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Campodeidae (Hexapoda: Diplura) from Kyrgyzstan, Central Asia, with the description of a remarkable new genus and species

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Abstract. Samples collected in Central Asia, Kyrgyzstan, have revealed a hitherto unknown diversity of Campodeidae (Diplura) in soil and cave habitats, including a new genus and species, *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov., *Turkmenocampa edaphica* Sendra & Sánchez-García sp. nov. and a previously recognized soil-dwelling species, *Campodea* (*Dicampa*) *catalana* Denis, 1930. *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov. was collected in the deep zone of an interesting geological and cultural cave, Ak-Turpak Cave, located near the western margin of Kadamjay District, Batken Province. This genus belongs to the subfamily Campodeinae, sharing the morphology of the pretarsus with *Eutrichocampa* and other related genera, but differing from them in the shape of the claws and the laminar lateral processes, in addition to its unique cupuliform organ and the macrosetal pattern on the thorax and abdomen. *Turkmenocampa edaphica* Sendra & Sánchez-García sp. nov. was

found in humid edaphic habitats, under stones or near roots, and is morphologically and geographically very similar to the cave-dwelling species *Turkmenicampa mirabilis* Sendra & Stoev, 2017, which occurs in an isolated cave in the nearby country of Turkmenistan.

Key words. Asia, biogeography, caves, soil fauna.

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Introduction

Diplurans are one of three groups of entognathous hexapods present in almost every soil, cave, or any other empty subsurface space, and represented with 1009 species in 141 genera (Sendra *et al.* 2021). The order Diplura is divided into ten families, of which Campodeidae Meinert, 1865, with 491 species, accounts for nearly half (49%) of the known species (Sendra *et al.* 2021). Despite their worldwide distribution, diplurans are virtually unknown in Central Asia. This vast geographical region covers an area of approximately 4 million square kilometres, stretching from the Caspian Sea (west) to the border of China (east), and from the southern borders of Russia (north) to the northern borders of Iran, Afghanistan, and China (south). Central Asia is politically composed of five independent countries, the former Soviet republics of Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan, and Turkmenistan. Only one taxon of Campodeidae has been recorded from all of Central Asia, the recently described *Turkmenocampa mirabilis* Sendra & Stoev, 2018 found in Kaptarhana Cave, an isolated habitat in Eastern Turkmenistan (Sendra *et al.* 2017). Two soil-dwelling species (*Campodea* (*Dicampa*) *sprovierii* Silvestri, 1932 and *Campodea* (*Campodea*) *fragilis* Meinert, 1865) have been described from the northern fringe of Iran (Azadbakhsh & Nozari 2016).

In this paper, a new genus and two new species are described. The first records of Campodeidae from Kyrgyzstan are provided; diplurans of the family Japygidae Haliday, 1864 were also collected but have not yet been studied. The new records presented here come from sampling conducted during two expeditions in Kyrgyzstan. The first sampling effort, carried out 10–24 Jul. 2019, was targeted especially at cave and non-cave arthropod fauna, and was conducted by a Spanish team guided by Kyrgyzstan speleologists. The second effort, carried out by a team of Brazilian and Kyrgyzstan researchers, took place 5–16 Aug. 2019, and aimed to sample cave invertebrates in order to understand how communities respond to habitat traits.

Material and methods

Study area

Although Kyrgyzstan is a highly mountainous country (from the southern Chatkal Mountains to the northern slopes of the Altái Mountains), it has variable landscapes ranging from vast deserts to shrublands (Fig. 1). As a result, it has areas with warm continental and cold desert climates, and only in the soils of the mountain relief have samples of diplurans been found, probably due to the hot weather at the time the expedition took place. In relation to caves, the first aim of both expeditions, the karst outcrops of Kyrgyzstan, include few natural caves distributed over an extensive karst area, about 30% of the country. However, its speleological potential is still poorly explored, especially due to the difficulties in accessing caves in the high mountains. The karst areas of Kyrgyzstan are mainly associated with Carboniferous and Devonian limestones.

Sampling and imaging

As previously mentioned, specimens from different species were found during two expeditions to Kyrgyzstan. In the first expedition, four caves and five external mountains areas were inventoried. Specimens were directly collected with a brush after sieving the soil samples and were stored in ethanol (70–75%). In the second expedition, eight caves were sampled by active search in 10-m transects and quadrants (1 m²), prioritizing locations such as organic deposits (e.g., guano piles) and potential microhabitats (e.g., under stones, moist soil, cracks, speleothems). Opportunistic sampling was also carried out throughout the caves in search of other invertebrates. Specimens of the new genus were collected with a fine brush moistened in 70% ethanol and were immediately transferred to vials containing 70% ethanol. These were the only Campodeidae found during the second expedition.

In the laboratory, specimens were washed with distilled water, mounted on a slide with Marc André II solution, and examined under a phase-contrast optical microscope (Leica DMLS). The illustrations were made with a drawing tube and measurements were taken with an ocular micrometer. To determine body length, specimens were mounted in toto and measured from the base of the distal macrochaetae on the frontal process to the supra-anal abdominal valve. Four specimens were coated with palladium-gold for SEM photography (Hitachi S-4900) and sensilla measurement.

Morphological study

The morphological descriptions and abbreviations follow Condé (1955). We use the term gouge sensilla for the concave-convexly shaped sensilla on the antennae (Bareth & Condé 1981).

Abbreviations for morphological measurements

For the position of macrosetae, we adopted the abbreviations of Condé (1955).

la = lateral-anterior
lp = lateral-posterior
ma = medial-anterior
post = posterior

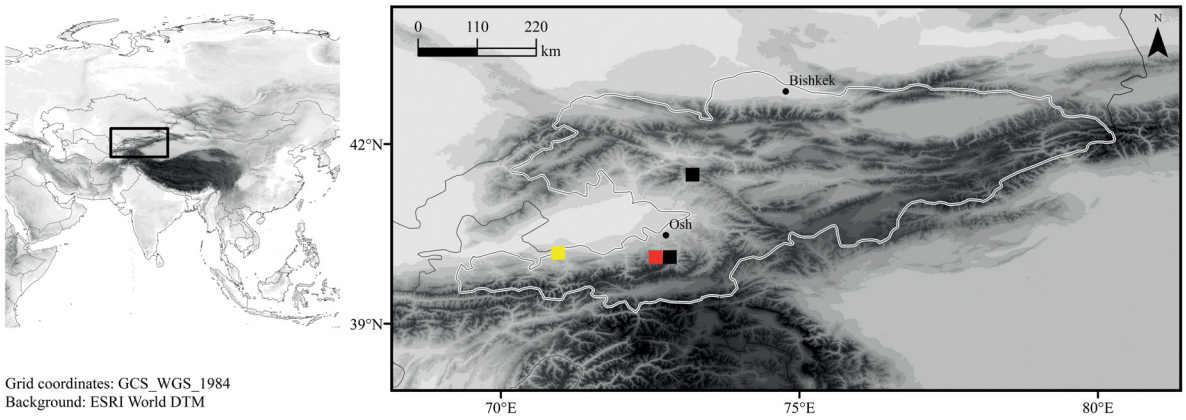

Fig. 1. Relief map of part of Asia with detail of Kyrgyzstan and adjacent regions with the localities at which diplurans were found; *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov. (yellow square); *Campodea* (*Dicampa*) *catalana* Denis, 1930 (red square); *Turkmenocampa edaphica* Sendra & Sánchez-García sp. nov. (black square).

Institutional abbreviations

The holotype, paratypes, and other specimens studied are housed in the following institutions:

Coll. AS = private collection of Alberto Sendra, València, Spain
IBB = Institute of Biology, Bishkek, Kyrgyzstan
ISLA = Coleção de Invertebrados Subterrâneos de Lavras, Lavras, Minas Gerais, Brazil
MZB = Museu de Ciències Naturals de Barcelona, Spain (MCNB)

Results

Class Diplura Börner, 1904
Superfamily Campodeoidea Lubbock, 1873
Family Campodeidae Meinert, 1865
Subfamily Campodeinae Condé, 1956
Genus *Campodea* Westwood, 1842
Subgenus *Dicampa* Silvestri, 1932

Campodea* (*Dicampa*) *catalana Denis, 1930

Campodea (*Dicampa*) *catalana* Denis, 1930: 28, figs 7–13.

Material examined

KYRGYZSTAN • 6 ♂♂, 11 ♀♀; Osh Province, Nookat District, Abshir Say River; 40º08′50″ N, 72º21′52″ E; alt. 1851 m; 21 Jul. 2019; Alberto Sendra leg.; endogean habitat near *Cupressus* tree; Coll. AS.

Remarks

Campodea (*Dicampa*) *catalana* is an abundant species in Western Mediterranean soil habitats. This finding seems to show a disjunct distribution on both sides of the Mediterranean region.

Genus ***Kyrgyzstancampa*** Sendra & Ferreira gen. nov.
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Type species

Kyrgyzstancampa sanare Sendra & Ferreira gen. et sp. nov.

Diagnosis

Sensilla of cupuliform organ paddle-shaped. Notal macrosetae pattern with 3+3 *ma*, *la*, and *lp* on pronotum and mesonotum. Femora with one dorsal macroseta and tibiae with one ventral macroseta. Claws subequal and regularly curved with ventral and lateral microspines. Laminar lateral processes striate on dorsal side with ridges surpassing apex and with short barbs on ventral side. Urotergites I–VII with up to 1+1 *la* and 2+2 *lp* macrosetae. First urosternite with 5+5 macrosetae, second to seventh urosternites with 3+3, and eighth urosternite with 1+1 macrosetae. First urosternite in males with glandular g_1, a_2 and a_1 setae; first urosternite in females with glandular a_1 setae.

Etymology

The genus name is a combination of ‘Kyrgyzstan’, the country where the material was found, and ‘campa’, a commonly applied suffix to dipluran generic names.

Kyrgyzstancampa sanare Sendra & Ferreira gen. et sp. nov.
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Figs 8–26

Etymology

The specific epithet is taken from the Latin 'sanare', meaning 'cure' and is related to the cave where the species was found, which is used for therapeutic purposes. This should be treated as a noun in apposition.

Type material

Holotype

KYRGYZSTAN • ♀; "holotype-♀ IBB 92101"; Ak-Turpak Cave; 40º10′35.18″ N, 71º03′45.36″ E; alt. 900 m; 12 Aug. 2019; R.L. Ferreira leg.; IBB 92101.

Paratypes

KYRGYZSTAN • 1 ♀, mounted in Marc André II solution; "paratype-♀01 MZB (MCNB) 2021-2338"; same collection data as for holotype; MZB (MCNB) 2021-2338 • 1 ♀, mounted in Marc André II solution; "paratype-♀02 Coll. AS"; same collection data as for preceding; Coll. AS • 1 ♂, mounted in Marc André II solution; "paratype-♂1 MZB (MCNB) 2021-2339"; same collection data as for preceding; MZB (MCNB) 2021-2339 • 1 ♂, mounted in Marc André II solution; "paratype-♂02 Coll. AS"; same collection data as for preceding; Coll. AS.

Other material

Two specimens with the same data as the holotype were mounted on an aluminium stage and coated with palladium-gold.

Description

Body. Length 3–3.9 mm (3–3.9 mm in females; 3.1 and 3.4 mm in males; 3.9 mm in holotype) (Figs 8–9). Epicuticle smooth under optical microscope on dorsal side of nota and legs, but, at high magnification, slightly reticulate with irregular polygonal structures of variable size (Figs 16–17). Body sparsely covered with short clothing setae bearing 0–3 tiny distal barbs.

Head. Two apparently intact antennae with 27–28 antennomeres; antennae 0.28–0.29 × length of body, with medial antennomeres 1.1 × as long as wide; apical antennomere 1.9 × as long as wide. Cupuliform organ with about eight plain paddle-shaped olfactory chemoreceptor sensilla, 7 µm long (Fig. 10). Distal and medial antennomeres with two whorls of barbed macrosetae and scattered smooth setae, plus 2–4 short thin gouge sensilla 8–9 µm long (Figs 11–12). Proximal antennomeres with typical trichobothria, plus small bacilliform sensillum 6–7 µm long on 3rd antennomere in ventral position (Figs 13–14). Plain frontal process with one anterior and three posterior smooth setae; length ratios of *a*/*p* 53/23 in holotype. Four short, smooth macrosetae along each side of antennomere insertion line with length ratios of *a*/*i1* and *i2*/*p* 11/15/14/11 in holotype; no *x* setae observed (Fig. 15). Small subtrapezoidal labial palp with small subcylindrical latero-external sensillum; two guard setae, up to three simple setae on anterior border, and up to 35 neuroglandular setae, as well as short and coniform palpiform sensillum, in holotype.

Thorax. Thoracic macrosetae distribution (Figs 16–18): pronotum and mesonotum with 1+1 *ma*, 1+1 *la*, 1+1 *lp* macrosetae; metanotum with 1+1 *ma* macrosetae. All macrosetae rather slender with short barbs along middle third; marginal setae similar to clothing setae (Fig. 17). Legs short, metathoracic legs reaching abdominal segment V, about 0.3 × length of body (Fig. 19). Large, deep joint between femur and tibia with longitudinal protrusion on inner side (Fig. 20). Femora I–III each with one middle-sized

Figs 2–9. Ak-Turpak Cave, Kadamjay District, Batken Region in Kyrgyzstan in Central Asia. **2**. Whitish, pinkish, or reddish clayey ground surface where the entrance is located. **3**. Entrance of the cave, exterior view. **4**. Entrance of the cave, interior view. **5**. Small platforms and mattresses near the entrance. **6**. Stairs installed deep inside the cave. **7**. Last chamber of the cave, which is always associated with old bat guano. **8**. Individual of *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov., observed amidst guano. **9**. Another specimen of *K. sanare* Sendra & Ferreira gen. et sp. nov.

dorsal macroseta with few distal barbs, slightly longer than ventral macroseta. Calcars slightly thickened with long barbs on one side. Tibiae I–III with one ventral macroseta with three or four distal barbs. Two rows of ventral barbed setae longer and thicker than clothing setae, with long thin barbs. Three smooth, distal dorsal tarsal setae longer than rest. Claws subequal, regularly curved, with tiny ventral and lateral microspines. Laminar lateral processes of pretarsus striated on dorsal side with ridges surpassing end of the apex, giving appearance of distal fringe, and with short barbs on ventral side (Figs 21–24).

Abdomen. Distribution of abdominal macrosetae on tergites: 1+1 *lp* on urotergite III; 1+1 *la*, 2+2 *lp* on urotergites IV–VIII; 3+3 *lp* on abdominal segment IX; 5+5 macrosetae on abdominal segment X; all macrosetae long, with thin barbs along distal half. Urosternite I apparently with 5+5 macrosetae (Figs 25–26); urosternites II–VII with 3+3 macrosetae; urosternite VIII with 1+1 macrosetae; long-sized urosternal macrosetae with few distal barbs. Stylus with apical seta with two long basal teeth, subapical seta and ventromedial seta, each bearing a row of barbs along distal half, more abundant on ventromedial setae.

Cerci. 0.71 × length of body (on a cercus apparently intact in the holotype), with basal article divided into four secondary articles plus 11 primary articles; each primary article with central constriction bearing whorl of long macrosetae with thin barbs on distal part and one or two whorls of thin smooth setae; each primary article ending in whorl of thin setae, including apical article.

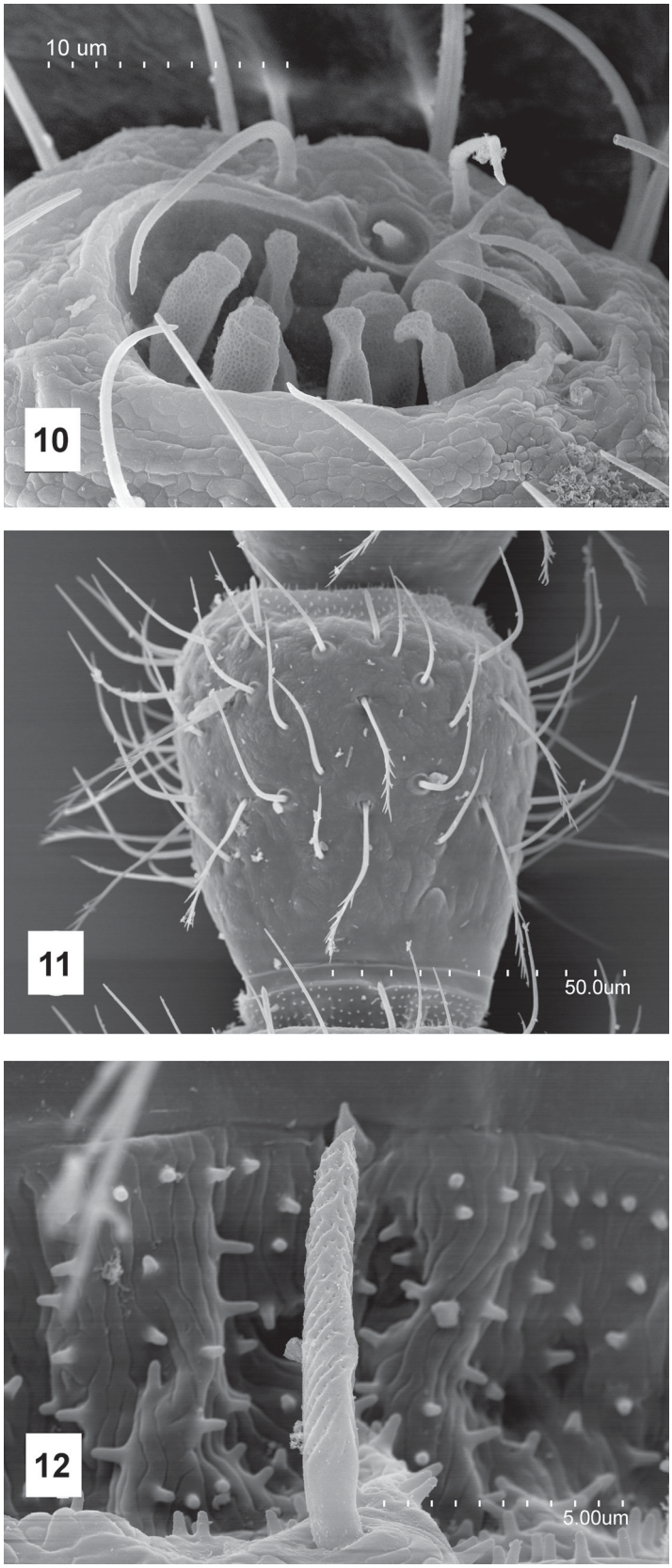
Secondary sex characters. Female urosternite I with short subcylindrical appendages, each bearing up to 11–13 glandular a_1 setae in distal field (Fig. 27). Male urosternite I with elongated subtrapezoidal appendages, each bearing up to 8 glandular a_1 setae in distal field and larger posterior field with up to 70 glandular a_2 setae; posterior edge of first urosternite with field of up to 44 glandular g_1 setae arranged in two rows (Fig. 25).

Type locality

Kyrgyzstan, Kadamjay District, Batken Region, Ak-Turpak Cave, gypsum cave located south of Ak-Turpak village; 40º10′35.18″ N, 71º03′45.36″ E.

Habitat

The specimens were observed only in the deep zone of Ak-Turpak Cave, located near the western margin of the Kadamjay District, Batken Province, Kyrgyzstan, which is located about 2.5 km south of the village of Ak-Turpak (northwestern part of Alai Mts.). The name of the locality means 'white land' in the local Turkish dialect and reflects the prevalence of the whitish, pinkish, or reddish clayey ground surface. Its entrance is located about 400 m from the right bank of the river Sokh (Kozheshken) (Fig. 2), approximately 40–50 m a.s.l. The Sokh River divides the northern macroslopes of the Turkestan Mt Range and Alai (or Alay) Mt System. This area can also be considered as the southern edge of the Fergana Depression. The cave entrance is surrounded by a hilly relief, without any tops above 1000 m a.s.l. in a one-kilometre-neighbourhood. The landscape surrounding the Kyzyl-Unkuyr Cave is quite dry (Figs 2−3), with only sparse shrubby vegetation typical of rocky outcrops, where the soil is extremely shallow when present. On the other hand, the Sokh River floodplain, located quite close to the cave, is moist although it is currently very altered due to the presence of crops and small villages. However, suitable habitats for soil invertebrates certainly occur along this floodplain. It is worth mentioning that although *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov. was found in a cave, it does not show any troglomorphic morphological characters. Thus, it is likely that the species is not troglobitic, although further sampling in the external area surrounding the cave (especially along the floodplain of the Sokh River) is needed to confirm this hypothesis.

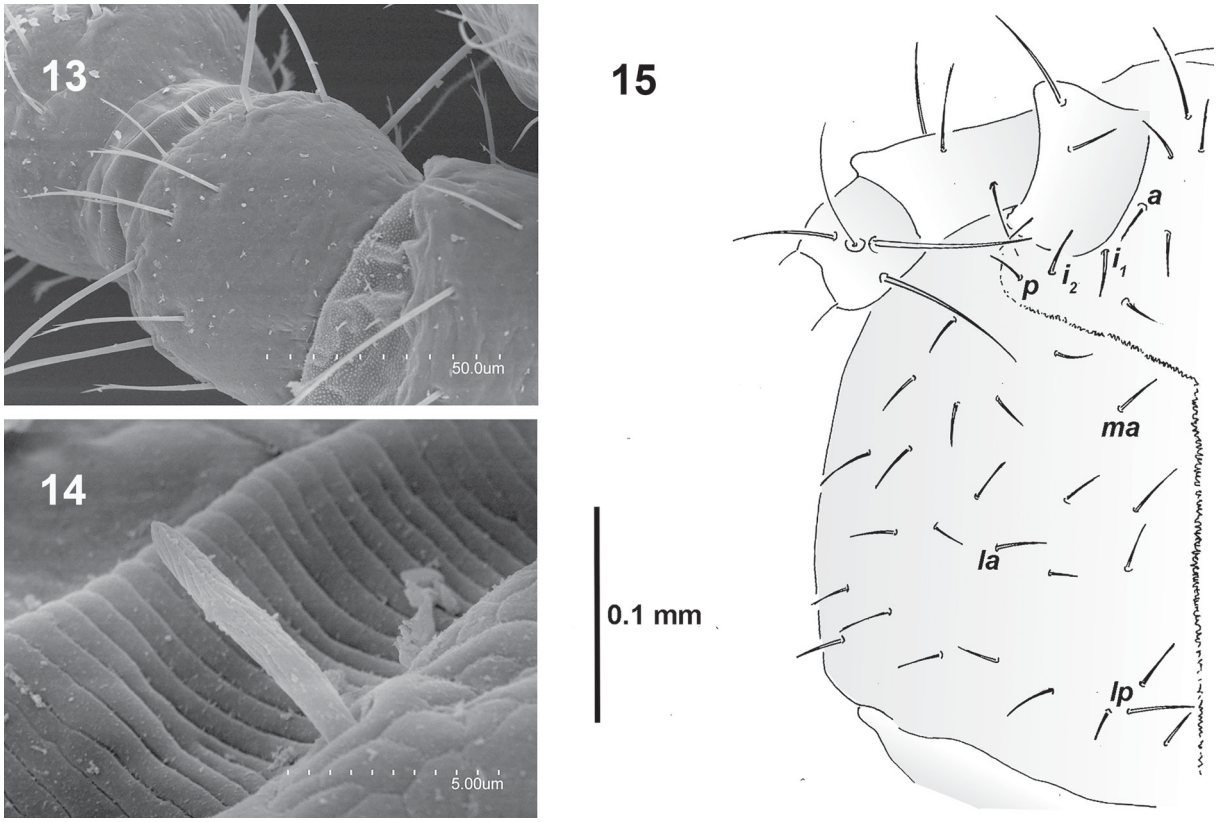


Figs 10–12. *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov., ♂, paratype (Coll. AS). **10**. Cupuliform organ in the last antennomere. **11**. Medial antennomere. **12**. Gouge sensillum.

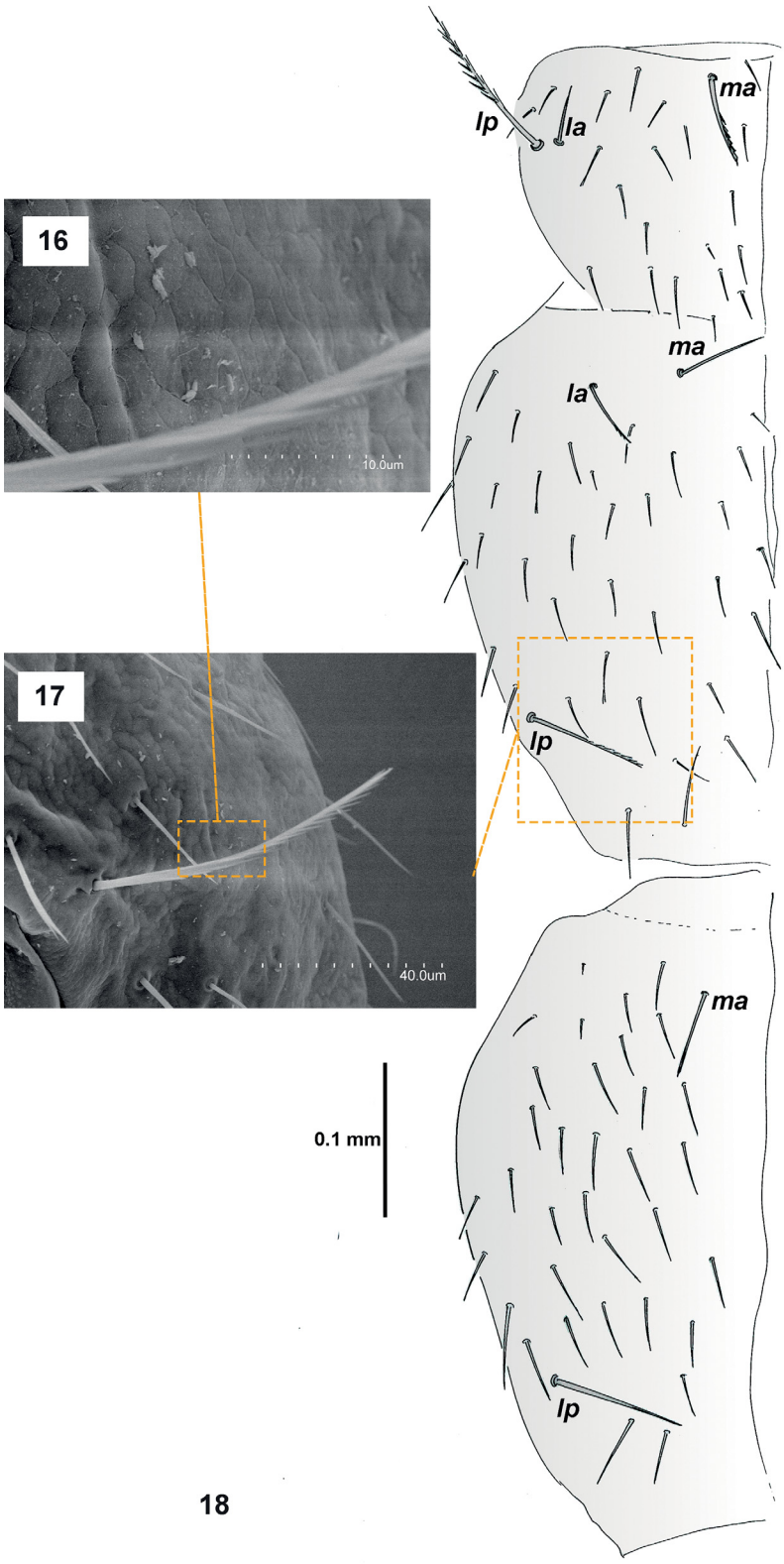
The Ak-Turpak cave has a single entrance, where a metallic structure was installed to safeguard and protect the cave's entrance (Figs 3−4). From the entrance inwards, stairs were built to facilitate access for visitors. The cave gallery is comparatively simple and oriented east-northeast, with 137 m of linear extension and about 40 m deep (Gvozdetskij 1981; Dudashvili & Mikhailyov 1990). The area of the cave was estimated to be 2400 m^2 and the volume is 8393 m^3 (Mamatkulov 1978). The cave is situated in a gypsum stratum (Gvozdetskij 1981) in the trough zone, where karstified rocks are represented by gypsum, marls, marlstones, limestones, and dolomites of Cretaceous and Paleogene ages (Beloglazova & Smirnova 1987; Sultanov 1972). The origin of all karst forms in Southern Fergana is related to tectonic faults and sedimentary breccias, and they often developed as a result of repeated and sometimes overlapping karst processes (Sultanov 1972).

In the upper part of the cave conduit, there is a noticeable proportion of soft marl that is somewhat dilapidated (during the last 5–10 years, this part of the gallery was equipped with a cement staircase and the walls were partly reinforced with rubble masonry panels to reduce dust and for balneological and recreational use). In the deeper parts of the gallery, the cave vaults are formed by fine-crystalline selenite (calcium sulphate dihydrate $CaSO_4 \bullet 2H_2O$) of several, sometimes contrasting, colour shades. The north side of the cave is preferentially formed by argillite. The atmosphere of the Ak-Turpak cave is rather dry and there are no traces of thermokarst processes (Dudashvili & Mikhailyov 1990); however, the cave vaults are somewhat crumbled after recent earthquakes.

Over the last decades, local residents (≈ 100–330 per year) have used the cave for therapeutic purposes (respiratory treatments: asthma, bronchitis, etc.) as word of mouth on the cave's 'healing properties'

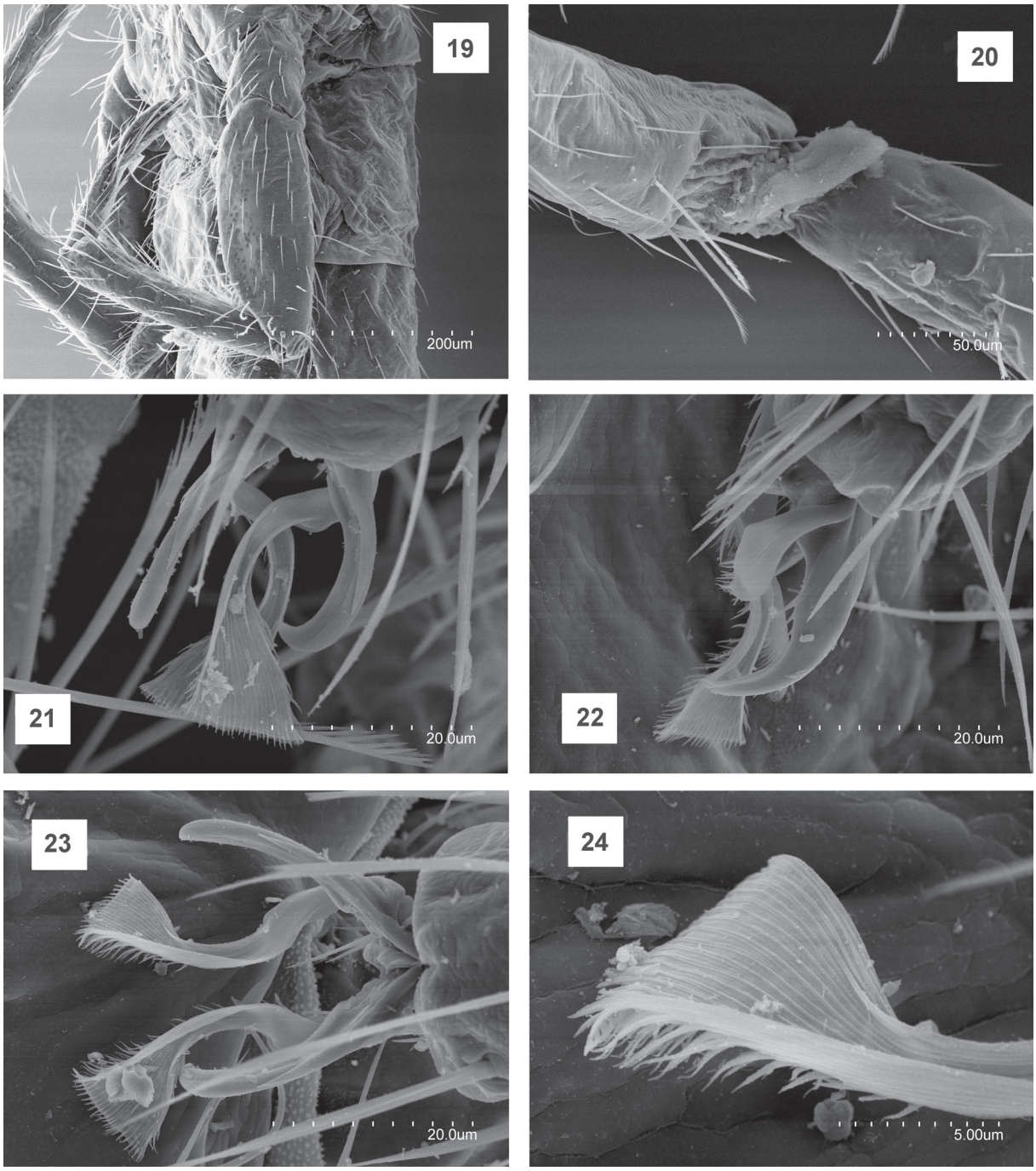


Figs 13−15. *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov. **13**. ♂, paratype (Coll. AS), 3rd antennomere. **14**. ♂, paratype (Coll. AS), sensillum of 3rd antennomere. **15**. ♀, holotype (IBB 92101), left portion of the head at dorsal view.



Figs 16–18. *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov. **16**. ♂, paratype (Coll. AS), detail of mesonotum. **17**. ♂, paratype (Coll. AS), detail of lateral posterior mesonotum. **18**. ♀, holotype (IBB 92101), thoracic nota.

has spread among them. Hence, one can see, especially in the entrance, small platforms and mattresses (Fig. 5). Visitors mostly use the entrance area, but stairs have also been installed deep inside the cave (Fig. 6), in which some mattresses were observed, indicating that the entire cave has been used for

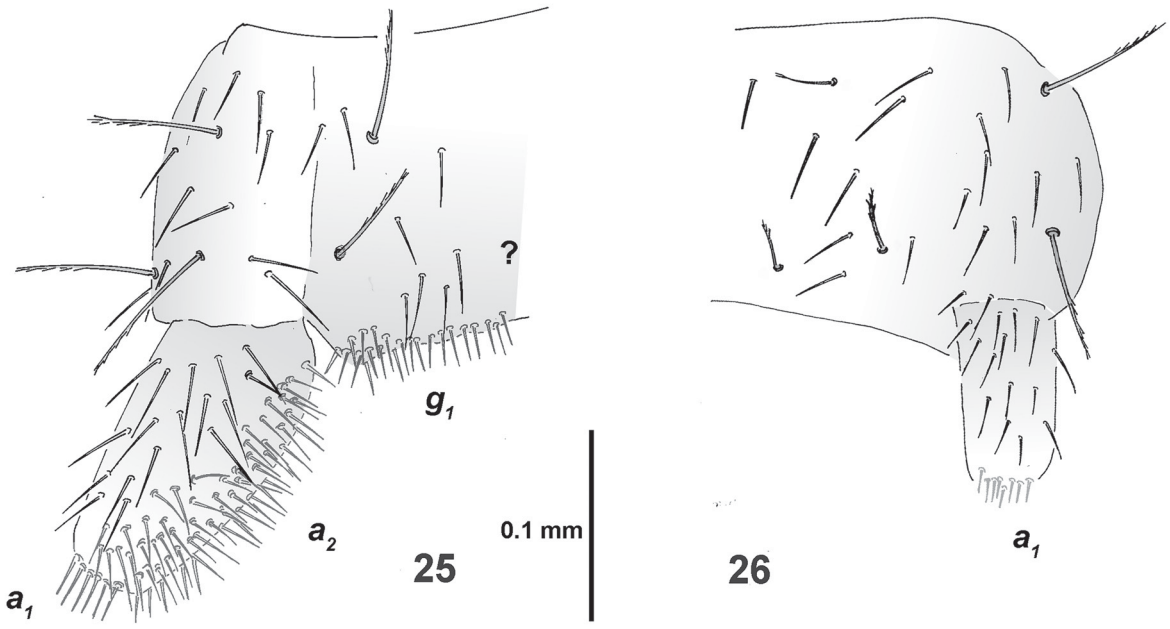


Figs 19–24. *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov., ♂, paratype (Coll. AS). **19**. Lateral view of end portion of metathorax and first and second abdominal segments with methatoracic legs. **20**. Large, deep joint between femur and tibia with a longitudinal protrusion on the inner side in a metathoracic leg. **21**. Lateral view of pretarsus in metathoracic leg. **22**. Lateral view of pretarsus in metathoracic leg, here they observed the ventral spines on the claws. **23**. Dorsal view of pretarsus in metathoracic leg. **24**. Detail of lateral processes on pretarsus.

therapeutic purposes. Specimens of *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov. were only found in the last chamber of the cave, and always associated with old bat guano (Fig. 7). Several individuals were observed amidst the guano (Figs 8−9), rapidly escaping when disturbed. In these cases, they tended to enter the small spaces between the chitin fragments observed in the pile, so it was difficult to capture specimens without injuring them. The only organic resource observed inside the cave was bat guano from species of *Rhinolophus* Lacépède, 1799 (horseshoe bats) and a few organic materials left by visitors (such as cardboard pieces and wood). The cave is not well preserved as many accesses were built, thus deeply altering the pristine substrates. However, considering the lack of troglomorphic traits in the species (indicating that the cave is not its unique habitat) and given that apparently few visitors access the deeper parts of the cave, the species does not appear to be threatened.

Phyletic affinities

Kyrgyzstancampa Sendra & Ferreira gen. nov. has similarities with several species of the paraphyletic genus *Eutrichocampa* Silvestri, 1902. In his diagnosis of *Eutrichocampa*, the tarsus ends abruptly instead of being acuminate towards the apex, which he considered to be a feature differentiating *Eutrichocampa* and *Campodea* (Silvestri 1902). For more than a century, several authors have been adding species to this genus, such as Wygodzinsky (1941, 1943), Condé (1947, 1994), Ionsecu (1955), Loksa (1960), García-Gómez (2016) and also Silvestri (1931a, 1932a, 1932b, 1933a), resulting in the current fifteen species of *Eutrichocampa* (Sendra *et al.* 2021). These species were described from localities scattered in the Americas, Africa, Asia, and Europe. In all of these contributions, the entire pretarsus shape is referred to as the differential character for *Eutrichocampa*: regularly curved claws with laminar or subcylindrical lateral processes with abundant barbs. Since Wygodzinsky (1941), *Eutrichocampa* has been considered a heterogeneous genus showing a wide variation in macrosetal patterns on the thorax and abdomen, including the presence or absence of dorsal macrosetae on the femora. In spite of the effort made by Condé (1956) to keep *Eutrichocampa* as a homogeneous taxon, several authors (including



Figs 25−26. *Kyrgyzstancampa sanare* Sendra & Ferreira gen. et sp. nov., urosternite I, lateral side. **25**. ♂, paratype (MZB (MCNB) 2021-2339). **26**. ♀, paratype (MZB (MCNB) 2021-2338). Abbreviations: a_1 = glandular setae in distal portion of appendages; a_2 = lateral-ventral glandular setae; g_1 = posterior glandular setae of urosternite.

Condé himself) have tried to arrange it into several genera and subgenera (Paclt 1957), proposing other genera with the same pretarsus trait and thoracic macrosetae of the *Campodea* pattern; for instance, *Parallocampa* Silvestri, 1933b with eleven species from North America, and *Remycampa* Condé, 1952, with two species from northwest Africa and the Canary Islands, and four monotypic genera: *Allocampa* Silvestri, 1931b from Cuba; *Edriocampa* Silvestri, 1933a from the South Aegean islands and Anatolian Peninsula; *Libanocampa* Condé, 1955 from Lebanon and Anatolia; and *Pseudolibanocampa* Xie & Yang, 1991 from Guangdong and Yunnan in China. In 1957, Paclt proposed an artificial arrangement of *Eutrichocampa* by dividing it into four subgenera and the genus *Leniwytsmania* Paclt, 1957 for two species, both from China: *L. orientalis* (Silvestri, 1931a) and *L. helvetica* (Wygodzinsky, 1941). Our proposal of *Kyrgyzstancampa* Sendra & Ferreira gen. nov. is another effort to unravel the diversity within the subfamily Campodeinae, in which this new genus can be included.

Several characters define *Kyrgyzstancampa* Sendra & Ferreira gen. nov., such as the pretarsus with a regularly curved claw with tiny ventral and lateral microspines; the laminar lateral processes, striated on the dorsal side with short barbs on the ventral side (Figs 21–24); a unique femur-tibia joint; the macroseta pattern on the nota: 3+3 *ma*, *la*, *lp* macrosetae on the pronotum and metanotum, 2+2 *ma*, *lp* on the metanotum plus one dorsal femoral macroseta; and 1+1 *la* and 2+2 *lp* on urotergites IV–VIII. Other notable features are the sparse clothing setae on the body, the plain paddle-shaped sensilla on the cupuliform organ, and the secondary sexual characters on the first urosternite. This combination of characters delineates *Kyrgyzstancampa* Sendra & Ferreira gen. nov. from other genera of Campodeinae and all species of *Eutrichocampa*. The closest species to *K. sanare* Sendra & Ferreira gen. et sp. nov. seems to be *Eutrichocampa birabei* Wygodzinsky, 1943, described from San Antonio de Arredondo, Córdoba in Argentina. Both share the shape of the pretarsus, the distribution of macrosetae on the nota and urotergites, and a dorsal macroseta on the femora. However, *K. sanare* Sendra & Ferreira gen. et sp. nov. and *E. birabei* differ in the number of urotergal macrosetae and in the secondary sexual characters of the first urosternite. Furthermore, reuniting both species in *Kyrgyzstancampa* Sendra & Ferreira gen. nov. would be a far-fetched approach, and new material on the South American species will be necessary to provide a more accurate description.

Subfamily Plusiocampinae Paclt, 1957
Genus *Turkmenocampa* Sendra & Stoev, 2017

Turkmenocampa edaphica Sendra & Sánchez-García sp. nov.
urn:lsid:zoobank.org:act:6B28F41D-4B21-4E3C-A9B6-23FA7F8B0E17
Figs 27−31

Etymology

The specific epithet refers to the habitat of the new species.

Type material

Holotype

KYRGYZSTAN • ♀; "holotype-♀07 MZB (MCNB) 2021-2340"; Jalal-Abad Region, Suzak Province, Kara Alma; 41º15′59″ N, 73º22′43″ E; alt. 1661 m; 16 Jul. 2019; A. Sendra leg.; endogean habitat near tree roots; MZB (MCNB) 2021-2340.

Paratypes

KYRGYZSTAN • 1 ♂, mounted in Marc André II solution; "paratype-♂01 MZB (MCNB) 2021-2341"; same collection data as for holotype; MZB (MCNB) 2021-2341 • 1 ♂, mounted in Marc André II

solution; "paratype-♂02 Coll. AS"; same collection data as for preceding; Coll. AS • 1 ♀, mounted in Marc André II solution; "paratype-♀05 Coll. AS"; same collection data as for preceding; Coll. AS • 1 ♀, mounted in Marc André II solution; "paratype-♀08"; same collection data as for preceding; Coll. AS • 1 ♀, mounted in Marc André II solution; "paratype-♀09 Coll. AS"; same collection data as for preceding; Coll. AS • 1 ♀, mounted in Marc André II solution; "paratype-♀10 MZB (MCNB) 2021-2342 paratype"; same collection data as for preceding; MZB (MCNB) 2021-2342 • 1 ♀; "♀01-paratype MCB (MCNB) 2021-2343"; Osh Province, Nookat District, Abshir Say River; 40º08′50″ N, 72º21′52″ E; alt. 1851 m; 21 Jul. 2019; A. Sendra leg.; endogean habitat near *Cupressus* tree; MCB (MCNB) 2021-2343 • 1 ♀; "paratype-♀02 MZB (MCNB) 2021-2344"; same collection data as for preceding; MZB (MCNB) 2021-2344 • 1 ♀; "paratype-♀03 Coll AS"; same collection data as for preceding; Coll AS • 1 ♀; "paratype-♀04"; same collection data as for preceding; Coll. AS • 1 juv.; "paratype-J01 Coll AS"; same collection data as for preceding; Coll AS • 1 juv.; "paratype-J02 Coll AS"; same collection data as for preceding; Coll AS.

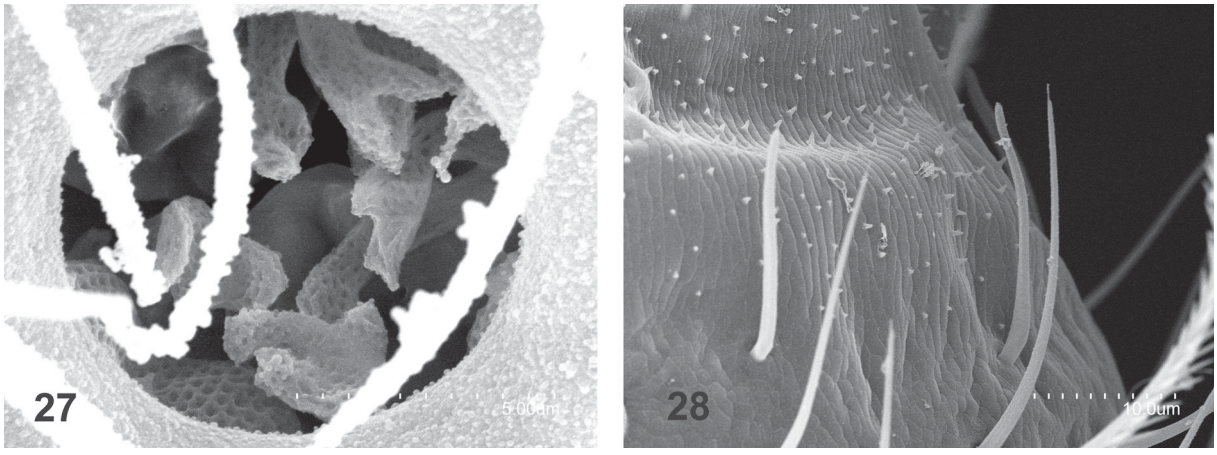
Other material

KYRGYZSTAN • 2 specs, mounted on an aluminium stage and coated with palladium-gold; same collection data as for holotype; Coll. AS.

Description

Body. Length 3.0 and 3.1 mm in two males, 3.5–4.8 mm in nine females, 2.2 and 2.3 mm in two juveniles (Table 1). Epicuticle smooth under optical microscope but slightly reticulated at high magnifications with irregular polygonal structures of variable size. Body with short to middle-sized smooth clothing setae.

Head. Antennae with 25–30 antennomeres in 10 complete intact antennae; antennae 0.6–0.8 × length of body in adults and 0.9 × in juveniles (Table 1). Medial antennomeres 1.4 × as long as wide, apical antennomere 2.3 × as long as wide. Cupuliform organ with about ten oviform sensilla of types I and II and an unknown number of tree-shaped sensilla (type III) in this olfactory complex (Fig. 27). Distal and central antennomeres with five whorls of barbed macrosetae and scattered smooth setae, plus single distal whorl of about ten short, thin gouge sensilla 15–18 µm long (Fig. 28). Proximal antennomeres with typical trichobothria, plus small and slightly shallow, 7 µm long sensillum on 3rd antennomere in ventral position.



Figs 27–28. *Turkmenocampa edaphica* Sendra & Sánchez-García sp., ♂, paratype (Coll. AS). **27**. Cupuliform organ in the last antennomere. **28**. Medial antennomere with gouge sensilla.

Plain frontal process with one frontal and two posterior macrosetae with length ratios a/p 45/30; three macrosetae along each side of insertion line of antennomere and setae x with thin distal barbs; length ratios a/i/p/x 28/38/27/30 in paratype ♀05 IBB-92102. Occiput of the head dorsally with 6+6 macrosetae, including 3+3 *la*, *lp* and *mp* macrosetae, longer than clothing setae and with few distal barbs. Large suboval labial palps each with microsensillae on the surface, small shallow latero-external sensillum, two guard setae, and up to ten clothing setae in anterior position, with up to 120 neuroglandular setae in medial and posterior positions, in holotype.

Thorax. Thoracic macroseta distribution: pronotum and mesonotum with 1+1 *ma*, 1+1 *la*, 2+2 *lp* macrosetae; metanotum with 1+1 *ma*, 2+2 *lp* macrosetae. All macrosetae long and slightly thickened, with barbs along distal five-fourths of each seta; marginal setae up to twice as long as and thicker than clothing setae, well barbed near base (Fig. 29). Metathoracic legs reaching abdominal segment VI, about 0.3–0.4× as long as body length (Table 1). Femora II–III each with one long, thick dorsal macroseta with barbs along distal half and with two long ventral macrosetae. Calcars with long barbs along one side. Tibiae I–III with two short, thick ventral macrosetae with barbs along distal two-thirds. Two rows of ventral barbed setae. Three smooth, dorsal distal tarsal setae longer than rest. Subequal claws with

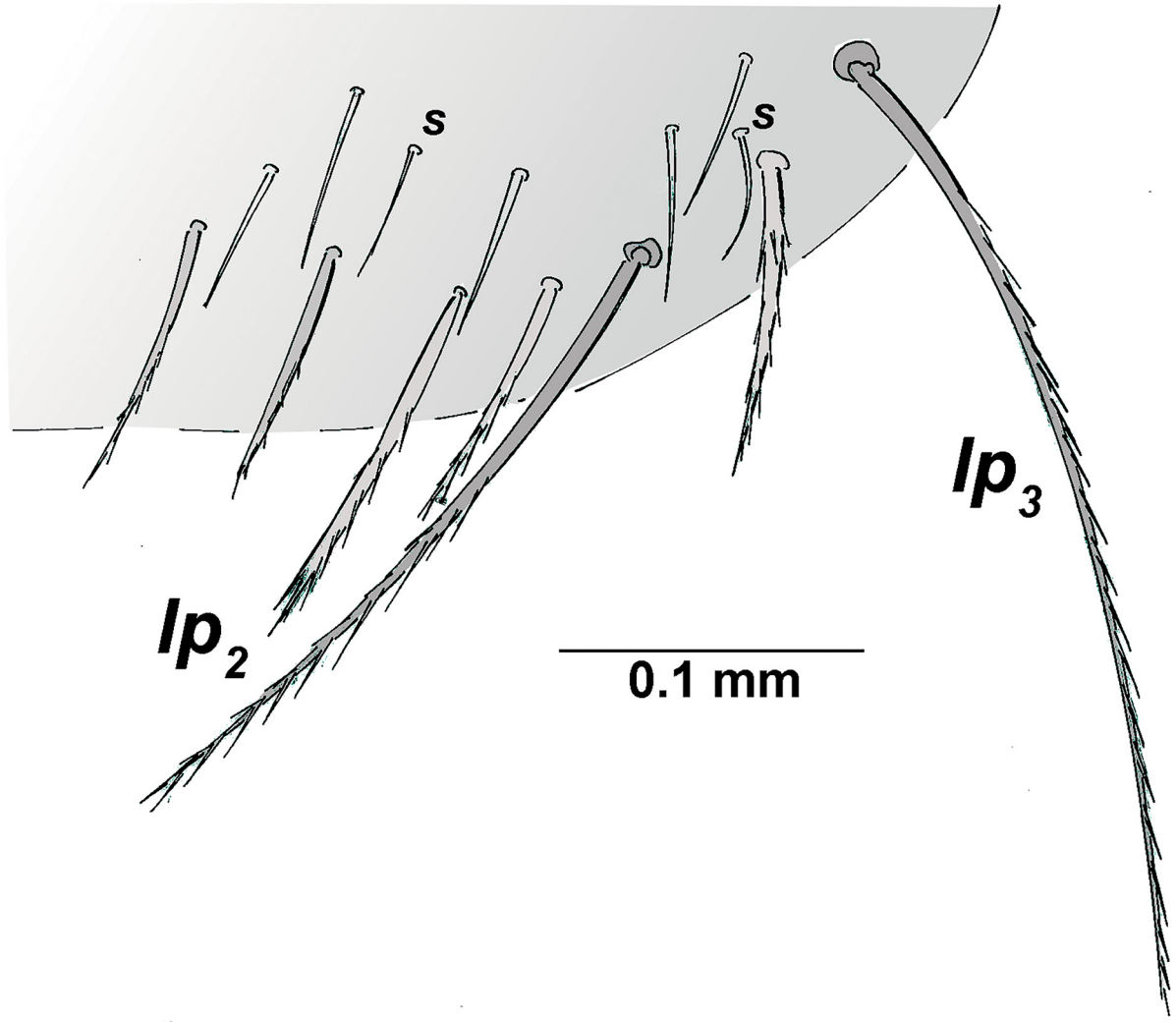


Fig. 29. *Turkmenocampa edaphica* Sendra & Sánchez-García sp. nov., ♀, holotype (MZB (MCNB) 2021-2340), lateral posterior view of mesonotum.

Table 1. *Turkmenocampa edaphica* Sendra & Sánchez-García sp. nov., length of body, antennae, metathoracic legs, and cerci (measured in mm); and number of antennomeres, cercal articles, and number of glandular a_1 setae on the first urosternite appendages.

Specimen	Body length	Antennae		Metathoracic legs	Cerci		Glandular a_1 setae
		Length	No. of antennomeres		Length	No. of articles	
J02-paratype (Coll. AS)	2.2	2.0	30	1.0	–	–	17
J01-paratype (Coll. AS)	2.3	2.0	29	1.1	–	–	18
♂01-paratype (MZB (MCNB) 2021-2341)	3.0	2.0	26	1.1	–	–	22
♂02-paratype (Coll. AS)	3.1	1.8	25	1.0	1.9	5 (b3)	19
♀10-paratype (Coll. AS)	3.3	2.3	26	1.2	–	–	38
♀03-paratype (Coll. AS)	3.8	–	–	1.2	–	–	39
♀08-paratype (Coll. AS)	4.0	2.9	26	1.7	–	–	47
♀01-paratype (MZB (MCNB) 2021-2343)	4.2	3.4	30	1.5	–	–	32
♀07-holotype (Coll. AS)	4.3	3.0	26	1.6	–	–	58
♀04-paratype (Coll. AS)	4.4	–	–	1.5	3.8	7 (b3)	45
♀02-paratype (MZB (MCNB 2021-2344)	4.5	2.8	29	1.5	–	–	38
♀05-paratype (Coll. AS)	4.8	3.0	25	1.9	3.1	7 (b3)	49
♀09-paratype (Coll. AS)	4.8	3.4	26	1.9	–	–	64

large basal half with tiny dorsal spines and distal half curved and thinner. Laminar processes of pretarsus smooth on dorsal side and with long, thin, ending curved and with enlarged on ventral side.

Abdomen. Distribution of abdominal macrosetae on tergites: 1+1 $post_1$ on I–II; 2+2 $post_{1–2}$ on III; 4+4 $post_{1–4}$ on IV–VII; 5+5 $post_{1–5}$ on VIII; and 7+7 $post_{1–7}$ on abdominal segment IX. All tergal abdominal macrosetae long, thick and short, with thin barbs along the distal fourth-fifths.

Urosternite I with 8+8 macrosetae (Figs 30−31); urosternites II–VII with 4+4 macrosetae; urosternite VIII with 1+1 macrosetae; urosternal macrosetae of medium length or longer, with long barbs in single row along distal one-fourth to three-fourths. Stylus with apical seta, subapical seta and ventromedial seta with few long barbs arranged in one row along distal half to four-fifths. Cerci 0.6–0.85 × length of body, with 5 and 7 primary articles, not counting multi-divided basal article (Table 1). Each primary article covered with unarranged whorls of barbed macrosetae and typical whorl of short setae with tiny distal barbs.

Secondary sex characters. Female first urosternite with slightly thickened cylindrical appendages, each bearing microsensillae and 32–64 glandular a_1 setae in a distal field (Table 1; Fig. 31). Male first urosternite with short subcylindrical appendages, each bearing microsensillae and 19–22 glandular a_1 setae in distal field (Table 1; Fig. 30).

Type locality

Kyrgyzstan, Kara Alma Village, Suzak Province, Jalal-Abad Region, 41º15′59″ N, 73º22′43″ E, 1661 m a.s.l.

Habitat

The morphological features and locations where *Turkmenocampa edaphica* Sendra & Sánchez-García sp. nov. has been found are congruent with those of a soil-dwelling species. In all cases, the species

has been found in endogean habitats: under stones or among tree roots, always in humid places at 1661 m a.s.l. and 1851 m a.s.l., which is an average elevation for this mountainous country.

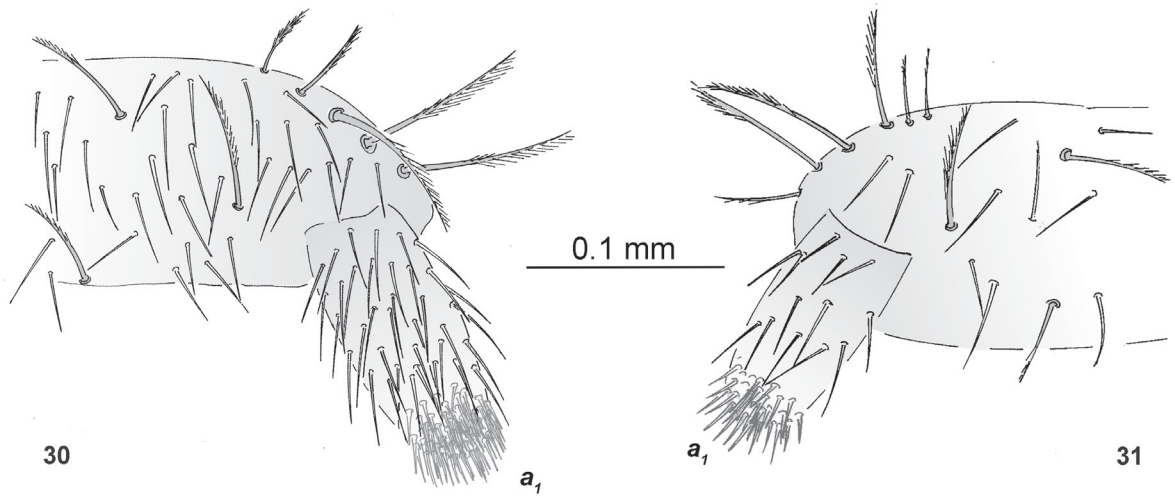
Phyletic affinities

Turkmenocampa edaphica Sendra & Sánchez-García sp. nov. is the second known species of a genus known previously from a troglobitic species inhabiting Kaptarhana Cave in Eastern Turkmenistan, *Turkmenocampa mirabilis* Sendra & Pavel, 2017, which is characterized by a Plusiocampinae pattern of macrosetae on the thorax and abdomen. *Turkmenocampa* also has a unique pretarsus consisting of subequal claws comprised of a large basal half with tiny dorsal spines, a thin, curved distal half and lateral laminar processes with long ventral barbs. *Turkmenocampa mirabilis* shows slight troglobiomorphic features: 30–32 antennomeres; up to twenty oviform sensilla on the cupuliform organ; gouge sensilla 18–26 µm long; middle antennomeres 2–2.5 × as long as wide; legs slightly elongated; metathoracic legs reaching abdominal segment VIII; and much longer than wide appendages of the first urosternite, both in males and females (Sendra *et al.* 2017). However, *T. edaphica* Sendra & Sánchez-García sp. nov. shows body characters of a soil dweller: 25–30 antennomeres; up to ten oviform sensilla on the cupuliform organ; middle antennomeres 1.4 × as long as wide; gouge sensilla 15–18 µm long; metathoracic legs reaching abdominal segment VI; and much longer than wide appendages of the first urosternite in both females and males. *Turkmenocampa edaphica* Sendra & Sánchez-García sp. nov. differs from *T. mirabilis* by the greater thickness of barbed marginal setae and by the greater number of glandular a_1 setae on the first urosternite appendages in females: with 32–64 in *T. edaphica* Sendra & Sánchez-García sp. nov., 12–21 in *T. mirabilis*.

Discussion

Updated knowledge of the Campodeidae fauna of Central Asia

The lack of knowledge in Central Asia about Diplura, including its most diverse family, Campodeidae, even in the limitrophe regions, is quite striking (Sendra *et al.* 2017, 2020). Only three species were previously known: *Campodea* (*Campodea*) *fragilis* and *C.* (*Dicampa*) *sprovierii* are soil-dwellers and *Turkmenocampa mirabilis* is a cave dweller. The present contribution adds three more species, two of which are soil-dwelling species: *C.* (*D.*) *catalana* and *T. edaphica* Sendra & Sánchez-García sp. nov.,



Figs 30–31. *Turkmenocampa edaphica* Sendra & Sánchez-García sp. nov., urosternite I, lateral side. **30**. ♂, paratype (MZB (MCNB) 2021-2341). **31**. ♀, holotype (MZB (MCNB) 2021-2340). Abbreviation: a_1 = glandular setae in distal portion of appendages.

and one non-troglomorphic species inhabiting a cave habitat: *Kyrgyzstacampa sanare* Sendra & Ferreira gen. et sp. nov. The low density of caves in an area, sometimes located in very dry areas, usually results in a poor cave fauna which includes diplurans (Sendra *et al.* 2017). Knowledge of soil diplurans is very poor due to little sampling effort in both edaphic and cave ecosystems. Only three references, including this paper, have been published from Central Asia and nearby areas, compared to more than a thousand references worldwide (Sendra *et al.* 2021). In addition, cave research in Kyrgyzstan is scarce, especially when considering biospeleological assessments. Most of the subterranean arthropod species known to Kyrgyzstan are interstitial stygophiles / stygobionts (Turbanov *et al.* 2016a), only a few terrestrial cave species have been recorded (Turbanov *et al.* 2016b) and no Diplura have been mentioned in previous studies on the cave fauna of Kyrgyzstan. Hence, the soil and subterranean biodiversity of Kyrgyzstan can certainly be considered underestimated. Moreover, Kyrgyzstan has no specific laws on the protection of subterranean habitats. Therefore, various human activities (e.g., agriculture, mining, urbanization) may occur in karst areas, which threaten caves and associated fauna. Central Asia remains a poorly explored region from a zoological point of view, especially for some groups such as the diplurans.

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References

Azadbakhsh S. & Nozari J. 2016. First faunistic study of Diplura in north of Iran with records of two species of *Campodea* (Campodeidae). *Entomologica Fennica* 27: 53–56. https://doi.org/10.33338/ef.59123

Beloglazova V.N. & Smirnova N.B. (eds) 1987. *Atlas of the Kirghiz USSR. Vol. 1. Natural Conditions and Resources*. USSR State Board for Geodesy & Cartography, Moscow. [In Russian]

Börner C. 1904. Zur Systematik der Hexapoden. *Zoologischer Anzeiger* 27: 511−533.

Condé B. 1947. *Eutrichocampa remyi* n. sp. (Diploures Campodéidés). *Bulletin de la Société des Sciences de Nancy* (nouvelle série) 6 (1): 60−62.

Condé B. 1952. Contribution à la faune endogée du Sahara. Diplopodes Pénicillates, Protoures, Diploures Campodéidés. *Bulletin de la Société zoologique de France* 76 (5–6): 349–365.

Condé B. 1955. Mission Henri Coiffait au Liban (1951). 4. Protoures et Diploures Campodéidés. *Biospeologica* 75: 397–412.

Condé B. 1956. Matériaux pour une monographie des Diploures Campodéidés. *Mémoires du Muséum National d'Histoire naturelle Série A. Zoologie* 12: 1−202.

Condé B. 1994. Nouveaux Campodéidés endogés de Thaïlande. *Revue suisse de la Zoologie* 101 (2): 335−359. https://doi.org/10.5962/bhl.part.82493

Denis J.R. 1930. Sur la faune française des Aptérygotes, XI^{e} note: Diploures avec tableau de détermination des espèces françaises. *Bulletin de la Société zoologique de France* 55: 19–41.

Dudashvili S.D. & Mikhailyov V.N. 1990. *In the Labyrinths of the Heavenly Mountains. 'Kyrghyzstan'*. Frunze. [In Russian]

García-Gómez A. 2016. Descripción de una nueva especie de *Eutrichocampa* (*Idiocampa*) (Diplura: Campodeidae) de Durango y Zacatecas, México. *Revista Mexicana de Biodiversidad* 87: 376−379. https://doi.org/10.1016/j.rmb.2016.05.003

Gvozdetskij N.A. 1981. *Karst*. 'Mysl', Moscow. [In Russian]

Ionescu M.A. 1955. Diplura. *In*: Academiei (ed.) *Fauna Republicii Populare Române*, Insecta 7 (2): 48.

Loksa I. 1960. Faunistisch-Systematische und Ökologische Untersuchungen in der Lóczy-Höhle bei Balatonfüred (Biospeologica Hungarica XL). *Annales Universitatis Scientiarum Budapestinensis, Sectio Biologica* 3: 253−266.

Lubbock J. 1873. *Monograph of the Collembola and Thysanura*. Ray Society, London. https://doi.org/10.5962/bhl.title.11583

Mamatkulov M.M. 1978. Some morphometric indicators of the caves of Central Asia. *In*: *Peshchery (Caves)* 17: 34–37. Geographical Society of the U.S.S.R., Perm. [In Russian]

Meinert F. 1865. *Campodea*: en familie af Thysanurernes orden. *Naturhistorisk Tidsskrift* 3: 400–440.

Paclt J. 1957. Diplura. *In*: Wytsman P. (ed.) Genera Insectorum. Fascicle 212. Mercurius, Antwerpen.

Sendra A., Sket B. & Stoev P. 2017. A striking new genus and species of troglobitic Campodeidae (Diplura) from Central Asia. *Subterranean Biology* 23: 47–68. https://doi.org/10.3897/subtbiol.23.14631

Sendra A., Palero F., Jiménez-Valverde A. & Reboleira A.S.P.S. 2020. Diplura in caves: diversity, ecology, evolution and biogeography. *Zoological Journal of the Linnean Society* 192 (3): 675–689. https://doi.org/10.1093/zoolinnean/zlaa116

Sendra A., Jiménez-Valverde A., Selfa J. & Reboleira A.S.P.S. 2021. Diversity, ecology, distribution and biogeography of Diplura. *Insect Conservation and Diversity* 14 (4): 415–425. https://doi.org/10.1111/icad.12480

Silvestri F. 1902. Materiali per lo studio dei Tisanuri. *Bollettino della Società entomologica italiana* 33: 204−249.

Silvestri F. 1931a. Campodeidae (Insecta Thysanura) dell'estremo Oriente. *Bolletino del Laboratorio d'Entomologia agraria in Portici* 25: 286−320.

Silvestri F. 1931b. Campodeidae (Insecta, Thysanura) di Cuba. *Bolletino del Laboratorio di Zoologia generale e agraria della R. Scuola superiore d'Agricoltura in Portici* 24: 299–318.

Silvestri F. 1932a. Campodeidae (Thysanura) de España (primera parte). *Eos* 8: 115−164.

Silvestri F. 1932b. Campodeidae (Insecta, Thysanura) dell'Unione dell'Africa Meridionale. *Bolletino del Laboratorio di Zoologia generale e agraria in Portici* 26: 54−86.

Silvestri F. 1933a. Nuovi contributi alla conoscenza della fauna delle isole italiane dell'Egeo. *Bolletino del Laboratorio di Zoologia generale e agraria in Portici* 27: 61−111.

Silvestri F. 1933b. Quarto contributo alla conoscenza dei Campodeidae (Thysanura) del Nord America. *Bolletino del Laboratorio di Zoologia generale e agraria della R. Scuola superiore d'Agricoltura in Portici* 27: 156–204.

Sultanov Z.S. 1972. Underground karst forms in Southern Fergana and their origin. *In*: *Peshchery (Caves)* 12–13: 88–95. Geographical Society of the U.S.S.R., Perm. [In Russian]

Turbanov I.S., Palatov D.M. & Golovatch S.I. 2016a. The state of the art of biospeleology in Russia and other countries of the former Soviet Union: a review of the cave (endogean) invertebrate fauna. 1. Introduction – Crustacea. *Entomological Review* 96 (7): 926–963. https://doi.org/10.1134/S0013873816070162

Turbanov I.S., Palatov D.M. & Golovatch S.I. 2016b. The state of the art of biospeleology in Russia and other countries of the former Soviet Union: a review of the cave (endogean) invertebrate fauna. 2. Arachnida – acknowledgments. *Entomological Review* 96 (9): 1297–1333. https://doi.org/10.1134/S0013873816090116

Westwood J.O. 1842. Description of a new genus of apterous hexapod insects found near London. *The Annals and Magazine of Natural History* 10: 231–234. https://doi.org/10.1111/j.1365-2311.1842.tb03276.x

Wygodzinsky P. 1941. Beiträge zur Kenntnis der Dipluren und Thysanuren der Schweiz. *Mémoires de la Société hélvetiques des Sciences naturelles* 74 mémorie 2: 113−223.

Wygodzinsky P. 1943. Una nueva especie de *Eutrichocampa* Silvestri, 1901 (Campodeida, Diplura). *Notas del Museo de La Plata* 8 (Zoologia nº 66): 141−145.

Xie R. & Yang Y. 1991. Description of two new genera and three new species of Campodeidae in China (Diplura). *Contributions from the Shanghai Institute of Entomology* 10: 95−102.

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