

# Expanding the knowledge on the diversity of the cavernicolous Styloniscidae Vandel, 1952 (Oniscidea, Synocheta) from Brazil, with descriptions of two new species from the semiarid karst regions

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## Abstract

Two new species of *Pectenoniscus* from two caves in karst areas of the Brazilian semiarid region are described. *Pectenoniscus pankaru* Campos-Filho, Torres & Bichuette, **sp. nov.** from Gruna do Govi cave, Serra do Ramalho karst area, state of Bahia, and *Pectenoniscus fervens* Campos-Filho, Taiti & Bichuette, **sp. nov.** from Toca Coroa do Frade cave, Barra Bonita karst area, state of Piauí. In addition, specimens of *Cylindroniscus flaviae* from Gruta da Tapagem (= Caverna do Diabo), Açungui karst area were also recorded. An updated diagnosis of *Pectenoniscus* and a distribution map of the species examined herein are given.

## Keywords

Açungui geomorphological group, Bambuí geomorphological group, Casa Nova geomorphological group, *Cylindroniscus*, Neotropical, *Pectenoniscus*

## Introduction

Terrestrial isopods (Oniscidea) comprise approximately 4,000 species and more than 500 genera distributed in 38 families (Sfenthourakis and Taiti 2015; Dimitriou et al. 2019; Campos-Filho and Taiti 2021). The Oniscidea are one of the most representative taxa in the Brazilian subterranean environments, due to their favourable habitat conditions with high humidity and many different substrates and micro-habitats (Fernandes et al. 2016, 2019). To date, more than 210 species are known from Brazil, of which 70 have been recorded from caves. Among them, 31 species are considered troglobites (obligatory and restricted cave-dwellers) and several are troglophiles (facultative cave-dwellers) or troglonexes (epigean species with individuals using subterranean resources) (Trajano 2012; Trajano and Carvalho 2017; Campos-Filho et al. 2018, 2019, 2020; Cardoso et al. 2020a, b, 2021). However, both troglobitic and troglophile species are not assigned with certainty to these categories due the lack of sampling outside caves. Endogean species exhibiting classical troglomorphic characters, such as lack or reduction of body pigments and eyes, might also occur in the unconsolidated substrate outside caves (Campos-Filho et al. 2014).

The family Styloniscidae comprises 120 species distributed in 18 genera (WoRMS 2021). The family has a worldwide distribution, with species inhabiting many terrestrial environments, including caves (Schmalfuss 2003). Fifty-eight species distributed in 13 genera have been recorded from caves, i.e., *Bamaoniscus* Taiti & Montesanto, 2020 (1 sp.), *Chaimowiczia* Cardoso, Bastos-Pereira, Souza & Ferreira, 2021 (2 spp.), *Clavigeroniscus* Arcangeli, 1930 (2 spp.), *Cordioniscus* Gräve, 1914 (15 spp.), *Cylindroniscus* Arcangeli, 1929 (5 spp.), *Indoniscus* Vandel, 1952 (1 sp.), *Iuiuniscus* Souza, Ferreira & Senna, 2015 (1 sp.), *Pectenoniscus* Andersson, 1960 (7 spp.), *Spelunconiscus* Campos-Filho, Araujo & Taiti, 2014 (1 sp.), *Styloniscus* Dana, 1853 (7 spp.), *Thailandoniscus* Dalens, 1989 (3 spp.), *Trogloniscus* Taiti & Xue, 2012 (5 spp.), and *Xangoniscus* Campos-Filho, Araujo & Taiti, 2014 (8 spp.) (for all recorded species see Dalens 1987; Mulaik 1960; Schultz 1970, 1995; Green 1971; Vandel 1973, 1977, 1981; Ferrara and Taiti 1979; Taiti et al. 1992; Taiti and Howarth 1997; Schmalfuss and Erhard 1998; Andreev and Bozarova 2000; Andreev 2002; Green et al. 2002; Taiti and Xue 2012; Campos-Filho et al. 2014; Souza et al. 2015; Bastos-Pereira et al., 2017; Fernandes et al. 2018; Cardoso et al. 2020a, b, 2021; Taiti and Montesanto 2020).

To date, in Brazil, 26 species of the family distributed in nine genera have been recorded from caves, i.e., *Chaimowiczia* (2 spp.), *Clavigeroniscus* (1 sp.), *Cordioniscus* (1 sp.), *Cylindroniscus* (2 spp.), *Iuiuniscus* (1 sp.), *Pectenoniscus* (8 spp.), *Spelunconiscus* (1 sp.), *Styloniscus* (2 spp.), and *Xangoniscus* (8 spp.) (Campos-Filho et al. 2018, 2019; Cardoso et al. 2020a, b, 2021). It is worth mentioning that the Styloniscidae in Brazil hold the highest diversity of troglobitic isopods comprising 20 out of 31 species (Campos-Filho et al. 2018, 2019, 2020; Cardoso et al. 2020a, b, 2021).

Two new species of *Pectenoniscus* from caves of two distinct Brazilian karst regions are described here. The first species comes from Gruna do Govi, Serra do Ramalho karst region, inserted in the Bambuí geomorphological group, state of Bahia, and the second

from Toca Coroa do Frade, Barra Bonita karst region, Casa Nova geomorphological group, state of Piauí. In addition, specimens of *Cylindroniscus flaviae* Campos-Filho, Araujo & Taiti, 2017 from Gruta da Tapagem (also known as Caverna do Diabo), Açungui geomorphological group, are recorded here. An updated diagnosis of the genus *Pectenoniscus* is given to include the species described by Cardoso et al. (2020b) and the two new species. Ecological and conservation remarks considering IUCN threat categories, are provided.

## Materials and methods

### Collections and taxonomy

Specimens were collected by hand with the aid of tweezers and brushes and 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 was also recorded. Descriptions are based on morphological characters with the use of micro-preparations in Hoyer's medium (Anderson 1954). For each new species, the diagnosis, type material, description, etymology and remarks are given. The *habitus* images were taken with the stereomicroscope model Motic SMZ-168 and the Celestron Microcapture Pro. 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 using the software GIMP (v. 2.8) with the method proposed by Montesanto (2015, 2016). A map highlighting the caves where all species occur, as well the hydrological attributes and pressures of economic activities in the region, is presented. The distribution map was constructed with the QGIS software (v. 3.18.1) and the final edition with PowerPoint Microsoft 365 (v. 2108).

The material is deposited in the scientific collection of cave fauna of the Laboratório de Estudos Subterrâneos (**LES**), Universidade Federal de São Carlos, São Carlos, Brazil.

### Study areas

#### Parque Estadual Caverna do Diabo, Açungui geomorphological group

The Açungui geomorphological group comprises the metamorphic limestone and dolomite rocks of ~ 600 million years ago, extending from south of the São Paulo state to north of the Paraná state (Rubbioli et al. 2019). Due to the altitudinal range, this group has one of the largest concentrations of irregular limestone areas in the country, including very ornamented caves crossed by rivers (Rubbioli et al. 2019). The Açungui group is located in the Chacoan subregion, in all provinces of the Parana domain, i.e., Atlantic Forest, *Araucaria* Forest, and Paraná Forest (Morrone 2014). According to Köppen's criteria, it shows a warm temperate climate, fully humid with warm summer (Kottek et al. 2006).

This region includes the Caverna do Diabo State Park (PECD, in Portuguese, Parque Estadual da Caverna do Diabo), state of São Paulo (Fig. 1), which covers the

municipalities of Barra do Turvo, Cajati, Eldorado and Iporanga (Fundação Florestal, 2010). The PECD was created in 2008 and it has more than 40,000 ha, constituting the Jacupiranga mosaic of conservation units (Fundação Florestal 2010). Gruta da Tapagem, also known as Caverna do Diabo (Fig. 2A), is ~ 8 km long and it is considered one of the most important caves of the PECD. The cave is inserted in the Tapagem dolomitic marble, in the André Lopes carbonate belt, and it is a sinkhole of the Ribeirão da Tapagem, a river which develops its subterranean course in ~ 4 km to the resurgence in the Vale do Rio das Ostras, a right-bank tributary of the Ribeira de Iguape (Karmann and Sánchez 1979; Hiruma et al. 2008; Rubbioli et al. 2019). The temperature and relative humidity of the air of the cave ranged from 28.8 °C and 60% RH in the entrance zone to 26.5 °C and 78% RH in the aphotic zone. This cave is notable for its scenic beauty with large halls and speleothems, and a stretch with illumination, stairs, and walkways for touristic activity (Silverio 2014).

### **Serra do Ramalho karst area, Bambuí geomorphological group**

The Bambuí geomorphological group has the largest limestone area (ca. 146,000 km<sup>2</sup>) and the highest number of caves in Brazil (Rubbioli et al. 2019). The group includes the Serra do Ramalho karst area, located in the southwestern of the state of Bahia and the municipalities of Coribe, Feira da Mata, Carinhanha and Serra do Ramalho (Rubbioli et al. 2019). This area is inserted in the middle of the São Francisco River basin, dominated by a plateau of carbonate rocks with a high number of caves, mostly without legal protection (Auler et al. 2001; Rubbioli et al. 2019). According to Köppen's criteria, the climate is tropical dry, characterised by dry winters and annual precipitation of ~ 640 mm (Bedeck et al. 2018, 2020). The dominant vegetation is “Caatinga”, composed of mesophytic and xeromorphic forests interspersed with “Cerrado” (savannah-like vegetation) (Bichuette and Rizzato 2012).

The Gruta do Góvi (Figs 1, 3) is located in a private property of the municipality of Feira da Mata. The surrounding of the cave harbours native vegetation and pastures, and anthropic impacts like garbage, graffiti on the walls and systems for capturing water from the subterranean drainage (Fig. 3C, D).

### **Barra Bonita karst region, Casa Nova geomorphological group, state of Piauí**

The Barra Bonita karst region is inserted in the Casa Nova geomorphological group, and it is formed by quartzites, mica schists, and limestones of ~ 740 Myr (Rubbioli et al. 2019). The limestone area has a restricted occurrence in southeastern of the Piauí state, surrounded by “Caatinga” as typical vegetation domain, annual temperatures ranging from 25 °C to 31 °C, and 689 mm of average annual precipitation (Nascimento & Mantesso-Neto 2013; Hadler et al. 2018).

The Gruta Toca Coroa do Frade (Figs 1, 2C, D) is located in the municipality of Coronel José Dias, outside of the Parque Nacional da Serra da Capivara. The temperature and relative humidity of the air of the cave ranges from 30.9 °C and 49% RH in the entrance zone to 31 °C and 63% RH in the aphotic zone.

## Systematic account

### Genus *Cylindroniscus* Arcangeli, 1929

**Type species.** *Cylindroniscus seurati* Arcangeli, 1929 by monotypy (see Schmidt and Leistikow 2004).

### *Cylindroniscus flaviae* Campos-Filho, Araujo & Taiti, 2017

Figs 1, 2B

*Cylindroniscus flaviae* Campos-Filho, Araujo & Taiti, in Campos-Filho et al. 2017a: 229, figs 1–5.

*Cylindroniscus flaviae*; Campos-Filho et al. 2017b: 70; Campos-Filho et al. 2018: 4; Fernandes et al. 2018: 441; Silva et al. 2018: 56.

**Material examined.** BRAZIL●1♀, Gruta da Tapagem (Caverna do Diabo), Eldorado, Parque Estadual Caverna do Diabo, Açungui geomorphological group, state of São Paulo, 24°38'17.00"S, 48°24'4.00"W, leg. ME Bichuette, T Zepon, JE Gallão, 24.III.2021, LES 27755●1♀, same locality and collectors as for preceding, 24.III.2021, LES 27756●1♂, 1♀, same locality and collectors as for preceding, 24.III.2021, LES 27757●1♀, same locality and collectors as for preceding, 24.III.2021, LES 27758●2♀♀, same locality and collectors as for preceding, 24.III.2021, LES 27759●1♂, same locality and collectors as for preceding, 25.III.2021, LES 27760.

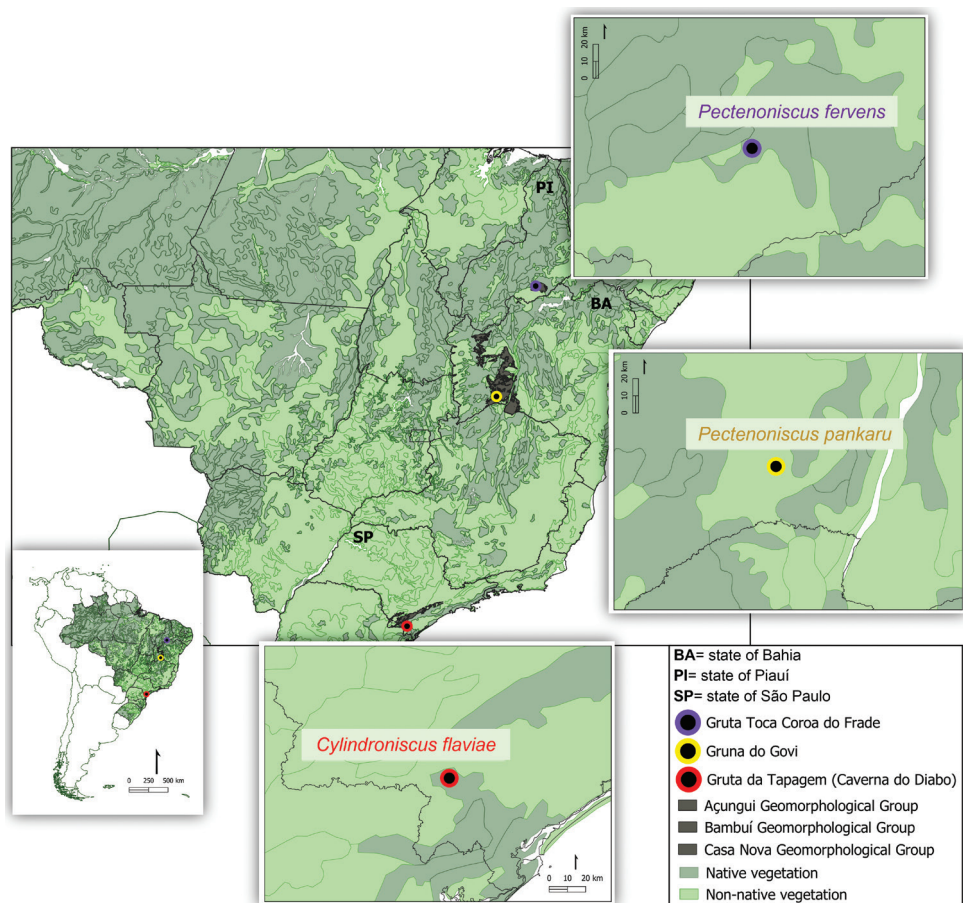
**Remarks.** *Cylindroniscus flaviae* shows preference for organic matter deposits and highly humid areas in the aphotic zone (Fig. 2B). The organic matter was observed in several conduits of the Gruta da Tapagem, always far from the touristic stretches, and it was composed of particulate vegetal debris or small tree branches. The environmental variables along the cave ranged from 19.9 °C to 20.4 °C and the relative air humidity from 95% to 99.1%. The individuals demonstrated sensitivity to the flash lights of the lanterns, always moving in opposite direction.

**Distribution.** This species is recorded from several caves in the Açungui geomorphological group (see Campos-Filho et al. 2017).

### Genus *Pectenoniscus* Andersson, 1960

**Type species.** *Pectenoniscus angulatus* Andersson, 1960 by monotypy (see Schmidt and Leistikow 2004).

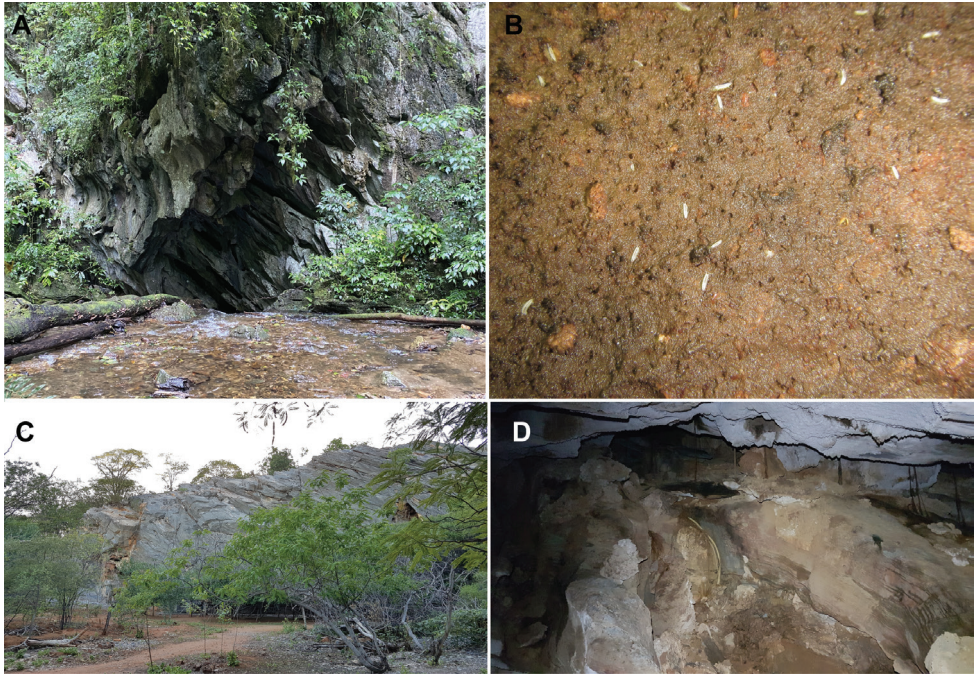
**Diagnosis.** After Andersson (1960) and Campos-Filho et al. (2019). Animals of reduced size, ≤ 3.5 mm. Body unpigmented and eyes absent. Body slender with lateral sides almost parallel. Dorsal surface of cephalon and pereon bearing small transverse tubercles, conferring granulated appearance, pleon smooth or slightly tuberculate. Cephalon with 4–6 rows of tubercles, gradually reducing in number from posteri-



**Figure 1.** Distribution map of *Cyldroniscus flavae* Campos-Filho, Araujo & Taiti, 2017, *Pectenonsiscus pankaru* Campos-Filho, Torres & Bichuette, sp. nov., *Pectenonsiscus fervens* Campos-Filho, Taiti & Bichuette, sp. nov.

or to distal portion, pereonite 1 with two or three rows of tubercles, pereonites 2–7 with two rows of tubercles. Dorsal scale-setae triangular. Cephalon with antennary lobes and suprantennal line. Pleonites 3–5 epimera not developed (only developed in *P. angulatus*). Telson triangular with lateral sides concave and rounded apex. Antennula of three articles, distal article with aesthetascs arranged in one longitudinal row. Antennal flagellum of 3–5 articles. Mandibles with strong molar process, left mandible with two penicils, right mandible with one penicil (sometimes one penicil on molar process). Maxillula inner endite with three penicils, proximal one longest; outer endite composed of eight or nine teeth plus slender stalks. Maxilla of two lobes covered with thick and fine setae, inner lobe wider. Maxilliped basis with lateral sides almost parallel, endite rectangular bearing one stout penicil. Uropod protopod subquadrangular, exopod longer than endopod, protopod and exopod sometimes bearing glandular pores,





**Figure 2.** **A** Gruta da Tapagem (Caverna do Diabo), Açungui geomorphological group **B** *Cylindroniscus flaviae* Campos-Filho, Araujo & Taiti, 2017 foraging in the organic matter **C** surrounding area outside Gruta Toca Coroa do Frade, Casa Nova geomorphological group **D** aphotic zone of the Toca Coroa do Frade.

endopod inserted proximally. Male pleopod 1 endopod of two articles, distal article flagelliform. Male pleopod 2 endopod consisting of two articles, distal portion stout bearing complex apparatus.

**Remarks.** The genus *Pectenoniscus* was created by Andersson (1960) to allocate the new species *P. angulatus* from Itá, Nova Teutônia, state of Santa Catarina, Brazil. The author defined the genus by having the cephalon of “*Trichoniscus*-type”, dorsal surface of the cephalon and pereon with rounded tubercles, pleonites epimera large, left mandible with two penicils near lacinia mobilis, right mandible with one penicil near lacinia mobilis plus one in the molar process, maxillula outer endite composed of nine teeth and two slender stalks, inner endite of three penicils and proximal one longer than distal ones, genital papilla pear-shaped with tubelike termination, male pleopod 1 of “*Styлонiscus*-type”, male pleopod 2 endopod with distal portion broad and bearing a comb-like formation, and male pleopod 5 exopods with a dorsal lobe to fit the pleopod 2 endopod. Campos-Filho et al. (2019) described *P. liliae* Campos-Filho, Bichuette & Taiti, 2019 from Caverna Chico Pernambuco, Coribe, Serra do Ramalho karst area, state of Bahia, and added some characters in the diagnosis of the genus. Recently, Cardoso et al. (2020b) described six new species from karst areas of the states of Bahia and Minas Gerais, increasing the knowledge on the diversity of the genus, that now comprises eight species, i.e., *P. angulatus*, *P. carinhanhensis* Cardoso, Bastos-Pereira, Souza &





**Figure 3.** Gruna do Govi, Bambuí geomorphological group **A** surrounding area outside the cave **B** cave entrance **C,D** outside cave illustrating the anthropic impacts **E** *Pectenoniscus pankaru* Campos-Filho, Torres & Bichuette, sp. nov. foraging in the organic matter **F** cave habitat where the specimens were collected.

Ferreira, 2020, *P. iuiensis* Cardoso, Bastos-Pereira, Souza & Ferreira, 2020, *P. juvenilis* Cardoso, Bastos-Pereira, Souza & Ferreira, 2020, *P. liliae*, *P. montalvaniensis* Cardoso, Bastos-Pereira, Souza & Ferreira, 2020, *P. morrensis* Cardoso, Bastos-Pereira, Souza & Ferreira, 2020, and *P. santanensis* Cardoso, Bastos-Pereira, Souza & Ferreira, 2020.



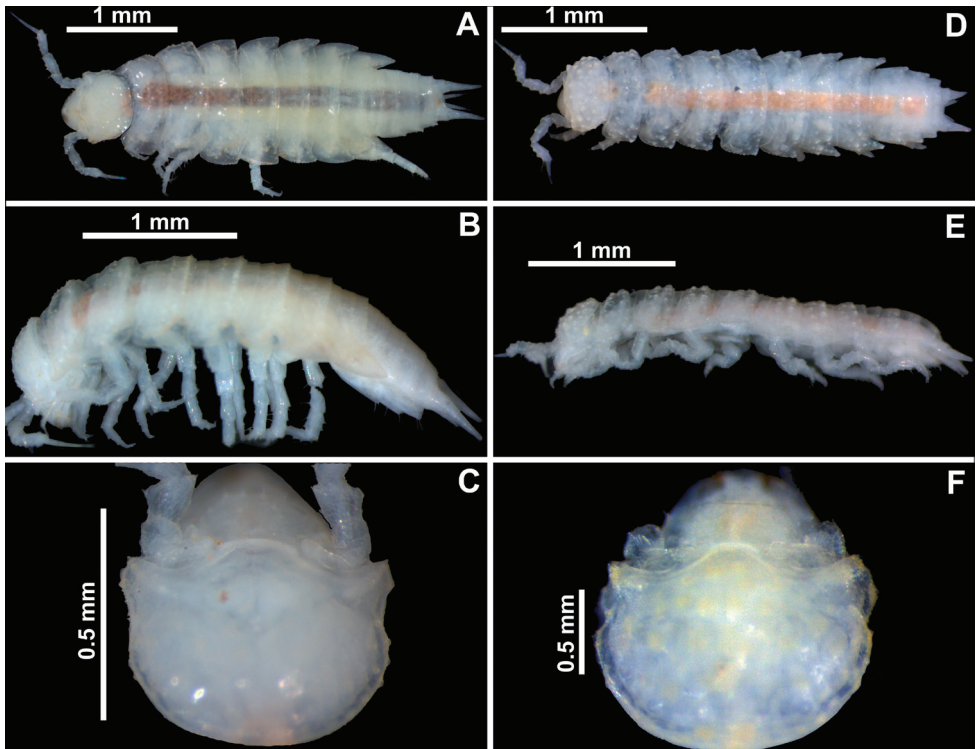
***Pectenoniscus pankaru* Campos-Filho, Torres & Bichuette, sp. nov.**

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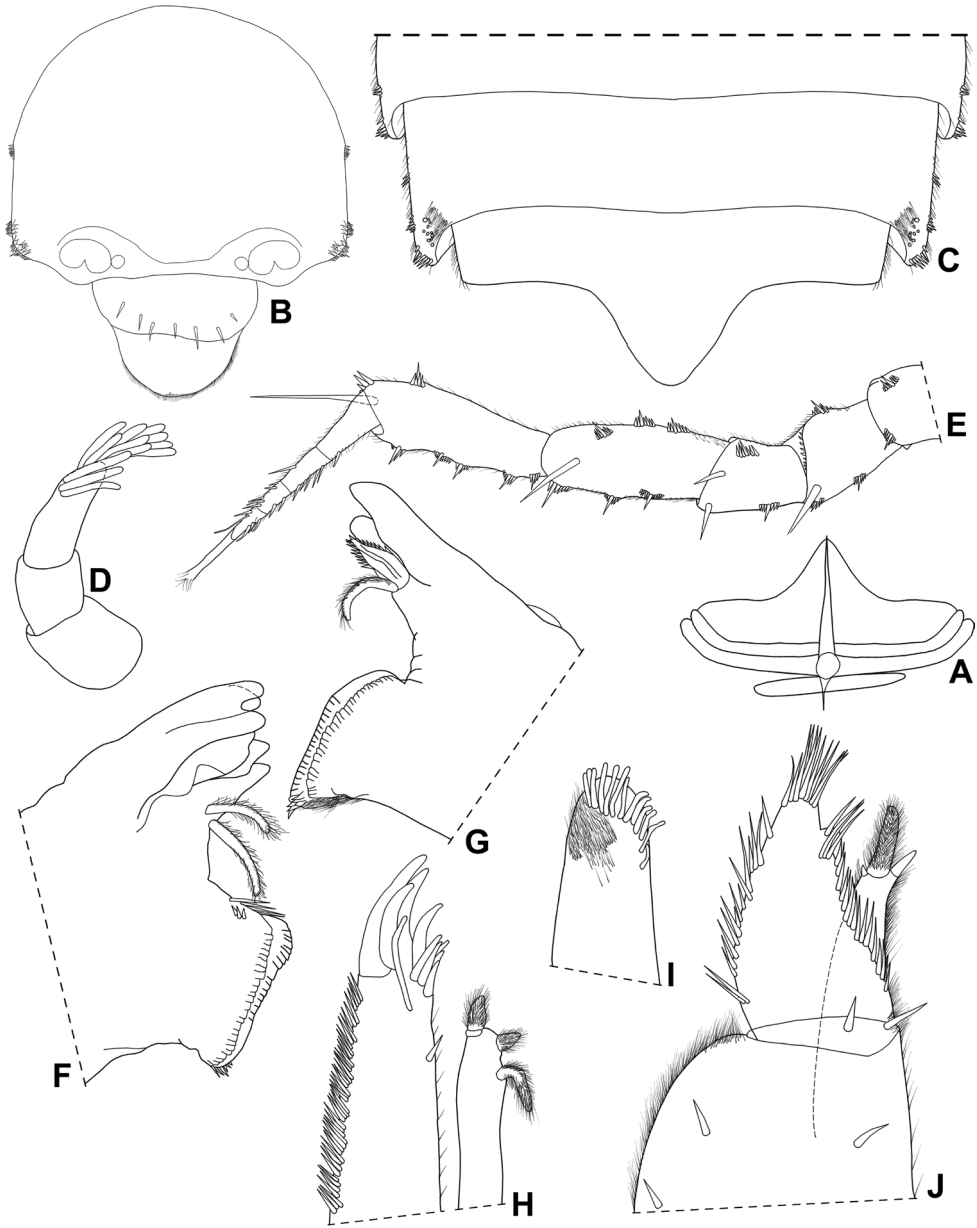
Figs 1, 3E, 4A-C, 5, 6

**Material examined.** BRAZIL • 1 ♂, **holotype**, Gruna do Govi, Feira da Mata, Serra do Ramalho karst area, Bambuí geomorphological group, state of Bahia, 13°56'43.30"S, 44°14'25.94"W, 12.X.2020, leg. ME Bichuette, DF Torres, JS Gallo, LS Horta and JE Gallão, LES 27761 • 1 ♂ (parts in micropreparations), **paratype**, same data as for holotype, LES 27762 • 2 ♀♀, **paratypes**, same data as for holotype, LES 27763.

**Description.** Maximum length: ♂ 2.2 mm, ♀ 3.5 mm. Dorsal surface slightly granulated, granules on pereonites 1–7 in two transverse rows, pleon smooth (Fig. 4A, B). Dorsal scale-setae tricorn-shaped (Fig. 5A). Cephalon (Figs 4C, 5B) with well-developed quadrangular antennary lobes, slightly directed outwards; profrons with suprantennal line bent downwards medially. Pereonite 1–3 epimera with postero-lateral corners right-angled, 4–7 progressively more acute and directed backwards; pleonite 5 epimera with glandular pores at sides near distal margins (Figs 4A, B, 5C). Telson (Fig. 5C) almost three times as wide as long, with concave sides and rounded apex. Antennula (Fig. 5D) with distal article longer than

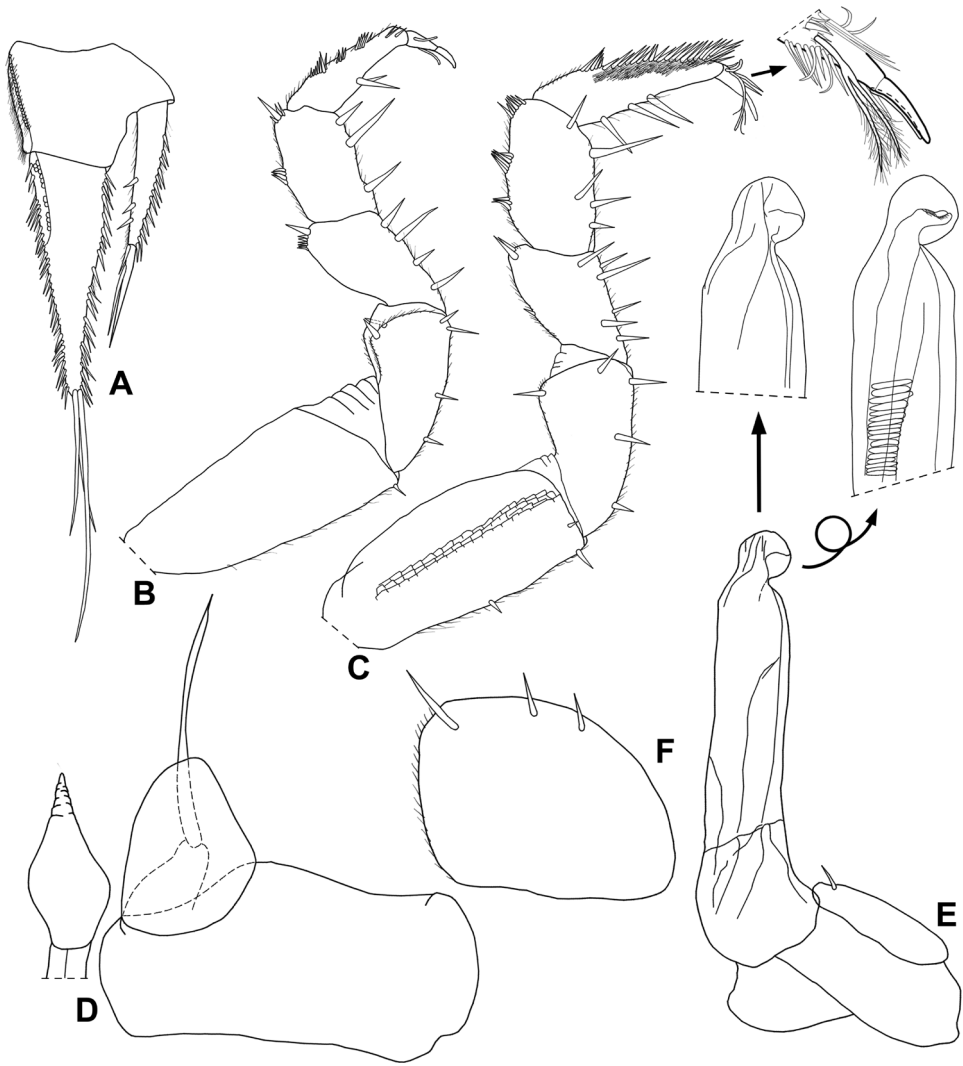


**Figure 4.** *Pectenoniscus pankaru* Campos-Filho, Torres & Bichuette, sp. nov. (♀, LES 27763) **A** habitus, dorsal view **B** habitus, lateral view **C** cephalon, dorsal view. *Pectenoniscus fervens* Campos-Filho, Taiti & Bichuette, sp. nov. (♀, LES 27764) **D** habitus, dorsal view **E** habitus, lateral view **F** cephalon, dorsal view.



**Figure 5.** *Pectenoniscus pankaru* Campos-Filho, Torres & Bichuette, sp. nov. (♂, LES 27762) **A** dorsal scale-seta **B** cephalon, frontal view **C** pleonites 4, 5 and telson **D** antennula **E** antenna **F** left mandible **G** right mandible **H** maxillula **I** maxilla **J** maxilliped.

second and first, and bearing at least 12 aesthetascs. Antenna (Fig. 5E) with fifth article of peduncle as long as flagellum, bearing one distal strong seta; flagellum of four articles, first article longest, apical organ as long as distal article of flagellum.



**Figure 6.** *Pectenoniscus pankaru* Campos-Filho, Torres & Bichuette, sp. nov. (♂, LES 27762) **A** uropod **B** pereopod 1 **C** pereopod 7 **D** genital papila and pleopod 1 **E** pleopod 2 **F** pleopod 5 exopod.

Mandibles as in Fig. 5F, G, right mandible with leaf-like lacinia mobilis. Maxillula (Fig. 5H) with two robust penicils; outer endite with 4+5 teeth, apically simple, one subapical slender stalk near medial margin. Maxilla as in Fig. 5I. Maxilliped (Fig. 5J) basis with lateral sides fringed with fine setae; palp with first article bearing two setae, distal articles fused and bearing many setae on lateral margins; endite much longer than wide, lateral margins covered with fine setae, distal margin bearing two strong setae and one elongated penicil. Grooves and scales for water conducting system on ischium, merus, carpus and propodus of pereopod 6 and basis of pereopod 7 (Fig. 6C). Dactylus with unguinal seta simple and dactylar seta bifid and setose.



Uropod (Fig. 6A) protopod and exopod grooved on outer margins bearing glandular pores; exopod longer than endopod, endopod inserted proximally.

**Male.** Pereopods 1–6 (Fig. 6B) without any sexual modifications. Pereopod 7 (Fig. 6C) propodus with brush of setae on rostral margin. Genital papilla (Fig. 6D) enlarged on median portion, apical part narrow and elongated. Pleopod 1 (Fig. 6D) protopod subrectangular, distal margin sinuous; exopod subtriangular, outer margin almost straight, proximal and outer margins convex; endopod longer than exopod, basal article short, distal article three times longer than basal one. Pleopod 2 (Fig. 6E) exopod ovoid, more than three times as wide as long; endopod of two articles, thick-set, second article more than twice as long as first, distally bearing round shaped lobe directed outwards. Pleopod 5 exopod (Fig. 6F) subquadrangular, slightly wider than long, bearing three setae, distal margin rounded.

**Etymology.** The new species is named for the indigenous people Pankaru, who inhabited the northern portion of Serra do Ramalho region.

**Remarks.** *Pectenoniscus pankaru* sp. nov. differs from all other species of the genus in the shape of the male pleopod 2 endopod. Moreover, it differs in having the antennal flagellum composed of four articles (vs. five in *P. angulatus*, three in *P. carinhanhensis*, *P. iuiuensis*, *P. juveniliensis*, *P. lilae*, *P. montalvaniensis*, *P. morrensis* and *P. santanensis*), antennula bearing 12 aesthetascs (vs. six in *P. morrensis* and *P. santanensis*, eight in *P. angulatus* and *P. montalvaniensis*, nine in *P. juveniliensis* and *P. lilae*, ten in *P. iuiuensis*, and 11 in *P. carinhanhensis*) (see also Andersson 1960; Campos-Filho et al. 2019; Cardoso et al. 2020b).

Specimens of *Pectenoniscus pankaru* sp. nov. were found only in the aphotic zone associated to the sediment banks close to a small subterranean stream (Fig. 2B) and characterised by high humidity levels, which are more suitable for terrestrial isopods. The specimens were collected near vegetable debris.

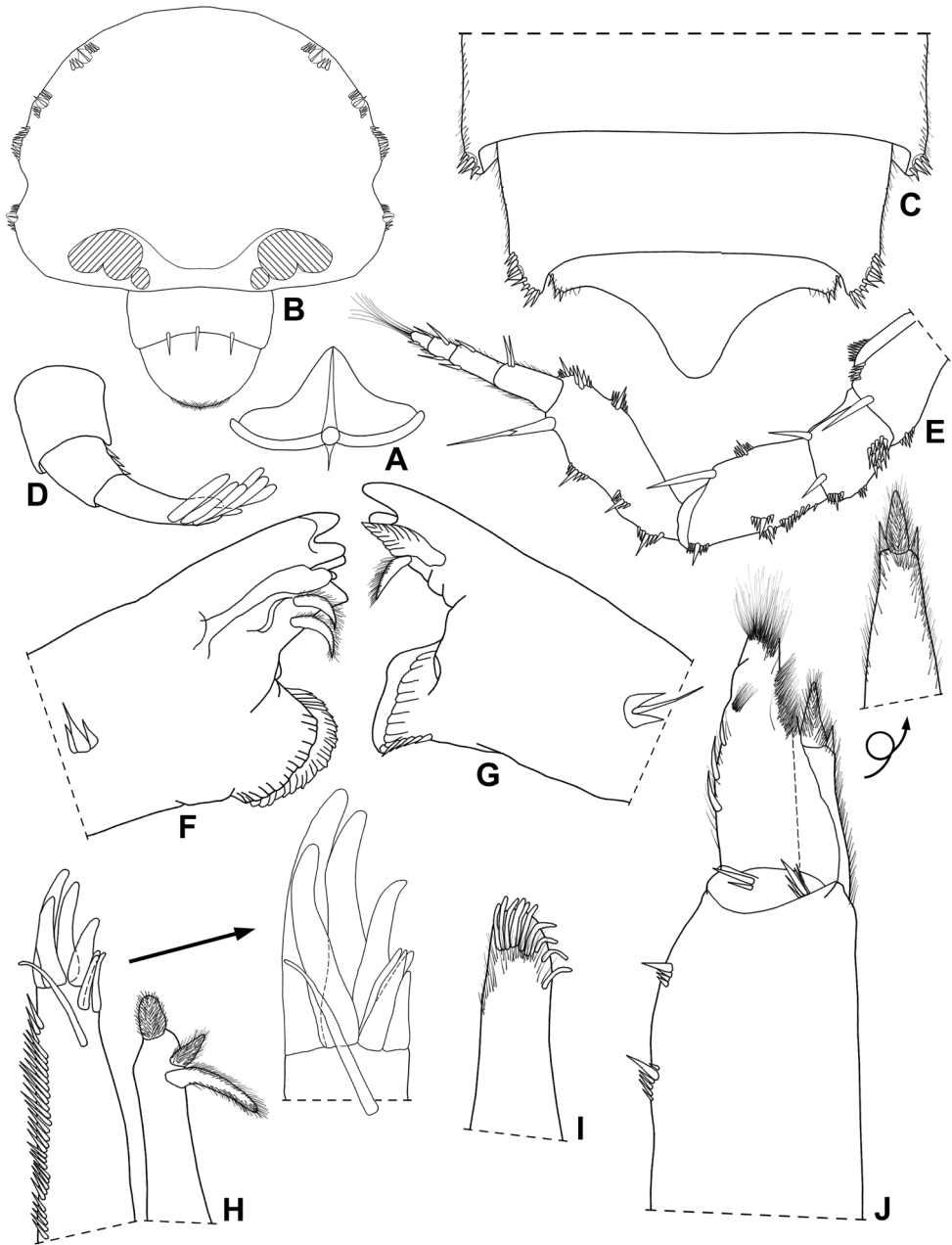
***Pectenoniscus fervens* Campos-Filho, Taiti & Bichuette, sp. nov.**

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Figs 1, 2C, D, 4D, E, 7, 8

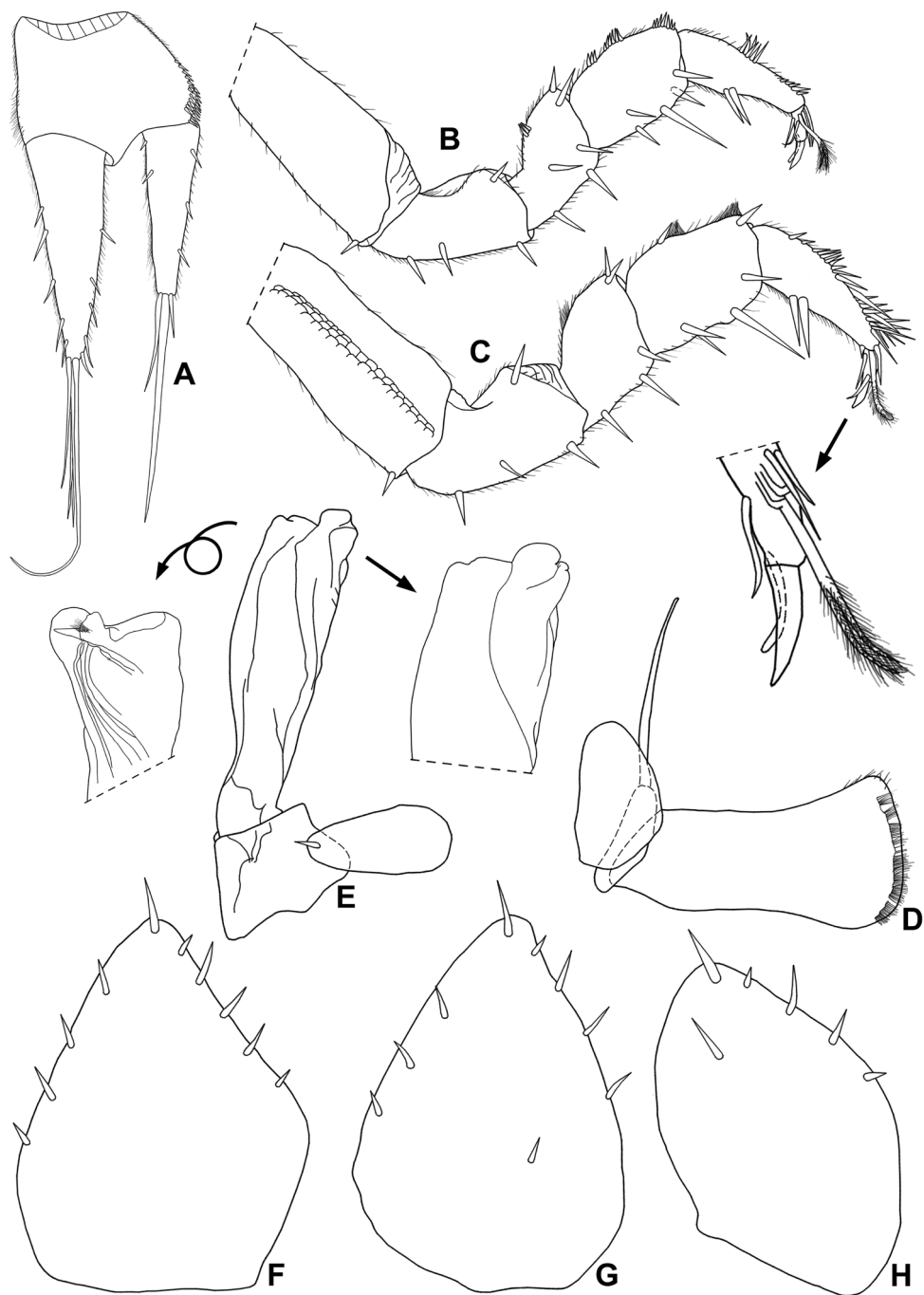
**Material examined.** BRAZIL●1♂ (parts in micropreparations), **holotype**, Gruta Toca Coroa do Frade, Coronel José Dias, Barra Bonita karst region, Casa Nova geomorphological group, state of Piauí, 8°47'51.58"S, 42°25'1.47"W, 8.I.2018, leg. DM Schimonsky, DF Torres and JE Gallão, LES 22421●6♀♀ (one with parts in micropreparations), **paratypes**, same data as for holotype, LES 27764.

**Description.** Maximum length: ♂ and ♀ 3 mm. Dorsal surface granulated, granules on pereonites 1–7 in two transverse rows, on pleonites 3–5 in one row (Fig. 4D, E). Dorsal scale-setae tricorn-shaped in middle segments (Fig. 7A). Cephalon (Figs 4F, 7B) with antennary lobes small, triangular and slightly directed outwards; profrons with suprantennal line bent downwards medially. Pereonites 1 and 2 epimera with postero-lateral corners rounded, 4–7 progressively directed backwards and more acute (Fig. 4D, E). Pleonites 3–5 epimera without glandular pores (Fig. 7C). Telson (Fig. 7C) twice as wide as long,



**Figure 7.** *Pectenoniscus fervens* Campos-Filho, Taiti & Bichuette, sp. nov. (♀, LES 27764) **A** dorsal scale-seta **B** cephalon, frontal view **C** pleonites 4, 5 and telson **D** antennula **E** antenna **F** left mandible **G** right mandible **H** maxillula **I** maxilla **J** maxilliped.

with concave sides and rounded apex. Antennula (Fig. 7D) with distal article longer than second and first, and bearing at least six aesthetascs plus distal tip. Antenna (Fig. 7E) with fifth article of peduncle slightly longer than flagellum, bearing one distal strong seta; fla-



**Figure 8.** *Pectenoniscus fervens* Campos-Filho, Taiti & Bichuette, sp. nov. (♀, LES 27764) **A** uropod (♂, LES 22421) **B** pereopod 1 **C** pereopod 7 **D** pleopod 1 **E** pleopod 2 **F** pleopod 3 exopod **G** pleopod 4 exopod **H** pleopod 5 exopod.



gellum of four articles, first and second articles subequal in length, third and fourth articles shorter; apical organ longer than distal article of flagellum. Mandibles as in Fig. 7F, G; right mandible with leaf-like lacinia mobilis. Maxillula (Fig. 7H) inner endite with apical penicil robust; outer endite of 4+5 teeth, apically simple, one subapical slender stalk near medial margin. Maxilla as in Fig. 7I. Maxilliped (Fig. 7J) basis with lateral sides fringed with fine setae; palp with first article bearing two setae, distal articles fused and bearing distal fringe of fine setae; endite much longer than wide, lateral margins covered with fine setae, distal margin bearing two strong setae and one elongated penicil. Grooves and scales for water conducting system on ischium, merus, carpus and propodus of pereopod 6 and basis of pereopod 7 (Fig. 8B). Dactylus with ungual seta simple and dactylar seta simple and apically setose. Uropod (Fig. 8A) protopod and exopod not grooved on sternal margin; exopod longer than endopod and inserted almost at same level.

**Male.** Pereopods 1–7 (Fig. 8B, C) without any sexual modifications. Genital papilla as in previous species. Pleopod 1 (Fig. 8D) protopod subrectangular, distal margin concave; exopod ovoidal, outer margin almost straight, proximal, inner and distal margins rounded; endopod longer than exopod, basal article short, distal article ca. twice longer than basal one. Pleopod 2 (Fig. 8E) exopod ovoidal, twice as wide as long, one seta on inner margin; endopod of two articles, thickset, second article more than three times longer than first, distal portion subquadrangular, distal outer margin with round shaped lobe directed outwards bearing one triangular process on ventral margin. Pleopod 3–5 exopods as in Fig. 8F–H.

**Etymology.** Latin. *fervens* for very hot, boiling hot. The new species name refers to the very hot temperatures of the Brazilian state of Piauí.

**Remarks.** *Pectenoniscus fervens* sp. nov. differs from all other species of the genus in the shape of the male pleopod 2 endopod. Moreover, it differs from *P. pankaru* sp. nov. in having the antennula bearing six aesthetascs, the dactylar seta stout and in the different shape of the male pleopod 1 and pleopod 3–5 exopods. The new species shows the same number of aesthetascs of the antennula as in *P. morrensis* and *P. santanensis*, from which it differs in the antennal flagellum composed of four articles (three in *P. morrensis* and *P. santanensis*), male pleopod 1 protopod with the distal margin concave (vs. straight in *P. morrensis*, almost straight in *P. santanensis*), male pleopod 4 exopod triangular (vs. subrectangular in *P. morrensis*, subquadrangular in *P. santanensis*), and male pleopod 5 exopod rhomboid and longer than wide (vs. triangular and as long as wide in *P. morrensis*, subquadrangular in *P. santanensis*).

The specimens of *Pectenoniscus fervens* sp. nov. were found only in the aphotic zone (Fig. 2J), in vegetable debris with clay and under rocks, where the humidity was higher than at the cave entrance.

## Discussion

The new species of *Pectenoniscus* described here showed strict dependence on high humidity. Their occurrence in the caves present in semiarid regions, where the exter-

nal temperatures are high and the humidity is low, reinforce the idea that these caves are probably important refuges for these animals due to their favourable conditions. Moreover, both species show remarkable troglomorphism, such as absent body pigments and eyes, which reinforces the classification of both species as troglobites.

A preliminary evaluation of the conservation status of the new species described here was carried out following the IUCN (International Union of Conservation of Nature) classification. *Pectenoniscus pankaru* sp. nov. and *Pectenoniscus fervens* sp. nov. were classified as Critically Endangered (CR) by the criteria B2ab(iii). The surrounding areas of the caves (Gruta do Góvi and Gruta Toca Coroa do Frade) are impacted by deforestation and the remaining native vegetation is present only close to their entrances. The Serra do Ramalho karst area is historically threatened by agricultural activities and potential mining projects (Gallão and Bichuette 2018). Furthermore, the Gruta do Góvi is used to capture subterranean water for the consumption of the local people and has pastures close to the cave, while the Gruta Toca Coroa do Frade, despite being close to the Parque Nacional da Serra da Capivara, is out of its boundaries and it is threatened by mining activities and increasing urbanisation. Moreover, both caves are not protected by any law.

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## 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>
- Andersson Å (1960) South American terrestrial isopods in the collection of the Swedish State Museum of Natural History. *Arkiv för Zoologi* 12: 537–570.
- Andreev S (2002) Trois nouvelles espèces des genres *Cordioniscus* et *Trichoniscus* (Isopoda: Oniscidea) et nouvelles données sur les isopodes terrestres de la Bulgarie. *Historia Naturalis Bulgarica* 15: 55–72.
- Andreev S, Bozarova F (2000) Type material of Isopoda (Crustacea: Oniscidea, Anthuridae) from the collections of the National Museum of Natural History in Sofia. *Historia Naturalis Bulgarica* 11: 25–32.
- Arcangeli A (1929) Isopodi terrestri raccolti in Cuba dal Prof. F. Silvestri. *Bollettino del Laboratorio di Zoologia generale e agraria della R. Scuola superiore d'Agricoltura in Portici* 23: 129–148.
- Arcangeli A (1930) Contributo alla conoscenza del “microgenton” di Costa Rica. I. Isopodi terrestri. *Bollettino del Laboratorio di Zoologia generale e agraria della R. Scuola superiore d'Agricoltura in Portici* 25: 1–29.
- Auler A, Rubbioli E, Brandi R (2001) As grandes cavernas do Brasil. Grupo Bambuí de Pesquisas Espeleológicas, Belo Horizonte, 2303 pp.
- Bastos-Pereira R, Souza LA, Ferreira RL (2017) A new amphibious troglobitic stytoniscid from Brazil (Isopoda, Oniscidea, Synocheta). *Zootaxa* 4294(2): 292–300. <https://doi.org/10.11646/zootaxa.4294.2.11>
- Bedek HE, Zimmermann NE, McVicar TR, Vergopolan N, Berg A, 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, 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>
- Bichuette ME, Rizzato PP (2012) A new species of cave catfish from Brazil, *Trichomycterus rubbioli* sp.n., from Serra do Ramalho karstic area, São Francisco River basin, Bahia State (Siluriformes: Trichomycteridae). *Zootaxa* 3480(1): 48–66. <https://doi.org/10.11646/zootaxa.3480.1.2>
- Campos-Filho IS, Araujo PB, Bichuette ME, Trajano E, 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, Bichuette ME, Araujo PB, Taiti S (2017a) Description of a new species of *Cylindroniscus* Arcangeli, 1929 (Isopoda: Oniscidea) from Brazil, with considerations on the family placement of the genus. *North-Western Journal of Zoology* 13(2): e161305. [https://biozoojournals.ro/nwjz/content/v13n2/nwjz\\_e161305\\_Campos.pdf](https://biozoojournals.ro/nwjz/content/v13n2/nwjz_e161305_Campos.pdf) [accessed on 27 September 2021]
- Campos-Filho IS, Bichuette ME, Montesanto G, Araujo PB, Taiti S (2017b) The first troglotic species of the family Pudeoniscidae (Crustacea, Isopoda, Oniscidea), with descriptions of a new genus and two new species. *Subterranean Biology* 23: 69–84. <https://doi.org/10.3897/subtbiol.23.20963>
- Campos-Filho IS, Cardoso GM, Aguiar JO (2018) Catalogue of terrestrial isopods (Crustacea, Isopoda, Oniscidea) from Brazil: an update with some considerations. *Nauplius* 26: e2018038. <https://doi.org/10.1590/2358-2936e2018038>
- Campos-Filho IS, Fernandes CS, Cardoso GM, Bichuette ME, Aguiar JO, Taiti S (2019) Two new species and new records of terrestrial isopods (Crustacea, Isopoda, Oniscidea) from Brazilian caves. *Zootaxa* 4564(2): 422–448. <https://doi.org/10.11646/zootaxa.4564.2.6>
- Campos-Filho IS, Fernandes CS, Cardoso GM, Bichuette ME, Aguiar JO, 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. <https://doi.org/10.5852/ejt.2020.606>
- Campos-Filho IS, Taiti S (2021) Oniscidea taxonomy: present and future. Abstract book of the 11<sup>th</sup> International Symposium on Terrestrial Isopod Biology. Spinicornis, Ghent, 9 pp. <https://spinicornis.be/istib2021/presentations/>
- Cardoso GM, Bastos-Pereira R, Souza LA, Ferreira RL (2020a) New troglotic species of *Xanagoniscus* (Isopoda: Styлонiscidae) from Brazil, with notes on their habitats and threats. *Zootaxa* 4819(1): 84–108. <https://doi.org/10.11646/zootaxa.4819.1.4>
- Cardoso GM, Bastos-Pereira R, Souza LA, Ferreira RL (2020b) New cave species of *Pectenoniscus* Andersson, 1960 (Isopoda: Oniscidea: Styлонiscidae) and an identification key for the genus. *Nauplius* 28: e2020039. <https://doi.org/10.1590/2358-2936e2020039>
- Cardoso GM, Bastos-Pereira R, Souza LA, Ferreira RL (2021) *Chaimowiczia*: a new Iuiuniscinae genus from Brazil (Oniscidea, Synocheta, Styлонiscidae) with the description of two new troglotic species. *Subterranean Biology* 39: 45–62. <https://doi.org/10.3897/subtbiol.39.65305>
- Dalens H (1987) Sur deux oniscoïdes cavernicoles nouveaux de Thaïlande. *Travaux du Laboratoire d'Écobiologie des Arthropodes édaphiques* 5: 43–53. [2 pls]
- Dalens H (1989) Sur un nouveau genre d'oniscoïde “aquatique” provenant du sud-est Asiatique: *Thailandoniscus annae* (Isopoda, Oniscidea, Styлонiscidae). *Spixiana* 12: 1–6.
- Dana JD (1853) Crustacea, Part II. Isopoda. United States exploring expedition during the years 1838, 1839, 1840, 1841, 1842 under the command of Charles Wilkens, U.S.N., Vol. 14. C. Sherman, Philadelphia, 696–805. [pls 46–53]
- 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>

- Fernandes CS, Batalha MA, Bichuette ME (2016) Does the cave environment reduce functional diversity? PLoS ONE 11(3): e0151958. <https://doi.org/10.1371/journal.pone.0151958>
- Fernandes CS, Campos-Filho IS, Araujo PB, Bichuette ME (2019) Synopsis of terrestrial isopods (Crustacea: Isopoda: Oniscidea) from Brazilian caves, with emphasis on new records from north, midwest, northeast and southeast regions. Journal of Natural History 53(17–18): 1095–1129. <https://doi.org/10.1080/00222933.2019.1634225>
- Fernandes CS, Campos-Filho IS, Bichuette ME (2018) *Cylindroniscus platoi* (Isopoda: Oniscidea: Styloniscidae), a new cave-dwelling species from Lagoa Santa Karst, Southeastern Brazil. Zootaxa 4461(3): 411–420. <https://doi.org/10.11646/zootaxa.4464.3.6>
- Ferrara F, Taiti S (1979) A check-list of terrestrial isopods from Africa (south of the Sahara). Monitore zoologico italiano, Nuova Serie, Supplemento 12: 89–215. <https://doi.org/10.1080/03749444.1979.10736595>
- Fundação Florestal (2010) Plano de manejo espeleológico: Caverna do Diabo, volume principal e anexos. Secretaria do Meio Ambiente (Governo de São Paulo), Ekos Brasil, São Paulo 108 pp.
- Gallão JE, Bichuette ME (2018) Brazilian obligatory subterranean fauna and threats to the hypogean environment. ZooKeys 746: 1–23. <https://doi.org/10.3897/zookeys.746.15140>
- Gräve W (1914) Die Trichoniscinen der Umgebung von Bonn. Zoologische Jahrbücher, Abteilung für Systematik, Ökologie und Geographie der Tiere 36: 199–228, pls 4–6. <https://doi.org/10.5962/bhl.part.1490>
- Green A (1971) Styloniscidae (Isopoda, Oniscoidea) from Tasmania and New Zealand. Papers and Proceedings of the Royal Society of Tasmania 105: 59–74.
- Green A, Lew Ton H, Poore G (2002) Suborder: Oniscidea Latreille, 1802. In: Houston W, Beesley P (Eds) Zoological Catalogue of Australia Vol. 19.2A. Australian Biological Resources Study, Melbourne, 279–344.
- Hadler P, Mayer EL, Motta F, Ribeiro AM (2018) Fossil bats from the Quaternary of Serra da Capivara, northeast Brazil. Quaternary International 464(Part B): 411–416. <https://doi.org/10.1016/j.quaint.2017.11.022>
- Hiruma ST, Ferrari JA, Amaral R (2008) Caracterização de feições cársticas de superfície da Faixa André Lopes (Vale do Ribeira, SP). In: SBG, Congresso Brasileiro de Geologia, 44, Curitiba, Anais, 993.
- Karmann I, Sánchez LE (1979) Distribuição das rochas carbonáticas e províncias espeleológicas do Brasil. Espeleo-Tema, Monte Sião 13: 105–167.
- Kottek M, Grieser J, Beck C, Rudolf B, Rubel F (2006) World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift 15(3): 259–263. <https://doi.org/10.1127/0941-2948/2006/0130>
- 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>
- Morrone JJ (2014) Biogeographical regionalization of the Neotropical Region. Zootaxa 3782(1): 1–110. <https://doi.org/10.11646/zootaxa.3782.1.1>

- Mulaik S (1960) Contribución al conocimiento de los isópodos terrestres de México (Isopoda, Oniscoidea). *Revista de la Sociedad Mexicana de Historia Natural* 21: 79–292.
- Nascimento MAL, Mantesso-Neto V (2013) Speleological heritage in Brazil's proposed Geoparks, as presented in the book "Geoparques do Brasil: propostas". *Tourism and Karst Areas* 6(1): 27–42.
- Rubbioli E, Auler A, Menin D, Brandi R (2019) *Cavernas-Atlas do Brasil Subterrâneo*. ICM-Bio Brasília, DF, Brazil, 340 pp.
- Schmalfuss H (2003) World catalog of terrestrial isopods (Isopoda: Oniscoidea). *Stuttgarter Beiträge zur Naturkunde, Serie A* 654: 1–341.
- Schmalfuss H, Erhard F (1998) Die Land-Isopoden (Oniscoidea) Griechenlands. 19. Beitrag: Gattung *Cordioniscus* (Styloniscidae). *Stuttgarter Beiträge zur Naturkunde, Serie A* 582: 1–20.
- Schmidt C, Leistikow A (2004) Catalogue of genera of the terrestrial Isopoda (Crustacea: Isopoda: Oniscoidea). *Steenstrupia* 28: 1–118.
- Schultz G (1970) *Cylindroniscus vallesensis* sp. nov.: Description with review of genus (Isopoda, Trichoniscidae). *Transactions of the American microscopical Society* 89: 407–412. <https://doi.org/10.2307/3224360>
- Schultz G (1995) *Sinoniscus cavernicolus*, a new genus and species of terrestrial isopod crustacean from a cave of China (Styloniscidae: Oniscoidea). *Proceedings of the Biological Society of Washington* 108: 201–206.
- Sfenthourakis S, Taiti S (2015) Patterns of taxonomic diversity among terrestrial isopods. *ZooKeys* 515: 13–25. <https://doi.org/10.3897/zookeys.515.9332>
- Silva APB, Oliveira IPMR, Bastos-Pereira R, Ferreira RL (2018) Are laboratory studies on behavior of troglobitic species always trustful? A case study with an isopod from Brazil. *Behavioural Processes* 153: 55–65. <https://doi.org/10.1016/j.jbeproc.2018.05.009>
- Silverio MO (2014) Atuação da arquitetura no uso público de cavernas. Conceitos, métodos e estratégias para ocupação. *Caverna do Diabo, SP. Dissertação (Mestrado) - Faculdade de Arquitetura e Urbanismo, Universidade de São Paulo, São Paulo*.
- Souza LA, Ferreira RL, Senna AR (2015) Amphibious shelter-builder Oniscoidea species from the New World with description of a new subfamily, a new genus and a new species from Brazilian Cave (Isopoda, Synocheta, Styloniscidae). *PLoS ONE* 10(5): 1–18. <https://doi.org/10.1371/journal.pone.0115021>
- Taiti S, Ferrara F, Kwon D (1992) Terrestrial Isopoda (Crustacea) from the Togian Islands, Sulawesi, Indonesia. *Invertebrate Taxonomy* 6: 787–842. <https://doi.org/10.1071/IT9920787>
- Taiti S, Howarth F (1997) Terrestrial isopods (Crustacea, Oniscoidea) from Hawaiian caves. *Mémoires de Biospéologie* 24: 97–118.
- Taiti S, Montesanto G (2020) Troglobiotic terrestrial isopods from Myanmar, with descriptions of a new genus and three new species (Crustacea, Oniscoidea). *Raffles Bulletin of Zoology Supplement* 35: 109–122.

- Taiti S, Xue Z (2012) The cavernicolous genus *Trogloniscus* nomen novum, with descriptions of four new species from southern China (Crustacea, Oniscidea, Styloniscidae). *Tropical Zoology* 25(4): 183–209. <http://dx.doi.org/10.1080/03946975.2012.751240>
- Trajano E (2012) Ecological classification of subterranean organisms. In: White W, Culver D (Eds) *Encyclopedia of Caves*. 2<sup>nd</sup> Edn. Academic Press, Oxford, 275–277. <https://doi.org/10.1016/B978-0-12-383832-2.00035-9>
- Trajano E, Carvalho MR. (2017) Towards a biologically meaningful classification of subterranean organisms: a critical analysis of the Schiner-Racovitza system from a historical perspective, difficulties of its application and implications for conservation. *Subterranean Biology* 22: 1–26. <https://doi.org/10.3897/subtbiol.22.9759>
- Vandel A (1952) Les trichoniscides (crustacés – isopodes) de l’hémisphère austral. *Mémoires du Muséum National d’Histoire Naturelle, Série A* 6: 1–116.
- Vandel A (1973) Les isopodes terrestres de l’Australie. Étude systématique et biogéographique. *Mémoires du Muséum national d’Histoire naturelle, Nouvelle Série, Série A* 82: 1–171. [and one map]
- Vandel A (1977) Les oniscoïdes (isopodes terrestres) de la Nouvelle-Zélande et de l’Archipel Kermadec. *Mémoires du Muséum national d’Histoire naturelle, Nouvelle Série, Série A* 102: 1–56.
- Vandel A (1981) Les isopodes terrestres et cavernicoles de l’île de Cuba (second mémoire). *Résultats des Expéditions biospéologiques cubano-roumaines à Cuba* 3: 35–76.
- WoRMS, World Register of Marine Species (2021) Oniscidea. <http://www.marinespecies.org/aphia.php?p=taxdetails&id=146505> [accessed on 27 September 2021]