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## Research article

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# Remarkable micro-endemism and high congeneric richness: eight new cave-restricted species of *Pseudochthonius* Balzan, 1892 (Pseudoscorpiones, Chthoniidae) from the Brazilian semi-arid

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**Abstract.** Eight new species of pseudoscorpions belonging to the genus *Pseudochthonius* Balzan, 1892 are described from the semi-arid region of Brazil. Comprehensive morphological descriptions, diagnostic characters, detailed illustrations, and ecological remarks of the habitats are provided for *Pseudochthonius celestialis* sp. nov., *P. caritas* sp. nov., *P. patientia* sp. nov., *P. temperantia* sp. nov., *P. diligentia* sp. nov., *P. castitas* sp. nov., *P. humilitas* sp. nov., and *P. benignitas* sp. nov. In addition, we present a brief discussion of the potential factors underlying the remarkable congeneric species richness observed in this geographically restricted region, as well as the principal threats faced by these species. These findings underscore the importance of conserving caves in order to protect their highly specialized fauna, with particular emphasis on the genus *Pseudochthonius*, which is increasingly recognized as strongly associated with subterranean environments.

**Keywords.** Cave, conservation, pseudoscorpion, taxonomy, troglomorphy.

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## Introduction

The family Chthoniidae Daday, 1889 is one of the most diverse lineages within the order Pseudoscorpiones, comprising 954 described species distributed across 55 genera (Harvey 2025; WPC 2025). Within this family, the genus *Pseudochthonius* Balzan, 1892 stands out as one of the most species-rich with 44 species described worldwide, 23 of which occur in Brazil and 18 are associated with cave environments (von Schimonsky *et al.* 2022; Assis *et al.* 2023; Guimarães *et al.* 2025a, 2025b; WPC 2026). Remarkably, 14 new species have been described in the last five years alone (Assis *et al.* 2021; von Schimonsky *et al.* 2022; Prado & Ferreira 2023, 2024; Guimarães *et al.* 2025a, 2025b; WPC 2025),

all originating from subterranean habitats. This pattern underscores both the exceptional diversity of the genus in Brazil and its strong ecological association with cave systems.

The genus *Pseudochthonius* is characterized by the presence of plumose coxal spines on coxae I and II, absence of an intercoxal tubercle, and the distinctive sigmoid shape of the chelae. The latter trait is absent in *P. orthodactylus* Muchmore, 1970, from Pará (Chamberlin 1929; Muchmore 1970; Prado & Ferreira 2024). In addition to these, a further character is the trichobothrial pattern, with *ist* positioned distal to *eb* and *esb*, approximately midway between *esb* and *est*. This condition is shared with *Caribchthonius* Muchmore, 1976, but the latter can be readily distinguished by the presence of nearly contiguous chelal teeth (Muchmore 1976).

Despite recent advances, a substantial knowledge gap persists regarding the true diversity of *Pseudochthonius*, largely due to the extensive number of unexplored subterranean habitats in South America, particularly in Brazil, which contains the most extensive karst landscapes on the continent. The country currently has more than 30 000 officially registered caves, representing only about 10% of the estimated total number of caves (Auler & Piló 2011; ICMBio/Cecav 2025). Moreover, only a small fraction of these registered caves has been the focus of biological inventories, highlighting that much of Brazil's speleological heritage remains biologically unexplored.

In Brazil, species of *Pseudochthonius* are distributed across four regions (North, Northeast, Southeast, and South) with the highest richness recorded in the Northeast (ten species) and Southeast (eight species). In this study, we describe eight new cave-restricted species of *Pseudochthonius* from northeastern Brazil, increasing the number of species known from the country to 31. We also provide detailed habitat descriptions and a brief discussion of the potential factors driving the high species diversity in this geographically restricted area, as well as the main threats to these species.

## Material and methods

### Study area

The Serra de Iuiú karst landscape, situated in the municipalities of Iuiú and Malhada (south-central Bahia, Brazil) (Fig. 1B–C), occupies a prominent sector of the São Francisco River basin. Its carbonate bedrock belongs to the Bambuí Group, a Neoproterozoic sedimentary succession dominated by thick limestones and dolostones that form non-contiguous carbonate plateaus. The Serra de Iuiú massifs extend over roughly 250 km<sup>2</sup>, with elevations of 500–860 m a.s.l., and display a characteristic karst geomorphology comprising caves, dolines, sinkholes, and extensive limestone pavements and scarps. Climatically, the region falls within the Köppen “Aw” category (tropical savanna with a pronounced dry winter), receiving on the order of 640 mm yr<sup>-1</sup> of precipitation (Alvares *et al.* 2013). Biogeographically, it lies within the Caatinga domain (the only Brazilian semiarid biome) with local ecotonal transitions to the Cerrado (Brazilian savanna) (Cole 1960).

Vegetation is dominated by xerophytic shrublands and seasonally dry forests interspersed with rocky outcrops. Fine-scale variation in topography, lithology, and soil depth generates considerable microhabitat heterogeneity in the area. However, the surrounding epigeal landscape has undergone substantial land-use change, as deforestation, charcoal production, pasture expansion, and small-scale agriculture, which can disrupt organic matter inputs and microclimatic stability in subterranean environments, with negative implications for cave communities (Cardoso *et al.* 2022). Detailed habitat information for each species treated herein is provided in the respective “Ecological remarks” sections.

## Collection, preservation and storage

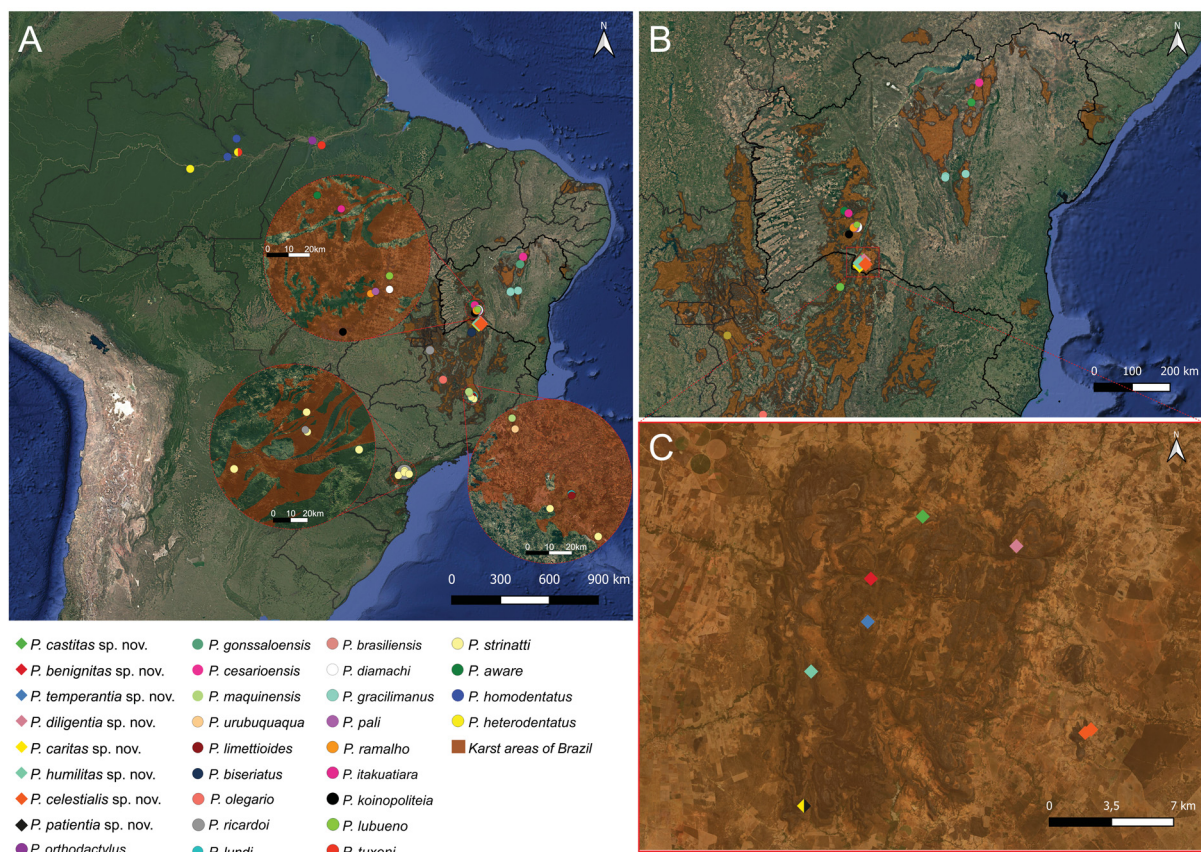
Specimens were collected through targeted visual inspections using manual collection methods, following the Direct Intuitive Search (DIS) approach described by Wynne *et al.* (2019). Within the caves, individuals were carefully removed using fine brushes lightly moistened with ethanol and immediately preserved in vials containing 70% ethanol. Holotypes and paratypes were stored separately in 50 mL vials assigned to each species.

The material examined in this study was obtained during multiple field campaigns conducted in the Iuiú karst area, encompassing a total of ten expeditions carried out between 2007 and 2023. These expeditions occurred in 2007 (one expedition), 2010 (one), 2013 (two), 2014 (one), 2016 (two), 2021 (one), 2022 (one), and 2023 (one). Each expedition lasted on average 15 days, during which several caves were surveyed.

The complete type series, along with all additional examined material, is deposited in the Subterranean Invertebrates Collection of Lavras (ISLA), housed at the Center for Studies on Subterranean Biology (CEBS), Federal University of Lavras (UFLA), Brazil.

## Analysis and preparation

Specimens were examined under a Zeiss Axio Scope A1 compound microscope and images were processed using the ZEN 2012 software. Detailed drawings of morphological structures and appendages



**Fig. 1.** Distribution of the genus *Pseudochthonius* Balzan, 1892 in Brazil. **A.** Distribution map of the genus in Brazil. **B.** Distribution of *Pseudochthonius* species in the state of Bahia, including the areas where the new species occur. **C.** Serra de Iuiu and Serrinha, detailed view of the areas of occurrence of the new species.



were made with a drawing tube attached to a Leica DM750 microscope equipped with phase contrast. Slides were prepared using Kaiser's glycerol gelatin to maintain specimen stability during both observation and illustration. Selected anatomical structures were photographed using a Zeiss Axio Zoom V16 system, with images captured in ZEN 2.1 software and later converted into vector graphics through Inkscape ver. 1.1 (Montesanto 2015; available at [inkscape.org](https://inkscape.org)).

### Lists of abbreviations

Abbreviations for the trichobothria: *b* = basal; *dx* = duplicate trichobothria; *eb* = exterior basal; *esb* = exterior sub-basal; *est* = exterior sub-terminal; *et* = exterior terminal; *ib* = interior basal; *isb* = interior sub-basal; *ist* = interior sub-terminal; *it* = interior terminal; *sb* = sub-basal; *st* = sub-terminal; *t* = terminal.

Abbreviations for the cheliceral setae: *db* = dorsal basal; *dt* = dorsal terminal; *dst* = dorsal sub-terminal; *gl* = galeal; *vt* = ventral terminal; *vb* = ventral basal.

Abbreviations for the carapace: *al* = anterolateral setae of carapace; *ame* = anteromedial setae of carapace; *an* = anterior setae row of carapace; *il* = intermedial lateral setae of carapace; *in* = intermedial setae row of carapace; *me* = median setae row of carapace; *ml* = median lateral setae of carapace; *mm* = median medial setae of carapace; *oc* = ocular setae of carapace; *ol* = lateral ocular setae of carapace; *om* = medial ocular setae of carapace; *pl* = posterolateral setae of carapace; *po* = posterior setae row of carapace.

Abbreviation for repository: ISLA = Coleção de Invertebrados Subterrâneos de Lavras, Lavras, Brazil.

### Terminology

Terminology follows Chamberlin (1931), Harvey (1992), Judson (2007), and Zaragoza (2017). For the comparative diagnoses, each new species was compared with the most morphologically similar taxa, with similarities and diagnostic differences explicitly highlighted. When the closest morphological analogue was another species described herein, additional comparisons were made with previously described species exhibiting similar morphology. This approach ensured that each new species was directly compared with at least one formally described species.

### Results

Class Arachnida Lamarck, 1801  
Order Pseudoscorpiones de Geer, 1778  
Superfamily Chthonioidea Daday, 1888  
Family Chthoniidae Daday, 1888  
Genus *Pseudochthonius* Balzan, 1892

*Pseudochthonius celestialis* sp. nov.

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Figs 2A–B, 3–4

### Diagnosis

*Pseudochthonius celestialis* sp. nov. most closely resembles *P. tuxeni* Mahnert, 1979 based on the following combination of characters: presence of eyespots, rectangular-shaped carapace, number of teeth on the fixed chelal finger, and distance ratio *ist*–*est*/*ist*–*esb* = 2.00. It differs from *P. tuxeni* in the shape of the epistome, which is prominent and dentate (small in *P. tuxeni*); by having a more elongated chela, with a chelal length of 0.719–0.725 mm and a movable finger length of 0.454–0.458 mm (in *P. tuxeni* 0.41 mm and 0.31 mm, respectively); and in the number of teeth on the movable chelal finger 32–34 (24 in *P. tuxeni*).



### Etymology

The specific epithet '*celestialis*' is derived from the Latin and means 'heavenly'. It alludes to the *Septem virtutes caelestes*, a traditional group of Christian virtues that symbolize moral discipline and spiritual orientation toward God. These virtues (chastity, temperance, charity, diligence, patience, kindness, and humility) represent ideals of ethical conduct and inner refinement. The specific epithet is a Latin adjective.

### Type material

#### Holotype

BRAZIL • ♂; Bahia State, Iuiú Municipality, Toca Fria Cave; 14°32'48.69" S, 43°32'10.97" W; 23 Oct. 2021; R.L. Ferreira leg.; preserved in ethanol; ISLA 151529.

#### Paratypes

BRAZIL • 1 ♂; same data as for holotype; ISLA 151531 • 4 ♂♂, 1 ♀; Bahia State, Iuiú Municipality, Toca Urubu Jatobá Cave; 14°32'55.25" S, 43°32'21.92" W; 23 Oct. 2021; R.L. Ferreira leg.; preserved in ethanol; ISLA 151530, ISLA 151532 – 151535.

### Description

PRESERVED SPECIMEN. Body yellowish beige, translucent; appendages a slightly darker shade of beige (Fig. 2A). Female paratype: body orange beige, translucent; appendages a slightly darker shade of orange (Fig. 2B). Some parts of the body scaly. Vestibular setae thin, pointed, and anteriorly project on prosoma and posteriorly on opisthosoma.

CARAPACE (Fig. 3B–C). 1.141–1.158 times as long as wide, difference between ocular width and posterior width of 0.054–0.061 mm, rectangular-shaped; presence of eyespots; smooth anterior margin, except in the central portion (between the setae *ame*); epistome prominent and strongly serrated; posterior margin smooth; chaetotaxy 4+2: 4: 4: 2: 2 (18).

CHELICERAE (Fig. 3J). Hand with 5 setae; movable finger with 1 subbasal setae; galea present as a tubercle in both sexes. Fixed finger with 8 [♀ paratype 9] acute teeth, the two most proximal separated from the others; movable finger with 9 [♀ paratype 13] acute teeth, the last four smaller and the first distal one separated; rallum with 7 blades; exterior and interior serrula with 12–13 and 10 blades, respectively.

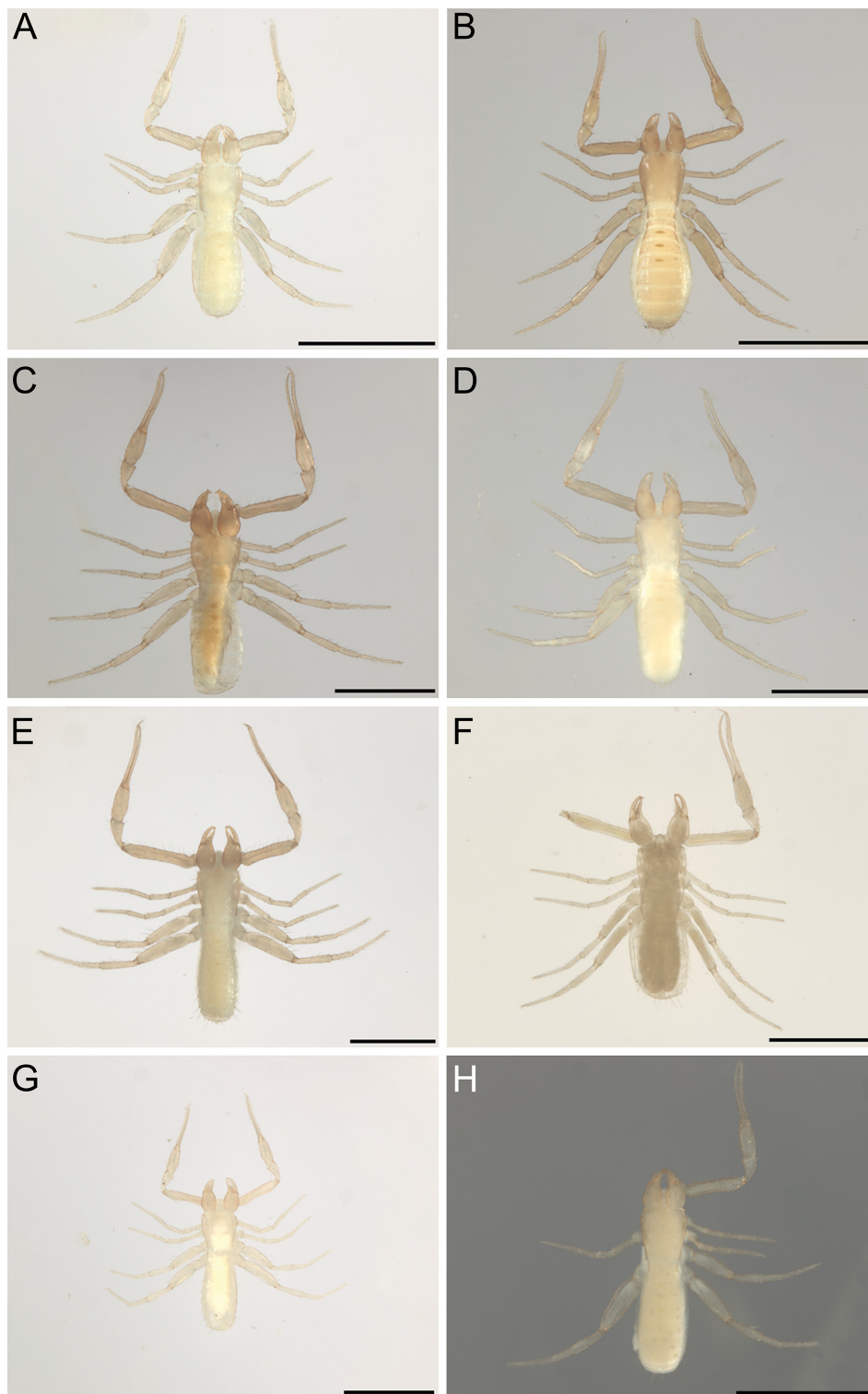
TERGITES. Undivided; smooth surface; chaetotaxy uniseriate: I–XI 4: 4: 4: 4: 6: 6: 6: 6: 6: 6: 2. Female paratype chaetotaxy I–XI: 4: 4: 4: 4: 4: 6: 6: 6: 4: 4: 6. Pleural membranes striated.

COXAE (Fig. 3A, F). Manducatory process with two apical setae; the palpal coxae with 3 setae arranged in a triangle; delicate lamellae bordered by 11(9) small spines. Pedal coxae: plumose coxal spines arranged in a single transverse row on coxae I (3) and II (4–5) (Fig. 3F); chaetotaxy: I 4, II 5, III 7, IV 8, [♀ paratype 5: 5: 7: 8]; intercoxal tubercle absent.

MALE GENITAL OPERCULUM (Fig. 3E). Anterior genital operculum with 8 discal setae, 10 lateral genital setae, and 14 setae along the third sternite, with 4 microsetae in left side.

FEMALE GENITAL OPERCULUM (Fig. 3G). Chaetotaxy: 8: 9 on sternites II and III, respectively. Genital opening not bifurcated.

STERNITES. Chaetotaxy IV–XI: 8: 6: 6: 6: 6: 6: 4: 4+2 sensory. Female paratype chaetotaxy IV–XI: 10: 8: 8: 8: 6: 6: 4: 6+2 sensory. Anal operculum with 2 ventral setae.



**Fig. 2.** Habitus of species of the genus *Pseudochthonius* Balzan, 1892. **A.** *P. celestialis* sp. nov., holotype, ♂ (ISLA 151529), Toca Fria Cave. **B.** *P. celestialis* sp. nov., paratype, ♀ (ISLA 151530), Toca Urubu Jatobá Cave. **C.** *P. caritas* sp. nov., holotype, (ISLA 151522). **D.** *P. temperantia* sp. nov., holotype, (ISLA 151527). **E.** *P. diligentia* sp. nov., holotype, (ISLA 151528). **F.** *P. castitas* sp. nov., holotype, (ISLA 151539). **G.** *P. humilitas* sp. nov., holotype, (ISLA 151536). **H.** *P. benignitas* sp. nov., holotype, (ISLA 151538). Scale bars: A–H = 1.0 mm.

PALP (Fig. 3H, K). Trochanter 1.53–1.56 times as wide as long, patella 2.16–1.79 times as long as wide, femur 5.07–5.19 times as long as wide. Femoral chaetotaxy 4 : 5 : 3 : 5 : 1 [♀ paratype 4 : 6 : 5 : 5 : 2]. Trichobothrial pattern: *ib* and *isb* located halfway on the hand portion, adjacent to each other, *eb* proximal to *esb*, *ist* distal to *esb*, *it* is slightly distal to *est*, *et* proximal to *dx*; *ist* is between *esb* and *est*, closer to *esb* than to *est* (*ist-est/ist-esb* distance ratio = 2.0 [♀ paratype 1.83]); chelal fixed finger with alternating heterodonty after the 7<sup>th</sup> tooth, with 33–35 [♀ paratype 30] acute, triangular teeth, with those in the medial portion notably larger and two distal ones smaller and separated. Movable finger with 30–34 [♀ paratype 29] projected backwards teeth (Fig. 3K).

LEG IV (Fig. 3D). Arolia is slightly smaller than claws.

MEASUREMENTS HOLOTYPE, ♂. (length/width or depth in mm and ratios in parentheses calculated with three significant digits). Body length 1.101–1.191. Carapace 0.363–0.381/0.318–0.329 (1.141–1.158), palps: trochanter 0.155–0.154/0.101–0.099 (1.535–1.556), femur 0.507–0.514/0.100–0.099 (5.070–5.192), patella 0.201–0.174/0.093–0.097 (2.161–1.794), chela 0.719–0.725/0.112–0.115 (6.420–6.304), movable finger length 0.454–0.458. Leg I: trochanter 0.114–0.113/0.084–0.085 (1.357–1.329), femur 0.260–0.277/0.057–0.058 (4.561–4.776), patella 0.127–0.139/0.045–0.046 (2.822–3.022), tibia 0.161–0.166/0.036–0.035 (4.472–4.743), tarsus 0.222–0.284/0.029–0.032 (7.655–8.875). Leg IV: trochanter 0.148/0.092 (1.609), femur/patella 0.454/0.178 (2.550), tibia 0.276/0.067 (4.119), basitarsus 0.161/0.050 (3.220), telotarsus 0.311/0.029 (10.724).

MEASUREMENTS PARATYPE FROM URUBU JATOBÁ CAVE, ♂ (♀ in square brackets). Body length 1.231 [1.084]. Carapace 0.395/0.342 (1.15) [0.328/0.278 1.18], palps: trochanter 0.141/0.102 (1.38) [0.136/0.085 1.6], femur 0.491/0.103 (4.76) [0.376/0.080 4.7], patella 0.202/0.100 (2.02) [0.116/0.099 1.17], chela 0.722/0.121 (5.96) [0.555/0.093 5.97], movable finger length 0.459 [0.361]. Chelicera 0.318/0.140 (2.27), movable finger length 0.158. Leg I: trochanter 0.120/0.086 (1.39) [0.100/0.057 1.75], femur 0.247/0.051 (4.84) [0.190/0.050 3.8], patella 0.120/0.044 (2.73) [0.099/0.041 2.41], tibia 0.139/0.036 (3.86) [0.122/0.034 3.59], tarsus 0.265/0.032 (8.28) [0.217/0.030 7.23]. Leg IV: trochanter 0.110/0.125 (0.88) [0.093/0.044 2.11], femur/patella 0.454/0.167 (2.72) [0.343/0.111 3.09], tibia 0.279/0.065 (4.29) [0.208/0.054 3.85], basitarsus 0.152/0.045 (3.38) [0.108/0.041 2.63], telotarsus 0.271/0.030 (9.03) [0.214/0.027 7.92].

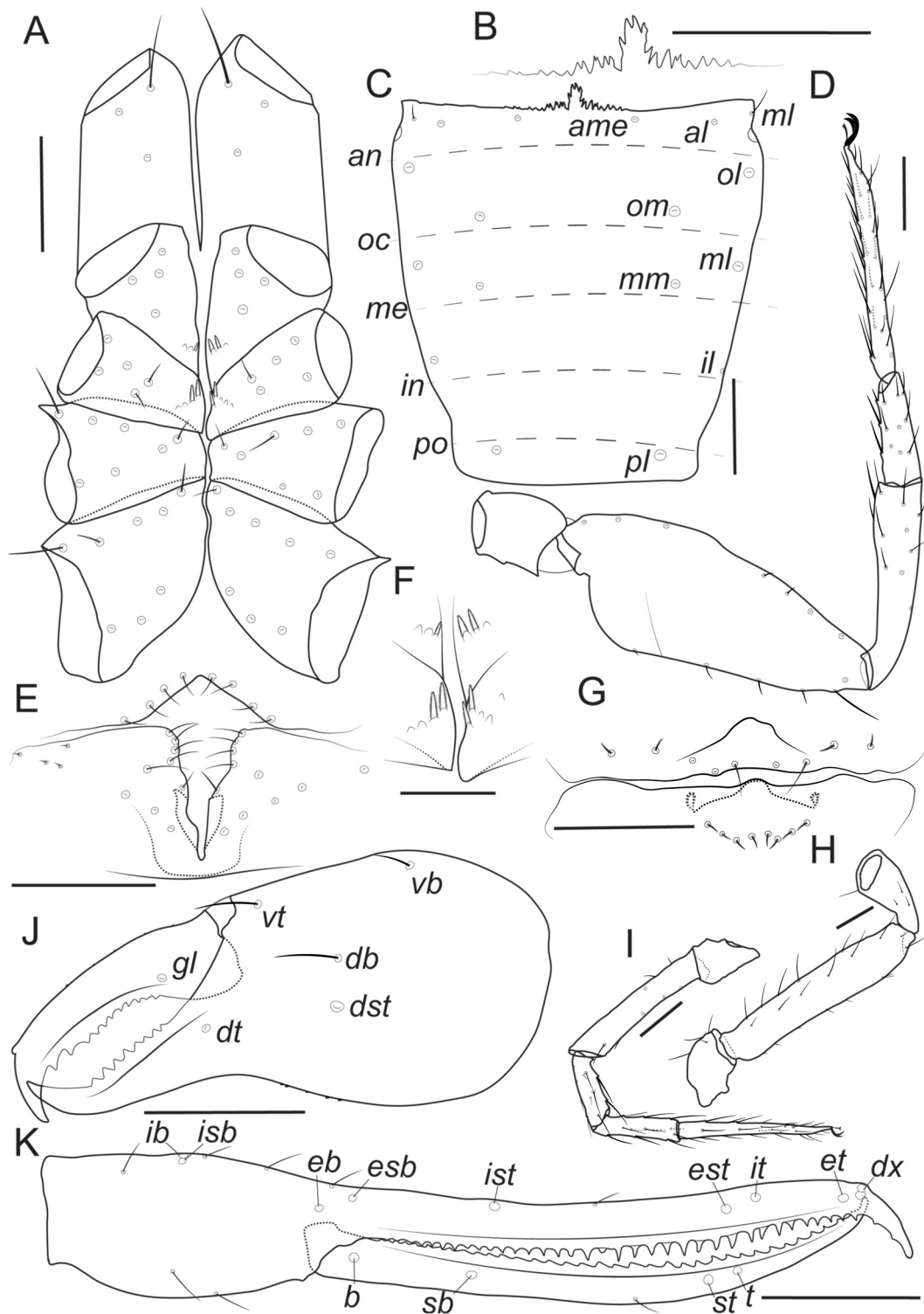
### Ecological remarks

Specimens of *Pseudochthonius celestialis* sp. nov. were collected in the Toca Fria and Urubu-Jatobá caves, both situated within the Serrinha outcrop in the municipality of Iuiú, Bahia, Brazil (Fig. 4A). This carbonate outcrop, relatively small in size (2.4 km in length and 1.3 km in width), lies approximately 4 km from the main karstic massif of the region, the Serra de Iuiú.

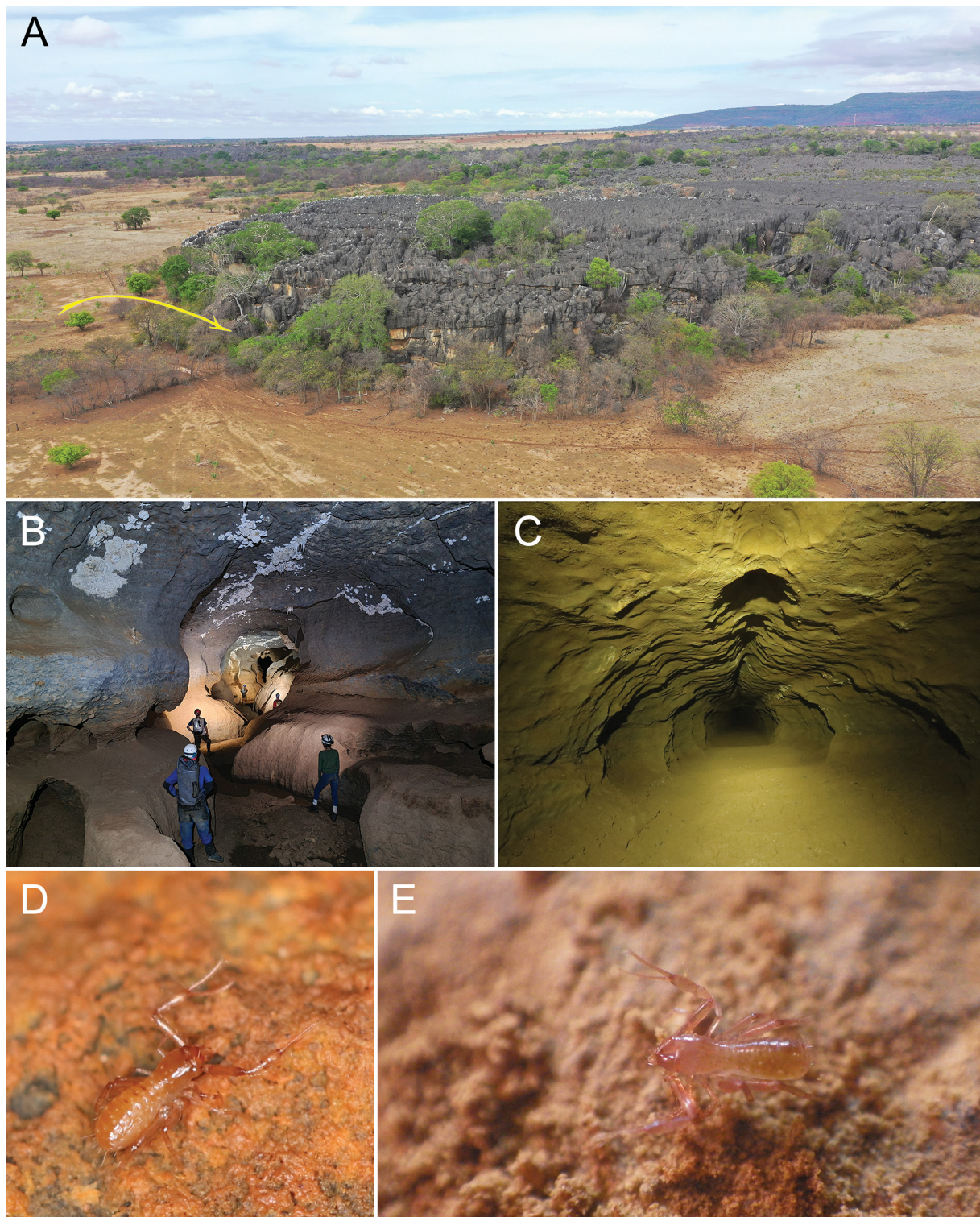
The Toca Fria cave is labyrinthine, with a mapped extension of about 2500 m and multiple entrances, most located along the outcrop margins (Fig. 4A). It lacks perennial water bodies in most of its extent; however, during the rainy season several conduits become temporarily flooded, creating moist substrates that may persist for months after rainfall. At the end of the dry season, most substrates are desiccated, and residual moisture is restricted to small microhabitats beneath rocks in sheltered areas of the cave floor (Fig. 4B). Specimens of *Pseudochthonius celestialis* sp. nov. (Fig. 4D) were consistently found in such moist, secluded microhabitats, usually far from cave entrances.

The Gruta Urubu-Jatobá Cave is also labyrinthine, with more than 3000 m of mapped conduits, although ongoing exploration suggests that its total extension is likely greater. Most of its entrances are located on the upper portions of the outcrop. Similar to Toca Fria, the cave lacks perennial water bodies; however, seasonal rainfall temporarily floods some conduits, creating moist substrates that persist for a few





**Fig. 3.** *Pseudochthonius celestialis* sp. nov. A–F, H–K. Holotype, ♂ (ISLA 151529). G. Paratype, ♀ (ISLA 151532). A. Pedipalp and pedal coxae, ventral view. B. Detail of epistome. C. Carapace, dorsal view. D. Leg IV, antiaxial view. E. Male genitalia, ventral view. F. Details of coxae I and II, showing the arrangement of coxal spines. G. Genitalia, ventral view. H. Pedipalp, dorsal view. I. Leg I, antiaxial view. J. Right chelicera, antiaxial view. K. Right chela, antiaxial view, showing the trichobothrial pattern. Scale bars: A–K = 0.1 mm.



**Fig. 4.** Habitat of *Pseudochthonius celestialis* sp. nov. **A.** Outcrop where Toca Fria Cave is located, the yellow arrow indicates the main cave entrance. **B.** One of the cave entrances. **C.** Interior of the cave. **D.** Specimen of *Pseudochthonius celestialis* sp. nov. in Toca Fria Cave. **E.** Specimen of *Pseudochthonius celestialis* sp. nov. in Urubu Jatobá Cave. Photos: A–D = Rodrigo Lopes Ferreira; E= Lucas Rabelo.



months, while the majority of the cave passages remain dry throughout the year (Fig. 4C). Individuals of *Pseudochthonius celestialis* sp. nov. were likewise recorded under rocks in humid areas located deep inside the cave (Fig. 4E).

Given the proximity of the two caves and their complex internal networks, it is highly probable that Toca Fria and Gruta Urubu-Jatobá represent interconnected sectors of a single, larger cave system. Furthermore, although the species has so far been recorded only in these two caves, the presence of several other caves within the same outcrop suggests that additional populations may exist. Consequently, the distribution of *Pseudochthonius celestialis* sp. nov. likely extends across much of the subterranean habitat within the Serrinha outcrop.

Both caves receive only occasional visits by local residents, with human presence generally restricted to areas near the larger entrances (particularly in Toca Fria) because of the difficulty of traversing the irregular conduits. As a result, the innermost sectors remain relatively well preserved in both caves. In contrast, the external environment surrounding the Serrinha outcrop is severely degraded: most of the native vegetation has been replaced by pastures (Fig. 4A), and extensive patches of exposed soil are common. These alterations increase the risk of sediment input into the caves during rainy periods, which may not only modify internal microhabitats but also reduce the availability of organic matter reaching the subterranean ecosystem. Such external impacts pose potential threats to the persistence of specialized taxa such as *Pseudochthonius celestialis* sp. nov.

*Pseudochthonius caritas* sp. nov.

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Figs 2C, 5–6

### Diagnosis

*Pseudochthonius caritas* sp. nov. most closely resembles *P. cesarioensis* Guimarães, Prado & Ferreira, 2025 based on the following combination of characters: absence of ocular apparatus; carapace broad anteriorly, distinctly narrowed posteriorly; number of teeth on the movable chelal finger; and number of teeth on the fixed cheliceral finger. It differs from *P. cesarioensis* in the anterior margin of the carapace, which is serrated between the *ame* and *al* setae (in *P. cesarioensis*, serrated until the *ame* seta), in the shape of the epistome, which is prominent and dentate (small and highly dentate in *P. cesarioensis*), in the number of teeth on the fixed chelal finger, 34–35 (31 in *P. cesarioensis*), in the distance ratio *ist–est/ist–esb* = 1.45 (3.09 in *P. cesarioensis*), and in the number of teeth on the movable cheliceral finger 14–15 (8 in *P. cesarioensis*).

### Etymology

The specific epithet '*caritas*' is derived from the Latin and means 'charity', which denotes selfless love and benevolence in Christian theology. The name alludes to the concept of charitable love as a guiding moral virtue. The specific epithet is a noun in apposition.

### Type material

#### Holotype

BRAZIL • ♂; Bahia State, Malhada Municipality, Tabocas Cave; 14°35'12.61" S, 43°41'10.99" W; 28 Jul. 2022; R.L. Ferreira leg.; preserved in ethanol; ISLA 151522.

#### Paratypes

BRAZIL • 2 ♀♀, 1 ♂; same data as for holotype; ISLA 151523–151525.

## Description

**PRESERVED SPECIMEN.** Body and appendices orange beige, translucent (Fig. 2C) Some parts of the body scaly. Vestitural setae thin, sharp and anteriorly projected on prosoma and posteriorly projected on opisthosoma.

**CARAPACE** (Fig. 5B, D). 0.99 times as long as wide, broad anteriorly and distinctly narrowed posteriorly, with a difference between ocular width and posterior width of 0.149 mm [♀ paratype 0.155 mm]; anterior margin almost entirely serrate, extending between the *ame* and *al* setae; epistome strongly serrate, prominent with one apical and one medio basal tip (Fig. 5B); ocular apparatus absent; posterior margin of the carapace smooth; chaetotaxy 4+2 : 4 : 4 : 2 : 2 (18).

**CHELICERAE** (Fig. 5I). Hand with 5 setae; movable finger with 1 subdistal setae; galea prominent as a tubercle in both sexes; fixed finger with 11 [♀ paratype 9] acute, regular and continuous teeth, the last one slightly shorter; movable finger with 14 [♀ paratype 13] acute teeth (six proximal shorter), including an isolated distal tooth; rallum with 7 blades; exterior and interior serrula with 12 and 16 blades, respectively.

**TERGITES.** Undivided; smooth surface; chaetotaxy uniseriate: I–XI 4 : 4 : 4 : 4 : 6 : 6 : 6 : 6 : 6 : 6 : 2. Pleural membranes striated.

**COXAE** (Fig. 5A, E). Manducatory process with two apical setae; the palpal coxae with 3 setae arranged in a triangle; delicate lamellae bordered by 11 small spines. Pedal coxae: plumose coxal spines arranged in a single transverse row on coxae I (3) and II (4) (Fig. 5E), chaetotaxy: I–IV 4 : 5 : 7 : 8; intercoxal tubercle absent.

**MALE GENITAL OPERCULUM** (Fig. 5F). Anterior genital operculum with 7–8 discal setae, 12 lateral genital setae, and 13 setae along the third sternite, with 1 lateral microsetae on each side.

**FEMALE GENITAL OPERCULUM** (Fig. 5J). Chaetotaxy 8 : 10 on sternites II and III, respectively; genital opening not bifurcated.

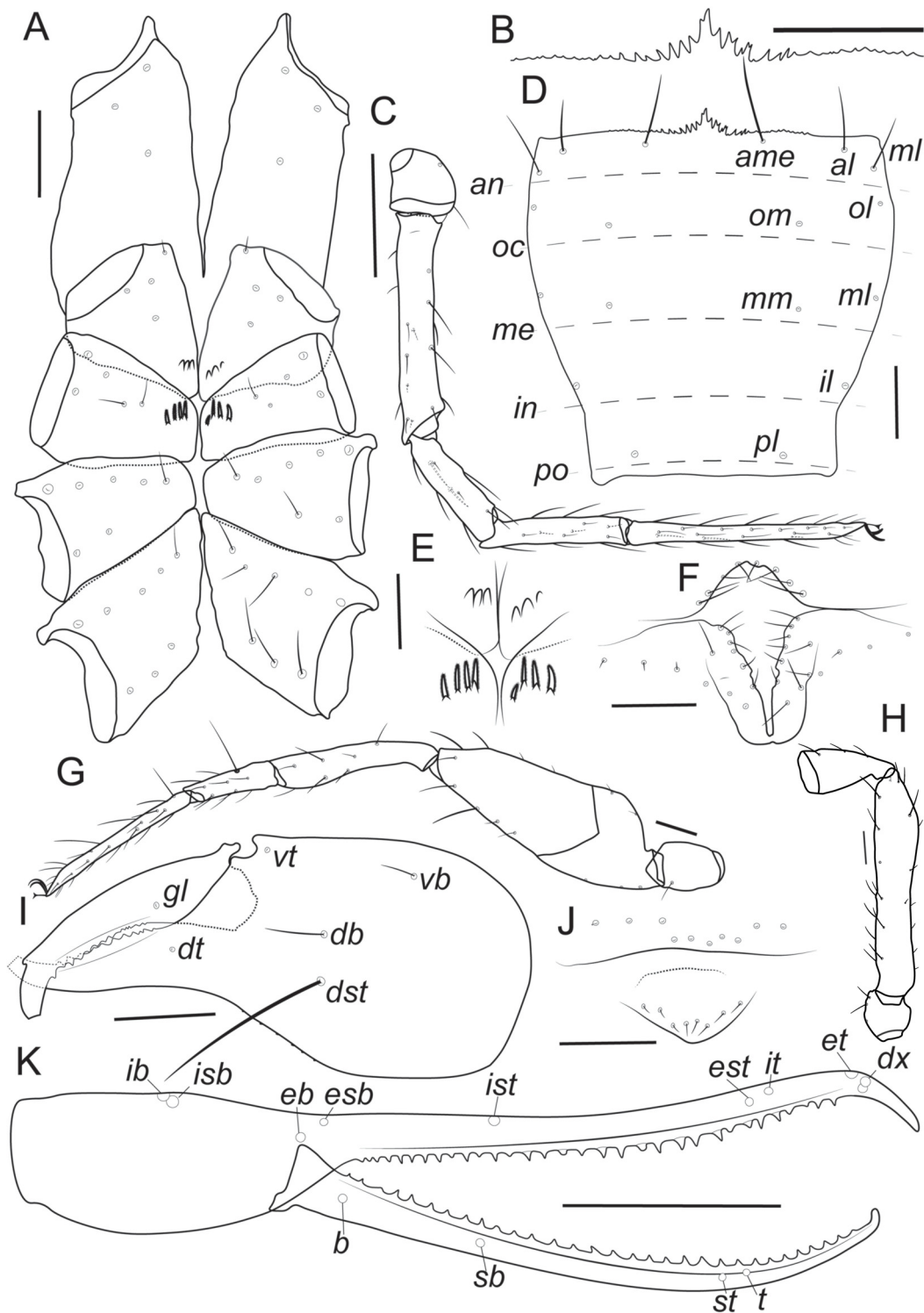
**STERNITES.** Chaetotaxy IV–XI 10 : 6 : 6 : 6 : 6 : 6 : 5 : 2+2. Anal operculum with 2 ventral setae.

**PALP** (Fig. 5H, K). Trochanter 1.34 times as wide as long, patella 2.16 times as long as wide, femur 5.11 times as long as wide. Femoral chaetotaxy 4 : 6 : 4 : 6 : 1. Trichobothrial pattern: *ib* and *isb* located halfway on the hand portion, *isb* slightly more distal than *ib*, *eb* proximal to *esb*, *ist* distal to *esb*, *it* distal to *est*, *et* proximal to *dx*; *ist* is halfway between *esb* and *est*, slightly closer to *esb* than *est* (*ist-est/ist-esb* distance ratio = 1.45 [♀ paratype 1.67]); chelal fixed finger with alternating heterodonty after the 4<sup>th</sup> teeth, with 32–34 acute, regular and continuous tooth, absence of microdents in the distal portion; movable finger with 31 teeth projected upwards, regular, continuous and acute, except for the third proximal one, which is rounded, and the two distal ones smaller (Fig. 5K).

**LEG IV** (Fig. 5G). Arolia is slightly smaller than claws.

**MEASUREMENTS HOLOTYPE, ♂.** (Length/width or depth in mm and ratios in parentheses calculated with three significant digits). Body length 1.629. Carapace 0.497/0.501 (0.99), palps: trochanter 0.195/0.145 (1.34), femur 0.761/0.149 (5.11), patella 0.304/0.141 (2.16), chela 1.049/0.159 (6.6), movable finger length 0.676. Chelicera 0.470/0.217 (2.16), movable finger length 0.242. Leg I: trochanter 0.106/0.110 (0.96), femur 0.388/0.069 (5.62), patella 0.211/0.058 (3.64), tibia 0.214/0.046 (4.65), tarsus 0.334/0.041 (8.15). Leg IV: trochanter 0.184/0.121 (1.52), femur/patella 0.626/0.218 (2.87), tibia 0.408/0.087 (4.69), basitarsus 0.228/0.058 (3.93), telotarsus 0.424/0.041 (10.34).





**Fig. 5.** *Pseudochthonius caritas* sp. nov. **A–I, K.** Holotype, ♂ (ISLA 151522). **J.** Paratype, ♀ (ISLA 151523). **A.** Pedipalp and pedal coxae, ventral view. **B.** Detail of epistome. **C.** Leg I, antiaxial view. **D.** Carapace, dorsal view. **E.** Details of coxae I and II, showing the arrangement of coxal spines. **F.** Male genitalia, ventral view. **G.** Leg IV, antiaxial view. **H.** Pedipalp, dorsal view. **I.** Right chelicera, antiaxial view. **J.** Genitalia, ventral view. **K.** Right chela, antiaxial view, showing the trichobothrial pattern. Scale bars: A–K = 0.1 mm.

MEASUREMENTS ♀ PARATYPE. Body length 1.647. Carapace 0.513/0.518 (0.990), palps: trochanter 0.204/0.152 (1.342), femur 0.775/0.148 (5.236), patella 0.290/0.148 (1.959), chela 1.099/0.165 (6.660), movable finger length 0.715. Chelicera 0.508/0.230 (2.209), movable finger length 0.272. Leg I: trochanter 0.148/0.117 (1.265), femur 0.416/0.071 (5.859), patella 0.215/0.060 (3.583), tibia 0.239/0.044 (5.432), tarsus 0.398/0.040 (9.950). Leg IV: trochanter 0.196/0.130 (1.508), femur/patella 0.640/0.231 (2.770), tibia 0.430/0.090 (4.778), basitarsus 0.224/0.071 (3.155), telotarsus 0.438/0.040 (10.950).

### Ecological remarks

*Pseudochthonius caritas* sp. nov. was recorded exclusively in Tabocas Cave, situated in the southern sector of the Iuiú outcrop, municipality of Malhada, Bahia State, Brazil. The cave is formed by a single meandering conduit, with no lateral branches, that originates at the only entrance and extends for approximately 1.2 km, following the course of a vadose stream. Although the entrance lies in a topographic position that prevents the cave from functioning as a resurgence, part of the conduit is crossed by an intermittent autogenic stream (Fig. 6C). This stream emerges in the deepest portion of the cave, traverses part of the main gallery and disappears into a siphon located in the midsection. Beyond this point, the conduit exhibits increased habitat complexity, with abundant speleothems (Fig. 6E). The considerable length of the main conduit, combined with the presence of a single entrance, confers high humidity and thermal stability throughout the cave.

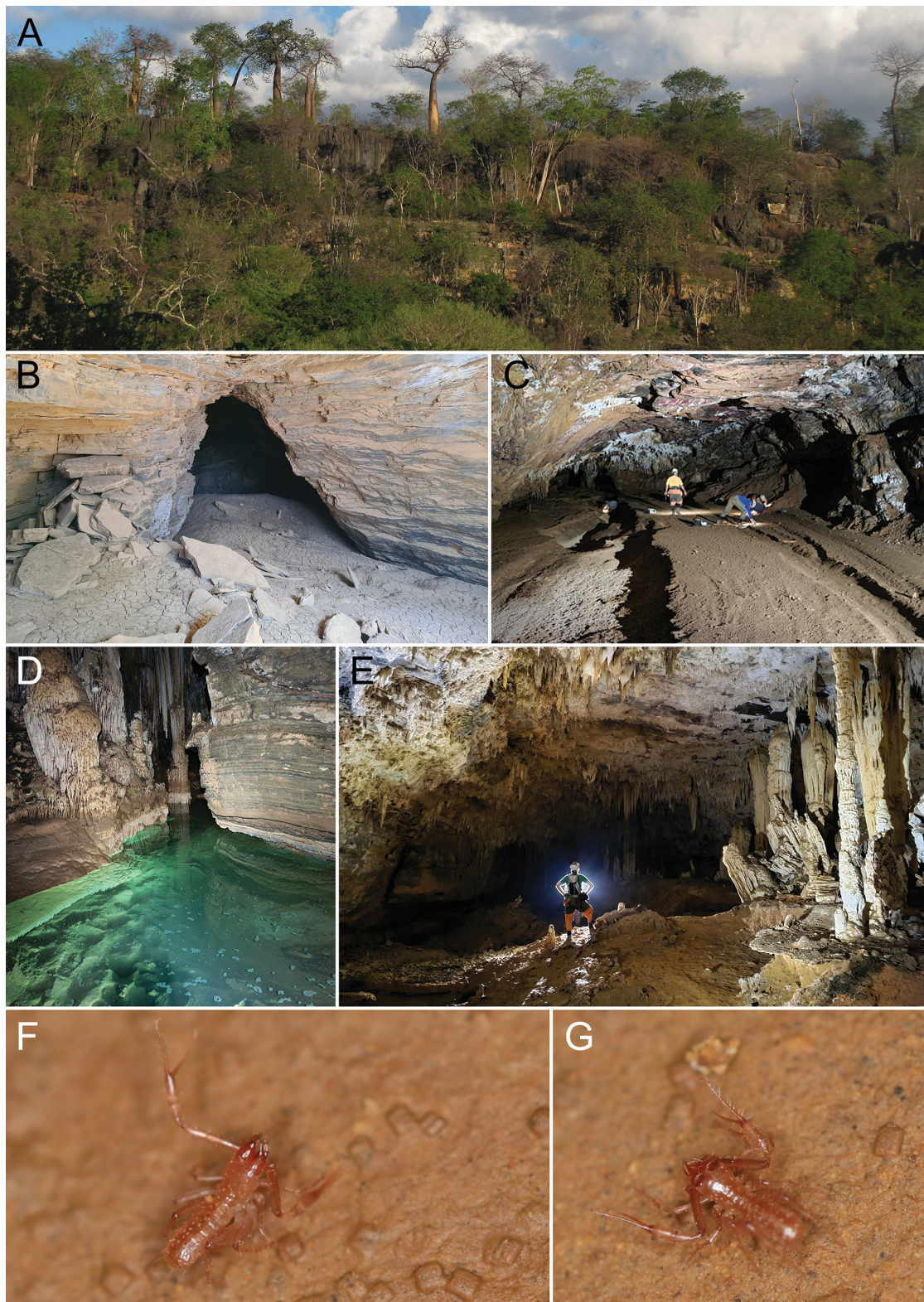
Specimens of *Pseudochthonius caritas* sp. nov. were recorded throughout most of the first half of the cave, indicating a relatively broad distribution within this portion of the system. The species was absent only from areas near the entrance and from sectors located beyond a constriction situated approximately 600 m from the entrance. Beyond this constriction, the cave habitat undergoes a marked transition, becoming more structurally complex and markedly more oligotrophic, as organic resources were rarely observed. The species exhibited variability in microhabitat use, with some individuals observed actively moving across highly moist, muddy substrates (Fig. 6F–G), whereas others were recorded beneath rocks on the cave floor.

Tabocas Cave also harbors the troglobitic pseudoscorpion *Spelaeobochica iuiú* Ratton, Mahnert & Ferreira, 2012 as well as the congeneric species *Pseudochthonius patientia* sp. nov., which is also described herein. The coexistence of *S. iuiú* with species of *Pseudochthonius* has been documented in other caves within the region, suggesting that competitive exclusion between these two genera is unlikely. This apparent coexistence is probably facilitated by their pronounced differences in body size, which likely promotes differential prey selection and resource partitioning.

By contrast, *Pseudochthonius caritas* sp. nov. could potentially compete with *P. patientia* sp. nov., as both species are congeneric and may exhibit similar trophic requirements; however, the single specimen of *P. patientia* sp. nov. was collected from the innermost sector of Tabocas Cave, indicating that the two *Pseudochthonius* populations occurring in this cave may occupy distinct microhabitats and therefore may not be spatially overlapping. However, additional sampling efforts within the cave are necessary to accurately determine the spatial distribution and degree of overlap between the two *Pseudochthonius* species occurring there.

Prior to the present survey, Tabocas Cave had never been visited. Its substrates were pristine, with no evidence of human disturbance, and the interior remains in an excellent state of preservation. The surrounding area is also relatively well conserved, being largely covered by native arboreal vegetation (Fig. 6A), although some nearby areas have been converted to pasture.





**Fig. 6.** Habitat of *Pseudochthonius caritas* sp. nov. and *Pseudochthonius patientia* sp. nov. **A.** Karst outcrop where the cave is located. **B–C.** Entrance of Tabocas Cave. **D.** Wet cave conduit. **E.** Cave interior. **F–G.** Living specimen of *Pseudochthonius caritas* sp. nov. inside the cave. Photos: Rodrigo Lopes Ferreira.



*Pseudochthonius patientia* sp. nov.

urn:lsid:zoobank.org:act:3CC0B946-5472-4538-B2D5-3089B06D9DB0

Figs 6A–E, 7

### Diagnosis

*Pseudochthonius patientia* sp. nov. most closely resembles *P. biseriatus* Mahnert, 2001 based on the following combination of characters: absence of ocular apparatus, carapace broad anteriorly and distinctly narrowed posteriorly, and number of chelal teeth. It differs from *P. biseriatus* in the anterior margin of the carapace, serrated before the *ame* seta (in *P. biseriatus*, serrated until the *ame* seta), in the shape of the epistome, which bears a single larger apical projection (in *P. biseriatus*, three apical projections of nearly equal size), in the number of teeth on the movable cheliceral finger, 14 (8–10 in *P. biseriatus*), in the rallum with 7 blades (9 in *P. biseriatus*), and in the chaetotaxy of the male genital operculum, with 8 discal and 12 lateral setae (6 discal and 12 lateral in *P. biseriatus*).

### Etymology

The specific epithet '*patientia*' is derived from the Latin and means 'patience', referring to the virtue of endurance and perseverance in the face of adversity. The name alludes to patience as a moral ideal associated with restraint and resilience. The specific epithet is a noun in apposition.

### Type material

#### Holotype

BRAZIL • ♂; Bahia State, Malhada Municipality, Tabocas Cave; 14°35'12.61" S, 43°41'10.99" W; 28 Jul. 2022; R.L. Ferreira leg.; preserved in ethanol; ISLA 151540.

### Description

**PRESERVED SPECIMEN.** Body beige-brown orange, translucent; appendages and carapace in a slightly darker shade of orange. Vestibular setae thin, pointed and anteriorly project on prosoma and posteriorly on opisthosoma.

**CARAPACE** (Figs 7B–C). 0.10 times as long as wide, with a difference between ocular width and posterior width of 0.098 mm; broad anteriorly and distinctly narrowed posteriorly; absence of ocular apparatus; smooth anterior margin, except in the central portion (between the setae *ame*); epistome prominent with one apical tips (Fig. 7B); posterior margin smooth; chaetotaxy 4+2 : 4 : 4 : 2 : 2 (18).

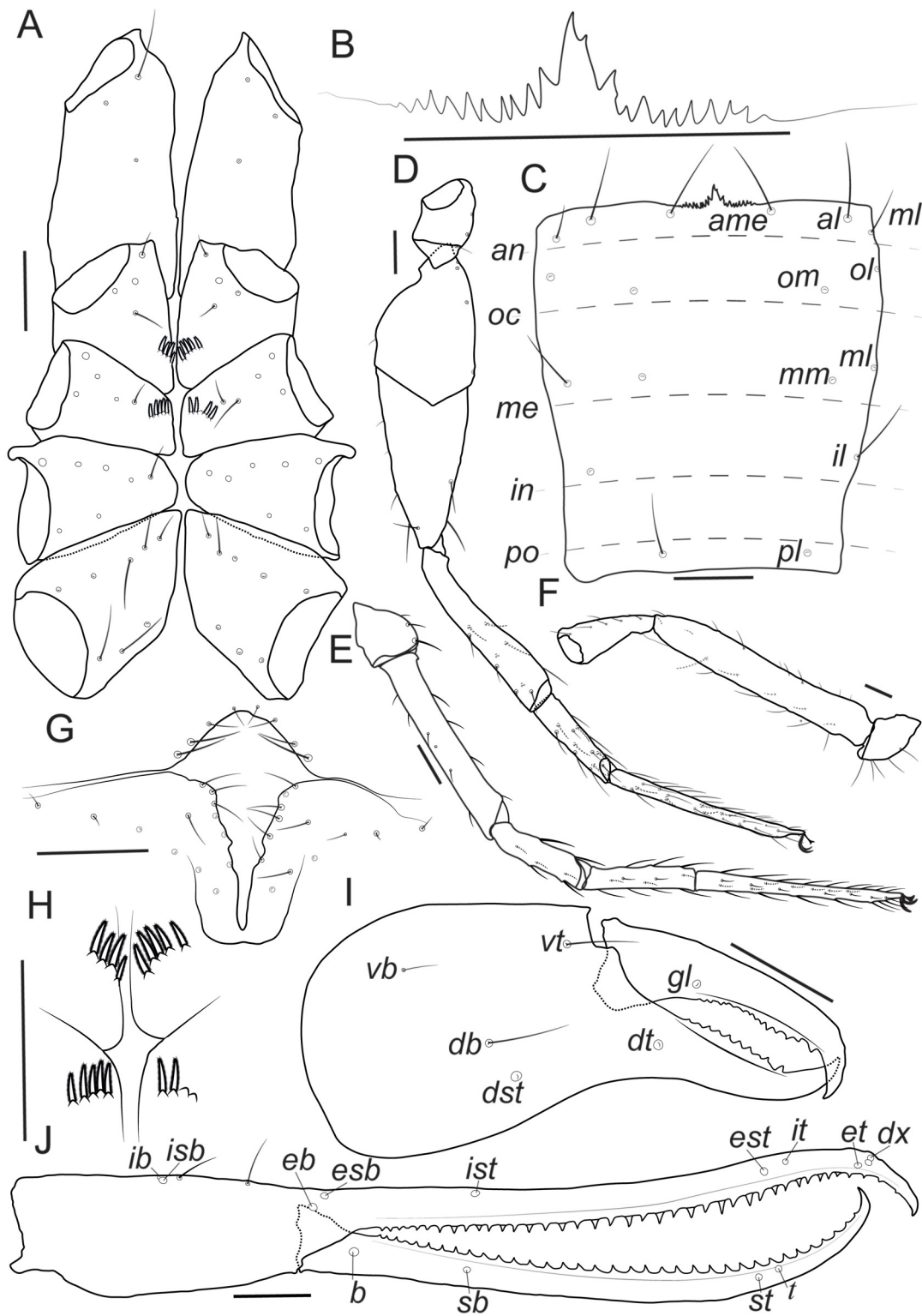
**CHELICERAE** (Fig. 7I). Hand with 5 setae; movable finger with 1 subproximal setae; galea absent. Fixed finger with 10 acute and uniform teeth, The first most distally separated; movable finger with 14 acute and irregular teeth, the first most distal one is separate, and the seven more proximal ones are smaller; rallum with 7 blades; exterior and interior serrula with 19–18 and 13 blades, respectively.

**TERGITES.** Undivided; smooth surface and with central spots between 2–4 segments of the tergite; chaetotaxy uniseriate: I–XI 4 : 4 : 4 : 4 : 6 : 6 : 6 : 6 : 6 : 3–4 : 4. Pleural membranes striated.

**COXAE** (Fig. 7A, H). Manducatory process with two apical setae; the palpal coxae with 3 setae arranged in a triangle; delicate lamellae bordered by 16 small spines. Pedal coxae: plumose coxal spines arranged in a single transverse row on coxae I 4–5 and II 4–5 (Fig. 7H); chaetotaxy: I 4, II 5, III 7, IV 8; intercoxal tubercle absent.

**MALE GENITAL OPERCULUM** (Fig. 7G). Anterior genital operculum with 8 discal setae, 12 lateral genital setae, and 14 setae along the third sternite, with 2 lateral microsetae.

**STERNITES.** Chaetotaxy IV–XI 12 : 8 : 8 : 8 : 8 : 6 : 6 : 4+2 sensory. Anal operculum with 2 ventral setae.



**Fig. 7.** *Pseudochthonius patientia* sp. nov., holotype, ♂ (ISLA 151540). **A.** Pedipalp and pedal coxae, ventral view. **B.** Detail of epistome. **C.** Carapace, dorsal view. **D.** Leg IV, antiaxial view. **E.** Leg I, antiaxial view. **F.** Pedipalp, dorsal view. **G.** Male genitalia, ventral view. **H.** Details of coxae I and II, showing the arrangement of coxal spines. **I.** Left chelicera, antiaxial view. **J.** Right chela, antiaxial view, showing the trichobothrial pattern. Scale bars: A–J = 0.1 mm.

PALP (Fig. 7F, J). Trochanter 1.65 times as wide as long, patella 2.4 times as long as wide, femur 6.8 times as long as wide. Femoral chaetotaxy 6 : 3 : 5 : 5 : 2. Trichobothrial pattern: *ib* and *isb* located halfway on the hand portion, adjacent to each other, *eb* proximal to *esb*, *ist* distal to *esb*, *it* is slightly distal to *est*, *et* proximal to *dx*; *ist* is between *esb* and *est*, closer to *esb* than to *est* (*ist-est/ist-esb* distance ratio = 2.07); chelal fixed finger with alternating heterodonty after the 4<sup>th</sup> tooth, with 40 acute, triangular teeth, with the three most distal ones smaller and separated. Movable finger with 35 acute, triangular teeth and slightly obliquely directed (Fig. 7J).

LEG IV (Fig. 7D). Arolia is slightly smaller than claws.

MEASUREMENTS HOLOTYPE, ♂. (length/width or depth in mm and ratios in parentheses calculated with three significant digits). Body length 1.713. Carapace 0.508/0.478 (1.063), palps: trochanter 0.248/0.150 (1.653), femur 0.865/0.127 (6.811), patella 0.344/0.136 (2.529), chela 1.196/0.161 (7.428), movable finger length 0.755. Chelicera 0.480/0.215 (2.232), movable finger length 0.258. Leg I: trochanter 0.171/0.128 (1.336), femur 0.473/0.069 (6.855), patella 0.252/0.064 (3.937), tibia 0.270/0.050 (5.400), tarsus 0.475/0.044 (10.795). Leg IV: trochanter 0.201/0.149 (1.35), femur/patella 0.745/0.247 (3.02), tibia 0.470/0.093 (5.05), basitarsus 0.260/0.071 (3.66), telotarsus 0.523/0.047 (11.13).

### Ecological remarks

*Pseudochthonius patientia* sp. nov. was recorded exclusively from Tabocas Cave, municipality of Malhada, Bahia State, Brazil. A detailed description of the cave has been provided previously. The single known specimen of *P. patientia* sp. nov. was collected from a deeper sector of the cave, located beyond the constriction situated in the middle portion of the system. As discussed above, it is currently not possible to determine the full distribution of this species within the cave. The same limitation applies to *P. caritas* sp. nov., which was also recorded from Tabocas Cave but in a different sector, suggesting potential spatial segregation within the cave system.

### *Pseudochthonius temperantia* sp. nov.

urn:lsid:zoobank.org:act:B7137D4E-7C70-493B-9EE8-A42F67E4F12D

Figs 2D, 8–9

### Diagnosis

*Pseudochthonius temperantia* sp. nov. most closely resembles *P. lubueno* Assis, Schimonsky, Gallão & Bichuette, 2023 based on the following combination of characters: absence of ocular apparatus; number and morphology of chelal teeth; and distance ratio *ist-est/ist-esb* = 1.8 (1.9 in *P. lubueno*). It differs from *P. lubueno* in the anterior margin of the carapace, which is serrated between the *ame* and *al* setae (in *P. lubueno*, serrated until the *ame* seta), in the number of teeth on the fixed and movable cheliceral fingers, 13 and 17, respectively (7–8 on the fixed finger and 8–9 on the movable finger in *P. lubueno*), and in the male genital chaetotaxy, with 8 discal, 12 lateral, and 12 scattered setae on the III segment (9 discal, 5 lateral, and 5 scattered setae in *P. lubueno*).

### Etymology

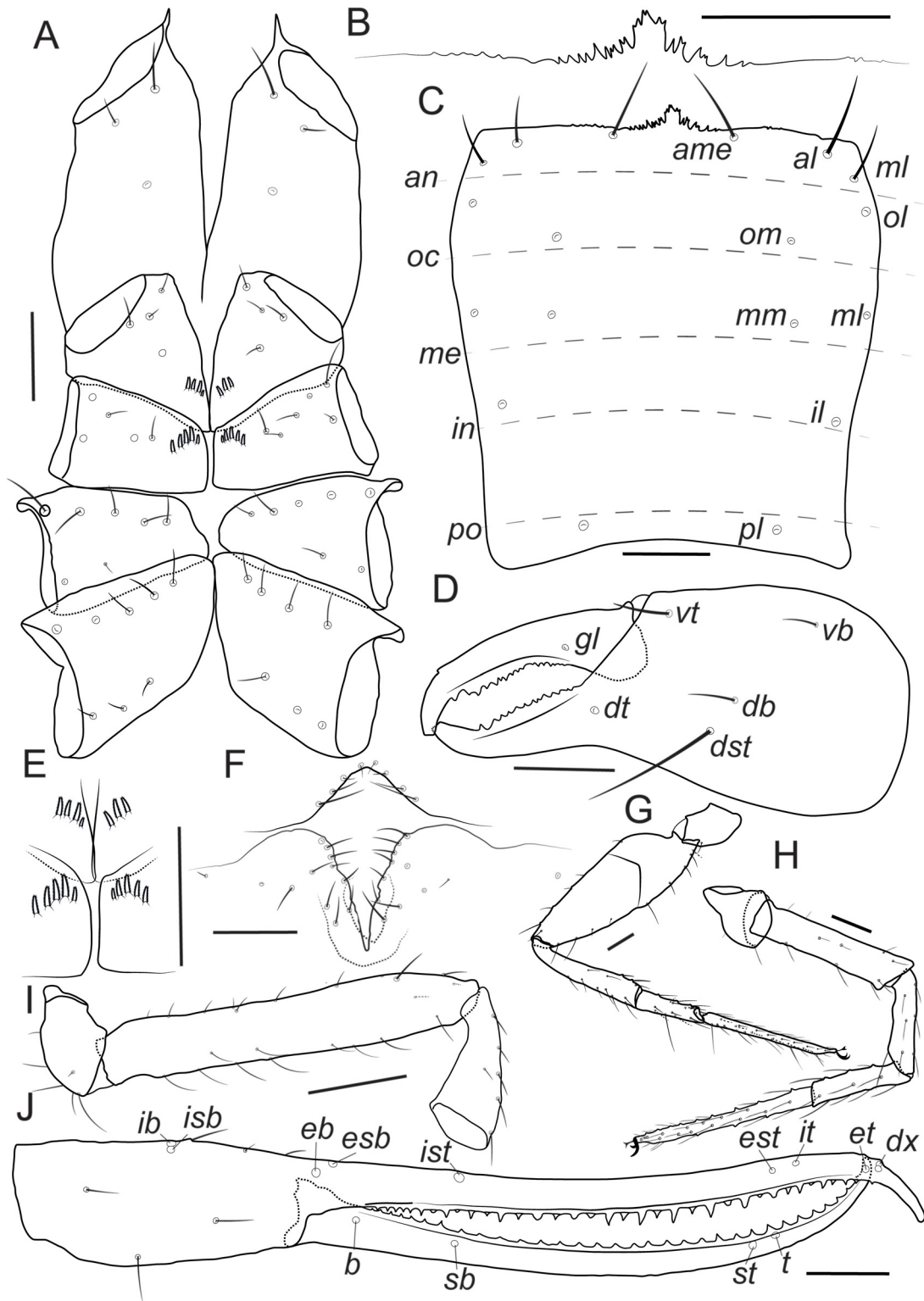
The specific epithet '*temperantia*' is derived from the Latin and means 'temperance', referring to moderation, self-restraint, and balance in conduct. The name alludes to temperance as a moral virtue associated with control and equilibrium. The species name is a noun in apposition.

### Type material

#### Holotype

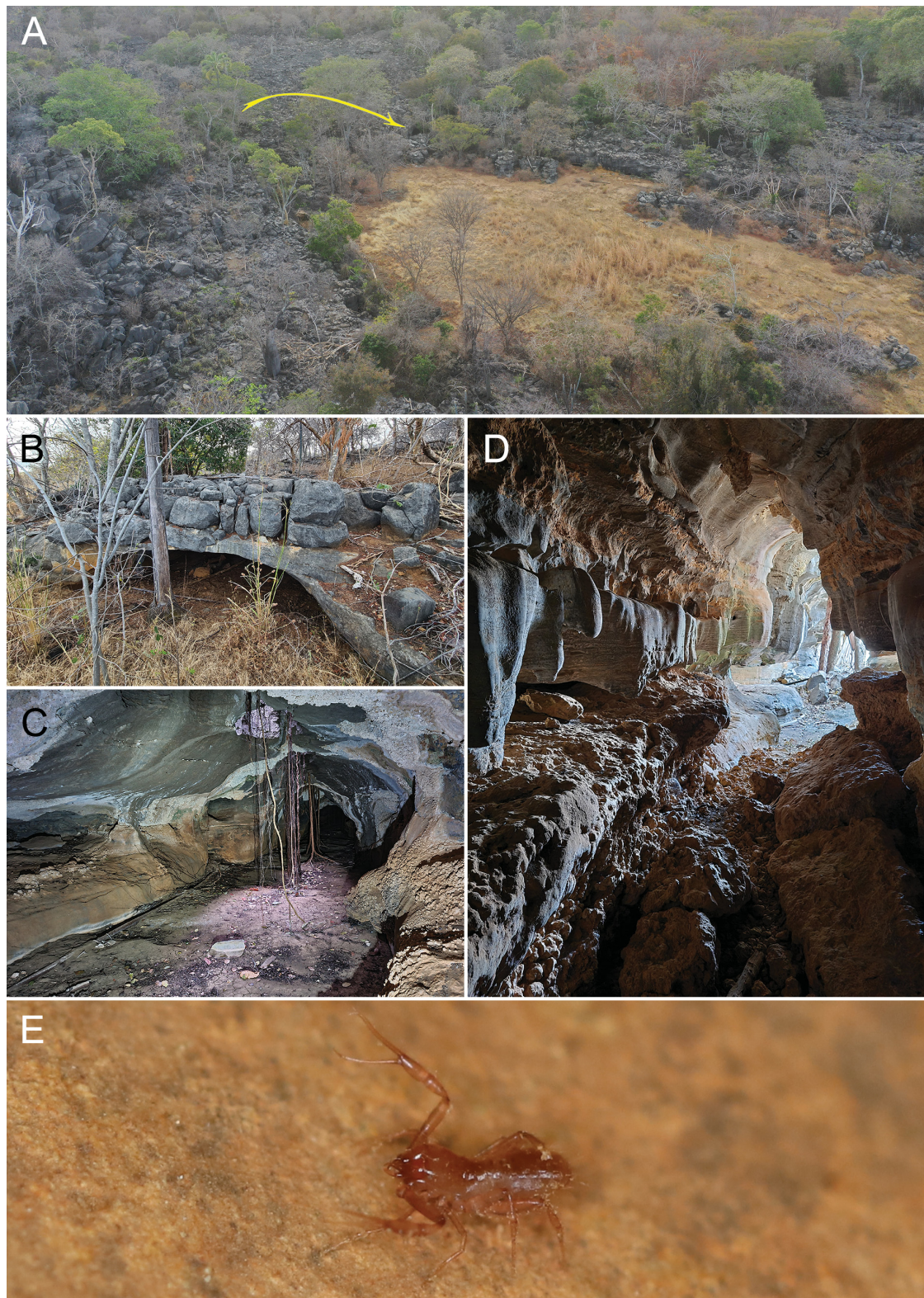
BRAZIL • ♂; Bahia State, Iuiú Municipality, Imbé Cave; 14°29'26.22" S, 43°39'11.06" W; 24 Jul. 2022; R.L. Ferreira leg.; preserved in ethanol; ISLA 151527.





**Fig. 8.** *Pseudochthonius temperantia* sp. nov., holotype, ♂ (ISLA 151527). **A.** Pedipalp and pedal coxae, ventral view. **B.** Detail of epistome. **C.** Carapace, dorsal view. **D.** Right chelicera, antiaxial view. **E.** Details of coxae I and II, showing the arrangement of coxal spines. **F.** Male genitalia, ventral view. **G.** Leg IV, antiaxial view. **H.** Leg I, antiaxial view. **I.** Pedipalp, dorsal view. **J.** Right chela, antiaxial view, showing the trichobothrial pattern. Scale bars: A–J = 0.1 mm.





**Fig. 9.** Habitat of *Pseudochthonius temperantia* sp. nov. **A.** External landscape of the karst area in the municipality of Campo Formoso. The yellow arrow indicates the cave entrance.. **B–C.** Entrance of Toca do Imbé Cave. **D.** Cave interior. **E.** Living specimen of *Pseudochthonius temperantia* sp. nov. inside the cave. Photos: Rodrigo Lopes Ferreira.



## Description

**PRESERVED SPECIMEN.** Body yellowish beige, translucent; appendices in a dark beige tone (Fig. 2D) Some parts of the body scaly. Vestitural setae thin, sharp and anteriorly projected on prosoma and posteriorly projected on opisthosoma.

**CARAPACE** (Fig. 8B–C). 1.02 times as long as wide, broad anteriorly and slightly narrowed posteriorly, with a difference between ocular width and posterior width of 0.079 mm; margin almost entirely serrate, except at the edges, from the *al* setae; epistome strongly serrate, prominent with three bifurcated apical tips, extending slightly before the *ame* setae. (Fig. 8B); ocular apparatus absent; posterior margin smooth; chaetotaxy 4+2: 4: 4: 2: 2 (18).

**CHELICERAE** (Fig. 8D). Hand with 5 setae; movable finger with 1 subdistal setae; galea present as a tubercle; fixed finger with 13 acute and uniform teeth, the first distal one separated; movable finger with 17 acute and irregular teeth, the first distal one separated; rallum with 7 blades; exterior and interior serrula with 17 and 15–16 blades, respectively.

**TERGITES.** Undivided; smooth surface; chaetotaxy uniseriate: I–XI 4: 4: 4: 6: 6: 6: 6: 6: 6: 4. Pleural membranes striated.

**COXAE** (Fig. 8A, E). Manducatory process with two apical setae; the palpal coxae with 3 setae arranged in a triangle; delicate lamellae bordered by 11 small spines. Pedal coxae: plumose coxal spines arranged in a single transverse row on coxae I (3–4) and II (5) (Fig. 8E), chaetotaxy: I–IV 4: 5(6): 7: 7(8); intercoxal tubercle absent.

**MALE GENITAL OPERCULUM** (Fig. 8F). Anterior genital operculum with 8 discal setae, 12 lateral genital setae, and 10 setae along the third sternite, with 1 lateral microsetae on each side.

**STERNITES.** Chaetotaxy IV–XI: 12: 8: 8: 8: 8: 6: 5: 4+2 sensory. Anal operculum with 2 ventral setae.

**PALP** (Fig. 8I–J). Trochanter 1.75 times as wide as long, patella 2.3 times as long as wide, femur 5.48 times as long as wide. Femoral chaetotaxy 5: 5: 4: 6: 2. Trichobothrial pattern: *ib* and *isb* located halfway on the hand portion, adjacent to each, *eb* proximal to *esb*, *ist* is distal to *esb*, *it* distal to *est*, *et* proximal to *dx*, *ist* is halfway between *esb* and *est*, closer to *esb* than *est* (*ist-est/ist-esb* distance ratio = 1.8); chelal fixed finger with alternating heterodonty after the 1<sup>st</sup> tooth, with 36 acute and continuous teeth, the distal and proximal portions with smaller teeth; movable finger with 32 acute teeth projected upwards (Fig. 8J).

**LEG IV** (Fig. 8G). Arolia is slightly smaller than claws.

**MEASUREMENTS** ♂ HOLOTYPE. (length/width or depth in mm and ratios in parentheses calculated with three significant digits). Body length 1.725. Carapace 0.505/0.495 (1.020), palps: trochanter 0.234/0.134 (1.746), femur 0.745/0.136 (5.478), patella 0.326/0.143 (2.280), chela 1.161/0.152 (7.638), movable finger length 0.719. Chelicera 0.461/0.210 (2.195), movable finger length 0.252. Leg I: trochanter 0.185/0.131 (1.412), femur 0.434/0.076 (5.710), patella 0.220/0.064 (3.437), tibia 0.252/0.049 (5.143), tarsus 0.422/0.043 (9.814). Leg IV: trochanter 0.226/0.136 (1.662), femur/patella 0.616/0.223 (2.762), tibia 0.439/0.093 (4.720), basitarsus 0.253/0.070 (3.614), telotarsus 0.478/0.038 (12.579).

## Ecological remarks

*Pseudochthonius temperantia* sp. nov. was recorded in Toca do Imbé Cave, situated at approximately 850 m a.s.l. in the central upper sector of the Serra de Iuiú limestone massif (Fig. 9A). The cave extends for about 300 m and displays a labyrinthine morphology, with multiple entrances (Fig. 9B, D) giving



access to interconnected conduits. Its interior is predominantly dry, although seasonal infiltration occurs during the rainy season, when water percolates through fractures, creating localized moist areas. Organic input into the cave is mainly derived from bat guano deposits, roots penetrating from the surface vegetation (Fig. 9C), and plant debris carried by wind, the latter more frequently accumulating near entrances.

A single specimen of *Pseudochthonius temperantia* sp. nov. (Fig. 9D) was collected in a deeper aphotic and moistened sector of the cave. Despite extensive surveys in other caves of the region, no additional specimens were found, even in nearby systems. Given its clear troglomorphic features, the species likely maintains populations across a broader subterranean environment, including mesocaverns, although its true distribution remains unknown. The limestone outcrops where Toca do Imbé is located still retain native vegetation; however, surrounding areas have been cleared and converted into pastures. The cave is only occasionally visited by local residents, and most of its inner sectors remain in a well-preserved state.

*Pseudochthonius diligentia* sp. nov.

urn:lsid:zoobank.org:act:F88EB328-CD27-46B8-A339-8D41FC7FFCFC

Figs 2E, 10–11

### Diagnosis

*Pseudochthonius diligentia* sp. nov. most closely resembles *P. biseriatus* based on the following combination of characters: absence of ocular apparatus; carapace broad anteriorly and distinctly narrowed posteriorly; distance ratio  $ist-est/ist-esb = 1.81$  ( $1.78-2.10$  in *P. biseriatus*); number and morphology of chelal teeth. It differs from *P. biseriatus* in the number of teeth on the movable cheliceral finger, 15 ( $8-10$  in *P. biseriatus*); in the number of blades in the rallum, 7 (9 in *P. biseriatus*); in the chaetotaxy of coxae I–IV 4:4–5:6–7:8–7 (I–IV 5:5:7–8:8 in *P. biseriatus*).

### Etymology

The specific epithet '*diligentia*' is derived from the Latin and means 'diligence' referring to carefulness, persistence, and attentive effort. The name alludes to diligence as a moral virtue associated with sustained effort and conscientious conduct. The species name is a noun in apposition.

### Type material

#### Holotype

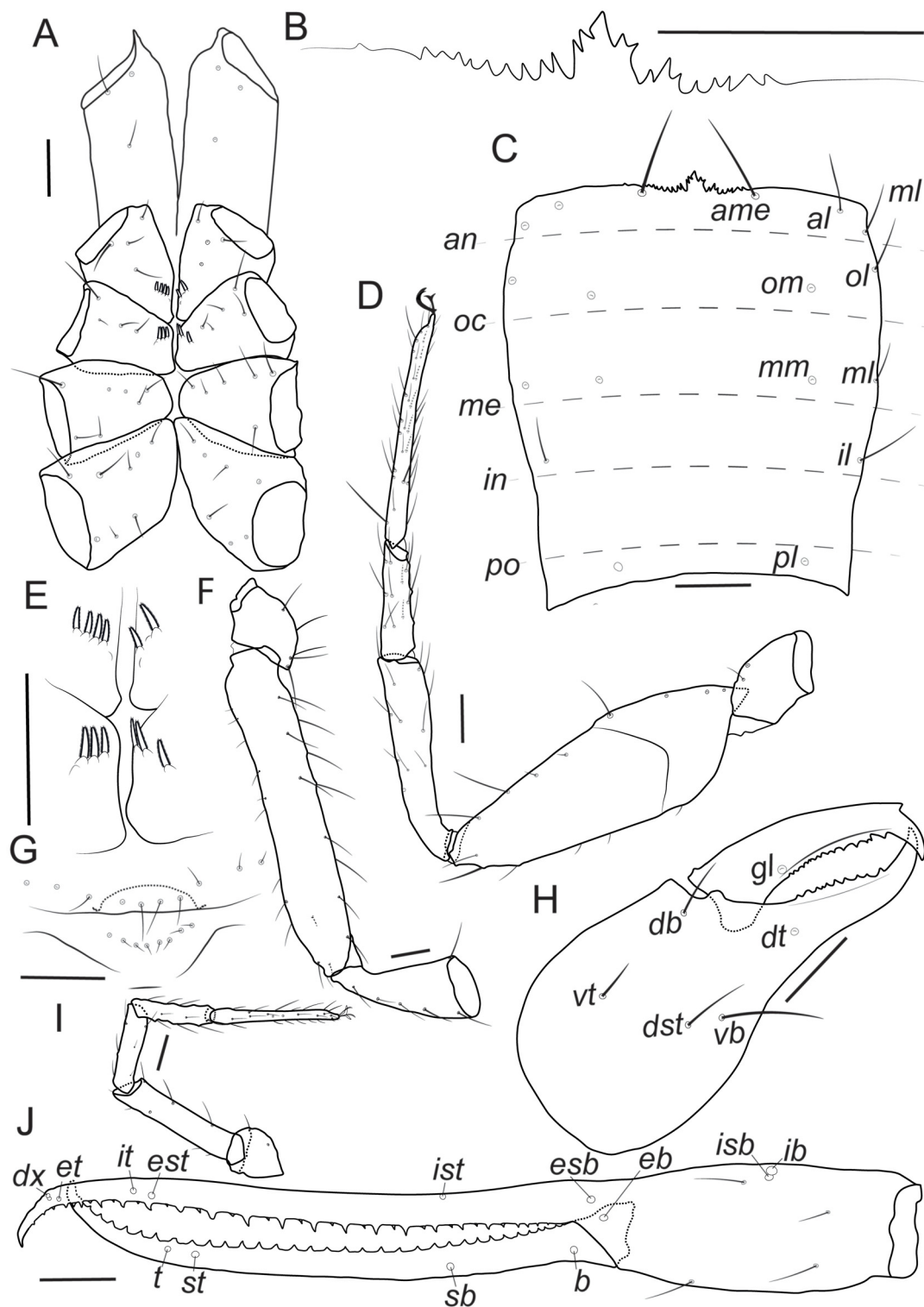
BRAZIL • ♀; Bahia State, Iuiú Municipality, Olho d'Água do Aylton Cave;  $14^{\circ}27'4.08''$  S,  $43^{\circ}34'31.45''$  W; 26 Jul. 2022; R.L. Ferreira leg.; preserved in ethanol; ISLA 151528.

### Description

PRESERVED SPECIMEN. Body dark orange-beige, translucent; appendages in a darker shade. (Fig. 2E) Some parts of the body scaly. Vestitural setae thin, sharp and anteriorly projected on prosoma and posteriorly projected on opisthosoma.

CARAPACE (Fig. 10B–C). 1.05 times as long as wide broad anteriorly and distinctly narrowed posteriorly, with a difference between ocular width and posterior width of 0.097 mm; smooth anterior margin, except in the central portion; epistome prominent and serrated with five apical tips, slightly extending beyond the *ame* seta. (Fig. 10B); ocular apparatus absence; posterior margin smooth. Chaetotaxy 4+2: 4: 4: 2: 2 (18).

CHELICERAE (Fig. 10H). Hand with 5 setae; movable finger with 1 subdistal setae; galea present, prominent, as a large tubercle; fixed finger with 10 acute teeth, the 7 proximal teeth are smaller, the first distal one separated; movable finger with 15 acute teeth, except for the two last proximal teeth, which



**Fig. 10.** *Pseudochthonius diligentia* sp. nov., holotype, ♀ (ISLA 151528). **A.** Pedipalp and pedal coxae, ventral view. **B.** Detail of epistome. **C.** Carapace, dorsal view. **D.** Leg IV, antiaxial view. **E.** Details of coxae I and II, showing the arrangement of coxal spines. **F.** Pedipalp, dorsal view. **G.** Female genitalia, ventral view. **H.** Right chelicera, antiaxial view. **I.** Leg I, antiaxial view. **J.** Right chela, antiaxial view, showing the trichobothrial pattern. Scale bars: A–J = 0.1 mm.

are rounded; the first distal one is separated; rallum with 7 blades; exterior and interior serrula with 20 and 15 blades, respectively.

TERGITES. Undivided; smooth surface; chaetotaxy uniseriate: I–XI 4: 4: 4: 4: 4: 6: 6: 6: 6: 4: 4. Pleural membranes striated.

COXAE (Fig. 10A, E). Manducatory process with two apical setae; the palpal coxae with 3 setae arranged in a triangle; delicate lamellae bordered by 19 small spines. Pedal coxae: plumose coxal spines arranged in a single transverse row on coxae I (4–5) and II (3–4) (Fig. 10E). Chaetotaxy: I–IV 4: 4(5): 6(7): 8(7). Intercoxal tubercle absent.

FEMALE GENITAL OPERCULUM (Fig. 10G). Chaetotaxy 8:10 on sternites II and III, respectively. Genital opening not bifurcated.

STERNITES. Chaetotaxy IV–XI 6: 6: 6: 8: 8: 8: 6: 6: 4+2 sensory. Anal operculum with 2 ventral setae.

PALP (Fig. 10F, J). Trochanter 1.61 times as wide as long, patella 2.44 times as long as wide, femur 5.64 times as long as wide. Femoral chaetotaxy 5: 6: 6: 5: 2. Trichobothrial pattern: *ib* and *isb* located halfway on the hand portion, adjacent to each other and slightly displaced towards the paraxial face of the chela, *eb* proximal to *esb*, *ist* is slightly distal to *esb*, *it* distal to *est*, *et* proximal to *dx*; *ist* is halfway between *esb* and *est*, closer to *esb* than *est* (*ist-est/ist-esb* distance ratio = 1.81); Chelal fixed finger with alternating heterodonty after the 2<sup>nd</sup> tooth, with 39 acute teeth, the two distal teeth are separated. Movable finger with 33 acute teeth projected upwards.

LEG IV (Fig. 10D). Arolia is slightly smaller than claws.

MEASUREMENTS HOLOTYPE, ♀. (length/width or depth in mm and ratios in parentheses calculated with three significant digits). Body length 1.880. Carapace 0.558/0.532 (1.049), palps: trochanter 0.268/0.166 (1.614), femur 0.885/0.157 (5.637), patella 0.378/0.155 (2.439), chela 1.252/0.180 (6.956), movable finger length 0.799. Chelicera 0.533/0.236 (2.258), movable finger length 0.284. Leg I: trochanter 0.186/0.132 (1.409), femur 0.474/0.078 (6.077), patella 0.233/0.070 (3.328), tibia 0.270/0.052 (5.192), tarsus 0.471/0.048 (9.812). Leg IV: trochanter 0.191/0.147 (1.299), femur/patella 0.766/0.247 (3.101), tibia 0.469/0.095 (4.937), basitarsus 0.262/0.072 (3.634), telotarsus 0.498/0.044 (11.318).

### Ecological remarks

*Pseudochthonius diligentia* sp. nov. was recorded exclusively in Olho d'água do Aylton Cave, municipality of Iuiú, Bahia State, Brazil. The cave has a single small entrance that leads into a short conduit, crossed by a drainage that originates from a resurgence in the innermost sector (Fig. 11B) and flows toward the entrance. The entire system is relatively small, extending approximately 40 m from the entrance to the deepest portion. Because the drainage occupies most of the cave floor, suitable terrestrial habitats are restricted to sediment banks along the stream and to some elevated areas, often associated with speleothem formations. *P. diligentia* sp. nov. was collected beneath a rock in an elevated sector rich in speleothems, located in the innermost portion of the cave.

Due to its narrow entrance, the cave is not visited, even by local residents, and the interior remains in a highly preserved condition. In contrast, the external environment is severely degraded, with extensive deforestation and large areas of exposed soil (Fig. 11A). Only a few neighboring caves have been surveyed, and no additional specimens of *P. diligentia* sp. nov. were recorded. It is noteworthy that most caves in the surrounding area are markedly dry. As *P. diligentia* sp. nov. is trogllobitic, the presence of a perennial drainage in Gruta do Aylton may be critical for its persistence, suggesting that the species could be endemic to this particular habitat.





**Fig. 11.** Habitat of *Pseudochthonius diligentia* sp. nov. **A.** External landscape of the karst area surrounding the cave. **B.** Cave interior. Photos: Rodrigo Lopes Ferreira.



*Pseudochthonius castitas* sp. nov.

urn:lsid:zoobank.org:act:17931ACD-1C5C-459D-8413-495388B75D73

Figs 2F, 12–13

### Diagnosis

*Pseudochthonius castitas* sp. nov. most closely resembles *P. aware* Prado & Ferreira, 2024 based on the following combination of characters: absence of ocular apparatus; anterior margin of the carapace serrated; number of teeth on the fixed (40) and movable (43) chelal fingers (with slight variation in *P. aware*, fixed finger with 35–38 teeth and movable finger with 36–40 teeth); and dentition of the fixed cheliceral finger. It differs from *P. aware* in having a carapace with a rectangular aspect (ocular–posterior width difference = 0.062 mm) (in *P. aware*, carapace broad anteriorly and distinctly narrowed posteriorly, difference = 0.12–0.13 mm); with heterodonty in the fixed chelal finger starting from the 6<sup>th</sup> tooth (in *P. aware*, heterodonty present from the 10<sup>th</sup> tooth); movable chelal finger more strongly curved (less curved in *P. aware*); in the distance ratio  $ist-est/ist-esb = 2.8$  (2.34–2.61 in *P. aware*), and in the female genital operculum.

### Etymology

The specific epithet '*castitas*' is derived from the Latin and means 'chastity' referring to purity, restraint, and moral integrity. The name alludes to chastity as a moral virtue associated with self-control and discipline. The species name is a noun in apposition.

### Type material

#### Holotype

BRAZIL • ♀; Bahia State, Iuiú Municipality, Baixão Cave; 14°26'8.46" S, 43°37'27.66" W; 8 Jun. 2010; R.L. Ferreira leg.; preserved in ethanol; ISLA 151539.

### Description

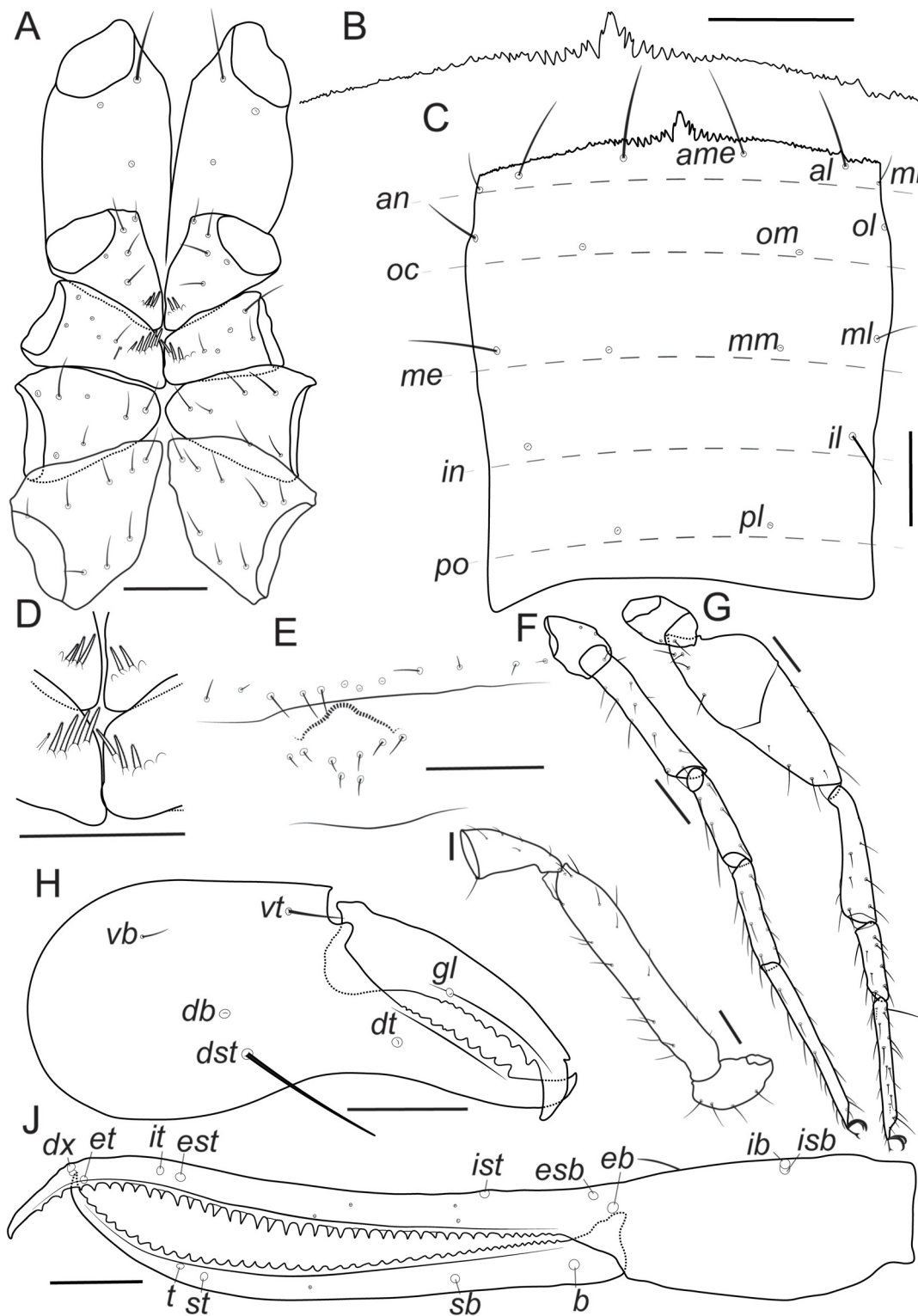
PRESERVED SPECIMEN. Body and appendices opaque beige, translucent (Fig. 2F). Some parts of the body scaly. Vestitural setae thin, sharp and anteriorly projected on prosoma and posteriorly projected on opisthosoma.

CARAPACE (Fig. 12B–C). 1.12 times as long as wide, posteriorly constricted, showing a difference between ocular width and posterior width of 0.062 mm, resulting in a rectangular-shaped; anterior margin completely serrated; prominent epistome with 1 bifurcated tip (Fig. 12B); ocular apparatus absent; posterior margin of the carapace smooth; chaetotaxy 4+2 : 4 : 4 : 2 : 2 (18).

CHELICERAE (Fig. 12H). Hand with 5 setae; movable finger with 1 subdistal setae; galea present as a tubercle; fixed finger with 11 teeth, the four proximal teeth are rounded and the seven distal ones acute, the sixth tooth considerably smaller. Movable finger with 9 acute and uniform teeth, the first tooth in distal portion is slightly separated, and the five proximal ones are smaller; rallum with 7 blades; exterior and interior serrula with 14–15 and 12–13 blades, respectively.

TERGITES. Undivided; smooth surface; chaetotaxy uniseriate: I–XI 4 : 4 : 4 : 4 : 4 : 6 : 6 : 6 : 6(7) : 6 : 4. Pleural membranes striated.

COXAE (Fig. 12A, D). Manducatory process with two apical setae; the palpal coxae with 3 setae arranged in a triangle; delicate lamellae bordered by 10 small spines. Pedal coxae: plumose coxal spines arranged in a single transverse row on coxae I (4) and II (5) (Fig. 12D). Chaetotaxy: I–IV 5 : 5 : 6(7) : 8; intercoxal tubercle absent.



**Fig. 12.** *Pseudochthonius castitas* sp. nov., holotype, ♀ (ISLA 151539). **A.** Pedipalp and pedal coxae, ventral view. **B.** Detail of epistome. **C.** Carapace, dorsal view. **D.** Details of coxae I and II, showing the arrangement of coxal spines. **E.** Female genitalia, ventral view. **F.** Leg I, antiaxial view. **G.** Leg IV, antiaxial view. **H.** Left chelicera, antiaxial view. **I.** Pedipalp, dorsal view. **J.** Left chela, antiaxial view, showing the trichobothrial pattern. Scale bars: A–E = 0.1 mm; F = 0.05 mm; G–J = 0.1 mm.



FEMALE GENITAL OPERCULUM (Fig. 12E). Chaetotaxy: 8:12 on sternites II and III, respectively. Genital opening not bifurcated.

STERNITES. Chaetotaxy IV–XI 14: 8: 9(10): 9(10): 8: 6: 6: 4+2 sensory. Anal operculum with 2 ventral setae.

PALP (Fig. 12I–J). Trochanter 1.39 times as wide as long, patella 2.22 times as long as wide, femur 5.76 times as long as wide. Femoral chaetotaxy 4: 6: 4: 6: 1. Trichobothrial pattern: *ib* and *isb* located halfway on the hand portion, adjacent to each other, *eb* proximal to *esb*, *ist* is slightly distal to *esb*, *it* distal to *est*, *et* proximal to *dx*; *ist* is halfway between *esb* and *est*, closer to *esb* than *est* (*ist-est/ist-esb* distance ratio = 2.8); chelal fixed finger with alternating heterodonty after the 6<sup>th</sup> tooth, with 40 acute teeth, the five proximal teeth are rounded, the two distal ones separated and smaller. except in the medial portion, where they are directed upwards. Movable finger with 43 acute teeth projected upwards, teeth smaller in the proximal portion.

LEG IV (Fig. 12G). Arolia is slightly smaller than claws.

MEASUREMENTS HOLOTYPE, ♀. (Length/width or depth in mm and ratios in parentheses calculated with three significant digits). Body length 1.475. Carapace 0.527/0.470 (1.12), palps: trochanter 0.143/0.103 (1.39), femur 0.726/0.126 (5.76), patella 0.300/0.135 (2.22), chela 1.016/0.159 (6.39), movable finger length 0.646. Chelicera 0.453/0.208 (2.18), movable finger length 0.255. Leg I: trochanter 0.132/0.088 (1.5), femur 0.359/0.070 (5.13), patella 0.185/0.052 (3.56), tibia 0.207/0.042 (4.93), tarsus 0.335/0.036 (9.31). Leg IV: trochanter 0.199/0.119 (1.67), femur/patella 0.551/0.208 (2.65), tibia 0.342/0.080 (4.275), basitarsus 0.188/0.058 (3.24), telotarsus 0.308/0.034 (9.06).

### Ecological remarks

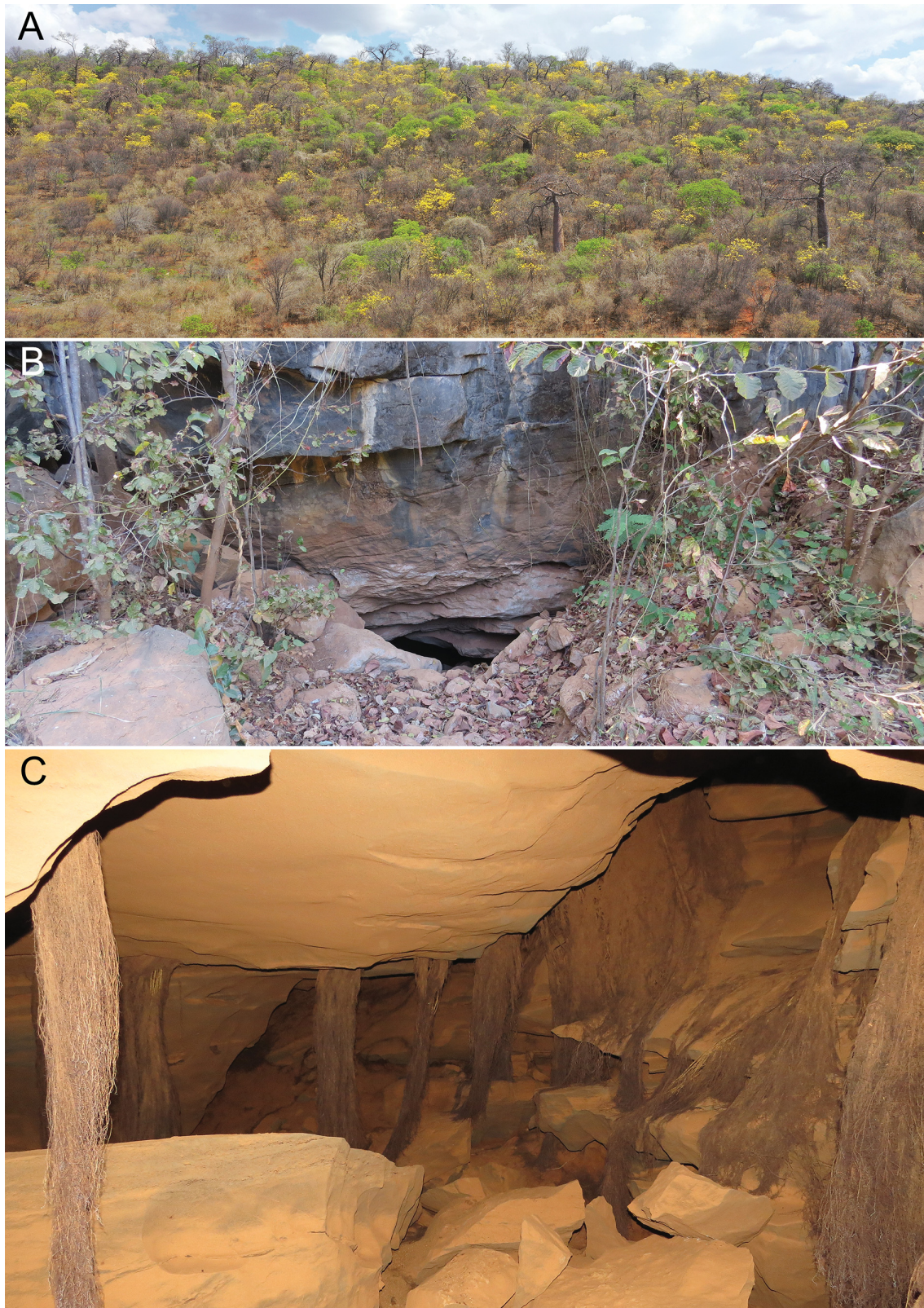
*Pseudochthonius castitas* sp. nov. was recorded exclusively in Lapa do Baixo Cave, located on the northern portion of the main outcrop of the Serra do Iuiú, municipality of Iuiú, Bahia State, Brazil. The cave has a single entrance (Fig. 13B) leading to a labyrinthine sector, from which a narrow passage provide access to the innermost conduit. This deeper section remains humid throughout the year and constitutes the primary microhabitat where the species was observed.

The cave is subject to seasonal groundwater fluctuations, as indicated by water stains of varying heights on the walls. During heavy rainfall, the entire system may become flooded, preventing access except by diving. This hydrological regime imposes strong seasonal variation in available habitats, with large conduits remaining submerged for extended periods. Despite these conditions, *Pseudochthonius castitas* sp. nov. was observed walking on muddy substrates in the innermost humid zones during dry period, on the cave floor, where shelters are scarce. Its persistence in such unstable conditions suggests an ability to migrate vertically to upper subterranean habitats during floods, indicating a potential distribution broader than the limits of Lapa do Baixo itself. However, the presence of several other *Pseudochthonius* species in the region may eventually constrain its colonization of adjacent caves.

Abundant plant roots penetrate the cave (Fig. 13C) and provide a major source of organic input for the hypogean fauna. Although some deforestation occurs in the surroundings, the hill where the entrance is located remains relatively well preserved (Fig. 13A), ensuring the maintenance of root mats as a key trophic resource.

Lapa do Baixo Cave is also the type locality of several other cave-restricted taxa, including *Iuiuniscus iuiensis* (Souza *et al.* 2015), *Spelaeobochica iuiu* (Ratton *et al.* 2012), *Iuiuia caeca* (Hoch & Ferreira 2016), and *Troglorhopalurus iuiu* (Carvalho *et al.* 2025). The discovery of *Pseudochthonius castitas* sp. nov. further highlights the exceptional biological importance of this cave and its role as a hotspot of subterranean diversity in the Serra do Iuiú karst.





**Fig. 13.** Habitat of *Pseudochthonius castitas* sp. nov. **A.** Outcrop where Gruta do Baixão Cave is located, showing the surrounding external landscape. **B.** Entrance of Gruta do Baixão Cave. **C.** Cave conduit. Photos: Rodrigo Lopes Ferreira.



*Pseudochthonius humilitas* sp. nov.

urn:lsid:zoobank.org:act:F899CD39-16A1-4D32-9020-2112A2D25518

Figs 2G, 14–15

**Diagnosis**

*Pseudochthonius humilitas* sp. nov. most closely resembles *P. gracilimanus* Mahnert, 2001 based on the number and morphology of cheliceral teeth. It differs from *P. gracilimanus* by the absence of the ocular apparatus (two weak eyes present in *P. gracilimanus*), by the anterior margin of the carapace serrated between the *ame* and *al* setae (in *P. gracilimanus*, serrated only between the *ame* setae), and by the shape of the epistome, which is prominent (smaller in *P. gracilimanus*). Additionally, *P. humilitas* also resembles *P. caritas* sp. nov., from which it differs in the number of teeth on the fixed chelal finger, 29 (34–35 in *P. caritas*), in the femoro-palpal chaetotaxy, 6–3–6–5–1 (4–6–4–6–1 in *P. caritas*), in the number of teeth on the fixed cheliceral finger, 8 (11–12 in *P. caritas*), in the absence of the galea in the male (present in both sexes in *P. caritas*), in the male genital opening, which is wider (narrower in *P. caritas*), and in the chaetotaxy of the male genital operculum, with 8 discal, 10 lateral, and 10 scattered setae on the segment (7 discal, 12 lateral, and 13 scattered setae in *P. caritas*).

**Etymology**

The specific epithet '*humilitas*' is derived from the Latin and means 'humility' referring to modesty, restraint, and the absence of pride. The name alludes to humility as a moral virtue associated with simplicity and self-effacement. The species name is a noun in apposition.

**Type material**

**Holotype**

BRAZIL • ♂; Bahia State, Malhada Municipality, Tapera d'Água Cave; 14°30'59.84" S, 43°40'57.60" W; 18 Oct. 2021; R.L. Ferreira leg.; preserved in ethanol; ISLA 151536.

**Paratype**

BRAZIL • 1 ♀; same data as for holotype; ISLA 151537.

**Description**

PRESERVED SPECIMEN. Body and appendages yellowish beige, translucent (Fig. 2G). Some parts of the body scaly. Vestitural setae thin, sharp and anteriorly projected on prosoma and posteriorly projected on opisthosoma.

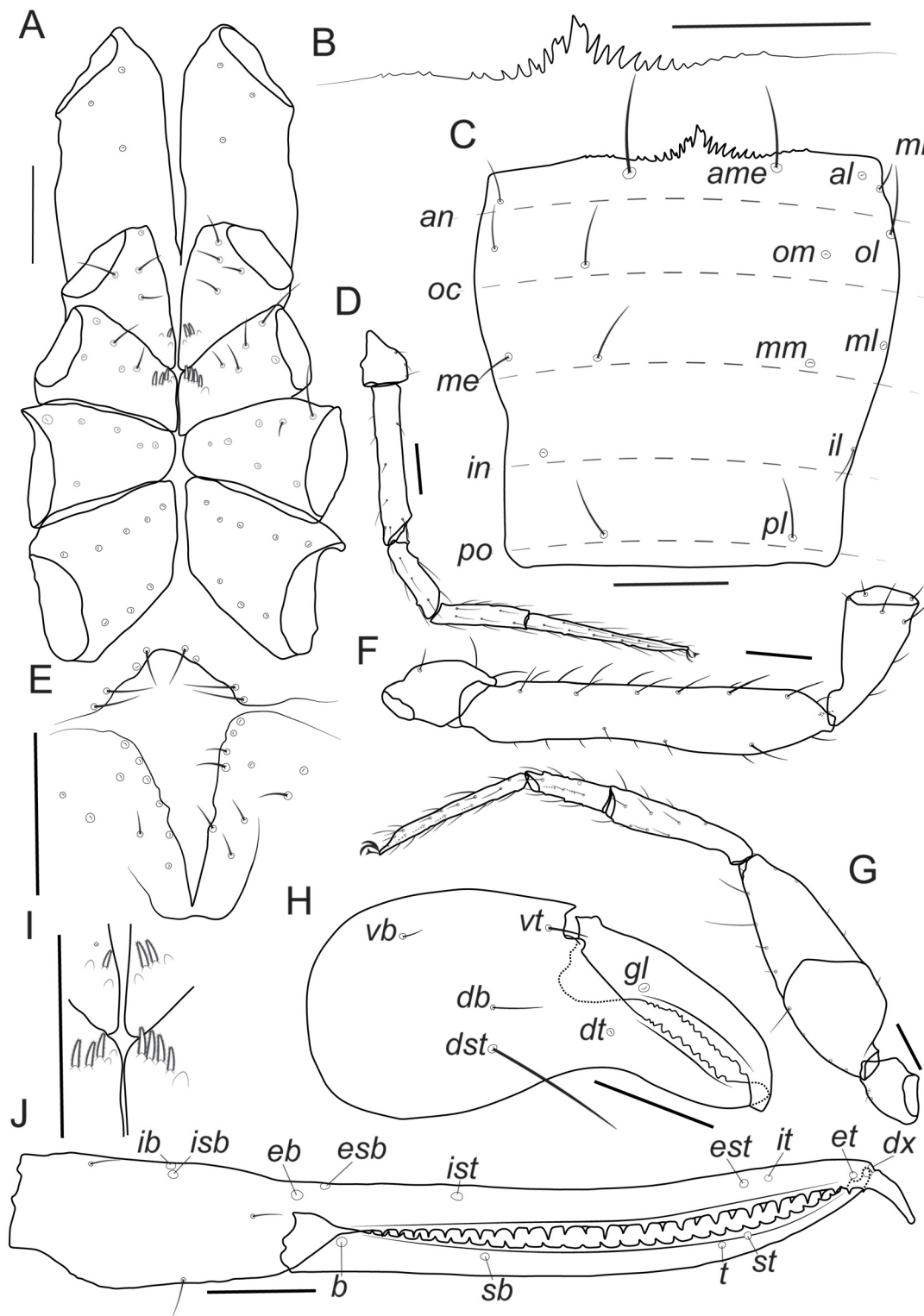
CARAPACE (Fig. 14B–C). 0.97 times as long as wide, broad anteriorly and distinctly narrowed posteriorly, with a difference between ocular width and posterior width of 0.103 mm; smooth anterior margin, except in the central portion; epistome strongly toothed, prominent with two apical tips, extending beyond the *ame* setae (Fig. 14B); ocular apparatus absent; posterior margin smooth; chaetotaxy 4+2: 4: 4: 2: 2 (18).

CHELICERAE (Fig. 14H). Hand with 5 setae; movable finger with 1 subdistal setae; galea absent; fixed finger with 8 acute and continuous teeth, the two proximal smaller; movable finger with 13 irregular and rounded teeth at the apex; in the distal portion, the first tooth is separated; rallum with 7 blades; exterior and interior serrula with 16 and 10 blades, respectively.

TERGITES. Undivided; smooth surface; chaetotaxy uniseriate: I–XI 4: 4: 4: 4: 6: 6: 6: 6: 6: 4: 4. Pleural membranes striated.

COXAE (Fig. 14A, I). Manducatory process with two apical setae; the palpal coxae with 3 setae arranged in a triangle; delicate lamellae bordered by 10 small spines. Pedal coxae: plumose coxal spines arranged





**Fig. 14.** *Pseudochthonius humilitas* sp. nov., holotype, ♂ (ISLA 151536). **A.** Pedipalp and pedal coxae, ventral view. **B.** Detail of epistome. **C.** Carapace, dorsal view. **D.** Leg I, antiaxial view. **E.** Male genitalia, ventral view. **F.** Pedipalp, dorsal view. **G.** Leg IV, antiaxial view. **H.** Left chelicera, antiaxial view. **I.** Details of coxae I and II, showing the arrangement of coxal spines. **J.** Left chela, antiaxial view, showing the trichobothrial pattern. Scale bars: A–J = 0.1 mm.

in a single transverse row on coxae I 3–4 and II 5 (Fig. 14I), chaetotaxy: I–IV 4: 5: 6–7: 8; intercoxal tubercle absent.

MALE GENITAL OPERCULUM (Fig. 14E). Anterior genital operculum with 8 discal setae, 10 lateral genital setae, and 10 setae along the third sternite.

STERNITES. Chaetotaxy IV–XI 8: 10: 8: 10: 6: 6: 6: 4+2 sensory. Anal operculum with 2 ventral setae.

PALP (Fig. 14F, J). Trochanter 1.56 times as wide as long, patella 1.56 times as long as wide, femur 5.39 times as long as wide. Femoral chaetotaxy 6: 3: 6: 5: 1. Trichobothrial pattern: *ib* and *isb* located halfway on the hand portion, *isb* slightly distal to *ib*, *eb* proximal to *esb*, *ist* is distal to *esb*, *it* slightly distal to *est*, *et* proximal to *dx*; *ist* is halfway between *esb* and *est*, closer to *esb* than *est* (*ist-est/ist-esb* distance ratio = 1.46). Chelal fixed finger with alternating heterodonty after the 3<sup>rd</sup> tooth, with 29 acute and continuous teeth; movable finger with 28 acute and projecting upwards teeth.

LEG IV (Fig. 14G). Arolia is slightly smaller than claws.

MEASUREMENTS HOLOTYPE, ♂. (length/width or depth in mm and ratios in parentheses calculated with three significant digits). Body length 1.220–1.250. Carapace 0.394–0.339/0.406–0.345 (0.970–0.983), palps: trochanter 0.190–0.152/0.122–0.097 (1.557–1.567), femur 0.588–0.505/0.109–0.102 (5.394–4.951), patella 0.190–0.179/0.122–0.100 (1.557–1.790), chela 0.842–0.716/0.123–0.114 (6.845–6.281), movable finger length 0.551–0.481. Chelicera 0.376–0.295/0.174–0.146 (2.161–2.020), movable finger length 0.204–0.158. Leg I: trochanter 0.128/0.081 (1.580), femur 0.327–0.273/0.060–0.051 (5.450–5.353), patella 0.164–0.129/0.049–0.044 (3.347–2.932), tibia 0.151–0.164/0.042–0.039 (3.595–4.205), tarsus 0.271–0.277/0.033–0.032 (8.212–8.656). Leg IV: trochanter 0.155–0.148/0.106–0.107 (1.462–1.383), femur/patella 0.401–0.451/0.196–0.189 (2.046–2.386), tibia 0.285–0.295/0.071–0.069 (4.014–4.275), basitarsus 0.184–0.165/0.050–0.048 (3.680–3.437), telotarsus 0.294–0.278/0.032–0.031 (9.187–8.968).

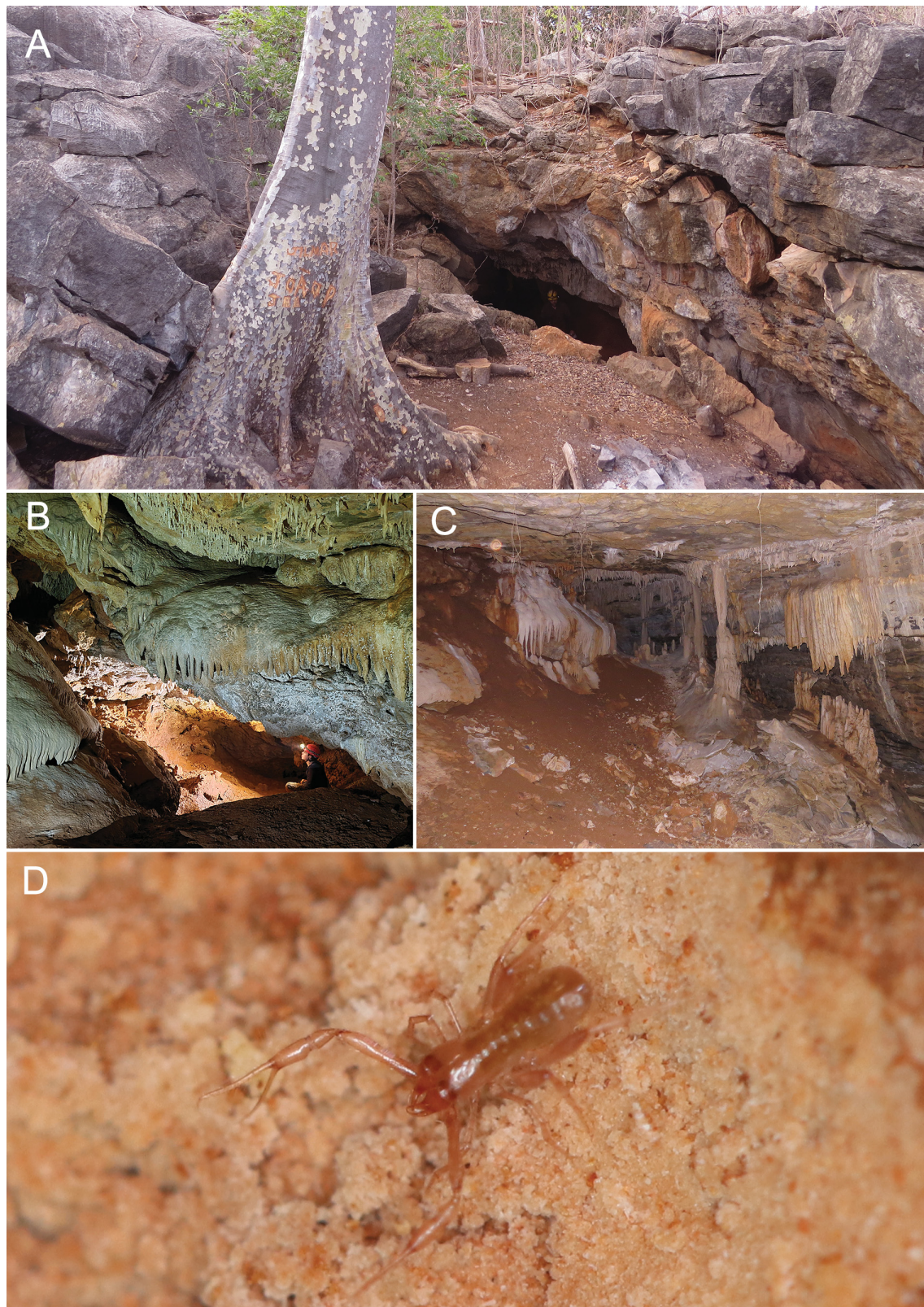
### Ecological remarks

*Pseudochthonius humilitas* sp. nov. was recorded exclusively in Tapera D'Água Cave, Malhada Municipality, Bahia State, Brazil. The cave has a single entrance (Fig. 15A) that leads to an initial chamber crossed by a small underground stream. This drainage originates from a resurgence at the end of the chamber and flows toward the entrance, disappearing into a nearby sinkhole without becoming epigeal. From this chamber, an upper conduit provides access to the innermost sectors of the cave. Passage through this conduit is marked by a noticeable shift in microclimatic conditions, with the cave interior becoming warmer and more humid, although temperature and humidity were not quantitatively measured.

A second chamber (Fig. 15B) is reached through this conduit, and it is at this point that *Pseudochthonius humilitas* sp. nov. was observed (Fig. 15D). The specimen was associated with moist substrates, freely walking on the floor. Although some dry areas exist in elevated portions of the inner cave (Fig. 15C), no individuals were recorded there. During the rainy season, the water level of the drainage rose considerably, submerging most of the moist substrates where the specimen had been found during the dry season. This fact suggests that the population may migrate to upper sectors of the cave, possibly inaccessible to human collectors, during flooding events.

Tapera D'Água Cave also harbors *Spelaeobochica iuiu*, another cave-restricted pseudoscorpion. Given the pronounced difference in body size, direct competition between the two pseudoscorpions is unlikely, as they presumably prey upon invertebrates of different sizes. Other troglotic species known from this cave include the spider *Loxosceles troglobia* Souza & Ferreira, 2018, and the planthopper *Iuiuia caeca* Hoch & Ferreira, 2016.





**Fig. 15.** Habitat of *Pseudochthonius humilitas* sp. nov. **A.** Entrance of Tapera d'Água Cave. **B–C.** Cave interior. **D.** Living specimen of *Pseudochthonius humilitas* sp. nov. inside the cave. Photos: Rodrigo Lopes Ferreira.



Although the surroundings of the cave have experienced past human use, including logging and water extraction, these activities ceased decades ago. Today, only remnants of unpaved roads are visible, and the difficult access prevents visitation even by local residents. As a result, the cave remains in good conservation condition.

*Pseudochthonius benignitas* sp. nov.

urn:lsid:zoobank.org:act:4E830445-E87D-4FCA-9E54-200764ADE7C4

Figs 2H, 16–17

**Diagnosis**

*Pseudochthonius benignitas* sp. nov. most closely resembles *P. maquinensis* Guimarães, Prado & Ferreira, 2025 based on the carapace broad anteriorly and distinctly narrowed posteriorly, the anterior margin of the carapace serrated until the *ame* seta, and the number of chelal teeth. It differs from *P. maquinensis* by the presence of eyespots (absent in *P. maquinensis*), by the distance ratio  $ist-est/ist-esb = 0.6$  (2.6 in *P. maquinensis*), and by the number of teeth on the fixed cheliceral finger, 7 (10–12 in *P. maquinensis*). Additionally, *P. benignitas* also resembles *P. celestialis* sp. nov., from which it differs in having a carapace broad anteriorly and slightly narrowed posteriorly (rectangular-shaped in *P. celestialis*), in the distance ratio  $ist-est/ist-esb = 0.6$  (2.0 in *P. celestialis*), in the presence of a single isolated tooth in the distal region of the chela (two smaller, separated distal teeth in *P. celestialis* sp. nov.), in the male genital opening, which is wider (narrower in *P. celestialis*), and in the male genital chaetotaxy, with 8 discal, 12 lateral, and 5 scattered setae on the segment (8 discal, 10 lateral, and 10 scattered setae in *P. celestialis*).

**Etymology**

The specific epithet '*benignitas*' is derived from the Latin and means 'kindness' or 'goodness' referring to benevolence, gentleness, and goodwill. The name alludes to benignity as a moral virtue associated with compassionate and favorable disposition. The species name is a noun in apposition.

**Type material**

**Holotype**

BRAZIL • ♂; Bahia State, Iuiú Municipality, Toca do Belarmino Cave; 14°28'5.38" S, 43°39'5.19" W; 20 Oct. 2021; R.L. Ferreira leg.; preserved in ethanol; ISLA 151538.

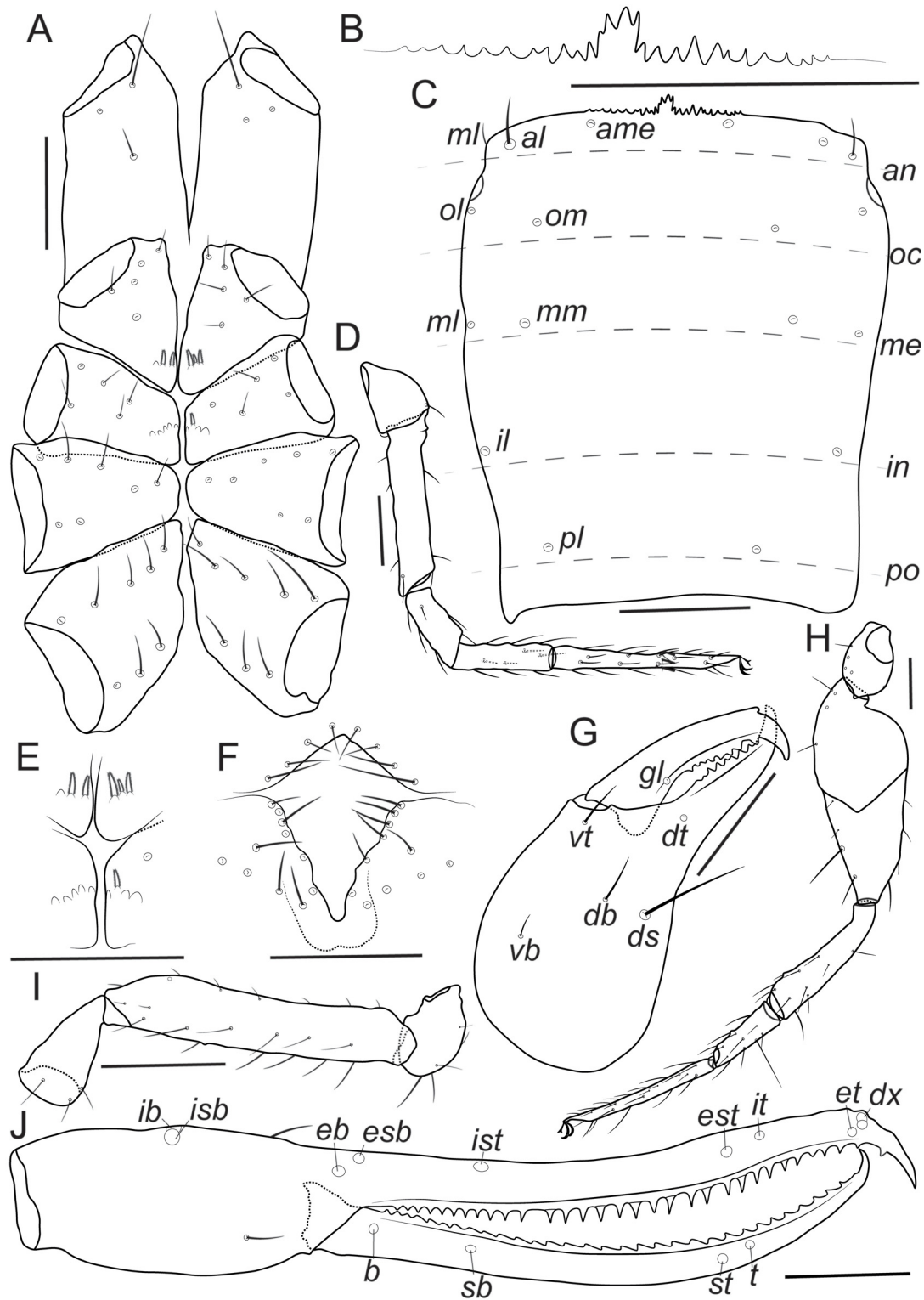
**Description**

PRESERVED SPECIMEN. Body opaque beige, translucent, appendages a slightly dark beige shade (Fig. 2H). Some parts of the body scaly. Vestitural setae thin, sharp and anteriorly projected on prosoma and posteriorly projected on opisthosoma.

CARAPACE (Fig. 16 B–C). 1.22 times as long as wide, broad anteriorly and slightly narrowed posteriorly, with a difference between ocular width and posterior width of 0.076 mm; smooth anterior margin, except in the central portion. Epistome strongly toothed, prominent with three apical tips, slightly extending beyond the *ame* setae (Fig. 16B); eyespots present; posterior margin smooth; chaetotaxy 4+2: 4: 4: 2: 2 (18).

CHELICERAE (Fig. 16G). Hand with 5 setae; movable finger with 1 subdistal setae; galea present as a tubercle; fixed finger with 7 acute and continuous teeth, the two proximal smaller and rounded; movable finger with 9 irregular and rounded teeth at the apex; in the distal portion, the first tooth is separated; rallum with 7 blades; exterior and interior serrula with 17 and 13 blades, respectively.

TERGITES. Undivided; smooth surface; chaetotaxy uniseriate: I–XI 4: 4: 4: 6: 6: 6: 6: 6: 4: 4: 4. Pleural membranes striated.



**Fig. 16.** *Pseudochthonius benignitas* sp. nov., holotype, ♂ (ISLA 151538). **A.** Pedipalp and pedal coxae, ventral view. **B.** Detail of epistome. **C.** Carapace, dorsal view. **D.** Leg I, antiaxial view. **E.** Details of coxae I and II, showing the arrangement of coxal spines. **F.** Male genitalia, ventral view. **G.** Left chelicera, antiaxial view. **H.** Leg IV, antiaxial view. **I.** Pedipalp, dorsal view. **J.** Right chela, antiaxial view, showing the trichobothrial pattern. Scale bars: A–J = 0.1 mm.

COXAE (Fig. 16A, E). Manducatory process with two apical setae; the palpal coxae with 3 setae arranged in a triangle; delicate lamellae bordered by 10 small spines. Pedal coxae: plumose coxal spines arranged in a single transverse row on coxae I (3) and II (4-5) (Fig. 16E), chaetotaxy: I–IV 5 : 5 : 6(7) : 8; intercoxal tubercle absent.

MALE GENITAL OPERCULUM (Fig. 16F). Anterior genital operculum with 8 discal setae, 12 lateral genital setae, and 10 setae along the third sternite.

STERNITES. Chaetotaxy IV–XI: 10 : 6 : 6 : 6 : 6 : 6 : 5 : 4+2 sensory. Anal operculum with 2 ventral setae.

PALP (Fig. 16I–J). Trochanter 1.32 times as wide as long, patella 1.97 times as long as wide, femur 5.06 times as long as wide. Femoral chaetotaxy 5 : 3 : 6 : 5 : 2. Trichobothrial pattern: *ib* and *isb* located halfway on the hand portion, adjacent to each other, *eb* proximal to *esb*, *ist* is distal to *esb*, *it* slightly distal to *est*, *et* proximal to *dx*; *ist* is halfway between *esb* and *est*, closer to *esb* than *est* (*ist-est/ist-esb* distance ratio = 0.6); Chelal fixed finger with alternating heterodonty after the 6<sup>th</sup> tooth, with 34 acute and continuous teeth, with the most distal separated; movable finger with 32 acute and projected backwards teeth.

LEG IV (Fig. 16H). Arolia is slightly smaller than claws.

MEASUREMENTS HOLOTYPE, ♂. (length/width or depth in mm and ratios in parentheses calculated with three significant digits). Body length 1.233. Carapace 0.414/0.339 (1.221), palps: trochanter 0.143/0.108 (1.324), femur 0.521/0.103 (5.058), patella 0.209/0.106 (1.972), chela 0.767/0.121 (6.339), movable finger length 0.479. Chelicera 0.326/0.148 (2.203), movable finger length 0.171. Leg I: trochanter 0.132/0.088 (1.500), femur 0.279/0.054 (5.167), patella 0.147/0.051 (2.882), tibia 0.160/0.038 (4.210), tarsus 0.287/0.034 (8.441). Leg IV: trochanter 0.163/0.112 (1.455), femur/patella 0.458/0.176 (2.602), tibia 0.297/0.067 (4.432), basitarsus 0.156/0.046 (3.391), telotarsus 0.246/0.029 (8.483).

### Ecological remarks

*Pseudochthonius benignitas* sp. nov. was recorded exclusively in Gruta do Belarmino Cave, municipality of Iuiú, Bahia State, Brazil. The cave has a single entrance (Fig. 17B) leading into a conduit that terminates in a blockage formed by speleothems (Fig. 17C). This conduit receives sediment and organic input from surface runoff during heavy rains, which seasonally alters the cave floor. Most of the cave is illuminated by indirect light, and only a small aphotic sector occurs in the deepest portion, where speleothems obstruct the passage of light. The single known specimen of *P. benignitas* sp. nov. was collected beneath a rock on a sediment bank in this innermost aphotic zone.

Because the cave is strongly influenced by the external environment, with stable conditions (aphotic and moist) restricted to only a few meters at the end of the conduit, it is likely that the species' distribution extends beyond this specific microhabitat. Since no other caves in the vicinity of Gruta do Belarmino have been sampled, further surveys are needed to better understand the distribution of this species.

The landscape surrounding the cave exhibits signs of anthropogenic disturbance, including selective logging and areas of exposed soil (Fig. 17A). Nevertheless, native forest remains largely intact near the cave entrance. However, as will be discussed further, large-scale threats (particularly mining) pose a serious risk to the integrity of the entire region.





**Fig. 17.** Habitat of *Pseudochthonius benignitas* sp. nov. **A.** Karst outcrop where the cave is located. **B.** Entrance of Toca do Belarmino Cave. **C.** Cave interior. Photos: Rodrigo Lopes Ferreira.



## Discussion

### Taxonomic challenges in cave-dwelling pseudoscorpions: the roles of cryptic diversity and rarity

Subterranean ecosystems, particularly caves, are characterized by having a high degree of abiotic similarity, encompassing climatic stability, limited trophic inputs, and relatively homogeneous microhabitat conditions. Under such circumstances, cryptic speciation is expected to be especially prevalent, with many taxa comprising unrecognized species complexes as a consequence of strong morphological convergence (Bento *et al.* 2024). In addition, most cave-obligate species exhibit extremely restricted geographic distributions, a pattern largely driven by their limited dispersal capacities and the intrinsically isolated nature of cave habitats. This pattern is consistently documented in pseudoscorpions, with numerous hypogean species often associated with individual caves or a few subterranean localities (Zaragoza 2013; Harvey *et al.* 2023), while broader regional syntheses reveal high levels of endemism and spatially fragmented diversity (Gardini 2013). These patterns likely reflect limited dispersal, strong habitat specialization, and the fragmented nature of subterranean environments, leading to population isolation. As a result, such species are likely to represent evolutionarily distinct lineages. Thus, although caves may share highly similar environmental conditions that facilitate cryptic diversification, they function as discrete and discontinuous units within the subterranean landscape. The absence of connectivity among these habitats further intensifies population isolation, thereby increasing opportunities for allopatric divergence and speciation.

Consequently, numerous cave-restricted species previously thought to have unusually wide distributions are now being re-evaluated using integrative approaches, including molecular analyses and geometric morphometrics. These reassessments have increasingly demonstrated that several such taxa represent species complexes, as documented across diverse groups such as fishes (Chakrabarty *et al.* 2014), centipedes (Kos *et al.* 2025), springtails (Cramphorn 2024), and crustaceans (Rastorgueff *et al.* 2014; Delić *et al.* 2017; Bento *et al.* 2024), among others. While some taxa formerly regarded as single species have been shown to comprise remarkably diverse complexes (e.g., Delić *et al.* 2017), there are rare but notable cases of genuinely widespread cave-restricted species, such as the troglobitic linyphiid spider *Phanetta subterranea* (Kennedy *et al.* 2024).

For pseudoscorpions, a comparable pattern is observed: cave-restricted species are typically micro-endemic and are most frequently described based on small type series (Prado *et al.* 2021; Viana & Ferreira 2021; Jeong *et al.* 2025). Large type series are relatively uncommon (Viana *et al.* 2018) and, when available, generally result from repeated sampling efforts conducted at the same locality (Harms & Harvey 2013). In some instances, however, specimens are not recovered even after multiple visits to the cave, thereby substantially limiting the acquisition of sufficiently representative type series for robust species descriptions (Guimarães *et al.* 2025b). Among the 18 *Pseudochthonius* species described from caves, 10 were described based on only one or two specimens, further underscoring the rarity of species of this genus when associated with subterranean environments.

### What drives so many congeners to coexist in such a small geographic area?

Although the genus *Pseudochthonius* has revealed a remarkable diversity, with numerous species described in recent years, most exhibit highly disjunct distributions, typically occurring in caves separated by hundreds of kilometers, with only a few known exceptions (Prado & Ferreira 2023, 2024). In this context, the presence of eight species within a relatively small geographic area (approximately 180 km<sup>2</sup>) is particularly striking. To account for this unexpectedly high species richness in the Serra de Iuiú region, we propose three non-mutually exclusive hypotheses which, although preliminary, provide plausible explanations and warrant further investigation: (i) the presence of geographic barriers; (ii) limited dispersal capacity; and (iii) competitive exclusion.

The first hypothesis may apply specifically to *Pseudochthonius celestialis* sp. nov., which inhabits caves within the outcrop locally known as Maciço da Serrinha. This outcrop is situated approximately 4 km (straight-line distance) from the main Serra de Iuiú massif, representing a potential geographic barrier. However, this explanation does not appear to account for the remaining species, all of which occur in caves within the main massif of the Serra do Iuiú. Due to the lack of detailed information on the geomorphological structure of the main massif, it is not yet possible to assess the extent of potential subterranean connections (such as mesocaverns or fracture networks) linking the caves. Nevertheless, given the lithological characteristics of the local carbonates, a complete absence of connectivity appears extremely unlikely. This inference is further supported by the occurrence of other cave-restricted species inhabiting geographically distant caves within the Serra de Iuiú massif, such as the pseudoscorpion *Spelaeobochica iuiui*, recorded in caves approximately 20 km apart, the planthopper *Iuiuia caeca*, known from caves located about 13 km from each another and the troglobitic scorpion *Troglorhopalurus iuiui*, known from caves located about 25 km from each another (Carvalho *et al.* 2025).

An alternative explanation (hypothesis II) is that these pseudoscorpions possess inherently low dispersal ability. Under this scenario, multiple lineages may have become isolated in distinct caves following independent colonization events, ultimately giving rise to several species. However, in the absence of a phylogenetic framework for the genus, it is premature to infer the number or direction of colonization events, and thus this hypothesis requires further testing.

Finally (hypothesis III), caves constitute simplified ecosystems in which major selective pressures (such as permanent darkness and environmental stability) are readily identifiable, making them valuable natural models for studying ecological and evolutionary processes (Mammola 2019). Their typical oligotrophic conditions impose strong resource limitations, intensifying competition. As competition increases, it may lead to competitive exclusion, a mechanism rarely examined in subterranean habitats but already documented in cave systems (Martins & Ferreira 2020). In this context, it is plausible that competitive exclusion contributed to the segregation of lineages within Serra de Iuiú, promoting the formation of distinct species in close geographic proximity. Given that the species described here exhibit similar body sizes and morphologies, they may also share comparable ecological requirements. Such overlap would increase niche similarity and, consequently, the likelihood of competitive exclusion. Supporting this hypothesis, most species described in this study were not found to co-occur within the same cave, with the exception of *Pseudochthonius caritas* sp. nov. and *P. patientia* sp. nov., both recorded from Tabocas Cave. However, occurrence within the same cave does not necessarily imply true sympatry. Tabocas Cave comprises two distinct levels, and the populations of these species may in fact be spatially segregated, occupying different habitats within the cave system.

Among the hypotheses proposed, competitive exclusion and limited dispersal ability appear particularly compelling, especially given the low likelihood of major physical barriers restricting movement across the main Serra de Iuiú massif. Nevertheless, all of these hypotheses remain speculative and require future studies to confirm or refute them.

### Conservation and threats

The Iuiú karst region is undergoing increasing environmental pressure, mainly as a consequence of accelerated land-use changes over recent decades. Expanding agricultural frontiers, pasture establishment and selective logging have reshaped the surrounding landscapes, with direct repercussions on subterranean environments. As shown by Cardoso *et al.* (2022), changes in land cover and management practices in the vicinity of caves significantly alter subterranean ecosystems, compromising both the stability of microhabitats and the structure of terrestrial invertebrate assemblages. Their findings demonstrate that deforestation not only reduces invertebrate richness but also drives shifts in species composition, ultimately diminishing the diversity and availability of specialized subterranean microhabitats.



Such impacts are particularly concerning in the Iuiú karst, an area recognized for its high degree of endemism and the presence of several cave-restricted species, including isopods, pseudoscorpions, planthoppers, scorpions and spiders (Ratton *et al.* 2012; Souza *et al.* 2015; Hoch & Ferreira 2016; Cardoso *et al.* 2021; Carvalho *et al.* 2025). The persistence of these taxa is closely tied to the integrity of subterranean habitats, which are highly sensitive to external disturbances due to their dependence on surface-derived inputs and stable environmental conditions.

Even more alarming is the planned construction of a railway through the surroundings of the Serra de Iuiú, intended to channel mineral commodities from the country's interior to the coast for export. This new transport corridor will almost certainly stimulate large-scale exploitation of carbonate deposits in the Serra de Iuiú. Such activity poses a severe future threat, as the installation of major mining operations in the area would inevitably result in extensive habitat loss and the destruction of subterranean ecosystems, leading to the decline or extinction of several cave-restricted species.

Given this scenario, the Iuiú karst stands as a priority area for conservation action. Safeguarding its subterranean biodiversity requires immediate attention from Brazilian environmental authorities, not only to mitigate ongoing land-use pressures but also to establish long-term protective measures that preserve the ecological and speleological significance of this unique region.

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