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Two new species of *Plutomurus* Yosii (Collembola, Tomoceridae) from the Caucasus

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Abstract

Two new species of *Plutomurus, P. pichkhaiai* **sp. nov.** from Garakha and Letsurtsume caves and *P. shurubumuensis* **sp. nov.** from Shurubumu Cave (Chkhorotsku district, Western Georgia) are described, and illustrated. The new species are very similar to *P. kelasuricus* from the Tsebelda karst massif formation in Apkhazeti, Georgia, but differ in having two inner spine-like chaetae on the inner edge of the hind tibiotarsus (only one in *P. kelasuricus*) and in occupying different, isolated cave formations separated by a geographic distance of nearly a 100 km. A key to the species of *Plutomurus* with 6 prelabral chaetae is provided.

Key words: Springtail, Garakha, Shurubumu, cave, Georgia

რეზიუმე

Plutomurus-ის გვარის ორი ახალი სახეობა *P. pichkhaiai* **sp. nov.** გარახას და ლეწურწუმეს მღვიმეებიდან და *P. shurubumuensis* **sp. nov.** შურუბუმუს მღვიმიდან (ჩხოროწყუს რაიონი, დასავლეთ საქართველო) არის აღწერილი დაილუსტრირებული. ახალი სახეობები ძალიან ჰგვანან *P. kelasuricus*-ს წებელდას კარსტული მასივის ფორმაციიდან, აფხაზეთი, საქართველო, თუმცა განსხვავდებიან უკანა ტიბიოტარზუსზე 2 შიდა ეკლისმაგვარი ჯაგრების ქონით (მხოლოდ 1 აქვს *P. kelasuricus*-ს) და განსხვავებული და იზოლირებული მღვიმური ფორმაციების დაკავებით, რომლებიც ერთმანეთისაგან გამოყოფილია დაახლოებით 100 კმ. გეოგრაფიული მანძილით. უზრუნველყოფილია გვარ *Plutomurus*–ის 6 პრელაბრალური ჯაგრების მქონე სახეობების სარკვევი.

Introduction

The genus *Plutomurus* Yosii, 1956 groups all members of Tomoceridae with large lateral macrochaetae on the base of the dens and well-developed trochanteral and femoral organs (Yosii 1956, 1966, 1967). Currently, the genus comprises 29 species found in caves and leaf litter across the northern hemisphere: thirteen are found in Asia, twelve in Europe, and four in Western North America (Christiansen & Bellinger 1998; Kniss & Thibaud 1999; Jordana *et al*. 2012; Barjadze *et al.* 2016).

The fauna of *Plutomurus* of Georgia, Caucasus is particularly diverse, and six species are known from the region (Barjadze & Djanashvili 2008) (Fig. 1): *P. abchasicus* Martynova, 1969 (soil); *P. birsteini* Djanashvili & Barjadze, 2011 (cave); *P. eristoi* Barjadze, Baquero, Soto-Adames, Giordano & Jordana, 2016 (cave); *P. kelasuricus* Martynova, 1969 (north and south Caucasus, cave); *P. ortobalaganensis* Jordana & Baquero, 2012 in

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Jordana *et al.* 2012 (cave); and *P. revazi* Barjadze, Baquero, Soto-Adames, Giordano & Jordana, 2016 (cave). A series of recent collections made by the senior author in caves in different regions of Western Georgia provided additional material of several morphospecies belonging to *Plutomurus*, two of which are here described as new.

Dorsal chaetotaxy is extensively used to diagnose species in scaled Entomobryomorpha, including members of the family Tomoceridae (Gisin 1963, 1964, 1967; Yosii 1967; Yu *et al.* 2014, 2015; Yu & Deharveng 2015). Felderhoff *et al*. (2010) discussed macrochaetal maps of several North American *Pogonognathellus* species and showed chaetotaxy to be a useful character system to diagnose lineages supported by a molecular phylogenetic analysis of the 5'–3' exoribonuclease II gene. In similar fashion, Yu *et al.* (2014, 2017) circumscribed Chinese *Monodontocerus* and *Tomocerus* species based on dorsal cephalic macrochaetotaxy and COI sequences. Barjadze *et al.* (2016) investigated cave-dwelling *Plutomurus* species from Georgia, Caucasus, and found congruence between species-level groups delimited by macrochaetotaxy and lineages supported by analysis of mitochondrial COI sequences.

Of the 29 species of *Plutomurus* so far described, complete or partial dorsal macrochaetal maps are known for eight species: *P. californicus* (Folsom, 1913), *P. eristoi*, *P. grahami* (Christiansen, 1980), *P. ortobalaganensis*, *P. revazi*, *P. riugadoensis* (Yosii, 1939), *P. unidentatus* (Börner, 1901) and *P. wilkeyi* (Christiansen, 1964). Christiansen & Bellinger (1998) illustrated diagnostic differences in chaetotaxy between North American *Plutomurus* species, but in general this character system was not explicitly used until Barjadze *et al.* (2016) provided macrochaetotaxy-based diagnoses for Georgian species. Barjadze *et al.* (2016) also presented information about COI mtDNA sequence variation in support of morphology-based species diagnoses. *Plutomurus* samples from six caves analysed by Barjadze *et al.* (2016) yielded a tree suggesting the presence of five species, two of which remained undescribed.

In the present study we describe and distinguish as new species populations from Shurubumu and Garakha caves suggested by Barjadze's *et al.* (2016) analysis of COI to be heterospecific. The diagnosis is based on dorsal macrochaetotaxy, which is congruent with species-level groups delimited by COI sequences. The new species, *P. shurubumuensis* **sp. nov.** and *Plutomurus pichkhaiai* **sp. nov.** were previously reported as *Plutomurus* sp. 8 and *Plutomurus* sp. 4 in Barjadze *et al.* 2015 and as *Plutomurus* sp. 2 and *Plutomurus* sp 1 in Barjadze *et al.* 2016.

Material and methods

Springtails were sampled in Garakha and Shurubumu caves in 2014 and 2017. Baited traps with decomposing white cheese were placed directly on the floor, in different zones of the caves; *Plutomurus* individuals were captured with an aspirator starting 24 hours after the baited traps were laid down.

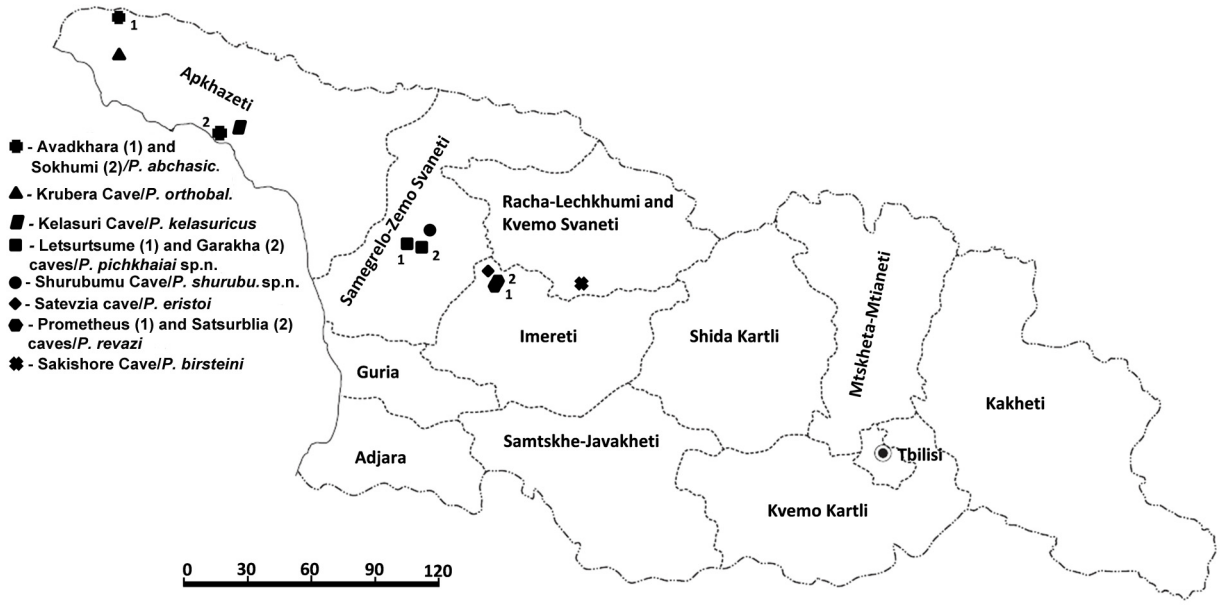
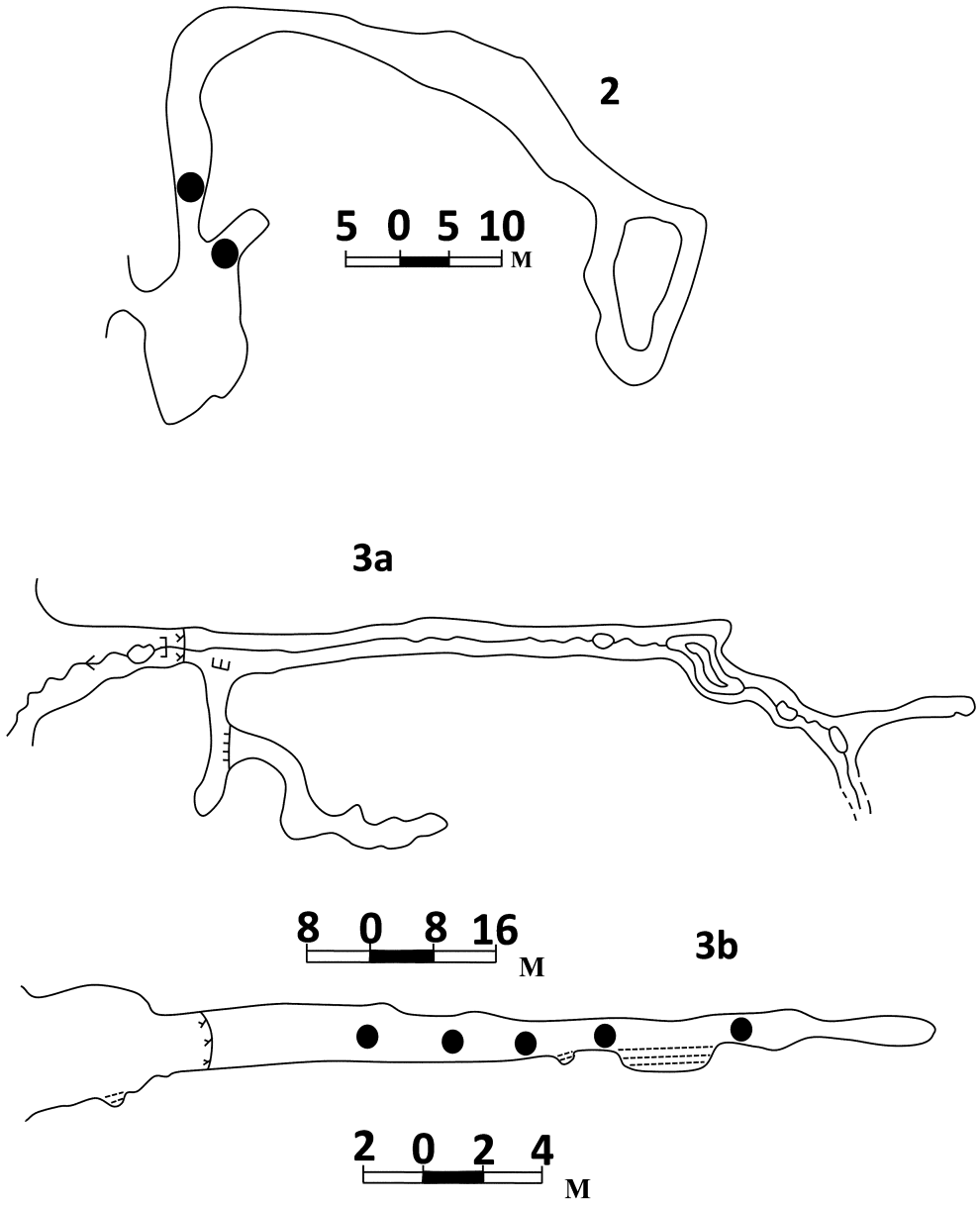


FIGURE 1. Distribution of *Plutomurus* species reported from Georgia.



FIGURES 2–3. Plan of caves where the types of the new species were collected (modified from Tatashidze *et al.* 2009). Black circles mark approximate collection site. 2, Shurubumu Cave plan; 3a, Garakha Cave plan; 3b, Garakha Cave profile. Entrance to the caves are to the left.

Garakha Cave (42°31'47.22"N, 42°10'39.18"E, 203 m alt.) is situated on the south bank of the Bume river, near the village of Garakha, Chkhorotsku district, Samegrelo–Zemo Svaneti region, Odishi plain, Georgia (Figs 1, 2). Garakha Cave is 320 m long and was formed in neogenic conglomerates (Tatashidze *et al.* 2009). This cave is poor with speleothems. There is a permanent water stream in the western (main) branch of the cave, emerging from a syphon, which flows along the length of the main branch of the cave. The eastern branch is dry (Tatashidze *et al.* 2009).

Shurubumu Cave (42°39'5.71"N, 42°13'44.58"E, 464 m alt.) is situated on the south bank of the Khobistskali river, 3 km from the village of Mukhuri, Chkhorotsku district, Samegrelo–Zemo Svaneti region, Migaria karst massif, Georgia (Figs 1, 3a, b). Shurubumu Cave is 320 m long and was formed in Upper Cretaceous limestones (Tatashidze *et al.* 2009). This cave is rich with speleothems. There is a small hall just beyond the cave's entrance and a syphon at the end. A permanent stream flows through the cave (Tatashidze *et al.* 2009).

Specimens were cleared in Nesbitt solution and slide mounted in Hoyer. Observation and measurements of slide mounted specimens were done with an Olympus BX50 microscope; drawings were prepared with the aid of a

drawing tube in Pamplona, Spain and Gainesville, Florida, USA. Some specimens were observed with a scanning electron microscope (SEM). Details on the preparation of specimens for SEM are as in Barjadze *et al.* 2016. Information about molecular analysis was provided in Barjadze *et al.* 2016.

The two species described below are closely related and morphologically very similar. Instead of repeating all details of the description for both species, we first provide the complete description and figures for *P. shurubumuensis* **sp. nov.**, followed by an abbreviated description for *P. pichkhaiai* **sp. nov.**

The macrochaetotaxy formula reports the number of macrochaetae on Th. II-Abd. 5, but the number for Th. 2 does not include the anterior macrochaetae associated with the collar.

In the formula describing the organization of dental spines Arabic numbers represent small spines and Roman numerals in bold Italics represent large spines, from the proximal to the distal segments of dens.

Abbreviations. Abd—abdominal tergite, Mc—macrochaeta, Th—thoracic segment, IZISU—Institute of Zoology, Ilia State University, Georgia, MZNA—Museum of Zoology, University of Navarra, Spain, FSCA—Florida State Collection of Arthropods, USA.

Taxonomy

Plutomurus shurubumuensis Barjadze, Jordana & Soto-Adames sp. nov.

Figs 4–22

Type locality. GEORGIA, Samegrelo—Zemo Svaneti region, Chkhorotsku district, 3 km from Mukhuri, Migaria karst massif, Shurubumu Cave, 4239'5.71"N, 4213'44.58"E, 464 m alt.

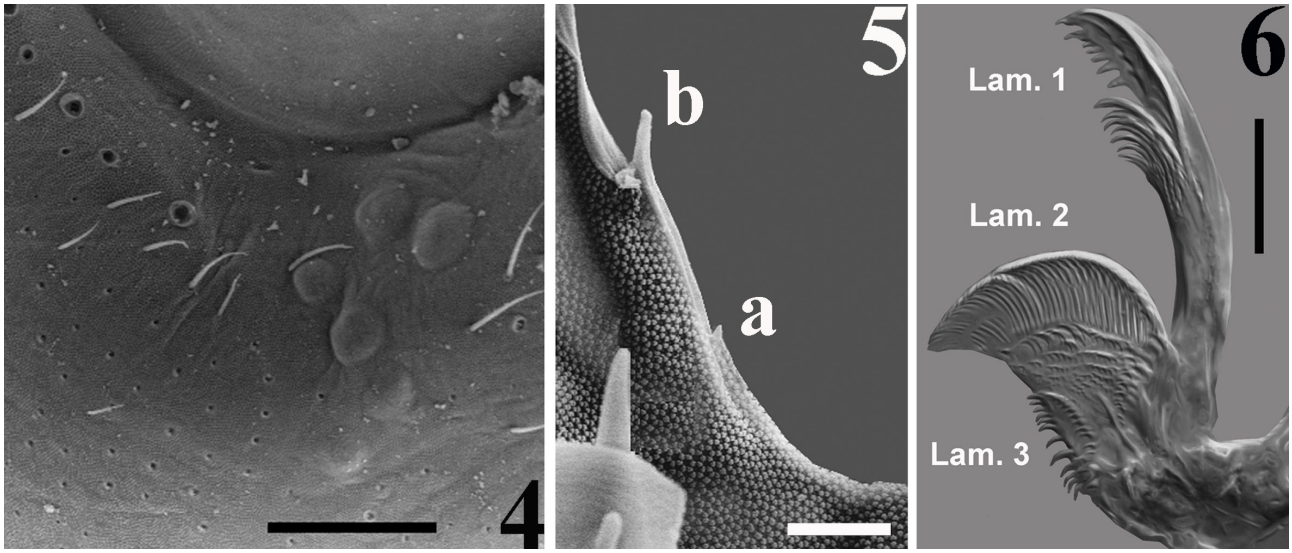
Type material. Holotype, female on slide: dark zone, 03.x.2014, leg. Sh. Barjadze (code GEOShu20141003–04). Paratypes (same data as holotype): four females on slides (code GEOShu20141003–01, 02, 03 and 05). Three specimens mounted on SEM stubs (GEOShu20141003–06, 07 and 08). Seven specimens in ethyl alcohol (GEOShu20141003–09–15); Paratypes (same data as holotype but 28.ix.2017) one male (GEOShu20170428–01) and one female (GEOShu20170428–02) on slides, leg. Sh. Barjadze; three additional females with same date as holotype but 28.ix.2017, leg. Sh. Barjadze. Holotype and paratypes 01, 02, 06, 07 and 08 deposited at MZNA; paratypes GEOShu20141003–03 and 05, GEOShu2017040328–01 and 02 deposited at IZISU; 3 female paratypes deposited at FSCA (N105–107).

Description. Body length up to 3.36 mm, excluding antennae and furcula.

Color pattern. Habitus and grey pigment distribution as in *P. pichkhaiai* **sp. nov**. (Fig. 23).

Scale distribution. Dorsally on Ant. I–II, head, body, all legs segments, both faces of collophore and ventral face of furcula. Postlabial region of head with few or no scales.

Head. Ratio body length to antennae length up to 1.09. Number of eyes unclear, apparently 6, but all cornea reduced and actual number difficult to determine in most specimens; under light microscope eye number appears to vary from 3 to 6, whereas the single individual evaluated using SEM clearly shows 6 eyes (Fig. 4). Head dorsally (Fig. 7) with one unpaired (A_0), and 6 (7) paired Mc: 2 anterior (A_2, A_3), 2 interocular (Ps_2, Ps_3) and 2(3) postocular ((Pa_2), Pa_3, Pa_5) (supplementary Mc represented by dotted line in Fig. 7). Prelabral and labral chaetae smooth (Fig. 11): prelabral chaetae 6 (3+3); labrum with 554 papillate chaetae as typical for genus; distal margin of labrum with 4 elongate, thin-walled, curved papillae. Outer maxillary lobe trifurcate (Fig. 12), basal chaetae shorter than apical process; sublobal plate with 4 processes each one resting on a short papilla. Sclerotized head of maxilla (Fig. 13) with 3 large and 1 small teeth; maxillary lamella 1 (Fig. 6) evidently longer and more slender than others, with a small posterior basal brush and better developed anterior medial brush, ventral margin with long cilia; lamella 2 (Fig. 6), and 4 (not shown) wide, densely covered with denticles and hooks; lamella 3 (Fig. 6) short, somewhat ellipsoidal, with cilia regularly distributed along its entire margin; lamella 5 (Fig. 14), sinuous but variable in shape, basal beard absent (i.e., prostheca not developed); lamella 6 narrow, comb-shaped, with short processes (Fig. 15). Labial papilla E with 6 guard processes; lateral modified process thin-walled, tapering and surpassing tip of papilla (Fig. 16 inset). Labium with 16–17 proximal chaetae (Fig. 16). Basomedial field (i.e., labial triangle) without scales, with 22–23 smooth chaetae; basolateral field with 5 chaetae (A3–A5 and L1–L2), chaetae on anterior row slightly longer than those on posterior row.



FIGURES 4–6. *Plutomurus shurubumuensis* **sp. nov.** 4, Right eye patch (bar: 0.04 mm); 5, Hind unguis. a: basal tooth; b: distal tooth (bar: 0.006 mm); 6, Maxilla, showing lamellae N1, N2 and N3 (bar: 0.02 mm).

Body. Dorsal bothriotrichal formula 2,1//0,0,1,2,0 (Figs 8–9). Dorsal Mc formula 4,2//3,3,4,1(2),4 (Figs 8–10). Thorax macrochaetotaxy as in Fig. 8: Th. II with 2 medial and 2 posterior Mc; Th. III with 2 posterior Mc. Abdominal macrochaetotaxy as in Figs 9–10: Abd. I—II each with 3 posterior Mc; Abd. III with 2 anterior and 2 posterior Mc as typical for genus; Abd. IV with 7 enlarged chaetae (labeled 1–7 in Figs 9–10), chaeta N7 always largest Mc, chaeta N2 a small Mc in 1 out of 6 individuals examined, all other differentiated posterior chaetae clearly enlarged, but sockets always small, mesochaeta-like; Abd. V with 4 posterior Mc, 1 additional lateral Mc always present, but often hidden by slide mounting induced deformation of cuticle, and segment appears as having 4 Mc.

Legs. Hind legs with well-developed trochanteral (18–35 chaetae) and femoral organs (20–44 chaetae) (n=9) (Fig. 17). Posterior face of hind tibiotarsus with 2 outstanding pointed spine-like chaetae, one basal and one distal, resulting in a 002 tibiotarsal spine formula (Fig. 20). Tenent hair acuminated, thinner and shorter than flanking chaetae, and inserted in a well-developed depression (Fig. 18). Ratio hind unguis: unguiculus: tenent hair as 1.54–3.55: 0.92–2.48: 1 (n=11). Inner edge of unguis on all legs with one minute proximal unpaired tooth (a in Figs 5 and 18), and 1 larger distal unpaired tooth (b in Figs 5 and 18). Unguis with lateral teeth 0.42–0.86 as long as length of inner edge (n=9), reaching proximal minute inner tooth. Unguiculus lanceolate, tapered, with 2 internal lamellae bearing 0–6 teeth (Fig. 18).

Collophore. Anterior, posterior and distal faces with 27, 45 and ca. 65 smooth chaetae, respectively.

Tenaculum**.** Corpus with 1 smooth chaeta; rami with 4 + 4 teeth (Fig 19).

Furcula. Ratio manubrium: dens: mucro as 3.83–6.00: 4.80–8.75: 1 (n=8, including holotype). Outer margin of basal segment of dens with 3(4) apically acuminate macrochaetae, distal macrochaeta largest, proximal shortest (Fig. 22). Inner edge of dens basally with well differentiated spine-like chaetae; spines on basal segment of dens forming 2–3 short and poorly organized rows, upper row usually formed by 2 large, well-differentiated spines; spines on distal segment forming a single row extending distally between 35–43% of dens length; 3 proximal spines always small, terminal spine always largest in row; with long spines intercalated between short spines (Fig. 22), but always with at least 2 (sometimes 3) distinctly larger distal spines; total dental spines formula variable as 9–13 ***II–IV***/10–13 ***III–IV***. Mucro with 2 proximal and 2 distal teeth (202 formula): proximal teeth fused throughout most of their length, separated only at tip. (Fig. 21).

Variation. The actual number of eyes is difficult to ascertain using light microscope preparations. The dorsal cephalic and Abd. IV chaetotaxies are variable: one individual has three posterior Mc on the head instead of the two normal Mc; several individuals have a distinctly enlarged dorsal posterior chaeta N2 on Abd. IV. The number of teeth on the inner lamellae of the unguiculus varies from 0 to 6. The total number of dental spines also varies as reported above. Ratio of unguis III: unguiculus III: tenent hair and ratio of manubrium: dens: mucro are variable characters.

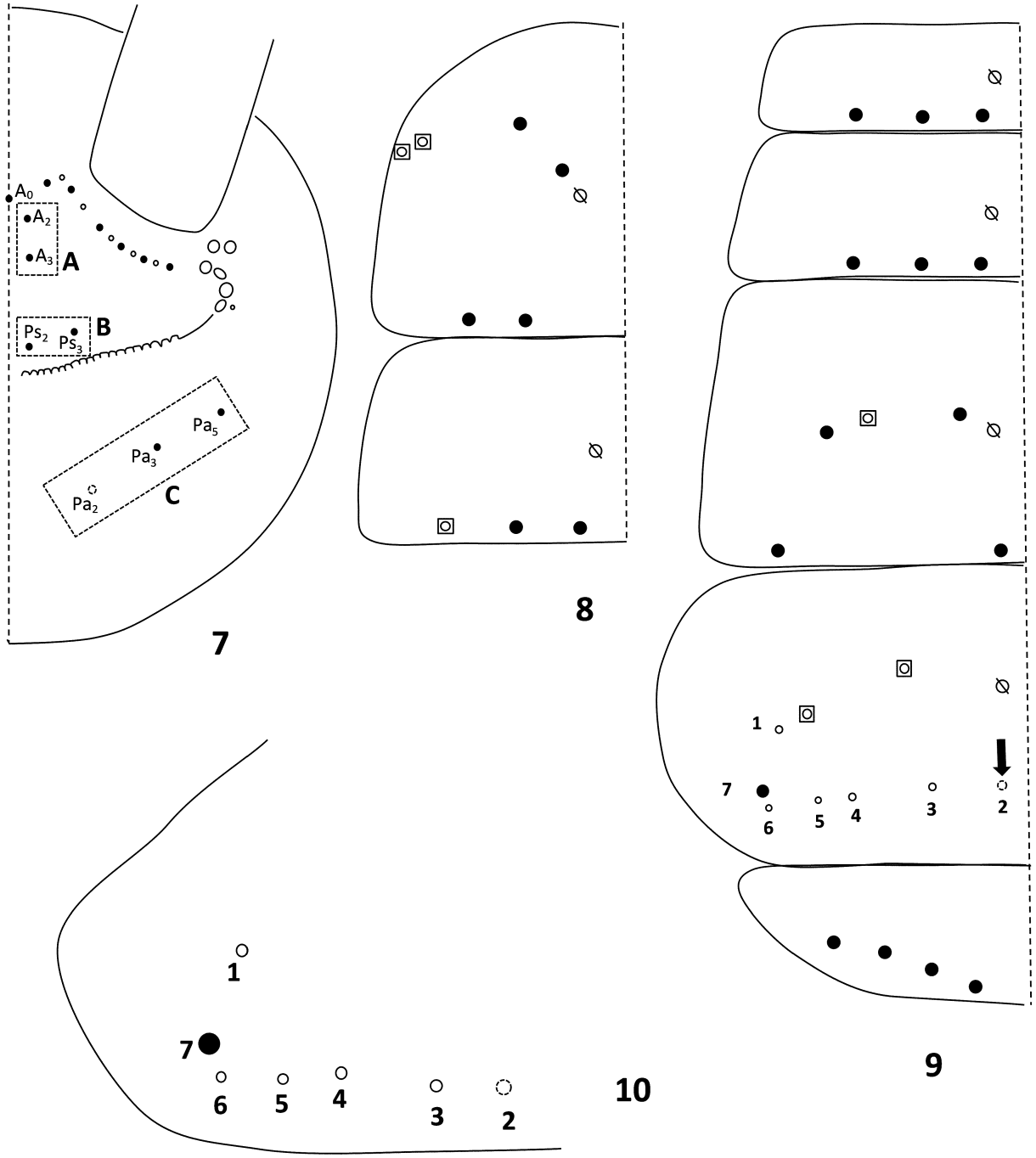
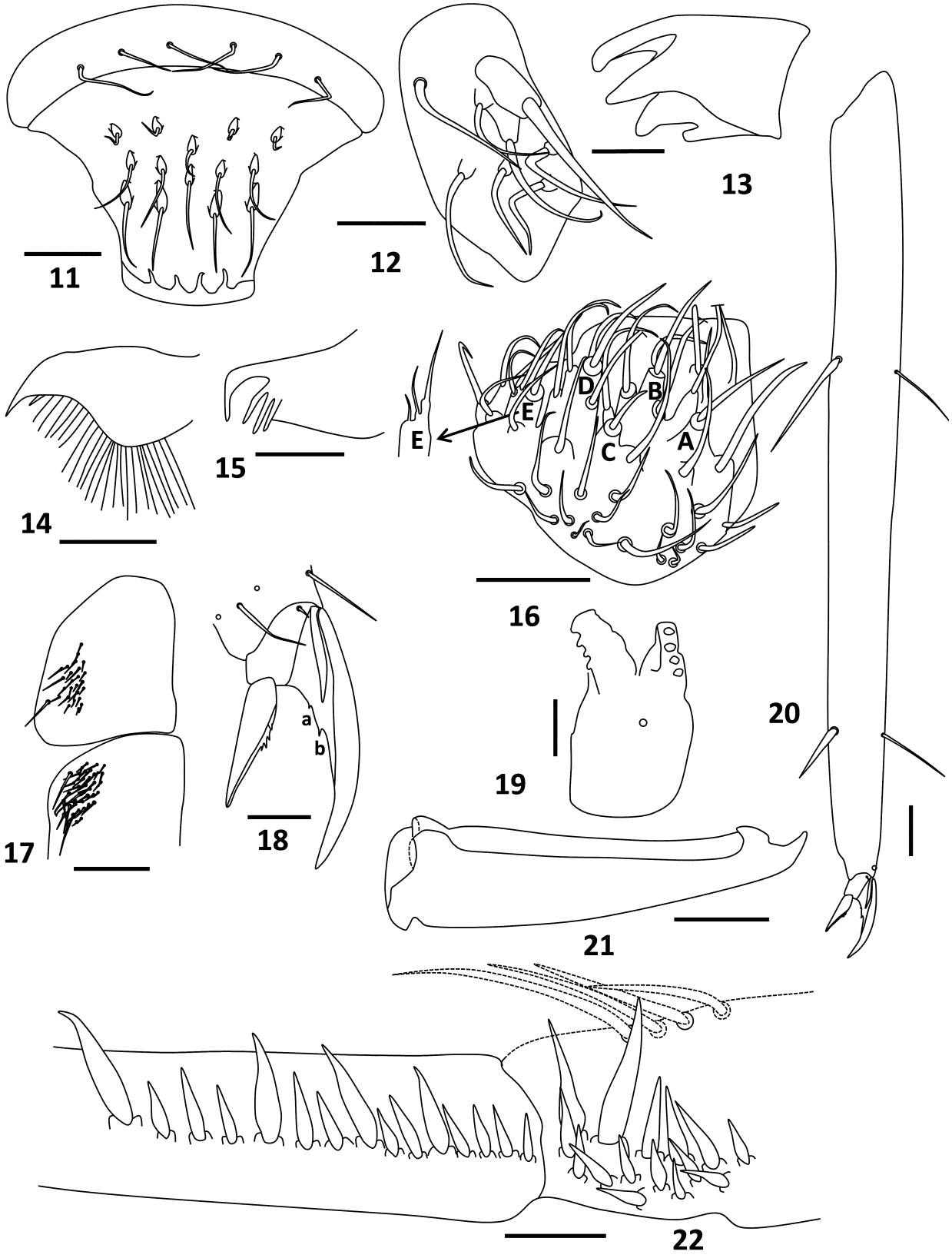


FIGURE 7–10. Generalized maps of dorsal chaetotaxy in *Plutomurus shurubumuensis* **sp. nov.:** 7, Head macrochaetae. A: Anterior; B: interocular; C: postocular; 8, Thoracic segments II–III, mesothoracic collar omitted; 9, Abdominal segments I–V, arrow points at element transformed into macrochaeta in one paratype; 10, Detail of differentiated chaetae on abdominal segment IV. Large black circle represents macrochaeta; empty circles represent mesochaetae; hatched circle (chaeta N2) represents variable meso– or macrochaeta; squares with circles represent bothriothricha; circles with a slash represent pseudopores.



FIGURES 11–22. *Plutomurus shurubumuensis* **sp. nov.** 11, Labrum and prelabral chaetae (bar: 0.04 mm); 12, Outer lobe of maxillary palp (bar: 0.02 mm); 13, Sclerotized portion of maxillary head (bar: 0.02 mm); 14, Maxillary Lamella N5 (bar: 0.01 mm); 15, Maxillary Lamella N6 (bar: 0.01 mm); 16, Labial palp (bar: 0.02 mm); 17, Trochanteral and femoral organs (bar: 0.06 mm); 18, Hind claw complex (bar: 0.02 mm); 19, Tenaculum (bar: 0.06 mm); 20, Hind tibiotarsus, showing location of spine–like chaetae (bar: 0.06 mm); 21, Mucro without chaetae and chaetal sockets (bar: 0.025 mm); 22, Dental spines (bar: 0.05 mm).

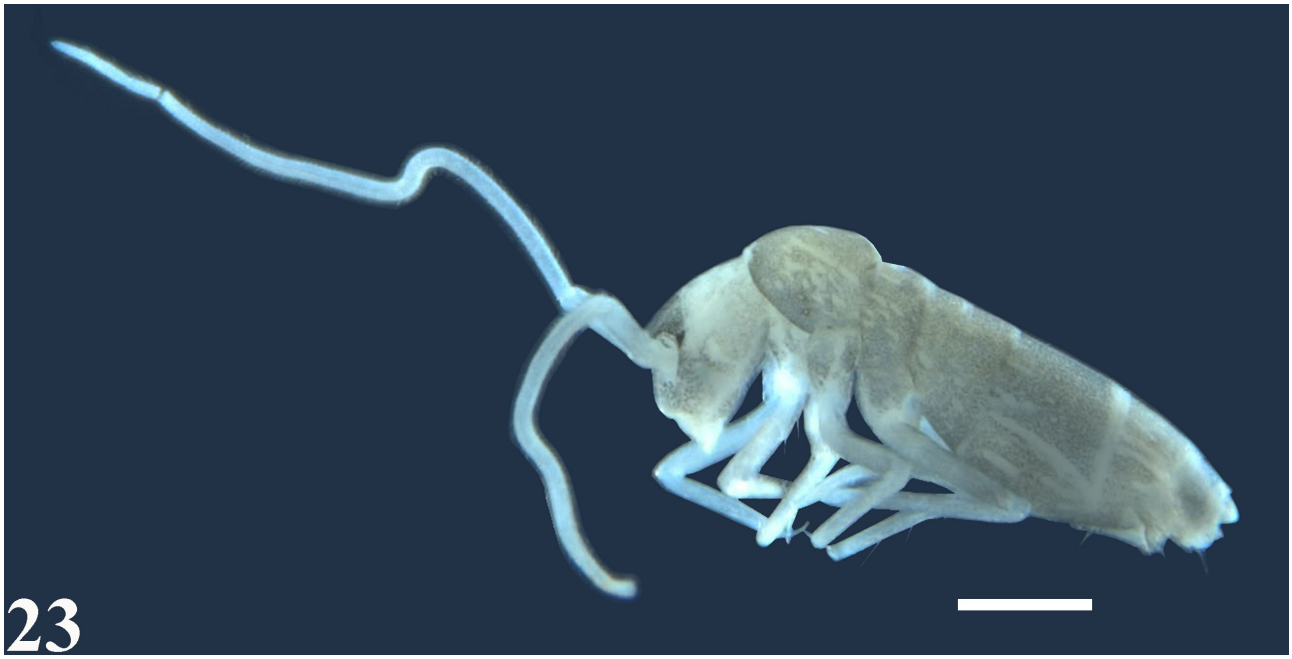


FIGURE 23. *Plutomurus pichkhaiai* **sp. nov.** Habitus, from Letsurtsume Cave (bar: 0.5mm).

Discussion. Among members of the genus *Plutomurus,* only *P. shurubumuensis* **sp. nov.** has eyes, 3+3 prelabral chaetae, 2 spines on the inner edge of metathoracic legs, and 1 (sometimes 2) posterior Mc on Abd. IV. The new species is most similar to *P. pichkhaiai* **sp. nov.**, and *P. kelasuricus*. The new species differs from *P. pichkhaiai* **sp. nov.**, in the number of posterior Mc on Abd. IV (1–2 in *P. shurubumuensis* **sp. nov.**, 3 in *P. pichkhaiai* **sp. nov.**) a p-distance of at least 13.7% in the 3' half of the COI mitochondrial gene, which results in reciprocally exclusive monophyletic sister groups in a Bayesian analysis (cf. Barjadze *et al.* 2016), and in that they occupy different cave formations (see Materials & Methods) isolated by a fault. From *P. kelasuricus* the new species differs in having 2 inner spine–like chaetae on the inner edge of the hind tibiotarsus (only 1 in *P. kelasuricus*) and in occupying different, isolated cave formations separated by a geographic distance of nearly a 100 km (Fig. 1).

Plutomurus shurubumuensis **sp. nov.** is also very similar to *P. revazi*, which has a capitate tenent hair (acuminate in the new species), and 5 (medial and posterior), 3 Mc on Th. II and Abd. V, respectively (4, 4 Mc in the new species). All other seven species of *Plutomurus* with 3+3 prelabral chaetae (*P. ehimensis* Yosii, 1956*, P. eristoi, P. gul* (Yosii, 1966)*, P. grahami, P. iwatensis* Yoshii, 1991*, P. kawasawai* Yosii, 1956*,* and *P. ortobalaganensis*) are blind and easily distinguished from *P. shurubumuensis* **sp. nov.**

Etymology. The species is named after the cave in which it was collected.

Ecology. The body and eye patch pigmentation, together with the thick, toothed unguis suggest this is a troglophilous species. The small number and size of the inner ungual teeth and presence of an acuminate tenent hair place it in the early stages of troglomorphy.

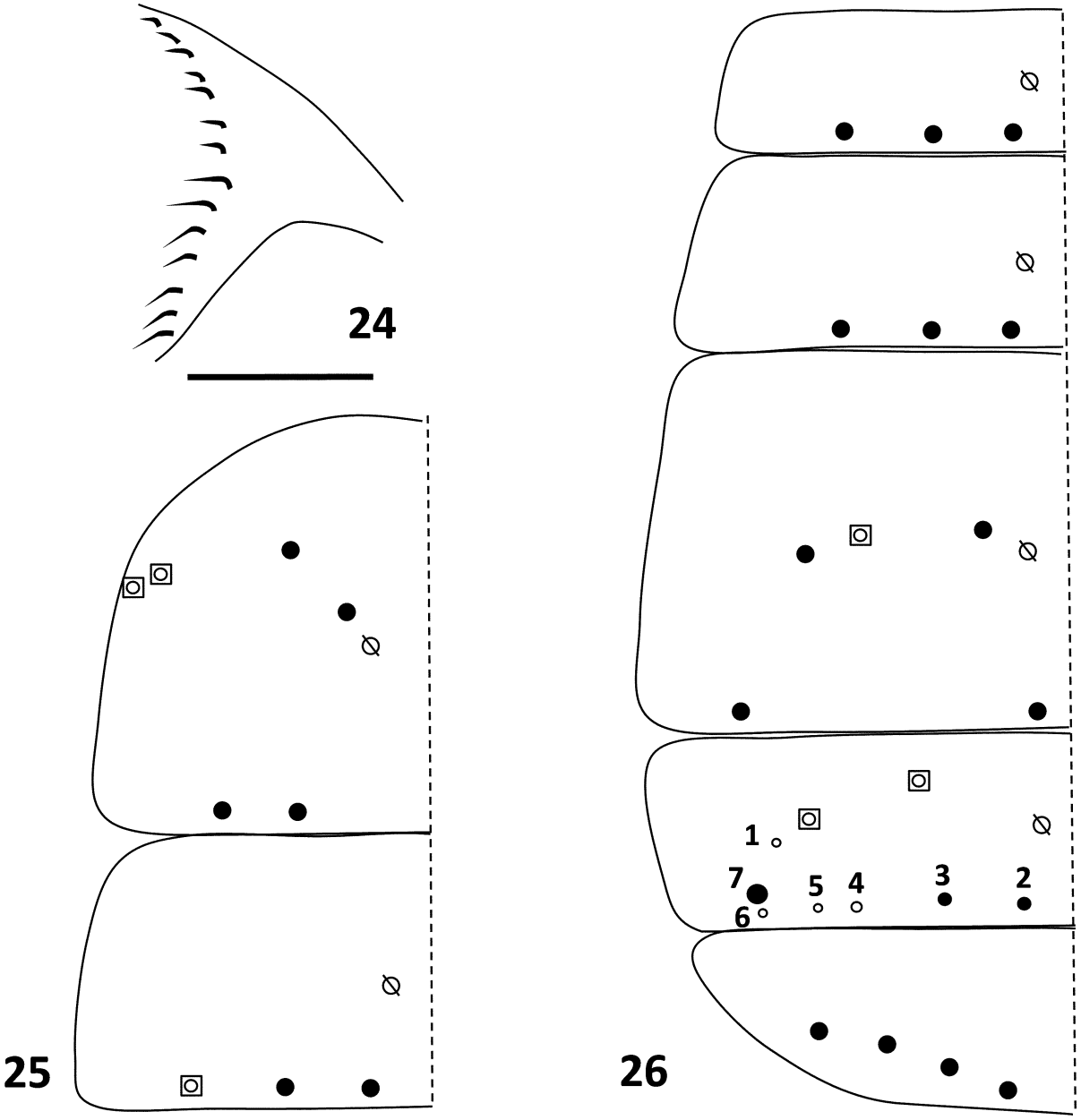
Plutomurus pichkhaiai **Barjadze, Jordana & Soto-Adames sp. nov.**

Figs 23–26

Type locality. GEORGIA, Samegrelo—Zemo Svaneti, Chkhorotsku, near Garakha, Garakha Cave, 42°31'47.22"N, 42°10'39.18"E, 203 m alt.

Type material. Holotype, female on slide: dark zone, 13.ii.2014, leg. Sh. Barjadze (code GeoGar20140213–02). Paratypes (same as holotype): 2 females on slides (code GEOShu20140213–01 and 03). Two specimens mounted on SEM stubs (GeoGar20140213–04 and 05). Three specimens in ethanol (GeoGar20140213–06, 07 and 08). Paratypes: two females on slide, dark zone, 30.iv.2017, leg. G. Nebieridze (GeoGar20170430–01 and 02); one female on slide, twilight zone, 30.iv.2017, leg. G. Nebieridze (GeoGar20170430–03). Two specimens (FSCA108–

109, males) same date as holotype but 30.iv.2017, leg. G. Nebieridze. The material from 13.ii.2014 was previously mentioned as "*Plutomurus* sp. 4" in Barjadze *et al.* (2015) and as "*Plutomurus* sp. 1" in Barjadze *et al.* (2016).



FIGURES 24–26. *Plutomurus pichkhaiai* **sp. nov.** 24, Maxillary lamella N5 (bar: 0.01 mm); 25, Dorsal chaetotaxy of thoracic segments. II-III; 26, Dorsal chaetotaxy of abdominal segments I–VI.

Additional material. GEORGIA, Samegrelo–Zemo Svaneti, Chkhorotsku, Letsurtsume, Letsurtsume Cave, 42°32'21.4"N, 42°06'47.3"E, 183 m alt. Two specimens (FSCA110, female and FSCA111 male) on slides, dark zone, 29.iv.2017, leg. Sh. Barjadze and two specimens (GeoLet20170429–01, male) and (GeoLet20170429–02, female) on slides, dark zone, 29.iv.2017, leg. Sh. Barjadze. Holotype and paratypes 01, 03–08 deposited at MZNA; paratypes: GeoGar20170430–01, 02, 03 at IZISU, and N108–109 at FSCA. Additional materials (GeoLet20170429–01 and 02) at IZISU, and N110–111 at FSCA.

Description. Body length up to 3.76 mm excluding antennae.

Color pattern. Habitus and distribution of grey pigment as in Fig. 23.

Scale distribution. As in *P. shurubumuensis* **sp. nov.**

Head. Ratio of body to antennae length up to 0.85. Number of eyes unclear, observations under compound microscope show 3–5 eyes, but field where eyes sit often distorted. Head dorsally with 1 unpaired, and 6 paired Mc as in P. *shurubumuensis* **sp. nov.** Prelabral chaetae 3+3, labral chaetae and papillae typical for genus. Maxilla as in *P. shurubumuensis* **sp. nov.,** but lamella N5 sometimes appearing Y-shaped (Fig. 24) Proximal chaetae of labium 16–17. Basomedial field with 22–23 smooth chaetae; basolateral field with 5 chaetae.

Body. Dorsal Mc formula 4,2//3,3,4,3,4 (Figs 25–26). Abd. IV with 7 differentiated chaetae, chaeta #7 always a large Mc, chaetae N2 and N3 always developed into a small Mc (Fig. 26), other chaetae always small, mesochaeta-like as in *P. shurubumuensis* **sp. nov.**

Legs. Hind legs with well-developed trochanteral (16–30 chaetae) and femoral organs (25–36 chaetae) (n=7). Tibiotarsal outstanding spine-like chaetae formula as 002. Tenent hair acuminated, as in *P. shurubumensis* **sp. nov.** Ratio hind unguis: unguiculus: tenent hair as 1.50–3.00: 1.50–2.28: 1 (n=7). Inner edge of unguis on all legs with 2 unpaired teeth, proximal tooth minute, distal tooth evidently larger; lateral outer teeth 0.38–0.83 times length of inner edge of uguis (n=7). Unguiculus lanceolate and tapered, with 0–7 inner teeth.

Collophore. Chaetotaxy as in *P. shurubumuensis* **sp. nov.**

Furcula. Ratio manubrium: dens: mucro as 3.52–5.00: 7.17–8.17: 1 (n=6, including holotype). Outer margin of dens with 3–5 acuminate spine–like macrochaetae. Inner edge of dens with a variable number of basal spines; row of spines on distal segment of dens extending between 24–28% (3 out of 6 individuals=26%) of dens total length. Dental spines formula variable as 5–14 ***II–IV***/8–13 ***II–IV***. Mucronal teeth formula 202.

Variation. The number of teeth on inner lamellae of the unguiculus varies from 0 to 7. The number of dental spines is also variable. Ratio of hind unguis: unguiculus: tenent hair, and ratio of manubrium: dens: mucro are also variable.

Discussion. *Plutomurus pichkhaiai* **sp. nov.** is the only eyed member of the genus with 3+3 prelabral chaetae, 2 spines on the inner edge of the hind legs, and 3 posterior Mc on Abd. IV. The new species is most similar to *P. shurubumuensis* **sp. nov.**, from which it differs in the number of posterior Mc on Abd. IV, in mtDNA sequence and cave formation as described above for *P. shurubumuensis* **sp. nov.** From *P. kelasuricus* the new species differs in having 2 inner spine–like chaetae on the inner edge of the hind tibiotarsus (only 1 in *P. kelasuricus*); in addition, *P. pichkaiai* **sp. nov.** was collected in Garakha and Letsutsume caves, part of the Migaria karst massif formation, whereas *P. kelasuricus* was collected 100 km to the northwest, in Kelasuri Cave, which is part of the Tsebelda karst massif formation.

Etymology. The epithet honours Mr. Igor Pichkhaia, who has worked on the popularization of local caves in Chkhorotsku district during several decades.

Ecology. The presence of body and eye patch pigmentation suggest this is a troglophilous species.

Key to the species of the genus *Plutomurus* with 3+3 prelabral chaetae

Most characters used to diagnose *Plutomurus* species are ambiguous and open to interpretation. Only the number of prelabral chaeta is easy to see, discrete, and with insignificant levels of intraspecific variation. As discussed above, under light microscopy it is often difficult to determine the actual number of eyes present, although at least the 2–3 largest eyes are almost always visible. Hence, the key refers only to eyes present or absent.

1	Eyes present (usually 3–6)	2
-	Eyes absent	5
2	Hind tibiotarsus with 1 posterior spine	*P. kelasuricus*
-	Hind tibiotarsus with 2 posterior spines	3
3	Tenent hair capitate; Th. II and Abd. V with 5 (medial & posterior) and 3 (posterior) Mc, respectively	*P. revazi*
-	Tenent hair acuminate; Th. II and Abd. V each with 4 Mc	4
4	Abd. IV with 1 large lateral and sometimes a second smaller medial Mc (Figs 9–10)	*P. shuburumensis* **sp. nov.**
-	Abd. IV with 3 Mc: 1 large lateral and 2 smaller medial Mc (Fig. 26)	*P. pichkhaiai* **sp. nov.**
5	Tenent hair capitate	*P. grahami*
-	Tenent hair acuminate	6
6	Mucro with 1–3 intermediate teeth	7
-	Mucro without intermediate teeth	8
7	Mucro with 1 proximal tooth	*P. ehimensis*

-	Mucro with 2 proximal teeth	*P. gul*
8	Tenaculum with 2 chaetae; apical and subapical teeth of mucro truncate	*P. iwatensis*
-	Tenaculum with 1 chaeta; apical and subapical teeth of mucro rounded	9
9	Inner edge of hind unguis toothless; unguiculus basally swollen and medially excavated	*P. eristoi*
-	Hind unguis with 1–3 inner teeth; unguiculus narrower at base than near middle	10
10	Hind tibiotarsus with 1 inner spine; unguiculus inner teeth present	*P. orthobalaganesis*
-	Hind tibiotarsus with 2 inner spines; unguiculus inner teeth absent	*P. kawasawai*

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References

Barjadze, Sh. & Djanashvili, R. (2008) Checklist of the springtails (Collembola) of Georgia. *Caucasian Entomological Bulletin*, 4, 187–193.
https://doi.org/10.1080/09397140.2014.939812

Barjadze, Sh., Baquero, E., Soto-Adames, F., Giordano, R. & Jordana, R. (2016) New diagnosis for species of *Plutomurus* Yosii (Collembola, Tomoceridae), with descriptions of two new species from Georgian caves. *Zootaxa*, 4126 (1), 77–96.
https://doi.org/10.11646/zootaxa.4126.1.3

Barjadze, Sh., Murvanidze, M., Arabuli, T., Mumladze, L., Pkhakadze, V., Djanashvili, R. & Salakaia, M. (2015) *Annotated List of Invertebrates of the Georgian Karst Caves.* Georgian Academic Book, Tbilisi, 120 pp.

Börner, C. (1901) Über einige theilweise neue Collembolen aus den Höhlen der Gegen von Letmathe in Westfalen. *Zoologische Anzeiger*, 24, 333–345.

Christiansen, K. (1964) A revision of the Nearctic members of the genus *Tomocerus*. *Revue d' écologie et de biologie du sol*, 1, 639–678.

Christiansen, K. (1980) A new nearctic species of the genus *Tomocerus* (Collembola: Entomobryidae). *Proceedings of the Iowa Academy of Sciences*, 87, 121–123.

Christiansen, K. & Bellinger, P. (1998) *The Collembola of North America*, *North of the Rio Grande. A taxonomic analysis. Part 3.* Grinnell College, Iowa, pp. 877–1173.

Djanashvili, R. & Barjadze, S. (2011) A new species of the genus *Plutomurus* Yosii, 1956 (Collembola, Tomoceridae) from Georgian caves. *Journal of Cave and Karst Studies*, 73, 28–30.
https://doi.org/10.4311/jcks2010lsc0147

Felderhoff, K., Bernard, E.C. & Moulton, J.K. (2010) Survey of *Pogonognathellus* Börner (Collembola: Tomoceridae) in the southern Appalachians based on morphology and molecular data. *Annals of the Entomological Society of America*, 103, 472–491.
https://doi.org/10.1603/AN09105

Folsom, J.W. (1913) North American springtails of the subfamily Tomocerinae. *Proceedings of the United States National Museum*, 46, 451–472.
https://doi.org/10.5479/si.00963801.46-2037.451

Gisin, H. (1963) Collemboles d'Europe. V. *Revue Suisse de Zoologie*, 70, 77–101.

Gisin, H. (1964) Collemboles d'Europe. VII. *Revue Suisse de Zoologie*, 71, 649–678.
https://doi.org/10.5962/bhl.part.75615

Gisin, H. (1967) Espèces nouvelles et lignées évolutives de *Pseudosinella* endogés. *Memórias e Estudos do Museu Zoológico da Universidade de Coimbra*, 301, 5–25.

Jordana, R., Baquero, E., Reboleira, S. & Sendra, R. (2012) Reviews of the genera *Schaefferia* Absolon, 1900, *Deuteraphorura* Absolon, 1901, *Plutomurus* Yosii, 1956 and the *Anurida* Laboulbène, 1865 species group without eyes, with the description of four new species of cave springtails (Collembola) from Krubera-Voronya cave, Arabika Massif, Abkhazia. *Terrestrial Arthropod Reviews*, 5, 35–85.
https://doi.org/10.1163/187498312X622430

Kniss, V. & Thibaud, J. (1999) Le genre *Plutomurus* en Russie et en Georgie (Collembola, Tomoceridae). *Revue française d'Entomologie*, *New Series*, 21, 57–64.

Martynova, E. (1969) Springtails of the family Tomoceridae (Collembola) from the fauna of the USSR. *Entomological Review*, 43, 299–314. [in Russian]

Tatashidze, Z.K., Tsikarishvili, K.D. & Jishkariani, J.M. (2009) *The Cadastre of the Karst Caves of Georgia.* Petiti Publishing House, Tbilisi, 670 pp. [in Georgian]

Yoshii, R. (1991) About the *proserpinae* group of *Hypogastrura* (Collembola) in the Caves of Pref. Iwate. *Annals of the Speleological Research Institute of Japan (Iwaizumi)*, 9, 3–10.

Yosii, R. (1939) Two new species of Tomocerid collembola from limestone caves of Japan. *Annotationes Zoologicae Japonenses*, 18, 177–181.

Yosii, R. (1956) Monographie zur Höhlencollembolen Japans. *Contribution from the Biological Laboratory Kyoto University*, 3, 1–109.

Yosii, R. (1966) Results of the Speleological Survey in South Korea 1966. IV. Cave Collembola of South Korea. *Bulletin of the National Science Museum*, 4, 541–561.

Yosii, R. (1967) Studies on the Collembolan family Tomoceridae, with special reference to Japanese forms. *Contributions from the Biological Laboratory Kyoto University*, 20, 1–54.

Yu, D.Y. & Deharveng, L. (2015) The first eyeless species of *Tomocerus* from China (Collembola, Tomoceridae) with notes on genera *Tomocerus* and *Pogonognathellus. Zootaxa*, 3914 (2), 175–184. https://doi.org/10.11646/zootaxa.3914.2.7

Yu, D., Ding, Y. & Ma Y. (2017) Revision of *Tomocerus similis* Chen & Ma, with discussion of the *kinoshitai* complex and the distal tibiotarsal chaetae in Tomocerinae (Collembola, Tomoceridae). *Zootaxa*, 4268 (3), 395–410. https://doi.org/10.11646/zootaxa.4268.3.5

Yu, D.Y., Zhang, F. & Deharveng, L. (2014) New species of *Monodontocerus* (Collembola: Tomoceridae) from southern China with diagnostic notes on the genus and introduction of new taxonomic characters. *Zootaxa*, 3768 (5), 557–575. https://doi.org/10.11646/zootaxa.3768.5.3

Yu, D., Zhang, F., Stevens, M.I., Yan, Q., Liu, M. & Hu, F. (2015) New insight into the systematics of Tomoceridae (Hexapoda, Collembola) by integrating molecular and morphological evidence. *Zoologica Scripta*, 45, 286–299. https://doi.org/10.1111/zsc.12149