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Description of two new species of *Charinus* Simon, 1892 from Brazilian caves with remarks on conservation (Arachnida: Amblypygi: Charinidae)

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Abstract

The genus *Charinus* comprises eleven described species in Brazil. Herein we describe two new species, *Charinus caatingae* **sp n.** and *Charinus iuiu* **sp n.**, from caves of the state of Bahia, Brazil. *Charinus caatingae* is threatened, requiring special attention to its conservation. Furthermore, we present an updated identification key and a table of characters for the genus in the country.

Key words: Neotropics, taxonomy, morphology, whip spider

Resumo

O gênero *Charinus* no Brasil compreende onze espécies descritas. Neste trabalho nós descrevemos duas novas espécies, *Charinus caatingae* **sp n.** e *Charinus iuiu* **sp n.**, de cavernas do estado da Bahia, Brasil. *Charinus caatingae* encontra-se ameaçado, necessitando de especial atenção em relação à sua conservação. Além disso, apresentamos uma chave de identificação atualizada e uma tabela de caracteres para as espécies do gênero no país.

Palavras chave: Neotrópico, taxonomia, morfologia, amblipígio

Introduction

Amblypygi Thorell, 1883 comprises one of the least diverse groups of Arachnida. Its number of species exceeds only Opilioacarida, Holothyrida, Ricinulei, Palpigradi and Thelyphonida (Harvey 2003; Zhang 2013). Seiter *et al.* (2015) counted current 190 species of Amblypygi based on Harvey (2013), Armas *et al.* (2014) and Seiter & Wolff (2014). However, including two species of the genus *Charinus* from Brazil that were not added to the count (Vasconcelos *et al*. 2013, 2014), plus the recent described species *Charinus sillami* Réveillion & Maquart 2015 from French Guiana (Réveillion & Maquart 2015), a total of 193 species have been recognized globally in the order.

The current distribution of Amblypygi covers Paleotropical and Neotropical regions to Southern United States, Australasia and the Mediterranean portion of Europe. However, the greatest diversity of Amblypygi lies in the Neotropics, which has about 100 described species (Harvey 2015). Within the Neotropical region, Cuba, Mexico and Brazil hold the diversity hotspots of the order.

Among the amblypygids, the genus *Charinus* is the most specious and widely distributed in the world. In Brazil, the genus includes eleven species: *Charinus schirchii* (Mello-Leitão, 1931), *Charinus brasilianus* Weygoldt, 1972, *Charinus montanus* Weygoldt, 1972, *Charinus asturius* Pinto-da-Rocha, Machado & Weygoldt 2002, *Charinus acaraje* Pinto-da-Rocha, Machado & Weygoldt 2002, *Charinus mysticus* Giupponi & Kury, 2002, *Charinus troglobius* Baptista & Giupponi, 2002, *Charinus eleonorae* Baptista & Giupponi, 2003, *Charinus vulgaris* Miranda & Giupponi, 2011, *Charinus potiguar* Vasconcelos, Giupponi & Ferreira 2013 and *Charinus jibaossu* Vasconcelos, Giupponi & Ferreira 2014. *Charinus schirchii* (Mello-Leitão, 1931) is currently considered as *species inquirenda,* since the holotype has been lost and its description is vague (Pinto-da-Rocha *et al*. 2002).

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Amblypygids are most active at night and shelter during the day under rocks, leaves, tree trunks or in caves (Weygoldt 2000). The caves make up environments with conducive conditions to house the Amblypygi fauna in Brazil, especially in Caatinga and Cerrado, since these biomes present reduced number of moist external microhabitats. In this work we describe two new species of *Charinus* collected in caves located in Caatinga in the state of Bahia, Brazil.

Material and methods

The specimens were collected through visual searching on floors and walls throughout the caves. The collects of the species were conducted in 2008, 2012 and 2014 during humid season in Várzea Nova, Bahia, Brazil, and in 2013 during dry season in Iuiu, Bahia, Brazil. All specimens were captured with a fine forceps and placed in vials containing 70% ethanol.

The descriptions of the species were based on the entire type material. The terminology of the pedipalp and legs followed Harvey & West (1998). The article called tarsus by Harvey & West (1998) is divided here into tarsus and claw (apotele), as there is no fusion of these two segments in Charinidae. For measurements and general terminology we followed the proposals of Quintero (1981). Measurements of the pedipalpal articles were taken between the condyles of each segment in order to establish fixed points and adequate length measurements. The terminology of the structures of male gonopods followed Giupponi & Kury (2013). Measurements were taken of the entire type-series and fully-grown specimens separately, presenting first their mean values followed by the range of variation in parentheses.

The following abbreviations are used: BT = basitibia; DT = distitibia; GO = genital operculum; Fi = fistula (gonopod tube); LoL1 = lobus lateralis primus; LoL2 = lobus lateralis secundus; LaM = lamina medialis; LoD = lobus dorsalis.

Photographs of the male gonopod were taken using Axio Scope A1 Axio Zoom V16, and the others using Leica M205A stereomicroscope with the software Leica Application Suite Automontage. Illustrations of the male and female gonopods were made using a camera lucida coupled to a Leica MDLS phase contrast microscope.

The specimens were deposited in the Seção de Invertebrados Subterrâneos, Coleção de Zoologia of the Universidade Federal de Lavras, Minas Gerais, Brazil (ISLA).

Additional material. *Charinus acaraje*: 4 females: BRAZIL, Bahia, Santa Luzia, Gruta Pedra do Sino (ISLA 3843, ISLA 3844, ISLA 3845, ISLA 3846); 1 female: BRAZIL, Bahia, Santa Luzia, Gruta Lapão de Santa Luzia (ISLA 3840).

Charinus potiguar: Paratypes: 1 male: BRAZIL, Rio Grande do Norte, Felipe Guerra, Caverna da Rumana (ISLA 1890); 1 male: BRAZIL, Rio Grande do Norte, Governador Dix-Sept Rosado, Gruta da Escada (ISLA 1894); 1 female: BRAZIL, Rio Grande do Norte, Felipe Guerra, Caverna do Pau (ISLA 3924); 1 female: BRAZIL, Rio Grande do Norte, Felipe Guerra, Caverna Buraco da Nega (ISLA 1875); 1 female: BRAZIL, Rio Grande do Norte, Governador Dix-Sept Rosado, Gruta Boca de Peixe (ISLA 1888).

Charinus asturius: 2 males: BRAZIL, São Paulo, Ilha Bela, Gruta da Serrania (ISLA 3917).

Charinus jibaossu: Paratypes: 1 male: BRAZIL, Minas Gerais, Arcos, Gruta da Cazanga (ISLA 3835); 1 male: BRAZIL, Minas Gerais, Arcos, Gruta Branca (ISLA 483); 1 male: BRAZIL, Minas Gerais, Pains, Gruta da Mineração (ISLA 480); 2 females: BRAZIL, Minas Gerais, Pains, Gruta da Vila Corumbá (ISLA 482, ISLA 3830).

Charinus troglobius: 1 male and 1 female: BRAZIL, Bahia, Carinhanha, Gruta do Peixe (ISLA 3680).

Charinus eleonorae: 1 male: BRAZIL, Minas Gerais, Itacarambi, Gruta Olhos d'Água (ISLA 1868).

Taxonomy

Charinidae Quintero, 1986

Charinus Simon, 1892

Type species: *Phrynus australianus* L. Koch, 1867, by original designation.

***Charinus caatingae* sp. n.**
(Figs. 1–11)

Type material. BRAZIL: *Bahia*: Várzea Nova: Fazenda Jurema cave (11º03´23.51"S, 41º05´34.47"W): Female holotype: 21.I.2012, *leg.* R. L. Ferreira (ISLA 3918); Female paratypes: 02.I.2008, *leg.* R. L. Ferreira (ISLA 3919; ISLA 3920; ISLA 3921; ISLA 4104); Female paratypes: 07.I.2014, *leg.* R. L. Ferreira (ISLA 4996; ISLA 4997). Male unknown.

Diagnosis. *Charinus caatingae* differs from others species of the genus by having the following combination of characteristics: anterior margin of the carapace slightly elongated with 8 strong setae; lateral eyes underdeveloped, being reduced by only an eyespot; tritosternum with 1 apical pair and 2 median pair of strong setae; pedipalpal femur with 5 dorsal spines (4 can be found) and 5 ventral (4 can be found), pedipalpal patella with 5 dorsal spines (can be found one more basal of reduced size) and 3 ventral (can be found one more basal of reduced size), and pedipalpal tarsus with 3 dorsal spines on the cleaning organ; female gonopods sucker-like, with length similar to the width, opening rounded, edges with a small fold and a pronounced bottleneck below these.

Description. Carapace (Figs. 1–3)**:** Flattened. Ratio length/width slightly more than 3/4. Anterior margin slightly elongated, with corners flattened downwards; 8 strong setae on the anterior margin projected upwards, the central two located directly in front of the median eyes tubercle. Frontal process triangular in shape, with thickened apex, length similar to the width and not visible in dorsal view. Carina begins at the corners of the anterior margin and extends from the coxa of legs II to the corners of the posterior margin. Median eyes developed, with low tubercle, located in a small depression. Lateral eyes underdeveloped, without pigmentation (little pigmentation in juvenile) and with 1 small posterior seta. Frontal hump present at each side, starting just at the front of the lateral eyes and ending in a depression located at each side; fovea located posterior to the center, from which radiate two pairs of furrows in anterior and posterior orientation like an X; median depression located on each side between these two pair of furrows; a thin furrow follows medially from the median eye tubercle and reaches the posterior margin. Punctuations in lines and spots, more dense in the anterior region.

Sternum (Fig. 5)**:** Tri-segmented, with all segments sclerotized and convex. Tritosternum projected anteriorly, elongated and cone-shaped, with one apical and two medial pairs of strong setae, and some setulae in the base. Second segment (tetrasternum) slightly conical shaped, with one strong seta at each upper corner and some setulae encircling the base. Third segment (pentasternum) a little more flattened than the second, with one strong seta at each upper corner and few setulae encircling the base. The segments are separated from each other approximately by the diameter of the tetrasternum.

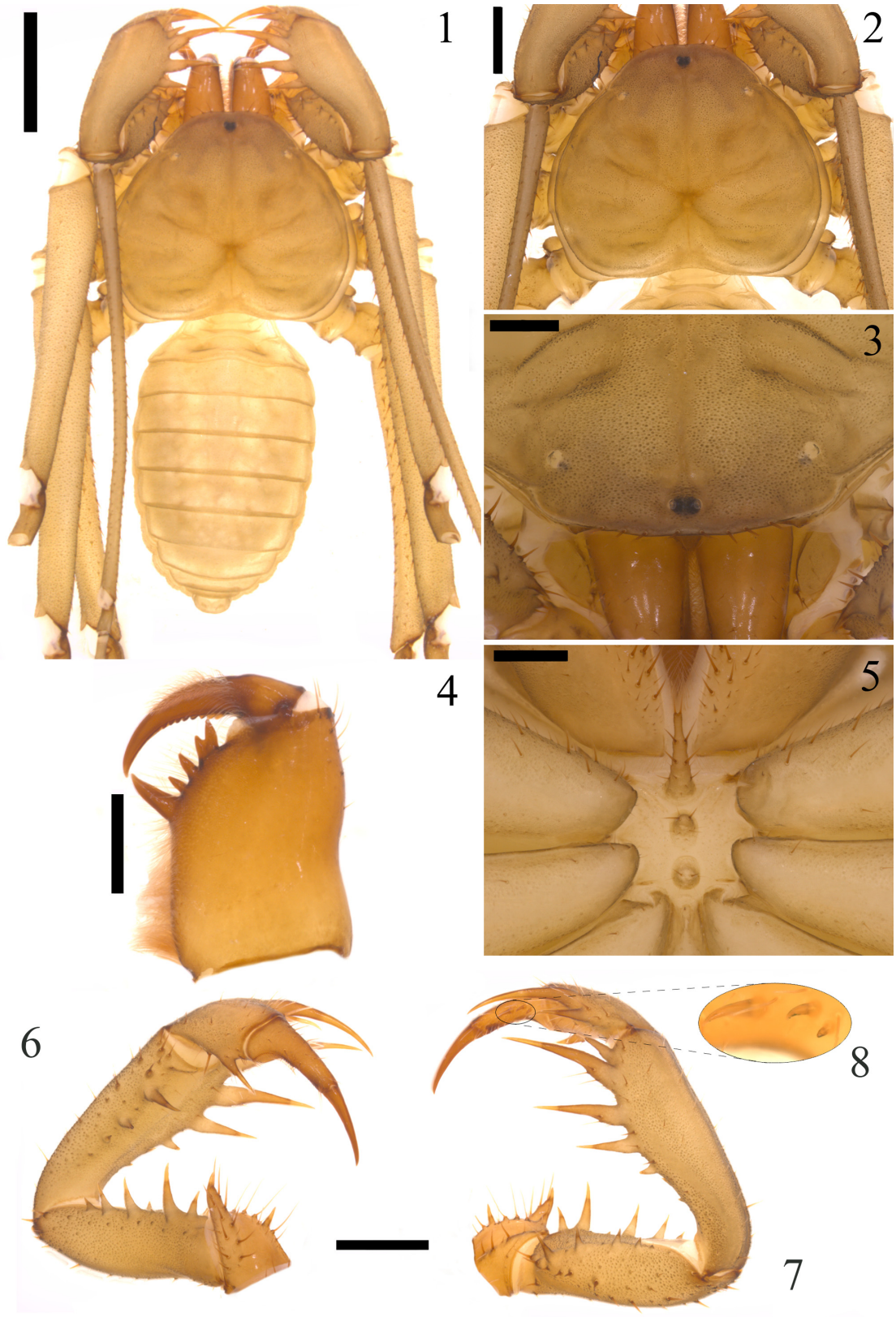
Abdomen (Fig. 1)**:** Oblong, with punctuations distinguishable.

Chelicera (Fig. 4)**:** Cheliceral furrow of the basal segment with 4 inner teeth. The distal tooth is bifid, the distal cusp being larger than the proximal. Teeth length: IV>Ia>Ib=II>III. Claw with 8 denticles (can be found up to 10). Strong setae located distally on the dorsal side of the chelicera.

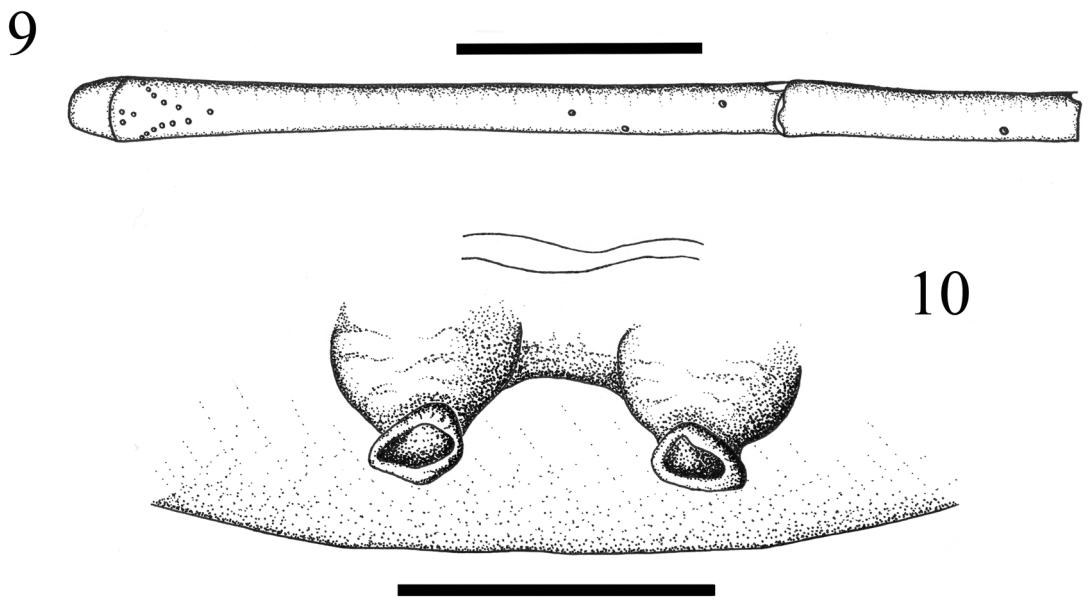
Pedipalp (Figs. 6–8)**: Trochanter:** Ventral spiniform apophysis pointed forwards with a series of strong setiferous tubercles. 2 spines aligned on the prolateral face, the first being near to the medial region, and the second above the projection of the apophysis and close to the femur. First spine is slightly thinner than the second one. Second spine and the spine AI of the ventral femur are subequal in some specimens. One or two strong setae of basal location to the first spine and three aligned between the two spines. Dorsal series of strong setae. **Femur:** Strong dorsal setae. 5 dorsal spines (4 can be found) of sizes: F1>F2>F3>F4>F5. 5 ventral spines (4 can be found) of sizes: FI>FII>FIII>AI>FIV. **Patella:** Strong dorsal setae between the spines. 5 dorsal spines (can be found one more basal of reduced size) of sizes: 1>2>3>A1>4>5. Strong ventral setae. 3 ventral spines (can be found one more basal of reduced size) of sizes: I>II>III. The spines III and IV (when present) are generally pointed forward. **Tibia:** Strong dorsal setae. 2 dorsal spines, spine 2 being approximately twice larger than the spine 1. One strong ventral setae in the basal portion of the ventral spine. 1 ventral spine located in the distal half of size slightly smaller than dorsal spine 1. **Tarsus:** Several strong dorsal setae and long ventral setae. 3 dorsal spines on the cleaning organ in ascending order of size, the third being three times larger than the first spine (Fig. 8). Cleaning organ occupies about half the length of the article. **Claw:** Long with sharp curved tip.

Legs: All densely setose. Femur lengths: I>III>II>IV. **Leg I**: Tibia with 23 articles and tarsus with 41 articles. **Leg IV** (Fig. 9)**:** Basitibia with 4 pseudo-articles. One trichobothrium located proximally on the last article. Distitibia with 3 trichobothria positioned proximally and 15 trichobothria positioned distally; frontal and caudal

series with 6 trichobothria each. Basitibia-distitibia length: DT>BT1>BT4>BT2=BT3. Ratio tarsus/metatarsus is approximately 3/4. Tarsus composed of 4 segments.



FIGURES 1–8. *Charinus caatingae* **sp. n.:** Holotype: 1. Habitus. Scale bar = 2 mm. 2. Carapace. Scale bar = 1 mm. 3. Frontal view of the carapace and frontal process. Scale bar = 500 µm. Paratype: 4. Right chelicerae. Scale bar = 500 µm. Holotype: 5. Sternum. Scale bar = 500 µm. 6. Right pedipalp in ventral view. 7. Right pedipalp in dorsal view with spines on the tarsus detached. Scale bar = 1 mm. 8. Spines on the tarsus of the right pedipalp in detail.



FIGURES 9–10. *Charinus caatingae* **sp. n.:** Holotype: 9. Distitibia and last pseudo-article of the basitibia of the left leg IV. Scale bar = 1 mm. 10. Female gonopod. Scale bar = 250 µm.

Measurements (total specimens=7): Total length: 8.29 mm (5.29–12.60). Cephalothorax: Length: 3.10 mm (2.32–4.54); Width: 4.03 mm (2.96–5.70). Pedipalp: Femur: 2.24 mm (1.38–4.21); Patella: 2.43 mm (1.48–4.75); Tibia: 1.13 mm (0.78–1.89); Tarsus: 0.86 mm (0.62 – 1.38); Claw: 0.70 mm (0.52–1.06). **Measurements (fully-grown specimens=4):** Total length: 9.91 mm (8.84–12.60). Cephalothorax: Length: 3.60 mm (3.08–4.54); Width: 4.69 mm (3.88–5.70). Pedipalp: Femur: 2.80 mm (2.02–4.21); Patella: 3.05 mm (2.11–4.75); Tibia: 1.35 mm (1.08–1.89); Tarsus: 1.01 mm (0.84 – 1.38); Claw: 0.81 mm (0.64–1.06).

Color: Body light brown with reddish chelicerae (Fig. 11E). In alcohol (Fig. 1): Body yellowish brown in general. Some specimens exhibit slightly reddish coloration on the carapace, pedipalps, chelicerae and legs.

Genitalia: Female (Fig. 10)**:** Rounded genital operculum margin with few scattered setae. Gonopods sucker-like, barrel shaped and with length similar to the width. Gonopods opening rounded; edges with a small fold and a pronounced bottleneck below these. Gonopods separated from each other by a distance smaller than its diameter and positioned from the margin of the operculum by a distance larger than its length.

Etymology. The specific epithet "caatingae" is treated as a noun in apposition and refers to the biome (Caatinga) where the species inhabits.

Natural history. The Fazenda Jurema cave belongs to the Una limestone group (Fig. 27), and is located in the Caatinga biome, which is the only semi-arid biome occurring in Brazil (Fig. 11A) (De Oliveira *et al.* 2012). It comprises a relatively small cave (around 100 meters long), with a single small entrance. The cave conduit descends in a considerable slope reaching the final chamber, in which the phreatic level is observed. Specimens were mainly found in this final portion of the cave. Many other caves were sampled in the area, and specimens of *C. caatingae* were only found in the Fazenda Jurema cave, which suggests that the species is endemic to this single locality. Potential preys include crickets (*Endecous* sp.) and moths (Tineidae).

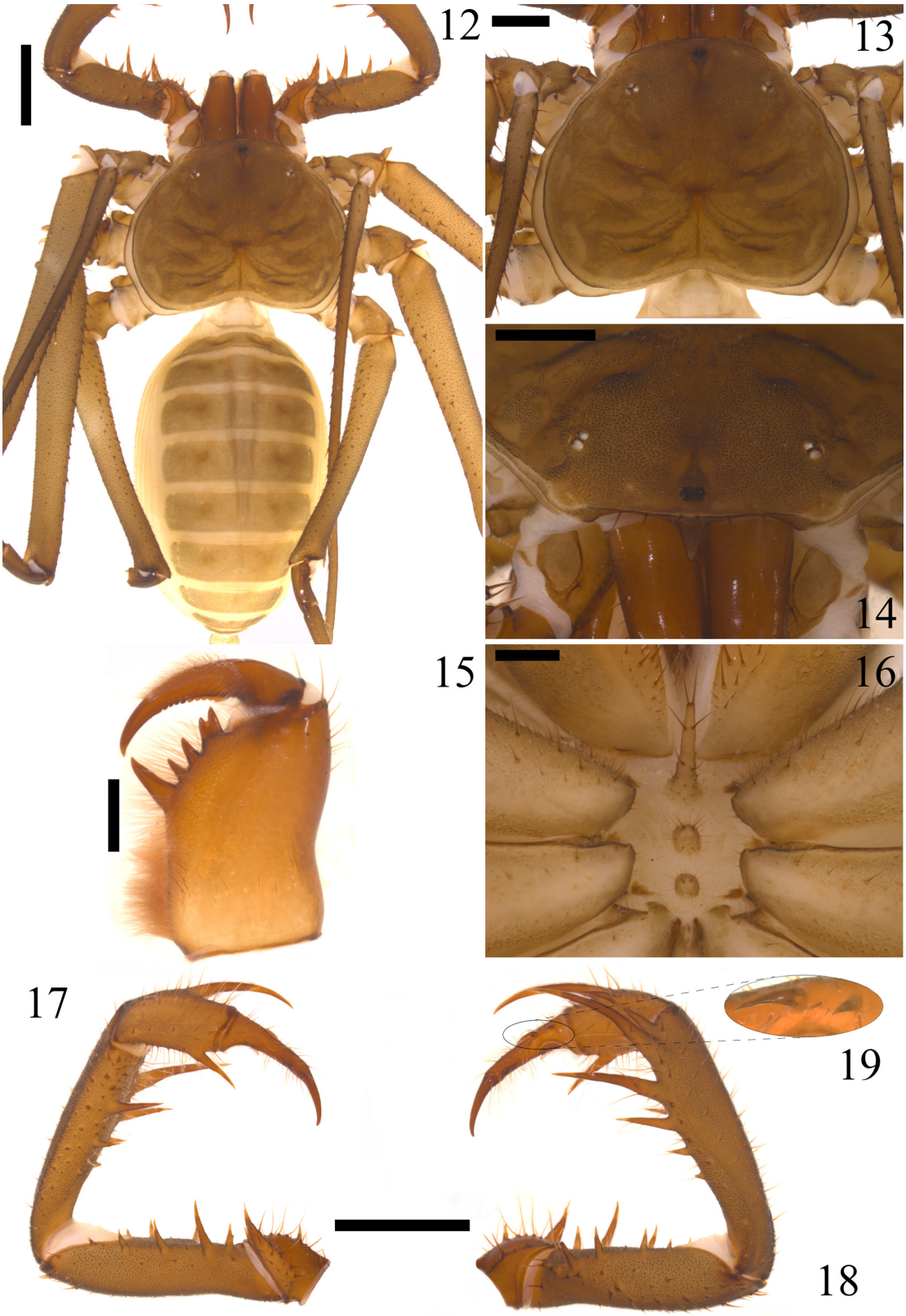
The external vegetation was partially removed for the establishment of corn and manioc crops. In the first visit to the cave (in 2008), apparently the entrance had not been modified by human activities (Fig. 11B). However, in 2014, the last visit to the area, we asserted that an electric pump was installed inside the cave to pump water for crop irrigation (Fig. 11D). Among the anthropogenic impacts, we can emphasize electric light installation and modifications in the surrounding area near the cave entrance (Fig. 11C). Due to all these harsh influences inside and outside the cave, it is likely that this species is severely threatened. Accordingly, urgent actions are required in this cave in order to protect this endangered species and its natural habitat.

FIGURE 11. *Charinus caatingae* **sp. n.:** A. External environment of the Fazenda Jurema cave. B. Entrance of the cave in 2008. C. Entrance modified by human activities in 2014. D. Electric pump inside the cave. E. Female inside the Fazenda Jurema cave.

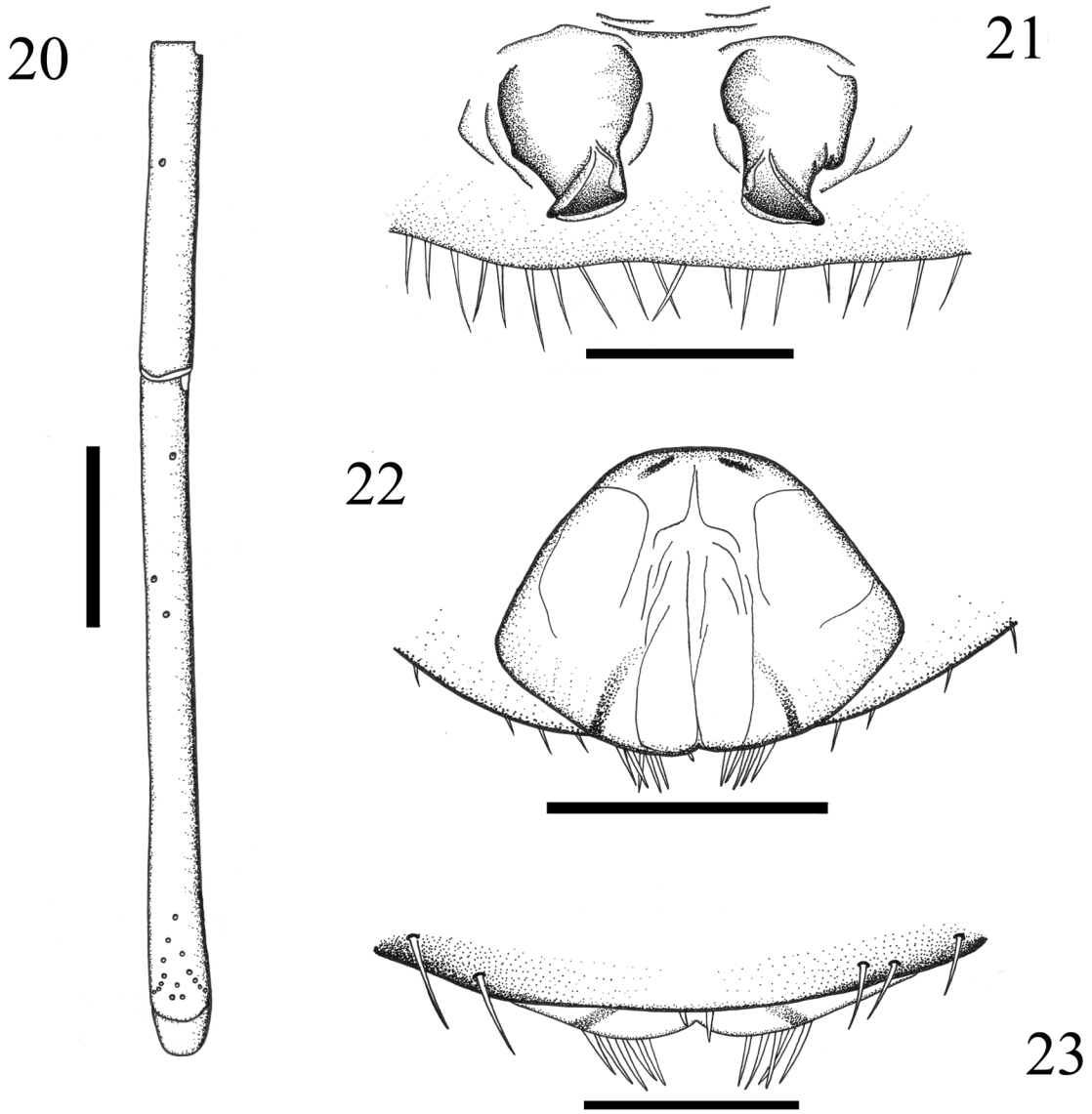
***Charinus iuiu* sp. n.**
(Figs. 12–26)

Type material. BRAZIL: *Bahia*: Iuiu: Lapa do Baixão (14º23´8.13"S, 43º37´35.06"W): Female holotype: 07.VIII.2013, *leg.* R. L. Ferreira (ISLA 4097); Female paratypes: 07.VIII.2013, *leg.* R. L. Ferreira (ISLA 4098;

ISLA 4099; ISLA 4101); Male paratype: 07.VIII.2013, *leg.* R. L. Ferreira (ISLA 4100). BRAZIL: *Bahia*: Iuiu: Toca Fria (14º32´53"S, 43º32´10"W): Female paratype: 07.VIII.2013, *leg.* R. L. Ferreira (ISLA 4103); Male paratype: 07.VIII.2013, *leg.* R. L. Ferreira (ISLA 4102).



FIGURES 12–19. *Charinus iuiu* **sp. n.:** Holotype: 12. Habitus. Scale bar = 2 mm. 13. Carapace. Scale bar = 1 mm. 14. Frontal view of the carapace and frontal process. Scale bar = 1 mm. Female paratype: 15. Right chelicerae. Scale bar = 500 µm. Holotype: 16. Sternum. Scale bar = 500 µm. 17. Right pedipalp in ventral view. 18. Right pedipalp in dorsal view with spines on the tarsus detached. Scale bar = 2 mm. 19. Spines on the tarsus of the right pedipalp in detail.

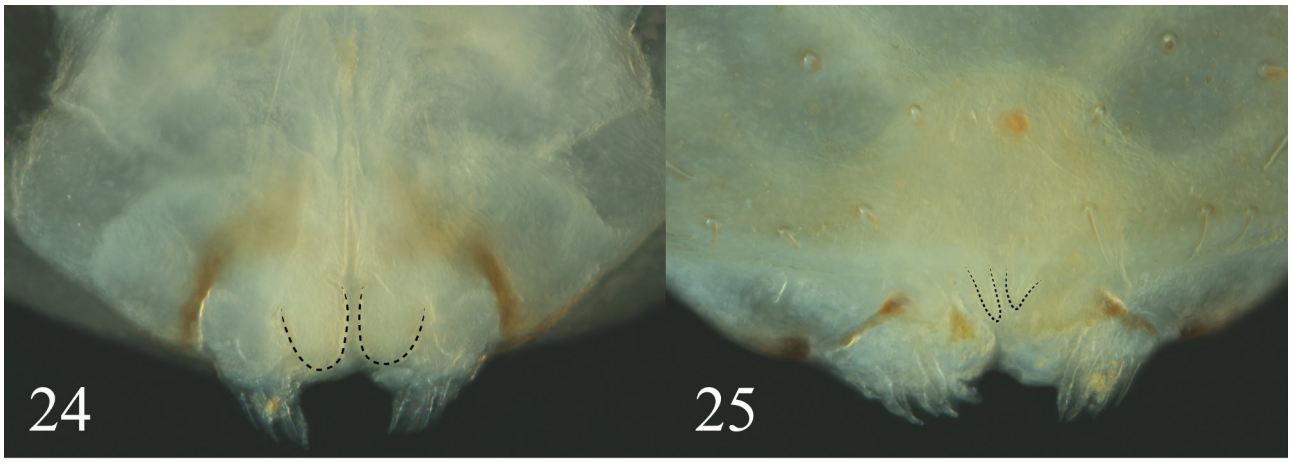


FIGURES 20–23. *Charinus iuiu* **sp. n.:** Holotype: 20. Distitibia and last pseudo-article of the basitibia of the right leg IV. Scale bar = 1 mm. 21. Female gonopod. Scale bar = 250 μm. Paratype: 22. Dorsal view of the male gonopod. Scale bar = 500 μm. 23. Ventral view of the male gonopod. Scale bar = 250 μm.

Diagnosis. *Charinus iuiu* differs from others species of the genus by having the following combination of characteristics: Anterior margin of the carapace with 6 strong and elongated setae; frontal process triangular in shape, longer than wide and with a thickened apex; chelicera claw with 10 denticles; pedipalp densely setose with femur with 4 dorsal spines (3 can be found) and 5 ventral (4 can be found), and patella with 6 dorsal spines (5 are found in smaller specimens) and 3 ventral; female gonopods sucker-like, with length larger than the width, opening rounded and a posterior slit to the upper region of each structure, edges with a fold and a small bottleneck below these; male gonopods with several long lobes (LoL2 and LoL1) emerging from the Fi.

Description. Carapace (Figs. 12–14)**:** Flattened. Ratio length/width slightly less than 3/4. Portions above the coxae of leg I slightly curved upwards. Anterior margin rounded, with corners flattened down; 6 strong and elongated setae on the anterior margin projected upwards, the central two located directly in front of the median eyes tubercle. Frontal process triangular in shape, with thickened apex, longer than wide and visible in dorsal view. Carina begins at the corners of the anterior margin and extends from the coxa of legs II to the corners of the posterior margin. Median eyes developed, with low tubercle slightly divided between the two eyes, and located in a small depression. Lateral eyes developed, with internal pigmentation and one seta posterior to each triad. Frontal hump present at each side, starting just at the front of the lateral eyes and ending in a depression located at each

side; fovea located posterior to the center, from which radiate two pairs of furrows in anterior and posterior orientation like an X; median depression located on each side between these two pair of furrows; a thin furrow follows medially from the median eye tubercle and reaches the posterior margin. Punctuations in lines and spots, more dense in the anterior region.



FIGURES 24–25. *Charinus iuiu* **sp. n.:** Male paratype: 24. Dorsal view of the gonopod with LoD detached in dashed lines. 25. Ventral view of the gonopod with LaM detached in dashed lines.

Sternum (Fig. 16)**:** Tri-segmented, with all segments sclerotized and convex. Tritosternum projected anteriorly, elongated and cone-shaped, with one apical pair, one medial and one basal pair of strong setae, and several setulae in the base. Second segment (tetrasternum) rounded, with one strong setae at each upper corner and several setulae encircling the base. Third segment (pentasternum) slightly smaller than the second, with one strong seta at each upper corner and several setulae encircling the base. The segments are separated from each other approximately by the diameter of the tetrasternum.

Abdomen (Fig. 12)**:** Oblong, with punctuations distinguishable.

Chelicera (Fig. 15)**:** Cheliceral furrow with 4 inner teeth in the basal segment. The distal tooth is bifid, with the distal cusp slightly larger than the proximal. Teeth length: IV>Ia>Ib=II>III. Claw with 10 denticles. Strong setae located distally on the dorsal and on the surface of the inner side of the chelicera.

Pedipalp (Figs. 17–19)**: Trochanter:** Ventral spiniform apophysis pointed forwards with a series of strong setiferous tubercles. 2 subequal spines aligned on the prolateral face, the first being close to the medial region and the second above the projection of the apophysis and close to the femur. Three strong setae, on average, of basal location to the first spine and three or four setae aligned between the two spines. **Femur:** Many strong dorsal setae along the segment. 4 dorsal spines (3 can be found) of sizes: F1>F2>F3>F4. 5 ventral spines (4 can be found) of sizes: FI>FII>FIII>AI>FIV. **Patella:** Densely setose. 6 dorsal spines (5 are found in smaller specimens) of sizes: 1>2>3>A1>4>5. 3 ventral spines of sizes: I>II>III. **Tibia:** Densely setose with long ventral setae. 2 dorsal spines, spine 2 being almost three times larger than spine 1. 1 ventral spine located in the distal half slightly larger to almost twice the size of dorsal spine 1. **Tarsus:** Densely setose with long ventral setae. 2 spines above the cleaning organ, the second being two to three times larger than the first spine (Fig. 19). Cleaning organ occupies about half the article length. **Claw:** Long with sharp curved tip.

Legs: All densely setose. Femur lengths: I>III>II>IV. **Leg I**: Tibia with 23 articles and tarsus with 41 articles. **Leg IV** (Fig. 20)**:** Basitibia with 4 pseudo-articles. One trichobothrium located proximally on the last article. Distitibia with 3 trichobothria positioned proximally and 15 trichobothria positioned distally; frontal and caudal series with 6 trichobothria each. Basitibia-distitibia length: DT=BT1>BT4>BT3>BT2. Ratio tarsus/metatarsus is approximately 3/4. Tarsus composed with 4 segments.

Measurements (total specimens=7): Total length: 9.80 mm (6.64–13.92). Cephalothorax: Length: 3.22 mm (2.43–3.97); Width: 4.46 mm (3.19–5.57). Pedipalp: Femur: 2.50 mm (1.20–3.72); Patella: 2.79 mm (1.51–4.00); Tibia: 1.34 mm (0.8–1.75); Tarsus: 1.01 mm (0.68–1.32); Apotele (claw): 0.68 mm (0.44–0.94). **Measurements (fully-grown specimens=4):** Total length: 11.71 mm (10.40–13.92). Cephalothorax: Length: 3.69 mm (3.46–3.97); Width: 5.12 mm (4.59–5.57). Pedipalp: Femur: 3.15 mm (2.48–3.72); Patella: 3.48 mm (2.72–4.00); Tibia: 1.62 mm (1.32–1.75); Tarsus: 1.18 mm (1.01–1.32); Apotele (claw): 0.79 mm (0.62–0.94).

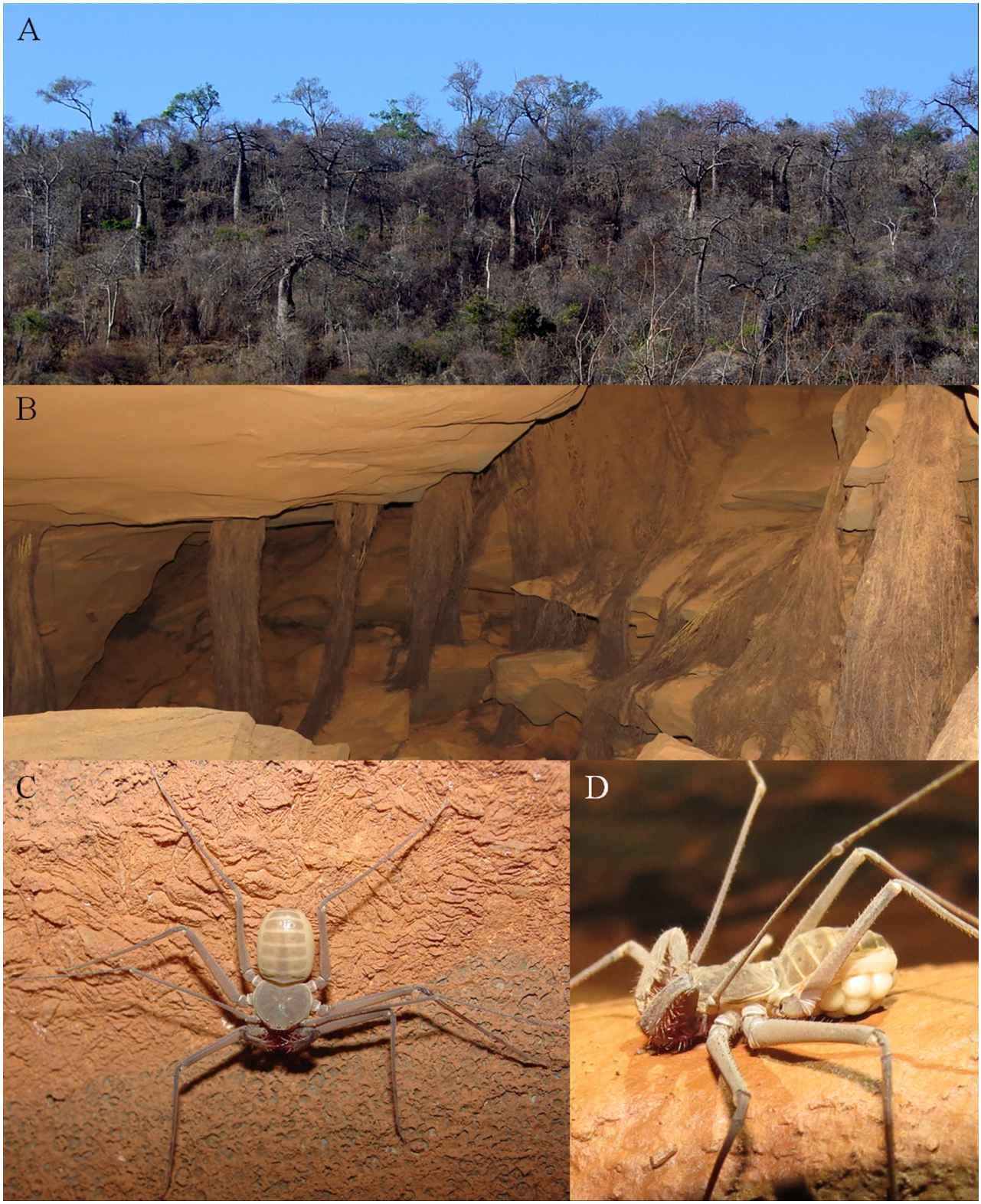


FIGURE 26. *Charinus iuiu* **sp. n.:** A. External environment of the Lapa do Baixão cave. B. Interior of the Lapa do Baixão cave where specimens were collected. C. Individual inside the cave. D. Female with egg sac.

Color: Body grayish brown, abdomen with lighter coloring and reddish chelicerae (Figs. 26C–26D). In alcohol (Fig. 12): Body reddish brown with the abdomen yellowish brown.

Genitalia: Female (Fig. 21)**:** Rounded genital operculum margin with many strong setae. Gonopods sucker-like, barrel shaped and with length larger than the width. Gonopods opening rounded and with a posterior slit to the upper region of each structure. Gonopods edges with a fold and a small bottleneck below these. Gonopods

separated from one another by a distance slightly smaller than the diameter of each one and from the margin of the operculum by a distance slightly larger than its length. **Male** (Figs. 22–25)**:** Margin of GO rounded with a few scattered setae. Genitalia wider than long. Fi exceeds the genital operculum margin, with sclerotized bands surrounding each side. Several long lobes (LoL2 and LoL1) emerge from each side of the gonopod tube. A pair of lobes (LoD) located dorsally in the interior of the gonopod (Fig. 24). A pair of small lobes (LaM) located medially and ventrally to the Fi (Fig. 25).

Etymology. The specific epithet "iuiu" is treated as a noun in apposition and refers to the municipality where the species inhabits.

Natural history. The specimens were found in "Lapa do Baixão" and in "Toca Fria" caves, both located in Iuiu municipality (Bahia state, Brazil), belonging to the Bambuí limestone group (Fig. 27). Some other caves in the area were also inventoried, but specimens were only found in these two caves, which are located around 18 km apart from each other. This area is located in the domains of the Caatinga biome (Fig. 26A). The surroundings of the entrance in both caves are severely impacted, mainly by human activities such as agriculture, extensive cattle and goat breeding. Such activities have resulted in a rather fragmented landscape, where remaining vegetation is mainly associated with the tops of outcrops (inappropriate areas for human use).

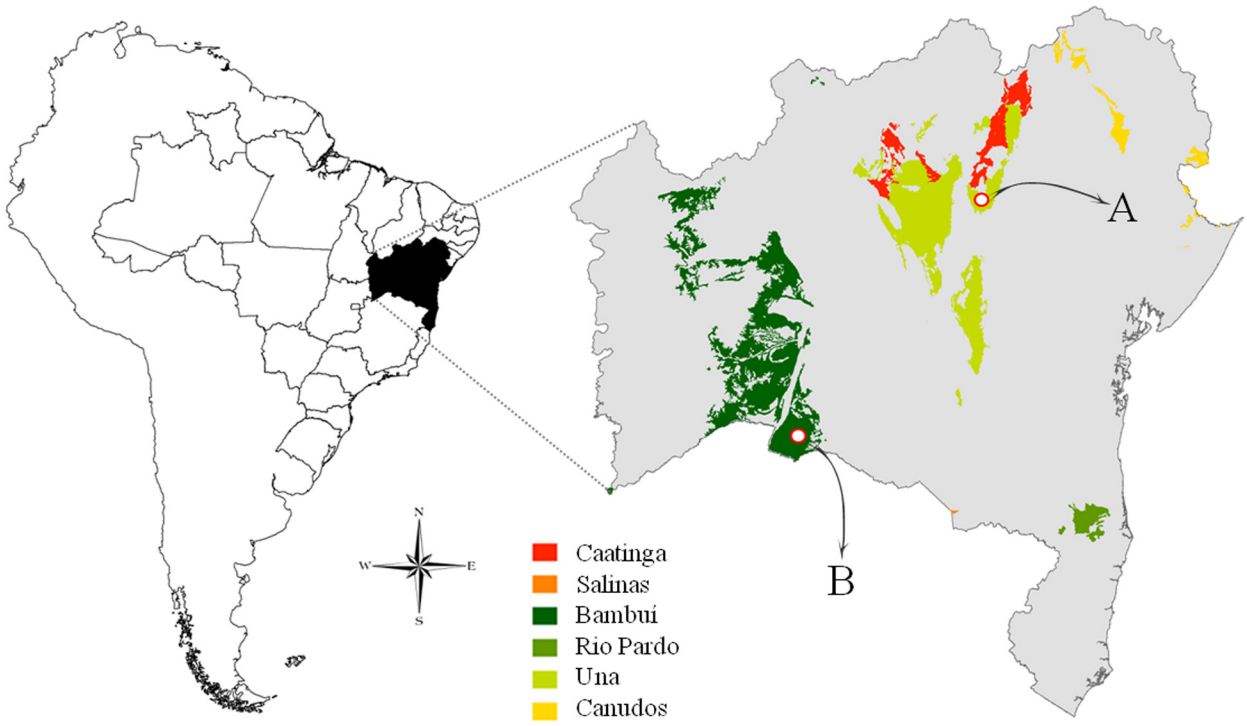


FIGURE 27. Map of Bahia state with the limestone groups represented. A. Locality of *Charinus caatingae*. B. Locality of *Charinus iuiu*.

The main population of *Charinus iuiu* was found in Lapa do Baixão cave, which comprises a labyrinthic cave in which some inner chambers become flooded during rainy periods. The only known entrance (with small dimensions - $1m^2$) is located at the bottom of a subsidence sinkhole, which makes the cave atmosphere quite isolated from the external environment. Many roots, which constitute an important nourishment source for the hypogean fauna, were observed inside the cave (Fig. 26B). Specimens of *C. iuiu* were mainly observed in deeper zones within the cave, and potential prey includes especially crickets (*Endecous* sp.). Fortunately, this cave has not been visited by anyone except the research team, so it is quite preserved.

Two specimens were found in Toca Fria cave. This cave comprises the biggest known cave in the Iuiu municipality. It has around 2 km of labyrinthic galleries with many connections to the external environment. The huge number of entrances (with distribution spread along the cave) promotes a higher influence of the external climate (which is mainly dry) on the cave atmosphere. Accordingly, most areas within this cave are dry. The

specimens were found under rocks on the cave floor. The Toca Fria cave is regularly visited by locals, exhibiting some impacts (such as trampling and graffiti) arising from these visits.

Key to the Brazilian species of *Charinus* (modified version of that present by Miranda & Giupponi (2011))

1	Median eyes absent	2
-	Median eyes present	3
2	Female gonopods conical with an apical sucker-like prehensile structure; basitibia of leg IV with four pseudoarticles (Bahia: Carinhanha, Serra do Ramalho, Zé do Bastos Cave)	*C. troglobius*
-	Female gonopods rounded, cushion-like with an apical sharp edge partially covering the atrium of the seminal receptacle; basitibia of leg IV with three pseudoarticles (Rondônia: Porto Velho)	*C. vulgaris*
3	Second and third sternal sclerites flattened and twice as wide as long (Espírito Santo: Domingos Martins)	*C. montanus*
-	Second and third sternal sclerites convex and rounded	4
4	Distitibia of the leg IV with 16 trichobothria (Espírito Santo: Serra)	*C. brasilianus*
-	Distitibia of the leg IV with 18 trichobothria	5
5	Patella of the pedipalp with 2 ventral spines	6
-	Patella of the pedipalp with 3 or more ventral spines	7
6	Lateral eyes triads with pigmentation (Bahia: Santa Luzia, Gruta Pedra do Sin Cave)	*C. acaraje*
-	Lateral eyes triads without pigmentation (Rio Grande do Norte: Felipe Guerra, Buraco Redondo Cave)	*C. potiguar*
7	Median eyes tubercle indistinct (Minas Gerais: Itacarambi, Olhos d'Água Cave)	*C. eleonorae*
-	Median eyes tubercle distinct	8
8	Lateral eyes underdeveloped (Bahia: Várzea Nova: Fazenda Jurema Cave)	*C. caatingae* **sp. n.**
-	Lateral eyes developed	9
9	Patella of the pedipalp with 3 ventral spines	10
-	Patella of the pedipalp with 4 or 5 ventral spines	11
10	Femur of the pedipalp with 3 or 4 dorsal spines (Bahia: Iuiu: Lapa do Baixão Cave)	*C. iuiu* **sp. n**
-	Femur of the pedipalp with 5 or 6 dorsal spines (Minas Gerais: Arcos: Gruta da Cazanga)	*C. jibaossu*
11	Tarsus of the pedipalp with 3 dorsal spines (Bahia: Gentio do Ouro, Encantados Cave)	*C. mysticus*
-	Tarsus of the pedipalp with 2 dorsal spines (São Paulo: Ilha Bela)	*C. asturius*

Rectification. In the distribution map presented by Vasconcelos *et al.* (2013) the location of *Charinus schirchii* and *C. asturius* were exchanged. *C. schirchii* was collected in the state of Rio de Janeiro and *C. asturius* in the state of São Paulo, Brazil.

Discussion

Charinus caatingae **sp. n.** and *C. iuiu* **sp. n**. present several differences from one another. First of them is the number of setae on the anterior margin of the carapace, *C. caatingae* has eight (Fig. 3), and *C. iuiu*, six setae (Fig. 14). The anterior portion of the carapace is also a little prolonged in *C. caatingae* compared to *C. iuiu* and other *Charinus* in Brazil. These species also differ in the shape of the frontal process and female gonopods, in the number of spines on the tarsus of the pedipalps and size of lateral eyes.

Pinto-da-Rocha *et al*. (2002) described *C. acaraje* based on a single specimen and found the frontal process markedly reduced on it when compared to other species of the genus. Since then, this structure has been classified as weak (reduced frontal process) or strong (developed frontal process), and thus used as a character to distinguish species (Baptista & Giupponi 2002; Miranda & Giupponi 2011). However, from the analysis of a larger series of *C. acaraje* specimens (see in "Additional material"), it was observed that its frontal process is similar in size to that of other species of *Charinus* in Brazil (Fig. 30). Nevertheless, among Brazilian species the frontal process generally varies in the shape of its apex (Table 1), which can be seen as rounded (thickened), as in *C. caatingae* (Fig. 28), *C. iuiu* (Fig. 29), *C. mysticus*, *C. acaraje* (Fig. 30), *C. potiguar*, *C. troglobius*, *C. asturius* and *C. vulgaris*, or pointed, as in *C. eleonorae* and *C. jibaossu* (Table 1). The rate of thickness and the length of the frontal process also vary among species. *C. iuiu* has the apex thicker and longer than *C. caatingae* (Figs. 28–29).

TABLE 1. Summary of features among Brazilian *Charinus* species derived from examined specimens in this work and data from the literature ([a]Weygoldt 1972; [b]Pinto-da-Rocha *et al.* 2002; [c]Baptista & Giupponi 2002, [d]2003; [e]Giupponi & Kury 2002; [f]Miranda & Giupponi 2011; [g]Vasconcelos *et al.* 2013, [h]2014). I=Average of body length; II=Presence and/or development of median eyes tubercle; III=Presence and/or development of median eyes; IV=Degree of development of lateral eyes; V=Shape of frontal process apex; VI=Number of spines of the femur of pedipalp (dorsal; ventral); VII=Number of spines of the patella of pedipalp (dorsal; ventral); VIII=Number of spines of the tarsus of pedipalp; IX=Number of denticles of chelicerae; X=Shape of the 1st sternal sclerites; XI=Shape of the 2nd and 3th sternal sclerites; XII=Number of tibial and tarsal articles of leg I; XIII=Number of pseudo-articles of the basitibia of leg IV; XIV=Number of trichobothria of the first pseudoarticle of basitibia IV; XV=Number of trichobothria of the last pseudoarticle of basitibia IV; XVI=Number of trichobothria of the distitbia IV (basal; distal); XVII=Shape of female gonopods.

Character	*C. caatingae* sp. n.	*C. iuiu* sp. n.	*C. mysticus*[e]	*C. acaraje*[b]	*C. potiguar*[g]	*C. troglobius*[c]
I	7.7 mm	9.8 mm	13.0 mm	9.4 mm	10.2 mm	9.3 mm
II	Low	Low	Low	Low	Low	Absent
III	Developed	Developed	Developed	Developed	Developed	Absent
IV	Underdeveloped	Developed	Developed	Developed	Underdeveloped	Underdeveloped
V	Thickened apex	Thickened apex	Thickened apex	Thickened apex	Thickened apex	Thickened apex
VI	4–5; 4–5	3–4; 4–5	6; 6	3–4; 5	3–4; 5	2; 2
VII	5–6; 3–4	5–6; 3	7; 4	5; 2	5; 2	4; 2
VIII	3	2	3	2	2	2
IX	8–10	10	?	7	9–13	9
X	Cone-shaped	Cone-shaped	Cone-shaped	Cone-shaped	Cone-shaped	Blunt tubercle
XI	Convex	Convex	Convex	Convex	Convex	Convex
XII	23; 41	23; 41	?	23; 41	23; 41	23; 40–42
XIII	4	4	4	4	4	4
XIV	0	0	0	0	0	0
XV	1	1	1	1	1	1
XVI	3; 15	3; 15	3; 15	3; 15	3; 15	3; 13
XVII	Sucker-like	Sucker-like	Sucker-like	Sucker-like	Sucker-like	Sucker-like

……*continued on the next page*

TABLE 1. (Continued)

Character	*C. eleonorae*[d]	*C. jibaossu*[h]	*C. brasilianus*[a]	*C. montanus*[a]	*C. asturius*[b]	*C. vulgaris*[f]
I	8.7 mm	Males: 13.02 mm Females: 12.06 mm	9.5 mm	8.5 mm	8.8 mm	8.0 mm
II	Absent	Low	High	High	High	Absent
III	Underdeveloped	Developed	Developed	Developed	Developed	Absent
IV	Underdeveloped	Developed	Developed	Developed	Developed	Developed
V	Pointed apex	Pointed apex	?	?	Thickened apex	Thickened apex
VI	3; 3	5–6; 5–6	4; 5	4; 4–5	5–6; 4–5	3; 2
VII	4; 3	6–7; 3	6–7; 4	5–7; 4	6–7; 4–5	4; 2
VIII	2	2–3	2	2	2	2
IX	10–11	10–12	?	?	8	4
X	Cone-shaped	Cone-shaped	Cone-shaped	Cone-shaped	Cone-shaped	Cone-shaped
XI	Convex	Convex	Convex	Flattened	Convex	Convex
XII	23; 40–41	23; 41	23; 41	23; 28	23–24; 41	22 (21–25); 38 (37–42)
XIII	4	4	4	4	4	3
XIV	0	0	0	0	0	1
XV	1	1	1	1	1	2
XVI	3; 15	3; 15	3; 13	3; 15	3; 15	4–3; 13
XVII	Sucker-like	Sucker-like	Sucker-like	Sucker-like	Sucker-like	Rounded cushion

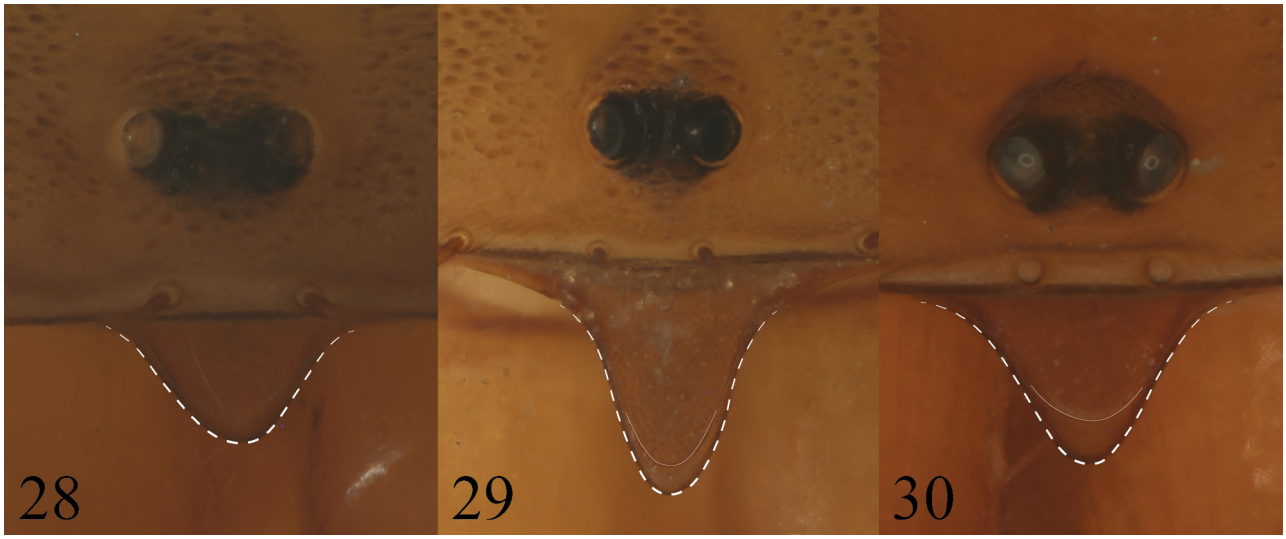


FIGURE 28–30. 28. Frontal process of *Charinus caatingae*. 29. Frontal process of *Charinus iuiu*. 30. Frontal process of *Charinus acaraje*.

One of the more usual aspects shared among *Charinus* species in Brazil is the female sucker-like gonopod. *C. caatingae*, *C. iuiu* and all other Brazilian species, with exception of *C. vulgaris*, have this type of genitalia (Table 1). *C. caatingae* presents a more rounded gonopod (Fig. 10) than *C. iuiu* and a well-pronounced constriction below its opening, similar to that of *C. mysticus* and *C. potiguar*. From *C. caatingae*, *C. iuiu* (Fig. 21) has as difference a wider opening of the gonopod, with subsequent presence of a smaller posterior slit, as present in *C. mysticus* and *C. brasilianus*, and a length greater than the width, as in *C. brasilianus*. The morphology of the male gonopod of *C. iuiu* (Fig. 22–25) is quite similar to the gonopod of *C. potiguar*, with LoL2 and LoL1 shaped like long lobes departing from the fistula.

The numbers of spines on the femur and patella of the pedipalps of *Charinus* species usually present polymorphism. The quantity of spines on these segments of *C. caatingae* does not allow separating this species from *C. iuiu* and from other species in Brazil, since their variations overlap. On the other hand, the spines on the tarsus of the pedipalps can be used to differentiate *C. caatingae* from *C. iuiu*. *C. caatingae* presents three (Fig. 8) and *C. iuiu,* two spines (Fig. 19) on this segment. Three spines on the tarsus can also be found in *C. mysticus* and *C. jibaossu*, while all other Brazilian species present only two spines (Table 1).

Charinus caatingae has the lateral eyes little developed (Fig. 3) compared to those of *C. iuiu* (Fig. 14). The triads located on each side of the carapace in amblypygids are found reduced to only an eyespot in *C. caatingae*, while in *C. iuiu* they are composed of three developed eyes. Besides the size of the eyes, *C. caatingae* also lacks their pigmentation, unlike *C. iuiu*. Underdeveloped lateral eyes are also found in *C. potiguar*, and in the troglobite species *C. troglobius* and *C. eleonorae*. Although *C. potiguar* and *C. eleonorae* present underdeveloped lateral eyes, they still exhibit triads on each side. The lateral eyes of *C. caatingae* resemble those of *C. troglobius*, which similarly has a single eyespot. However, *C. troglobius* possesses the most pronounced reduction in lateral and median eyes among species of *Charinus* in Brazil. The median eyes and ocular tubercle in *Charinus* highly vary within the genus. Both species described in this work present developed median eyes and low tubercle. The species *C. troglobius* and *C. vulgaris* totally lack the median eyes and the ocular tubercle. *C. eleonorae* also lacks the tubercle, but it still presents a much reduced median eyes. On the other hand, *C. asturius*, *C. brasilianus* and *C. montanus* present the median eyes and the ocular tubercle in a higher grade of development compared to the other species.

Reduction of eyes is one of the main traits present in troglobitic organisms (Culver 1982). However, it is important to highlight that troglobites are not determined by eyes reduction or its absence, but rather by their restriction in cave environments. Recently, studies regarding other invertebrate groups, such as crickets' inhabitants of caves, have demonstrated that strict dependence on hypogean habitats is not always connected with morphological adaptations (Bolfarini & Bichuette 2015; Souza-Dias *et al*. 2014). According with Bolfarini & Bichuette (2015), it is a good strategy to define troglobitic species by the existence of a population that only reproduce inside a cave and do not have populations established outside. The cricket *Endecous peruassuensis*

Bolfarini & Bichuette 2015 was described as a troglobitic species for presenting a well-established population living inside the Olhos d'Água cave, even it lacking reduction in the wings, which was used to define troglomorphic species within the genus. The condition of *C. caatingae* of living in a single cave (other caves in the area were sampled and individuals were not found in them), presenting reduced lateral eyes and lighter coloration, makes plausible for this species to be considered as a troglobitic species. Furthermore, the extremely dry external habitat certainly prevents the establishment of epigean populations. Therefore, even *C. caatingae* lacking some troglomorphisms, such as reduced median eyes and elongated spines on pedipapls, which are morphological characteristics present in other troglomorphic species in Brazil (*C. troglobius* and *C. eleonorae*), its ecological conditions suggest that this species can be considered a troglobite.

Charinus iuiu is placed in a different scenario for not exhibiting any troglomorphism and for being distributed in two caves relatively distant from each other (18 km). However, the external habitat of these caves is also extremely dry and severally impacted, so it is likely that this species do not present populations living outside. Possibly, *C. iuiu* dispersed in these caves either in the past where the environmental conditions were more appropriated and the species could occur outside, or through connections inside the limestone group that link the caves.

Conservation note

According to Delle Cave *et al.* 2009, species of Charinus are quite dependent on moisture to survive. Vasconcelos *et al*. (2013) verified the statement of Delle Cave *et al*. (2009) after having observed that *C. potiguar*, an inhabitant of the Caatinga, was found in greater abundance in caves in dry seasons. Weygoldt & Van Damme (2004) suggested that changes in temperature and vegetation in a region could cause organisms adapted to these conditions to take refuge in caves, which comprise more humid environments. This is especially true for the Brazilian Northeast, region where *C. caatingae* and *C. iuiu* occur. Several studies suggest that this region of Brazil used to be more humid in the past (Auler & Smart 2001; Dever *et al.* 1897; Czaplewski & Cartelle 1998) and was previously occupied by forest vegetation (Auler *et al.* 2004.). Thus, the occurrence of a humidity dependent animal in a dry region enforces the necessity of conservation of these habitats, even if the species are not considered troglobites. It is indeed true for *C. caatingae*, which is restricted to a single and threatened cave.

The description of *C. caatingae* and *C. iuiu* brings to five the number of described species for Bahia, which makes it the most *Charinus* rich state of Brazil. The other species from Bahia: *C. acaraje*, *C. mysticus* and *C. troglobius,* as *C. caatingae* and *C. iuiu*, were all described from individuals collected in caves. Over the past five years many cave species have been discovered in Brazil, including more than 500 species of troglobitic invertebrates, which reveals the still incipient knowledge of the fauna of this environment in the country (Ferreira, unpublished data). In Brazil, the presence of an endemic troglobiotic species assures the preservation of the cave in which it was found. Until 2008, all of the Brazilian caves were protected by law. However, the legislation was altered, and currently, Brazilian caves can be destroyed by different anthropogenic activities (especially mining activities).

With the intention of defining which caves can be eliminated and which should be preserved, categories that define the status of each cave (based on biological and geological parameters) were created. To assure the preservation of a cave in Brazil, it is necessary, from the biological point of view, that it possesses at least one endemic, troglobiotic or rare species. Therefore, the description of new species endemic to caves became important for the conservation of these environments, and thus, their inhabitants.

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