

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

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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.

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).

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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, Syncheta, 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 eleonora* 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 Martín, 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 were 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 Martín, 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 Köppen's 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 within the Amazonian Piedmont, province of Rioja, at the extreme north of the San Martín Region, northwestern Peru (CESPE-GBPE-GSBM, 2004a; 2004b). This karst massif forms

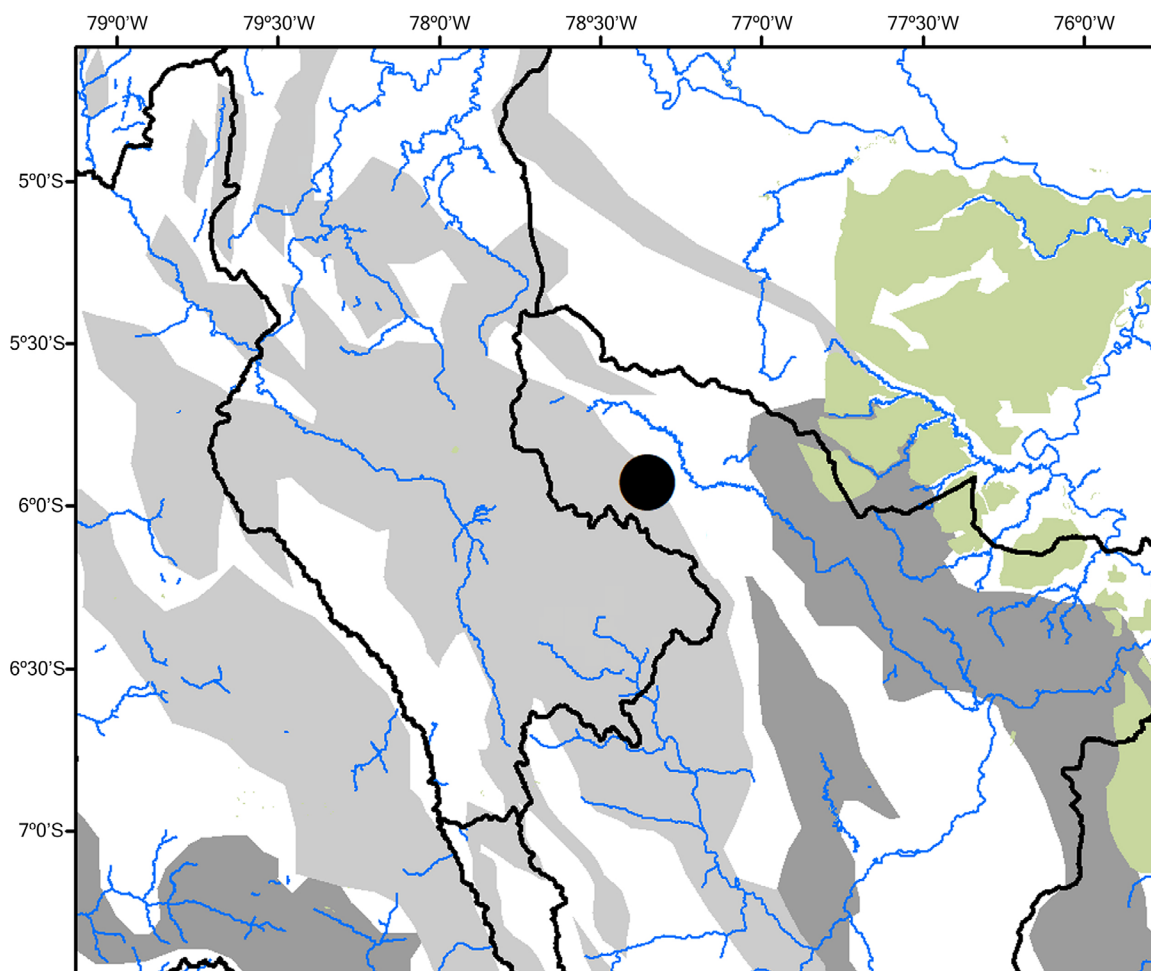


Figure 1. Map of the type locality of *Caecopactes chullachaqui* Campos-Filho, Sfenthourakis and Bichuette sp. nov. • Cueva de Palestina. Green areas: legal conservation units; dark grey: discontinuous carbonate rocks; light grey: continuous carbonate rocks.

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 Geológico, 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)

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Type material. Holotype: male adult (MUSM-CRUS 0100000), Peru, San Martin, Rioja, Nueva Cajamarca, Cueva de Palestina, 5°52'33"S 77°20'51.31"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.

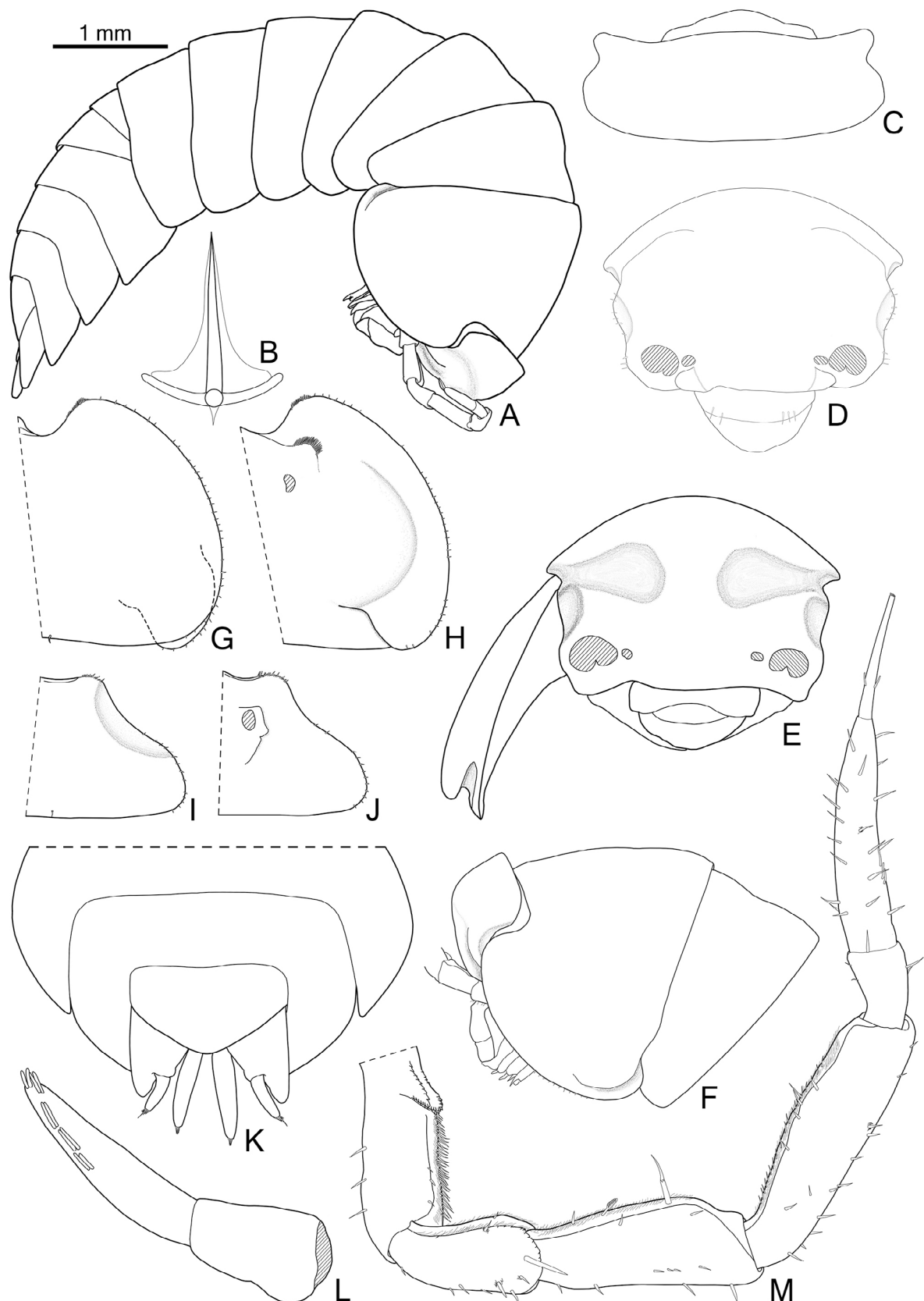


Figure 3. *Caecopactes chullachaqui* Campos-Filho, Sfenthourakis and Bichuette sp. nov., paratype. **A**, Habitus, lateral view; **B**, scale seta; **C**, cephalon, dorsal view; **D**, cephalon, frontal view; **E**, cephalon and pereonite 1, frontal view; **F**, cephalon and pereonites 1 and 2, lateral 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 unguis 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.

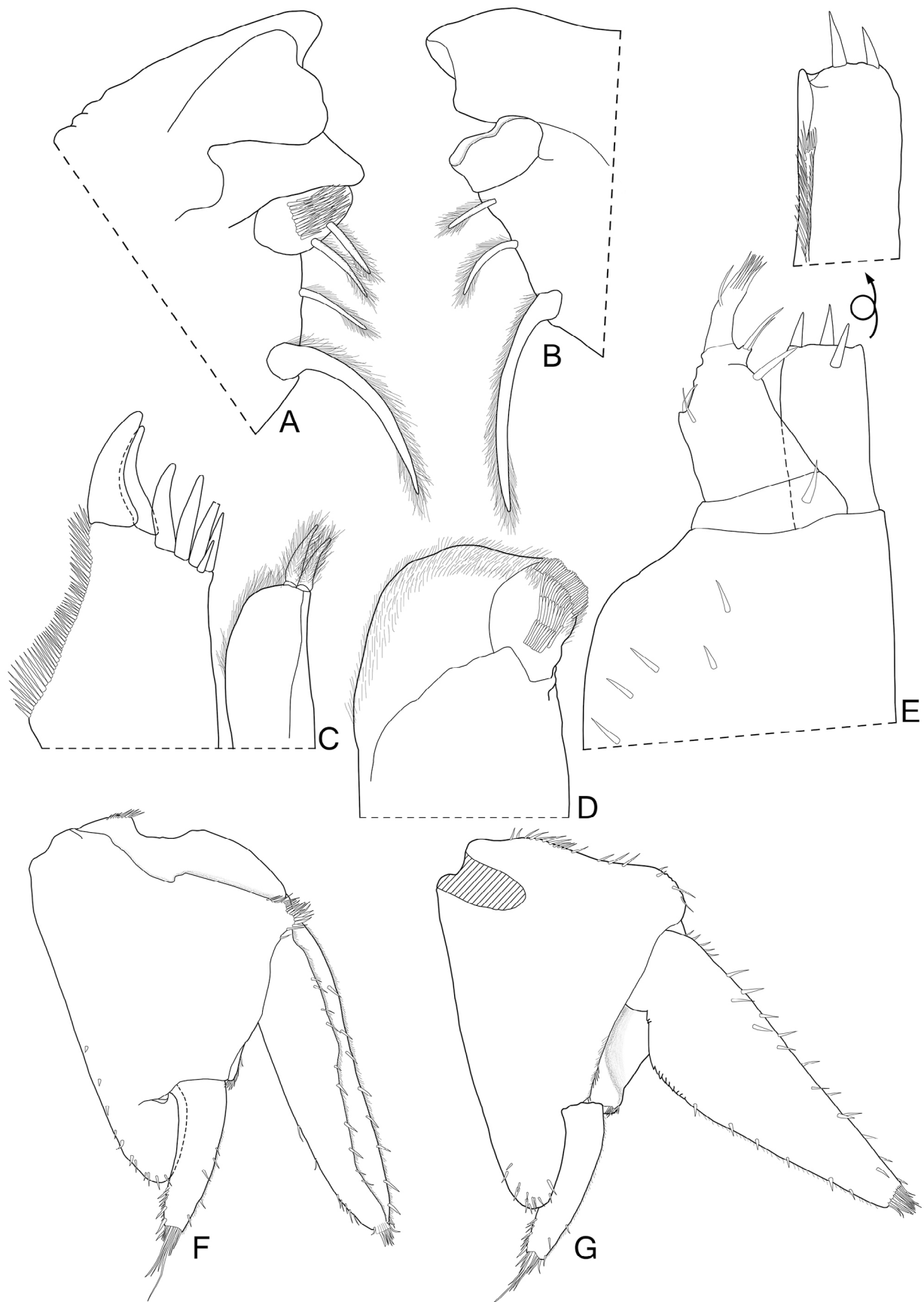


Figure 4. *Caecopactes chullachaqui* Campos-Filho, Sfenthourakis and Bichuette sp. nov, paratype. **A**, Left mandible; **B**, right mandible; **C**, maxillula; **D**, maxilla; **E**, maxilliped; **F**, uropod, ventral view; **G**, uropod, dorsal view.

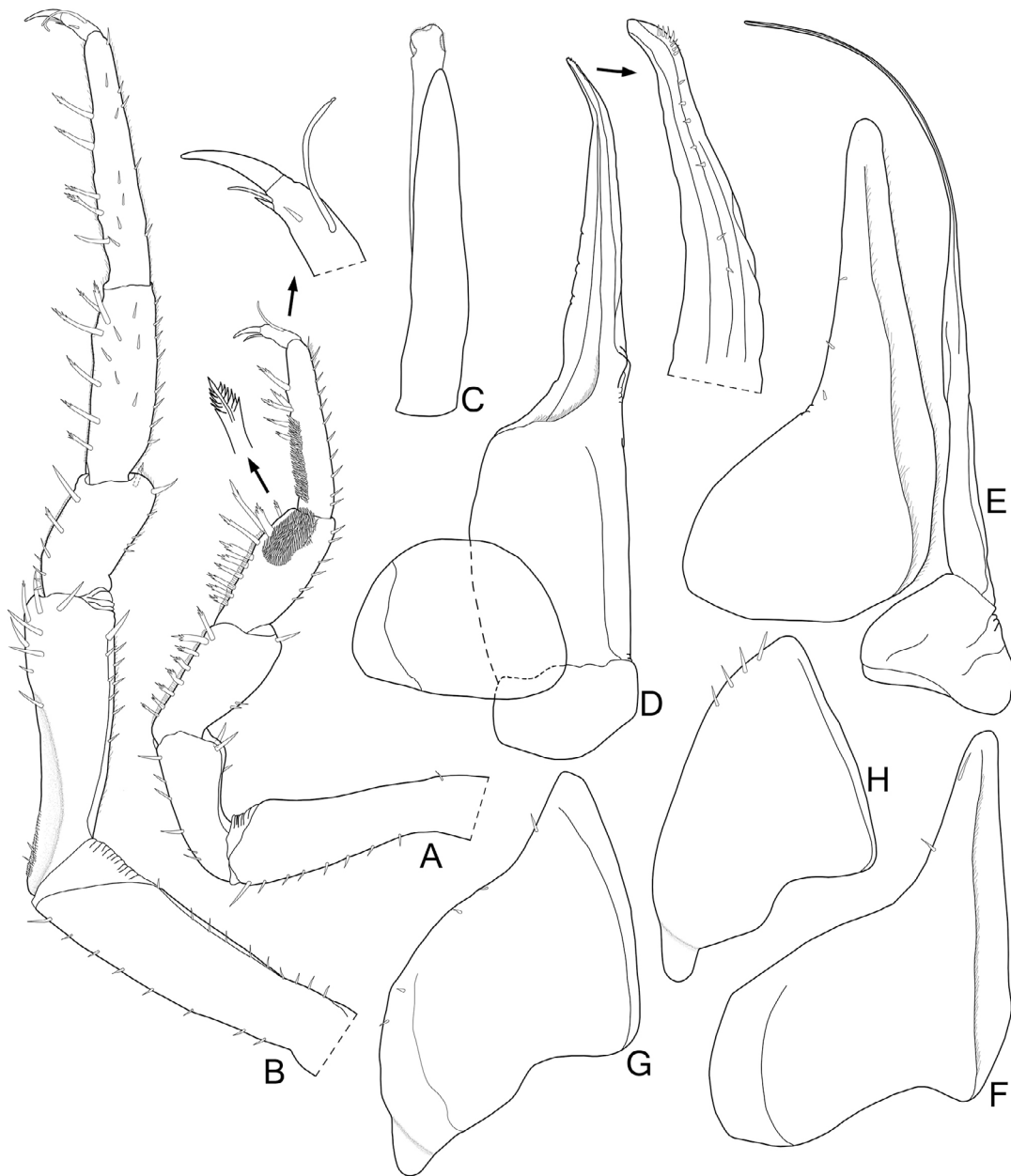


Figure 5. *Caecopactes chullachai* Campos-Filho, Sfenthourakis and Bichuette sp. nov., paratype. **A**, pereopod 1; **B**, pereopod 7; **C**, genital papilla; **D**, pleopod 1; **E**, pleopod 2; **F**, pleopod 3 exopod; **G**, pleopod 4 exopod; **H**, pleopod 5 exopod.

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.

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ADDITIONAL INFORMATION AND DECLARATIONS

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Conceptualization and Design: ISC-F, SS, JEG, MEB. Performed research: ISC-F, JEG, MEB. Acquisition of data: JEG, LH-S, MEB. Analysis and interpretation 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.

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