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# Two new troglobitic species of *Iansaoniscus* from Brazilian caves (Crustacea, Isopoda, Pudeoniscidae)

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## Abstract

*Iansaoniscus* species are troglobitic terrestrial isopods of the Pudeoniscidae family. In this work two new species are described from caves in the Bahia state, northeastern Brazil; *I. leilae* **sp. nov.** from Toca do Gonçalo cave, in the municipality of Campo Formoso; and *I. paulae* **sp. nov.** from Lapa do Bode cave in the municipality of Itaeté. Additionally, ecological notes and conservation status are provided for both new species.

## Keywords

Cave fauna, Neotropics, Oniscidea, terrestrial isopods, troglobites

## Introduction

Brazil currently shelters 36 described species of troglobitic oniscidean isopods, and this number has highly enhanced in the last few years (Cardoso et al. 2021, 2022; Campos-Filho et al. 2022). New species have continuously been discovered as new karstic areas are sampled. Styloniscidae stands out among the families with cave-restricted taxa, with 25 species (Fernandes et al. 2019; Cardoso et al. 2021, 2022; Campos-Filho et al. 2022); followed by Scleropactidae with five species (Campos-Filho and Araujo 2011; Campos-Filho et al. 2014, 2020), Philosciidae with four species (Campos-Filho et al. 2019, 2020), and Pudeoniscidae with two species (Campos-Filho et al. 2017).

Pudeoniscidae present nine species in four genera: *Brasiloniscus* Lemos de Castro, 1973, *Pudeoniscus* Vandel, 1963, *Iansaoniscus* Campos-Filho, Araujo & Taiti, 2017, and *Oxossioniscus* Campos-Filho, Lisboa & Cardoso, 2018 (Vandel 1963; Lemos de Castro 1973; Campos-Filho et al. 2017, 2018). Most species of this family occur in the Brazilian Atlantic Forest, with representatives found associated with leaf litter of cocoa, bromeliads, canopy of *Erythrina fusca* Lour., termite nests, and caves (Campos-Filho et al. 2017, 2018).

To date, *Iansaoniscus* is the only genus of this family with troglobitic species (Campos-Filho et al. 2017). The genus comprises two species: *Iansaoniscus georginae* Campos-Filho, Araujo & Taiti, 2017 from Borboletas cave, municipality of Paripiranga and *Iansaoniscus iraquara* Campos-Filho, Araujo & Taiti, 2017 from Buraco do Cão cave, municipality of Iraquara, both in Bahia state.

The genus is distinguished by the unique shape of cephalon with well-developed antennary lobes and the triangular frontal shield, that is laterally interrupted by antennal grooves; pereonite 1 epimeron with dorsolateral furrow reduced or absent; pleon outline continuous with pereon; telson triangular; uropod protopod subquadrangular; and pleopod exopods with no respiratory structures (Campos-Filho et al. 2017).

In the present work, two new troglobitic species of *Iansaoniscus* are described, both from limestone caves in the Bahia state. Furthermore, ecological notes and conservation status are provided for both new species.

## Materials and methods

The new species were manually collected, fixed in 70% ethanol, and taken to the Center of Studies on Subterranean Biology of the Federal University of Lavras (CEBS, UFLA), Lavras, Brazil. Photographs and measurements were taken with ZEISS Axio ZoomV16 stereomicroscope coupled with an Axio Cam 506 Color camera. The specimens were dissected and mounted with Hoyer's medium (Anderson 1954). Illustrations were based on photographs or taken with the aid of a camera lucida on a microscope Leica DM750, and digitally drawn using the software GIMP (v. 2.8) (Montesanto 2015, 2016). Some specimens were dried in alcoholic series for the analysis of dorsal cuticular structures using the scanning electron microscope Hitachi TM4000. The material is deposited in the Collection of Subterranean Invertebrates of Lavras (ISLA), UFLA.

## Taxonomy

### Family Pudeoniscidae Lemos de Castro, 1973

### Genus *Iansaoniscus* Campos-Filho, Araujo & Taiti, 2017

**Type species.** *Iansaoniscus iraquara* Campos-Filho, Araujo & Taiti, 2017, by original designation.

***Iansaoniscus leilae* sp. nov.**
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Figs 1–4

Sclreropactidae sp. nov. [sic!] – Souza-Silva and Ferreira 2016: 9, fig. 3F.

**Diagnosis.** Cephalon lateral lobes with straight distal margin; frontal shield triangular with frontal margin directed upwards with antennal socket depressed, vertex margin depressed; pereonite 1 epimeron without dorsolateral furrow; pereonite 1 grooved on ventral margin for two thirds of its length, pereonite 2 with well-developed ventral lobe; telson with acute apex; antennula distal article with two lateral and two apical aesthetascs; uropod exopod slightly shorter than endopod, as long as distal margin of telson.

**Material examined.** ***Holotype*:** Brazil • 1 male; Bahia state, municipality of Campo Formoso, Toca do Gonçalo cave (WGS84 -10.510992, -40.894659); 10th December 2018; RL Ferreira leg.; ISLA 95911. ***Paratypes*:** • 1 male (mounted in slide), 2 females (1 mounted in slide); same data as holotype; ISLA 95912. • 1 male, 1 female; 05th January 2008; same location as holotype; ISLA 95913. • 6 females; 05th January 2008; same location as holotype; ISLA 95914. • 1 male (mounted in slide), 1 female; municipality of Campo Formoso, Toca da Tiquara cave (-10.458611, -40.542222); RL Ferreira leg.; ISLA 95917.

**Etymology.** The new species is named after Dr. Leila Aparecida Souza, UECE, for her contributions on the systematics of Brazilian subterranean Oniscidea.

**Description.** Maximum length: male and female, 6 mm. Body outline in lateral view as in Fig. 1A, colorless, eyes absent (Fig. 1A–C). Cephalon lateral lobes with straight distal margin; frontal shield triangular with frontal margin directed upward with antennal socket depressed, vertex margin depressed (Fig. 1B, C). Pereonite 1 epimeron without dorsolateral furrow; pereonite 1 grooved on ventral margin for two thirds of its length, pereonite 2 with well-developed ventral lobe (Fig. 1D–F); pereonites 3–7 with sub-quadrangular epimera. Pleonites 3–5 with epimera sub-quadrangular and directed backwards (Figs 1A, G, 2A). Telson (Figs 1G, 2A) slightly wider than long with concave sides, apex acute. Antennula (Fig. 2B) with three articles, distal article longer than second article bearing two lateral and two apical aesthetascs. Antenna (Fig. 2C) surpassing pereonite 3 when extended backwards, fifth article of peduncle as long as flagellum; flagellum with three articles; second and third articles subequal in length, third article with lateral aesthetascs (Fig. 1H). Mandibles (Fig. 2D, E) molar penicil with 7–8 branches, left mandible with 2+1 penicils, right with 1+1 penicils. Maxillula (Fig. 2F) outer branch with 4 + 5 teeth (two apically cleft); inner branch with two penicils. Maxilla (Fig. 2G) with bilobate apex, outer lobe wider than inner lobe, round, covered with thin setae; inner lobe bearing thick setae. Maxilliped (Fig. 2H) basis rectangular; palp basal article with two setae distinct in length; endite sub-rectangular, long medial seta, distal margin with two teeth. Pereopods 1–7 (Fig. 3A, B) merus and carpus with sparse setae on sternal margin; carpus 1 with longitudinal antennal grooming brush, distal seta apically cleft; dactylus with dactylar organ and

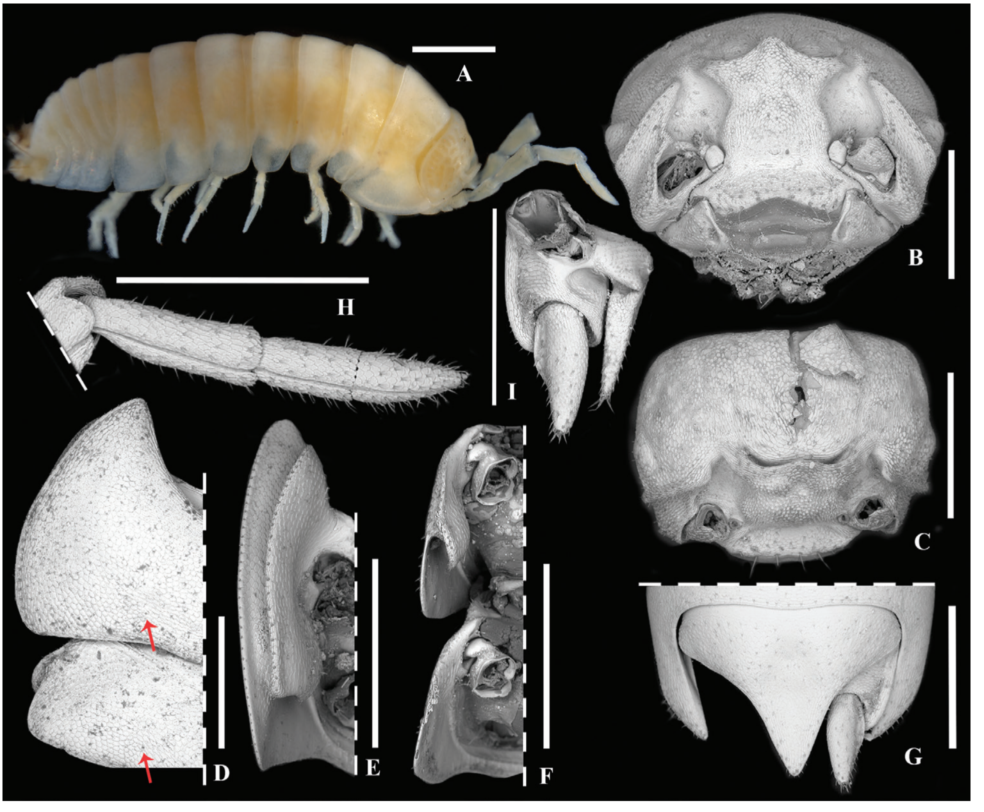


**Figure 1.** *Iansaoniscus leilae* sp. nov. **A** male holotype, lateral view. Female paratype **B** cephalon, frontal view **C** cephalon, dorsal view **D** pereonites 1 and 2, dorsal view, arrow indicating the *noduli laterales* **E** pereonite 1, ventral view **F** pereonites 2 and 3, ventral view **G** pleonite 5, telson and uropod, dorsal view **H** antennal flagellum **I** uropod. Scale bars: 1 mm (**A**); 500 µm (**B–I**).

ungual setae simple not surpassing outer claw. Uropod (Figs 1G, 2A) protopod longer than wide, with lateral groove; endopod inserted proximally, exopod slightly shorter than endopod, exopod slightly longer than distal margin of telson; proximal margin with lateral groove

**Male:** Genital papilla (Fig. 3C) with triangular ventral shield and subapical orifices. Pleopod 1 (Fig. 3C) exopod ovoid, margin straight, almost three times wider than long; endopod four times as long as exopod, distal portion slightly bent outwards, apex with small setae. Pleopod 2 exopod (Fig. 3D) triangular bearing one seta on outer margin, endopod flagelliform, almost three times as long as exopod. Pleopod 3–5 exopods as in Fig. 3E–G.

**Habitat and conservation issues.** The Toca do Gonçalo cave presents ca. 500 meters of mapped conduits. It is inserted at the Una geological group of carbonate rocks from the Caatinga Formation, which comprises relatively young rocks deposited around 600 million years ago (Auler 2019). It is located in the Campo Formoso

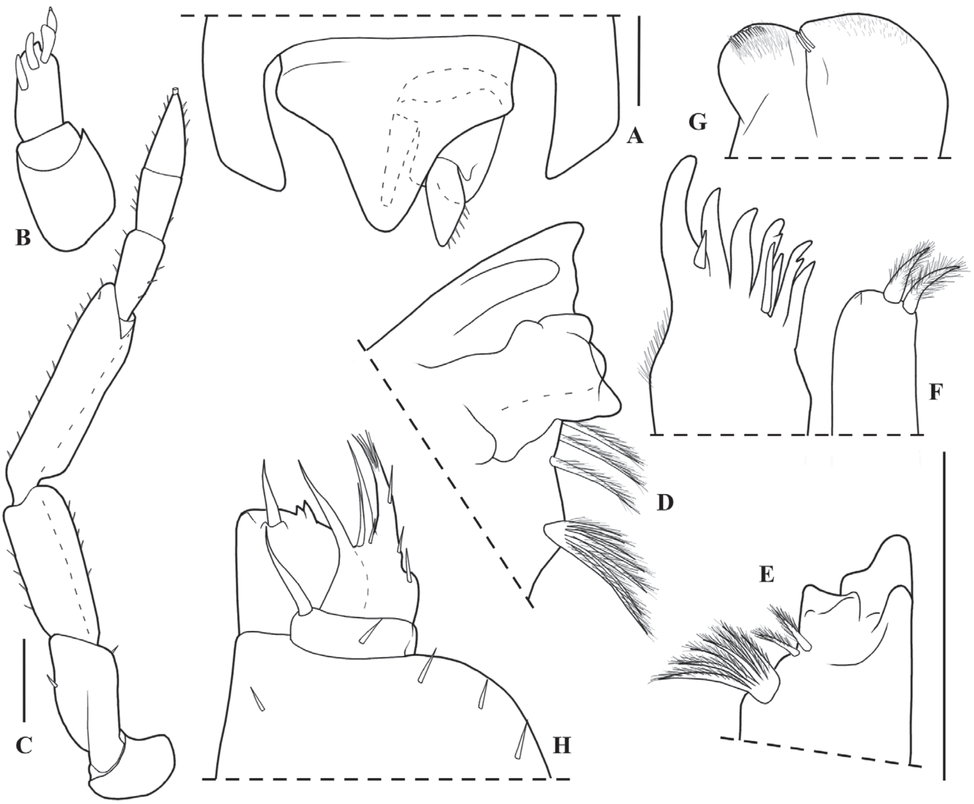


**Figure 2.** *Iansaoniscus leilae* sp. nov. Male holotype **A** telson and uropod, dorsal view **B** antennula **C** antenna **D** left mandible **E** right mandible **F** maxillula **G** maxilla **H** maxilliped. Scale bars: 0.2 mm.

municipality, Bahia state, Northeastern Brazil, within the Caatinga (a semiarid biome) (Fig. 9). The cave presents a single horizontal lenticular-shaped entrance, 2 m high and 8 m wide (Fig. 4A). It has two distinct levels: while the upper level is predominantly dry, the lower level used to be frequently filled with phreatic water (Fig. 4B, C). However, as will be discussed further on, several changes (at both local and regional scales) led to a massive reduction in the water table level, thus, exposing several conduits that used to be inaccessible to men in the past decades (Fig. 4C). The main food sources for both the terrestrial and aquatic fauna seem to be particulate organic matter from the surface, although there are some root mats in the water table level and small guano piles in some areas within the cave.

Culver and Sket (2000) defined hotspots of subterranean biodiversity as caves (or cave systems) with 20 or more cave-restricted species. The Toca do Gonçalo cave shelters 22 troglobitic species and represents one of the three hotspots of subterranean biodiversity known for South America (Souza-Silva and Ferreira 2016; Souza-Silva et al. 2021). Most troglobitic species occurring in this cave remain undescribed, with descriptions already known for only seven of them: the beetle *Coarazuphium caatinga*

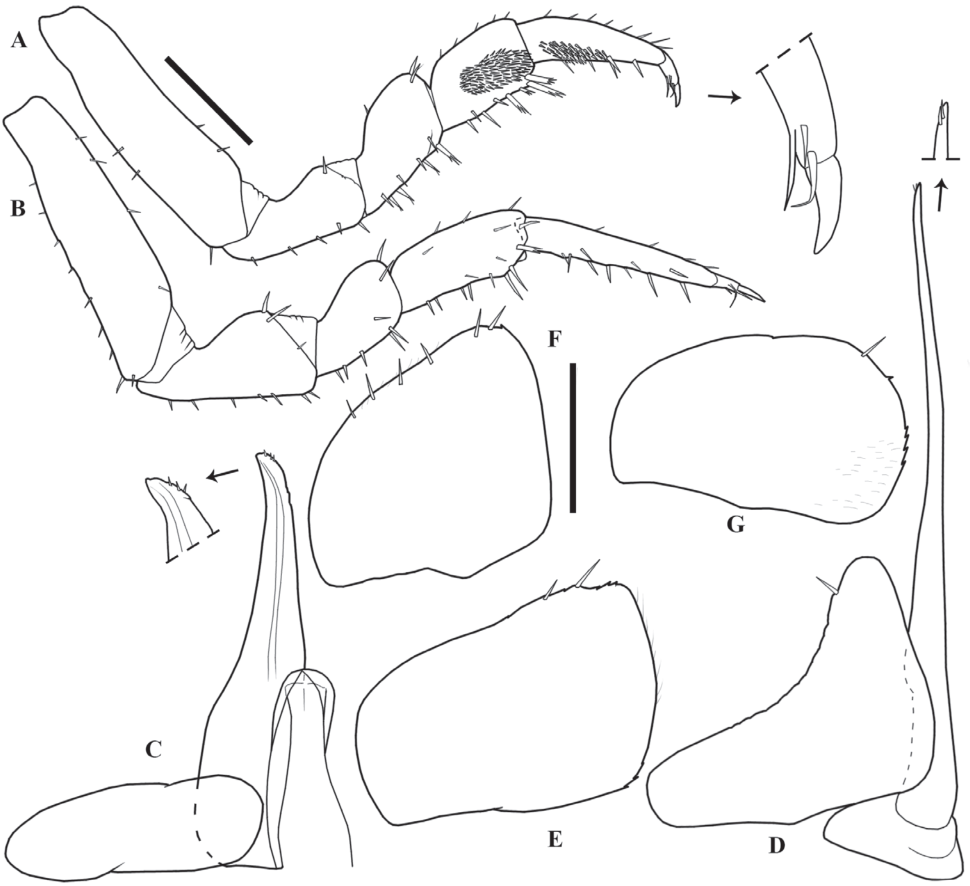


**Figure 3.** *Iansaoniscus leilae* sp. nov. Male holotype **A** pereopod 1 **B** pereopod 7 **C** pleopod 1 **D** pleopod 2 **E** pleopod 3 exopod **F** pleopod 4 exopod **G** pleopod 5 exopod. Scale bars: 0.2 mm.

(Pellegrini & Ferreira, 2014); the cricket *Erebonyx catacumbae* (Mello & Ferreira, 2021); the palpigrade *Allokoenenia canhembora* (Souza & Ferreira, 2022); the centipedes *Cryptops spelaeoraptor* (Ázara & Ferreira, 2014a) and *Newportia spelaea* (Ázara & Ferreira, 2014b); the amphipod *Spelaeogammarus trajanoae* (Koenemann & Holsinger, 2000); and the isopod *Pongycarcinia xyphidiorus* (Messana et al. 2002).

Specimens of *I. leilae* sp. nov. (Fig. 4D, E) were observed at the upper level in the first cave surveys, in the late 1990s. Several specimens were observed, especially near some old bat guano piles. At that moment, most of the lower level was filled with water. Hence, even the upper level was moist due to the influence of the high phreatic level on the whole cave atmosphere. However, local inhabitants use to draw water from the cave (as the region is quite dry) and this practice occurred for decades. This removal occurred manually at the beginning, but a diesel pump (Fig. 4F) was installed inside the cave in the 1980s, drying out previously flooded areas (Prevorčnik et al. 2012; Souza-Silva and Ferreira 2016). It is important to mention that the locals

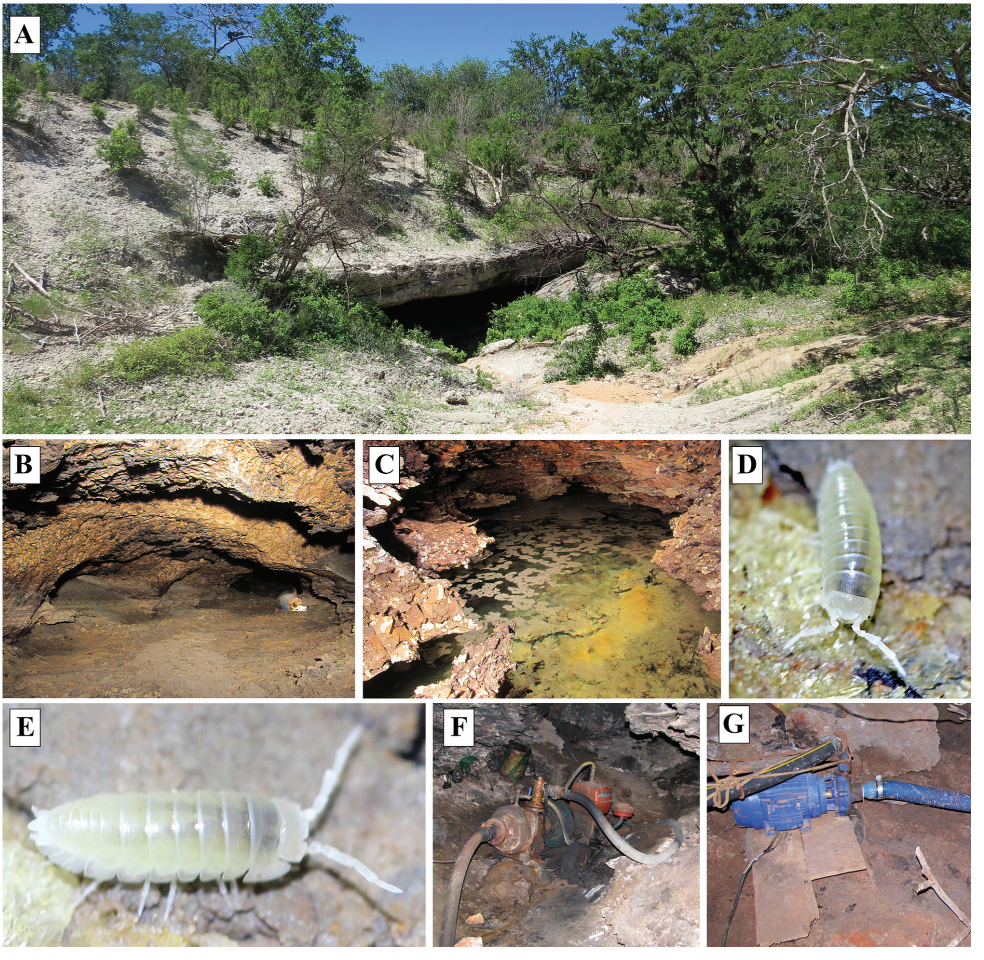


**Figure 4.** *Iansaoniscus leilae* sp. nov. habitat **A** Toca do Gonçalo cave entrance **B** cave floor in the inner portion of the cave, where specimens were found **C** water table at the cave lower level **D** adult specimen inside the cave, frontal view **E** adult specimen inside the cave, lateral view **F** diesel pump installed inside the cave in the 70's **G** electric pump installed inside the cave in 2010.

used to remove water from the cave once a week to fill up an external reservoir, hence the water table was persistent. However, in 2010, an electric pump employed by a local farmer for irrigation was installed in the cave (Fig. 4G), leading to a pronounced reduction of at least two meters in the water table inside the cave. Even after the removal of this electric pump (in 2012) the water table reduction continued, since artesian wells were built up outside the cave, so the water demand persisted. During a visit to the cave in August 2013, a major reduction in the water level was observed (approximately 3 m compared to the "pristine" level – observed in the 1990s). In 2013, specimens of *I. leilae* sp. nov. were no longer found in the upper level of the cave (that was extremely dry), being only observed on the moist substrates of the lower level, even though, in lower densities when compared to the first observations. In December 2018, in a visit to the cave, the whole water table was no longer observed, so previously inaccessible areas were explored, revealing the cave to be much longer than previously thought, and only a few cave-restricted species were observed. From the 22 previously observed troglobitic species, only two (one specimen of *I. leilae* sp. nov., and one springtail) were observed in some moist areas located deep inside the cave in previously flooded areas. The single individual of *I. leilae* sp. nov. was found in a small piece of wood, apparently attracted by the organic compounds. It is important to mention that this species may be seriously threatened, as other cave-restricted species from the Toca do Gonçalo cave. Urgent intervention by the competent environmental agency is needed to ensure the protection of this hotspot of subterranean biodiversity in South America, especially considering that even the most relevant caves can now be destroyed in Brazil (Brasil 2022).

### *Iansaoniscus paulae* sp. nov.

http://zoobank.org/4B0755B7-18B1-404D-B6F0-A6F7A86A4EF4
Figs 5–8

**Diagnosis.** Cephalon with well-developed lateral lobes with round distal margin; frontal shield rounded, weakly developed; pereonite 1 epimeron without dorsolateral furrow; pereonite 1 and 2 without ventral lobes; antennula distal article with two lateral and one apical aesthetascs; third article longer than second; uropod exopod longer than endopod, longer than distal margin of telson.

**Material examined.** ***Holotype*:** Brazil • 1 male (mounted in slide); Bahia state, municipality of Itaeté, Lapa do Bode cave (WGS84 -12.938889, -41.062222); 26th July 2007; RL Ferreira leg.; ISLA 95915. ***Paratypes*:** • 5 females; same data as holotype; ISLA 95916.

**Etymology.** The new species is named after Dr. Paula Beatriz Araujo, UFRGS, for her contribution to the knowledge of Brazilian terrestrial isopods.

**Description.** Maximum length: male, 3 mm; female 5 mm. Body outline as in Fig. 5A, colorless, vestigial eyes (Fig. 5A, B). Cephalon with well-developed lateral lobes, round distal margin; frontal shield rounded, weakly developed (Fig. 5B). Pereonite 1 epimeron without dorsolateral furrow; pereonites 1 and 2 without ventral lobes (Fig. 5C, D); pereonite 3–7 with subquadrangular epimera. Pleonites 3–5 with epimera subquadrangular and directed backwards (Fig. 5A). Telson (Fig. 6A) slightly wider than long with concave sides, acute apex. Antennula (Fig. 5E) with three articles, distal article longer than second article, with two lateral and one apical aesthetascs. Antenna (Fig. 5F, 6B) surpassing pereonite 3 when extended backwards, fifth article of peduncle as long as flagellum, flagellum with three articles; faint suture between second and third, third article longest, aesthetascs on second and third articles. Mandibles (Fig. 6C, D) with molar penicil of 4 branches, left mandible with 2+1 penicils, right with 1+1 penicils. Maxillula (Fig. 6E) outer branch with 4 + 5 teeth (two apically

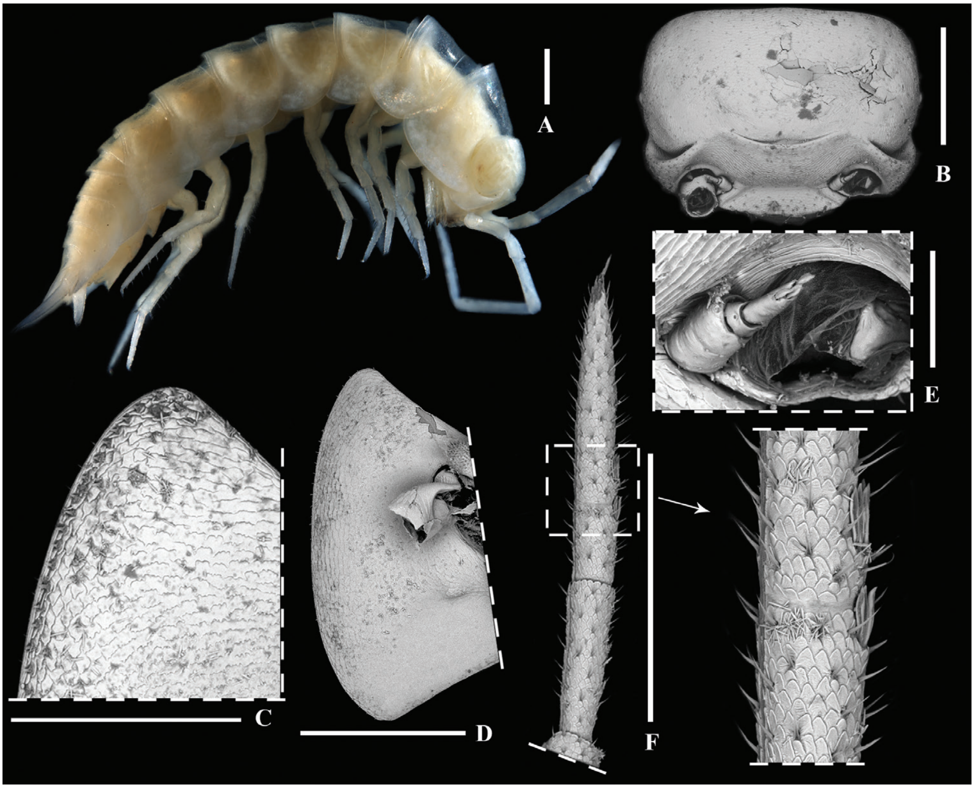


**Figure 5.** *Iansaoniscus paulae* sp. nov. Female paratype **A** lateral view **B** cephalon, dorsal view **C** pereonite 1, dorsal view **D** pereonite 1, ventral view **E** antennula **F** antennal flagellum. Scale bars: 0.5 mm (**A, B, D, E**); 0.3 mm (**C**); 0.1 mm (**E**).

cleft); inner branch with two penicils. Maxilla (Fig. 6F) with bilobate apex, outer lobe wider than inner lobe, rounded and covered with thin setae; inner lobe bearing thick setae. Maxilliped (Fig. 6G) basis rectangular; palp basal article with two setae distinct in length; endite rectangular, long medial seta, distal margin with two teeth. Pereopods 1–7 (Fig. 7A, B) merus and carpus with sparse setae on sternal margin; carpus 1 with longitudinal antennal grooming brush, distal setae cleft; dactylar organ and ungual seta simple not surpassing outer claw. Uropod (Fig. 7C) protopod distal margin and exopod proximal margin with lateral groove; endopod inserted proximally, exopod 1.4× longer than endopod and distinctly surpassing distal margin of telson.

**Male:** Pleopod 1 (Fig. 7D) exopod ovoid, twice wider than long; endopod almost four times longer than exopod, distal portion slightly bent outwards, apex with small setae. Pleopod 2 exopod (Fig. 7E) triangular bearing one seta on outer margin, endopod flagelliform, almost three times longer than exopod. Pleopod 3–5 exopods as in Fig. 7F–H.

**Habitat and conservation issues.** The Lapa do Bode cave consists of a dolomite cave with 1,430 meters of horizontal projection, with conduits of labyrinthine pattern. It is inserted in an upper unit of the Una geological group of carbonate rocks from the

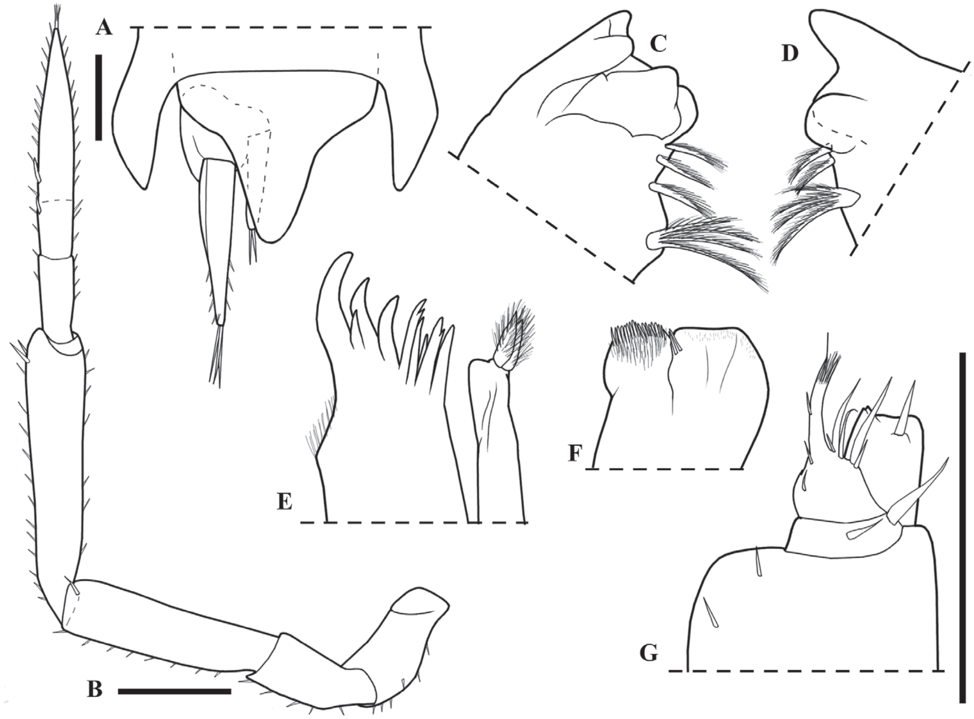


**Figure 6.** *Iansaoniscus paulae* sp. nov. Male holotype **A** telson and uropod, dorsal view **B** antenna **C** left mandible **D** right mandible **E** maxillula **F** maxilla **G** maxilliped. Scale bars: 0.2 mm.

Salitre Formation (Fig. 9) (Auler 2019). This cave presents five entrances (Fig. 8B, C) inserted in a rock wall parallel to the Una River, which flows close to the entrances (Fig. 8A). Although most of the cave is dry, the cave atmosphere is considerably moist due to water ponds in some inner areas. The temperature inside the cave is around 24.5 °C. The cave has been used for touristic purposes for the last decades, and the areas where individuals of *I. paulae* sp. nov. were found (inner portions of the cave, quite distant from the entrances) are also visited by tourists. They were observed walking on moist soil (Fig. 8D) and in some bat guano piles. Although the touristic activities apparently have not been altering intensively the cave features, there is concern that it could impact the species, especially by trampling (by visitors) due to the reduced size of the specimens and absence of structures guiding visitors to walk in specific pathways. The main available food resource is bat guano, that are concentrated in the inner chambers of the cave. It is worth mentioning that the Lapa do Bode cave presents ten cave-restricted species, among springtails, harvestmen, spiders, a beetle, a millipede, a silverfish, a palpigrade and a fish. However, only three of those species are currently described: the carabid beetle *Coarazuphium cessaima* (Gnaspini, Vanin & Godoy, 1998); the pholcid spider *Metagonia diamantina* (Machado, Ferreira & Brescovit, 2011)*;* and the catfish *Rhamdiopsis krugi* (Bockmann & Castro, 2010).

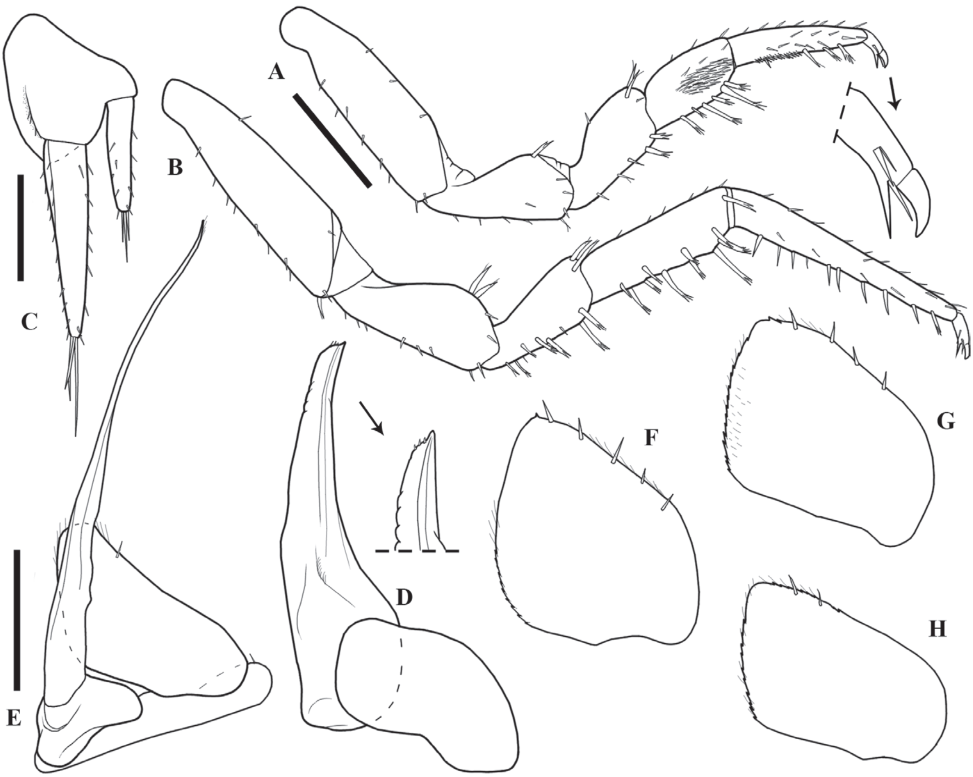


**Figure 7.** *Iansaoniscus paulae* sp. nov. Male holotype **A** pereopod 1 **B** pereopod 7 **C** uropod **D** pleopod 1 **E** pleopod 2 **F** pleopod 3 exopod **G** pleopod 4 exopod **H** pleopod 5 exopod. Scale bars: 0.2 mm.

## Discussion

### Taxonomy

The shape of cephalon is a unique feature in *Iansaoniscus* species, however it presents great phenotypic plasticity. *Iansaoniscus leilae* sp. nov. and *I. georginae* show similar patterns such as the frontal shield triangular with frontal margin directed upwards, lateral lobes weakly developed and antennal sockets depressed; while *I. paulae* sp. nov. and *I. iraquara* show well-developed lateral lobes with round margins and frontal shield rounded, weakly developed. The two new species are similar to *I. iraquara* due to pereonites 3 to 7 with subquadrangular epimera, maxillulae outer endite with 4+5 teeth (2 of them apically cleft) and absence of dorsolateral furrow on pereonite 1 epimera. However, while *I. iraquara* and *I. leilae* sp. nov. present ventral lobes on pereonites 1 and 2, such structures are absent in *I. paulae* sp. nov. In *I. georginae* the dorsolateral furrow and lobes are present, but weakly developed, while the maxillulae outer endite presents 4+6 teeth (2 apically cleft). Differently from the other three species, *I. georginae* presents subquadrangular epimera from pereonite 2. Regarding the telson shape, *I. iraquara*, *I. georginae* and *I. paulae* sp. nov. share the condition of a narrowly

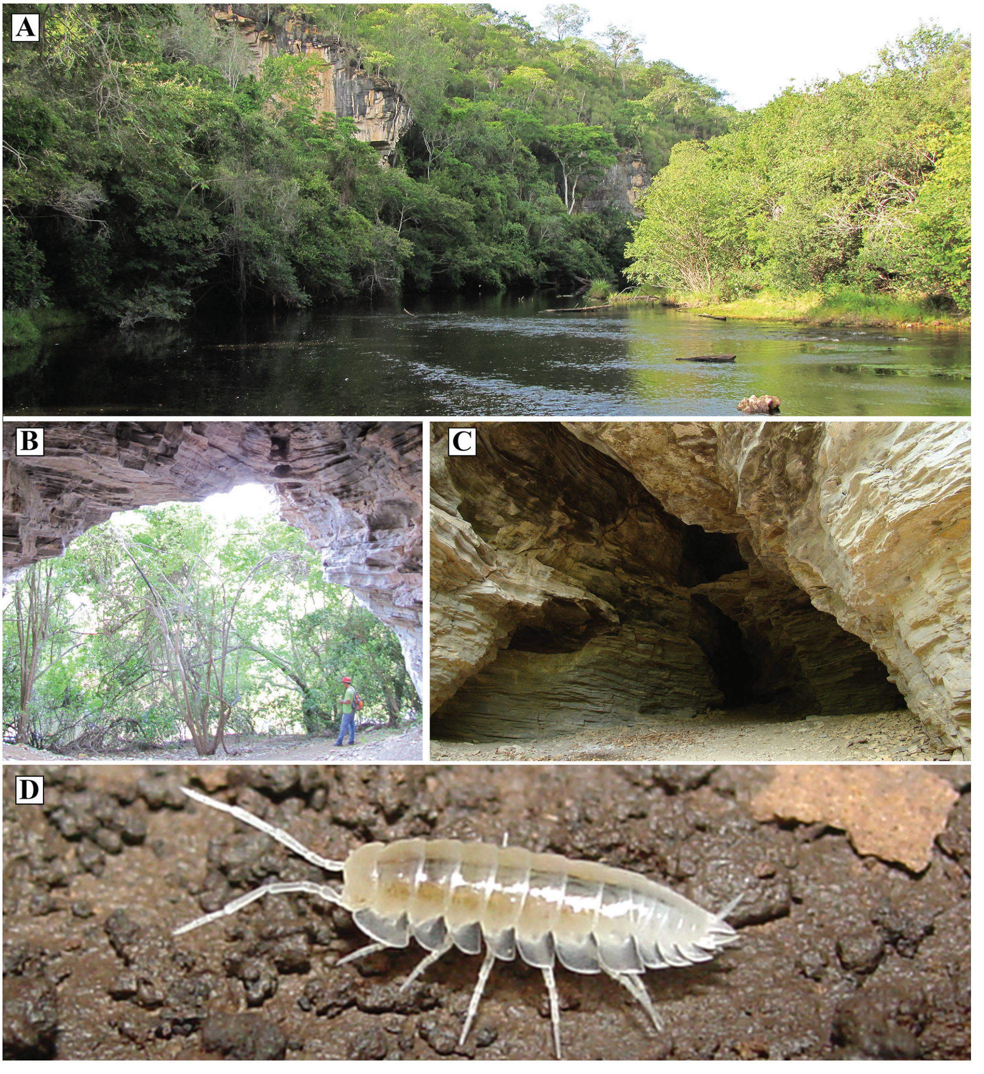

**Figure 8.** *Iansaoniscus paulae* sp. nov. habitat **A** limestone bordering the Paraguaçu river, where the Lapa do Bode cave's entrance is located **B** one of the entrances of Lapa do Bode cave **C** a secondary entrance of Lapa do Bode cave **D** adult specimen inside the cave.

rounded apex, which is acute in *I. leilae* sp. nov. Another difference among the species is that pleopod 1 exopod may present two conditions: ovoid (*I. iraquara*, *I. leilae* sp. nov. and *I. paulae* sp. nov.), and subquadrangular (*I. georginae*). In relation to eyes, such structures are absent in *I. iraquara*, *I. georginae* and *I. leilae* sp. nov., but present and vestigial in *I. paulae* sp. nov. Moreover, the *Iansaoniscus* species present distinct patterns of aesthetascs in the antennula distal article: *I. georginae* (four lateral plus one apical pair), *I. leilae* sp. nov. (two lateral plus two apical), *I. paulae* sp. nov. (two lateral plus one apical) and *I. iraquara* (missing antennule in the description). Additionally,

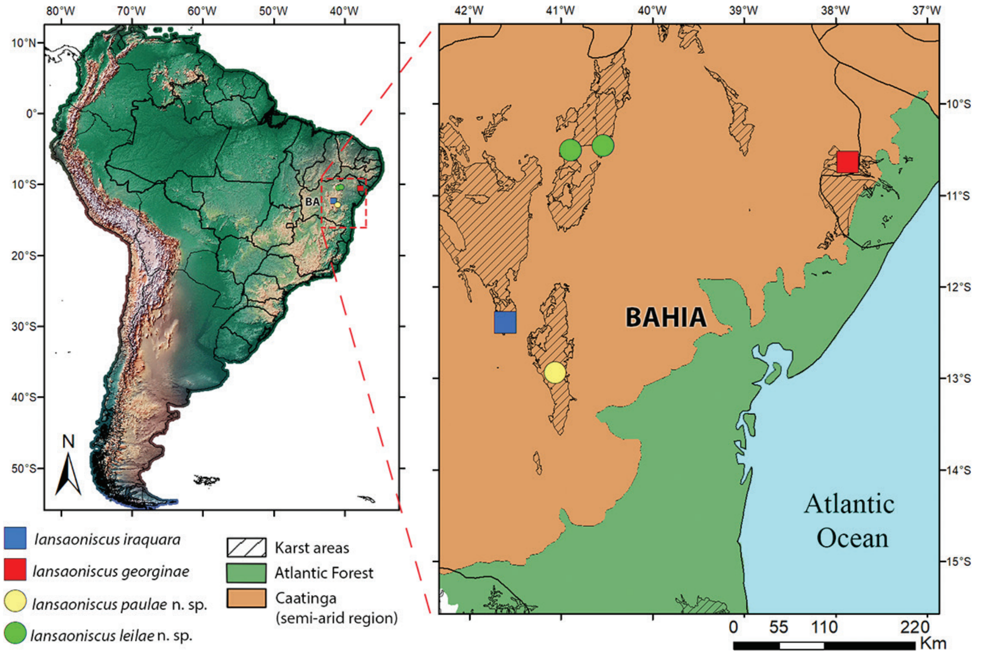


**Figure 9.** Geographical distribution of *Iansaoniscus* species, with Brazilian biomes and the karst areas delimited in the state of Bahia.

distinct patterns are observed regarding the number of branches in the mandible molar penicil: *I. iraquara* (5 to 7), *I. georginae* (6 to 7), *I. leilae* sp. nov. (7 to 8), *I. paulae* sp. nov. (4). The proportion of uropods exopod and endopod also varies among the species, with exopod as long as endopod in *I. iraquara*; exopod shorter than endopod in *I. leilae* sp. nov.; and exopod longer than endopod in *I. georginae* and *I. paulae* sp. nov. (being longer in *I. paulae* sp. nov. 1.4×).

## Ecology and distribution

Until the discovery of *Iansaoniscus* species in the Caatinga biome (semi-arid region) (Fig. 9), the family was believed to be restricted to the Atlantic Forest (Campos-Filho et al. 2018; Cardoso et al. 2018). The other three genera occur in forests along the coast of Brazil, mainly associated with vegetation and/or leaf litter (Vandel 1963; Lemos de Castro 1973; Campos-Filho et al. 2017). Until then, few collection efforts had been made in more arid areas of Brazil, which conditions are not very suitable for the occurrence of isopods in general. In this sense, *Iansaoniscus*, which are restricted to caves in the only Brazilian semi-arid biome (Caatinga), are supposed to represent a geographical relict.

The xeric conditions of Caatinga currently act as a limiting barrier to the dispersion of many hygrophilic components of fauna, such as isopods (Fernandes et al.

2016). However, Wang et al. (2004) dated speleothems and travertine deposits from the Bahia state and estimated 210,000 years of record of wet periods in northeastern Brazil caused by the displacement of the Intertropical Convergence Zone to the south. The rainforest distribution was affected during these wet periods, which formed a corridor between Amazonian and Atlantic Forests (Por 1992; Behling et al. 2000). Posteriorly, Cruz et al. (2009) observed an anti-phased relationship between precipitation in northeastern Brazil and the rest of tropical South America during the Holocene. The authors analyzed oxygen isotopic records from a speleothem in northeastern Brazil from the last 26,000 years and concluded that a predominantly wet climate dominated the currently semi-arid Caatinga. In this sense, the called south-eastern/north-western route (Bigarella et al. 1975), or the route across the Caatinga formation of eastern Brazil (Ledo and Colli 2017), seem to have favored many biotic exchanges in the past. Along this pathway and under climatic changes, some species or groups of species may have been isolated in moister areas, such as the subterranean conditions of many caves in Caatinga (Polhemus and Ferreira 2018), culminating in current geographical relicts, such as *Allokoenenia* (Palpigradi) (Souza & Ferreira, 2022) and *Iansaoniscus* species.

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