



## Two new cavernicolous species of Entomobryidae (Collembola) from Turkmenistan, Central Asia

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### Abstract

Descriptions of two new cavernicolous collembolans of the family Entomobryidae Womersley, 1934 from Turkmenistan resulted from speleological expeditions organized by the association Karstology & Researchs in Central Asia (KRAC) and sponsored by the Commission for International Relations and Expeditions (CREI) of the French Speleology Federation to caves and mines in the Koytendag Mountains in 2023–2024. Two new species, *Entomobryoides gruati* sp. nov. and *Drepanura koytendagi* sp. nov. are described as the first Collembola discovered from subterranean ecosystems of Turkmenistan, Central Asia. Tables summarizing the diagnostic characters of world species of *Entomobryoides* Maynard, 1951 and *Drepanura* Schött, 1891 are provided. Both new species are associated with subterranean habitats in dark cave zones. The discovery of two cave entomobryids highlight the high biodiversity potential of Turkmenistan's cave ecosystems and suggest that vast majority of undescribed species are yet to be found. Given the minimal exploration of this region, a further biospeleological effort is essential to reveal diversity, distribution and endemism of subterranean fauna in Central Asia.

**Key words:** biodiversity, *Drepanura*, *Entomobryoides*, taxonomy

### Introduction

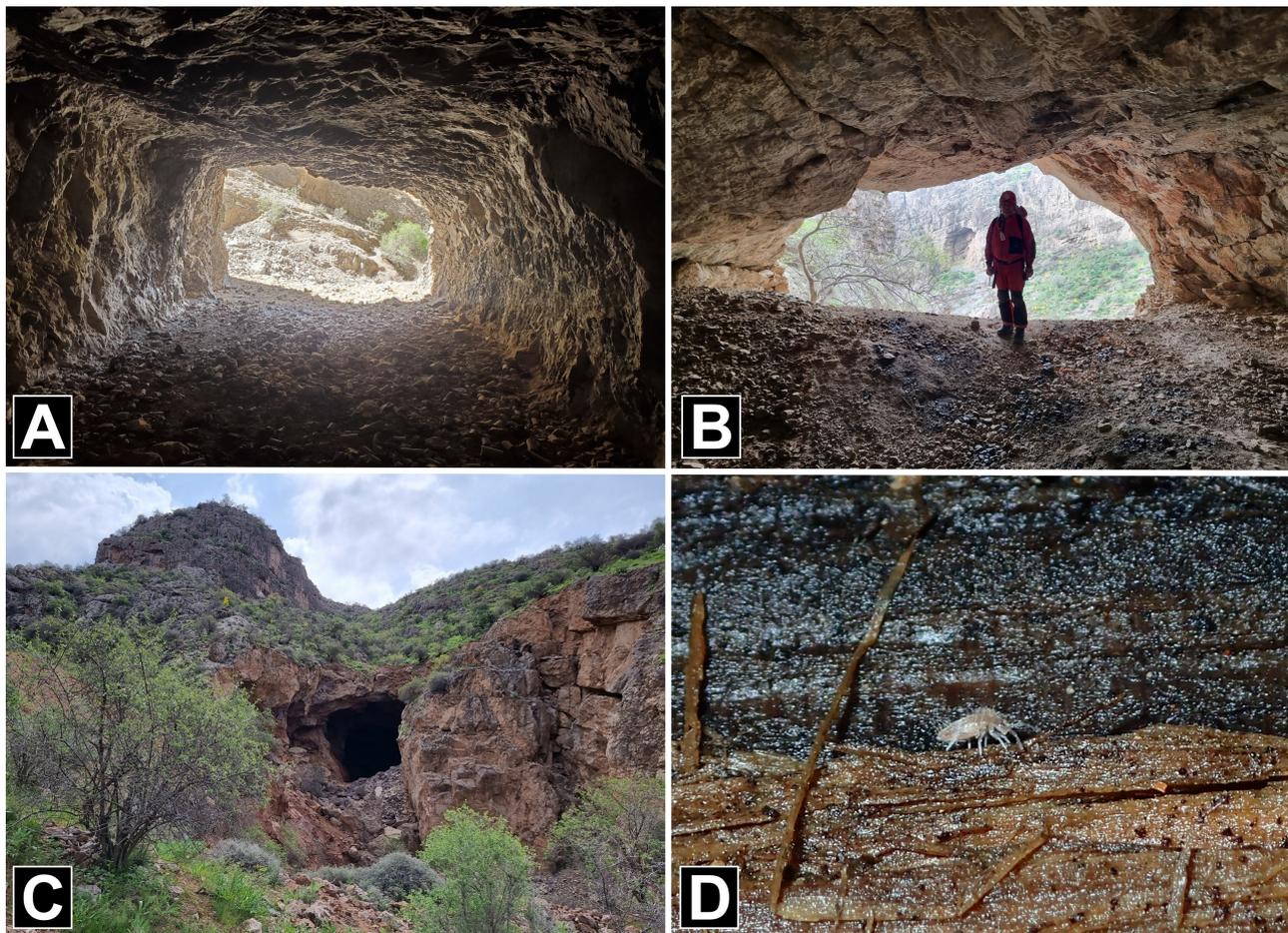
As the second-largest country in Central Asia, Turkmenistan is bordered by the Caspian Sea to the west, Iran and Afghanistan to the south, Uzbekistan to the north and east, and Kazakhstan to the northwest (Peyrouse 2012; Khadim & Khadim 2024). Characterized by a continental climate, it is the driest country in Central Asia, with nearly 80% of its land covered by desert. Nevertheless, certain areas of the country feature mountainous ecosystems. These include (1) the Koytendag (Kugitangtau) Mountains, a 50-kilometer-long karst massif along the border with Uzbekistan, (2) Kopet Dag Mountains in the south, which run along the border with Iran, and (3) the larger Balkan Mountain range in the west, which dominates the landscape near the Caspian Sea. These mountain systems host numerous caves that potentially support rich arthropod biodiversity. However, subterranean arthropods in Turkmenistan have been only scarcely studied, and current knowledge on these invertebrates remains highly limited (Babaev 1994; Peyrouse 2012; Sendra *et al.* 2017, 2021; Decu *et al.* 2019).

The present study is based on recent speleobiological fieldwork conducted in several caves and mines in Koytendag Mountains, eastern Turkmenistan, by the Commission for International Relations and Expeditions (CREI) of the French Speleology Federation. Here we report the discovery of two new species of Entomobryidae, described for the first time from Turkmenistan's caves. Additionally, tables summarizing the diagnostic characteristics of world species of *Entomobryoides* Maynard, 1951 and *Drepanura* Schött, 1891 are provided.

## Material and methods

### Cave descriptions

**Kattakamov Cave.** These former mining sites, primarily exploited for lead and zinc extraction, are aligned along a major geological fault that extends from north to south across the Koytendag massif. Several easily accessible galleries open into the Kattakamov Canyon. The explored sections include at least three of these galleries, which provide a relatively stable subterranean environment suitable for explorations of the subterranean invertebrates. The first gallery (37°51'30"N, 66°29'12"E) opens on the right wall of the canyon (Fig. 1A), on a small plateau formed by spoil heaps, at ~1,200 m a.s.l. The passage is a straight exploratory tunnel driven perpendicular to the mineralized vein, with a square cross-section of 2×2 m. Two very short side branches, each ≈ 7 m long, depart near the end of the gallery; from the terminal part of mine the daylight of the entrance remains still visible.



**FIGURE 1.** A–D, Kattakamov Cave, A, Entrance to the first gallery (Photo: Bernard Lips); B, Entrance to the second gallery (Photo: Bernard Lips); C, Entrance to the third gallery (Photo: Bernard Lips); D, *Entomobryoides gruati* **sp. nov.** in Kattakamov Cave (Photo: Josiane Lips).

The second gallery (Fig. 1B) is accessible through two separate entrances (37°51'25"N, 66°29'24"E). The gallery was excavated along the axis of the main fault, with several directional shifts oriented southeast. Numerous short side tunnels branch off from the main gallery, most ending abruptly at former mining faces. One of these side passages provides access to a shaft estimated to be 30–40 meters deep (22 m measured), while another shaft of similar depth (~40 m) opens directly from the main tunnel. Additionally, an ascending chimney measuring approximately 25 meters in height is accessible from one of the lateral branches. Also, the third gallery (Fig. 1C) represents a large and complex mining system developed across multiple levels (37°51'03"N, 66°29'29"E), located at the upper section of the mineral vein. The structure consists of extensive excavations and chambers.

**Gap-Gotan (Kap Kutan) and Promezhutochnaya (Promeszytochnaya) caves.** These caves form the largest known cave system in the area, with a total development of approximately 52 km, including numerous small loops and connections (Fig. 7). The system comprises four to five main parallel conduits extending in a north–south direction, spaced 200–300 meters apart and each measuring one to two kilometers in length. Numerous lateral passages, some of considerable size, frequently reconnect with the main galleries, resulting in a highly intricate and labyrinthine structure. Gap-Gotan Cave (Fig. 6A) is located at an altitude of approximately 676 meters above sea level (37°38'29"N, 66°24'29"E) and constitutes the eastern section of the system, while Promezhutochnaya Cave (Fig. 6B) (37°38'35"N, 66°24'05"E) represents western part of the system. The two sectors are connected by a long and narrow passage.

**Kaptarkhana (Kaptarhana) Cave.** This cave (Fig. 6C) is entirely developed in gypsum. It opens through a large collapse measuring approximately 12 × 25 meters. To enter the cave, one must descend a steep slope leading to a large underground gallery, measuring 12 to 20 meters in width and 6 to 8 meters in height (Fig. 8). This gallery extends approximately 120 meters upstream and eventually ends in a blockage. Upstream, the floor consists of a steep slope cluttered with blocks of varying sizes and stability. Several depressions contain shallow pools of water. All water bodies are situated at the same altitude, likely corresponding to base of the local groundwater drainage.

## Methods

Collembola specimens were collected using an aspirator. After transport to the laboratory, the specimens were placed in plastic tubes filled with 96% ethyl alcohol for the subsequent preservation. For observation under an optical microscope with phase contrast, the specimens were mounted in Heinz's medium, followed by clearing in Nesbitt's fluid (Jordana 2012). To compare the effectiveness of different clearing methods, additional specimens were gently boiled in a glass evaporating dish containing 95% ethyl alcohol on an electric hot plate for approximately one minute to remove fat from the body. For clearing, the specimens were transported to concave glass dish with 10% aqueous solution of KOH for 1 min. and then transferred to a dish containing chlorolphenol until they became transparent. Finally, the specimens were mounted in Swann medium (Rusek 1975). Once dry, the cover glasses were sealed with Canada balsam for protection of mounting medium against drying. The specimens were observed in Leica DM 2500 light microscope equipped with phase and DIC contrasts, and a drawing arm. The terminology used in descriptions follows: labial setal pattern after Gisin (1967); labral setal pattern after Cipola *et al.* (2014); labral papilla shape after Christiansen (1958); labial papilla and maxillary palp after Fjellberg (1999); claw and empodium form after Christiansen & Bellinger (1980); dorsal setal pattern after Szeptycki (1979), with additions of Jordana & Baquero (2005), Soto-Adames (2008) and Jordana (2012).

**Institutional abbreviations.** CoPJSU—Collembola collection of the Department of Zoology, Institute of Biology and Ecology, Faculty of Science, Pavol Jozef Šafárik University, Košice, Slovakia.

**Abbreviations of morphological characters.** Abd—abdomen or abdominal segment; Ant—antenna or antennal segment; a.s.l.—above sea level; l.p.—lateral process; Mc—macroseta; mes—mesoseta; Psp—pseudopore; Th—thorax or thoracic segments.

## Taxonomy

**Class COLLEMBOLA Lubbock, 1870**

**Order ENTOMOBRYOMORPHA Börner, 1913, *sensu* Soto Adames *et al.* 2008**

**Superfamily ENTOMOBRYOIDEA Womersley, 1934**

**Family ENTOMOBRYIDAE Womersley, 1934**

**Subfamily ENTOMOBRYINAE Schäffer, 1896 *sensu* Zhang & Deharveng 2015**

Tribe ENTOMOBRYINI Börner, 1906

Genus *Entomobryoides* Maynard, 1951

*Entomobryoides gruati* Mehrafrooz Mayvan & Kováč sp. nov.

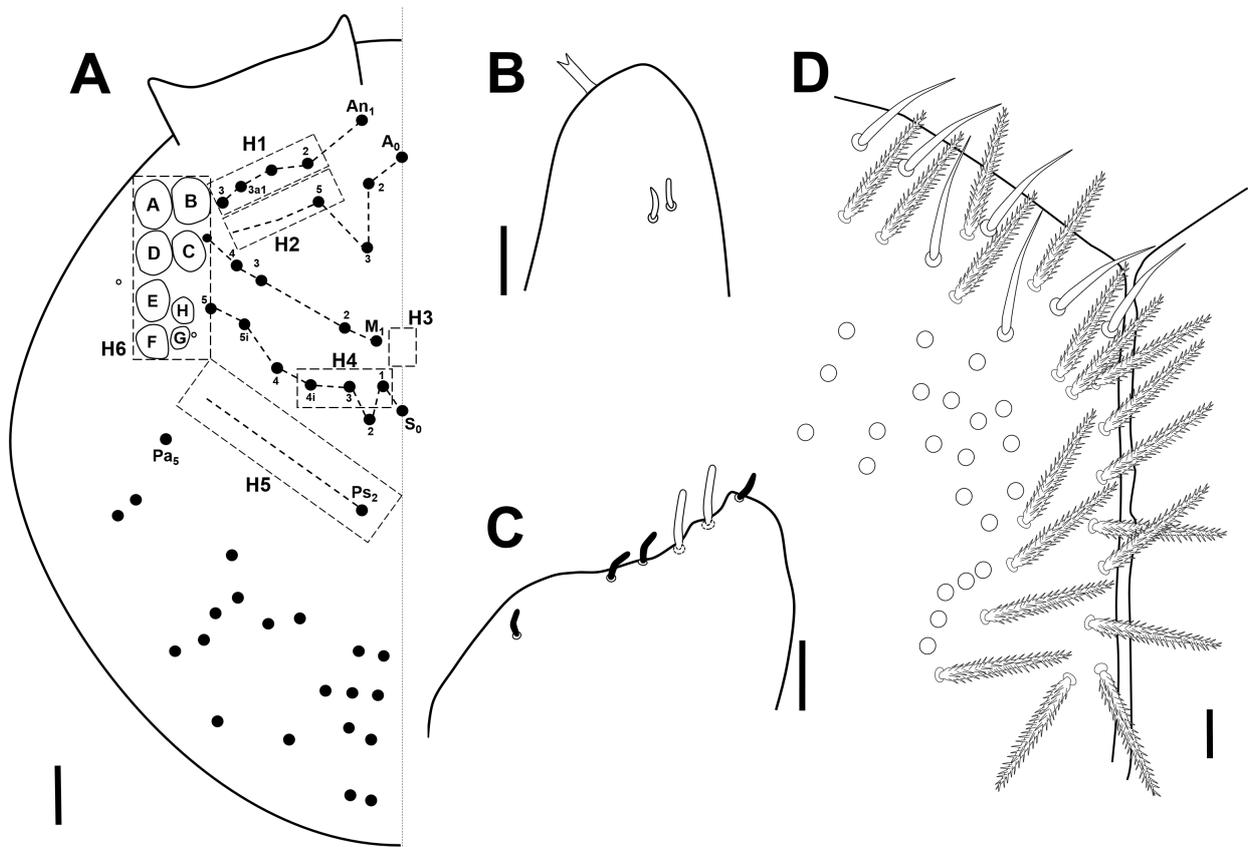
(Figs 1D, 2–5, Table 1)

**Type locality.** TURKMENISTAN, Lebap Province, Koýtendag District, v. Gurshun Magdanly (=Svintsovyi rudnik), Kattakamov Cave, Coordinates: 37°51'30.92"N, 66°29'12.37"E, 1240 m a.s.l.

**Type material.** *Holotype*: female on slide [KaEn101Tu], dark zone, hand collecting on rotten wood, 18.v.2023, leg. J. Lips. *Paratype*: 13 specimens on slides [KaEn102Tu- KaEn114Tu], ibidem, 18.v.2023, 18.iv.2024 and 20.iv.2024, leg. J. Lips. Holotype and paratypes deposited in CoPJSU.

**Description.** Body length (excluding antennae) 2.48 mm (n=14), up to 2.8 mm in holotype. Ground colour pale brown, antennae with bluish pigment, dorsal side of head paler in lateral parts than the body; coxa pale brown but other part of legs pale blue; eye spots black.

**Head.** Eight eyes, GH smaller in size to EF (Fig. 2A). Antenna longer than head, without apical bulb and scales. Antennae 1.71 times the length of the head, relative length of Ant I:II:III:IV in holotype as 1:2.67:2.25:3.60; Ant IV without apical vesicle (as characteristic remark for the genus), and pin seta bifurcate (Fig. 2B); subapical organite small and rod-shape, accompanied with a small sensillum only a little bigger; Ant III with sensory organ formed by 2 long-ovoidal sensilla and 4 additional guards sensilla (Fig. 2C); Labrum with 4 smooth prelabral setae and 3 rows of 5, 5 and 4 smooth setae; labral papillae very small, with a minute terminal projection (Fig. 4B). Maxillary palp with 1 apical appendage and 1 subapical seta, with three sublobal hairs (Fig. 4C). Head ventrally with 7 anterior smooth setae and other setae ciliated, setal pattern as in figure 2D. Labium setal pattern formed by 5 smooth setae (a<sub>1</sub>–a<sub>5</sub>) in anterior row; basal row with 7 smooth setae as m<sub>1</sub>, m<sub>2</sub>, r<sub>1</sub>, r<sub>2</sub>, e, l<sub>1</sub> and l<sub>2</sub> (Fig. 3C) with m<sub>2</sub>, r<sub>1</sub> and r<sub>2</sub> somewhat smaller than other setae. Labial palp as in figure 3B, with 5 main papillae (A–E) with 0, 5, 0, 4, 4 guard setae respectively; lateral process (l.p.) of labial papilla E surpassing their papilla apex. Right mandible with 4 teeth and left mandible with 5 teeth.

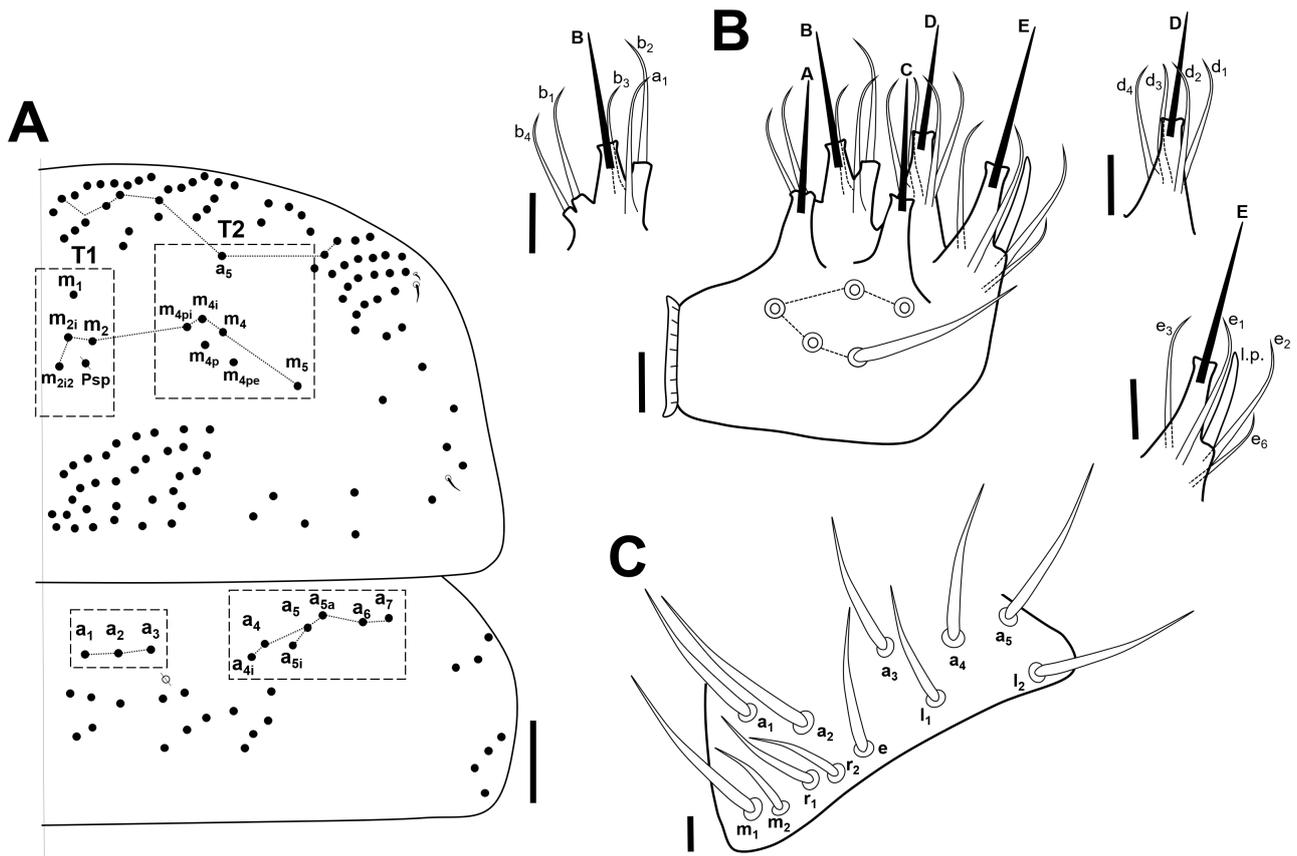


**FIGURE 2.** *Entomobryoides gruati* sp. nov. A, head, dorsal side—setal pattern; B, Ant IV tip: bifurcate pin seta, and special organite; C, Ant III, distal area with sensory organ; D, head, ventral side—setal pattern of postlabial area. Scale bars: A = 0.025 mm, B–C = 0.01 mm, D = 0.025 mm.

**TABLE 1.** Diagnostic characters of known *Entomobryoides* congeners.

Legend for the headers of the columns. Head (Fig 2A): **H1**, Mc number on series An<sub>2</sub>-An<sub>3</sub>; **H2**, Mc number on series A<sub>5</sub>-A<sub>7</sub>; **H3**, Mc S<sub>0</sub> presence; **H4**, Mc number on series S<sub>1</sub>-S<sub>3</sub>-S<sub>4</sub>; **H5**, Mc number on series Ps<sub>2</sub>-Ps<sub>3</sub>-Ps<sub>5</sub>. Th II: **T1**, Mc number on series m<sub>1</sub>-m<sub>2</sub>; **T2**, Mc number on series a<sub>5</sub>-m<sub>5</sub>. Abd II: **A1**, Mc number on series a<sub>2</sub>-a<sub>3</sub>; **A2**, Mc number on series m<sub>3</sub>. Abd III: **A3**, Mc a<sub>1</sub> presence; **A4**, Mc number in series a<sub>2</sub>-a<sub>3</sub>-a<sub>4</sub>; **A5**, covers the m<sub>3</sub> Mc complex. Abd IV: **A6**, Mc number on series A<sub>1</sub>-E<sub>1a</sub>; **A7**, Mc number on series A<sub>2</sub>-E<sub>1</sub>; **A8**, Mc number on series A<sub>4</sub>-C<sub>4</sub>; **A9**, Mc number on series A<sub>6</sub>-B<sub>6</sub>; **A10**, Mc number on series A<sub>6</sub>-B<sub>6</sub>. **LP**, labral papilla presence and shape: 0 = absent, 1 = simple, smooth papilla, 2 = multispinose, 3 = seta-like projection. **ES**, G & H eyes, relative size compared to the E & F eyes: 1 = E&F, 2 as <E&F, **RA**, Ant/head diagonal: 1 as > or = 3, 2 as > or = 2 < 3, 3 as < 2. Claw: **CP**, distance of first paired ventral teeth from claw base, % in relation with total claw length; **CU**, same as CP for first unpaired; **CD**, dorsal tooth: 0 = absent, 1 = basal, 2 = internal teeth level, 3 = intermediate, 4 = duplicate. **D**, total number of differences between the species and *E. gruitati* sp. nov. (percentage as respects to all considered characters, in brackets). “?”, unknown (lack of data in an original description).

Species	H1	H2	H3	H4	H5	T1	T2	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	LP	ES	RA	CP	CU	CD	D
<i>E. dagestanicus</i> Jordana & Baquero, 2021 (in Baquero <i>et al.</i> 2012)	4	1	0	3	1b	1*	6*	2	4	0	2	1	0	2(3)	2*	1*	2	0*	1*	3	50-60	80*	3*	8 (35%)
<i>E. gruitati</i> sp. nov.	4	1	0	3	1b	3	2	2	4	0	2	1	0	2	1	2	2	1	2	3	50-54	70	2	-
<i>E. guthriei</i> (Mills, 1931)	4	1	0	2*	2*	4*	4*	2	4	0	2	1	0	2	1	0*	2	3*	2	2*	50	71	2	7 (30%)
<i>E. kalakaua</i> Carpenter, 1904	3*	2*	0	3	2*	4*	6*	2	4	0	2	1	4*	5*	3*	0*	4*	0*	2	1*	20*	60*	1*	15 (65%)
<i>E. kea</i> Christiansen & Bellinger, 1992	3*	2*	0	3	1a*	4*	4*	2	4	0	2	2*	0	3*	3*	1*	2	1	1*	?	57	76	3*	11 (50%)
<i>E. malena</i> (Christiansen & Bellinger, 1992)	4	1	0	3	1a*	1*	0*	2	5*	0	2	1	0	2	2*	2	2	2*	2	1*	41*	69	3*	9 (39%)
<i>E. mauna</i> Christiansen & Bellinger, 1992	3*	1	0	3	1a*	5*	6*	2	4	0	2	2*	0	4*	2*	3*	2	3*	2	2*	50	75	3*	10 (43%)
<i>E. mineola</i> (Folsom, 1924)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	3*	2	55	76	1*	2 (33%)
<i>E. puakea</i> (Christiansen & Bellinger, 1992)	5*	1	0	3	?	2*	5*	2	5*	0	2	1	0	2	2*	2	2	3*	2	3	47	67	3*	7 (31%)
<i>E. purpurascens</i> (Packard, 1873)	4	1	0	3	1a*	4*	6*	2	3*	0	2	1	0	2	2*	1*	2	1	2	2*	50	70	2	7 (31%)
<i>E. sotoadamesi</i> Jordana, Potapov & Baquero, 2011	4	1	0	3	1a*	4*	6*	2	5*	0	3*	0*	0	2	0*	2	3*	1	2	2*	50	70	2	9 (39%)



**FIGURE 3.** *Entomobryoides gruati* sp. nov. A, Th II–III, dorsal side—setal pattern; B, labial palp with setae A–E on papillae and accessory setae on B, D, E; C, ventral labium—setal pattern of labial triangle. Scale bars: A = 0.05 mm, B–C = 0.01 mm.

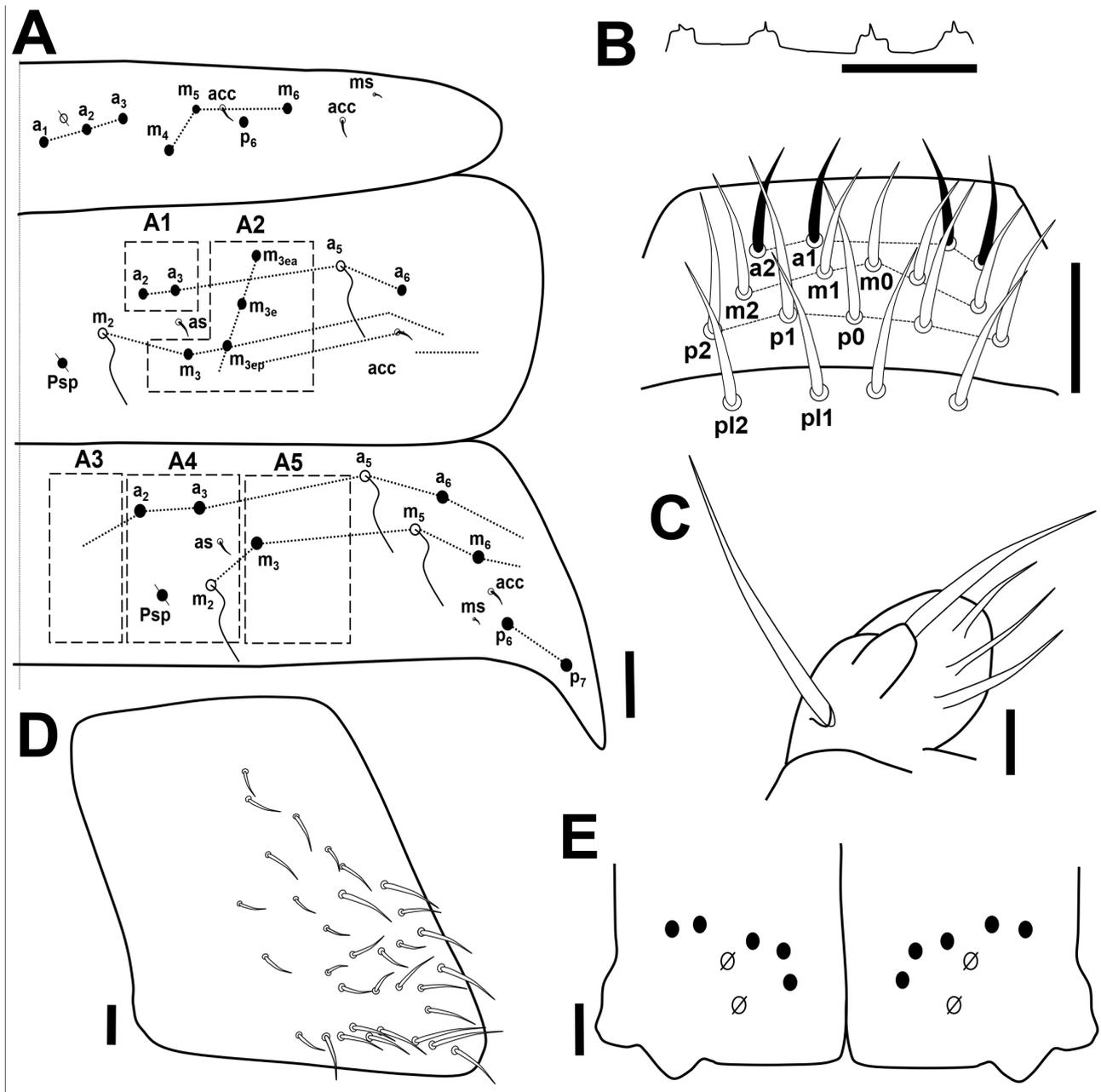
**Body.** Abd IV:III length ratio in holotype = 4. Trochanteral organ with approximately 29–33 setae (Fig. 4D). Tibiotarsus not sub-segmented, with a double row of appressed ciliated setae on all tibiotarsi. Claw (Fig. 5B) with 4 inner teeth: paired at 50–54% (one of them larger and forward), first unpaired at 70% from basis, and the last one closer than 90%; dorsal teeth present and at the level of lateral teeth. Empodium lanceolate, with serrated external lamella. Tenent hair is clavate, similar in length to the claw. Length of manubrium and dens in holotype as 0.47 and 0.52 mm, respectively. Manubrial plate with 5 setae and 2 pseudopores (Fig. 4E). Mucro with apical tooth slightly larger than subapical one, mucronal spine reaching the tip of the subapical tooth; not crenulated dental area about 2 times of the length of mucro (Fig. 5C). Simplified Mc formula: 4-1-0-3-1/4-7/2-4/0-2-1/0-2-1-2-2.

**Chaetotaxy of head.** Setal pattern of dorsal side of head as in figure 2A. H1 area with 3 Mc ( $An_2$ ,  $An_{3a1}$ , and  $An_3$  and an additional seta); H2 area with one Mc ( $A_5$ ); H4 area with 3 Mc ( $S_1$ ,  $S_3$ , and  $S_{4i}$ ); H4' area with 3 Mc ( $S_4$ ,  $S_5$ , and  $S_{5i}$ ); H5 area only with  $P_{s2}$  Mc.

**Chaetotaxy of mesothorax.** Dorsal setal pattern as in figure 3A. Area T1 with 4 Mc ( $m_1$ ,  $m_2$ ,  $m_{2i}$  and  $m_{2i2}$ ); T2 with 7 Mc ( $a_5$ ,  $m_4$ ,  $m_{4i}$ ,  $m_{4p}$ ,  $m_{4pi}$ ,  $m_{4pe}$ , and  $m_5$ ).

**Chaetotaxy of abdomen.** Dorsal setal pattern as in figure 4A & 5A. Abd I with 7 Mc, and with sensilla acc in two different positions, Abd II area A1 with 2 Mc ( $a_2$  and  $a_3$ ), area A2 with 4 Mc ( $m_3$ ,  $m_{3ep}$ ,  $m_{3e}$ , and  $m_{3ea}$ ); setae 'as' and 'acc' present; Abd III with Mc on A3 absent, area A4 with 2 Mc ( $a_2$  and  $a_3$ ) and one Mc on A5 ( $m_3$ ), 'acc' between  $m_6$  and  $p_6$ , 'ms' interior; Abd IV with Mc on A6 area absent, 2 Mc on A7 ( $A_3$  and  $B_3$ ), A8 with one Mc ( $B_4$ ), 2 Mc on A9 ( $B_5$  and  $A_5$ ), A10 with two Mc ( $A_6$  and  $B_6$ ); sensillar formula as 2,2/2,2,2,12–13,3; microsensillar formula: 1,0/1,0,1.

**Etymology.** The species is dedicated to Jean-Pierre Gruat, who played a major role in organizing the biospeleological expeditions to Turkmenistan. His continuous enthusiasm, time, and efforts were crucial in making these explorations possible.

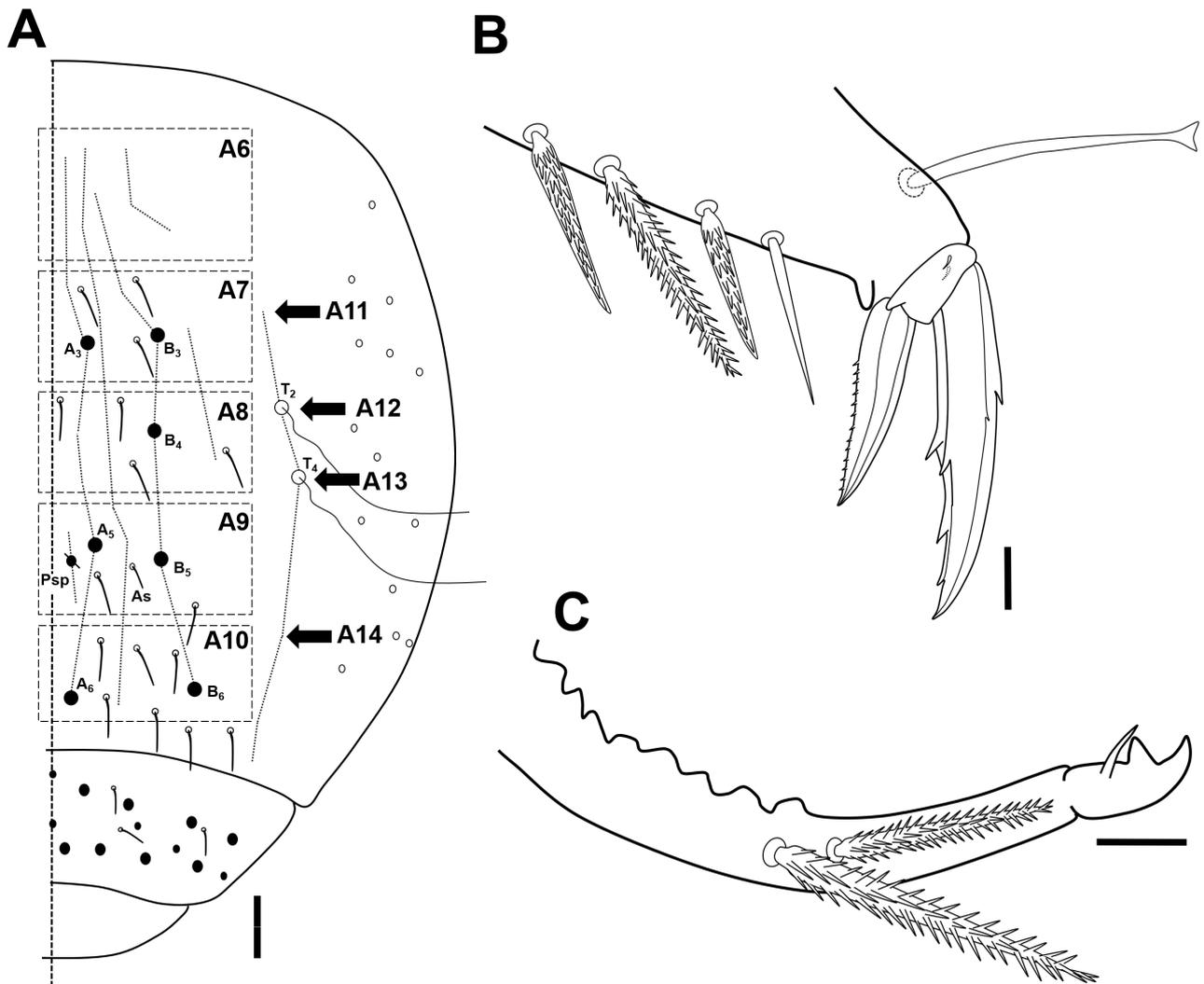


**FIGURE 4.** *Entomobryoides gruati* sp. nov. A, Abd I–III, dorsal side—setal pattern; B, labrum—setal pattern; C, maxillary palp; D, leg III, trochanteral organ; E, manubrium, ventral side—distal part of manubrial plate. Scale bars: A = 0.05 mm, B–E = 0.01 mm, D = 0.025 mm.

**Affinity to subterranean habitats.** Specimens of *E. gruati* sp. nov. were found to inhabit a dark zone of the Kattakamov Cave that represents in fact a complex of interconnected mining galleries artificially created in several levels inside the karst massif. The new species has full set of dark pigmented eyes, reduced body pigment and does not show any clearly troglomorphic character. Thus, it could be assigned to category of eutroglophiles, i.e. animals not strictly associated with subterranean habitats, but able to reproduce there.

**Remarks.** So far, 12 species of the genus *Entomobryoides* have been described worldwide (Bellinger *et al.* 1996–2025). In terms of dorsal macrochaetotaxy, the new species shows its closest resemblance to *E. dagestanicus* Jordana & Baquero, 2021, *E. guthriei* (Mills, 1931) and *E. kalakaua* Carpenter, 1904. Among these species, *E. kalakaua* differs from the *E. gruati* sp. nov. by 3 Mc in the H1 and 2 Mc in the H5 areas on dorsal side of head, whereas the new species has 4 Mc in H1 and only a single Mc ( $P_{s2}$ ) in H5 tergite area. *Entomobryoides guthriei* can

be distinguished from the new species by 2 Mc in H5 area, whereas the new species has only 1 Mc in this area. In addition, *E. guthriei* shows 4 Mc in the T2 area of Th II, while the new species has 7 Mc in the same area. Moreover, in *E. guthriei*, Mc in the A9 area of Abd IV are absent, in contrast to the new species, which has 2 Mc in this area (A<sub>5</sub> and B<sub>5</sub>). Also, *E. dagestanicus* differs from the *E. gruati* **sp. nov.** in 7 Mc in the T2 area of Th II, while the new species has 6 Mc there. In the A8 and A9 areas of Abd IV, *E. dagestanicus* has 2 (A<sub>4</sub> and B<sub>4</sub>) and 1 (B<sub>5</sub>) Mc, respectively, whereas the new species has 1 (B<sub>4</sub>) and 2 (A<sub>5</sub> and B<sub>5</sub>) Mc in these areas.



**FIGURE 5.** *Entomobryoides gruati* **sp. nov.** A, Abd IV–VI, dorsal side—setal pattern; B, claw, empodium and distal part of tibiotarsus; C, distal part of dens and mucro. Scale bars: A = 0.05 mm, B–C = 0.01 mm, D = 0.025 mm.

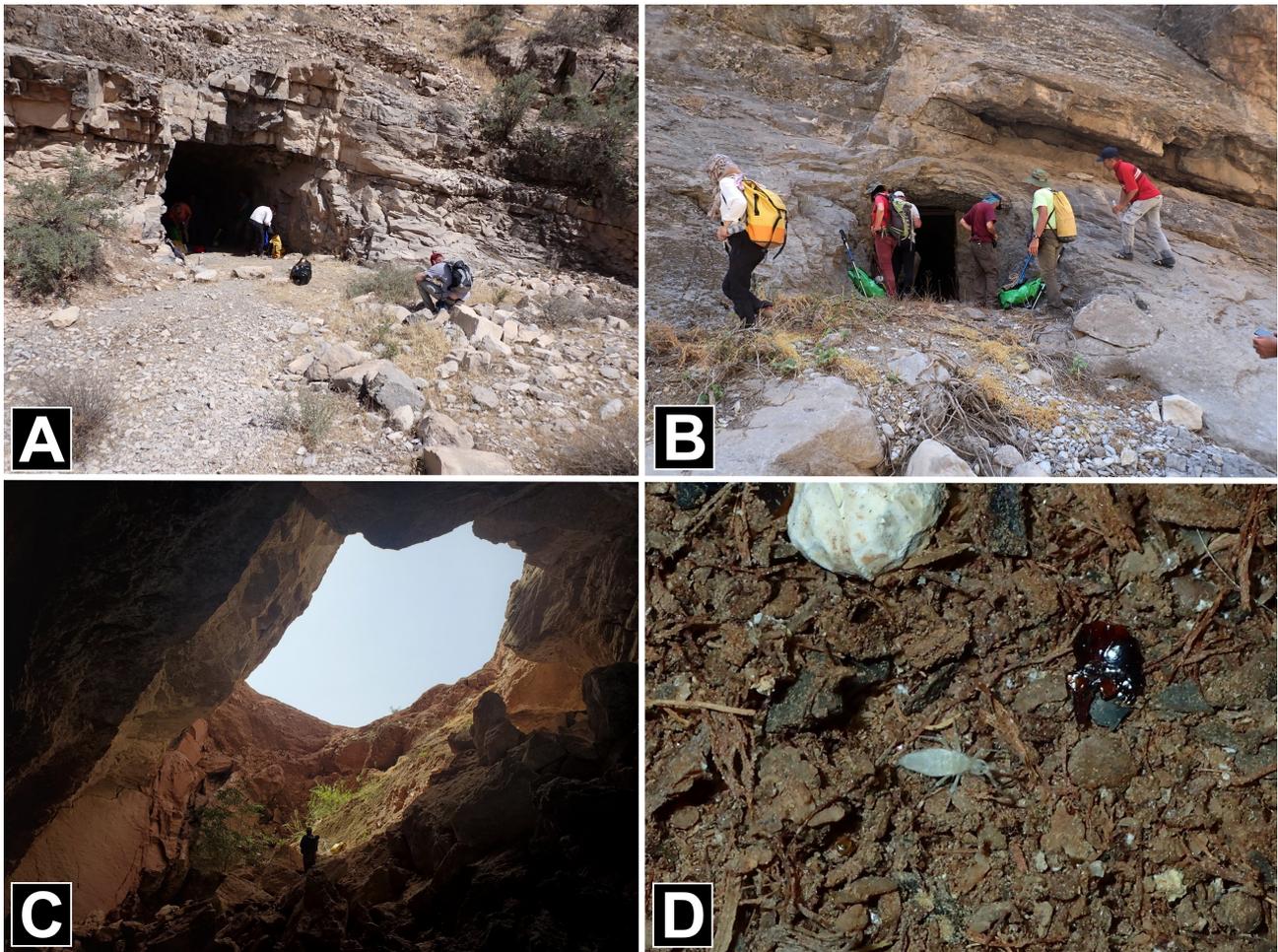
## Genus *Drepanura* Schött, 1891

### *Drepanura koytendagi* Mehrafrooz Mayvan & Kováč **sp. nov.**

(Figs 6D, 9–12, Table 2)

**Type locality.** TURKMENISTAN, Lebap Province, Koytendag District, v. Gurshun Magdanly (=Svintsovyi rudnik), Promezhutochnaya Cave, Coordinates: 37°38'35.37"N, 66°24'5.76"E, 670 m a.s.l.

**Type material.** *Holotype*: female on slide [PrDr115Tu], dark zone, hand collecting on bat guano, 18.v.2023, leg. J. Lips. *Paratype*: 10 specimens on slides [PrDr116Tu- PrDr125Tu], ibidem, 15.v.2023, leg. J. Lips. Holotype and paratypes deposited in CoPJSU.



**FIGURE 6.** A, Entrance of Gap-Gotan Cave (Photo: Bernard Lips); B, Entrance of Promezhutochnaya Cave (Photo: Bernard Lips); C, Entrance of Kaptarkhana Cave (Photo: Bernard Lips); D, *Drepanura koytendagi* sp. nov. in Kaptarkhana Cave (Photo: Josiane Lips).

**Additional material.** TURKMENISTAN, Lebap Province, Koytendag District, v. Gurshun Magdanly (=Svintsovyi rudnik), Kaptarkhana (Kaptarhana) Cave, Coordinates: 37°49'41.16"N, 66°24'37.62"E, 620 m a.s.l, 3 specimens on slides [KaDr126Tu- KaDr128Tu], dark zone, hand collecting, 16.v.2023, leg. J. Lips (CoPJSU).

TURKMENISTAN, Lebap Province, Koytendag District, v. Gurshun Magdanly (=Svintsovyi rudnik), Gap-Gotan (Kap Kutan) Cave, Coordinates: 37°38'29.65"N, 66°24'29.01"E, 740 m a.s.l, 3 specimens on slides [GADr129Tu- GaDr131Tu], dark zone, hand collecting, 10.v.2023, leg. J. Lips (CoPJSU).

**Description.** Body length (excluding antennae) 4.7 mm (n=17), up to 5 mm in Holotype. Ground colour white, antennae pale blue, and eye spots dark.

**Head.** Eight eyes, GH smaller in size to EF (Fig. 9B), G smaller than H and barely visible with a light microscope. Antennae longer than head, without scales. Antennae 2.92 times the length of the head, relative length of Ant I:II:III:IV in holotype as 1:3.3:0.93:0.8; Ant IV with apical vesicle; Ant III with sensory organ formed by 2 long-ovoidal sensilla and 3 additional guards sensilla (Fig. 9D); Labrum with 4 ciliated prelabral setae and 3 rows of 5, 5 and 4 smooth setae; subapical labral papillae 4, each with 7 secondaries apical spinules (Fig. 10B). Head ventrally with smooth setae. Labium setal pattern formed by 5 smooth setae ( $a_1$ – $a_5$ ) in anterior row; basal row with 5 ciliated setae  $M_1$ ,  $R_1$ , E,  $L_1$ ,  $L_2$  (Fig. 10C). Labial palp as in figure 11B, with 5 main papillae (A–E) with 0, 5, 0, 4, 3 guard setae respectively; papilla E conspicuously loop-shaped, deviating from the typical linear form; all guard setae of labial papilla finely ciliated except guard seta  $b_2$  on papilla B smooth. Right mandible with 4 teeth and left mandible with 5 teeth.

**TABLE 2.** Diagnostic characters of known *Drepanura* congeners.

Legend for the headers of the columns. Head (Fig 9A): **H1**, Mc number on series An<sub>2</sub>-An<sub>3</sub>; **H2**, Mc number on series A<sub>5</sub>-A<sub>7</sub>; **H3**, Mc S<sub>0</sub> presence; **H4**, Mc number on series S<sub>1</sub>-S<sub>3</sub>-S<sub>4</sub>; **H5**, Mc number on series S<sub>1</sub>-S<sub>3</sub>-S<sub>4</sub>. Th II: **T1**, Mc number on series m<sub>1</sub>-m<sub>2</sub>; **T2**, Mc number on series a<sub>5</sub>-m<sub>5</sub>. Abd II: **A1**, Mc number on series a<sub>2</sub>-a<sub>3</sub>; **A2**, Mc number on series m<sub>3</sub>. Abd III: **A3**, Mc a<sub>1</sub> presence; **A4**, Mc number in series a<sub>2</sub>-a<sub>2a</sub>-a<sub>3</sub>; **A5**, covers the m<sub>3</sub> Mc complex. Abd IV: **A6**, Mc number on series A<sub>1</sub>-E<sub>1a</sub>; **A7**, Mc number on series A<sub>3</sub>-E<sub>1</sub>; **A8**, Mc number on series A<sub>4p</sub>-C<sub>4</sub>; **A9**, Mc number on series A<sub>5</sub>-B<sub>5</sub>; **A10**, Mc number on series A<sub>6</sub>-B<sub>6</sub>. **LP**, labral papilla presence and shape: 0 = absent/ 1 = simple, smooth papilla, 2 = multispinose, 3 = seta-like projection; **ES**, G & H eyes, relative size compared to the E & F eyes: 1 = E&F, 2 as <E&F, RA, Ant/head diagonal: 1 as > or = 3, 2 as > or = 2 < 3, 3 as < 2. Claw: **CP**, distance of first paired ventral teeth from claw base, % in relation with total claw length; **CU**, same as CP for first unpaired; **CD**, dorsal tooth: 0 = absent, 1 = basal, 2 = internal teeth level, 3 = intermediate, 4 = duplicate. **MP**, Manubrial plaque. **D**, total number of differences between the species and *D. koytendagi* sp. nov. (percentage as respects to all considered characters, in brackets). “?”, unknown.

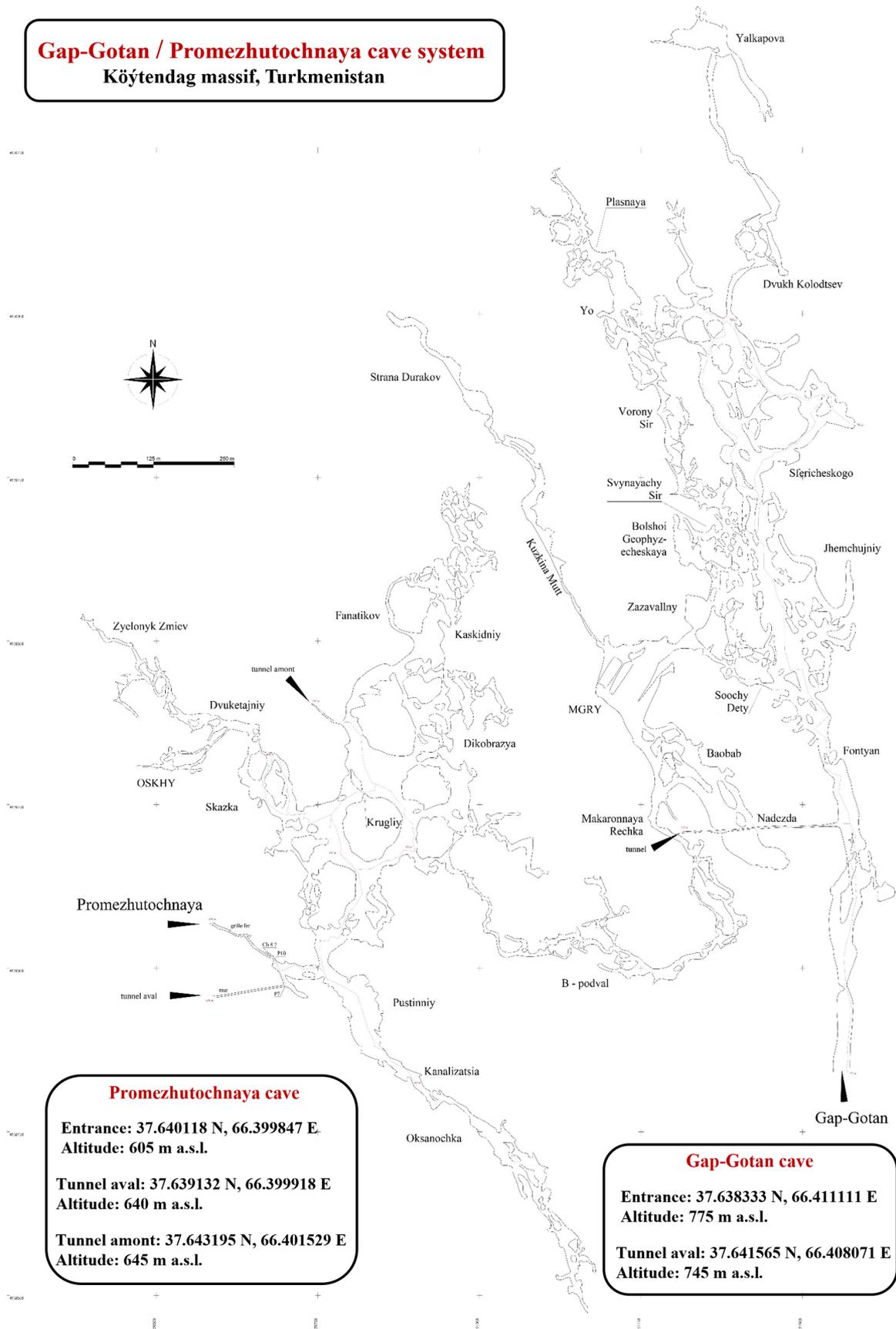
Species	H1	H2	H3	H4	H5	T1	T2	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	LP	ES	CP	CU	CD	MP	D
<i>D. albocoenulea</i> (Schött, 1917)	3*	1	0	2	2	3*	6*	2	2*	0	0*	1	25-29*	2	2	50*	70-80	2	2	50*	70-80	2	4 setae, 2 Psp*	8 (42%)
<i>D. aurifera</i> Salmon, 1941	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1 (50%)
<i>D. cingulinea</i> Womersley, 1934	3*	1	0	2	2	3*	4*	2	2*	0	0*	1	0	4	3	2	2*	2	2	50*	70*	1*	4 setae, 2 Psp*	10 (43%)
<i>D. citricola</i> Womersley, 1934	3*	1	0	2	2	3*	4*	2	2*	0	0*	1	0	2*	3	2	2*	?	2	40*	70*	1*	3 setae, 2 Psp*	11 (48%)
<i>D. cobaltina</i> (Schött, 1917)	?	?	?	?	?	2*	4*	2	2*	0	0*	1	22*	?	?	?	?	?	2	40*	60*	0*	?	8 (67%)
<i>D. coeruleopicta</i> (Schött, 1917)	3*	1	0	2	2	2*	2*	1*	2*	0	0*	1	0	1*	2*	2	2*	0*	2	?	?	?	3 setae, 2 Psp*	11 (55%)
<i>D. delibatica</i> Loksa & Bogojević, 1970	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	2	61*	79	0*	?	2 (50%)
<i>D. kirgisica</i> Martynova, 1971	3*	1	0	3*	1b*	3*	4*	2	4	0	2	1	0	1*	2*	2	2*	0*	2	58*	72*	0*	?	12 (55%)
<i>D. koytendagi</i> sp. nov.	4	1	0	2	2	4	7	2	4	0	2	1	0	4	3	2	3	2	2	77-79	80-83	2	6 setae, 2 Psp	-
<i>D. liuae</i> Ma, Chun & Greenslade, 2015	3*	1	0	2	2	3*	5*	1*	2*	0	1*	1	0	1*	2*	2	2*	0*	2	40-50*	70-80	0*	4 setae, 2 psp*	13 (57%)
<i>D. lombergi</i> (Wahlgren, 1899)	3*	1	0	3*	2	1*	4*	2	2*	0	2	1	0	1*	2*	2	2*	1*	1*	58*	74	0*	3 setae, 2 Psp*	13 (57%)

.....continued on the next page

TABLE 2. (Continued)

Species	H1	H2	H3	H4	H5	T1	T2	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	LP	ES	CP	CU	CD	MP	D
<i>D. ludmilae</i> Kaprus' & Szeptycki, 1992	2*	1	1*	3*	2	3*	5*	2	4	0	2	1	0	0*	3	2	2*	1*	1*	48*	74	2	4 setae, 2 Psp*	11 (48%)
<i>D. mongolica</i> Yosii, 1949	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	56*	74	2	?	1 (33%)
<i>D. montana</i> Martynova & Chikatunov, 1968	3*	1	0	3*	2	3*	7	2	5*	1*	2	2*	0	2*	2*	2	3	1*	2	60*	74	2	6 setae, 2 Psp	10 (44%)
<i>D. nubila</i> Barra & van Harten, 2009	3*	2*	0	2	3*	4	2*	1*	3*	0	1*	1	0	3*	0*	2	2*	?	?	?	?	2	?	10 (53%)
<i>D. pallens</i> Rusek, 1981	2*	1	0	2	2	3*	2*	1*	2	0	2	1	0	2*	3	1*	2*	1*	2	60*	67*	0*	3 setae, 1 Psp*	12 (52%)
<i>D. polychaeta</i> Ma, Chun & Greenslade, 2015	3*	1	0	2	2	2*	4*	2	14*	0	0*	1			53–61*		2	2	40*	70*	1*	5 setae, 2 Psp*	10 (53%)	
<i>D. quadrilineata</i> Stebaeva, 1973	3*	1	0	3*	2	3*	5*	2	4	0	2	1	0	0*	2*	2	2*	1*	2	50*	75	2	5 setae, 2 Psp*	10 (43%)
<i>D. sexmaculata</i> (Stach, 1963)	?	?	0	3*	2	3*	4*	2	4	0	2	1	0	0*	0*	1*	2*	1*	1*	65*	75	2	3 setae, 2 Psp*	11 (52%)
<i>D. sublateralis</i> Stach, 1963	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1*	1*	51*	81	0*	?	4 (80%)
<i>D. tuxeni</i> Nosek, 1964	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	64*	77	0*	?	?	2 (50%)
<i>D. vitorovi</i> Martynova, 1970	4	3*	0	3*	2	4	6*	2	5*	0	2	3*	0	7*	1*	1*	3	1*	2	51*	74	1*	10 setae, 2 Psp*	12 (52%)

**Gap-Gotan / Promezhutochnaya cave system**  
**Köytendag massif, Turkmenistan**



**FIGURE 7.** Ground plan of the Kap Gap-Gotan / Promezhutochnaya cave system (sketched by University of Bristol Spaeleological Society).

**Kaptarkhana (Kaptarhana) Cave**  
 Köýtendag, Lebap Province, Turkmenistan  
 Coordinates: 37.8281 N, 66.4104 E  
 True North: 4.72 degree Length 574 m Altitude: 620 m a.s.l.

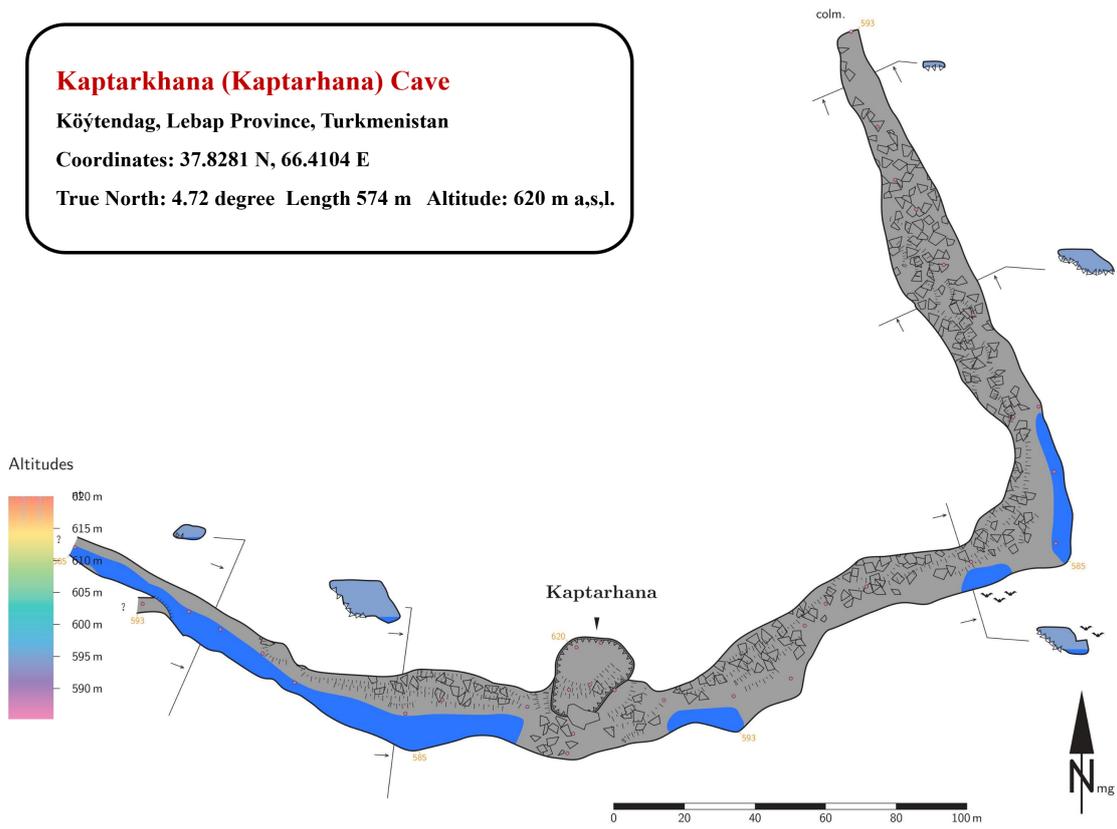


FIGURE 8. Ground plan of the Kaptarkhana Cave (sketched by Bernard Lips).

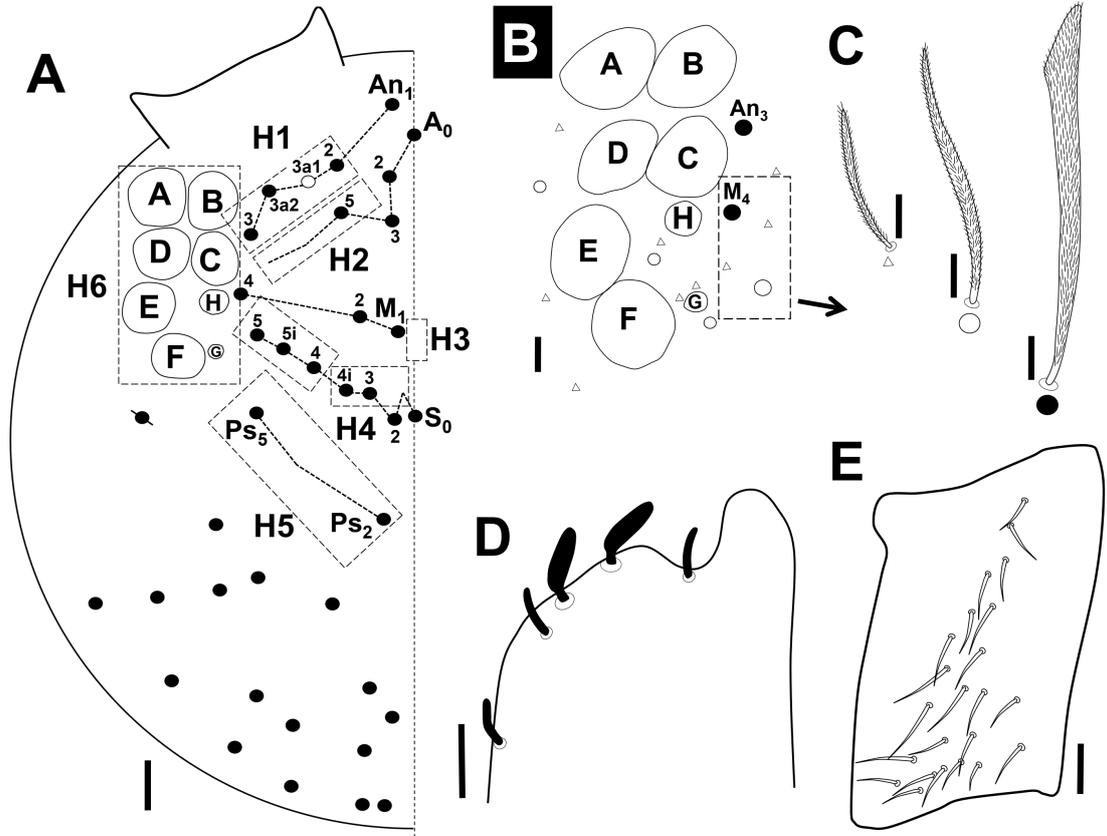


FIGURE 9. *Drepanura koytendagi* sp. nov. A, Head, dorsal side—setal pattern; B, eyes and interocular setal pattern; C, shape and size of macrosetae and mesosetae on head (hollow and black circles—Mc; triangles—mes); D, Ant III, distal area with sensory organ; E, leg III, trochanteral organ. Scale bars: A = 0.025 mm, B–E = 0.01 mm.

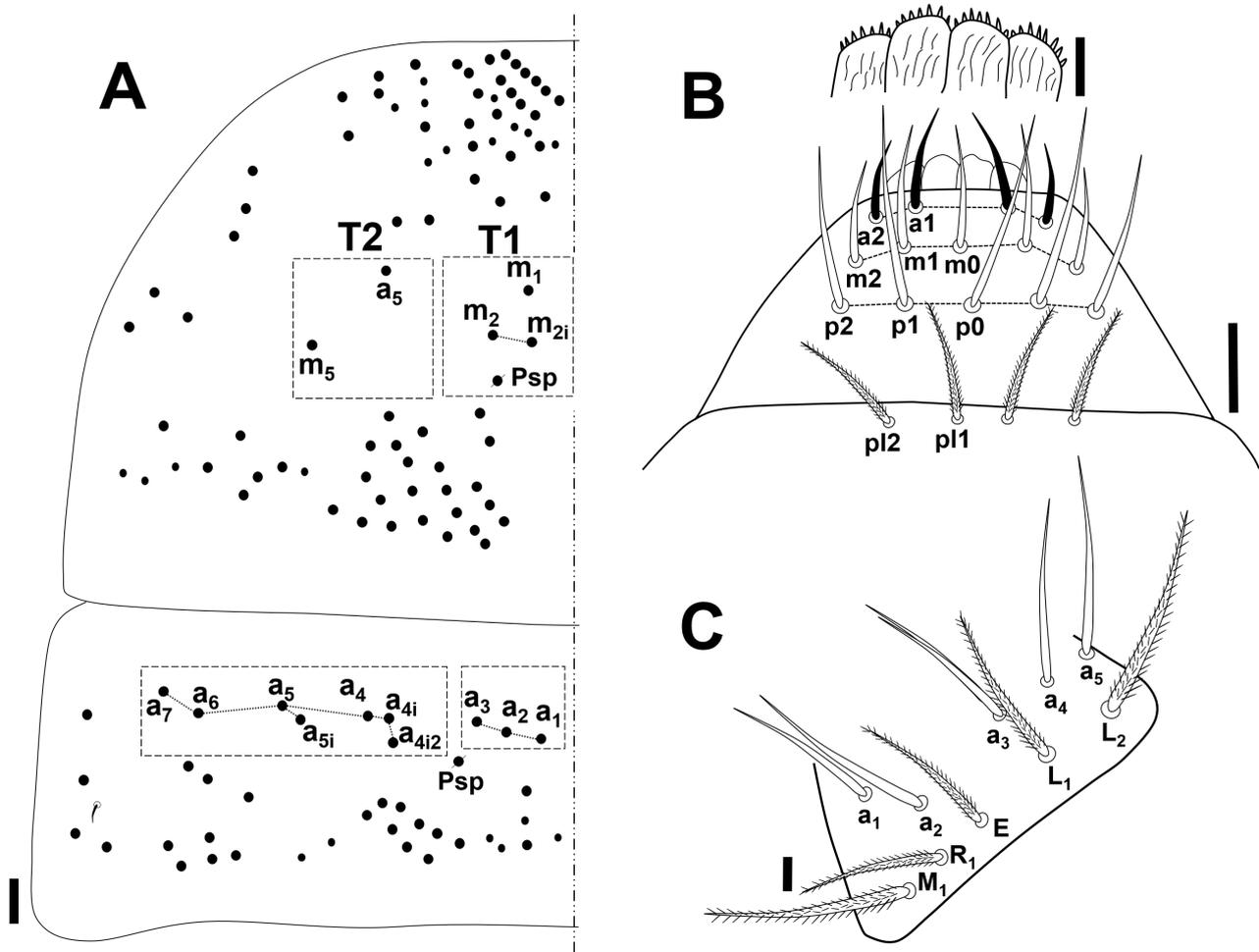


FIGURE 10. *Drepanura koytendagi* sp. nov. A, Th II–III, dorsal side—setal pattern; B, labrum with detail of its apical edge; C, labium—setal pattern of labial triangle. Scale bars: A = 0.05 mm, B–C = 0.01 mm.

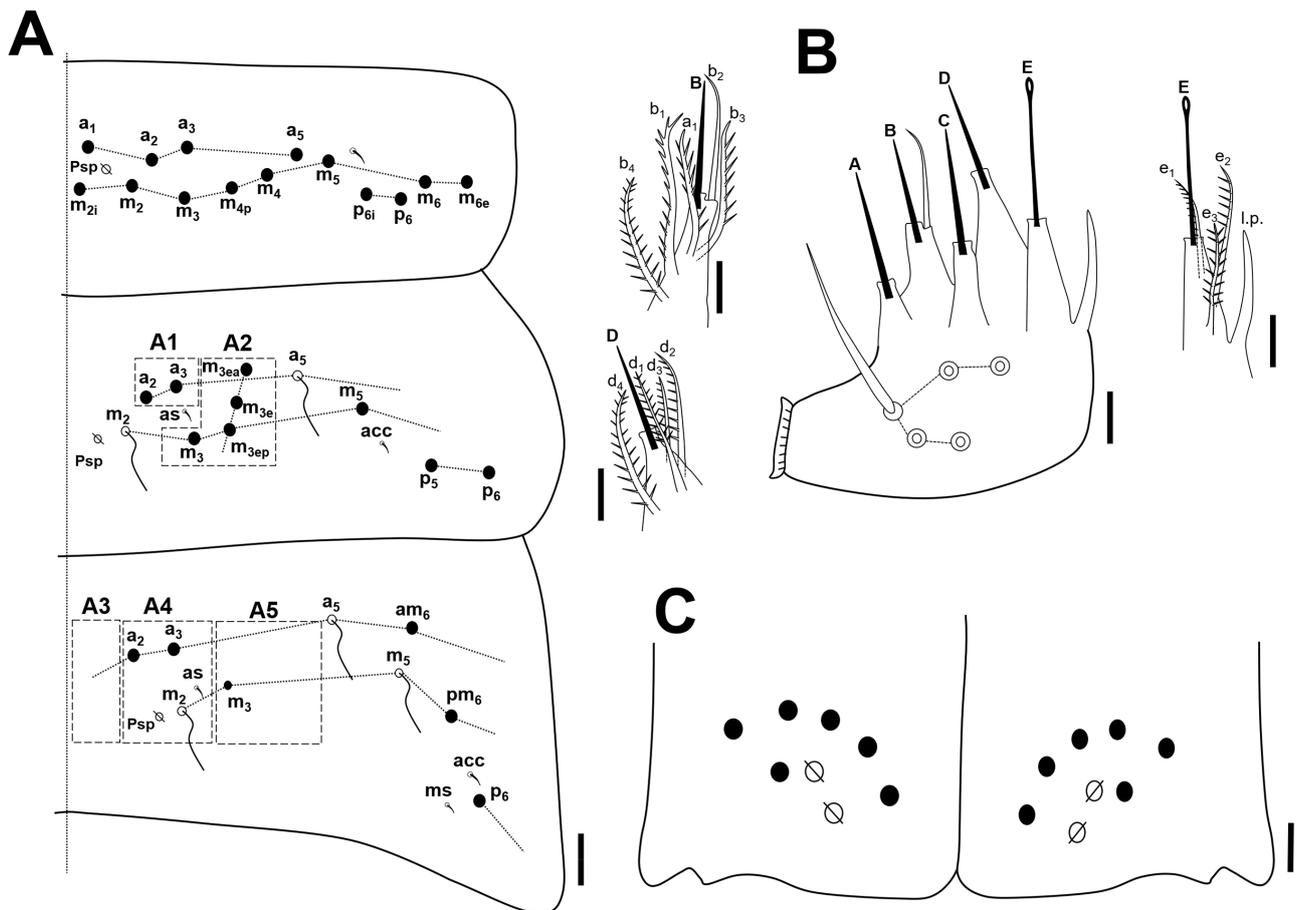
**Body.** Abd IV:III length ratio in holotype = 3.35. Trochanteral organ with approximately 23–26 setae (Fig. 9E). Tibiotarsus not sub-segmented. Claw (Fig. 12B) with 4 inner teeth: paired at 77–79%, first unpaired at 80–83% from basis, and the last one closer than 94%; dorsal teeth present and located at the level of lateral teeth. Empodium lanceolate, with serrated external lamella. Tenent hair is clavate, half of the length of the claw. Length of manubrium and dens in holotype as 0.71 and 0.86 mm, respectively. Manubrial plate with 6 setae and 2 pseudopores (Fig. 11C). Mucro falcate with mucronal spine; area not crenulated of dens about 1.8 times the length of mucro (Fig. 12C). Simplified Mc formula: 4-1-0-2-2/3-2/2-4/0-2-1/0-2-2-2-3.

**Chaetotaxy of head.** Setal pattern of dorsal head as in figure 9A. H1 area with 4 Mc ( $An_2$ ,  $An_{3a1}$ ,  $An_{3a2}$ , and  $An_3$ ); H2 area with one Mc ( $A_5$ ); H4 area with 2 Mc ( $S_3$  and  $S_{4i}$ ); H4' area with 3 Mc ( $S_4$ ,  $S_5$ , and  $S_{5i}$ ); H5 area with 2 Mc ( $P_{s2}$  and  $P_{s5}$ ).

**Chaetotaxy of mesothorax.** Dorsal setal pattern as in figure 10A. Area T1 with 3 Mc ( $m_1$ ,  $m_2$ , and  $m_{2i}$ ); T2 with 2 Mc ( $a_5$  and  $m_5$ ).

**Chaetotaxy of abdomen.** Dorsal setal pattern as in figure 11A & 12A. Abd I with 10 Mc ( $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_5$ ,  $m_{2i}$ ,  $m_2$ ,  $m_3$ ,  $m_{4p}$ ,  $m_4$ , and  $m_5$ ), Abd II area A1 with 2 Mc ( $a_2$  and  $a_3$ ), area A2 with 4 Mc ( $m_3$ ,  $m_{3ep}$ ,  $m_{3e}$ , and  $m_{3ea}$ ); Abd III without Mc on A3, area A4 with 2 Mc ( $a_2$  and  $a_3$ ) and one Mc on A5 ( $m_3$ ), 'acc' between  $p_{m6}$  and  $p_6$ , 'ms' interior; Abd IV without Mc on A6 area, A7 with 2 Mc ( $A_3$  and  $B_3$ ), A8 with 2 Mc ( $A_4$  and  $B_4$ ), A9 with 2 Mc ( $B_5$  and  $A_5$ ), A10 with 3 Mc ( $A_6$ ,  $A_{e7}$  and  $B_6$ ).

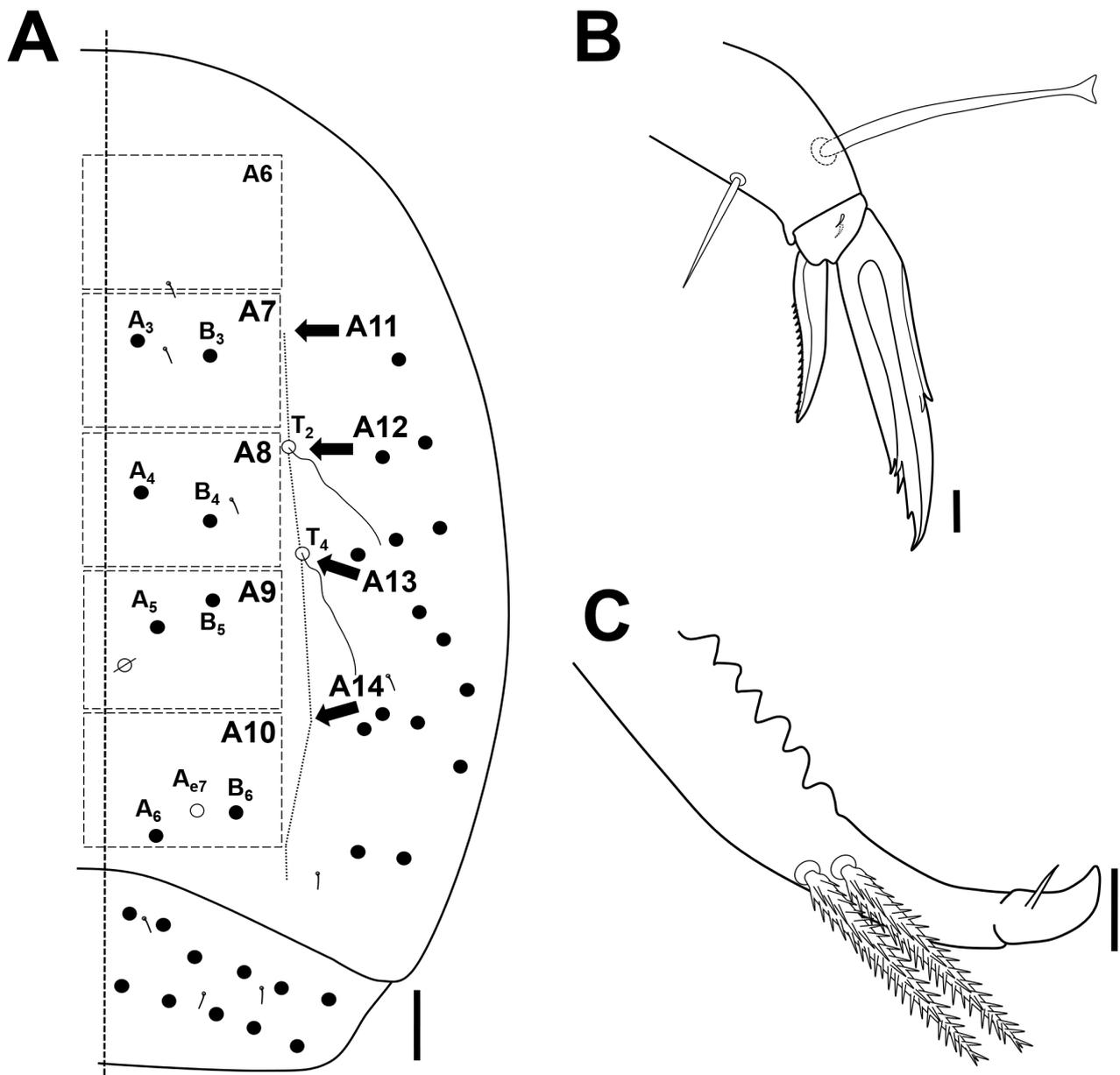
**Etymology.** The new species of the genus *Drepanura* is named after the Koytendag Mountains, a mountain range in the eastern Turkmenistan, where its *locus typicus* – Promezhutochnaya Cave — is situated.



**FIGURE 11.** *Drepanura koytendagi* sp. nov. A, Abd I–III, dorsal side—setal pattern; B, labial palp with setae A–E on papillae and accessory setae on B, D, E; C, manubrium, ventral side—apical part of manubrial plate. Scale bars: A = 0.05 mm, B–C = 0.01 mm.

**Affinity to subterranean habitats.** Specimens of *D. koytendagi* sp. nov. were collected in a dark zone of the Gap-Gotan–Promezhutochnaya cave system and Kaptarkhana gypsum cave. Part of the specimens were collected on bat guano, showing its affinity to this substrate. The new species is characteristic with relatively long antennae (three times longer than head), that can be considered as indication of troglomorphy. In addition, eye G is markedly diminished compared to other eyes, thus barely visible in a light microscope, showing a tendency to eye reduction not observed in other congeners. Regarding development of body pigmentation, the pigment is absent, except antennae that are pale blue. Based on the observed character states, the new species of *Drepanura* could be assigned to the category of troglobionts.

**Remarks.** Among 30 species of the genus described to date (Bellinger *et al.* 1996–2025), *D. koytendagi* sp. nov. shows the closest similarity in dorsal setal pattern to *D. quadrilineata* Stebaeva, 1973 and *D. sexmaculata* (Stach, 1963). The new species differs from *D. quadrilineata* in number of Mc on H1 area: *D. quadrilineata* has 3 Mc, while the new species has 4. In H4 area, *D. quadrilineata* has 4 Mc, while the new species has 2 Mc. Furthermore, *D. quadrilineata* has 3 Mc in T1 area on Th II and 5 Mc in T2 area, whereas the new species has 4 Mc in T1 and 7 in T2 areas. Additionally, the manubrial plate of *D. quadrilineata* contains 5 ciliated setae, whereas the new species has 6 ciliated setae. *Drepanura sexmaculata* differs from the new species in number of macrosetae on head: 4 Mc in H4 area, whereas the *D. koytendagi* sp. nov. has only 2 Mc there. Moreover, it differs from the new species in number of macrosetae on Th II: 3 and 5 Mc in areas T1 and T2, respectively, while there are 4 and 7 Mc, respectively, in the new species. In addition, it possesses 5 ciliated setae on the manubrial plate, compared to 6 ciliated setae in the new species.



**FIGURE 12.** *Drepanura koytendagi* sp. nov. A, Abd IV–VI, dorsal side of, setal pattern; B, claw and empodium; C, distal area of dens, and mucro. Scale bars: A = 0.05 mm, B–C = 0.01 mm, D = 0.025 mm.

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