Nauplius
The Journal of The Brazilian Crustacean Society

e-ISSN 2358-2936
www.scielo.br/nau
www.crustacea.org.br

Original Article

The first troglobitic terrestrial isopod (Isopoda, Oniscidea) from Peru

Ivanklin Soares Campos-Filho[1]
Spyros Sfenthourakis[1]
Jonas Eduardo Gallão[2]
Lilia Senna-Horta[3]
Maria Elina Bichuette[2,3]

1 University of Cyprus, Department of Biological Sciences. Lefkosia (Nicosia), Cyprus.
ISC-F isoare01@ucy.ac.cy, ivanklin.filho@gmail.com
SF sfendourakis.spyros@ucy.ac.cy

2 Universidade Federal de São Carlos, Departamento de Ecologia e Biologia Evolutiva. São Carlos, São Paulo, Brazil.
JEG jonasgallao@gmail.com
MEB lina.cave@gmail.com

3 Grupo Bambuí de Pesquisas Espeleológicas. Belo Horizonte, Minas Gerais, Brazil.
LS-H liliahorta@gmail.com

ZOOBANK: http://zoobank.org/urn:lsid:zoobank.org:pub:1455465B-8F89-4A1E-9328-6BE20F32F052

ABSTRACT

The present work aims to describe the first troglobitic terrestrial isopod (Oniscidea) from Peru. *Caecopactes chullachaqui* sp. nov. is described from Cueva de Palestina, Department of San Martín. The new species constitutes the third troglobitic taxon known for the country and extends the knowledge of the distribution of the genus.

KEYWORDS

Caecopactes, Neotropical, Scleropactidae, troglobiont.

Corresponding Author
Ivanklin Soares Campos-Filho
isoare01@ucy.ac.cy
ivanklin.filho@gmail.com

Submitted 06 May 2022
Accepted 19 September 2022
Published 21 April 2023

DOI 10.1590/2358-2936e2023003

INTRODUCTION

Life in subterranean environments requires some level of morphological and physiological modifications to allow the taxa to survive environmental conditions and ecological pressures; such as from karst landscape features, alterations in the chemical composition of micro habitats due to dissolution through the bedrock, absence of light and autotrophic food chains, intra- and interspecific competition, and predator pressures, among others (Gibert and Deharveng, 2002; Culver and Pipan, 2009; Culver, 2016; Deharveng and Bedos, 2018).

South America comprises some of the most important biodiversity hotspots at a global scale (Myers et al., 2000; Marchese, 2015). Considering the territorial extension of South America, only 2% of its territory shows suitable lithology for the development of karstic systems (Auler, 2017).

Considering all studies from South American caves, our knowledge on Peru's systems is still elementary (Ribera and Bellés, 1994; Trajano, 2019). Historically, Alexander von Humboldt is considered the pioneer of South American cave fauna. In 1799 he discovered, and later described, the "Guácharo" bird, *Steatornis caripensis* Humboldt, 1817, from Venezuela. In 1801, Humboldt carried out studies across many regions of Colombia, and at about the same period other naturalists studied bats and birds from Venezuela and Colombia. In the 20th century, the first South American troglobitic species was described from Brazil, the catfish *Pimelodella kronei* (Miranda-Ribeiro, 1907). Later, during the 1950's and 1960's, the studies increased mainly in Venezuela and Brazil (Trajano and Bichuette, 2006). In 1972 the first studies on the caves of Peru appeared, comprising faunal inventories, and in 1994 the first cavefish was described, namely *Astroblepus riberae* (Cardona and Guerao, 1994). Since then, only occasional works with descriptions of species, such as the collembolan *Acheroxenylla lipsae* Palacios-Vargas, 2020 (Palacios-Vargas, 2020), have been published.

Terrestrial isopods (Oniscidea) comprise more than 4,000 species distributed in more than 500 genera and 38 families in the sections Ligiida, Tylida, Microcheta, Synocheta, and Crinocheta, the last one including about 95% of the total diversity (Sfenthourakis and Taiti, 2015; Javidkar et al., 2015; Dimitriou et al., 2019). Oniscidea occur in almost all terrestrial habitats of the globe, including caves (Schmalfuss, 2003; Taiti, 2004). In recent years, many surveys in cave habitats have been conducted around the world (e.g., Kashani et al., 2013; Campos-Filho et al., 2014; 2020; Taiti, 2014; Reboleira et al., 2015; Bedek et al., 2019a; 2019b; Cardoso et al., 2020a; 2020b; Taiti and Montesanto, 2018; 2020; Cifuentes and Prieto, 2021). However, the taxonomic impediment still remains the main reason for the delay in our knowledge of the biodiversity of the group from subterranean environments (Ebach et al., 2011; Pearson et al., 2011; Campos-Filho et al., 2014).

The family Scleropactidae includes more than 110 species and 26 genera mainly distributed in circumtropical areas (Schmalfuss, 2003). The Neotropical representatives of the family had their phylogenetic relationships and taxonomy investigated, but until today the family's position within Crinocheta has not been unambiguously resolved (Schmidt, 2007; 2008).

In the Neotropics, nine species from the family have been recorded from caves, of which six are considered to be troglobionts, i.e., *Amazoniscus eleonorae* Souza, Bezerra and Araújo, 2006, *Amazoniscus spica* Campos-Filho, Aguiar and Taiti, 2020, *Circoniscus buckupi* Campos-Filho and Araujo, 2011, and *Circoniscus carajasensis* Campos-Filho and Araujo, 2011 from Brazil, *Spherarmadillo cavernicola* Mulaik, 1960 and *Spherarmadillo huatuscensis* Mulaik, 1960 from Mexico, and *Troglopactes botosaneanui* (Vandel, 1973) from Cuba (Schmidt, 2007; Campos-Filho et al., 2018; 2020).

To date, 24 species of Oniscidea have been recorded from Peru, with four belonging to Scleropactidae, i.e., *Circoniscus gaigei* Pearse, 1917, *Circoniscus ornatus* (Verhoeff, 1941), *Scleropactes incicus* Budde-Lund, 1885, and *Scleropactes concinnus* Budde-Lund, 1885 (Schmalfuss, 2003; Schmidt, 2007; Ocampo-Maceda et al., 2022), but no species of terrestrial isopod has previously been recorded from Peruvian caves.

The present work aims to describe a new troglobitic species of *Caecopactes* Schmidt, 2007 from Cueva de Palestina, Department of San Martin, Peru. This species is the third troglobitic species for the country. In addition, ecological and conservation remarks are given.

MATERIAL AND METHODS

Specimens were collected by hand with the aid of tweezers and brushes, and were stored in 70% and 100% ethanol. Information about the microhabitat (entrance, twilight or aphotic zones) and environmental variables (temperature and relative air humidity) of the caves were also recorded. Descriptions are based on morphological characters with the use of micro-preparation in Hoyer's medium (Anderson, 1954). For each new species, type material, description, etymology and remarks are given. The habitus images were taken with the stereomicroscope model Zeiss SteREO Discovery.V12 Modular Stereo Microscope adapted with Zeiss AxioCam ERc 5s camera. The photographs were prepared with Adobe Photoshop CC Lite (v. 17.1.1). The appendages were illustrated with the aid of a camera lucida mounted on a CH2 Olympus microscope. The final illustrations were prepared with the method proposed by Montesanto (2015; 2016). A map highlighting the cave where the specimens where collected, as well the hydrological and geological attributes in the region, is presented. The distribution map was constructed with ArcMap (v. 10.5).

The material is deposited in the scientific collections of Museo de Historia Natural Universidad Nacional Mayor de San Marcos (MUSM), Peru, and Laboratório de Estudos Subterrâneos (LES), Universidade Federal de São Carlos, São Carlos, Brazil.

Study Area

The region of Alto Mayo, San Martin, Nueva Cajamarca, is remarkable for its biodiversity. Alto Mayo is located in the Peruvian Amazon, including an area of the Amazon tropical rainforest (Fig. 1). The region borders with the Andes Cordillera to the east, and has borders with Brazil, Bolivia, Colombia, and Ecuador (Marchese, 2015). According to Köppens' criteria (Bedek et al., 2018; 2020), the region has a Tropical rainforest climate (Af). Moreover, according to the Servicio Nacional de Meteorología e Hidrología, Peru (SENAMHI), the precipitation range is about 1,500 to 3,000 mm and the average annual temperature is about 24 °C.

The massif of Alto Mayo is with in the Amazonian Piedmont, province of Rioja, at the extreme north of the San Martin Region, northwestern Peru (CESPE-GBPE-GSBM, 2004a; 2004b). This karst massif forms

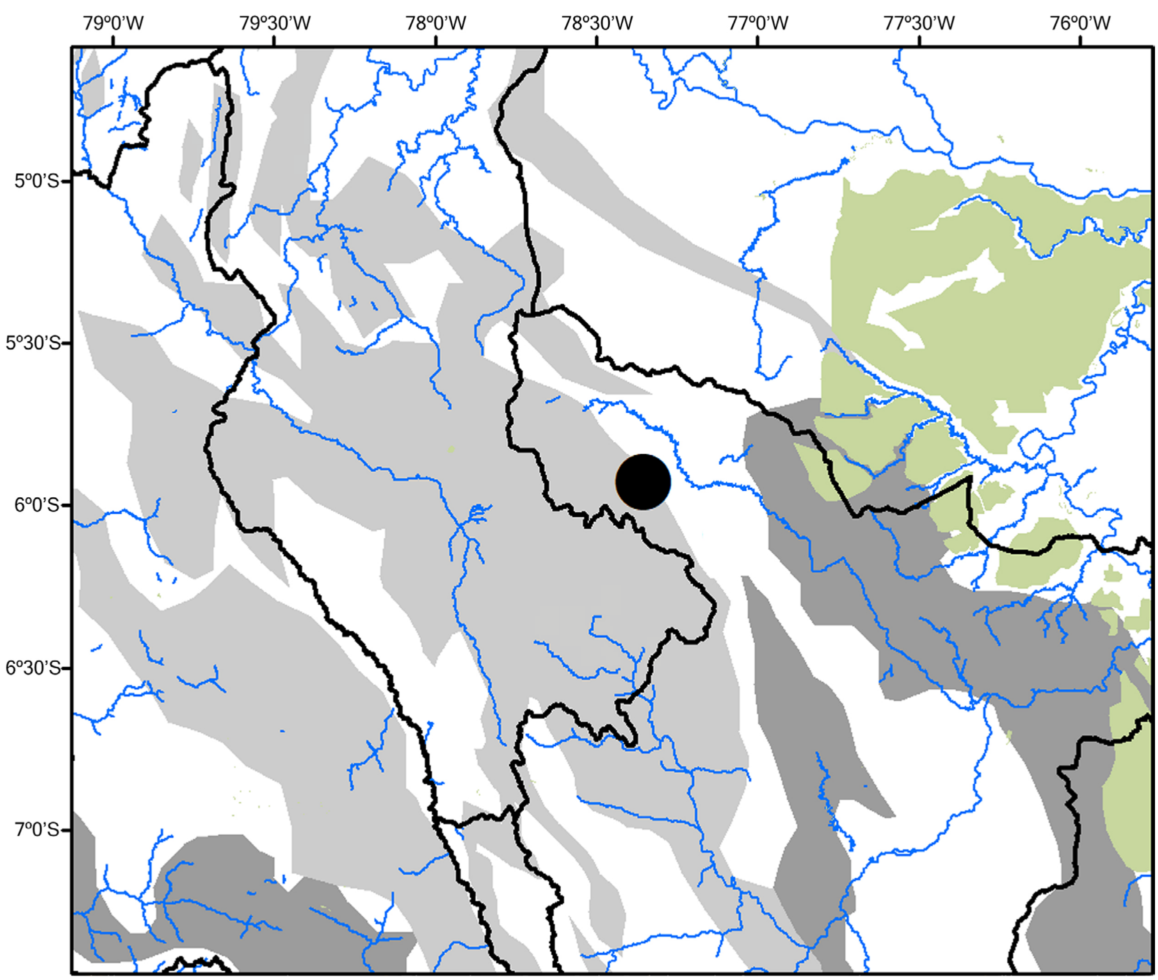

Figure 1. Map of the type locality of *Caecopactes chullachaqui* Campos-Filho, Sfenthourakis and Bichuette sp. nov. ● Cueva de Palestina. Green areas: legal conservation units; dark grey: discontinuous carbonate rocks; light gray: continuous carbonate rocks.

a distinct unit and belongs to the sub-Andean zone. The massif is structurally defined by the anticline of the Cerro Blanco, and the Pucará group forms the sides of this anticlinal (CESPE-GBPE-GSBM, 2004a; 2004b; Instituto Geologico, Minero y Metalúrgico, Peru - INGEMMET).

Cueva de Palestina (Fig. 2A) is located in the region of Alto Mayo and it has an extension of more than three kilometers, being the second largest cave in Peru. The specimens examined here were collected in the aphotic zone foraging on organic matter (Fig. 2B).

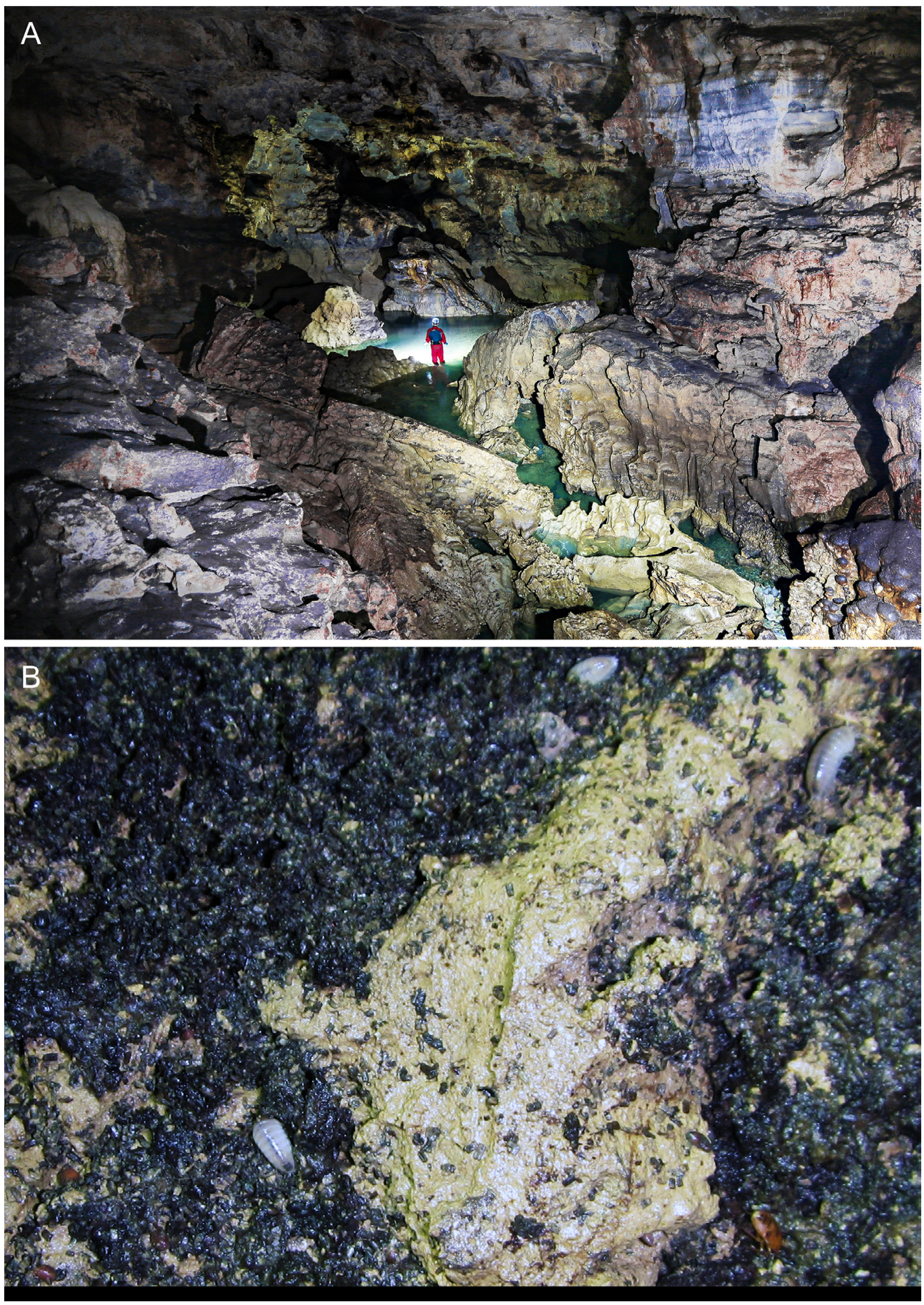

Figure 2. Cueva de Palestina. **A**, entrance zone of the cave , photo: A.O. Lobo; **B**, specimens foraging on guano on the cave floor.

SYSTEMATICS

Family Scleropactidae Verhoeff, 1938

Genus *Caecopactes* Schmidt, 2007

Type species. *Caecopactes minimus* Schmidt, 2007, by original designation and monotypy.

Diagnosis. Modified from Schmidt (2007). Body pigments and eyes absent, animals with endoantennal conglobation, or rolling, ability, cephalon with frontal shield fused with vertex (not delimited by frontal line), pereonite 1 epimera with schisma on posterior corner, antenulla of 2 articles, antennal flagellum of 2 articles, mandible with molar penicil simple, maxillula inner endite bearing 2 penicils, maxilla bilobate, maxilliped endite with 2 strong setae on distal margin, pereopod dactylus of 2 claws, inner claw short, uropod protopod enlarged and surpassing distal margin of telson, and exopod inserted on medial margin, and pleopod exopods without respiratory areas.

Remarks. The genus *Caecopactes* was erected by Schmidt (2007) to include *C. minimus* from Napo Province, Ecuador. The genus was defined by animals of reduced size, body pigments and eyes absent, endoantennal conglobation ability, pereonite 1 epimera with schisma at the posterior corner, cephalon with concave frons, antennal peduncle with fourth and fifth articles triangular and corners projected ventrally, and antennal flagellum of two articles (see also Schmidt, 2007). The new species described here is tentatively placed into the genus mainly due to the shape of the cephalon, the pereonite 1 epimera with posterior schisma, and the shape of uropods (see also Schmidt, 2007).

Regarding the characters mentioned by Schmidt (2007), the reduced size of animals, cephalon with concave frons and the triangular shape of the fourth and fifth articles of the antennal peduncle probably represent specific characteristics of *C. minimus*. Moreover, within the Neotropical Scleropactidae no other genera have a cephalon shape as in *Caecopactes*, with the frontal shield fused with the vertex. In a loose comparison, the shape of *Caecopactes* cephalon resembles that of *Aulaconiscus* Taiti and Howarth, 1997 from Hawaii, and *Kithironiscus* Schmalfuss, 1995 from Greece; however, the genus differs in the animals having endoantennal conglobation (vs. exoantennal in *Aulaconiscus*), the pereonite 1 epimera with posterior schisma (vs. schisma absent in *Aulaconiscus*), pereonite 2 epimera without ventral lobe (vs. present in *Aulaconiscus*), telson with distal margin rounded (vs. triangular in *Aulaconiscus* and *Kithironiscus*), and uropod exopod inserted on medial margin (vs. on distal margin in *Aulaconiscus* and *Kithironiscus*) (see also Schmalfuss, 1995; Taiti and Howarth, 1997; Tabacaru and Girginca, 2003).

Caecopactes chullachaqui Campos-Filho, Sfenthourakis and Bichuette sp. nov.

(Figs. 1 – 5)

http://zoobank.org/urn:lsid:zoobank.org:act:C0F77BDF-BFE8-4764-A656-B9164D7505B2

Type material. Holotype: male adult (MUSM-CRUS 0100000), Peru, San Martin, Rioja, Nueva Cajamarca, Cueva de Palestina, 5º52'33"S 77º20'51.31"W, 900 m a.s.l., 9 Sep 2016, leg. M.E. Bichuette, J.E. Gallão and L.S. Horta, specimens on decomposing organic material. Paratypes: one male (parts in micro-preparations), three females (one in micro-preparations) (MUSM-CRUS 0100001), same data as holotype; one male, two females (LES 27969), same data as holotype.

Description. Maximum body length: male and female 9 mm.

Body pigments and eyes absent.

Body (Fig. 3A) strongly convex; dorsum smooth bearing triangular scale-setae (Fig. 3B). Pereonite 1 epimera laterally rounded, anterior corner not surpassing distal margin of cephalon; pereonites 2 and 3 epimera rounded, 4–7 subquadrangular; pleonites 3–5 epimera with continuous outline with that of pereonite 7 (Fig. 3A, F); pereonite 1 epimera not grooved laterally, ventral lobe slightly surpassing outer lobe of schisma; pereonite 2 epimera without ventral lobe (Fig. 3G–J).

Cephalon (Fig. 3C–F) with lateral lobes well-developed and directed outwards; frontal shield fused with vertex; linea suprantennalis absent; lamina frontalis with 2 lateral rounded lobes (visible under light microscopy); lateral margins depressed to accommodate anterior corner of pereonite 1 epimera.

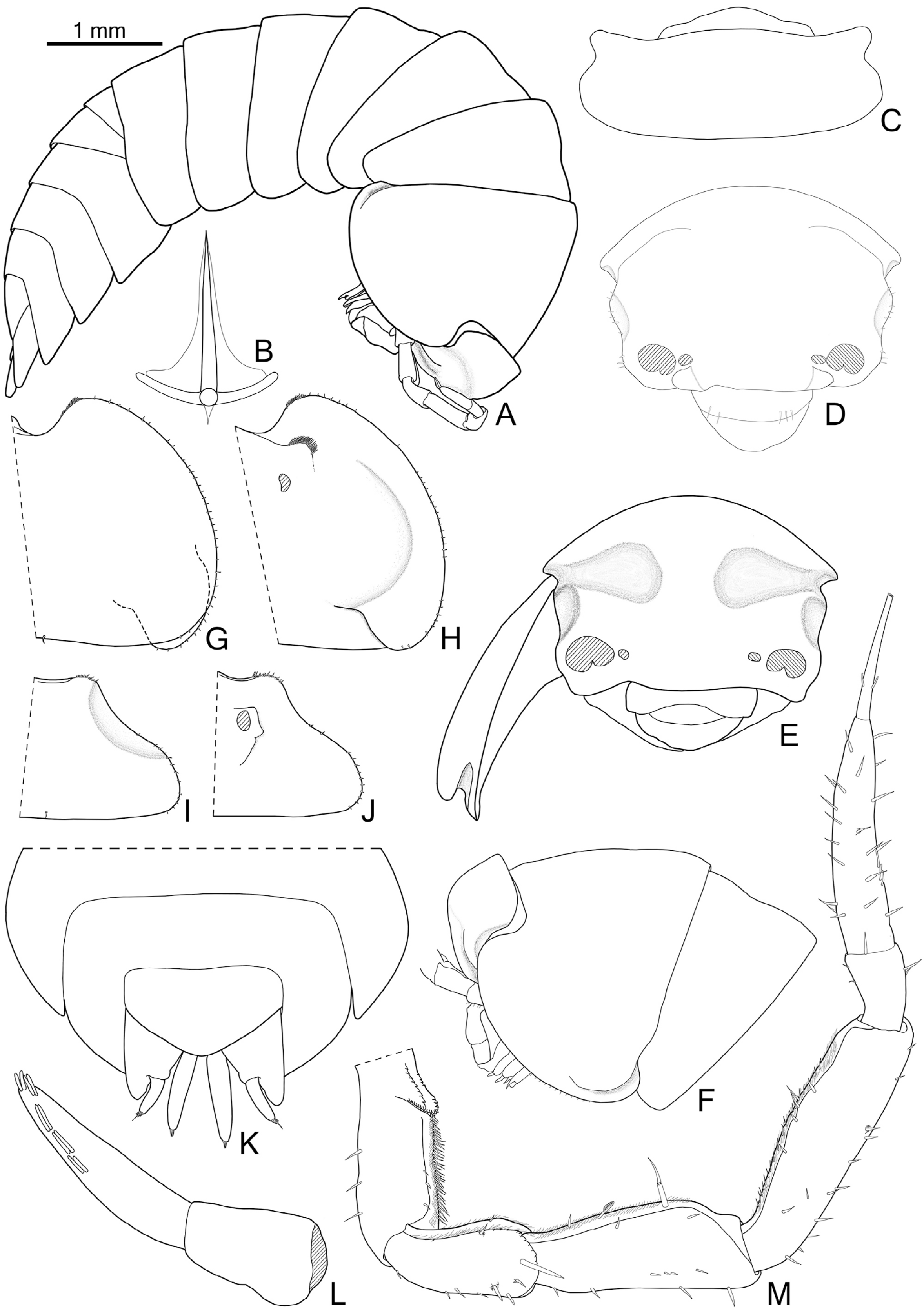

Figure 3. *Caecopactes chullachaqui* Campos-Filho, Sfenthourakis and Bichuette sp. nov., paratype. **A**, Habitus, lateral view; **B**, scale-seta; **C**, cephalon, dorsal view; **D**, cephalon, frontal view; **E**, cephalon and pereonite 1, frontal view; **F**, cephalon and pereonites 1 and 2, lateral view; **G**, epimeron 1, dorsal view; **H**, epimeron 1, ventral view; **I**, epimeron 2, dorsal view; **J**, epimeron 2, ventral view; **K**, pleonites 4 and 5, telson and uropods, dorsal view; **L**, antennula, **M**, antenna.

Pereonites 1–7 epimera (Fig. 3G, I) bearing 1 line of *noduli laterales* per side at same distance from lateral and posterior margins.

Pleonites 3–5 epimera (Fig. 3K) rectangular, epimera 5 surpassing distal margin of telson.

Telson (Fig. 3K) triangular, lateral sides almost straight, distal margin broad, not covering uropods.

Antennula (Fig. 3L) with distal article longest bearing 8 aesthetascs in 4 rows plus apical pair.

Antenna (Fig. 3M) not surpassing posterior margin of pereonite 1 when extended backwards; flagellum distal article about 3 times as long as proximal article bearing lateral aesthetascs.

Left mandible (Fig. 4A) with 2+1 penicils, right mandible (Fig. 4B) with 1+1 penicils.

Maxillula (Fig. 4C) inner endite with distal margin rounded covered with thin setae; outer endite composed of 3+4 simple teeth.

Maxilla (Fig. 4D) inner lobe rounded and covered with thick setae; outer lobe twice as wide as inner lobe and covered with thin setae.

Maxilliped (Fig. 4E) basis rectangular; palp proximal article bearing 1 seta; endite rectangular, medial seta stout.

Pereopods 1–7 (Fig. 5A, B) gradually increasing in size, merus and carpus 1–7 bearing sparse setae and hyaline fringe of scales on sternal margin; carpus 1 with distal seta with double-serrate apex, antennal grooming brush longitudinal reaching about half of its length; dactylus with dactylar and ungual setae simple.

Uropod (Figs 3K, 4F, G) protopod triangular and elongated, endopod twice as long as exopod bearing several distal setae; exopod inserted on medial portion bearing several distal setae.

Male: Pereopod 7 (Fig. 5B) ischium with sternal margin concave. Genital papilla (Fig. 5C) with elongated triangular ventral shield and distal papilla bearing subapical orifices. Pleopod 1 (Fig. 5D) exopod sub-trapezoidal, proximal margin straight, distal and lateral margins rounded; endopod 4 times as long as exopod, distal portion tapering, apex bent outwards bearing small setae on median portion. Pleopod 2 (Fig. 5E) exopod triangular, outer margin concave bearing 3 small setae; endopod flagelliform longer than exopod. Pleopod 3 exopod (Fig. 5F) triangular, outer portion rounded, outer margin concave bearing 2 setae. Pleopod 4 exopod (Fig. 5G) rhomboid, proximal outer corner depressed, outer margin sinuous bearing 5 small setae. Pleopod 5 exopod (Fig. 5H) triangular, proximal outer corner depressed, outer margin slightly convex bearing 4 setae, inner margin slightly grooved to fit distal portion of endopod 2.

Etymology. The new species is named after the Peruvian Amazonian myth 'El Chullachaqui'. In Quechua native language, *chulla* = unlike, and *chaqui* (pre-Hispanic Peruvian) = foot. The Chullachaqui is a dwarf who inhabits the mountain forests of Amazon and can transform into any animal or person. It is also known as the guardian of the rainforests, taking care of the animals and plants from hunters.

Habitat. The specimens were collected in decomposing organic matter and guano in the aphotic zone.

Remarks. *Caecopates chullachaqui* sp. nov. differs from *C. minimus* in having a cephalon lamina frontalis with protruding lateral corners (vs. not protruding in *C. minimus*), antennal peduncle with fourth and fifth articles not triangular shaped (vs. triangular shaped in *C minimus*), maxillula outer endite with the outer set of teeth simple (vs. maxillula outer endite with outer set bearing two teeth apically cleft), male pleopod 1 endopod with distal portion bent outwards (vs. straight in *C. minimus*), male pleopod 2 exopod elongated (vs. short in *C. minimus*), and male pleopods 4 and 5 exopods with outer proximal portion depressed (vs. not depressed in *C. minimus*).

DISCUSSION

Despite the fact that our knowledge on subterranean biodiversity around the world has been increasing during the last decades (Deharveng and Bedos, 2019), most of South American karstic regions still remain largely unknown. On the other hand, scientific collections both at local and at wider scales are continuously growing in the numbers of collected specimens.

Several taxonomic surveys have been conducted by the speleological groups Groupe Speleo Bagnols Marcoule, France (GSBM) and Espeleo Club Andino, Peru (ECA) in Cueva de Palestina, and several taxa are still waiting for formal taxonomic identification.

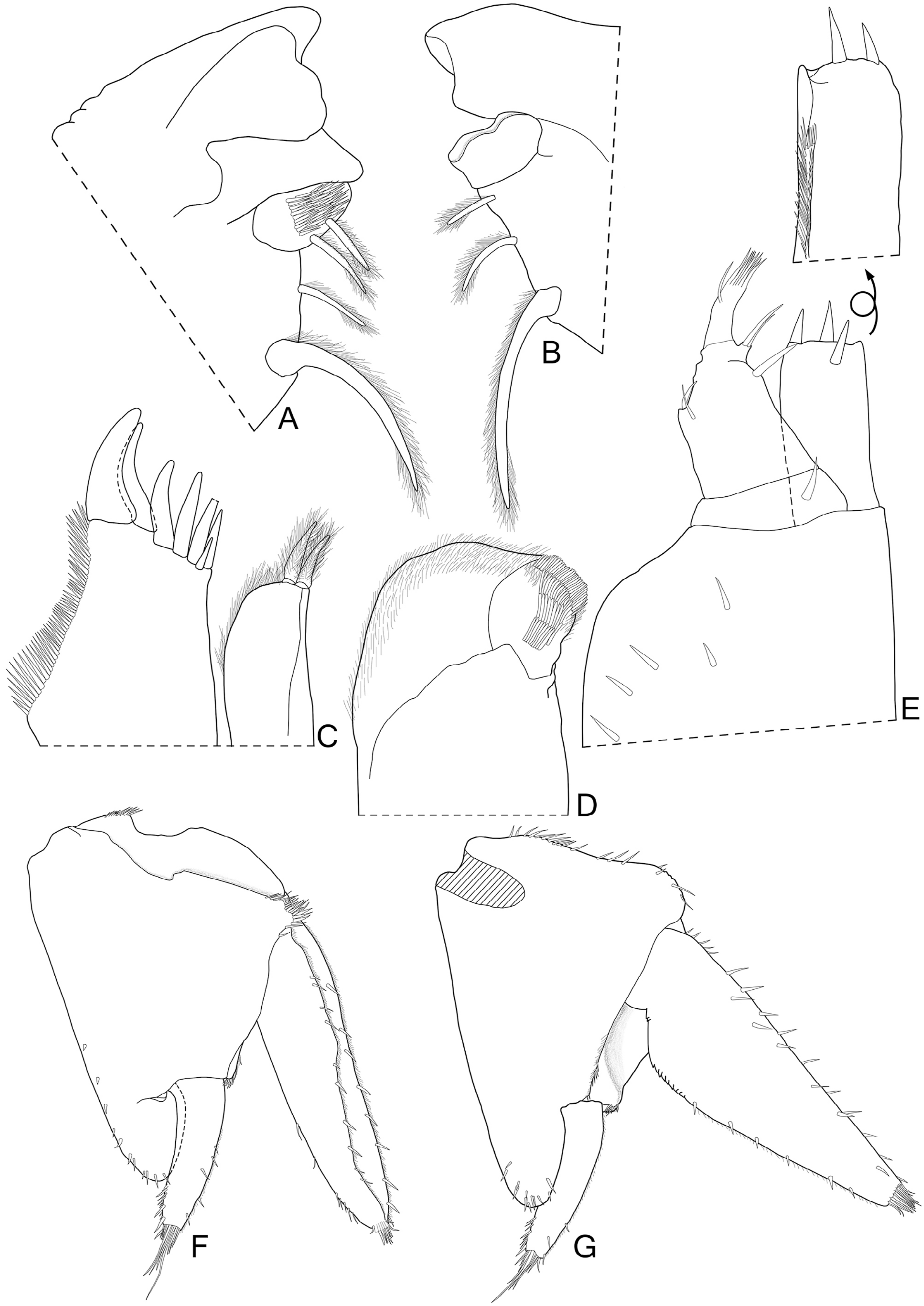

Figure 4. *Caecopactes chullachaqui* Campos-Filho, Sfenthourakis and Bichuette sp. nov, paratype. **A**, Left mandible; **B**, right mandible; **C**, maxillula; **D**, maxilla; **E**, maxilliped; **F**, uropod, ventral view; **G**, uropod, dorsal view.

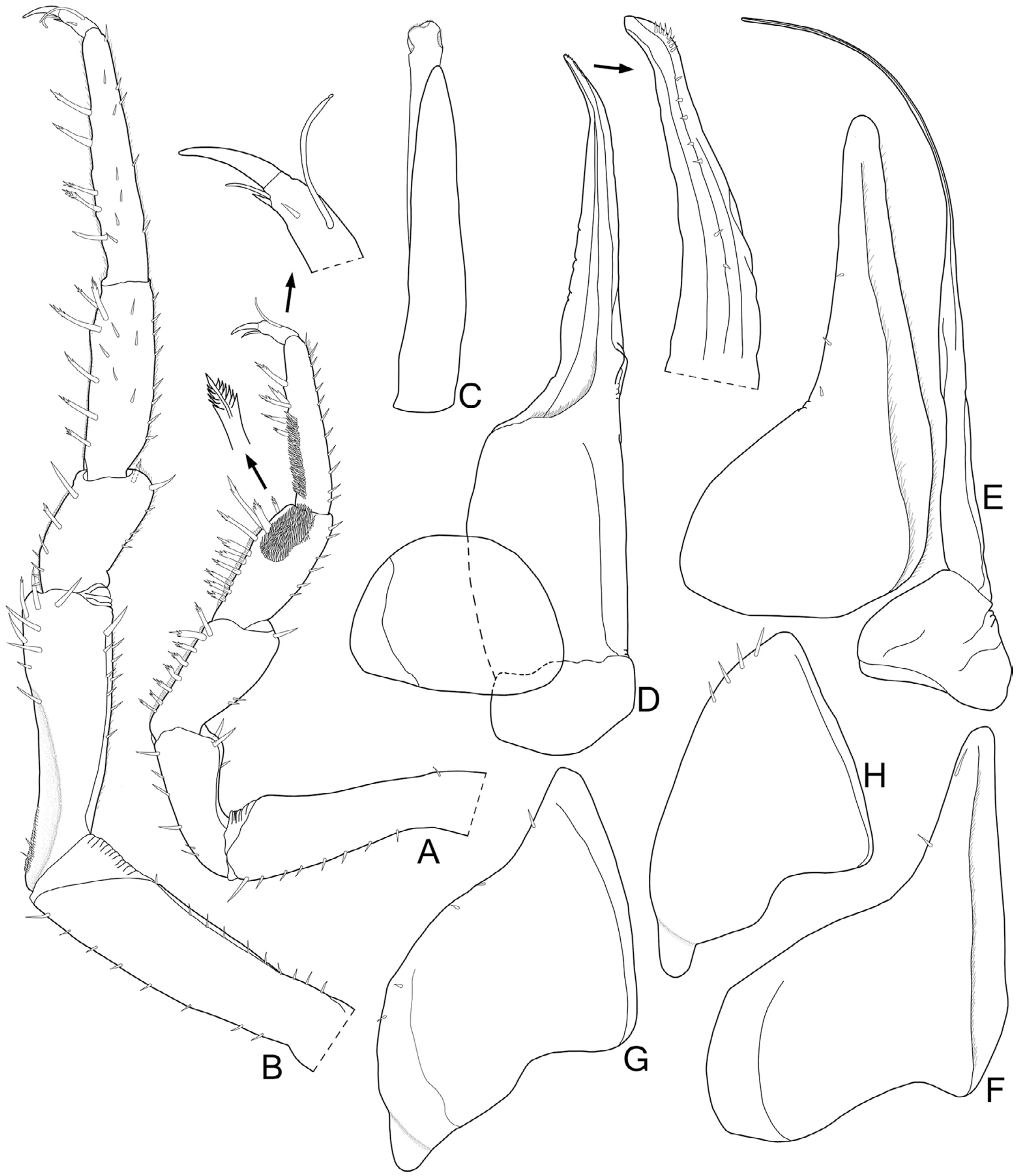

Figure 5. *Caecopactes chullachaqui* Campos-Filho, Sfenthourakis and Bichuette sp. nov., paratype. **A**, pereopod 1; **B**, pereopod 7; **C**, genital papilla; **D**, pleopod 1; **E**, pleopod 2; **F**, pleopod 3 exopod; **G**, pleopod 4 exopod; **H**, pleopod 5 exopod.

Considering the troglobitic fauna from Peru, only the collembolan *Acheroxenylla lipsae* Palacios-Vargas, 2020 (Collembola, Poduromorpha, Hypogastruridae), and the catfish *Astroblepus riberae* (Cardona and Guerao, 1994) (Actinopterygii, Siluriformes, Astroblepidae) are known (Cardona and Guerao, 1994; Palacios-Vargas, 2020). Thus, the present work describes the third troglobitic species and the first troglobitic terrestrial isopod for the country.

The Cueva de Palestina is a tourist cave with information being available in online public domains. However, the communities living around the cave area are committed to its conservation and employ several activities related to its environmental sustainability. All additions to our knowledge on the biodiversity of these caves are important contributions towards this goal, as they underline their importance for conservation.

ACKNOWLEDGMENTS

Our thanks go to Dr Diana Silva Dávila (Universidad Mayor de San Marcos, Museo de Historia Natural, Peru) for assisting with depositing new material; to James Apaéstegui from Espeleo Club Andino (ECA), for his invitation to LES/UFSCar in conducting surveys in Cueva de Palestina; to the GSBM (Groupe Spéléo Bagnols Marcoule, France), and to the GBPE (Grupo Bambuí de Pesquisas Espeleológicas, Brazil) for support during expeditions. We also thank Alexandre O. Lobo for Cueva de Palestina photography.

REFERENCES

Anderson LE 1954. Hoyer's Solution as a Rapid Permanent Mounting Medium for Bryophytes. *The Bryologist*, 57: e242. https://doi.org/10.2307/3240091

Auler AS 2017. Hypogene caves and karst of South America. p. 817–826. In: Klimchouk A; Palmer AN; De Waele J; Auler AS and Audra P (Eds.), Hypogene karst regions and caves of the world. Cave and karst systems of the world. Cham, Springer. https://doi.org/10.1007/978-3-319-53348-3_55

Bedek J; Gottstein S and Taiti S 2019a. Taxonomy of *Alpioniscus* (*Illyrionethes*): *A. magnus* and three new species from the Dinaric Karst (Isopoda: Oniscidea: Trichoniscidae). *Zootaxa*, 4657(3): 483–502. https://doi.org/10.11646/zootaxa.4657.3.4

Bedek HE; Zimmermann NE; McVicar TR; Vergopolan N; Berg A and Wood EF 2018. Present and future Köppen-Geiger climate classification maps at 1-km resolution. *Scientific Data*, 5: e180214. https://doi.org/10.1038/sdata.2018.214

Bedek HE; Zimmermann NE; McVicar TR; Vergopolan N; Berg A and Wood EF 2020. Publisher Correction: Present and future Köppen-Geiger climate classification maps at 1-km resolution. *Scientific Data*, 7: e274. https://doi.org/10.1038/s41597-020-00616-w

Bedek J; Taiti S; Bilandžija H; Ristori E and Baratti M 2019. Molecular and taxonomic analyses in troglobiotic *Alpioniscus* (Illyrionethes) species from the Dinaric Karst (Isopoda: Trichoniscidae). *Zoological Journal of the Linnean Society*, 187(3): 539–584. http://dx.doi.org/10.1093/zoolinnean/zlz056

Budde-Lund G 1885. Crustacea Isopoda Terrestria per Familias et Genera et Species Descripta. Copenhagen, Nielsen & Lydiche, 319p. https://doi.org/10.5962/bhl.title.109769

Campos-Filho IS and Araujo PB 2011. Two new troglobitic species of Scleropactidae (Crustacea: Isopoda: Oniscidea) from Pará, Brazil. *Nauplius*, 19(1): 27–39. https://doi.org/10.1590/S0104-64972011000100004

Campos-Filho IS; Araujo PB; Bichuette ME; Trajano E and Taiti S 2014. Terrestrial isopods (Crustacea: Isopoda: Oniscidea) from Brazilian caves. *Zoological Journal of the Linnean Society*, 172(2): 360–425. https://doi.org/10.1111/zoj.12172

Campos-Filho IS; Cardoso GM and Aguiar JO 2018. Catalogue of terrestrial isopods (Crustacea, Isopoda, Oniscidea) from Brazil: an update with some considerations. *Nauplius*, 26: e2018038. http://dx.doi.org/10.1590/2358-2936e2018038

Campos-Filho IS; Fernandes CS; Cardoso GM; Bichuette ME; Aguiar JO and Taiti S 2020. New species and new records of terrestrial isopods (Crustacea, Isopoda, Oniscidea) of the families Philosciidae and Scleropactidae from Brazilian caves. *European Journal of Taxonomy*, 606: 1–38. http://dx.doi.org/10.5852/ejt.2020.606

Cardona L and Guerao G 1994. *Astroblepus riberae*, una nueva especie de siluriforme cavernicola del Peru (Osteichthyes: Astroblepidae). *Mémoirs de Biospéléologie*, 21: 21–24. https://cuevasdelperu.org/publicaciones/peru/1994_MemoiresBiospeologie_21_Cardona.pdf

Cardoso GM; Bastos-Pereira R; Souza LA and Ferreira RL 2020a. New troglobitic species of *Xangoniscus* (Isopoda: Styloniscidae) from Brazil, with notes on their habitats and threats. *Zootaxa*, 4819(1): 084–108. https://doi.org/10.11646/zootaxa.4819.1.4

Cardoso GM; Bastos-Pereira R; Souza LA and Ferreira RL 2020b. New cave species of *Pectenoniscus* Andersson, 1960 (Isopoda: Oniscidea: Styloniscidae) and an identification key for the genus. *Nauplius*, 28: e2020039. http://dx.doi.org/10.1590/2358-2936e2020039

CESPE-GBPE-GSBM 2004a. Expédition Spéléologique Pucara 2003. Bulletin Hors-série du GSBM, Spécial Pucara 2003. http://www.gsbm.fr/publications/gsbm/2004_pucara2003/2004_GSBM_HS_Pucara2003.pdf

CESPE-GBPE-GSBM 2004b. Expédition Spéléologique Pucara 2003. Bulletin Hors-série du GSBM, Spécial Pucara 2003, vol. 1, 70p.

Cifuentes J and Prieto CE 2021. Descripción de dos nuevas especies cavernícolas de Trichoniscinae Verhoeff, 1908 de la Cordillera Cantábrica (Crustacea: Isopoda: Trichoniscidae). *Graelsia*, 77(1): e124. https://doi.org/10.3989/graellsia.2021.v77.275

Culver DC 2016. Karst environment. *Zeitschrift für Geomorphologie*, 60 (Suppl. 2): 103–117. https://doi.org/10.1127/zfg_suppl/2016/00306

Culver DC and Pipan T 2019. The Biology of Caves and other Subterraneans Habitats. 2nd ed. Biology of Habitat Series. New York, Oxford University Press Inc., 336p.

Deharveng L and Bedos A 2018. Diversity of terrestrial invertebrates in subterranean habitats. p. 107–172. In: Moldovan OT; Kováč L' and Halse S (Eds.), Cave Ecology. Ecological Studies 235. Cham, Springer. https://doi.org/10.1007/978-3-319-98852-8_7

Deharveng L and Bedos A 2019. Biodiversity in the tropics. p. 146–162. Encyclopedia of Caves, 3rd edition. London, Elsevier Academic Press. https://doi.org/10.1016/B978-0-12-814124-3.00040-6

Dimitriou AC; Taiti S Sfenthourakis S 2019. Genetic evidence against monophyly of Oniscidea implies a need to revise scenarios for the origin of terrestrial isopods. *Nature Scientific Reports*, 9: e18508. https://doi.org/10.1038/s41598-019-55071-4

Ebach MC; Valdecasas AG and Wheeler QD 2011. Impediments to taxonomy and users of taxonomy: accessibility and impact evaluation. *Cladistics*, 27: 550–557. https://doi.org/10.1111/j.1096-0031.2011.00348.x

Gibert J and Deharveng L 2002. Subterranean ecosystems: a truncated functional biodiversity. *BioScience*, 52(6): 473–481. https://doi.org/10.1641/0006-3568(2002)052[0473:SEATFB]2.0.CO;2

Kashani GM; Malekhosseini M-J and Sadeghi S 2013. First recorded cave-dwelling terrestrial isopods (Isopoda: Oniscidea) in Iran with a description of a new species. *Zootaxa*, 3734(5): 591–596. https://doi.org/10.11646/zootaxa.3734.5.8

Javidkar M; Cooper SJB; King RA; Humphreys WF and Austin A 2015. Molecular phylogenetic analyses reveal a new southern hemisphere oniscidean family (Crustacea: Isopoda) with a unique water transport system. *Invertebrate Systematics*, 29: 554–577. https://doi.org/10.1071/IS15010

Marchese C 2015. Biodiversity hotspots: A shortcut for a more complicated concept. *Global Ecology and Conservation*, 3: 297–309. https://doi.org/10.1016/j.gecco.2014.12.008

Montesanto G 2015. A fast GNU method to draw accurate scientific illustrations for taxonomy. *ZooKeys*, 515: 191–206. https://doi.org/10.3897/zookeys.515.9459

Montesanto G 2016. Drawing setae: a GNU way for digital scientific illustrations. *Nauplius*, 24: e2016017. https://doi.org/10.1590/2358-2936e2016017

Mulaik S 1960. Contribución al conocimiento de los isópodos terrestres de México (Isopoda, Oniscoidea). *Revista de la Sociedad Mexican de Historia Natural*, 21: 79–292.

Myers N; Mittermeier RA; Mittermeier CG; Fonseca GAB and Kent J 2000. Biodiversity hotspots for conservation priorities. *Nature*, 403: 853–858. https://doi.org/10.1038/35002501

Ocampo-Maceda AT; Ruelas-Cabana CM; López-Orozco CM and López-Tejeda EL 2022. Catalogue of terrestrial isopods (Isopoda, Oniscidea) from Peru, with new records of *Circoniscus ornatus* (Scleropactidae) and *Ethelum americanum* (Eubelidae). *Nauplius*, 30: e2022003. https://doi.org/10.1590/2358-2936e2022003

Palacios-Vargas JG 2020. *Acheroxenylla* (Collembola, Hypogastruridae), first record from the Americas with description of a new species from a Peruvian cave. *Subterranean Biology*, 34: 109–119. https://doi.org/10.3897/subtbiol.34.50673

Pearse AS 1917. Isopoda collected by the Bryant Walker Expedition to British Guiana, with notes on Crustacea from other localities. *Occasional Papers*, Museum of Zoology, University of Michigan, 46: 1–8.

Pearson DL; Hamilton AL and Erwin TL 2011. Recovery plan for the endangered taxonomy profession. *BioScience*, 61(1): 58–63. http://dx.doi.org/10.1525/bio.2011.61.1.11

Reboleira ASPS; Gonçalves F; Oromí P and Taiti S 2015. The cavernicolous Oniscidea (Crustacea: Isopoda) of Portugal. *European Journal of Taxonomy*, 161: 1–61. https://doi.org/10.5852/ejt.2015.161

Ribera C and Bellés X 1994. Pérou. p 569–576. In: Encyclopaedia Biospéologica. vol I. Société de Biospéologie. Moulis.

Schmalfuss H 1995. Die Land-isopoden Griechenlands. 16. Beitrag: gattugen *Xeroporcellio* und *Kithironiscus* gen. n. *Annalen des Naturhistorischen Museums in Wien*, Serie B, 97: 139–150. https://www.jstor.org/stable/41766951

Schmalfuss H. 2003. World catalog of terrestrial isopods (Isopoda: Oniscidea). *Stuttgarter Beiträge zur Naturkunde*, Serie A, 654: 1–341. https://isopods.nhm.org/pdfs/27577/27577.pdf

Schmidt C 2007. Revision of the Neotropical Scleropactidae (Crustacea: Oniscidea). *Zoological Journal of the Linnean Society*, 151(Suppl. 1): 1–339. https://doi.org/10.1111/j.1096-3642.2007.00286.x

Schmidt C 2008. Phylogeny of the Terrestrial Isopoda (Oniscidea): a Review. *Arthropod Systematics & Phylogeny*, 66(2): 191–226. https://www.zobodat.at/pdf/Arthropod-Systematics-Phylogeny_66_0191-0226.pdf

Sfenthourakis S and Taiti S 2015. Patterns of taxonomic diversity among terrestrial isopods. *ZooKeys*, 515: 13–25. https://doi.org/10.3897%2Fzookeys.515.9332

Souza LA; Bezerra AV and Araújo JP 2006. The first troglobitic species of Scleropactidae from Brazil (Crustacea, Isopoda, Oniscidea). *Subterranean Biology*, 4: 37–43.

Tabacaru I and Giurginca A 2003. The presence of the family Scleropactidae in Dobrogea. Systematic and zoogeographic remarks. In: Sfenthourakis S; Araujo PB; Hornung E; Schmalfuss H; Taiti S and Szlávecz (Eds.), The Biology of Terrestrial Isopods, V. Oniscidea rolling into the new millennium. Proceedings of the 5th International Symposium on the Biology of Terrestrial Isopods. *Crustacean Monographs*, 2: 13–22. https://doi.org/10.1163/9789047412854_005

Taiti S 2004. Crustacea: Isopoda: Oniscidea (woodlice). p. 547–551. In: Gunn J (Ed.), Encyclopedia of caves and karst science. New York, Taylor and Francis Group.

Taiti S 2014. New subterranean Armadillidae (Crustacea, Isopoda, Oniscidea) from Western Australia. *Tropical Zoology*, 27(4): 153–165. https://doi.org/10.1080/03946975.2014.984510

Taiti S and Howarth FG 1997. Terrestrial isopods (Crustacea, Oniscidea) from Hawaiian caves. *Mémoires de Biospélogie*, 24: 97–118.

Taiti S and Montesanto G 2018. New species of subterranean and endogean terrestrial isopods (Crustacea, Oniscidea) from Tuscany (central Italy). *Zoosystema*, 40(11): 197–226. https://doi.org/10.5252/zoosystema2018v40a11

Taiti S and Montesanto G 2020. Troglobiotic terrestrial isopods from Myanmar, with descriptions of a new genus and three new species (Crustacea, Oniscidea). *Raffles Bulletin of Zoology*, Supplement 35: 109–122. https://doi.org/10.26107/RBZ-2020-0043

Trajano E 2019. Biodiversity in South America, p. 177-186. In: White WB; Culver DC and Pipan T (Eds.), Encyclopedia of Caves. 3rd ed. Academic Press, London. https://doi.org/10.1016/B978-0-12-814124-3.00019-4

Trajano E and Bichuette ME 2006. Biologia subterrânea: Introdução. São Paulo, Redespeleo, 92p.

Vandel A 1973. Les isopodes terretres et cavernicoles de l'île de Cuba. p. 153–188. In: Orghidan T (Ed.), Résultats des expéditions biospéologiques Cubano-roumaines à Cuba. Bucharest, Editura Academiei Republicii Socialiste România.

Verhoeff KW 1938. Weltstellung der Isopoda terrestria, neue Familien derselben und neues System. *Zoologische Jahrbücher, Abteilung* für *Systematik,* Ökologie *und Geographie der Tiere*, 71: 253–264.

Verhoeff KW 1941. Über eine neue südamerikanische Gattung der Isopoda terrestria. *Zoologischer Anzeiger*, 134: 169–173.

ADDITIONAL INFORMATION AND DECLARATIONS

Author Contributions

Conceptualization and Design: ISC-F, SS, JEG, MEB. Performed research: ISC-F, JEG, MEB. Acquisition of data: JEG, LH-S, MEB. Analysis and intepretation of data: ISC-F, JEG, MEB. Preparation of figures/tables/maps: ISC-F, MEB. Writing - original draft: ISC-F. Writing - critical review & editing: ISC-F, SS, JEG, LS-H, MEG.

Consent for publication

All authors declare that they have reviewed the content of the manuscript and gave their consent to submit the document.

Competing interests

The author(s) declare(s) no competing interest.

Data availability

All data are archived in the Universidad Mayor de San Marcos, at the Museo de Historia Natural de Peru (Lima, Peru), and in the Universidade Federal de São Carlos (UFSCar) in the collection of LES (Laboratório de Estudos Subterrâneos) at the Ecology and Evolutive Biology Department of the Federal University of São Carlos (DEBE/UFSCar, São Carlos, Brazil), and available on request from DSD and MEB, respectively.

Funding and grant disclosures

This research was supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq, financial support and productivity fellowship grant # 457413/2014-0 and 310378/2017-6 to MEB; by "ONISILOS Research Program – 2018", University of Cyprus – UCY, Research Project titled "Biodiversity of terrestrial isopods (Crustacea, Isopoda, Oniscidea) from Cyprus in the light of integrative taxonomy", postdoctoral fellowship granted to ISC-F.

Study association

This works was developed in collaboration with Centro de Ecología y Biodiversidade del Perú and Museo de Historia Natural Universidad Nacional Mayor de San Marcos, Peru (MUSM).

Study permits

Field collection and transportation of specimens were made under the Servicio Nacional Forestal Y De Fauna Silvestre – SERFOR, permission number # 330-2017-SERFOR/DGGSPFFS, AUT-IFS-2017-075, to MEB and Frank Azorsa (CEBIO).