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Chthonius kirghisicus (Pseudoscorpiones, Chthoniidae), a new cave-dwelling species from Kyrgyzstan

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Abstract
A new pseudoscorpion species, *Chthonius kirghisicus* **sp. nov.**, is described. It can be distinguished from the other species of the genus mainly by the number and shape of chelal teeth, the number of coxae setae, the arrangement of carapacal setae, and its measurements. This new species represents the first record for the genus in Kyrgyzstan. We also provide recommendations for future research on this species.

Keywords
Cave-dwelling, pseudoscorpion, taxonomy

Introduction

Pseudoscorpions (Arachnida: Pseudoscorpiones) are widely distributed throughout terrestrial habitats. They are commonly found within leaf litter, beneath bark or stones, and bird nests and animal burrows. Numerous species are also adapted to subterranean environments (Harvey 1988). These arachnids are highly diverse, comprising 26 taxonomic families and 460 genera (Harvey 2013; Benavides et. al. 2019). Chthoniidae is the second most speciose family (Zhang and Zhang 2014), currently presenting 815 species (Harvey 2013; Zaragoza 2017; Benavides et. al. 2019). This group is widely distributed across almost all continents (except for Antarctica) and includes several cave-dwelling species (Chamberlin 1962; Ćurčić et al. 2014). The Chthoniidae group comprises 51 genera, of which ten have recently been classified as part of a related group (*Chthonius*-related group), due to presence of coxal spines on coxae II and III (Harvey 2013; Zaragoza 2017, 2018; Gardini 2020).

The genus *Chthonius* C.L. Koch, 1843 is the largest in the group. It has 139 species and has been documented across six continents (Ćurčić et al. 2012a, 2012b, 2012c; Harvey 2013; Zaragoza and Vadell 2013; Zaragoza 2017) with many species of this genus occurring within caves worldwide. Although *Chthonius* species are widely distributed, prior to this work, it had not been documented in Kyrgystan. However, *Chthonius tadzhikistanicus* Dashdamirov & Schawaller, 1992 is known from Tajikistan. Additionally, four species are known from the eastern Mediterranean including *C. ponticus* Beier, 1965 (Georgia and Turkey), *C. shelkovnikovi* Redikorzev, 1930 (Turkmenistan, Iran, Armenia, and Georgia), *C. azerbaidzhanus* Schawaller & Dashdamirov, 1988 (Azerbaijan), and *C. satapliaensis* Schawaller & Dashdamirov, 1988 (Georgia). Accordingly, we describe the first species of the genus *Chthonius* from Kyrgyzstan (Harvey 2013). We also provide some notes on its habitat and potential threats, a brief discussion on its association with the cave environment and a comparison with species from Central and Southeastern Europe and North Africa.

Materials and methods

Study area

Kyrgyzstan includes an impressive extent of karst (Fig. 6A, B), which covers nearly 30% of the country. Karst areas are mainly associated to Carboniferous and Devonian limestones (Morozov and Talitskii 2006). Despite the great diversity of landforms, the area surrounding the Duvankhan Cave is comprised of an isolated range of low elevation mountains in southeastern part of the Fergana Valley, which are part of the Osh Mountains. This mountain range straddles the border of Kyrgyzstan and Uzbekistan. The mountains are mainly formed by exposed limestone with sparse, shrubby vegetation, mainly composed of grass and small bushes (Fig. 6A, B). This vegetation is typical of rocky outcrops, as the soil is extremely shallow when present. The cave occurs in the Gissaro-Alai open woodlands ecoregion (WWF ID:PA0808), which covers the western foothills winding around two western offshoots of the Tian Shan Mountains (in western Tajikistan), and parts of eastern Uzbekistan and western Kyrgyzstan.

Duvankhan Cave is a limestone cave located around 3 km north of Aravan town, Aravan District, Osh Province, Kyrgyzstan (40°32'30.15"N, 72°29'49.05"E). Occurring approximately 1.5 km from the Kyrgyzstan-Uzbekistan border, the cave is situated on a mountain cliff on the northwestern ridge of Tchil-Ustun Mountain Ridge, located around 800 meters from the Aravansay River. Duvankhan Cave is a chimney-effect cave with a singular trunk passage connected by the lower main entrance and a smaller secondary entrance at a slightly higher elevation (Fig. 6B, C). The cave is believed to be extremely dry most of the year, which is due to air flow associated the chimney-effect configuration (Covington and Perne 2015). The cave floor consists primarily of breakdown and patches of cave sediment (Fig. 6D).

Field sampling

Fieldwork was conducted from August 5 through 16, 2019. The main objective of this expedition was to sample cave invertebrates in Kyrgyzstan as part of a worldwide scale study (with samplings in all continents, except Antarctica) which intends to understand how communities respond to habitat traits (manuscript in prep.). In Kyrgyzstan, eight caves were sampled. We used untimed direct intuitive searches (*sensu* Wynne et al. 2019) along 10×3 m transects and placed three quadrants (1 m^2) within each transect. The number of transects varied among caves and was proportional to the size of the cave. Arthropods were also collected as encountered via opportunistic sampling, prioritizing organic deposits (e.g., guano piles) and potential microhabitats (e.g., under stones, cracks, and speleothems). All arthropods were collected with a fine brush and immediately placed in 70% ethanol. Pseudoscorpions were encountered only within Duvankhan Cave.

Analysis and preparation

To properly examine taxonomic characters, specimens were photographed, dissected and mounted on temporary cavity slides, using glycerin as the medium. Subsequently, the paratype was studied using a Hitachi TM4000 scanning electron microscope (SEM). Prior to the SEM analysis, the specimen was mounted onto a stub with carbon tape.

Photographs were taken using a Zeiss Axio Zoom V16 stereomicroscope with software Zen 2.3. Images were scaled and used as the basis for illustrations using the Inkscape 1.1 (Montesanto 2015; inkscape.org). The holotype is deposited in the Institute of Biology collection, National Academy of Sciences, Bishkek, Kyrgyzstan. The paratype is deposited in the Coleção de Invertebrados Subterrâneos de Lavras (ISLA), Centro de Estudos em Biologia Subterrânea, Universidade Federal de Lavras, Minas Gerais, Brazil.

Terminology

Terminology follows Chamberlin (1931), Harvey (1992) and Judson (2007). Abbreviations for the trichobothria: *b* = basal; *sb* = sub-basal; *st* = sub-terminal; *t* = terminal; *ib* = interior basal; *isb* = interior sub-basal; *ist* = interior sub-terminal; *it* = interior terminal; *eb* = exterior basal; *esb* = exterior sub-basal; *est* = exterior sub-terminal; *et* = exterior terminal. Terminology of carapacal setae and lyrifissures follows Gabbut and

Vachon (1963) and Zaragoza (2017). Other character abbreviations include: *al* = anterolateral setae of carapace; *ame* = anteromedial setae of carapace; *an* = anterior setae row of carapace; *fa* = antiaxial lyrifissure of fixed chelal finger; *fb* = basal lyrifissure of fixed chelal finger; *fp* = paraxial lyrifissure of fixed chelal finger; fd_1 to fd_4 = dorsal lyrifissures of fixed finger; *hd* = distal lyrifissure of chelal hand; *hp* = proximal lyrifissure of chelal hand; *il* = intermedian lateral setae of carapace; *in* = intermedian setae row of carapace; *ldb*, *ldst*, *ldt*, *lvb*, *lve*, *lvt*: lyrifissures associated with cheliceral setae *db*, *dst*, *dt*, *vb*, *ve* and *vt*, respectively; ma_1, ma_2 = antiaxial lyrifissures of movable chelal finger; *me* = median setae row of carapace; *ml* = median lateral setae of carapace; *mm* = median medial setae of carapace; mv_1, mv_2 = ventral lyrifissures of movable chelal finger; *oc* = ocular setae row of carapace; *ol* = lateral ocular setae of carapace; *om* = medial ocular setae of carapace; osl = sublateral ocular setae of carapace; *pl* = posterolateral setae of carapace; *pm* = posteromedial setae of carapace; *po* = posterior setae row of carapace. Abbreviations for repositories: ISLA = Coleção de Invertebrados Subterrâneos de Lavras. IBB = The Institute of Biology in Bishkek.

Results

Family Chthoniidae Daday, 1888
Genus *Chthonius* C.L. Koch, 1843

***Chthonius kirghisicus* sp. nov.**
http://zoobank.org/C920BB66-43FC-4632-9DF8-437A0BFF1CBD

Material examined. ***Holotype*** female (IBB 82002, preserved in ethanol: Kyrgyzstan, Osh Province, vicinity of Aravan, Duvankhan Cave (40°32'30.15"N, 72°29'49.05"E), 09 August 2019, leg. R.L Ferreira. ***Paratype*** female (ISLA 66250), on SEM stub: same data as holotype.

Etymology. The epithet *kirghisicus* is an adjective that refers to the country where the specimens were collected, Kyrgyzstan.

Diagnosis. *Chthonius kirghisicus* sp. nov. differs from other members of the subgenus by the following combination of characters: one pair of eyes (*C. tadzhikistanicus* with four feebly small eyes, *C. aquasanctae* with two eyespots, *C. pagus* and *C. submontanus* bearing two anterior well-developed eyes and two posterior eyespots, *C. shelkovnikovi*, *C. carinthiacus*, *C. delmastroi* and *C. tenuis* with four well developed eyes, *C. azerbaidzhanus* and *C. satapliaensis* lack eyes or eye spots) (Redikorzev 1930; Schawaller and Dashdamirov 1988; Dashdamirov and Schawaller 1992; Gardini 2009; Christophoryová et al. 2011; Ćurčić et al. 2011, 2012a); epistome large and heavily dentated (*C. azerbaidzhanus*, *C pagus* and *C. satapliaensis* with small dentated epistome, *C. carinthiacus* and *C. aquasanctae* with a distinct but small epistome, *C. ponticus*, *C. delmastroi*, *C. tenuis* and *C. submontanus* without an epistome) (Beier 1964; Schawaller and Dashdamirov 1988; Gardini 2009; Christophoryová et al. 2011; Ćurčić et al. 2011, 2012a); anterior margin mostly serrated (ranging between seta *ame* and *al*) (*C. tadzhikistanicus* with anterior margin entirely serrated, *C. azerbaidzhanus*, *C. satapliaensis*, *C. pagus*, *C. aquasanctae*, *C. carinthiacus* and *C. ponticus* with only epistome region serrated) (Beier 1964; Schawaller and Dashdamirov 1988; Christophoryová et al. 2011; Ćurčić et al. 2011, 2012a); carapace with 20 setae, chaetotaxy 4: 2: 4: 4: 2: 4 (*C. ponticus* [4: 4: 2: 4: 2: 2], *C. carinthiacus*, *C. delmastroi*, *C. tenuis* and *C. submontanus* [4:6:4:2:2] with 18 setae); *il* located medially (in *C. tadzhikistanicus*, *C. shelkovnikovi* and *C. azerbaidzhanus il* is situated on the lateral margin), *pl* situated posteriorly to *pm* (in *C. satapliaensis pl* is located anteriorly to *pm*); palpal femur 5.2 times longer than wide (4.5 times in *C. tadzhikistanicus*, 3.0 times in *C. shelkovnikovi*, 5.4 times in *C. azerbaidzhanus* and 6.1 times in *C. satapliaensis*); chela 5.8 times longer than wide (5.4 times in *C. tadzhikistanicus*, 5.1 times in *C. satapliaensis*, 4.0 times in *C. shelkovnikovi* and 5.1 times in *C. ponticus*, 4.9 times in *C. aquasanctae*, 4.4 times in *C. delmastroi*, 5.3 times in *C. tenuis*, 4.5 times in *C. submontanus* and 4.8 times in *C. pagus*) (Redikorzev 1930; Beier 1964; Dashdamirov and Schawaller 1992; Gardini 2009; Ćurčić et al. 2011, 2012a); fixed chelal finger with 75–77 contiguous, acute and reclined backwards teeth (25 acute and straight teeth in *C. azerbaidzhanus*, 28 in *C. satapliaensis*, 33–38 acute, reclined backwards and close-set teeth in *C. carinthiacus*, 23–25 in *C. aquasanctae*, 30–33 in *C. pagus*, 32–36 in *C. submontanus*, 38 in *C. tenuis*, and 27–29 in *C. delmastroi*; 12–13 acute and sparse teeth in *C. ponticus* and 50 round and small teeth in *C. shelkovnikovi*); movable finger with 59–60 contiguous acute and retrorse teeth (18 acute and small teeth in *C. azerbaidzhanus*, 18 acute and straight teeth in *C. satapliaensis*, 17–20 acute, reclined backwards and close-set teeth in *C. carinthiacus*, 19–21 in *C. aquasanctae*, 25–39 in *C. pagus*, 23–30 in *C. submontanus*, 34 in *C. tenuis*, 26–29 in *C. delmastroi*; 24 flat and small teeth in *C. ponticus* and 50 round and small teeth in *C. shelkovnikovi*); absence of a protuberance near *ib* and *isb* (found in *C. tadzhikistanicus C. tenuis* and *C. delmastroi*); chelal hand long and slender (*C. ponticus* presents a ventrally round portion of the hand, *C. shelkovnikovi* exhibits short and robust chela) (Redikorzev 1930; Beier 1964; Schawaller and Dashdamirov 1988; Dashdamirov and Schawaller 1992; Gardini 2009; Christophoryová et al. 2011; Ćurčić et al. 2011, 2012a).

Description. (Fig. 6E). Body pale yellowish, mostly translucent; chelicerae slightly reddish orange, abdomen dark beige. Some parts of the body scaly. Vestitural setae sharp and anteriorly projected.

Carapace (Fig. 1A–C). 1.0–1.1 times longer than broad, strongly constricted posteriorly showing a difference between ocular breadth and posterior breadth of 0.12 mm (0.06 from each side of the carapace); anterior margin mostly serrated (ranging between seta *ame* and *al*); one pair of eyes; epistome strongly dentate and saw-like; presence of three furrows, one from the posterior to anterior margin, splitting in two in the area between *me* and *oc* (Fig. 1A); posterior margin of carapace scaly; chaetotaxy 4: 2: 4: 4: 2: 4 (20).

Chelicera (Figs 1D, 5A–D). Hand with 6 setae; movable finger with 1 subdistal seta; galea present as a tubercle; fixed finger with 8–10 acute teeth including two large ones (the two distalmost); movable finger with 7–8 acute teeth including one large distal tooth; rallum with 10 blades, middle blades long, presenting ramifications at the apex; serrula exterior with 15–17 blades, serrula interior with 12 blades.

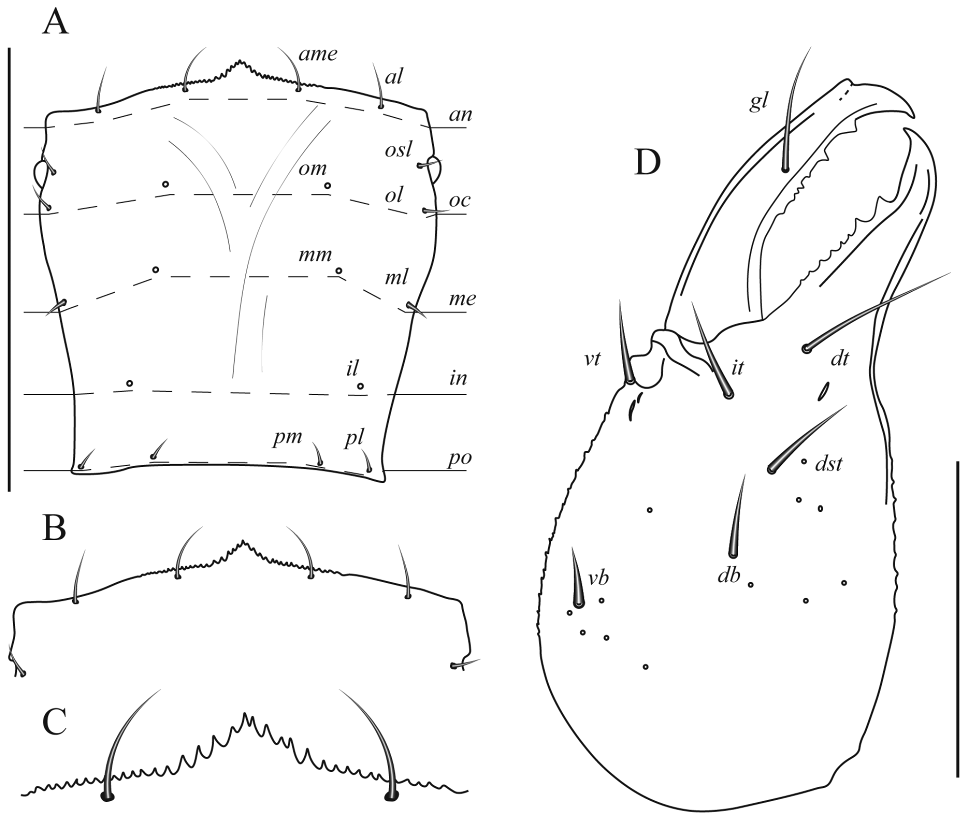

Figure 1. *Chthonius kirghisicus* sp. nov. holotype **A** carapace, showing distribution of setae and furrows **B** left chelicera, antiaxial view **C** detail of anterior margin of carapace **D** detail of epistome, showing highly dentate margin. Scale bars: 0.5 mm (**A**); 0.2 mm (**B**).

Tergites. Not divided; surface smooth; chaetotaxy uniseriate, I–XI 4: 4: 4: 4–6: 6: 6: 6: 6: 6: 4–6: 4. Anal operculum with two dorsal setae. Pleural membranes smooth.

Coxae (Fig. 3A, B). Manducatory process with 2 apical enlarged setae, delicate lamellae outlined by 17–19 small spines; rest of palp coxae with 3 setae arranged in a triangle; presence of two conspicuous pores on anterior region of palpal coxae. Pedal (Fig. 3A): coxal spines bipinnate, irregularly arranged in a rounded patch (Fig. 3A, B), present in coxae II (8–14) and coxae III (3–5), chaetotaxy: I 6, II 4, III 5, IV 7; intercoxal tubercle present between coxae III and IV, bearing two setae.

Genital operculum of female: setae distributed in four horizontal rows: 2: 4: 4: 2, genital opening angularly bifurcated.

Sternites: chaetotaxy IV–XI: 10–12: 7–8: 6–8: 6: 4: 2–4: 2: 0. Anal operculum without ventral setae.

Palp (Figs 2A–D, 4A–D). Trochanter 1.5–1.7 times longer than broad, patella 1.7–2.0 times longer than broad, femur 5.0–5.2 times longer than broad. Femoral chaetotaxy 3: 4: 2: 5: 1. Chelal hand fusiform, with 4 posterior setae (ph_3 present),

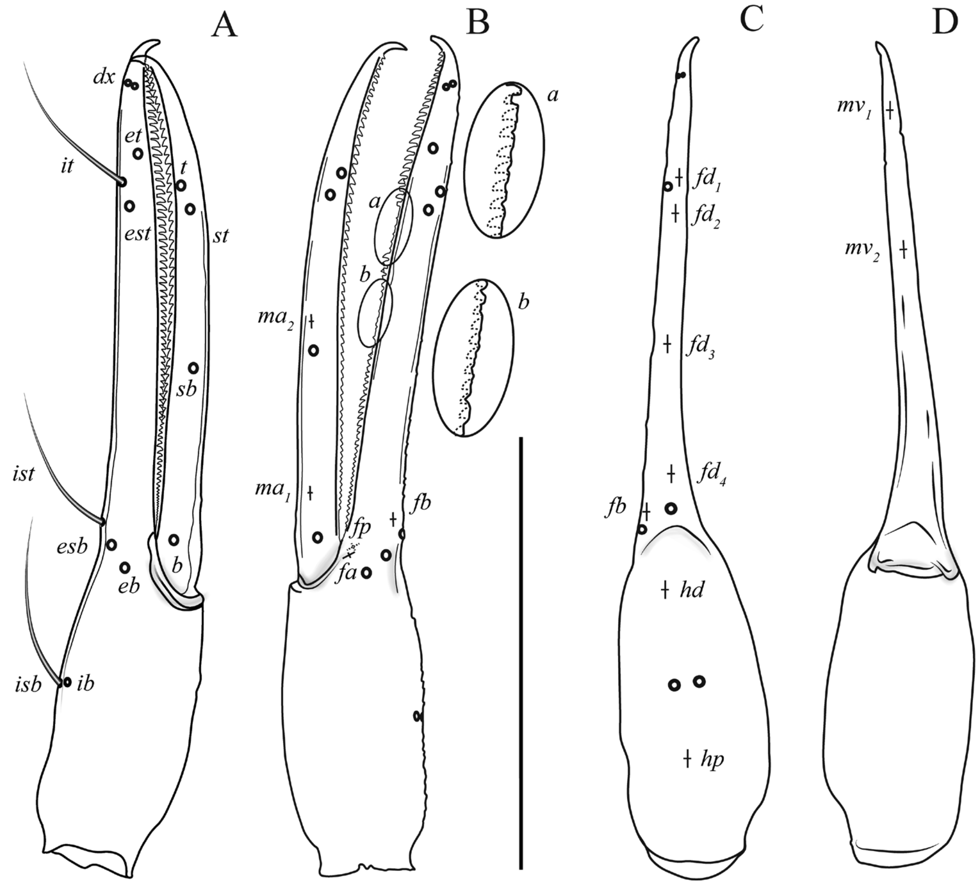

Figure 2. *Chthonius kirghisicus* sp. nov. holotype **A** right pedipalp chela, showing teeth morphology and trichobothrial pattern, antiaxial view **B** left pedipalp chela, showing the arrangement of teeth with detailed gaps and lyrifissures arrangement, antiaxial view **C** left pedipalp chela, dorsal view **D** left pedipalp chela, ventral view. See Material and methods for abbreviations. Scale bar: 0.5 mm.

apodeme reduced, almost absent, trichobothrial pattern: *ib* and *isb* located at the base of the hand, adjacent to each other, *eb* proximad to *esb*, *ist* distad to *esb*, *eb-esb-ist* located at the base of fixed finger, *it* proximad to *est*, *et* distad from *est*. Fixed finger almost straight, movable finger slightly bent (Fig. 2C, D). Left chelal fixed finger with 75–77 acute, not widely spaced teeth. In holotype left fixed chelal finger, teeth divided in three groups by gaps (probably frayed teeth), counting from basal to distal: 31 teeth, a gap of ca. 10 teeth; followed by 5 teeth, a gap of ca. 6 teeth and 23 more teeth (Fig. 2B). Movable finger with 59–60 acute teeth, growing from basal to distal; right chelal fixed finger with 75–77 teeth, not widely spaced, without gaps.

Leg IV (Figs 3C, 4E). Arolia shorter than claws; a small protuberance near end of tarsus.

Measurements (length/breadth or depth in mm; ratios in parenthesis calculated by using three significant digits): Female holotype and female paratype range. Body

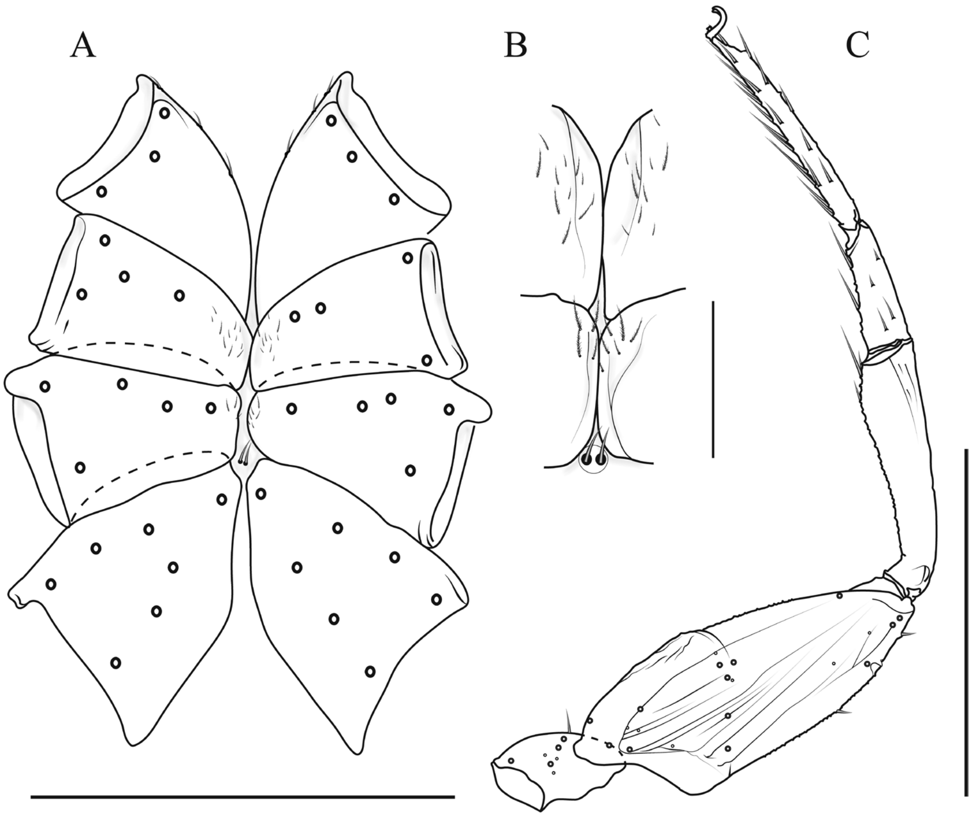

Figure 3. *Chthonius kirghisicus* sp. nov. holotype **A** pedal coxae **B** detail of coxae II and III showing coxal spines distribution and intercoxal tubercle bisetose **C** left leg IV, retrolateral view. Scale bar: 0.3 mm (**A**); 0.025 mm (**B**); 0.5 mm (**C**).

length 1.46 [1.44]. Carapace 0.50–0.51/0.47–0.48 (1.0–1.1). Palps: trochanter 0.21–0.22/0.13 (1.5–1.7), femur 0.65–0.66/0.13 (5.0–5.2), patella 0.26–0.28/0.14–0.15 (1.7–2.0), chela 0.94–0.96/0.1 (5.7–5.8), movable finger length 0.60–0.61. Leg I: trochanter 0.10–0.12/0.08–0.09 (1.2–1.4), femur 0.34–0.36/0.05–0.07 (4.9–5.9), patella 0.14–0.17/0.06 (2.6–2.7), femur/patella 2.1–2.4, tibia 0.21–0.22/0.04 (4.8–5.8), tarsus 0.35–0.38/0.04 (10.0–10.1). Leg IV: Trochanter: 0.13–0.17/0.10–0.12 (1.1–1.8), femur + patella 0.54–0.61/0.21–0.22 (2.5–2.9), tibia 0.36–0.38/0.09 (4.1–4.2), basitarsus 0.18–0.20/0.06 (2.9–3.1), telotarsus 0.33–0.35/0.03–0.04 (9.7–9.9).

Habitat. The two individuals of *C. kirghisicus* sp. nov. were found in the wet areas fed by percolating water. These drip areas were located approximately 30 m from the upper entrance and occurred within the cave's twilight zone. Even considering the proximity of the upper entrance (approximately 30 m from the drip area), the individuals were observed in a depression in the cave floor located in a lateral portion of the cave conduit, so that the light coming from the upper entrance (which is small - about 1 m^2) did not reach this area. Potential prey species include springtails, which were observed in this area.

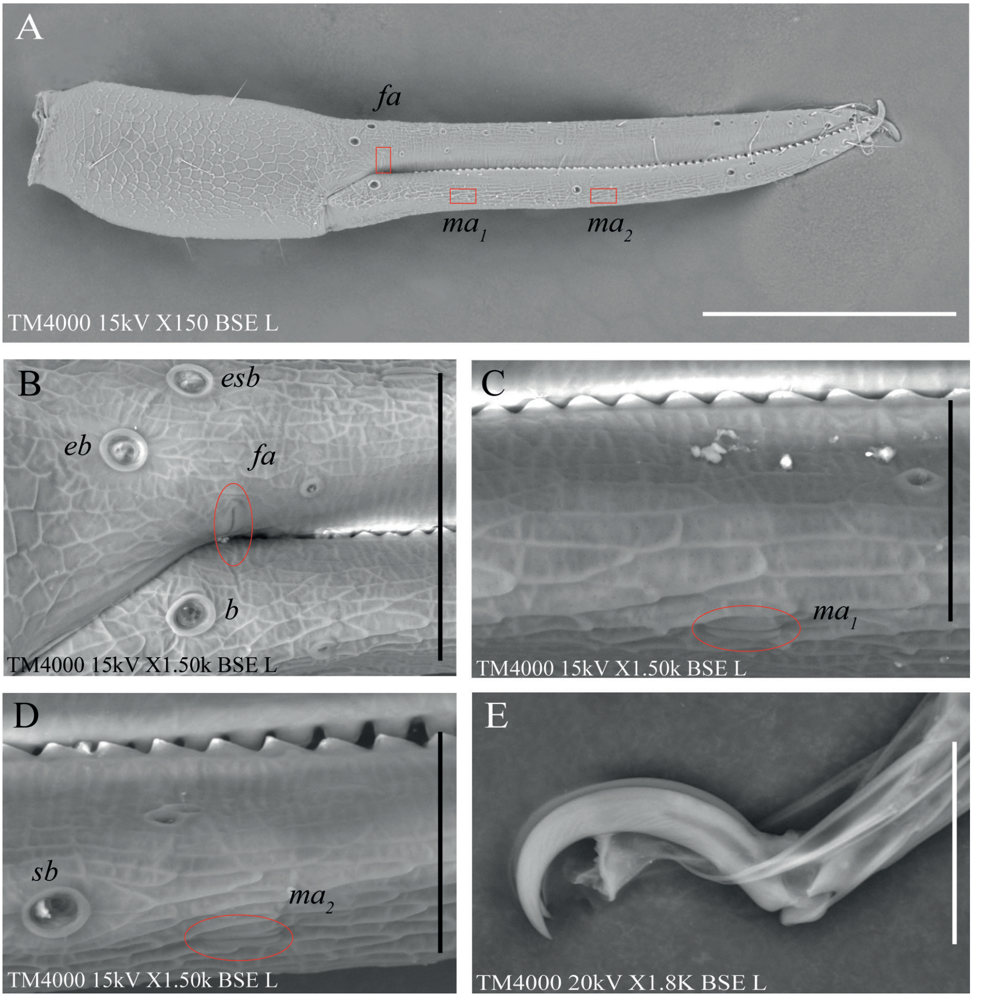

Figure 4. *Chthonius kirghisicus* sp. nov. SEM images of the paratype **A** right pedipalp chela, showing trichobothrial pattern and arrangement of antiaxial lyrifissures, antiaxial view **B** detail of *fa* lyrifissure at base of right chelal fixed finger, antiaxial view **C** detail of ma_1 lyrifissure at chelal movable finger, antiaxial view **D** detail of ma_2 lyrifissure at chelal movable finger, antiaxial view **E** claw and arolia of right Leg IV. Scale bars: 0.3 mm (**A**); 0.05 mm (**B**); 0.03 mm (**C–E**).

Discussion

Overall, the taxonomy and distribution of Pseudoscorpions in Kyrgyzstan has not been examined in the last few decades - the last study on pseudoscorpion taxonomy (*Pselaphochernes rybini* Schawaller, 1986) was published 35 years ago. Furthermore, cave research in Kyrgyzstan has been limited. Consequently, most subterranean species known to the country are interstitial stygophiles/stygobionts (Turbanov et al. 2016a), with only a few terrestrial species being reported (Turbanov et al. 2016b). The knowl-

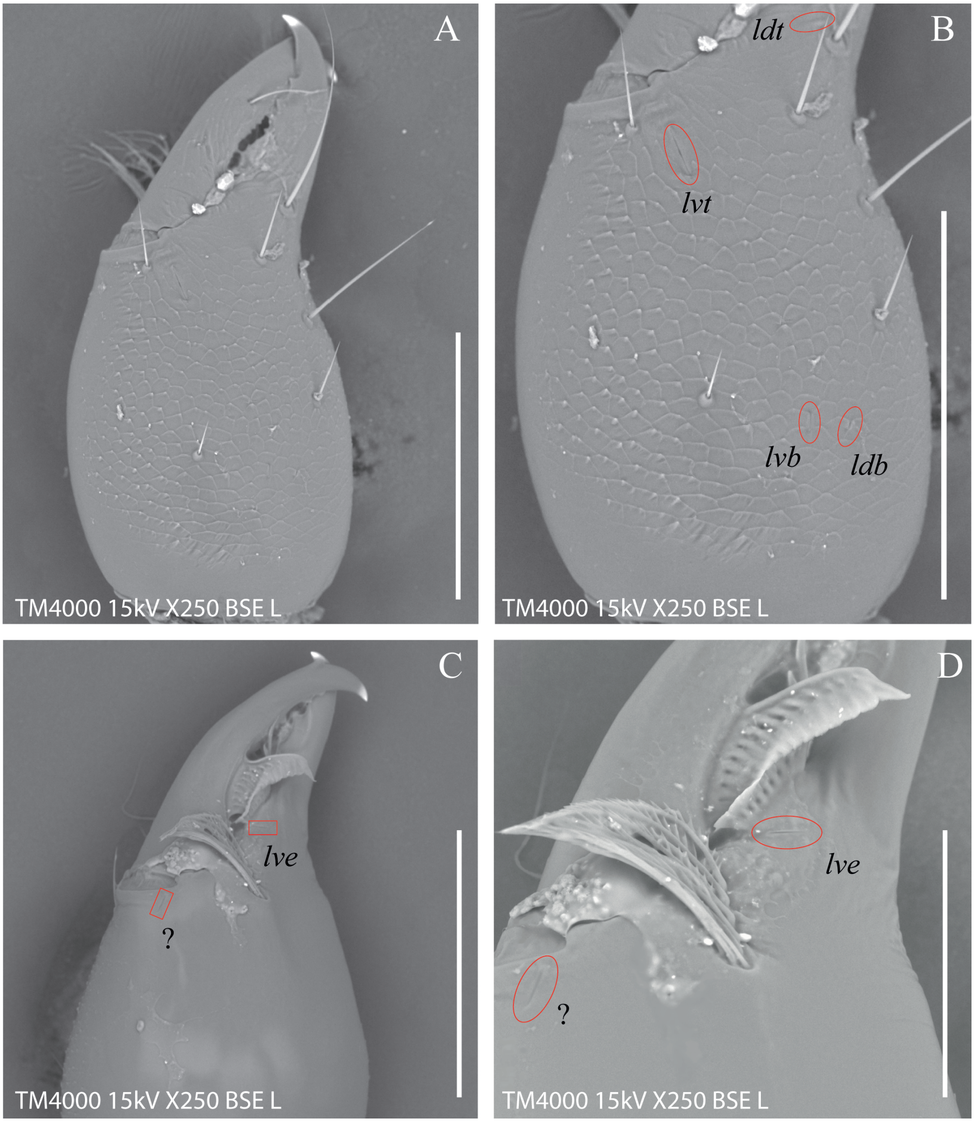

Figure 5. *Chthonius kirghisicus* sp. nov. SEM images of the paratype **A** left chelicera, showing the arrangement of setae, dorsal view **B** detail of left chelicera, showing dorsal lyrifissures, dorsal view **C** right chelicera, showing arrangement of lyrifissures, ventral view **D** detail of right chelicera, showing ventral lyrifissures. Scale bars: 0.2 mm (**A–C**); 0.1 mm (**D**).

edge concerning subterranean biodiversity of Kyrgyzstan is still in its infancy, and more studies on soil and cave invertebrates are encouraged.

Concerning challenges in taxonomy, recent morphological characters used to differentiate chthoniid species (e.g. lyrifissures arrangement, condylar and apodeme complex and chelal hand facies aspect, [Zaragoza 2017]) are undocumented for most of the described species of *Chthonius*, which renders comparisons with *C. kirghisicus* sp.

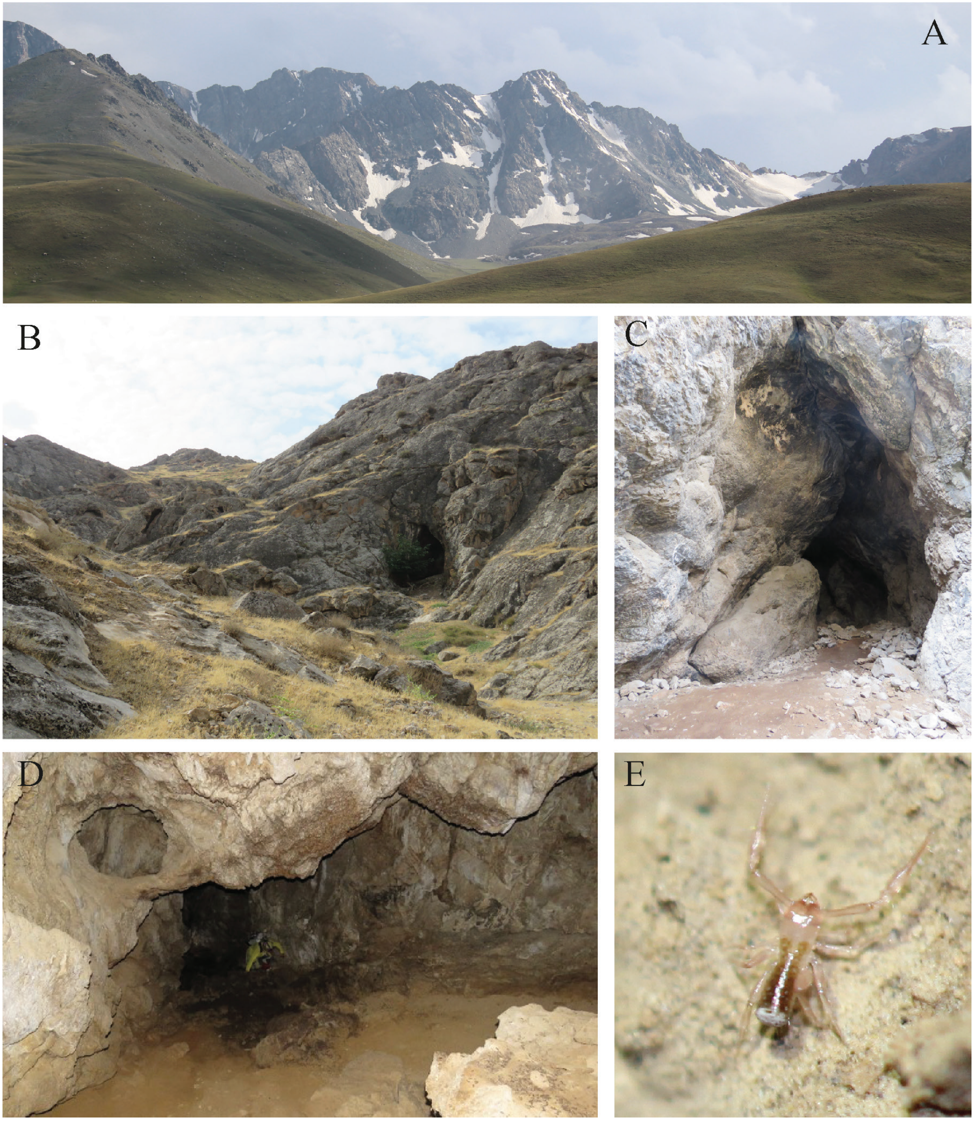

Figure 6. Type locality and habitat of *Chthonius kirghisicus* sp. nov. **A** Kyrgyzstan karst landscape **B** general area where the cave is located with the lower entrance featured **C** detail of the lower cave entrance **D** cave interior **E** live holotype.

nov., slightly difficult. Further research is required, especially on the chthoniid fauna of eastern Europe, and western and central Asia to analyze and apply these new and important taxonomic traits. During our analysis of the paratype female using SEM, two ventral lyrifissures on the chelicera were observed, instead of only one that was previously identified for this group (*lve*) (Zaragoza 2017). The non-nominated cheliceral lyrifissure is presented Fig. 5C, D.

Although one of the traits observed in *Chthonius kirghisicus* sp. nov. is often attributed to subterranean-adapted species (i.e., slender appendages), this characteristic is also known for epigean species of this genus – such as the two-eyed and blind epigean species *C. ponticus* and *C. azerbaidzhanus*, respectively (Beier 1965; Dashdamirov and Schawaller 1988). As the name implies for *C. azerbaidzhanus*, this epigean species lacks eyes (another key troglomorphic trait). Furthermore, the *C. satapliaensis* specimens found in Sataplia Cave, Georgia (Dashdamirov and Schawaller 1988), which were not assigned as troglobiontic, have more slender appendages than that observed in the new species. Despite the slender appendages observed in *C. kirghisicus* sp. nov., it would be unwise to classify it as troglobiontic without further investigation of its distribution. Additionally, further and more detailed comparisons with other species of the *Chthonius*-related group that were considered troglobiontic should be performed. Presently, as there are known surface-dwelling species within this genus with reduced eyes to eyeless and slender appendages, and that both *C. kirghisicus* specimens were found in the twilight zone, we presently consider this species to be a troglophile. However, this classification may be later confirmed or disregarded after a thorough investigation of its distribution has been conducted. Additional surveys should be focused on the surrounding epigean environment (especially adjacent to the cave entrance) and in other areas within the cave.

The primary nutrient resource within this cave was a large bat guano pile (approximately 15 m^2), located in the middle portion of the cave. With the exception of the wet areas beneath the drips, this cave was dry during our investigations. Guano usually represents the main trophic resource in permanently dry caves, where other organic substrates are not transported by water (Ferreira and Martins 1999). The guano concentration supports an entire community of potential prey species including mites, silverfish, springtails, Psocoptera, isopods and tenebrionid beetles, but also some predator species including reduviid bugs and chernetid pseudoscorpions. The specimens of *C. kirghisicus* were found far from this pile in a highly oligotrophic environment. It is possible that the higher humidity and moisture content of the wet areas represent the pseudoscorpion's primary habitat. However, given the guano pile and abundance of likely prey species, we suggest additional surveys should be conducted at the guano pile to test this question.

Additionally, it is noteworthy that we did not detect chthoniid pseudoscorpions in the other seven caves, some of which were quite humid. However, given that our study was baseline in nature, additional surveys in these and other adjacent caves should be conducted – as this may result in a range extension of this species.

The Duvankhan cave had few signs of human visitation, perhaps due to the proximity of the Kyrgyzstan-Uzbekistan border and the political conflict between the two countries. However, the surface environment surrounding the cave is somewhat altered. There is agriculture in the surrounding lowland areas, and the Aravan District is a quite populated (more than 20,000 inhabitants). So, as the human population continues to increase, there may be impacts to this cave in the future.

Presently, Kyrgyzstan lacks any laws to protect subterranean habitats. Since most underground ecosystems remain unknown globally (and Kyrgyzstan is no exception) and knowledge gaps hinder environmental conservation, efforts are needed to acquire a deeper understanding of subterranean species biodiversity (Mammola et al. 2019). Overall, these findings will serve to enhance the knowledge of subterranean-dwelling animals in the country, and we hope this work will generate additional interest in cave biological research. As cave research expands in Kyrgyzstan, we believe this will ultimately prompt the Kyrgyz decision-makers and conservation practitioners to establish protective measures to help conserve cave biodiversity in the country.

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