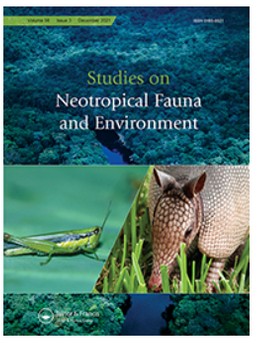

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ORIGINAL ARTICLE

Coarazuphium auleri sp. n. (Carabidae: Zuphiini), a new troglobitic ground-beetle in Central-Western Brazil

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ABSTRACT

In this paper, we describe *Coarazuphium auleri* **sp. n**. Until now, the species occurred in a single limestone cave, located at Nobres municipality (state of Mato Grosso – Central-Western Brazil). The new species comprises an apterous species from the genus *Coarazuphium* with the complete absence of hindwings, eyes are composed of very reduced eyes-scars, depigmentation and ommatidia are not evident. We also provide an updated key for species identification of *Coarazuphium* from the most recently published one. We followed the criteria of IUCN and classified the species as Critically Endangered – CR, IUCN criteria B1ab(iii)+2ab(iii), since the species has a restricted geographical distribution; estimated occurrence length <100 km^2; population in few locations and with a continued decline in area, extent, and quality of habitat. According to Brazilian law, the existence of a critically endangered species places the Lagoa Azul cave as one of maximum relevance.

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KEYWORDS
Cave; carabid; troglomorphisms; Araras karst formation; Neotropics

Introduction

The Neotropical genus *Coarazuphium* was described by Gnaspini et al. (1998). Nowadays, the genus includes 12 valid species, most are in Brazil and associated with the Bambui geomorphological unit, which includes *C. tessai* (Godoy & Vanin 1990), in Bahia state; *C. bezerra* Gnaspini, Vanin & Godoy 1998, at Goiás state; *C. pains* Álvares & Ferreira 2002 and *C. lundi* Pellegrini, Ferreira & Vieira 2020, these both in Minas Gerais state; and with the Carajás iron ore formation, including *C. tapiaguassu* Pellegrini & Ferreira 2011; *C. spinifemur* Pellegrini & Ferreira 2017; and *C. amazonicum* Pellegrini & Ferreira 2017, these three last in Pará state. The others are associated with the Caatinga formation, *C. formoso* Pellegrini & Ferreira 2011 and *C. caatinga* Pellegrini & Ferreira 2014; the Una group *C. cessaima* Gnaspini, Vanin & Godoy 1998, these three in Bahia state; and the Açungui group, only represented by *C. ricardoi* Benà & Vanin 2014, the Paraná state. The last species localization forms a large geographical gap, *C. whiteheadi* Ball & Shpeley 2013, found under rocks on the mountains of Oaxaca, Mexico (Ball & Shpeley 2013). All Brazilian species are considered troglobitic (*i.e.* obligatory cave-dwelling, which means that their populations are no longer able to colonize the surface environment), represented by endemic species. *Coarazuphium whiteheadi* is the only non-troglobitic species.

In Brazil, *Coarazuphium* species occur only in caves and present features considered typical troglomorphisms (e.g. elongated body and appendages, reduction until absence of eyes, and depigmentation). There is a single species that occurs in epigean habitats, *C. whiteheadi*, from Mexico, which also presents reduced eyes and depigmentation (Ball & Shpeley 2013). It is known that the arthropod fauna associated with deep leaf litter possesses morphological convergences with troglobitic species (Poulson & White 1969). Morphological studies involving *Coarazuphium* species suggest that the ancestral species of this group was probably well adapted to rainforest, living in deep leaf litter and pre-adapted to cave life (Ball & Shpeley 2013).

This study aims to describe a new species recorded in a single cave, the Lagoa Azul Cave in the municipality of Nobres, state of Mato Grosso. With the addition of this

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new species, the genus *Coarazuphium* contains 13 species. We discussed the morphological specializations of the group to cave life and provided an update on the key identification of *Coarazuphium* species. The conservation status of the new species followed the IUCN criteria.

Material and methods

Seven specimens were collected in the aphotic zone of Lagoa Azul Cave. The cave is inserted in the Speleological Province of Upper Paraguay – Araguaia, characterized by a straight strip that extends from the banks of the Araguaia River to the border with Bolívia, cutting the state in the east–west direction, with dozens of caves, mostly of carbonatic rock. This range contains the highest concentration of caves in the state. Geologically, the caves of this region are inserted in the Araras Group Formation, dated from Neoproterozoic, with a predominance of limestone and pelagic sediment, another layer of dolomitic limestone (Nogueira 2003).

The specimens are stored in vials containing 70% ethanol, deposited in the Scientific Collection of Laboratório de Estudos Subterrâneos (LES) from the Federal University of São Carlos (UFSCar), São Paulo, Brazil; Coleção Entomológica da Universidade Federal de Lavras (CEUFLA), Lavras, Brazil; and Museu de Zoologia da Universidade de São Paulo (MZUSP), São Paulo, Brazil. Detailed morphology of the specimens was visualized through a Stemi 508 (ZEISS) stereo microscope. Measurements and images were performed using the Leica M205 A stereo microscope, with the program Leica Application Suite auto-handing to combine the images, and the Axio Zoom V16 (ZEISS) stereo microscope. The images from the Leica M205 were used for making the hand-drawings; images from Axio Zoom V16 (ZEISS) were used for digital Photo-illustration.

Male genitalia was dissected and cleaned using fine entomological pins. For female genitalia, we followed procedures modified from Liebherr (2015), which consists first of the removal of the entire abdomen from the female also using fine entomological pins. Then, the abdomen was treated with an aqueous solution of cold 10% potassium hydroxide (KOH) for 24 hours. The female reproductive tract was placed in glycerin, isolated from other structures by first tearing off the tergites, then it was removed from the whole digestive tract and tracheae systems, and finally, the sternites were also removed. After that, the female reproductive tract was mounted on glass slides in Kayser glycerol gelatin using standard procedures developed for mites (Walter and Krantz 2009). Male and female genitalia were examined in a Zeiss Axio Scope A1 microscope equipped with phase contrast (DIC); photos and measurements were taken in an Axiocam 105 Color camera. Male and female genitalia drawings were made from the photos, female gonocoxites drawings were made using a camera Lucida apparatus from Leica DM750 phase-contrast microscope. Plates containing hand drawings and digital photo-illustrations were then mounted using Adobe Photoshop 2020 (version 21.2.1) software.

The names of structures on the male and female genitalia followed Ball and Shpeley (2013) and Liebherr and Will (1998),respectively. We used Ball and Shpeley (2013) measurement method combined with Pellegrini et al. (2020) – for head length – as follows:

Head length (**HL**) – linear distance from the apex of clypeus to the posterior margin of the postocciput;

Head width (**HW**) – maximum distance across head, including eyes;

Antenna length (**AL**) – from the base of the scape to tip of the antennomer 10th.

Pronotum length (**PL**) – linear distance from anterior to posterior margin, measured along the midline;

Pronotum maximum width (**PW**) – greatest linear transverse distance;

Elytra length (**EL**) – linear distance from humerus to apex;

Elytra maximum width (**EW**) – greatest linear transverse distance;

Hind wing length (**HWL**) – greatest linear transverse distance;

Overall body length (**OBL**) – the sum of HL, PL, and EL.

To express quantitative proportions of the phallus, measurements were made using left lateral and dorsal aspects as illustrated in Ball and Shpeley (2013): 42 and 45, Figure and 13:

Phallus length (**PAL**) – measured in a straight line from basal to apical margin;

Phallus width (**PAW**) – maximum transverse distance across the shaft, in dorsal aspect.

Ostial membrane length (**OML**) – measured in a straight line from basal to apical margin;

Left paramere length (**LPL**) – measured in a straight line from basal to apical margin;

Right paramere length (**RPL**) – measured in a straight line from basal to apical margin.

The acronym used for the collection where the types are deposited is:

LES Scientific Collection of Laboratório de Estudos Subterrâneos from Universidade Federal de São Carlos UFSCar, São Carlos, São Paulo, Brazil. Curator: Maria Elina Bichuette.

MZUSP Coleoptera Collection of Museu de Zoologia da Universidade de São Paulo (Zoology

Museum of the University of São Paulo), São Paulo, São Paulo, Brazil. Curator: Sônia Aparecida Casari.

CEUFLA Entomological Collection of Universidade Federal de Lavras, Lavras, Minas Gerais, Brazil. Curator: Marcel Gustavo Hermes.

Results

Taxonomy

Family CARABIDAE Latreille, 1802
Tribe Zuphiini Bonelli, 1810
Genus *Coarazuphium* Gnaspini, Vanin & Godoy 1998
Coarazuphium auleri **sp. n**. Pellegrini & Vieira

Type material.

Holotype: BRAZIL, 1 ♂, Mato Grosso, Nobres municipality, Lagoa Azul cave; 14°26′48.1”S 56°01′33.2”W, 323 m asl; 5 May 2015; M.E. Bichuette, A. Chagas-Jr., G. A. Nunes leg.; MZUSP – 46,485. Remarks: genitalia dissected.

Paratype I: BRAZIL, 1 ♂, Mato Grosso, Nobres municipality, Lagoa Azul cave; 14°26′48.1”S 56°01′33.2”W, 323 m asl; 5 May 2015; M.E. Bichuette, A. Chagas-Jr., G. A. Nunes leg.; MZUSP – 46,486.

Paratype II: BRAZIL, 1 ♂, Mato Grosso, Nobres municipality, Lagoa Azul cave; 14°26′48.1”S 56° 01′33.2”W, 323 m asl; 5 May 2015; M.E. Bichuette, A. Chagas-Jr., G. A. Nunes leg.; MZUSP – 46,487. Remarks: genitalia dissected.

Paratype III: BRAZIL, 1 ♀, Mato Grosso, Nobres municipality, Lagoa Azul cave; 14°26′48.1”S 56° 01′33.2”W, 323 m asl; 5 May 2015; M.E. Bichuette, A. Chagas-Jr., G. A. Nunes leg.; MZUSP – 46,488. Remarks: genitalia dissected; abdomen and elytra separated from head and pronotum.

Paratype IV: BRAZIL, 1 ♂, Mato Grosso, Nobres municipality, Lagoa Azul cave; 14°26′48.1”S 56° 01′33.2”W, 323 m asl; 5 May 2015; M.E. Bichuette, A. Chagas-Jr., G. A. Nunes leg.; LES 20176. Remarks: genitalia dissected.

Paratype V: BRAZIL, 1 ♂, Mato Grosso, Nobres municipality, Lagoa Azul cave; 14°26′48.1”S 56° 01′33.2”W, 323 m asl; 5 May 2015; M.E. Bichuette, A. Chagas-Jr., G. A. Nunes leg.; CEUFLA COL 0000001.

Additional material. BRAZIL, 1♀, Nobres, MT; 5 May 2015; M.E. Bichuette, A. Chagas-Jr., G. A. Nunes, Cols.; LES 20178. 1♂, Nobres, MT; 5 May 2015; M.E. Bichuette, A. Chagas-Jr., G. A. Nunes, Cols., LES 20175.

Type locality. The holotype is known from Lagoa Azul Cave (14°26′48.1”S 56°01′33.2”W, 323 m asl) (Figures 1–4).

Diagnosis. All characteristics of *C. auleri* **sp. n**. are consistent with the description of the genus *Coarazuphium*. This species differs from all other *Coarazuphium* by the following combination of characters: very reduced, flattened and depigmented eyes; apterous; elytra elongate, oval, with apical margin truncate, not sinuate and maximum width in the middle; head capsule dorsally with anterior pair of supraorbital setae (**asos**); one pair of postocular setae (**pos**) and a posterior pair of supraorbital setae (**psos**); the male genitalia right paramere is elongate, almost reaching the left paramere apices.

Description. Holotype male (Figures 5–8). OBL: 3.77 mm ♂ and 4.08 mm ♀; EW: 1.29 mm ♂ and 1.53 mm ♀; HW/PW: 0.92 ♂ and 0.87 ♀. Body pale brown color with dorsal integument covered with short recumbent hairs. Measurements are given in Table 1.

Head. Subtrapezoidal (Figures –9), HW/HL: 0.88 ♂ and 0.79 ♀; HW: 0.77 mm ♂ and 0.83 mm ♀. Head almost as wide as the pronotum. Eyes flattened, ommatidia not evident at 50x. Fixed setae disposition on the dorsal head: an anterior pair of supraorbital (**asos**) above eyes; one pair of postocular (**pos**) immediately behind eyes, laterally; and one posterior pair of supraorbitals (**psos**) posteriad eyes; ventrally are one pair of setae next to the gular region (Figure 9). Eyes situated laterally at the end of the genal sulcus (**gs**), reduced (Figure 9), depigmentation and ommatidia are not evident.

Antennae. Antennae filiform and flagellar (Figures 7–8), AL: 3.04 mm ♂ and 2.86 mm ♀; AL/PL: 3.63 ♂ and 3.37 ♀. First antennomere (scape) with a long seta distally close to the apical portion, and row of several semi-erect setae; 2nd very short. Segment 3 elongate, segments 4–10 subequal, and almost round in cross-section, except for the tip of the terminal antennomere, which is laterally flattened.

Pronotum. Shape trapezoidal, PL/PW: 1 ♂ and 0.89 ♀ (Figures 7–10). Maximum widths close to anterior angle, which is a little wider than head. Anterior angle rounded. Posterior angle acute. Dorsal surface with two pairs of lateral marginal erect setae: one close to the anterior 1/8 angles and the other shorter, close to the posterolateral angles. Ventral surface with one pair of anterior setae medially located (Figure 10).

Elytra. Elytra are free, EL/EW: 1.60 ♂ and 1.42 ♀ (Figures 7–8). Maximum width at the middle, EW/PW: 1.54 ♂ and 1.60 ♀. Apex of elytra truncate, not sinuated (Figure 8). Seven large setae on each elytron: three close to the anterior angle, two marginal in lateral posterior half, and two in posterior margin. Shorter setae located along lateral margin of elytra.

Hind wings. Absent (Figure 6).

Table 1. *Coarazuphium auleri* **sp. n.** body measurements given in millimeters. *NA* is in case the structure is broken.

Individual ID	*C. auleri* **sp. n.** Holotype MZSP-46485	*C. auleri* **sp. n.** Paratype I MZSP-46486	*C. auleri* **sp. n.** Paratype II MZSP-46487	*C. auleri* **sp. n.** Paratype III MZSP-46488	*C. auleri* **sp. n.** Paratype IV LES-20176	*C. auleri* **sp. n.** Paratype V COL-0000001
Sex	♂	♂	♂	♀	♂	♂
OBL	3.771	3.794	4.218	4.264	3.978	4,044
HL	0.872	0.912	1.174	1.230	1.002	0,986
HW	0.769	0.793	0.770	0.829	0.842	0,849
PL	0.836	0.808	0.861	0.849	0.851	0,864
PW	0.836	0.874	0.959	0.957	0.914	0,900
EL	2.063	2.074	2.183	2.185	2.125	2,194
EW	1.290	1.369	1.449	1.534	1.420	1,417
AL	3.037	3.011	3.229	2.858	*NA*	3,058
Profemur	0.975	0.922	1.053	0.921	1.071	0,899
Protibia	0.905	0.926	0.942	0.823	0.839	0,869
Protarsus	0.761	0.782	0.817	0.684	0.778	0,693
Mesofemur	0.916	0.926	0.974	0.902	0.934	0,942
Mesotibia	0.832	0.880	0.850	0.779	0.836	0,795
Mesotarsus	0.889	0.854	0.961	0.867	0.836	0,948
Metafemur	1.269	1.270	1.275	1.286	1.219	1,212
Metatibia	1.089	1.014	1.175	1.124	1.068	1,095
Metatarsus	1.193	1.215	1.306	1.139	1.241	1,263

Abdomen. Abdominal tergites 1–5, glabrous, sixth sternum with a small pair of ventral setae at its posterior margin.

Legs. Profemur 1.06 ♂ and 1.02 ♀ times longer than the mesofemur and 0.77 ♂ and 0.82 ♀ times the length of metafemur. Protibia 1.09 ♂ and 1.06 ♀ times longer than the mesotibia and 0.83 ♂ and 0.72 ♀ times the length of metatibia. Protibia 1.19 ♂ and 1.20 ♀ times longer than protarsus. Mesotibia 0.94 ♂ and 0.90 ♀ times the length of mesotarsus and metatibia 0.91 ♂ and 1 ♀ times the metatarsus. First tarsomere from pro-, meso-, and metatarsus almost equal to tarsomeres 2–4 together. Length of protibia and tarsus together 1.99 ♂ and 1.78 ♀ times the length of the pronotum. Mesotibia and tarsus length 2.06 ♂ and 1.94 ♀ times, and metatibia and tarsus length 2.73 ♂ and 2.68 ♀ times the length of pronotum.

Male genitalia. Phallus elongate and narrow (PAW/PAL: 0.23), slightly curved ventrally, tip narrowed and rounded, apical portion short (APL/PAL: 0.09), ostial membrane not very extensive (OML/PAL: 0.29) (Figures 11–13). Left paramere subtriangular or inverse t-shaped, conchoids (Figure 11). Right paramere long and slender, apex almost reaching the left paramere (RPL/LPL: 0.84) (Figure 13). The male genital segment is triangular shaped.

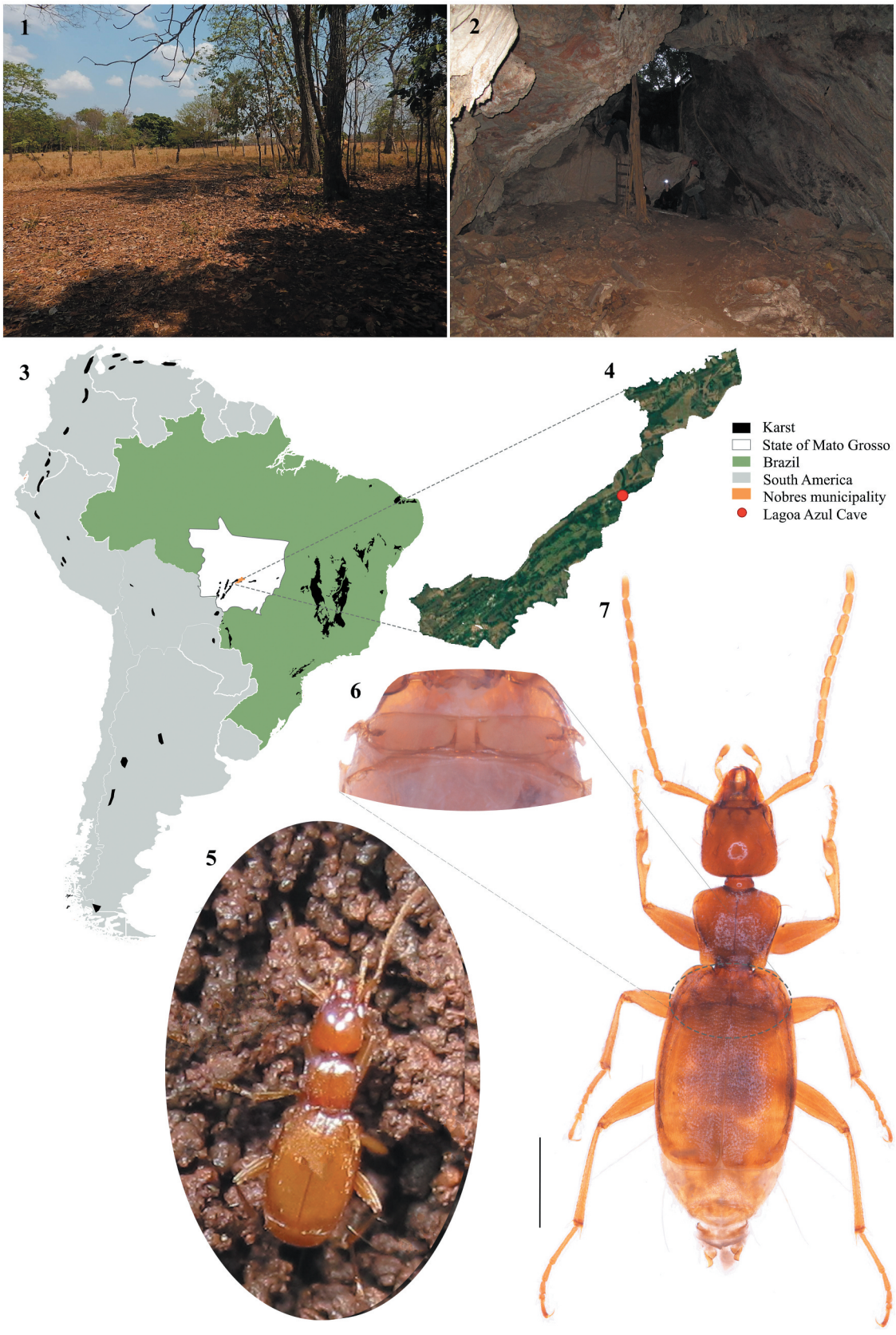
Female reproductive tract. Ovipositor (Figures 15–17): basal gonocoxite 1 (**gc1**) longer than apical gonocoxite 2, with patch of long trichoid setae in distal margin on ventral surface; gonocoxite 2 (**gc2**) strongly curved, falciform in lateral aspect, apex pointed, with preapical setose organ (**pso**) circuloid in lateral view; ventral surface with many marginal pit pegs (**mpp**); dorsal surface with marginal pit pegs and (**st**) trichoid setae. Female genital tract totally membranous (Figure 14). Bursa copulatrix (**bc**) bulbous, expanded on the bursal saculus (**bs**) anteriorly to insertion point of common oviduct (**co**). Spermatheca (**sp**) inserted near the junction of common oviduct and bursa copulatrix, is markedly elongated and slender, winding distally. The spermathecal gland duct (**spgd**) is broken and partially represented, with a distinct swelling close to spermathecal gland (**spg**). Without secondary spermathecal gland.

Etymology. The specific epithet '*auleri*' is named after Augusto Auler for his important contribution to Brazilian speleology and cave research.

Habitat and ecological notes. Lagoa Azul Cave (Figs. 1–4), the type-locality of *C. auleri* **sp. n.**, is a limestone cave (dolomitic), partially flooded by phreatic waters. The specimens were observed only in the aphotic zone of the cave (darkness), distant ca. 400 m from the main entrance, in a place with high humidity (ca. 80%) and temperature (24.5°C). The substrate where beetles occur is formed by silt, sand, and small roots, suggesting that the cave is shallow. *Coarazuphium auleri* **sp. n.** does not show a gregarious habit, since the individuals were observed relatively far from each other, ca. 1.5 m. The specimens showed constant activity, with rapid displacements in the substrate, not avoiding the light of flash lamps (light intensity of ca. 400 lumens).

Key to adult male and female species of the genus *Coarazuphium* (adapted from Pellegrini et al. 2020):

1. Maximum width near middle portion of elytra. Head elongate, HW/HL ratio about 0.6. Elytra with a deep sinuosity. Male genitalia: right paramere styliform (Gnaspini et al. 1998: 306, Figure), about as long as left paramere … … … *C. cessaima* Gnaspini, Vanin & Godoy 1998



Figures 1–7. Geographic localization and habitus of *C. auleri* **sp. n. 1**. Surface environment of Lagoa Azul cave, type locality; **2**. Lagoa Azul cave entrance aspect, type locality; **3**. Localization of Nobres municipality in the state of Mato Grosso, Brazil and South America; The black areas correspond to the limestone groups in South America; **4**. Localization of Nobres municipality represented by the Orange dot and Lagoa Azul cave type locality represented by the red star; **5**. *Coarazuphium auleri* **sp. n**. living specimen; **6**. Digital Photo-illustration of *C. auleri* **sp. n**. hindwings absent detail in dorsal aspect; **7**. Digital Photo-illustration, female *C. auleri* **sp. n**. habitus dorsal aspect. Bar scale = 0.5 mm. (Photographs 1, 2, 5 are from M. E. Bichuette).

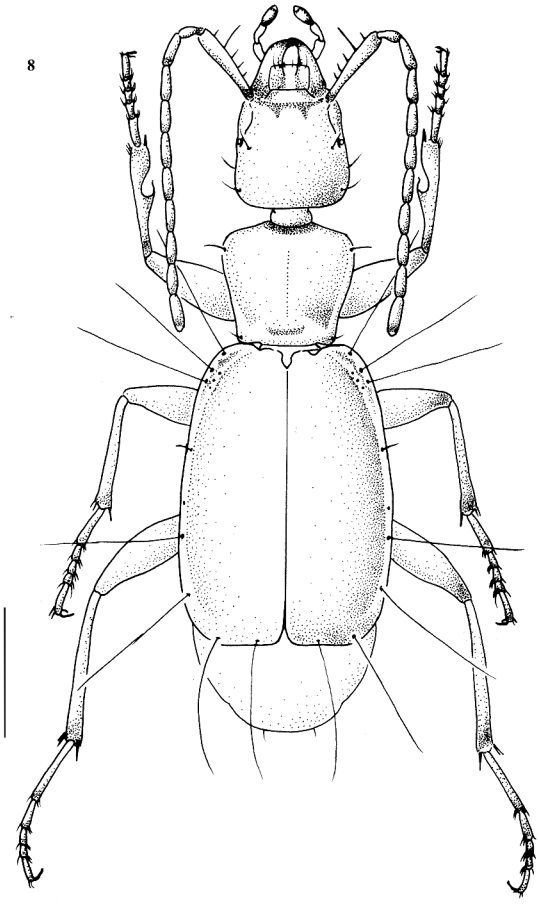


Figure 8. Line-illustration of *C. auleri* **sp. n**. male holotype, habitus dorsal view. Bar scale = 0.5 mm.

1′. Maximum width of elytra near middle or posterior middle. Head oviform to subquadrangular, HW/HL ratio from 0.75 to more than 1. Male genitalia: right paramere styliform or not, distinctly shorter than left paramere … … … …. 2

2(1′). Elytron with apical margin truncate (Figure 7), not sinuate. Male right paramere styliform or broad … … … … … … …. …. …. … … 3

2′. Elytron with apical margin sinuate (Pellegrini & Ferreira 2014: 529, Figure 2A), or with a slight sinuosity (Pellegrini et al. 2021: 291, Figure 5). Male right paramere broad, not styliform, distinctly shorter than left paramere … … … … … … … … … .9

3(2). Head dorsally bearing only one pair of anterior supraorbital setae and a pair of postocular setae (pos) (Pellegrini & Ferreira 2017: 556, Figure 5) … … … … … … … … .4

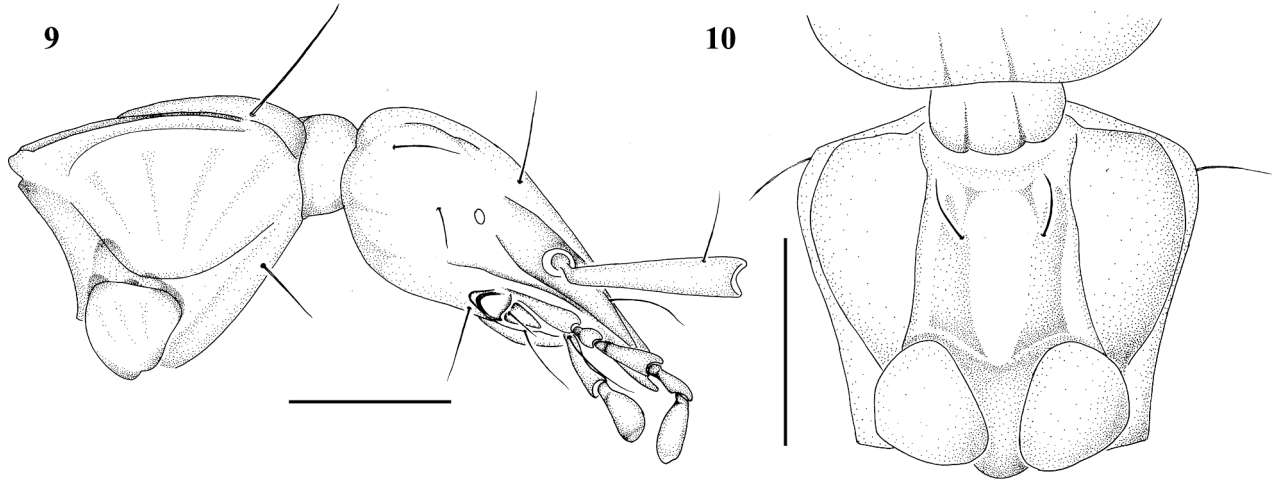
3′. Head dorsally with more than two pairs of setae – if with only two pairs it possesses a posterior supraorbital setae (psos) instead of the postocular (pos) pair … … … … 6

4(3). Metafemur bearing a spine on the middle ventral side (Pellegrini & Ferreira 2017: 556, Figure 4); antennae short, about 0.68 times body length … … … … … …... … … … … … … … …. … … … … … … *C. spinifemur* Pellegrini & Ferreira 2017

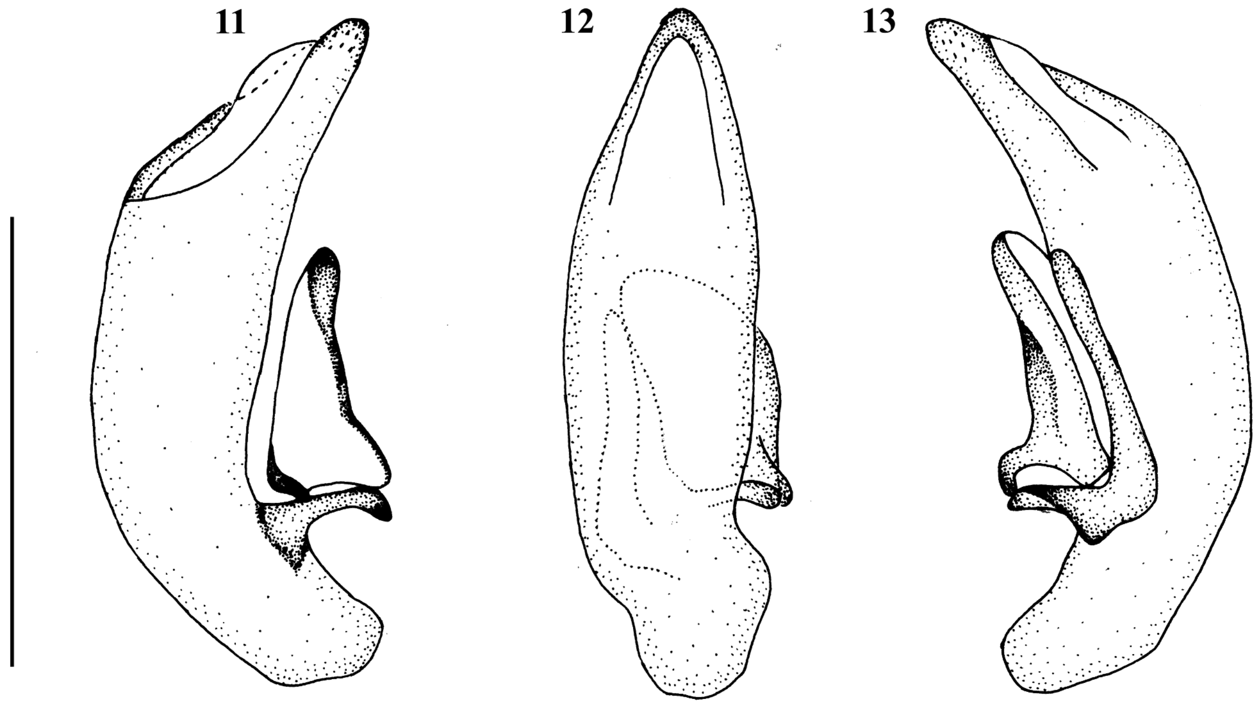
4`. Metafemur without a spine on the middle ventral side; antennae long, reaching metafemur … … … … … … … …. … … … … … … … …. … … … … … … … … … 5

5(4`). Aedeagus very long and slender, about 2.89 times left paramere (Pellegrini & Ferreira 2011b: 49, Figure 2D) … … … … *C. tapiaguassu* Pellegrini & Ferreira 2011

5`. Aedeagus shorter, about 2.6 times left paramere (Pellegrini & Ferreira 2017: 557, Figure 6 C). …



Figures 9, 10. Line-illustration of *C. auleri* **sp. n**. male holotype. **9**. Head, pronotum and prothorax, lateral view. Bar scale = 0.5 mm. **10**. Prothorax, ventral view. Bar scale = 0.5 mm.



Figures 11–13. Line-illustration of *C. auleri* **sp. n.** male holotype genitalia. **11**. Aedeagus left view; **12**. Aedeagus dorsal view; **13**. Aedeagus right view. Bar scale = 0.1 mm.

… … … … …. … … ….*C. amazonicum* Pellegrini & Ferreira 2017

6(3′). Head with two pairs of occipital setae (Ball & Shpeley 2013: 30, Figure 4A) …. *C. whiteheadi* Ball & Shpeley 2013

6′. Head with one pair or without occipital setae … …………………………………… 7

7(6). Head without postocular setae (Bená & Vanin 2014: 291, Figure 6). Maximum width of elytra near middle (Bená & Vanin 2014: 289 and 290, Figures 1 and 4) …. … … … … … …. … … … *C. ricardoi* Bená & Vanin 2014

7′. Head with postocular setae (Figure 9) … … … ……………………………………….8

8(7`). One pair of prosternal setae on the head dorsally (Figure 9) …… *C. auleri* **sp. n.**

8`. Two pairs of prosternal setae on the head dorsally (Pellegrini et al. 2020: 297, Fig. 22). ……… … … … … … … … … … … … *C. pains* Álvares & Ferreira 2002

9(2′). Head dorsally with three pairs of setae posteriad the anterior supraorbital setae (Pellegrini & Ferreira 2014: 529, Figure 2B) … … … … … ………… 11

9′. Head dorsally with one or two pairs of setae posterior to the anterior supraorbital setae (Gnaspini et al. 1998: 305, Figure 2) … … … ………………………………….12

10(9′). Elytra margins slightly rounded (Pellegrini et al. 2020: 291, Figure 5). Male right paramere short and triangular, not styliform (Pellegrini et al. 2020: 293, Figure 10) ………………………………… …… *C. lundi* Pellegrini et al. 2020

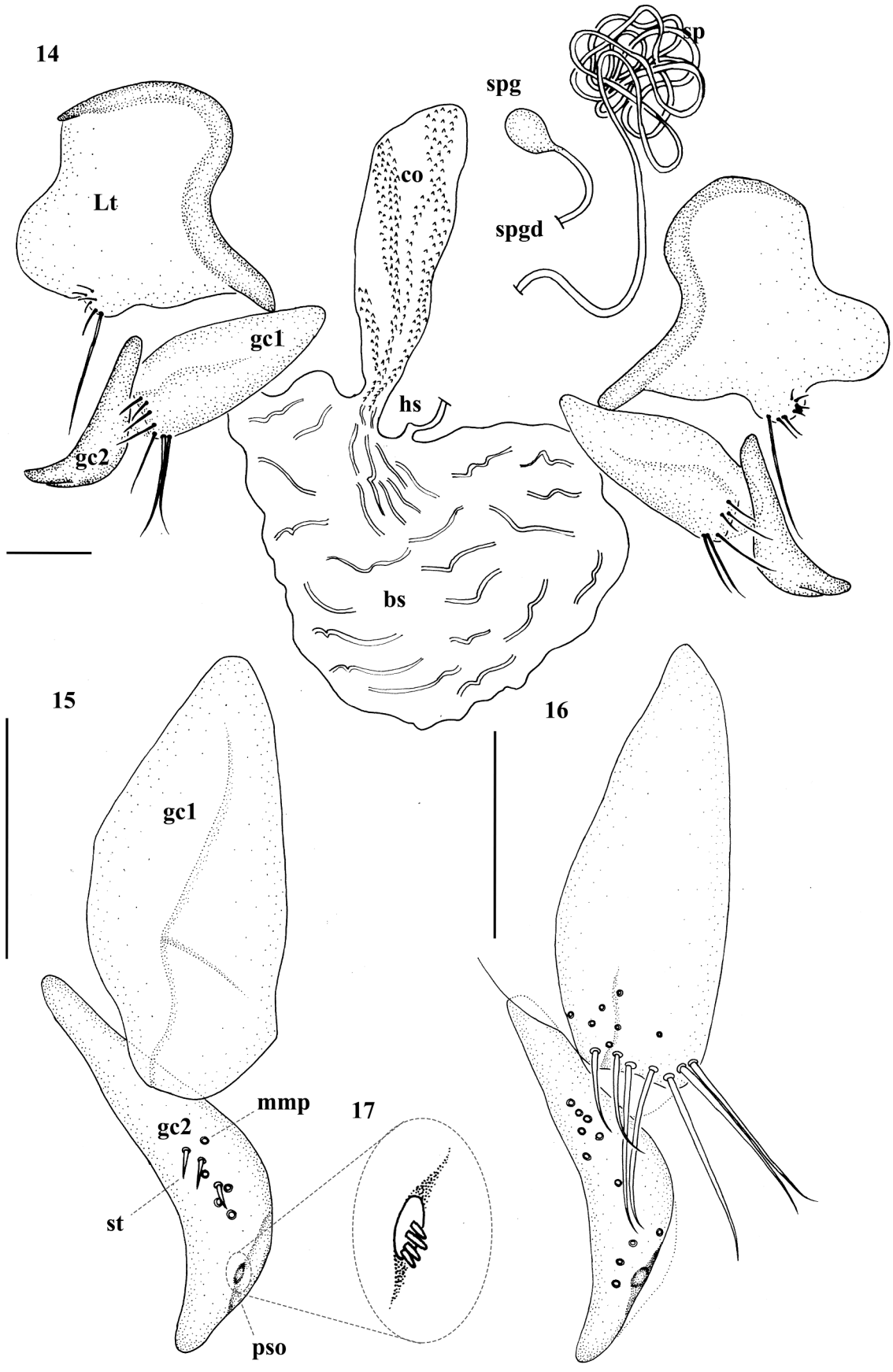
10′. Elytra margins straight, rectangular shape. Male right paramere slender, styliform (Pellegrini & Ferreira 2010: 535, Figure 10) …. …. …. …. …. …. …. …. …. 11

11(10). Slight apical sinuosity of elytron (Pellegrini & Ferreira 2014: 537, Figure 12A and C) ……… ………… *C. formoso* Pellegrini & Ferreira 2011

11′. Pronounced apical sinuosity of elytron, dorsal aspect of the head with two protuberances (Pellegrini & Ferreira 2014: 537, Figure 12B and D) …………………………………. ……… *C. caatinga* Pellegrini & Ferreira 2014

12(10′). Head dorsally with two pairs of setae (posterior supraorbitals and occipitals) at posterior border of head capsule (Gnaspini et al. 1998: 304, Figure 1). Male left paramere broad, conchoid (Gnaspini et al. 1998: 305, Figure 3) … … … … … … … … … …………….. …………………. …… *C. bezerra* Gnaspini, Vanin & Godoy 1998

12′. Single pair of setae (posterior supraorbitals) at posterior border of head capsule (Godoy & Vanin 1990: 796, Figure 1). Male left paramere styliform (Godoy & Vanin 1990: 798, Figure 2) … … … … … …. … *C. tessai* (Godoy & Vanin 1990)



Figures 14–17. Line-illustration of *C. auleri* **sp. n.**, female genitalia. **14**. Female reproductive tract in dorsal aspect. Bar scale = 500 µm. **15**. Gonocoxites, dorsal aspect. Bar scale: 125 µm. **16**. Gonocoxites, ventral aspect. Legend: (**bs**) bursa copulatrix; (hs) helminthoid sclerite; (**co**) common oviduct; (**sp**) spermatheca; (**spgd**) spermathecal gland duct; (**spg**) spermathecal gland; (**Lt**) laterotergite; (**gc1**) gonocoxite 1; (**gc2**) gonocoxite; (**st**) trichoid setae; (**pso**) preapical setose organ; (**mmp**) marginal pit pegs. Bar scale: 125 µm. **17**. Preapical setose organ in detail.

Discussion

Taxonomic discussion

Coarazuphium auleri **sp. n**. together with *C. spinifemur*, comprise the smallest species of this genus. The most striking differences between *C. auleri* **sp. n**. and *C. spinifemur* is the absence of the femoral spine in *C. auleri* **sp. n**. and the absence of posterior supraorbital setae on the head of *C. spinifemur*. *Coarazuphium auleri* **sp. n**. is also similar to those species with truncated elytra margins, which include *C. pains, C. tapiaguassu, C. amazonicum, C. spinifemur, C. ricardoi* and *C. whiteheadi*. However, all the species mentioned above differ from *C. auleri* **sp. n**. by the disposition of fixed setae dorsally on the head. *Coarazuphium pains* and *C. whiteheadi* have four pairs of fixed setae each; *C. tapiaguassu, C. amazonicum, C. spinifemur, C. ricardoi* have two pairs each; while *C. auleri* **sp. n**. has three pairs of fixed setae. On the other hand, species of *Coarazuphium* with three pairs of fixed setae dorsally on the head include *C. cessaima* and *C. tessai*. *Coarazuphium auleri* **sp. n**. differs from *C. cessaima* especially by the deep sinuosity of the elytra margins in *C. cessaima*, which is truncated in the new species. The elytra margins sinuate in *C. tessai* also differentiate it from *C. auleri* **sp. n**.; moreover *C. tessai* bears one pair of short setae behind the scutellum and two discal pairs which are absent in the new species (Godoy & Vanin 1990).

As mentioned before, all Brazilian species of *Coarazuphium* are found only in caves and are considered troglobitic. But, the total absence of hindwings, a remarkable troglomorphism, is a characteristic shared only by *C. auleri* **sp. n**. and *C. tessai*. *Coarazuphium cessaima* is considered the most specialized troglobitic beetle in Brazil (Gnaspini et al. 1998), with a very elongate body and appendices, the smallest eye spots of the genus, but still has reduced hindwings (Pellegrini et al. 2020). The variability of the degree of morphological adaptation to cave life in a taxon is favored by the occurrence of multiple isolated populations independently (Faille et al. 2014). According to Gnaspini et al. (1998) and reinforced by Ball and Shpeley (2013), an ancestral *Coarazuphium* species would probably have inhabit regions of Neotropical forests, colonized the humid caves, and became isolated in the early Tertiary Period (from about 65 to 48 million years ago), when the surface environment became drier. For the Mexican species, it was possible to remain in the surface environment, inhabiting the humid forest in leaf litter and wet wood (Ball & Shpeley 2013). However, such interesting evolutionary history highlights the need for further studies on morphological, ecological and molecular data that lead to better conclusions about the phylogenetic relationships of the genus.

Final remarks. When we consider the Araras Group, which comprises caves mainly in the state of Mato Grosso, we observe a relatively high number of caves (ca 585 records according to the Brazilian National Register of Speleological Information database – CANIE – CECAV 2021). Recent studies have shown that Mato Grosso is also rich in singular and fragile cave fauna, with several records of troglobitic and new species, under description (M.E. Bichuette pers. obs). *Coarazuphium auleri* **sp. n**. comprises the third record of a troglobitic species at the state of Mato Grosso and the second described for Araras Group. According to Gallão and Bichuette (2018) the other troglobitic species for the state is the spelaeogriphacean *Potiicoara brasiliensis* Pires, 1987, a relict crustacean whose type-locality is in another geological Group (Corumbá) located at Mato Grosso do Sul state, and the recently described freshwater triclad, *Girardia nobresis* Morais & Leal-Zanchet 2021, found in a cave also located at Nobres municipality (Morais et al. 2021).

Many subterranean ecosystems in the state of Mato Grosso are too threatened by anthropogenic changes such as uncontrolled tourism, siltation resulting from deforestation (Figure 1), small hydroelectric stations, mining projects, subsoil contamination, large-scale agriculture projects, involving livestock and large plantations, to guarantee the sustainable use of soil and aquifers (Gallão & Bichuette 2018). Another problem is the lack of speleological management plans for the various tourist caves of Nobres, which are visited by the general public throughout the year.

The type-locality of *C. auleri* **sp. n**. is not protected legally and presents regular visitation throughout the year. Even more, its surroundings present several impacts due to deforestation for agriculture practices. *Coarazuphium auleri* **sp. n**. occurs exclusively in Lagoa Azul Cave, being considered a possible species endemic to its type-locality. By IUCN (International Union of Conservation of Nature) criteria, we propose the inclusion of the species in the IUCN list as Critically Endangered (CR) according to criteria B1ab (iii) + 2ab (iii). That is, the species has a restricted geographical distribution; estimated occurrence length <100 km^2; population in few locations, and continued decline in area, extent and quality of habitat. According to the Brazilian law, the existence of a critically endangered species places the Lagoa Azul cave as one of maximum relevance. Protection action is urgent to avoid loss of the habitat of an unique species.

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