macrosetae. Lateral margins of thoracic nota bearing 5-8 pairs of lateral bristle-combs; posterior margins with 1 + 1 posterior small combs of 1-3 macrosetae each. Anterior trichobothrial areas of pronotum associated to the N-3 lateral combs; those of mesonotum associated to the antepenultimate (N-2) combs and those of metanotum associated to positions occupied by the penultimate comb. Posterior trichobothria inserted on the last lateral comb of each notum, although on metanotum the position of the last comb can lack insertions of macrosetae. All thoracic sterna with 1 + 1 subapical bristle-combs. Abdominal tergite I with 1 + 1 infralateral combs of 2 macrosetae. Urotergites II-V with 3 + 3 combs, urotergites VI-VIII with 2 + 2 combs and urotergite IX glabrous; infralateral combs consisting of 3-4 macrosetae; remaining dorsal combs of abdomen only with 1-3 macrosetae. Urotergite X trapezoidal, short; its posterior margin straight or slightly concave. Urosternites I and II bare; urosternites III-VIII with 1 + 1 lateral combs of 4-8 macrosetae. Only one pair of styli inserted on abdominal segment IX. Inner process of coxite IX about 1.2 times longer than wide at its base and about four times longer than the outer process. Ovipositor short, with about 20 divisions; its apex not clearly surpassing the tip of styli. Maximum length of cerci up to 7 mm. Male unknown (all populations studied parthenogenetic). *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. is the only European *Ctenolepisma* with 3 + 3 urotergal combs on abdominal segments II-V (the remaining species bear 3 + 3 combs on urotergites II-VI or II-VII) and the species with a lowest number of macrosetae per comb and shorter ovipositor. The presence of only three labial papillae and the pattern of scales of legs (truncate subtriangular scales on femora combined with absence of scales on tibiae) are other exclusive characteristics of this species in the European continent. It can be distinguished from other synanthropic species following the characters indicated for *C. calvum* in the key presented by Molero-Baltanás *et al.* (2024a). *Ctenolepisma calvum* (Ritter, 1910) from Kerala and Sri Lanka and *C. rothschildi* Silvestri, 1907 are the closest species, but both species show five papillae in labial palp, a greater number of macrosetae on most combs, and two pairs of abdominal styli; for a more detailed comparison with *C. calvum* from Kerala, see discussion and Tables 4 and 5.

ETYMOLOGY. — The specific name "phantasma" is taken from the Latin word that derives from the Ancient Greek φάντασμα (phántasma), which means phantom or ghost, and is used to follow the common name used in some previous publications (for example, Querner *et al.* (2022)) for records of this insect in Europe (ghost silverfish).

TYPE LOCALITY. — Spain, Córdoba, basement of a house in the city of Córdoba.

DESCRIPTION
Male unknown. Body length of holotype: 9 mm; some Japanese specimens up to 12 mm, but the maximum body length of studied European specimens not surpassing 10 mm. Habitus as in Figure 12 (see also figures in Kulma *et al.* 2022; Querner *et al.* 2022; Shimada *et al.* 2022). Epidermic pigment whitish to light yellowish, more intense on head and last abdominal segments; scales and appendages almost hyaline, except for dorsal scales of some specimens that can be light greyish. Head width up to 1.2 mm, thorax width up to 2.1 mm. Antennae shorter than body, reaching 7.5 mm when intact. Caudal filaments shorter than antennae, frequently broken; maximum length preserved in a paracercus about 7 mm. Macrosetae plumose, hyaline to yellowish.

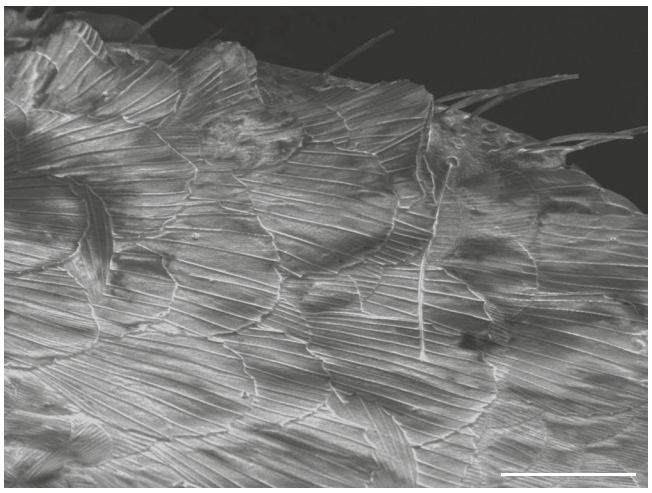

Fig. 13. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., SEM image of thoracic dorsal scales. Scale bar: 0.1 mm.

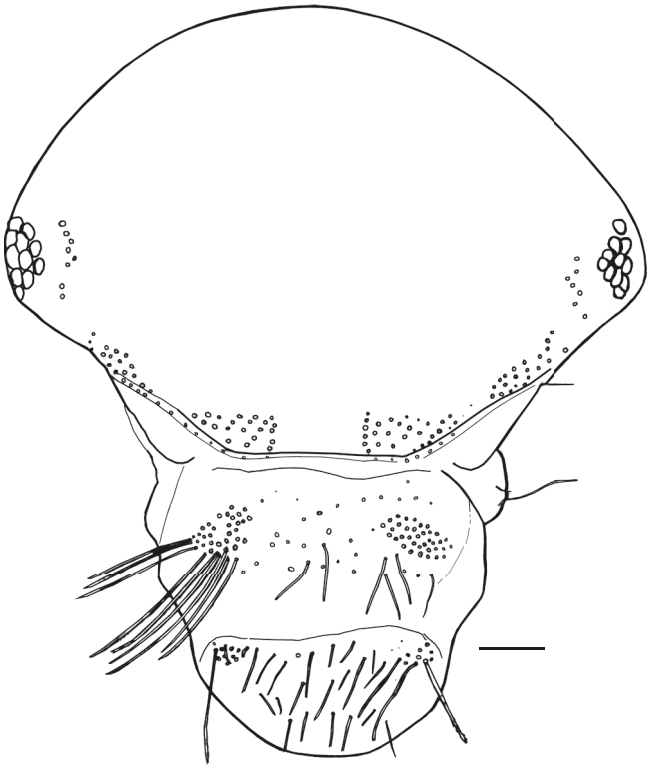

Fig. 15. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., head chaetotaxy. Illustration modified from Molero-Baltanás *et al.* (2024a). Scale bar: 0.1 mm.

Scales

Scales hardly visible even with stereomicroscope. Dorsal scales ovoid to quadrangular, with several widely spaced parallel ribs (Fig. 13); most of them with a low number of ribs, about 12-15, and a waxy sheen when observed by SEM. Ventral scales similar in shape but with more dense and numerous parallel ribs (up to 40 ribs per scale; see Figure 14). Appendages without scales except for antennal scape, coxae and femora (see below); clypeus and labrum also without scales.

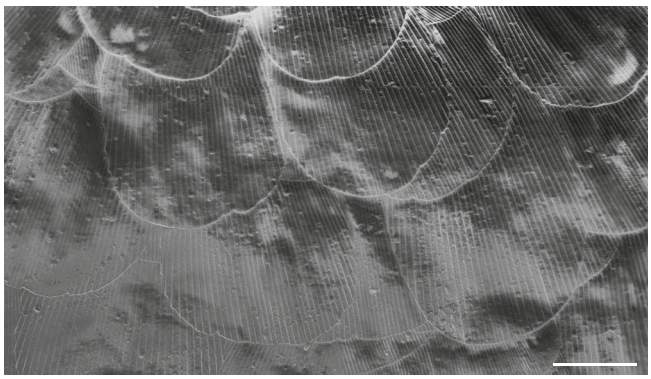

Fig. 14. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., SEM image of ventral scales. Photograph modified from Molero-Baltanás *et al.* (2024a). Scale bar: 50 µm.

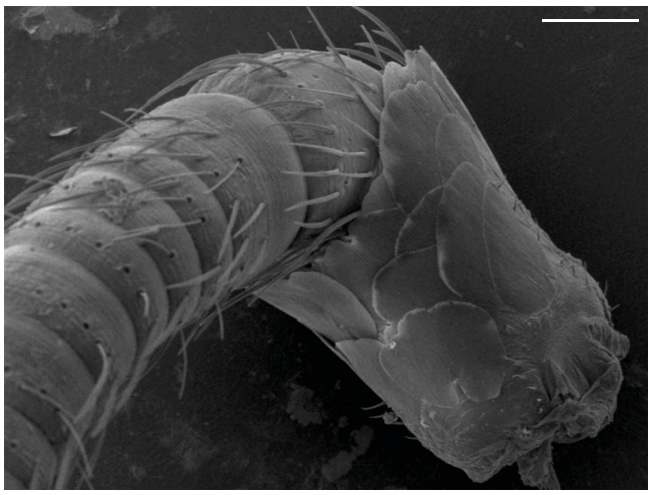

Fig. 16. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., SEM image of antennal base showing the presence of scales on scape and only setae on pedicel. Photograph modified from Molero-Baltanás *et al.* (2024a). Scale bar: 50 µm.

Head

Frons with 1 + 1 tuft of about 40 macrosetae separated by a distance similar to the width of a tuft. Inner margin of each eye surrounded by one row of 8-10 macrosetae; lateral areas of head bearing 1 + 1 frontolateral tufts of about 20 macrosetae between these periocular tufts and the frontal ones, and 1 + 1 small group of 2-3 macrosetae above the frontolateral tufts (Fig. 15). Clypeus with 1 + 1 lateral tufts bearing about 35 macrosetae and some thin acute setae on the median area between these tufts. Labrum with 1 + 1 small tufts of macrosetae and an irregular transverse fringe of thin acute setae connecting the tufts.

Antennal scape about twice longer than the pedicel, with a subapical ring of setae. Pedicel with a similar ring, and some additional setae forming two lateral groups. Scape covered with scales and pedicel without scales (Fig. 16). Scales of scape rounded, orbicular, with dense parallel ribs. Flagellomeres with one or two rows of chaetic sensilla. Basal flagellomeres with trichobothria; only some annuli of the distal part of the

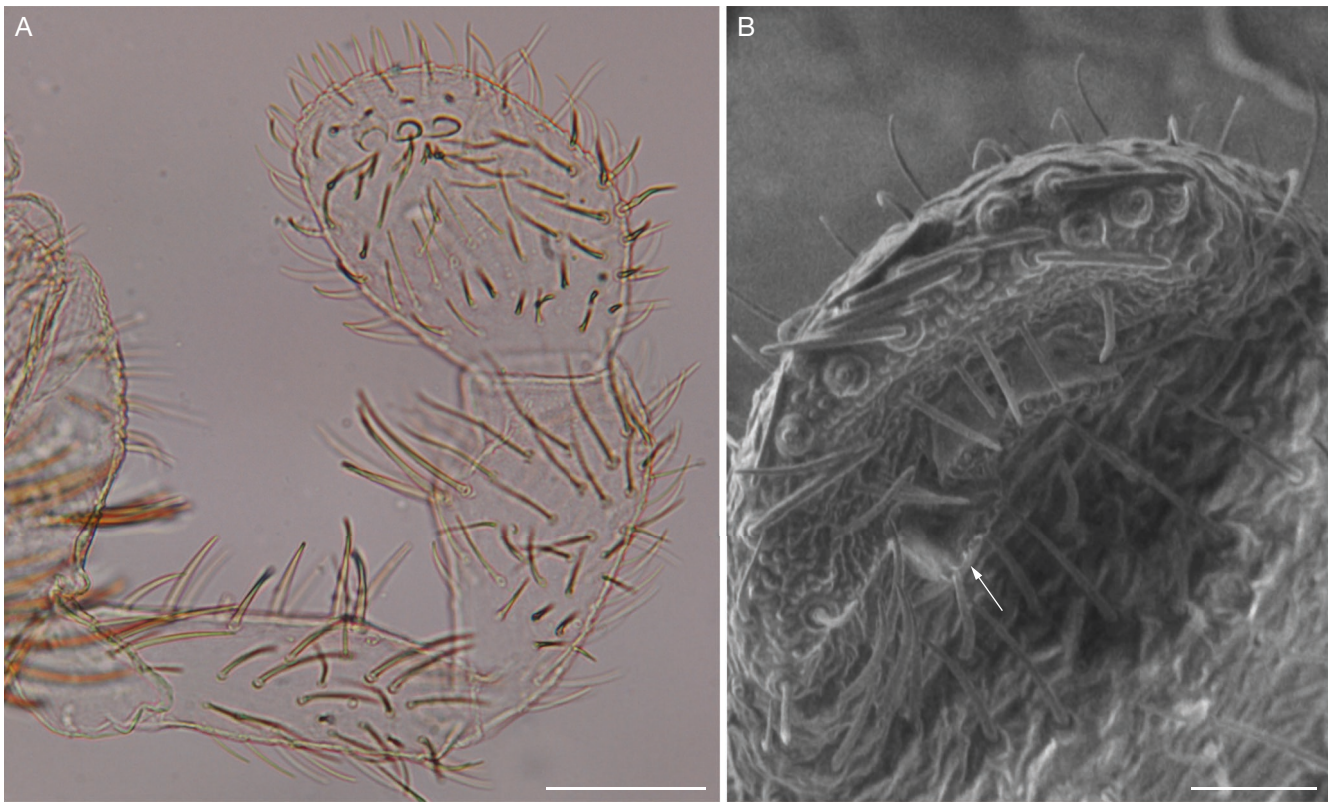

Fig. 17. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., labial palp: **A**, micrograph of the labial palp; **B**, SEM image of the three sensory papillae of the apical article of the labial palp, one of them marked with a **arrow**. Scale bars: A, 0.1 mm; B, 20 µm.

flagellum bearing trichobothria. Apart of these types of sensorial setae, other types of sensilla present on the flagellum: trichoid sensilla, coeloconic sensilla, campaniform sensilla and three types of basiconic sensilla; these latter belonging to types A, B and C according to the classification presented by Adel (1984).

Mandibles typical, bearing a subapical group of about 10 strong short setae that are pigmented and apically bifurcated, and a large outer tuft of about 55-60 macrosetae. Galea of the maxilla with 5-6 smooth acute setae in its basal half and some apical cilia; lacinia with two strong teeth, 6-7 lamellate processes and a row of five thin setae. Apical article of maxillary palps slender, about seven times longer than wide and similar in length to the penultimate article; distal part of the article with several basiconic sensilla of types B and C. Antepenultimate article of the maxillary palp slightly longer than the apical one. Labium wider than long; distal part of the prementum with a transverse row of setae. Glossae and paraglossae with some groups of setae forming an oblique fringe. Apical article of labial palp oval, about 1.1-1.2 times longer than wide and as long as the penultimate article or slightly shorter; bearing only three papillae arranged in a row (Fig. 17).

Thorax

Pronotum (Fig. 18A) with a setal collar consisting of 2-3 irregular combs of pectinate macrosetae. Between this collar and the anterolateral corners of the pronotum, an anterolateral row with some smooth and bifid setae. Lateral margins of the pronotum bearing about eight combs of 1-4 macrosetae; some of these combs difficult to identify because consisting of only one macroseta and, as a consequence of this reduction, interpretable as isolated marginal macrosetae. Anterior trichobothrial areas associated to the comb N-3, i.e., the anterior to the antepenultimate lateral comb; posterior trichobothrial areas associated to the last lateral comb or, if the comb in this position is not clearly distinguishable, posterior trichobothria located at about 0.72 the total length of the lateral margin. Trichobothria inserted on the inner part of the trichobothrial area.

Mesonotum (Fig. 18B) with 7-8 combs of 1-3 macrosetae on each lateral margin and usually two additional isolated setae on the anterolateral corner. Anterior trichobothrial areas on the antepenultimate lateral comb (N-2). Posterior trichobothrial areas associated with the last lateral comb or, when this comb is not clearly visible, to the position 0.77 of the lateral margin of this mesothoracic dorsal plate.

Metanotum (Fig. 18C) with 5-8 lateral combs on each lateral margin and usually 1-3 additional isolated setae on each anterolateral corner. Lateral combs very reduced, consisting of 1-3 macrosetae; the two posterior ones of each side reduced to one marginal macroseta; if combs are visible, anterior and posterior trichobothria associated to these two lateral combs; if not visible, inserted about 0.65 and 0.84 along the length of the lateral margin, respectively.

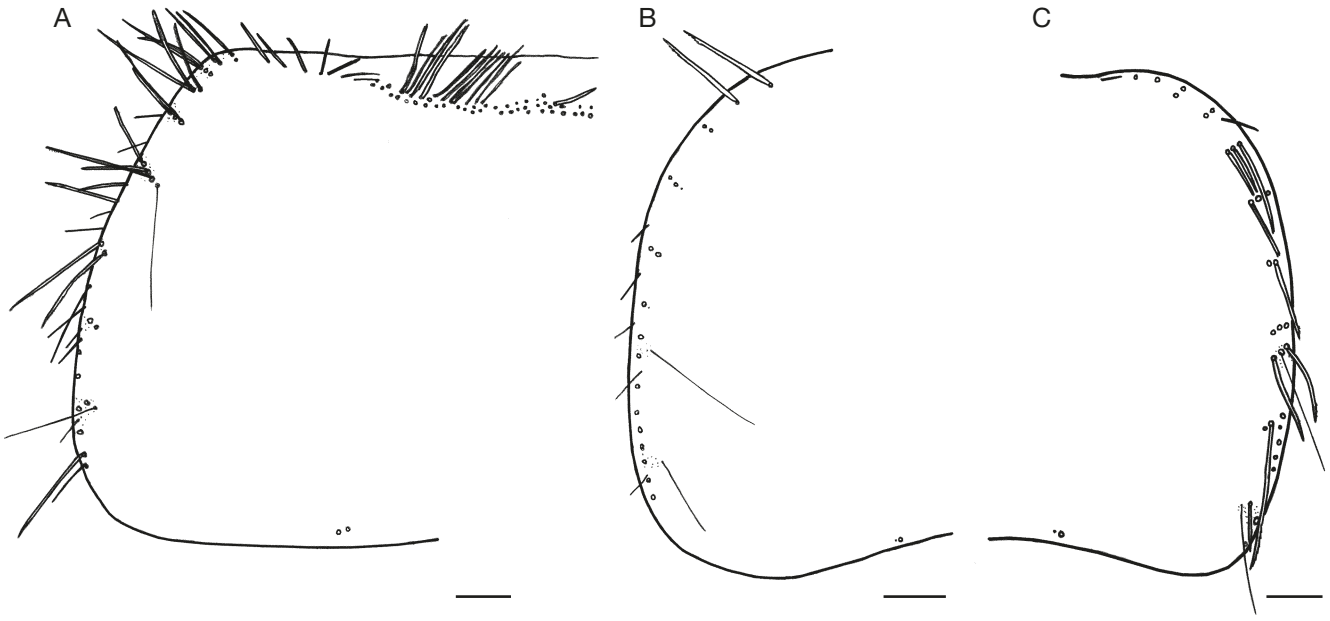

FIG. 18. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., thoracic nota: **A**, left side of the pronotum; **B**, left margin of the mesonotum; **C**, right margin of the metanotum. Illustrations modified from Molero-Baltanás *et al.* (2024a). Scale bars: 0.1 mm.

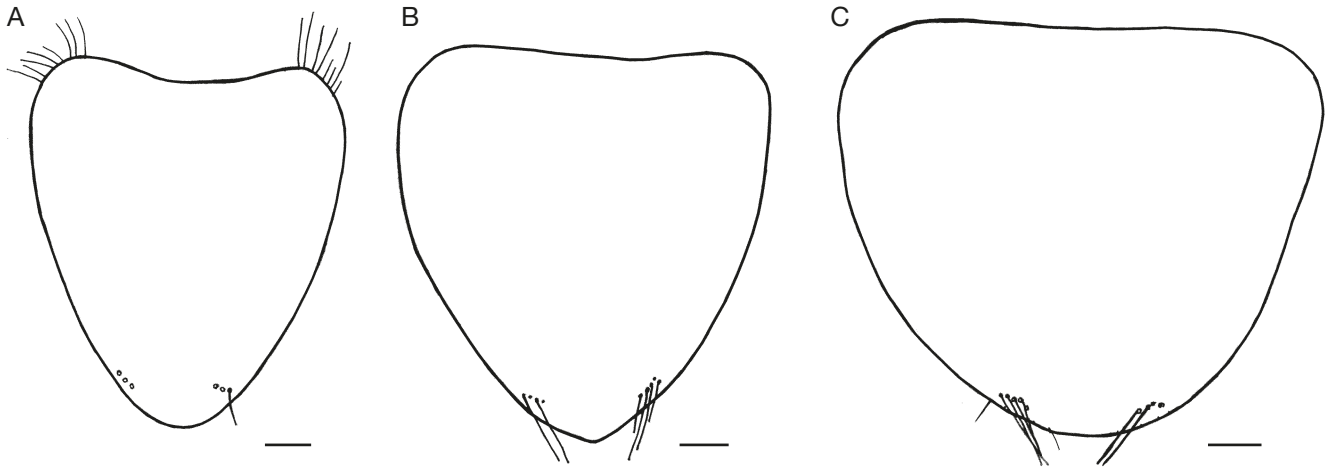

FIG. 19. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., thoracic sternites: **A**, prosternum; **B**, mesosternum; **C**, metasternum. Illustrations obtained from Molero-Baltanás *et al.* (2024a). Scale bars: 0.1 mm.

Posterior margin of the thoracic nota with 1 + 1 small lateral combs consisting of one or two macrosetae (in some specimens, those of the pronotum bear three macrosetae). When there are two macrosetae, one of them usually larger than the other (thicker, longer and with a larger insertion).

Prosternum (Fig. 19A) subtriangular, its posterior margin rounded; apical part sub-elliptical whith 1 + 1 subapical groups of 3-4 macrosetae that are not arranged in a clearly straight row; anterolateral corners and apical part of the sternite with some thin marginal setae. Mesosternum (Fig. 19B) with a similar shape, but larger than the prosternum, bearing 1 + 1 subapical oblique combs of 4-5 macrosetae. Metasternum (Fig. 19C) heart-shaped, with its posterior margin broadly convex to slightly truncate; 1 + 1 subapical combs of of 4-6 macrosetae; the distance separating these combs about four times longer than the width of a comb. Prosternum and mesosternum slightly longer than wide (ratio length/width about 1.1-1.15), metasternum clearly wider than long (ratio length/width about 0.87).

Legs

Size of legs increasing from the first to the third thoracic segment; metatibiae about 1.3-1.4 times longer than mesotibiae and 1.6 times longer than protibiae. Coxae with some marginal macrosetae, covered by rounded scales similar to the ventral scales covering the body. Femora covered with setae on the ventral/inner part of their outer side (visible dorsally); rest of the surface of this outer side of femora without scales or

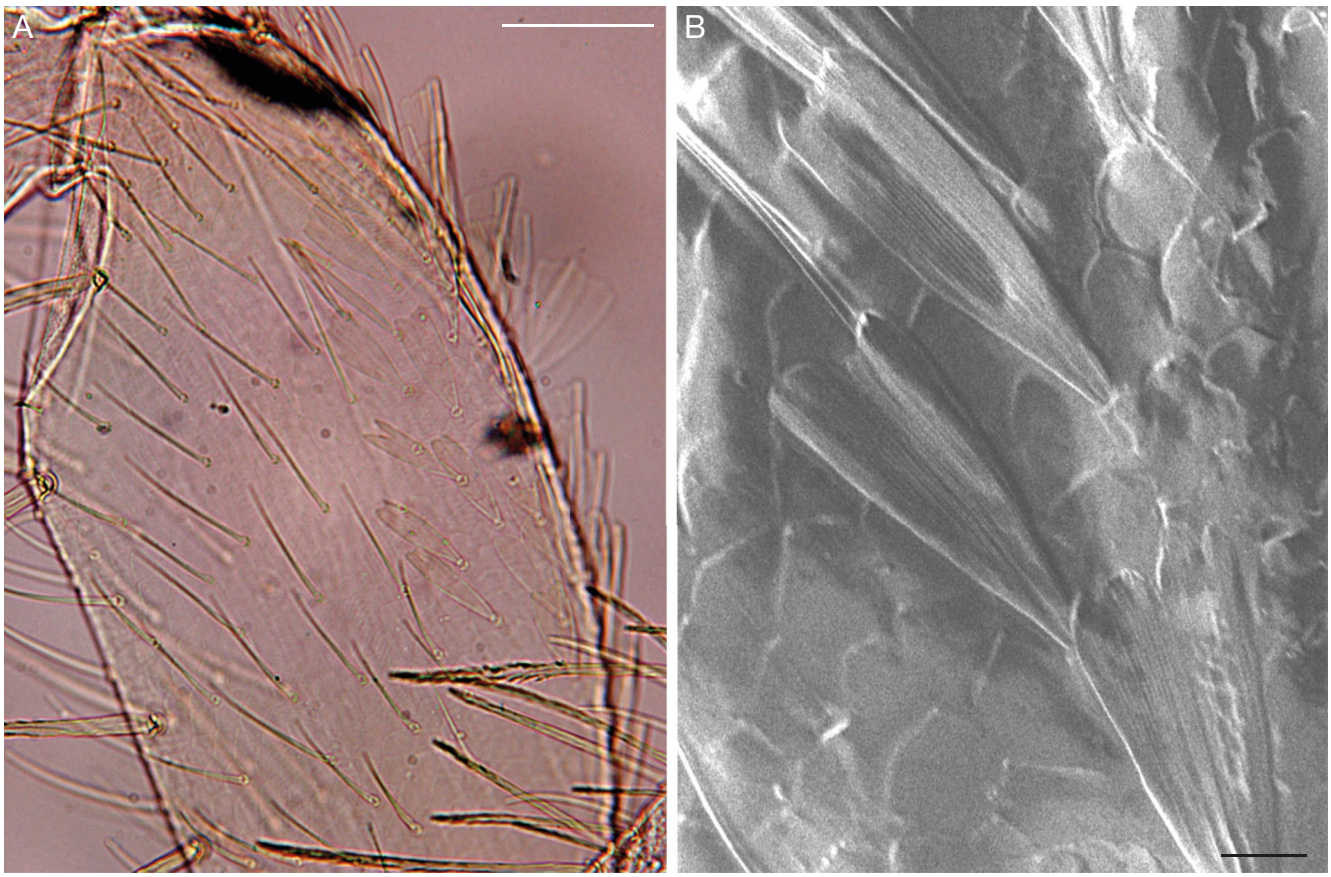

Fig. 20. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., femoral scales: **A**, micrograph of the inner side of mesofemur (ventral view) of the holotype, showing femoral scales on the outer part (B). **B**, SEM image of some scales of another specimen. Scale bars: A, 0.1 mm; B, 10 µm.

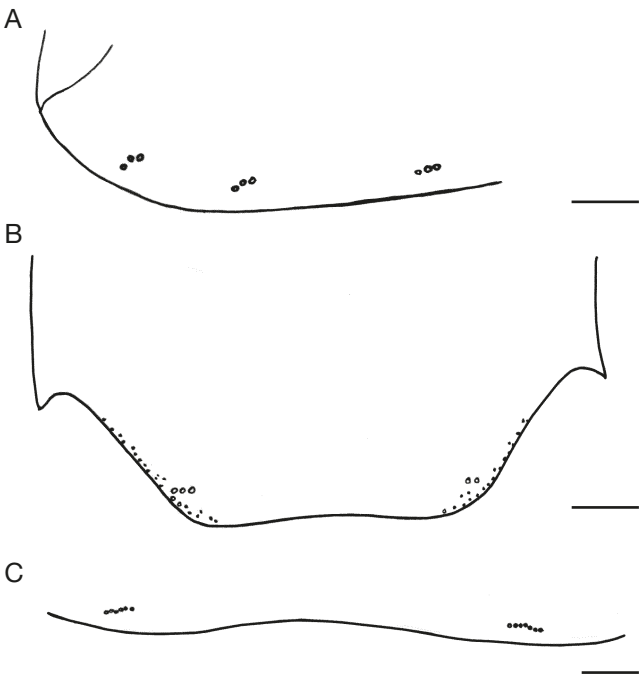

Fig. 21. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., abdominal chaetotaxy (only insertions of macrosetae are represented): **A**, urotergal chaetotaxy on one side of urotergite III; **B**, urotergite X shape and chaetotaxy; **C**, hind margin of the urosternite IV. Illustrations obtained from Molero-Baltanás *et al.* (2024a). Scale bars: 0.1 mm.

setae; inner side (visible ventrally) with modified scales and setae; scales triangular, usually longer than wide and truncate or concave apically, with slightly marked ribs (Fig. 20), present only on the dorsal/external part of the article. Protibiae about 3.3-3.4 times longer than wide, mesotibiae about 3.8-3.9 and metatibiae about 4.4-4.5 longer than wide. Tibiae lacking scales, only covered with setae and bearing two robust macrosetae on the dorsal (anterior) margin and 3-5 on the ventral (posterior) margin; these macrosetae about as long as the width of tibiae, or slightly shorter on metatibiae. Tarsi about 1.2 times longer than the corresponding tibia; basal tarsal article (tarsomere 1) about 0.7- 0.8 times longer than the tibia. Tarsomere 1 of first and second legs with two rows of slender spines that are absent in the third legs. Pretarsus with two claws and a small empodium.

Abdomen

Urotergite I with 1 + 1 lateral combs. Urotergites II-V with 3 + 3 combs of macrosetae (Fig. 21A). Urotergites VI-VIII with 2 + 2 combs, and urotergite IX lacking setae. Infralateral combs usually consisting of 3-4 macrosetae, except for those on urotergite I, that have two macrosetae. Lateral combs consisting of 2-3 macrosetae, and the submedian combs usually consisting of one or two macrosetae. Urotergite X (Fig. 21B) short trapezoidal, with a ratio length/width of the posterior trapezoidal part about 0.25-0.3; posterior margin straight or

slightly concave and lateral margins with several setae in their posterior part and 1 + 1 subapical combs of two macrosetae. Urosternites I and II devoid of setae; urosternites III-VII with 1 + 1 lateral combs of 4-8 macrosetae each (usually five or six). Distance between lateral urosternal combs 8-18 times higher than the width of a comb (Fig. 21C). Each coxite VIII with a comb of 4-5 macrosetae. Inner process of coxites IX about 1.2 times longer than wide at the base and about four times longer than the outer process. Only one pair of abdominal styli that are about 2.5 times longer than the length of the inner process of the coxite IX. Ovipositor short, with 19-21 divisions, far surpassing the apex of the inner processes of coxites IX but hardly exceeding the apex of styli (Fig. 22). Caudal filaments with large plumose macrosetae, smooth chaetic sensilla, trichoid sensilla and trichobothria.

Remarks

The abdominal chaetotaxy of this species is difficult to discern using stereomicroscope and even light microscope for dissected and mounted specimens, because most macrosetae are usually detached and only their insertions are visible, and examining these insertions is difficult in some slide-mounted specimens because of the presence of numerous drops of fat coming from the gut contents, probably related to the diet of the silverfish. In some cases, using SEM microscope helps to clarify several characters; Shimada *et al.* (2022) provided dorsal and ventral views of the abdomen that are very useful; moreover, appropriate micrographs such as those shown in this work and in Kulma *et al.* (2022) are also useful.

A complete description of this species was given by Molero-Baltanás *et al.* (2024a) with the name *Ctenolepisma calvum*. The present description does not provide additional information and only some figures are new. The morphological differences with other synanthropic silverfish were discussed in that work, together with molecular data and some comments regarding mistakes on previous papers where this species was recorded in Europe. Differences with the authentic *C. calvum* described here are given in the Discussion section and summarized in Tables 4 and 5.

Apart from those indicated in "Type material" and "Other material studied", no additional specimens have been reexamined. The remaining specimens referenced in other papers (Querner *et al.* 2022; Shimada *et al.* 2023; Bednar *et al.* 2023) are not examined, but the morphological details given in these papers, together with the DNA sequences of some of them, confirm that the specimens studied in all these papers are not *C. calvum*, but conspecific with *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp.

DISCUSSION

The characters used to describe *Peliolepisma calva* in Ritter's (1910) original description were compared to those examined in the specimens from Kerala and those presented in Molero-Baltanás *et al.* (2024a) for the specimens from Europe previously assigned to *Ctenolepisma calvum* (re-examined).

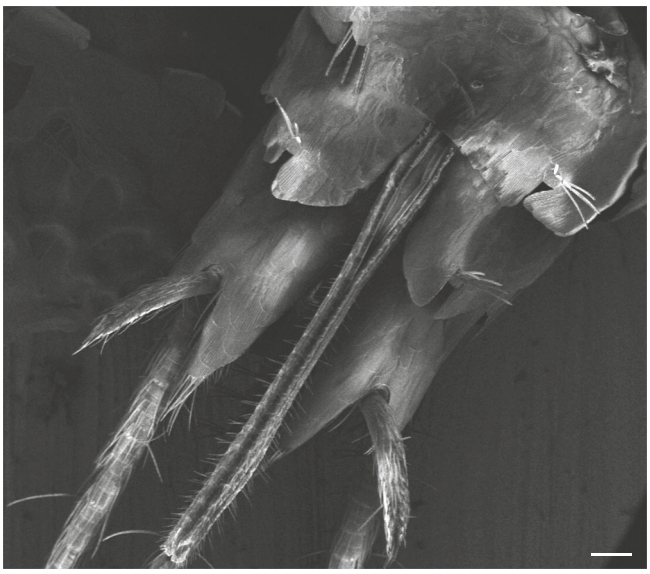

Fig. 22. — *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., SEM photograph of coxites of abdominal segments VIII and IX, and ovipositor. Illustration modified from Molero-Baltanás *et al.* (2024a). Scale bar: 0.1 mm.

The characters of abdominal chaetotaxy have not been considered in this comparison since Ritter (1910) considered that this species lacks macrosetae on abdomen, but it is clear that he overlooked the presence of this chaetotaxy, constant in all Ctenolepismatinae species, probably because the number of macrosetae per comb is low, they are hyaline and their insertions are difficult to see when detached. In fact, the genus *Peliolepisma* was established for this species considering that the species from Sri Lanka lacks abdominal setation (*calva*/*calvum* in Latin means "without hairs"). In spite of the presence of abdominal combs, Wygodzinsky (1972) maintained this species in the genus *Peliolepisma* considering that the presence of only one seta on posterior pronotal combs is a character relevant to exclude this species from *Ctenolepisma*, but this was not the criterion of Paclt (1967), who listed this species as a member of *Ctenolepisma*. The number of macrosetae of posterior pronotal combs is variable, from 1 to 3, both in the specimens from Kerala and in the European specimens (Molero-Baltanás *et al.* 2024a) that are now considered as a different species. It is likely that the American specimens studied by Wygodzinsky (1972) with only one macroseta in this position did not correspond to the Sri Lankan species (bearing more than one) but to *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., a hypothesis which will have to be confirmed with a re-examination of these specimens. Other relevant characters for the taxonomy of Ctenolepismatinae were not mentioned in the original description by Ritter, such as the number of papillae of labial palps, the shape and chaetotaxy of thoracic sternites, etc., but several characters match with those shown by the specimens from Kerala (Table 4), for example the trapezoidal shape of the urotergite X. *Ctenolepisma calvum* from Kerala and *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. are similar in body size, body colour, femoral scales, shape of urotergite X and chaetotaxy of

TABLE 4. — Comparison of significant similarities and differences between *Ctenolepisma calvum* (Ritter, 1910) in Kerala, *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. in Europe and Ritter's description. Measures marked with * should be considered with caution, since these appendages can be broken in their apical part in several specimens. For example, although in *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. the antennae are slightly longer than paracercus when intact, in some specimens antennae are broken and can be slightly shorter, as happens in the specimens photographed in Molero-Baltanás *et al.* (2024a; Fig. 19A).

Character	In Kerala species	In European Species	In Ritter's description
Relative length of antennae to body*	Body longer than antennae	Body longer than antennae	Antennae almost as long as body
Relative length of caudal filaments to antennae*	Antennae slight longer than caudal filaments	Antennae slight longer than caudal filaments	Caudal appendages slightly longer than antennae
Relative length of ovipositor to abdomen and styli	Ovipositor long; more than ¼th the length of abdomen but less than half the length of abdomen, clearly surpassing the apex of styli of segment 9	Short, ovipositor length less than ¼th of abdomen, not exceeding or barely exceeding the apex of styli of segment 9	Long; ¼th the length of abdomen
Number of segments in ovipositor	30-33	19-21	More than 35 as in diagram, not mentioned in text
Bristles of tergites	Well developed, but less than other *Ctenolepisma* Escherich, 1905	Well developed, but less than other *Ctenolepisma*	Rudimentary (probably overlooked by Ritter)
Shape of Urotergite X	Trapezoidal wider than long	Trapezoidal wider than long	Trapezoidal wider than long
Number of Styli	Two pairs	One pair	Two pairs

the nota (Table 5). While *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. shows many similarities with *C. calvum* and with the description of Ritter, there are two significant differences in the ovipositor and number of styli. Ritter (1910) provided a drawing of genital region of a female of *Peliolepisma calva* where two pairs of styli can be seen inserted on coxites VIII and IX, the ovipositor is long, clearly surpassing the apex of ninth styli, and the number of divisions, although not mentioned in the text, seems to be higher than 35. These characters resemble those of the specimens from Kerala much more than to those described for European specimens previously attributed to *C. calvum*, which bear only one pair of styli. Moreover, the ovipositor of Kerala specimens is similar in length to those illustrated by Ritter and have about 30-33 divisions in their ovipositor, while the ovipositor of European specimens is very short, slightly surpassing the apex of styli of segment 9 and having about 19-21 divisions. Molero-Baltanás *et al.* (2024a), when examining European specimens, interpreted that Ritter could have made a mistake when illustrating the genital region of their *Peliolepisma calva*, because he also collected *C. longicaudatum* in the same locality, and this genital region is more similar to this frequent synanthropic species than to the one that is recently spreading over Europe. The possibility of mistakes in Ritter's description was considered probable since he made evident mistakes when indicating the absence of abdominal chaetotaxy in this silverfish, and this led to the attribution of the specimens found in Europe to *C. calvum*. But the discovery of the specimens of Kerala with more similarities to the Sri Lankan taxon forces us to reconsider the identity of the taxon studied in Europe. DNA analyses also prove that these differences do not correspond to intraspecific variability and that the Indian specimens and those described mainly on specimens from Europe correspond to different lineages with specific identity. If one of them deserves retaining the name *C. calvum*, our morphological and distributional data show that this must be the species discovered in Kerala. We think that it is very likely that *C. calvum* is a species restricted to Sri Lanka and the southern part of India (Kerala) or may be spread to nearby tropical regions, and *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. occurs in Europe, Japan, and probably in other parts of the world, but given the marked morphological similarity with *C. calvum*, all the records of this species should be re-examined to determine its geographic distribution. The original area of *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. is unknown.

The number of styli and the length and number of divisions of the ovipositor are not the unique characters that distinguish the Oriental *C. calvum* from the European *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. Apart from COI sequences (Fig. 3), Table 5 presents a comparison of remarkable morphological traits of both species. They share characters as the shape of the urotergite X, the arrangement and low number of bristles of abdominal combs, the shape and chaetotaxy of thoracic sternites, the scale colour and general habitus, and the shape and arrangement of femoral scales, but the number of sensory papillae of the last article of the labial palp is different (five in the authentic *C. calvum* and three in *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp.) and the arrangement of anterior trichobothria on lateral combs of pronotum and mesonotum is also different. Moreover, it seems that dorsal scales of *C. calvum* are more diverse in size and density of ribs than those of *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., that has more uniform widely spaced ribs, and on average, the number of macrosetae of abdominal combs is higher in the authentic *C. calvum*. Other characters seem to show differences, such as the number of macrosetae of combs on thoracic sternites, and the ratio length/width of the metasternum, but it is likely that in some cases their variability could overlap.

Comparing *C. calvum* as redescribed here with other species of the genus *Ctenolepisma*, the most related species are those of the genus *Ctenolepisma* with trapezoidal tenth urotergite and 3 + 3 combs on urotergites II-V; this genus is now considered

TABLE 5. — Comparison of *Ctenolepisma calvum* (Ritter, 1910) (Kerala, India) and *Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. (European specimens described in Molero-Baltanás *et al.* (2024a) as *C. calvum*).

Character	***Ctenolepisma calvum* (Ritter, 1910) from Kerala**	***Ctenolepisma phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. from Europe**
Body length	Up to 10 mm	Up to 12 mm (usually 8-9 mm)
Number of sensory papillae in labial palp	5 in a single row	3 in single row
Number of lateral combs on pronotum	(8-9) + (8-10)	8
Number of macrosetae of lateral combs of pronotum	2-5	1-4
Number of lateral combs on mesonotum	(8-9) + (8-9)	(7-8) + (7-8)
Number of macrosetae of lateral combs of mesonotum	2-3	1-3
Number of lateral combs on metanotum	(5-6) + (5-7)	(5-8) + (5-8)
Number of macrosetae of lateral combs of metanotum	1-3	1-3
Number of macrosetae of posterolateral combs of thoracic nota	2-3	1-3
Anterior trichobothrial position of pronotum	N-4 (or N-5)	N-3
Anterior trichobothrial position of mesonotum	N-1	N-2
Number of macrosetae of prosternal combs	7-10	3-4
Number of macrosetae of mesosternal combs	5-8	4-5
Number of macrosetae of metasternal combs	7-10	4-6
Metasternum ratio length/width	0.9-1.0	0.87
Number of macrosetae of infralateral combs of urotergites II-VIII	3-5	3-4
Number of macrosetae of sublateral combs of urotergites II-VIII	2	2-3
Number of macrosetae of submedian combs of urotergites II-VIII	2-3	1-2
Number of macrosetae of lateral combs of urosternites	4-13	4-8
Number of pairs styli	2 pairs (on VIII and IX)	1 pair (on IX)
Scales on femora	Subtriangular, elongate, bifid or truncate apically	Subtriangular, elongate, bifid or truncate apically

in its strict sense, i.e., lacking several median combs on urosternites, after the recent redefinition of the subgenus *Sceletolepisma*, with median combs, as a separate genus (Molero-Baltanás *et al.* 2024b). This reduces the comparison to six species that share this combination of characters: *C. conductrix* Silvestri, 1918, *C. guineense* Mendes, 1985, *C. incitum* Silvestri, 1918, *C. nigericum* Mendes, 1982, *C. rothschildi* Silvestri, 1907, and *C. targionianum* Silvestri, 1908. The latter species has three pairs of styli (against two pairs in *C. calvum* and only one pair in *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp.), is bigger (can reach up to 15 mm of body length), and both its epidermic pigment and dorsal scales are darker. *Ctenolepisma conductrix*, described from Kenya, has a longer ovipositor, surpassing the level of the styli IX by 1.5 times their length, has a longer urotergite X and the metasternum has 2 + 2 combs (only 1 + 1 in *C. calvum* and *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp.). *Ctenolepisma guineense*, from Guinea-Bissau, has also a longer ovipositor with more than 40 divisions, different shape of the prosternum, dorsal scales more homogeneous, and a distribution of notal trichobothria more similar to that of *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp., with the anterior trichobothria of pronotum on the N-3 comb. *Ctenolepisma incitum* has been proposed by Irish (1995) as probable synonym of *C. rothschildi* (see below this species); anyway, the ovipositor presented in its original description is clearly longer than that of *C. calvum*. *Ctenolepisma nigericum* has more pigmented appendages, longer urotergite X, abdominal combs with a higher number of macrosetae (up to 18 macrosetae on urosternal combs), and the inner process of the coxite IX of females is clearly longer (ratio L/W about 3.5 mm in *C. nigericum* against about 1-1.7 in *C. calvum* from Kerala).

Ctenolepisma rothschildi is probably the most related species to *C. calvum*; moreover, it has been recorded in Sri Lanka (Irish 1995) and it occurs very likely in India, at least as a synanthropic form. *Ctenolepisma rothschildi* has very diverse dorsal scales, with different sizes and rib spacing, although the types of scales seem to be different to *C. calvum* as described here; those with a low number or ribs are usually bigger than the remaining ones. *Ctenolepisma rothschildi* shares with *C. calvum* and *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. the distribution and shape of femoral scales, which are usually rounded in other species of *Ctenolepisma* with trapezoidal urotergite X. But *C. rothschildi* is clearly different because of a more intense pigmentation in epidermis and dorsal scales, different arrangement of anterior trichobothrial areas in pronotum and mesonotum (on comb N-2 or N-3 of the pronotum of *C. rothschildi* and associated to combs N-4 or N-5 of the pronotum of *C. calvum*; on the antepenultimate comb [N-2] of the mesonotum of *C. rothschildi* and on the penultimate comb [N-1] of *C. calvum*). It also has a slightly longer ovipositor, surpassing the apex of the sternite 9 styli by more than the length of the styli, and a slightly longer inner process of the ninth coxite in females (about twice as long as wide); in *C. calvum* it is about 1.00-1.66 times longer than wide and in *C. phantasma* Molero-Baltanás, Raphel, Mitchell & Jose, n. sp. about 1.2 times longer than wide. COI sequences are also different, as shown in Molero-Baltanás *et al.* (2024a).

Another species recorded in India and probably related to *C. calvum* is *C. nigrum* (Oudemans 1890), but it has 3 + 3 bristle combs on urotergites II-VI (the urotergite VI in *C. calvum* has only 2 + 2 bristle combs) and it is usually more pigmented (the specific name *nigrum* means black); nevertheless, the description of this species requires an update. Other species of *Ctenolepisma* recorded in India are even more

different because additional differences in their chaetotaxy, scales (for example, they lack femoral scales with elongated shape), number of labial papillae, etc. (Hazra *et al.* 2022b).

CONCLUSION

In this context we conclude that Ritter's *C. calvum* is very likely a species restricted to Sri Lanka and southern part of India (Kerala) or may be spread over the nearby tropical regions, and *C. calvum* reported from Europe and other parts of the world is a completely different species showing marked morphological similarity. The redescription of *C. calvum* represents the first report of the species from India and the tenth of the genus *Ctenolepisma* recorded in this country, which is considered a significant contribution to our understanding of the Zygentoma from India.

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