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Original Article

Cave-dwellers *Diploexochus* (Isopoda, Armadillidae): new species and new records of the genus from Brazil

Giovanna Monticelli Cardoso
Rafaela Bastos-Pereira
Rodrigo Lopes Ferreira

Universidade Federal de Lavras (UFLA), Centro de Estudos em Biologia Subterrânea, Departamento de Biologia, Programa de Pós-Graduação em Ecologia Aplicada. Lavras, Minas Gerais, Brasil.
GMC E-mail: gmcardoso.bio@gmail.com
RB-P E-mail: rafaelabastospereira@gmail.com
RLF E-mail: drops@ufla.br

ZOOBANK: https://zoobank.org/urn:lsid:zoobank.org:pub:88BC9632-9146-4B75-B62F-59480ABB3E24

ABSTRACT

Two new species of *Diploexochus* are described. *Diploexochus spinatus* sp. nov. from Lapa do Honorato cave, located in the municipality of Iuiu, and *Diploexochus obscurus* sp. nov. from Água Escura I cave, located in the municipality of Carinhanha, both in the southwest of Bahia State, northeastern Brazil. Both species are likely to occur in caves due to anthropogenic impacts in the surrounding area (such as deforestation) and/or looking for the stable microclimatic conditions found in the subterranean realm. Additionally, *D. echinatus* is recorded in a cave in the municipality of Rurópolis, Pará State, northern Brazil. These represent the first records of the genus for subterranean environments.

KEYWORDS

Bahia, cave species, Neotropics, terrestrial isopods, Woodlice

Corresponding Author
Giovanna Cardoso
gmcardoso.bio@gmail.com

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INTRODUCTION

Although described in 1833 by Brandt, the genus *Diploexochus* Brandt, 1833 currently has only one valid taxon, the type species *Diploexochus echinatus* (Schmalfuss, 2003). Most species originally described as belonging to *Diploexochus* had been relocated into other armadillid genera, namely: *Venezillo* Verhoeff, 1928, *Lobodillo* Taiti, Paoli and Ferrara, 1998, *Pseudodiploexochus* Lewis, 1998, *Parasphaerillo* Arcangeli, 1934, *Sphaerillodillo* Taiti, Paoli and Ferrara, 1998, *Spherillo* Dana, 1853, *Ctenorillo*

Verhoeff, 1942, *Myrmecodillo* Arcangeli, 1934, *Armadillo* Latreille, 1802, *Pachydillo* Taiti, Paoli and Ferrara, 1998, and *Aulacodillo* Verhoeff, 1942 (Bokyo et al., 2022). This scenario reveals how diffuse and poorly explored the diagnoses are within Armadillidae Brandt, 1831, reinforcing the urgent need for revisional studies.

Endemic to Central America and northern South America, *Diploexochus* was already recorded from Brazil, French Guiana, Guyana, and Trinidad (Schmalfuss, 2003). Campos-Filho et al. (2017) redescribed *D. echinatus*, recording the species from Floresta Nacional Caxiuanã in the state of Pará, northern Brazil. The present work reports a new occurrence of this species, the first in the subterranean realm, also in the state of Pará. Moreover, two new species from caves in the state of Bahia, northeastern Brazil, are described. Additionally, ecological notes and conservation status are provided for the new species and *D. echinatus*.

MATERIAL AND METHODS

In the field, specimens were manually collected with the aid of brushes and fixed in 70% ethanol. In the laboratory, they were measured and photographed with a ZEISS Axio ZoomV16 stereomicroscope with an Axio Cam 506 Color camera, dissected and mounted on slides using Hoyer's medium. Drawings were made either from photographs or from dissected mounted specimens with the aid of a camera lucida on a Leica DM750 microscope. Final illustrations were prepared in the software GIMP (v. 2.8) (Montesanto 2015; 2016) with a Cintiq Drawing Pad (Wacom). Some specimens were analyzed under an Hitachi TM4000 scanning electron microscope. For this purpose, the specimens were dissected and their parts were glued onto an aluminum support stub with double-sided adhesive carbon tape. Specimens were not sputter-coated with gold, since this SEM operates at low vacuum. Holotype and paratypes of the new species were deposited in the Subterranean Invertebrate Collection of Lavras (ISLA - UFLA) in the Center of Studies on Subterranean Biology of the Federal University of Lavras (CEBS/UFLA, Lavras, Brazil).

SYSTEMATICS

Family Armadillidae Brandt, 1831

Genus *Diploexochus* Brandt, 1833

Diploexochus echinatus Brandt, 1833

(Figs. 1, 2)

Diploexochus echinatus Brandt, 1833: 192, pl. IV, figs. 20, 21; H. Milne-Edwards, 1840: 180; Budde-Lund, 1909: 54; Richardson, 1912: 479; Arcangeli, 1934: 92, 1957: 101; Van Name, 1936: 398, figs. 241–243; Lemos de Castro, 1967: 322; Souza-Kury, 1998: 6532; Leistikow and Wägele, 1999: 44; Schmalfuss, 2003: 90; Campos-Filho et al., 2017: 22, figs. 98–122; Campos-Filho et al., 2018: 27.

Armadillo echinatus — Budde-Lund, 1879: 7; Budde-Lund, 1885: 26; Budde-Lund, 1904: 104, pl. IX figs. 35–37.

Cubaris echinatus — Pearse, 1917: 3.

Cubaris gaigei — Pearse, 1917: 2, fig. 1; Van Name, 1925: 467.

Material examined. 2 males (ISLA 77541), Brazil, Pará State, municipality of Rurópolis, Lucas cave (-4.139791° -55.071947°), 09 October 2020, R.L. Ferreira coll.

Previous records. French Guiana, Guyana, Trinidad (Schmalfuss, 2003, Campos-Filho et al., 2017), and Brazil, Pará State: Acará and Belém (Ilha do Marajó) (Lemos de Castro, 1967), and Caxiuanã (Floresta Nacional Caxiuanã) (Campos-Filho et al., 2017).

Habitat and ecological remarks. Two specimens of *D. echinatus* (Fig. 1) were found in a sandstone cave (Lucas cave – Fig. 2) located in the municipality of Rurópolis, Pará State, northern Brazil. Paleozoic rocks covered by a dense Amazon ombrophilous rainforest represent the regional geology. The area is located in the hot tropical climate domain with annual dry period of 2 to 3 months. The annual average temperatures are above 20 °C and the annual precipitation is around 1,754 mm (Tereso et al., 1975). Lucas cave presents a single entrance (Fig. 2A) leading to the main cave conduit (Fig. 2B, C), which presents 365 m of horizontal projection.

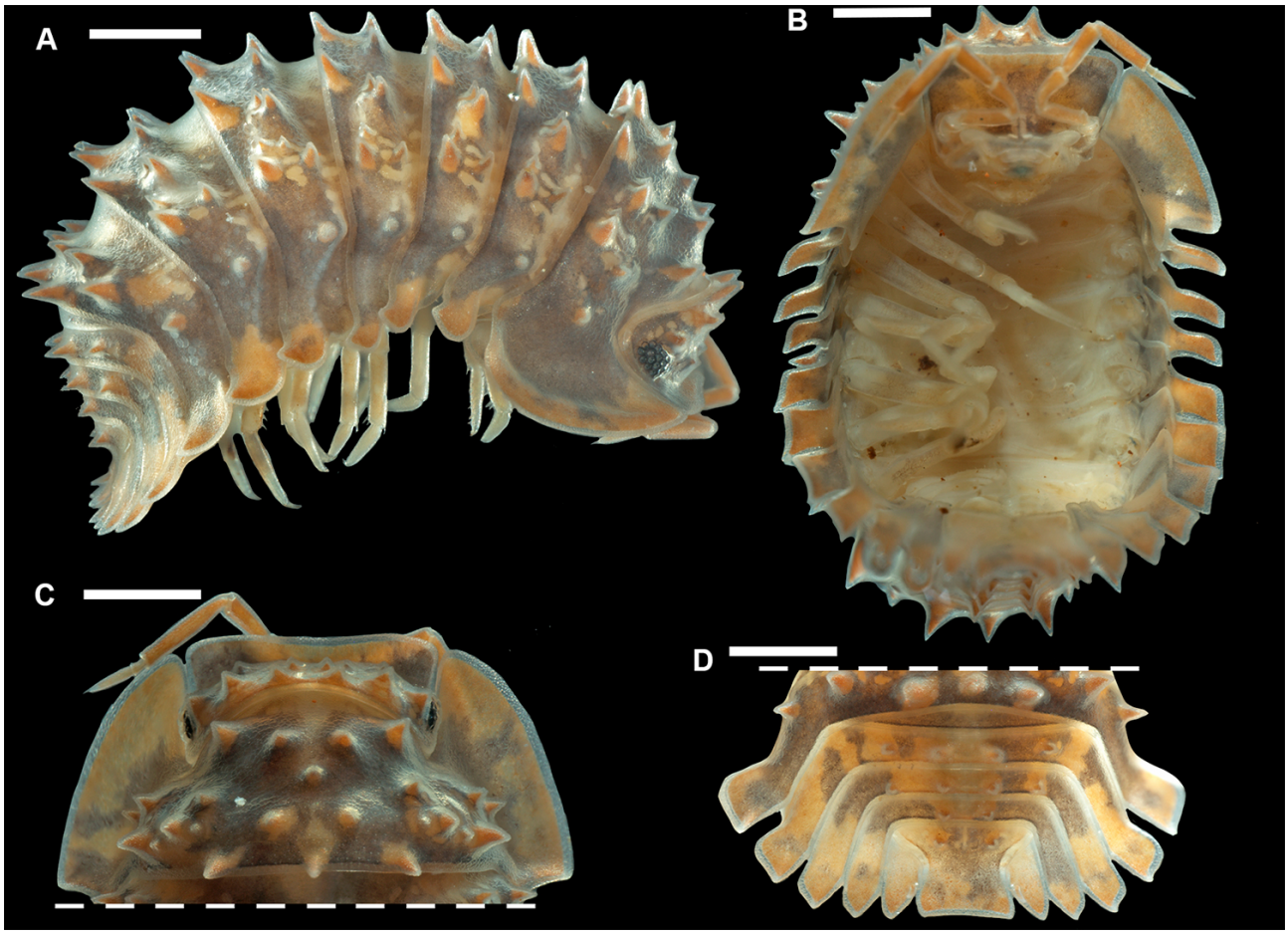

Figure 1. *Diploexochus echinatus,* female. **A**, Habitus, lateral view; **B**, epimera of pereonites 1-7, ventral view; **C**, cephalon and pereonite 1, dorsal view; **D**, pereonite 7, pleonites and telson, dorsal view. Scale bars: 1 mm.

The cave does not present any drainage, although the atmosphere is moist due to the external forest and climate. A big bat colony inhabits the cave, producing massive amounts of guano, which covers a considerable portion of the floor. Both specimens of *D. echinatus* were found in a region close to the entrance, though already aphotic, around 25 m from the entrance on a pile of stones made by ancient inhabitants of the region (unknown reason) (Fig. 2D). These organisms are quite sensitive, curling up at the slightest touch, like other armadillids (Fig. 2E). Even though the cave was meticulously inspected looking for invertebrates, only these two specimens of *Diploexochus* were found. In addition, other caves sampled in the region did not reveal the presence of this species. It is important to mention that this represents the first record of this species from cave environments.

***Diploexochus spinatus* sp. nov.**

(Figs. 3 – 6)

Zoobank: urn:lsid:zoobank.org:act:7A394BCA-F660-4424-A8A3-5AE58475F71C

Type material. Holotype: male (ISLA 77536), Brazil, Bahia State, municipality of Iuiu, Lapa do Honorato cave (-14.4628º -43.5931º), 19 October 2021, R.L. Ferreira coll. Paratypes: 2 males (1 in slide), 7 females (ISLA 77537), same data as holotype.

Additional material. 1 female (ISLA 77537), Brazil, Bahia State, municipality of Malhada, Tapera d'Água cave (-14.517270º -43.682842º), 18 October 2021, R.L. Ferreira coll.

Diagnosis. Dorsal surface covered with acute and rectangular tubercles; pleonites 3–5 with 2 paramedian tubercles, telson with 2 tubercles or smooth; pereonites epimera flattened directed backwards; pleonites epimera quadrangular with round distal corner.

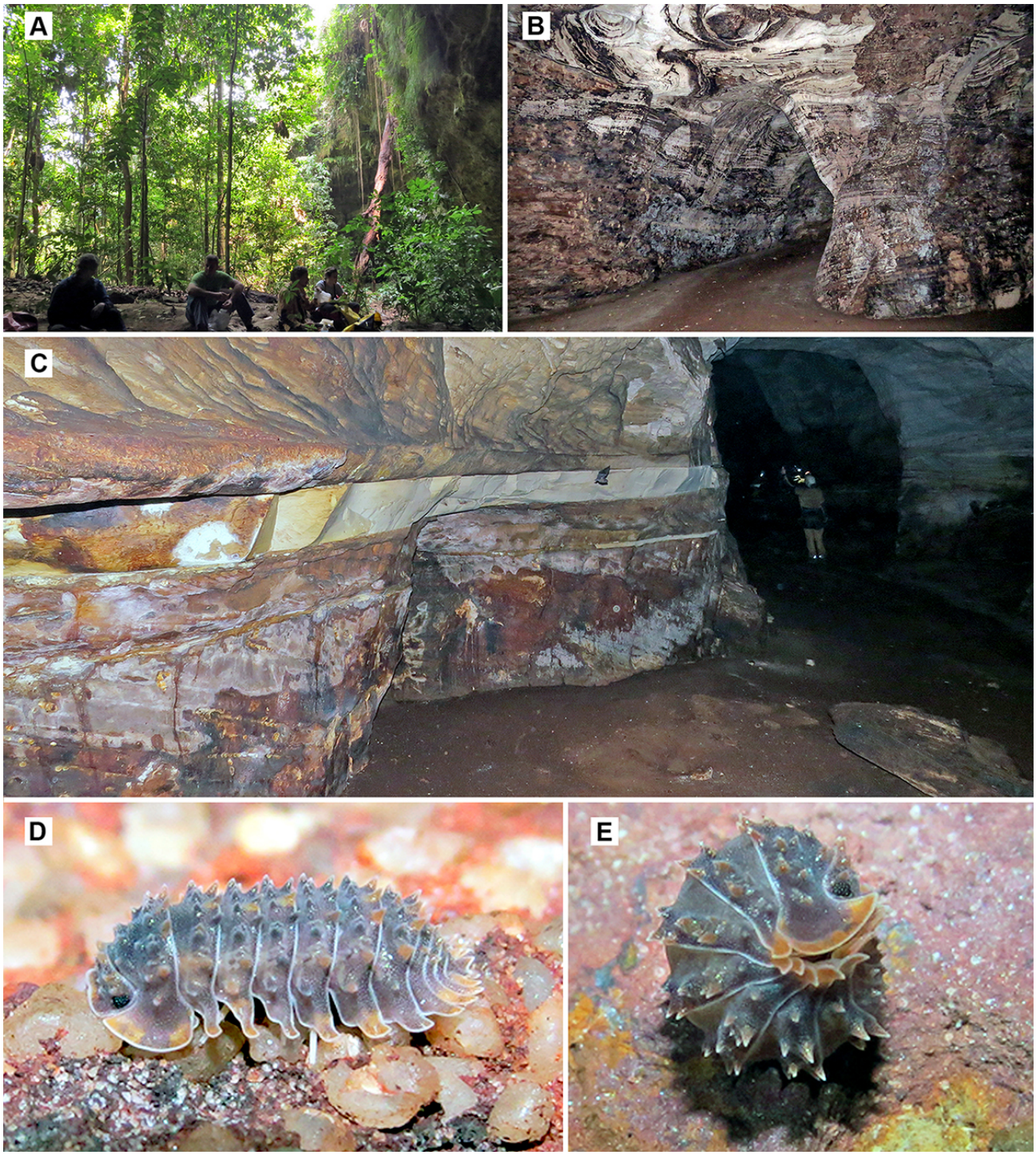

Figure 2. Lucas cave, Rurópolis, Pará State, Brazil. **A**, Surrounding area; **B**, main cave conduit; **C**, cave conduit; **D**, live specimen of *Diploexochus echinatus* in lateral view; **E**, live specimen of *Diploexochus echinatus* showing the ability to roll into a ball.

Description. Body length: ♂ 10 mm, ♀ 12 mm. Body dark gray with depigmented spots, antenna yellowish (Fig. 3A). Endoantennal conglobation (Fig. 4A, B). Dorsal surface covered with acute and rectangular tubercles disposed as follows (Fig. 4B): cephalon with 11 tubercles in 3 rows; pereonite 1 with 21 tubercles in 3 rows; pereonites 2–6 with 13 tubercles in 2 rows; pereonite 7 with 11 tubercles in 2 rows; pleonites 3–5 with 1 row of 2 paramedian tubercles each, telson smooth (holotype) or with 2 small tubercles. Dorsal surface with short semi-circular scale-setae, one nodulus lateralis on the second line of tubercles far from lateral margin, on outer distal margin (Fig. 3B). Cephalon with frontal shield prominent, distal margin

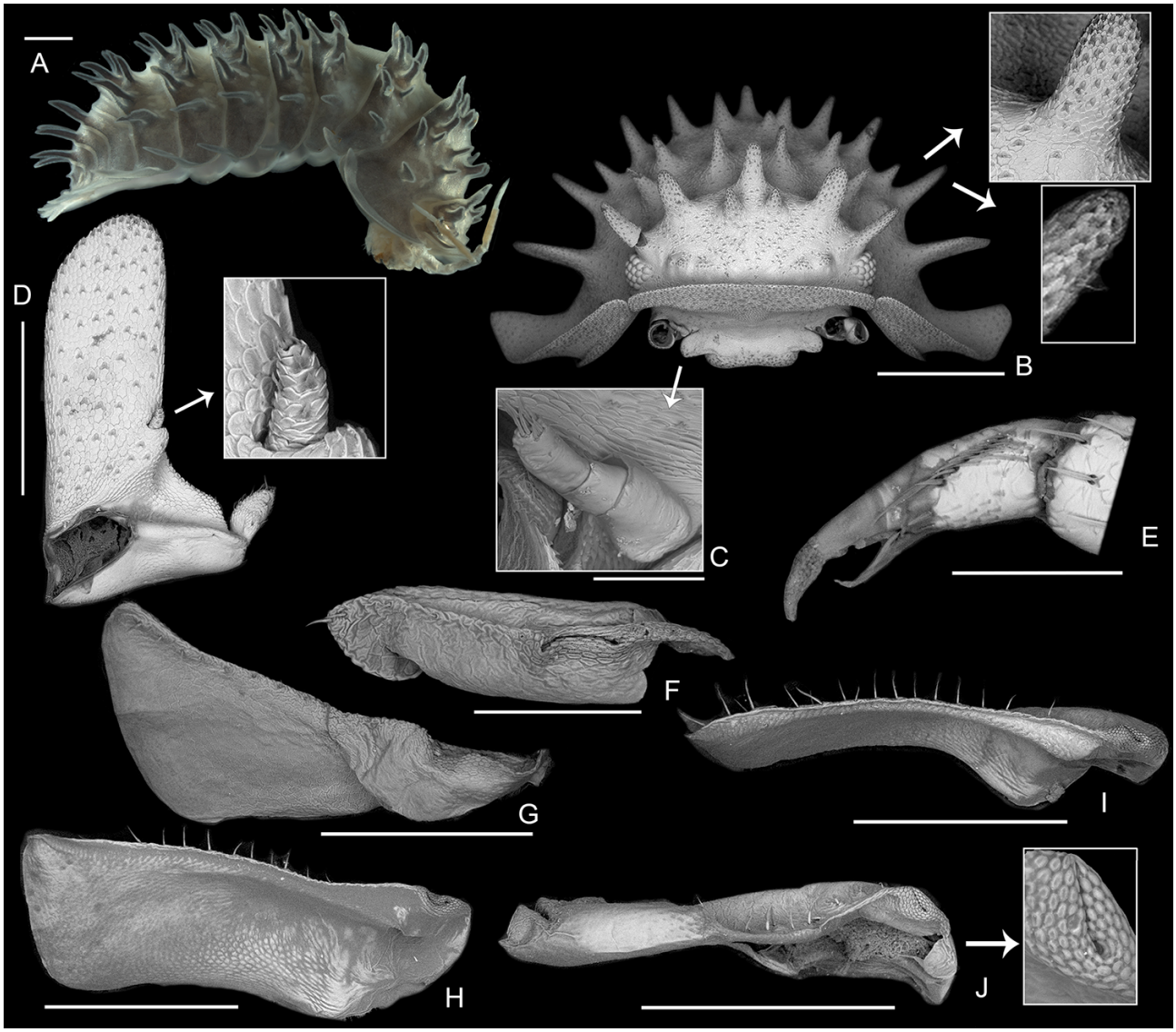

Figure 3. *Diploexochus spinatus* sp. nov., female paratype. **A**, Habitus, lateral view; **B**, cephalon and pereonite 1, frontal view; **C**, antennula; **D**, pereopod 7 dactylus; **E**, pleopod 1 exopod; **F**, pleopod 2 exopod; **G**, pleopod 3 exopod; **H**, pleopod 4 exopod; **I**, pleopod 5 exopod; **J**, uropod, dorsal view. Scale bars: **A, B**: 1 mm; **C, E**: 100μm; **F**: 200μm; **D, G–J**: 500μm.

slightly curved, protruding above vertex; eye with about 20 ommatidia (Figs. 3B; 4C, D). Pereonites with epimera flattened and directed backwards; pereonite 1 strongly grooved on lateral margin, inner lobe of schisma rounded (Figs. 3B, 4C–E), pereonite 2 with triangular ventral lobe; pereonites 5–7 with oblique ventral ridge (Fig. 4E). Pleonites 3–5 with well-developed epimera, quadrangular with round distal corner slightly directed outwards (Fig. 4F). Telson hourglass-shaped, base broader than distal part, distal margin straight (Fig. 4F). Antennula (Figs. 3C, 4G) with 3 articles, proximal and distal articles subequal in length, distal article with 9 apical aesthetascs. Antenna (Fig. 4H) short, not surpassing distal margin of pereonite 1; flagellum with 2 articles, distal article about 2 times longer than first, with 1 row of aesthetascs. Mandibles (Fig. 4I, J) molar penicil simple, right mandible with 1 + 1, left mandible with 2 + 1 free penicils. Maxillula (Fig. 4K) outer branch with 4 + 5 simple teeth; inner branch with 2 long penicils. Maxilla (Fig. 4L) bilobate, outer lobe twice wider than inner lobe, covered with thin setae. Maxilliped (Fig. 4M) endite with medial seta surpassing distal margin, distal margin slightly rounded with 2 short triangular setae; palp with 2 setae on basal article. Pereopod 1 with longitudinal antennal grooming

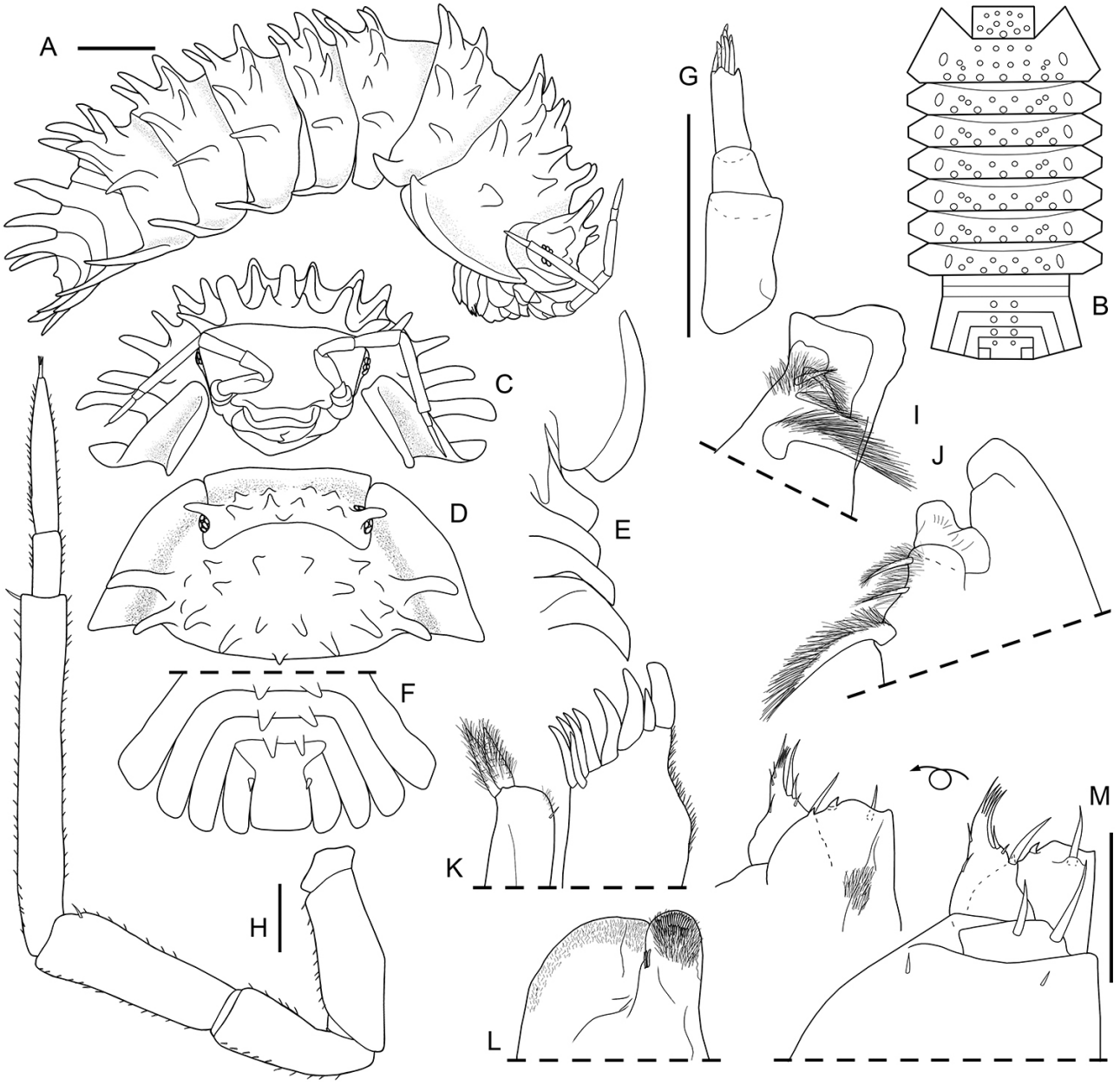

Figure 4. *Diploexochus spinatus* sp. nov., female paratype. **A**, Habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon and pereonite 1, frontal view; **D**, cephalon and pereonite 1, dorsal view; **E**, epimera 1–5 ventral view; **F**, pleonites 3–5, uropods and telson, dorsal view. Male paratype: **G**, antennula; **H**, antenna; **I**, right mandible; **J**, left mandible; **K**, maxillula; **L**, maxilla; **M**, maxilliped. Scale bars: **A**: 1 mm; **C**–**M**: 0.2 mm.

brush (Fig. 5A), dactylus inner claw not surpassing outer claw, dactylar organ and ungual seta simple, with longitudinal scale-field (Fig. 3E). Pleopods 1–5 with monospiracular lungs (Fig. 3E–I). Uropod (Fig. 3J) protopod flattened, distal part subrectangular with round apex, exopod short inserted medially; endopod stout, short, not reaching the insertion of exopod, around 2 times exopod length.

Male: pereopods 1 and 7 (Figs. 3D; 5A, B) with no particular modifications. Genital papilla with triangular ventral shield, papilla slightly surpassing ventral shield with apical orifices (Fig. 5C). Pleopod 1 (Fig. 5C) exopod small, triangular, wider than long; endopod about threefold longer than exopod, distal part slightly bent outwards. Pleopod 2 (Fig. 5D) exopod triangular, outer margin strongly concave

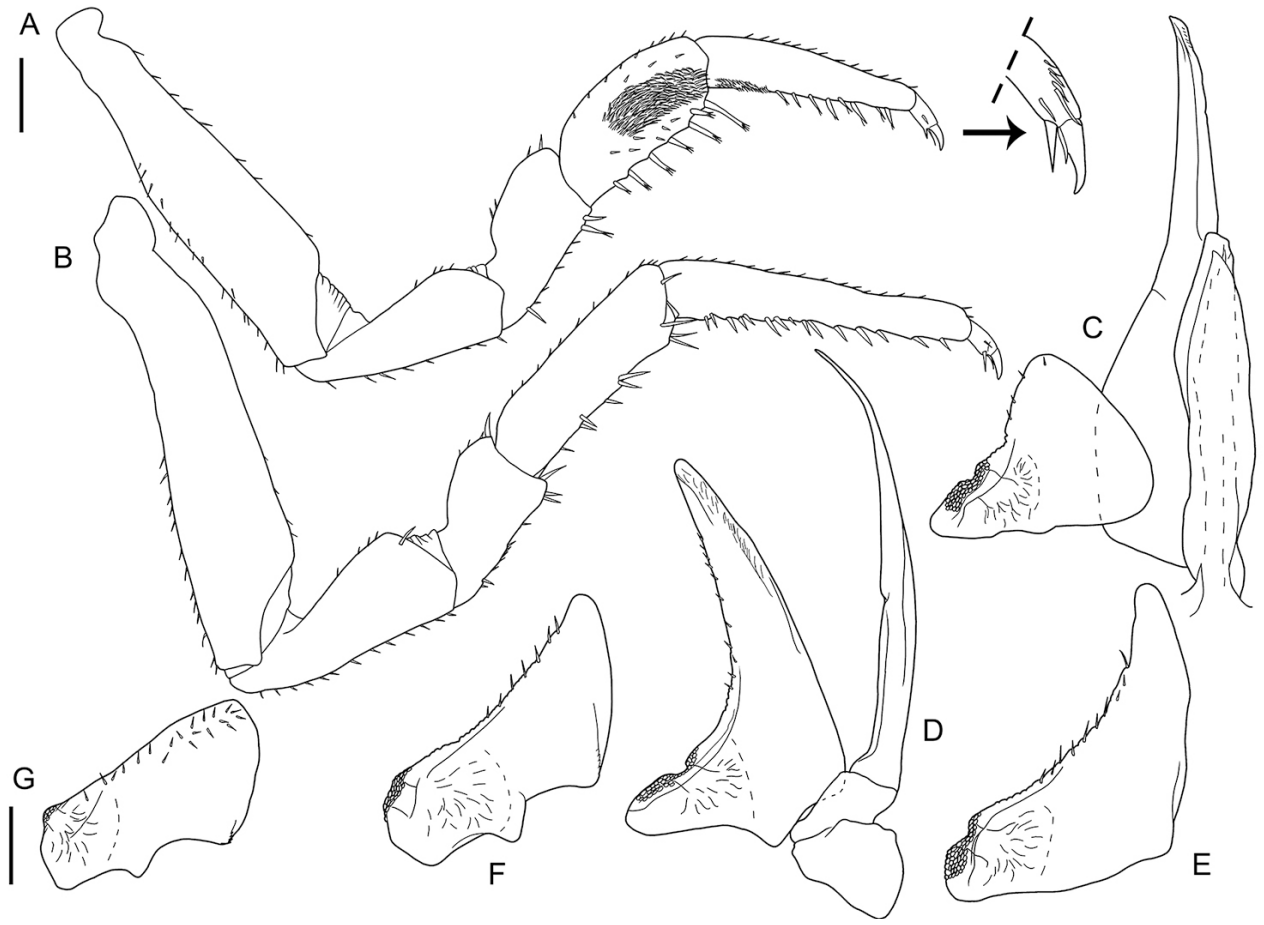

Figure 5. *Diploexochus spinatus* sp. nov., male paratype. **A**, Pereopod 1; **B**, pereopod 7; **C**, pleopod 1 and genital papilla; **D**, pleopod 2; **E**, pleopod 3 exopod; **F**, pleopod 4 exopod; **G**, pleopod 5 exopod. Scale bars: 0.2 mm.

bearing setae; endopod longer than exopod. Pleopods 3–5 exopods as in Fig. 5E–G.

Etymology. The specific epithet "*spinatus*" refers to the morphology of the dorsal tubercles, which in this species are like spines.

Morphological remarks. The specimens from Honorato cave showed variations in the tubercle development on the telson, being very reduced in relation to the tubercles on pleonites (in 4 specimens) or absent (in 5 specimens); while on the female from Tapera D'água cave these tubercles are as long as those on pleonites 3–5 (Fig. 6D, E). Furthermore, the female from Tapera D'água cave presents the cephalon with seven tubercles and pereonites and pleonite epimera with posterior points well-developed, curved and directed outwards, in a pattern similar to *D. echinatus* (Fig. 6E).

Habitat and ecological remarks. Specimens of *D. spinatus* sp. nov. were found in two caves in the municipality of Iuiú, a region with several caves and cave-restricted endemic species (Souza et al., 2015; Souza and Ferreira, 2018; Cardoso et al., 2020; 2021). Other caves in the area were also inventoried, however specimens of *D. spinatus* sp. nov. were only found in these two caves. This area is located in the Caatinga domain, the only xeric biome of Brazil with xeromorphic and deciduous vegetation (Fig. 6A). Several specimens of *D. spinatus* sp. nov. were found in Honorato cave, a limestone cave with 150 meters of horizontal projection. This cave has a single entrance leading to a wide chamber (Fig. 6B), partially trespassed by an intermittent stream that occurs in the cave main conduit. During dry periods, only a few ponds are observed inside the cave, while during rainy periods the stream can flow, especially after strong rains. Several specimens were found from the middle

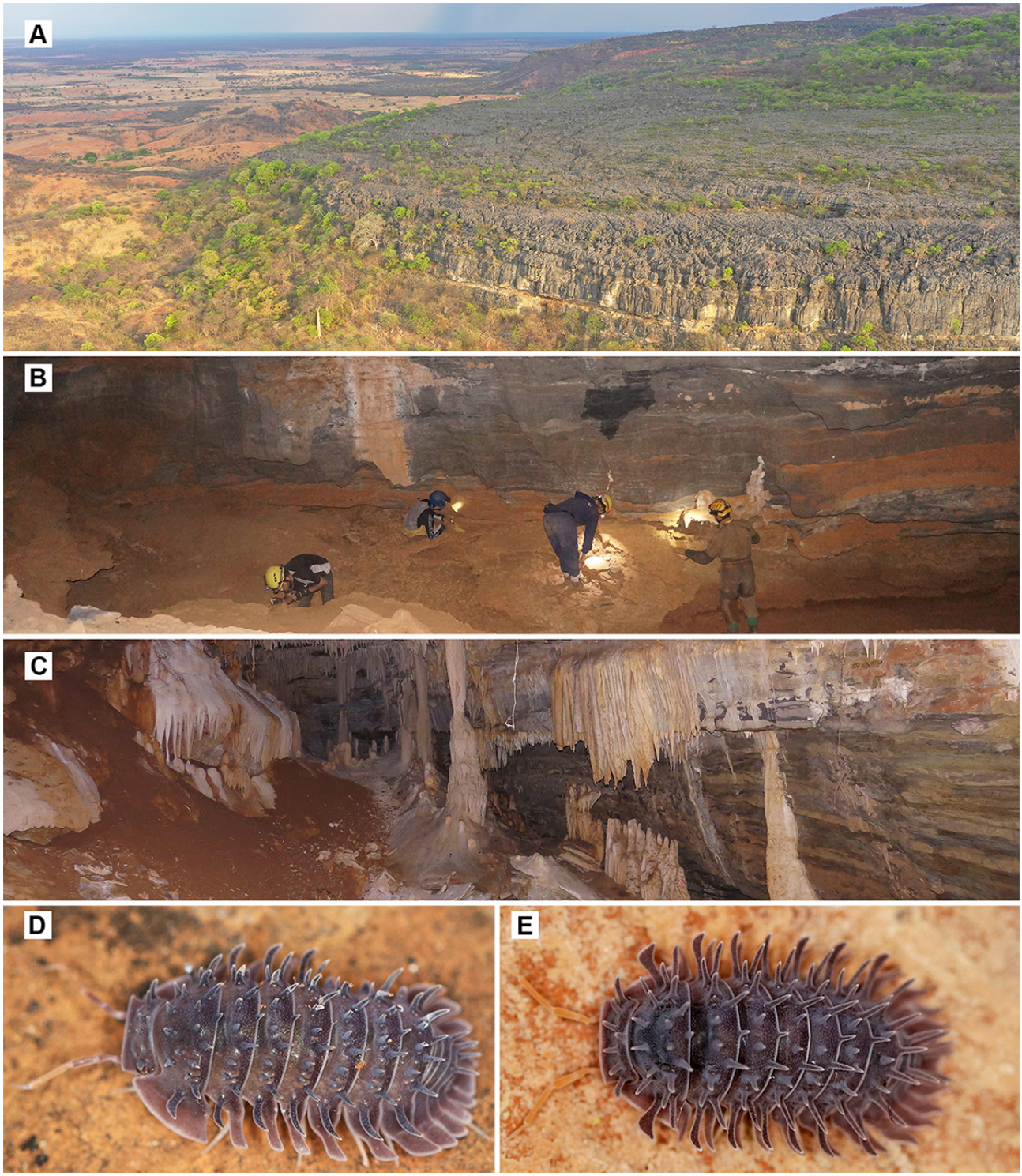

Figure 6. **A**, Karstic area surrounding Honorato cave; **B**, Honorato cave; **C**, Tapera D'água cave; **D**, *Diploexochus spinatus* sp. nov. from Honorato cave; **E**, *Diploexochus spinatus* sp. nov. from Tapera D'água cave.

portion of the cave to the deepest chamber (Fig. 6D). In all cases, they were sheltered under rocks on the cave floor distant from the potentially flooded areas. Although three samplings have been performed in this cave (in 2008, 2012, and 2021), specimens of *D. spinatus* sp. nov. were only found in the last sampling event, although body remnants potentially belonging to this species were observed in 2008. It is worth mentioning that in the first two samplings, there was a forested area surrounding the cave. In the last sampling, however, this forest was no longer present, and a considerable area of exposed soil was observed.

The presence of living specimens of *D. spinatus* sp. nov. only in the last sampling may have occurred due to their migration from the external area to the cave environment, seeking more suitable habitat. Considering that the species lacks any troglomorphic traits, it is likely that it exhibits external populations and their occurrence in caves may be related to the presence of impacts (such as deforestation) in the epigean environments. A single specimen was observed in Tapera D'água cave, located around 11.5 km away from Honorato cave. This cave presents around 300 meters of horizontal projection, trespassed by a stream. The single specimen (Fig. 6E) was also found under a rock on the cave floor, in a chamber located in the deep portion of the cave (Fig. 6C), far from the potentially flooded areas. The surrounding area of this cave is more preserved, although there are signs of human impacts in the past (like deforested areas and some abandoned water reservoirs). In this sense, several suitable habitats seem to exist for the species in the cave surroundings.

***Diploexochus obscurus* sp. nov.**

(Figs. 7 – 10)

Zoobank: urn:lsid:zoobank.org:act:E2B21901-1FE9-4731-B8B0-B00C3FA56987

Type material. Holotype: male (ISLA 77539, part in slide), Brazil, Bahia State, municipality of Carinhanha, Água Escura I cave (-13.817694º -43.950366º), 17 September 2021, G.M. Cardoso and R.L. Ferreira coll. Paratypes: 3 females (1 in slide) (ISLA 77540), same data as holotype.

Diagnosis. Dorsal surface covered with acute and rectangular tubercles; pereonites 2–7 with 11 tubercles in 2 rows; pleonite 3 with 4 tubercles, pleonites 4, 5 and telson with 2 paramedian tubercles; uropod exopod inserted medially, endopod around threefold exopod length.

Description. Body length: ♂ 7.5 mm, ♀ 6 mm. Body gray with depigmented spots; antenna 5th article and flagellum yellowish (Fig. 7A). Endoantennal conglobation. Dorsal surface covered with acute and rectangular tubercles disposed as follows (Fig. 8A, B): cephalon with 12 tubercles in 3 rows; pereonite 1 with 21 tubercles in 3 rows; pereonite 2 with 13 tubercles in 2 rows; pereonites 3–7 with 11 tubercles in 2 rows; pleonite 3 with 4 tubercles, pleonites 4 and 5 with 2 paramedian tubercles, telson with 2 tubercles. Dorsal surface with short semi-circular scale-setae (Fig. 7C). Cephalon (Figs. 7B, 8C, D) with frontal shield prominent, protruding above vertex, distal margin straight; eye with about 16 ommatidia. Pereonites with epimera flattened and directed backwards; pereonite 1 strongly grooved on lateral margin, inner lobe of schisma rounded (Fig. 8C, E); pereonite 2 with triangular ventral lobe; pereonites 5–7 with oblique ventral ridge. Pleonites 3–5 (Fig. 8F) with epimera well developed, quadrangular with round distal margin, slightly directed outwards. Telson hourglass-shaped, base wider than distal part, distal margin straight. Antennula (Fig. 7D) of 3 articles, proximal and distal articles subequal in length, distal article with 2 lateral and 5 apical aesthetascs. Antenna (Fig. 8G) short, not surpassing distal margin of pereonite 1; flagellum of 2 articles, distal article about fourfold longer than first, with 1 row of aesthetascs. Mandible (Fig. 8H, I) molar penicil simple; left mandible with 2 + 1 and right mandible with 1 + 1 free penicils. Maxillula (Fig. 8J) outer branch with 4 + 5 simple teeth. Maxilla (Fig. 8K) bilobate, outer lobe twice wider than inner lobe, covered with thin setae. Maxilliped (Fig. 8L) endite with medial seta surpassing distal margin, distal margin slightly rounded with 2 short triangular setae; palp with 2 setae on basal article. Pereopod 1 with longitudinal antennal grooming brush, dactylus inner claw not surpassing outer claw, dactylar organ and ungual seta simple, with longitudinal scale-field (Fig. 9A). Pleopods 1–5 with monospiracular lungs. Uropod (Fig. 7D) protopod flattened, distal part subrectangular, exopod short inserted medially, endopod stout, short, not reaching the insertion of exopod, around threefold exopod length.

Male: pereopods 1 and 7 (Fig. 9A, B) with no particular modifications. Genital papilla with triangular ventral shield, papilla slightly surpassing ventral shield with apical orifices (Fig. 9C). Pleopod 1 (Fig. 9C) exopod small, triangular, wider than long; endopod about 4 times longer than exopod, distal part straight. Pleopod 2 (Fig. 9D) exopod triangular, outer margin strongly concave bearing setae; endopod longer than exopod. Pleopods 3 and 4 exopods as in Fig. 9E, F.

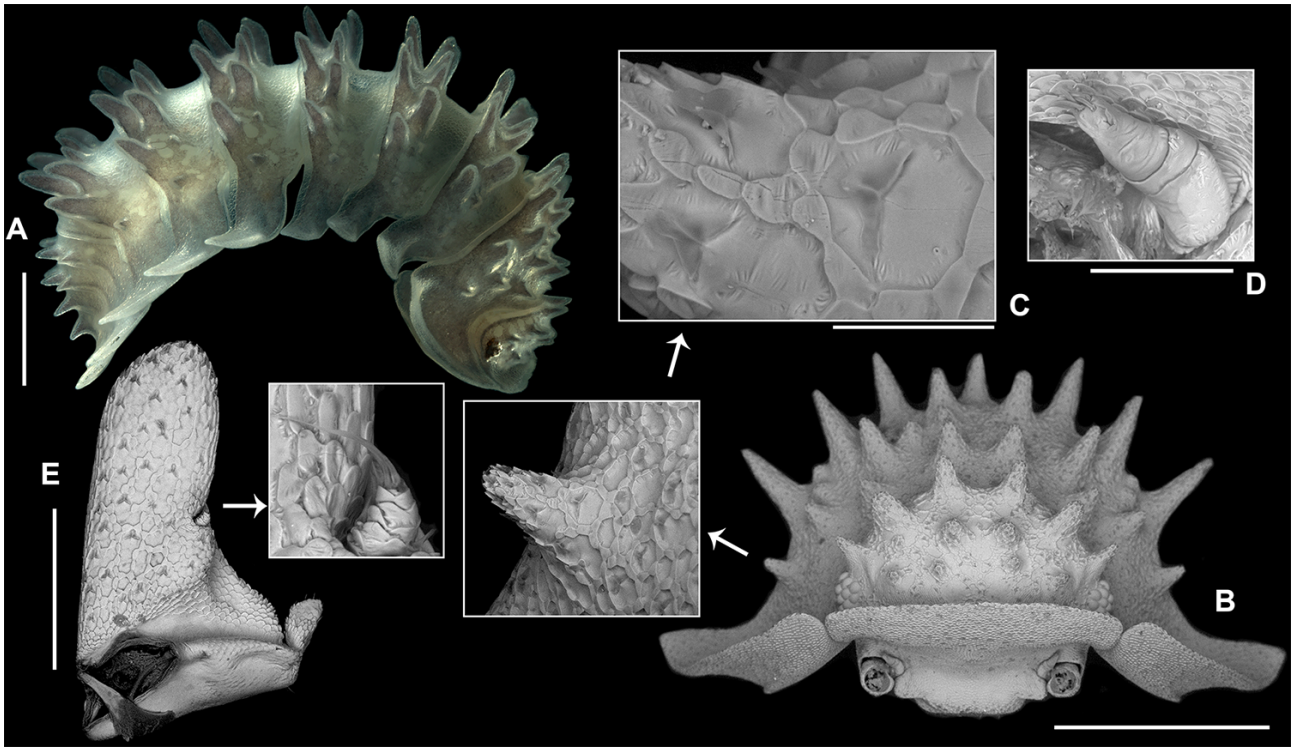

Figure 7. *Diploexochus obscurus* sp. nov., female paratype. **A**, Habitus, lateral view; **B**, cephalon and pereonite 1, frontal view; **C**, scale setae; **D**, antennula; **E**, uropod. Scale bars: **A, B**: 1 mm; **C**: 50μm; **D**: 100μm; **E**: 300μm.

Etymology. The specific epithet *"obscurus"* refers to the cave where the species was collected, Água Escura (that in Portuguese means dark water).

Habitat and ecological remarks. Specimens of *D. obscurus* sp. nov. were found in a limestone cave (Água Escura I cave) located in the region of "Serra do Ramalho", northeastern Brazil. This area has hundreds of caves and several cave-restricted species (e.g., Baptista and Giupponi, 2002; Kamimura and Ferreira, 2018; Hellmann et al., 2020). Although many other caves in the area were also inventoried, specimens of *D. obscurus* sp. nov. were only found in this cave. Although this cave is peripheral to the main subterranean drainage in the area, it can be considered part of the Água Clara cave system, which comprises the richest hotspot of subterranean biodiversity in South America (Souza-Silva et al., 2021). The Água Escura I cave presents a single entrance, located at the base of a limestone outcrop (Fig. 10A). The cave presents two main conduits (one intercepting the other), which were extremely dry during the samplings (Fig. 10C). However, the cave conduits are located at a lower level when compared to the surface, so that the water from floods can enter the cave, submerging part of its chambers during strong rains (Fig. 10B). According to Köppen's climate classification system, the local climate is "Aw", with dry winter and an average annual rainfall of 640 mm^3 (Alvares et al., 2013). Only four specimens of *D. obscurus* sp. nov. were found in the cave (Fig. 10D, E), all sheltered under big rocks, in which microhabitats still retained some moist content on the subjacent floor (Fig. 10C). The cave surroundings are severely impacted (Fig. 10A), mainly by deforestation and fires, although cattle and goat breeding were also observed. As mentioned for *D. spinatus* sp. nov., the cave is likely being used by *D. obscurus* sp. nov. as a refuge, considering the highly impacted area surrounding the cave.

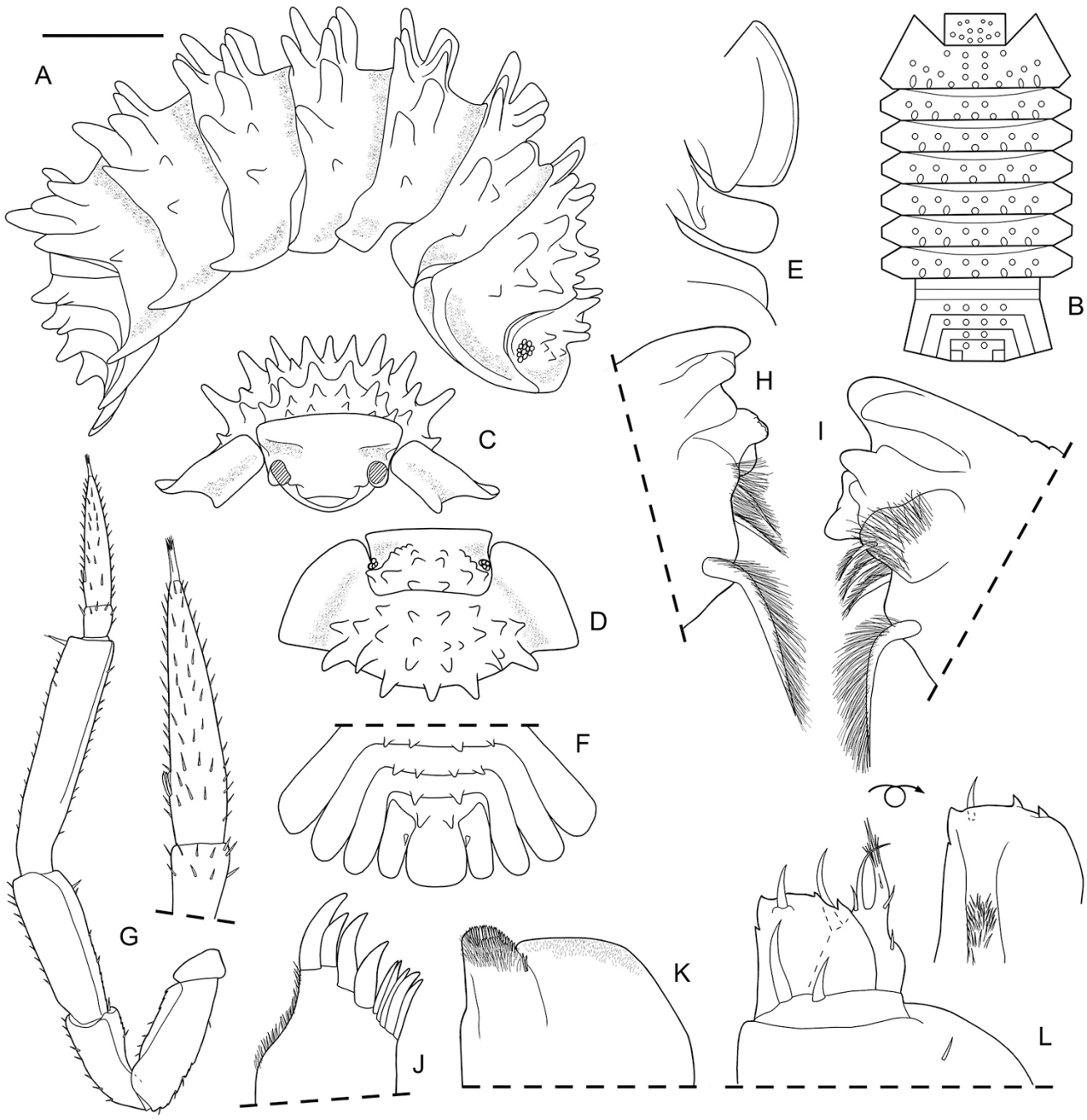

Figure 8. *Diploexochus obscurus* sp. nov., female paratype. **A**, Habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon and pereonite 1, frontal view; **D**, cephalon and pereonite 1, dorsal view; **E**, epimera 1–4 ventral view; **F**, pleonites 3-5, uropods and telson, dorsal view. Male paratype: **G**, antenna; **H**, right mandible; **I**, left mandible; **J**, maxillula; **K**, maxilla; **L**, maxilliped. Scale bars: **A**: 1 mm; **C**–**L**: 0.2 mm.

DISCUSSION

The disposition of tubercles has shown to be a strong character that varies among *Diploexochus* species, along with the shape of the male pleopod exopod, the proportion of the uropod exopod, and the shape of the telson. The number and topology of pereonite tubercles differ in the new species in relation to *D. echinatus*, which shows 15 tubercles on pereonites 2–6; and 13 tubercles on pereonite 7. *Diploexochus spinatus* sp. nov. presents 13 tubercles in two rows on pereonites 2–6 and 11 tubercles on pereonite 7; while *D. obscurus* sp. nov. presents 13 tubercles on pereonite 2, and 11 tubercles on pereonites 3–7. Regarding the pleonites, each species shows a different pattern. In

D. echinatus there are four tubercles on pleonites 3 and 4 and two paramedian tubercles on pleonite 5 and telson; in *D. spinatus* sp. nov. there are two paramedian tubercles on pleonites 3–5, with some species showing tubercles on the telson; and in *D. obscurus* sp. nov. there are four tubercles on pleonite 3, and two paramedian tubercles on pleonites 4 and 5 and telson.

The shape of the male pleopod 1 exopod in *D. spinatus* sp. nov. is similar to *D. echinatus*. In comparison with *D. echinatus*, the uropod exopods and endopods in *D. spinatus* sp. nov. and *D. obscurus* sp. nov. are minute. In proportion, in *D. spinatus* sp. nov. the endopod is around twice as long as the exopod, similar to *D. echinatus*, while in *D. obscurus* sp. nov. the endopod is around threefold longer than the exopod. Lastly, the distal part of the telson in *D. echinatus* is quadrangular with the dorsum slightly depressed, and the distal margin concave, while in both new species it is rectangular with the distal margin straight.

Although several species have been described as belonging to the genus *Diploexochus*, all of them ended up being reallocated into other genera. Accordingly, almost two centuries after the description of the genus, two new species are described, which not only contributes to the taxonomy of this group but also points to potential discoveries. Furthermore, the occurrence of the herein described species in a semi-arid biome, quite distinct from the moist Amazon region where *D. echinatus* is found, demonstrates the great adaptive plasticity of the species in this genus.

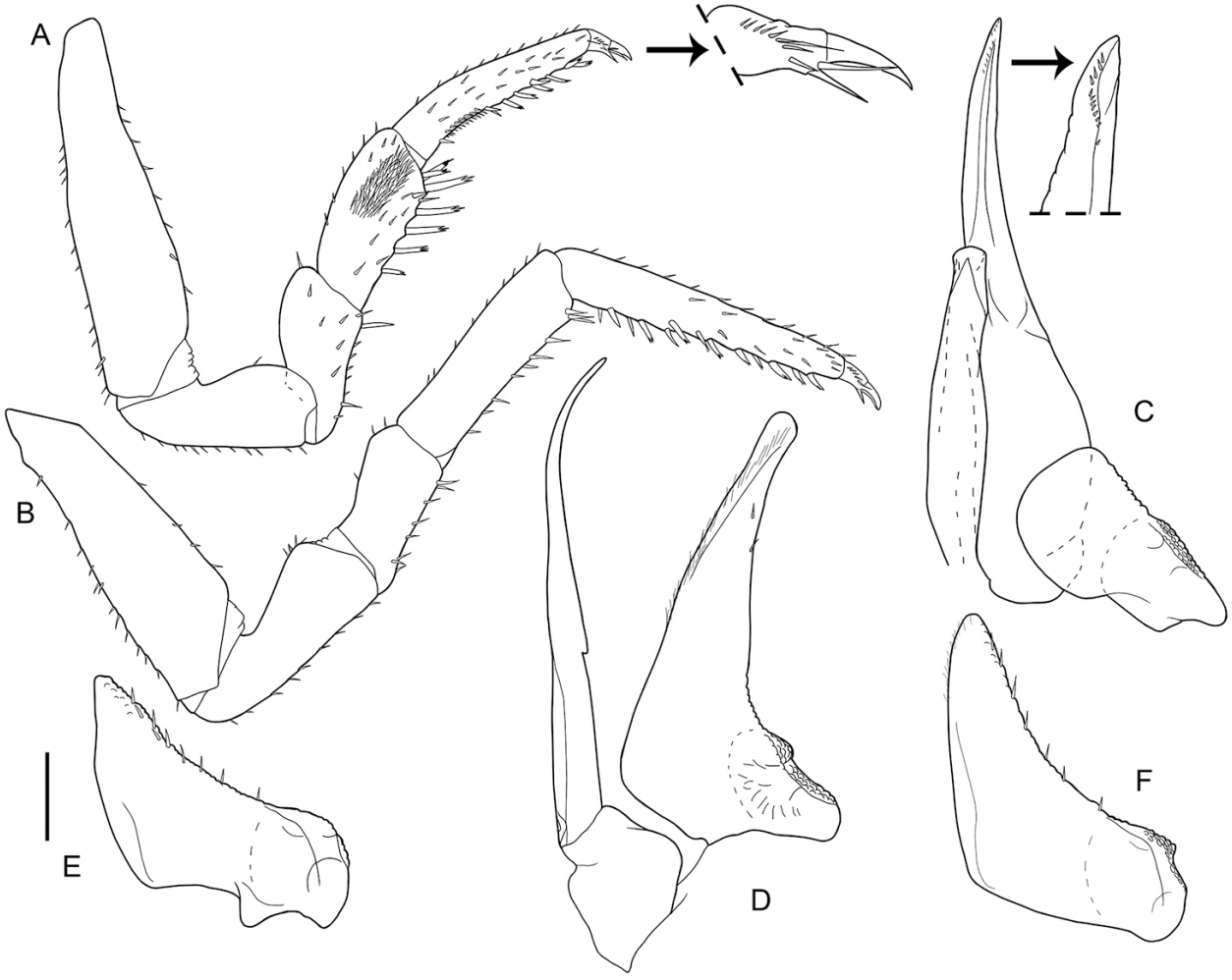

Figure 9. *Diploexochus obscurus* sp. nov., male paratype. **A**, Pereopod 1; **B**, pereopod 7; **C**, pleopod 1 and genital papilla; **D**, pleopod 2; **E**, pleopod 3 exopod; **F**, pleopod 4 exopod. Scale bar: 0.2 mm.

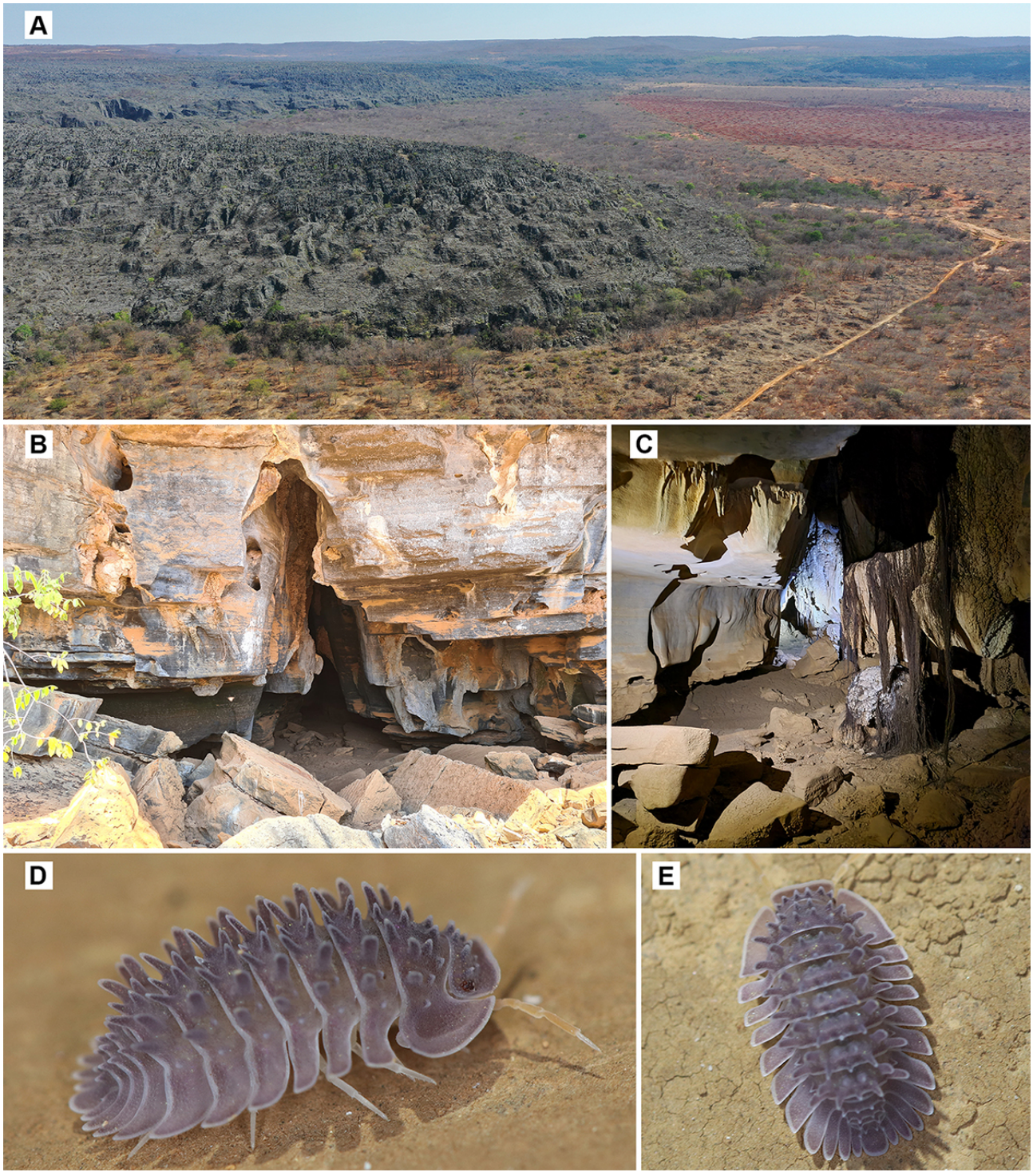

Figure 10. **A**, Karstic area surrounding Água Escura I cave; **B**, entrance of Água Escura I cave; **C**, conduit where the specimens were found; **D**, live specimen of *Diploexochus obscurus* sp. nov. in lateral view; **E**, live specimen of *Diploexochus obscurus* sp. nov. in dorsal view.

Finally, it is important to highlight the increase in threats to Brazilian speleological heritage. Even considering caves as possible peripheral habitats of the herein described species, the high degree of alterations in the external environments may have forced their populations to migrate into the caves. In turn, such subterranean habitats are under unprecedented threat due to recent changes in laws regarding the protection of Brazilian speleological heritage (Ferreira et al., 2022). Thus, although little is known about the real distribution of these new species, it is worrying that they may already be threatened.

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ADDITIONAL INFORMATION AND DECLARATIONS

Author Contributions

Illustrations and figures: GM; preparation, editing and review of the manuscript: GMC, RBP, RFL.

Consent for publication

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

Data availability

All data are archived within the Universidade Federal de Lavras (UFLA) in the Subterranean Invertebrate Collection of Lavras (ISLA – UFLA) at the Center of Studies on Subterranean Biology of the Federal University of Lavras (CEBS/UFLA, Lavras, Brazil), and available on request from RLF.

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