

Unveiling a hidden diversity: descriptions of nine new species of *Ctenorillo* Verhoeff, 1942 (Isopoda, Armadillidae) discovered in Brazilian caves and their importance for conservation

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Habitus of the species of the genus *Ctenorillo* Verhoeff, 1942 discussed in the present paper.

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ABSTRACT

Nine species of *Ctenorillo* Verhoeff, 1942 are described from Brazil, revealing a great diversity of the genus in South America. *Ctenorillo pelado* Cardoso & Ferreira, n. sp., and *C. araguaia* Cardoso & Ferreira, n. sp. are described, and *C. ferrarai* Campos-Filho, Araujo & Taiti, 2014 has the knowledge of its distribution expanded from the state of Pará (north of Brazil); *Ctenorillo intertidalis* Cardoso & Ferreira n. sp., *C. ubajarensis* Cardoso & Ferreira, n. sp., *C. cearensis* Cardoso & Ferreira, n. sp. and *C. quiteriensis* Cardoso & Ferreira, n. sp. are described from the state of Ceará (northeast Brazil); *C. potiguar* Cardoso & Ferreira, n. sp. from the state of Rio Grande do Norte (northeast Brazil); *C. iuiuensis* Cardoso & Ferreira, n. sp. from the state of Bahia (northeast Brazil); and *C. jequitinhonha* Cardoso & Ferreira, n. sp. from the state of Minas Gerais (southeast Brazil). Most of the newly identified species are found in protected conservation areas and are therefore legally protected. However, special attention should be paid to *C. iuiuensis* Cardoso & Ferreira, n. sp., a troglobitic species, due to its distinctive ecological features and its habitat being limited to a single cave, which is currently not protected.

KEY WORDS

Woodlice,
terrestrial isopods,
cave species,
Brazil,
Neotropics,
troglobitic,
new species.

RÉSUMÉ

Une diversité cachée dévoilée : description de neuf nouvelles espèces de Ctenorillo Verhoeff, 1942 (Isopoda, Armadillidae) découvertes dans des grottes brésiliennes et leur importance pour la conservation.

Neuf espèces de *Ctenorillo* Verhoeff, 1942 sont décrites du Brésil, révélant une grande diversité du genre en Amérique du Sud. *Ctenorillo pelado* Cardoso & Ferreira, n. sp. et *C. araguaia* Cardoso & Ferreira, n. sp. sont décrites, et *C. ferrarai* Campos-Filho, Araujo & Taiti, 2014 voit la connaissance de sa distribution étendue à l'État de Pará (nord du Brésil); *Ctenorillo intertidalis* Cardoso & Ferreira, n. sp., *C. ubajarensis* Cardoso & Ferreira, n. sp., *C. cearensis* Cardoso & Ferreira n. sp. et *C. quiteriensis* Cardoso & Ferreira, n. sp. sont décrites dans l'État de Ceará (nord-est du Brésil); *C. potiguar* Cardoso & Ferreira, n. sp. dans l'État de Rio Grande do Norte (nord-est du Brésil); *C. iuiuensis* Cardoso & Ferreira, n. sp. dans l'État de Bahia (nord-est du Brésil); et *C. jequitinhonha* Cardoso & Ferreira, n. sp. dans l'État de Minas Gerais (sud-est du Brésil). La plupart des espèces nouvellement identifiées se trouvent dans des zones de conservation protégées et sont donc légalement protégées. Toutefois, une attention particulière devrait être accordée à *C. iuiuensis* Cardoso & Ferreira, n. sp., une espèce troglobie, en raison de ses caractéristiques écologiques originales et de son habitat limité à une seule grotte, qui n'est pas protégée à l'heure actuelle.

MOTS CLÉS

Cloporte,
isopodes terrestres,
espèces cavernicoles,
Brésil,
néotropiques,
troglobie,
espèces nouvelles.

BACKGROUND

The genus *Ctenorillo* Verhoeff, 1942 is distributed across Africa and South America (Taiti *et al.* 1998; Schmalfuss 2003; Boyko *et al.* 2008; Campos-Filho *et al.* 2014, 2017; Cifuentes & Da Silva 2023; Carpio-Díaz *et al.* 2023). In Brazil, three species are known: *C. mineri* (Van Name, 1936) from Brazil, Guyana and Venezuela; *C. ferrarai* Campos-Filho, Araujo & Taiti, 2014 from Brazil; and *C. tuberosus* (Budde-Lund, 1904) from Brazil, Haiti and Germany (introduced) (Campos-Filho *et al.* 2018).

Ctenorillo is distinguished by its diminutive size and strongly convex body shape, endoantennal conglobation and dorsal surface featuring more or less developed ribs and/or tubercles; cephalon with a subquadrangular frontal shield, and the pereonite 1 epimera with a schisma; pereonites 1 and 2 with ventral lobes, the latter bearing a triangular lobe; telson with hour-glass shape; antenna with two articles on flagellum, with the distal article longer than the proximal one; subquadrangular uropod with flattened protopod, with a concave medial margin and a tiny exopod inserted near the medial margin; and pleopod 1-5 exopods with monospiracular-covered lungs (Carpio-Díaz *et al.* 2018). As previously noted by Schmalfuss & Ferrara (1983), Campos-Filho *et al.* (2014, 2017) and Taiti (2018), species of *Ctenorillo* are often similar and can be distinguished by the shape, number, and disposition of dorsal tubercles.

This manuscript presents the taxonomic descriptions of nine newly discovered species (Figs 1-27), expanding the known diversity of the genus and its distribution within the Neotropical Region. Of these newly described species, two were found in Northern Brazil (Pará state), six in northeastern Brazil (Ceará, Rio Grande do Norte and Bahia states), and one in southeastern Brazil (Minas Gerais state). A notable finding is the discovery of the first troglobitic species within the genus, which was found in a cave located in Iuiu municipality, Bahia state. Additionally, this manuscript pro-

vides new occurrences of *C. ferrarai* and offers notes on the habitats along with a discussion on the conservation status of each new species herein described.

MATERIAL AND METHODS

Specimens were collected using brushes and fixed in 70% ethanol. In the Center of Studies on Subterranean Biology at the Federal University of Lavras (CEBS/UFLA), located in Lavras, Brazil, the specimens were measured and photographed with a ZEISS Axio ZoomV16 stereomicroscope equipped with an Axio Cam 506 Color camera. After dissection, they were mounted on slides using Hoyer's medium. Drawings were produced through a combination of photographic and dissected specimens with the aid of a camera lucida fitted to a Leica DM750 microscope. Final illustrations were created in GIMP software (v. 2.8) (Montesanto 2015, 2016) using a Wacom Cintiq drawing tablet. A subset of specimens (from some species) were investigated further using a Hitachi TM4000 scanning electron microscope. The utilization of low vacuum imaging technology allowed the examination of non-conductive samples without the need for a metal coating. All material is deposited in the Collection of Subterranean Invertebrates of Lavras (ISLA), some were collected by consulting companies that collect the material to evaluate the significance of caves, as mandated by Brazilian environmental agencies in their review of potentially environmentally impactful projects. The holotype and paratypes are deposited at ISLA. In this study, we have employed the cave fauna classification system proposed by Sket (2008).

ABBREVIATION

ISLA Collection of Subterranean Invertebrates of Lavras (ISLA), at the Ecology and Conservation Department of the Federal University of Lavras, Lavras, Minas Gerais, Brazil.

SYSTEMATIC ACCOUNT

Family ARMADILLIDAE Brandt, 1831
Genus *Ctenorillo* Verhoeff, 1942

Ctenorillo ferrarai Campos-Filho, Araujo & Taiti, 2014
(Figs 1; 27A)

Ctenorillo ferrarai Campos-Filho, Araujo & Taiti in Campos-Filho *et al.*, 2014: 412, figs 37–40. — Campos-Filho *et al.* 2017: 20; 2018: 27. — Fernandes *et al.* 2019: 1119, table 1.

nec *Ctenorillo ferrarai* – Campos-Filho *et al.* 2023: 560, figs 22, 23.

MATERIAL EXAMINED. — **Brazil.** Pará state, Parauapebas municipality, Serra Norte plateau • 1 ♀; N1_0002 cave; GEM_578; 6°0'14"S, 50°17'56"W; 24.II-13.III.2015; ISLA 30422 • 1 ♀; N1_0002 cave; GEM_805; 11.VI-2.VII.2014; ISLA 30636 • 1 ♂; N1_0002 cave; GEM_818; 11.VI-2.VII.2014; ISLA 30644 • 1 ♂; N1_0004 cave; GEM_812; 6°0'48"S, 50°18'24"W; 17.VII-4.VIII.2014; ISLA 30638 • 2 ♀; N1_0004 cave; GEM_817; 11.VI-2.VII.2014; ISLA 30643 • 1 ♀; N1_0004 cave; GEM_824; 17.VII-4.VIII.2014; ISLA 30649 • 1 ♀; N1_0004 cave; GEM_1032; 7-28.I.2015; ISLA 30840 • 1 ♂; N1_0004 cave; GEM_1049; 7-28.I.2015; ISLA 30857 • 2 ♀; N1_0005 cave; GEM_589; 6°0'44"S, 50°18'52"W; 24.II-13.III.2015; ISLA 30432 • 4 ♀; N1_0007 cave; GEM_555; 6°6'30"S, 50°8'0"W; 2-29.IV.2015; ISLA 30399 • 1 ♀; N1_0007 cave; GEM_820; 11.VI-2.VII.2014; ISLA 30646 • 1 ♀; N1_0009 cave; GEM_558; 6°0'40"S, 50°18'51"W; 24.II-13.III.2015; ISLA 30402 • 1 ♀; N1_0009 cave; GEM_591; 24.II-13.III.2015; ISLA 30434 • 1 ♂; N1_0012 cave; GEM_588; 6°6'23"S, 50°8'7"W; 24.II-13.III.2015; ISLA 30431 • 1 ♀; N1_0013 cave; GEM_1027; 6°6'23"S, 50°8'7"W; 7-28.I.2015; ISLA 30835 • 1 juv.; N1_0030 cave; GEM_551; 6°2'4"S, 50°16'19"W; 24.II-13.III.2015; ISLA 30395 • 1 ♀; N1_0033 cave; GEM_514; 6°1'9"S, 50°16'46"W; 24.II-13.III.2015; ISLA 30388 • 1 ♂; N1_0044 cave; GEM_915; 6°2'3"S, 50°16'16"W; 4.IX-6.X.2014; ISLA 30735 • 1 ♂; N1_0050 cave; GEM_911; 6°1'37"S, 50°17'28"W; 4.IX-6.X.2014; ISLA 30731 • 1 ♀; N1_0056 cave; GEM_1030; 6°2'33"S, 50°16'27"W; 7-28.I.2015; ISLA 30838 • 1 ♀; N1_0056 cave; GEM_1045; 7-28.I.2015; ISLA 30853 • 1 ♀; N1_0060 cave; GEM_816; 6°2'32"S, 50°16'28"W; 4.IX-6.X.2014; ISLA 30742 • 1 ♀; N1_0060 cave; GEM_1005; 7-28.I.2015; ISLA 30813 • 1 juv.; N1_0062 cave; GEM_559; 6°2'39"S, 50°16'24"W; 2-29.IV.2015; ISLA 30403 • 1 ♂, 1 ♀; N1_0062 cave; GEM_919; 4.IX-6.X.2014; ISLA 30739 • 1 ♀; N1_0063 cave; GEM_547; 6°7'41"S, 50°8'5"W; 24.II-13.III.2015; ISLA 30391 • 1 ♀; N1_0063 cave; GEM_550; 24.II-13.III.2015; ISLA 30394 • 1 ♂; N1_0063 cave; GEM_584; 24.II-13.III.2015; ISLA 30428 • 1 juv.; N1_0064 cave; GEM_537; 6°7'42"S, 50°8'7"W; 24.II-13.III.2015; ISLA 30381 • 1 ♂; N1_0067 cave; GEM_564; 6°1'17"S, 50°18'5"W; 2-29.IV.2015; ISLA 30408 • 1 ♀; N1_0074 cave; GEM_789; 6°1'24"S, 50°17'59"W; 11.VI-2.VII.2014; ISLA 30620 • 2 ♀; N1_0074 cave; GEM_833; 11.VI-2.VII.2014; ISLA 30658 • 1 ♂, 1 ♀; N1_0078 cave; GEM_548; 6°7'23"S, 50°7'48"W; 24.II-13.III.2015; ISLA 30392 • 1 ♀; N1_0092 cave; GEM_570; 6°1'28"S, 50°17'56"W; 2-29.IV.2015; ISLA 30414 • 1 ♀; N1_0096 cave; GEM_569; 6°1'28"S, 50°17'55"W; 2-29.IV.2015; ISLA 30413 • 1 ♂, 1 ♀; N1_0096 cave; GEM_1033; 7-28.I.2015; ISLA 30841 • 2 ♀; N1_0103 cave; GEM_774; 6°1'29"S, 50°17'54"W; 11.VI-2.VII.2014; ISLA 30605 • 1 ♀; N1_0106 cave; GEM_790; 6°2'36"S, 50°16'34"W; 11.VI-2.VII.2014; ISLA 30621 • 2 ♀; N1_0106 cave; GEM_1019; 7-28.I.2015; ISLA 30827 • 1 ♀; N1_0108 cave; GEM_778; 6°2'25"S, 50°16'13"W; 17.VII-4.VIII.2014; ISLA 30609 • 1 ♂; N1_0108 cave; GEM_796; 17.VII-4.VIII.2014; ISLA 30627 • 1 ♀; N1_0108 cave; GEM_1018; 7-28.I.2015; ISLA 30826 • 2 ♀; N1_0113 cave; GEM_562; 6°2'24"S, 50°17'38"W; 2-29.IV.2015; ISLA 30407 • 1 ♀; N1_0116 cave;

GEM_823; 6°2'14"S, 50°16'1"W; 11.VI-2.VII.2014; ISLA 30648 • 1 ♀; N1_0116 cave; GEM_1035; 7-28.I.2015; ISLA 30843 • 1 ♀; N1_0117 cave; GEM_1013; 6°1'22"S, 50°18'45"W; 7-28.I.2015; ISLA 30821 • 1 ♀; N1_0119 cave; GEM_592; 6°1'15"S, 50°18'6"W; 2-29.IV.2015; ISLA 30435 • 1 ♂, 2 juv.; N1_0123 cave; GEM_566; 6°1'9"S, 50°16'46"W; 24.II-13.III.2015; ISLA 30410 • 2 ♀; N1_0142 cave; GEM_543; 6°1'37"S, 50°17'29"W; 2-29.IV.2015; ISLA 30387 • 1 ♀; N1_0148 cave; GEM_581; 6°1'20"S, 50°16'27"W; 2-29.IV.2015; ISLA 30425 • 1 ♂; N1_0150 cave; GEM_527; 6°0'25"S, 50°18'17"W; 24.II-13.III.2015; ISLA 30380 • 1 ♀; N1_0158 cave; GEM_787; 6°0'31"S, 50°18'7"W; 11.VI-2.VII.2014; ISLA 30618 • 2 ♀; N1_0166 cave; GEM_795; 6°1'47"S, 50°16'24"W; 17.VII-4.VIII.2014; ISLA 30626 • 3 ♀; N1_0166 cave; GEM_1037; 3-17.XII.2014; ISLA 30845 • 1 ♂; N1_0167 cave; GEM_1050; 6°1'51"S, 50°16'29"W; 3-17.XII.2014; ISLA 30858 • 1 ♂; N1_0168 cave; GEM_819; 6°2'24"S, 50°16'13"W; 17.VII-4.VIII.2014; ISLA 30645 • 1 ♀; N1_0168 cave; GEM_840; 17.VII-4.VIII.2014; ISLA 30665 • 1 ♀; N1_0168 cave; GEM_1029; 3-17.XII.2014; ISLA 30837 • 1 ♂; N1_0169 cave; GEM_837; 6°1'24"S, 50°17'59"W; 17.VII-4.VIII.2014; ISLA 30662 • 1 ♀; N1_0170 cave; GEM_1034; 6°1'14"S, 50°16'42"W; 3-17.XII.2014; ISLA 30842 • 1 ♂, 1 ♀; N1_0172 cave; GEM_1023; 6°2'24"S, 50°16'12"W; 7-28.I.2015; ISLA 30831 • 1 ♂; N1_0173 cave; GEM_777; 6°1'28"S, 50°17'56"W; 17.VII-4.VIII.2014; ISLA 30608 • 1 ♀; N1_0174 cave; GEM_776; 6°1'12"S, 50°16'45"W; 17.VII-4.VIII.2014; ISLA 30607 • 1 ♂, 1 ♀; N1_0174 cave; GEM_781; 17.VII-4.VIII.2014; ISLA 30612 • 3 ♀; N1_0174 cave; GEM_782; 17.VII-4.VIII.2014; ISLA 30613 • 2 juv.; N1_0174 cave; GEM_784; 17.VII-4.VIII.2014; ISLA 30615 • 1 ♂, 1 ♀; N1_0174 cave; GEM_785; 17.VII-4.VIII.2014; ISLA 30616 • 2 ♂; N1_0174 cave; GEM_786; 17.VII-4.VIII.2014; ISLA 30617 • 1 ♀; N1_0174 cave; GEM_791; 17.VII-4.VIII.2014; ISLA 30622 • 1 ♂, 2 ♀; N1_0174 cave; GEM_793; 17.VII-4.VIII.2014; ISLA 30624 • 2 ♀; N1_0174 cave; GEM_800; 17.VII-4.VIII.2014; ISLA 30631 • 4 ♂; N1_0174 cave; GEM_801; 17.VII-4.VIII.2014; ISLA 30632 • 1 ♂, 1 ♀; N1_0174 cave; GEM_803; 17.VII-4.VIII.2014; ISLA 30634 • 1 ♀; N1_0174 cave; GEM_829; 17.VII-4.VIII.2014; ISLA 30654 • 1 ♂; N1_0174 cave; GEM_830; 17.VII-4.VIII.2014; ISLA 30656 • 1 juv.; N1_0174 cave; GEM_834; 17.VII-4.VIII.2014; ISLA 30659 • 1 ♂; N1_0174 cave; GEM_834; 17.VII-4.VIII.2014; ISLA 30660 • 1 juv.; N1_0174 cave; GEM_834; 17.VII-4.VIII.2014; ISLA 30661 • 1 ♂, 1 ♀; N1_0174 cave; GEM_841; 17.VII-4.VIII.2014; ISLA 30666 • 1 ♀; N1_0174 cave; GEM_842; 17.VII-4.VIII.2014; ISLA 30667 • 1 ♂; N1_0174 cave; GEM_1022; 17.VII-4.VIII.2014; ISLA 30830 • 1 ♂; N1_0174 cave; GEM_1026; 17.VII-4.VIII.2014; ISLA 30834 • 1 ♂, 1 ♀; N1_0174 cave; GEM_1028; 17.VII-4.VIII.2014; ISLA 30836 • 2 ♂; N1_0174 cave; GEM_1040; 7-28.I.2015; ISLA 30848 • 2 ♂; N1_0174 cave; GEM_1041; 7-28.I.2015; ISLA 30849 • 2 ♂; N1_0174 cave; GEM_1042; 7-28.I.2015; ISLA 30850 • 1 ♀; N1_0174 cave; GEM_1043; 7-28.I.2015; ISLA 30851 • 1 ♀; N1_0174 cave; GEM_1046; 7-28.I.2015; ISLA 30854 • 2 ♂, 2 ♀; N1_0174 cave; GEM_1047; 7-28.I.2015; ISLA 30855 • 1 ♀; N1_0174 cave; GEM_1048; 7-28.I.2015; ISLA 30856 • 1 ♀; N1_0174 cave; GEM_1051; 7-28.I.2015; ISLA 30859 • 1 ♂, 1 ♀; N1_0174 cave; 17-14.VIII.2014; ISLA 37900 • 1 juv.; N1_0175 cave; GEM_828; 6°1'13"S, 50°16'42"W; 17.VII-4.VIII.2014; ISLA 30653 • 2 ♀; N1_0185 cave; GEM_1036; 6°1'10"S, 50°16'45"W; 7-28.I.2015; ISLA 30844 • 1 ♀; N1_0200 cave; GEM_587; 6°1'8"S, 50°16'46"W; 2-29.IV.2015; ISLA 30430 • 1 ♂; N1_0227 cave; GEM_565; 6°2'14"S, 50°16'1"W; 2-29.IV.2015; ISLA 30409 • 1 ♂; N1_0229 cave; GEM_930; 6°1'43"S, 50°17'21"W; 4.IX-6.X.2014; ISLA 30750 • 1 ♀; N1_0231 cave; GEM_811; 6°2'23"S, 50°16'13"W; 11.VI-2.VII.2014; ISLA 30637 • 1 ♀; N1_0235 cave; GEM_571; 6°1'17"S, 50°16'50"W; 2-29.IV.2015; ISLA 30415 • 1 ♀; N1_0236 cave; GEM_1031; 6°1'16"S, 50°16'53"W; 3-17.XII.2014; ISLA 30839 • 1 ♀; N1_0236 cave; GEM_1044; 3-17.XII.2014; ISLA 30852 • 1 ♀; N1_0239 cave; GEM_788; 6°2'21"S, 50°16'14"W; 11.VI-2.VII.2014; ISLA 30619 • 1 ♀; N1_0244 cave;

GEM_783; 6°0'43"S, 50°18'15"W; 11.VI-2.VII.2014; ISLA 30614 • 1 ♂; N1_0246 cave; GEM_557; 6°1'10"S, 50°16'59"W; 2-29.IV.2015; ISLA 30401 • 1 ♀; N1_0246 cave; GEM_557; 2-29.IV.2015; ISLA 30433 • 1 ♂; N1_0246 cave; GEM_792; 11.VI-2.VII.2014; ISLA 30623 • 1 ♂; N1_0246 cave; GEM_838; 11.VI-2.VII.2014; ISLA 30663 • 2 ♀; N5S_0002 cave; 6°5'33"S, 50°7'32"W; 10-17.IV.2017; ISLA 95925 • 1 juv.; N5S_0023 cave; 6°5'30"S, 50°7'34"W; 10-17.IV.2016; ISLA 95921 • 3 ♀; N5S_0072 cave; RESCUE; 6°6'3"S, 50°8'7"W; 11.I.18; ISLA 48885 • 1 ♂, 2 ♀; N5SM1_0005 cave; GEM_1178; 6°6'26"S, 50°8'2"W; 18.II.2011; ISLA 96759 • 1 ♀; N5SM1_0007 cave; GEM_1180; 6°6'26"S, 50°8'7"W; 26.II.2010; ISLA 96760 • 1 ♂, 2 ♀, 3 juv.; N5SM1_0008 cave; GEM_1181; 6°6'23"S, 50°8'8"W; 31.VIII.2010; ISLA 96758 • 2 ♂, 5 ♀; N5SM1_0008 cave; GEM_1181; 1.II.2011; ISLA 96765 • 1 ♀; N5SM1_0011 cave; GEM_1184; 6°6'22"S, 50°8'7"W; 24.II.2011; ISLA 6266 • 1 ♀; N5SM1_0014 cave; GEM_1187; 6°6'20"S, 50°8'16"W; 23.VIII.2010; ISLA 6273 • 1 ♀; N5SM1_0015 cave; GEM_1188; 6°6'21"S, 50°8'8"W; 21.VIII.2010; ISLA 6279 • 1 ♀; N5SM1_0016 cave; GEM_1189; 6°6'21"S, 50°8'13"W; 21.VIII.2010; ISLA 6285 • 1 ♂; N5SM1_0018 cave; GEM_1191; 6°6'21"S, 50°8'12"W; 19.VIII.2010; ISLA 6287 • 1 ♂; N5SM1_0020 cave; GEM_1193; 6°6'34"S, 50°8'7"W; 22.VIII.2010; ISLA 6292 • 1 ♂, 1 ♀; N5SM1_0020 cave; GEM_1193; 24.II.2011; ISLA 96763 • 1 ♀; N5SM1_0023 cave; GEM_1776; 6°6'32"S, 50°8'6"W; 8.II.2010; ISLA 6257 • 1 ♂, 3 ♀; N5SM1_0026 cave; GEM_1779; 6°6'29"S, 50°8'8"W; 25.II.2011; ISLA 96762 • 1 ♀; N5SM1_0027 cave; GEM_1184; 6°6'22"S, 50°8'20"W; 27.II.2011; ISLA 6271 • 1 ♀; N5SM1_0027 cave; GEM_1195; 01.IX.2010; ISLA 96757 • 1 ♂; N5SM1_0028 cave; GEM_1782; 6°6'19"S, 50°8'18"W; 22.IX.2010; ISLA 6276 • 1 juv.; N5SM1_0029 cave; GEM_1783; 6°6'32"S, 50°8'6"W; 19.II.2011; ISLA 96761 • 2 ♂; N5SM1_0030 cave; GEM_1784; 6°6'19"S, 50°8'19"W; 19.II.2010; ISLA 6280 • 1 ♀; N5SM1_0031 cave; GEM_1785; 6°6'19"S, 50°8'18"W; 27.VIII.2010; ISLA 6226 • 2 ♂, 3 ♀; N5SM1_0031 cave; GEM_1785; 21.II.2011; ISLA 6254 • 2 ♂; N5SM1_0032 cave; GEM_1786; 6°6'22"S, 50°8'11"W; 27.VIII.2010; ISLA 6282 • 1 ♀; N5SM1_0033 cave; GEM_1787; 6°6'19"S, 50°8'19"W; 19.VIII.2010; ISLA 6274 • 1 ♀; N5SM1_0034 cave; GEM_1788; 6°6'22"S, 50°8'7"W; 8.II.2010; ISLA 6239 • 1 juv.; N5SM1_0035 cave; GEM_1789; 6°6'42"S, 50°8'8"W; 25.II.2011; ISLA 96764 • 1 ♂, 2 ♀; N5SM1_0041 cave; GEM_1795; 6°6'30"S, 50°8'0"W; 25.II.2011; ISLA 6252 • 1 ♀; N5SM1_0044 cave; GEM_1798; 6°6'31"S, 50°8'3"W; 17.II.2011; ISLA 6248 • 4 ♀; N5SM1_0082 cave; GEM_1786; 6°6'17"S, 50°8'17"W; 7.II.2011; ISLA 6265 • 1 ♀; N5SM2_0001 cave; RESCUE; 6°8'32"S, 50°8'1"W; 21-31.X.2018; ISLA 61683 • 1 ♂, 1 ♀; N5SM2_0003 cave; GEM_1701; 6°8'23"S, 50°8'16"W; ISLA 15740 • 2 ♂, 3 ♀; N5SM2_0006 cave; GEM_1707; 6°8'27"S, 50°8'9"W; 25.XI.2010; ISLA 21143 • 2 ♂, 1 ♀; N5SM2_0007 cave; GEM_1708; 6°8'17"S, 50°8'17"W; 23.XI.2010; ISLA 15744 • 1 ♂, 1 ♀; N5SM2_0008 cave; GEM_1709; 6°8'16"S, 50°8'10"W; 26.X.2010; ISLA 6325 • 1 ♂, 1 ♀; N5SM2_0009 cave; GEM_1705; 6°8'18"S, 50°8'0"W; 23.XI.2010; ISLA 96747 • 1 ♂, 5 ♀; N5SM2_0010 cave; GEM_1699; 6°8'18"S, 50°8'1"W; 23.XI.2010; ISLA 6316 • 3 ♂, 6 ♀; N5SM2_0012 cave; GEM_1696; 6°7'58"S, 50°7'51"W; 29.XI.2010; ISLA 21144 • 2 ♂, 3 ♀; N5SM2_0013 cave; GEM_1703; 6°8'7"S, 50°8'6"W; 25.XI.2010; ISLA 6353 • 3 ♀; N5SM2_0015 cave; GEM_1735; 6°8'6"S, 50°8'5"W; 28.XI.2010; ISLA 6329 • 1 ♂, 1 ♀; N5SM2_0018 cave; GEM_1774; 6°8'7"S, 50°8'6"W; 28.X.2010; ISLA 21141 • 3 ♂, 1 ♀; N5SM2_0021 cave; GEM_1727; 6°8'8"S, 50°8'5"W; 27.X.2010; ISLA 21142 • 2 ♂, 2 ♀; N5SM2_0022 cave; GEM_1721; 6°8'4"S, 50°8'15"W; 19.IX.2010; ISLA 6352 • 3 ♀; N5SM2_0023 cave; GEM_1722; 6°8'4"S, 50°8'9"W; 18.X.2010; ISLA 6336 • 1 ♀; N5SM2_0024 cave; GEM_1723; 6°8'31"S, 50°8'5"W; 20.XI.2010; ISLA 6319 • 2 ♂, 3 ♀; N5SM2_0025 cave; GEM_1766; 6°8'1"S, 50°8'5"W; 18.XI.2010; ISLA 96745 • 3 ♀; N5SM2_0028 cave; GEM_1702; 6°7'59"S, 50°8'4"W; 20.XI.2010; ISLA 21138 • 1 ♀; N5SM2_0029 cave; GEM_1762; 6°7'58"S, 50°8'4"W; 18.XI.2010;

ISLA 15750 • 2 ♂, 1 ♀; N5SM2_0029 cave; GEM_1726; 18.XI.2010; ISLA 96750 • 2 ♂, 4 ♀; N5SM2_0035 cave; GEM_1720; 6°7'57"S, 50°8'6"W; 26.X.2010; ISLA 6332 • 1 ♂, 2 ♀; N5SM2_0036 cave; GEM_1713; 6°7'58"S, 50°8'11"W; 26.X.2010; ISLA 6346 • 5 ♀; N5SM2_0038 cave; GEM_1715; 6°7'58"S, 50°8'12"W; 19.X.2010; ISLA 6322 • 1 ♀; N5SM2_0039 cave; GEM_1755; 6°7'56"S, 50°8'11"W; 19.X.2010; ISLA 6340 • 1 ♀; N5SM2_0040 cave; GEM_1756; 6°7'55"S, 50°8'10"W; 23.X.2010; ISLA 15751 • 7 ♀; N5SM2_0040 cave; GEM_1756; 23.X.2010; ISLA 96751 • 2 ♂, 2 ♀; N5SM2_0041 cave; GEM_1764; 6°7'54"S, 50°8'5"W; 25.X.2010; ISLA 6320 • 2 ♂, 2 ♀; N5SM2_0042 cave; GEM_1770; 6°7'54"S, 50°8'6"W; 21.X.2010; ISLA 6330 • 1 ♀; N5SM2_0043 cave; GEM_1757; 6°7'48"S, 50°8'3"W; 25.X.2010; ISLA 6350 • 2 ♂, 2 ♀; N5SM2_0045 cave; GEM_1717; 6°7'46"S, 50°8'4"W; 22.III.2011; ISLA 6341 • 2 ♂; N5SM2_0046 cave; GEM_1718; 6°7'46"S, 50°8'5"W; 20.X.2010; ISLA 15745 • 2 ♀; N5SM2_0054 cave; GEM_1694; 6°7'45"S, 50°8'5"W; 18.X.2010; ISLA 6345 • 1 ♂, 1 ♀; N5SM2_0056 cave; GEM_1626; 6°8'27"S, 50°8'9"W; 18.X.2010; ISLA 6343 • 3 ♂; N5SM2_0057 cave; GEM_1692; 6°7'41"S, 50°8'5"W; 16.X.2010; ISLA 6339 • 1 ♂; N5SM2_0059 cave; GEM_1690; 6°8'26"S, 50°8'11"W; 30.IX.2010; ISLA 6748 • 1 ♂; N5SM2_0063 cave; GEM_1688; 6°7'31"S, 50°7'54"W; 30.IX.2010; ISLA 15739 • 2 ♀; N5SM2_0075 cave; GEM_1743; 6°7'23"S, 50°7'48"W; 23.IX.2010; ISLA 21139 • 1 ♀; N5SM2_0078 cave; GEM_1761; 6°7'22"S, 50°7'49"W; 28.IX.2010; ISLA 6318 • 1 ♀; N5SM2_0079 cave; GEM_1745; 6°8'26"S, 50°8'9"W; 27.IX.2010; ISLA 6334 • 1 ♀; N5SM2_0081 cave; GEM_1752; 6°7'19"S, 50°7'43"W; 27.IX.2010; ISLA 15749 • 2 ♂, 1 ♀; N5SM2_0081 cave; GEM_1752; 27.IX.2010; ISLA 96749 • 2 ♀; N5SM2_0084 cave; GEM_1768; 6°7'19"S, 50°7'40"W; 29.IX.2010; ISLA 6311 • 10 ♀; N5SM2_0088 cave; GEM_1760; 6°7'14"S, 50°7'44"W; 24.XI.2010; ISLA 21140 • 2 ♂, 1 ♀; N5SM2_0093 cave; GEM_1731; 6°8'29"S, 50°8'14"W; 24.IX.2010; ISLA 6348 • 1 ♀; N5SM2_0094 cave; GEM_1729; 6°7'17"S, 50°7'55"W; 24.IX.2010; ISLA 15741 • 1 ♂; N5SM2_0096 cave; GEM_1698; 6°7'9"S, 50°7'54"W; 29.XI.2010; ISLA 21145 • 1 ♂; N8_0003 cave; GEM_541; 6°10'10"S, 50°9'34"W; 2-29.IV.2015; ISLA 30385 • 1 ♂; N8_0003 cave; GEM_923; 4.IX-6.X.2014; ISLA 30743 • 2 ♀; N8_0004 cave; GEM_562; 6°10'7"S, 50°9'29"W; 24.II-13.III.2015; ISLA 30406 • 1 ♂; N8_0004 cave; GEM_579; 24.II-13.III.2015; ISLA 30423 • 1 ♂, 1 ♀; N8_0004 cave; GEM_912; 4.IX-6.X.2014; ISLA 30732 • 1 ♀; N8_0004 cave; GEM_934; 4.IX-6.X.2014; ISLA 30754 • 1 ♂; N8_0007 cave; GEM_542; 6°10'5"S, 50°9'30"W; 2-29.IV.2015; ISLA 30386 • 1 ♂; N8_0007 cave; GEM_780; 17.VII-4.VIII.2014; ISLA 30611 • 1 ♂; N8_0007 cave; GEM_794; 17.VII-4.VIII.2014; ISLA 30625 • 1 ♂, 1 ♀; N8_0007 cave; GEM_827; 17.VII-4.VIII.2014; ISLA 30652 • 1 ♂; N8_0008 cave; GEM_552; 6°10'6"S, 50°9'33"W; 2-29.IV.2015; ISLA 30396 • 2 ♂; N8_0008 cave; GEM_583; 2-29.IV.2015; ISLA 30427 • 1 ♂, 1 ♀; N8_0009 cave; GEM_779; 6°10'6"S, 50°9'31"W; 17.VII-4.VIII.2014; ISLA 30610 • 1 ♂, 1 ♀; N8_0010 cave; 6°10'10"S, 50°9'28"W; 02-29.IV.2015; ISLA 37887 • 1 ♂; N8_0011 cave; GEM_916; 6°10'7"S, 50°9'27"W; 4.IX-6.X.2014; ISLA 30736 • 1 juv.; N8_0013 cave; GEM_6°10'8"S, 50°9'28"W; ISLA 30390 • 1 ♀; N8_0013 cave; GEM_572; 2-29.IV.2015; ISLA 30416 • 1 ♂; N8_0013 cave; GEM_914; 4.IX-6.X.2014; ISLA 30734 • 1 ♂, 2 ♀; N8_0013 cave; GEM_925; 4.IX-6.X.2014; ISLA 30745 • 1 ♀; N8_0013 cave; GEM_949; 4.IX-6.X.2014; ISLA 30764 • 1 ♂, 1 ♀; N8_0014 cave; GEM_913; 6°10'11"S, 50°9'26"W; 4.IX-6.X.2014; ISLA 30733 • 1 juv.; N8_0015 cave; GEM_560; 6°10'9"S, 50°9'26"W; 2-29.IV.2015; ISLA 30404 • 1 ♂, 2 ♀; N8_0017 cave; GEM_574; 6°10'6"S, 50°9'29"W; 2-29.IV.2015; ISLA 30418 • 3 ♂; N8_0017 cave; GEM_929; 4.IX-6.X.2014; ISLA 30749 • 1 ♀; N8_0017 cave; GEM_943; 4.IX-6.X.2014; ISLA 30758 • 1 ♀; N8_0018 cave; GEM_539; 6°10'7"S, 50°9'30"W; 2-29.IV.2015; ISLA 30383 • 1 ♀; N8_0018 cave; GEM_540; 2-29.IV.2015; ISLA 30384 • 1 ♂; N8_0018 cave; GEM_567; 2-29.IV.2015; ISLA 30411 • 1 ♀; N8_0019 cave; GEM_804; 6°10'30"W,

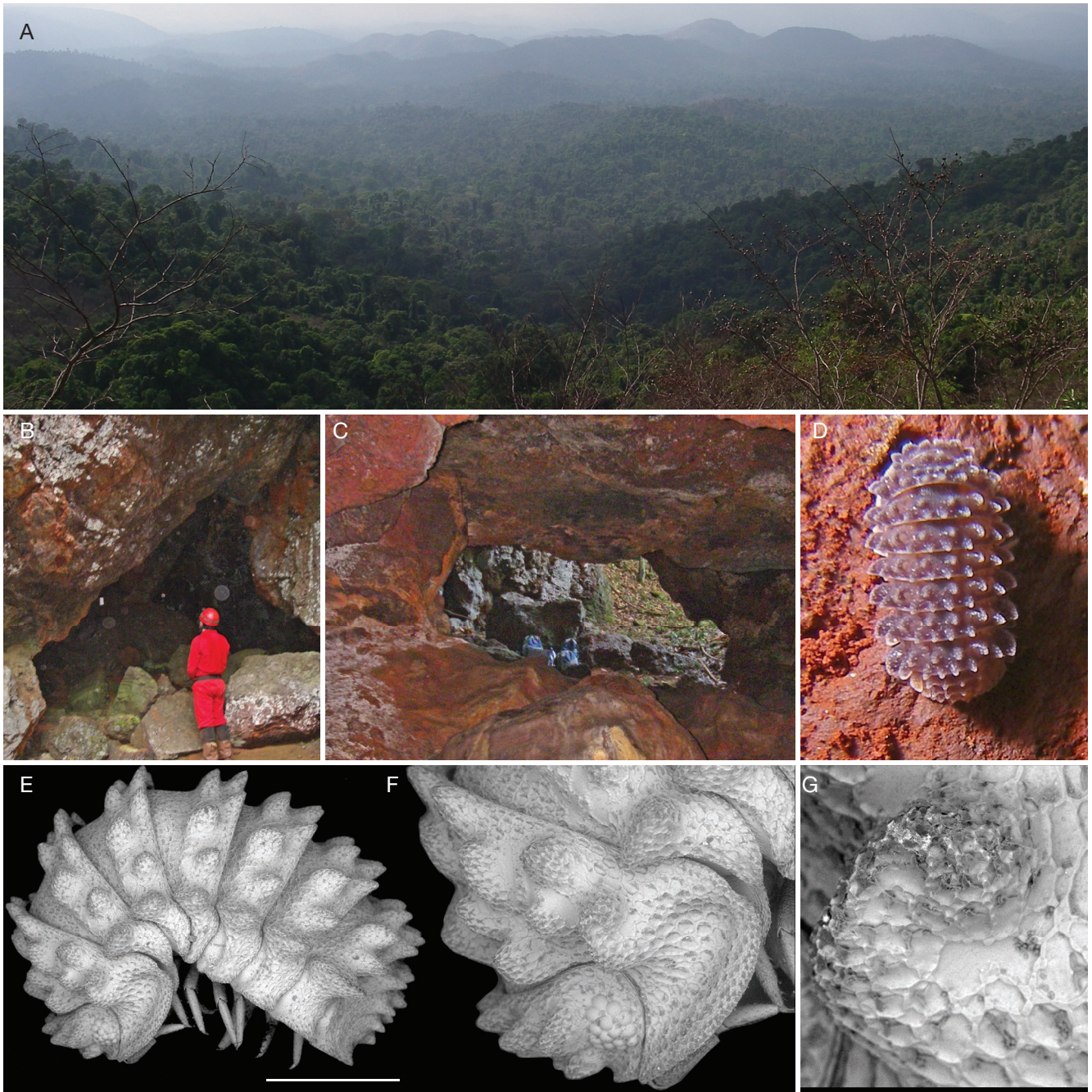


FIG. 1. — *Ctenorillo ferrarai* Campos-Filho, Araujo & Taiti, 2014: **A**, Serra Norte Mountain range in the Carajás National Forest; **B**, entrance of an iron ore cave in the Serra Norte region where specimens are found; **C**, inner portion of an iron ore cave where specimens are found; **D**, habitus in natural condition; **E**, lateral view; **F**, cephalon and epimeron 1, lateral view; **G**, dorsal tubercle with nodulus lateralis. Scale bar: 1 mm.

50°9'5"W; 17.VII-4.VIII.2014; ISLA 30635 • 1 ♀; N8_0020 cave; GEM_549; 6°10'16"S, 50°9'30"W; 24.II-13.III.2015; ISLA 30393 • 1 ♂; N8_0020 cave; GEM_830; 17.VII-4.VIII.2014; ISLA 30655 • 1 ♂, 2 ♀; N8_0022 cave; GEM_545; 6°10'32"S, 50°9'28"W; 2-29.IV.2015; ISLA 30389 • 1 ♂, 2 ♀; N8_0022 cave; GEM_545; 2-29.IV.2015; ISLA 30405 • 1 ♂; N8_0022 cave; GEM_775; 17.VII-4.VIII.2014; ISLA 30606 • 1 ♂; N8_0022 cave; GEM_814; 17.VII-4.VIII.2015; ISLA 30640 • 1 ♀; N8_0023 cave; GEM_553; 6°10'31"S, 50°9'3"W; 2-29.IV.2015; ISLA 30397 • 1 ♂, 1 ♀; N8_0023 cave; GEM_553; 2-29.IV.2015; ISLA 30412 • 1 juv.; N8_0023 cave; GEM_573; 2-29.IV.2015; ISLA 30417 • 1 ♀; N8_0023 cave; GEM_585; 2-29.IV.2015; ISLA 30429 • 1 ♀;

N8_0023 cave; GEM_917; 4.IX-6.X.2014; ISLA 30737 • 1 ♀; N8_0023 cave; GEM_940; 4.IX-6.X.2014; ISLA 30755 • 1 ♀; N8_0025 cave; GEM_582; 6°10'6"S, 50°9'31"W; 2-29.IV.2015; ISLA 30426 • 1 ♂; N8_0026 cave; GEM_797; 6°10'25"S, 50°8'50"W; 17.VII-4.VIII.2016; ISLA 30628 • 1 ♂; N8_0026 cave; GEM_815; 17.VII-4.VIII.2016; ISLA 30641 • 1 ♂, 2 ♀; N8_0028 cave; GEM_580; 6°10'7"S, 50°9'28"W; 2-29.IV.2015; ISLA 30424 • 1 ♂; N8_0029 cave; GEM_802; 6°10'6"S, 50°9'35"W; 17.VII-4.VIII.2014; ISLA 30633 • 1 ♀; N8_0038 cave; GEM_554; 6°10'6"S, 50°9'33"W; 2-29.IV.2015; ISLA 30398 • 1 ♀; N8_0038 cave; GEM_799; 17.VII-4.VIII.2014; ISLA 30630 • 3 juv.; N8_0038 cave; GEM_825; 17.VII-4.VIII.2014; ISLA 30650 • 1 ♀; N8_0038

cave; GEM_839; 17.VII-4.VIII.2014; ISLA 30664 • 1 ♂, 2 ♀; N4E_016; RESCUE; 6°27'S, 50°9'38"W; 16.I.2018; ISLA 48892 • 1 ♀; N4E_018; RESCUE; 6°2'5"S, 50°9'38"W; 5.II.2018; ISLA 48895 • 1 ♀; N4E_027; 6°2'15"S, 50°10'4"W; 10-17.IV.2018; ISLA 95922 • 1 ♀; N4E_027; 10-17.IV.2018; ISLA 95926 • 1 ♀; N4E_027; 10-17.IV.2018; ISLA 95933 • 1 ♀; N4E_036; 6°2'9"S, 50°9'36"W; 14.II.2014; ISLA 40735 • 1 ♀; N4E_039; 6°1'59"S, 50°9'40"W; 21-30.VII.2018; ISLA 61310 • 1 ♀; N4E_043; 6°1'56"S, 50°9'51"W; 21-30.VII.2022; ISLA 61314 • 1 ♀; N4E_044; 6°1'56"S, 50°9'51"W; 21-30.VII.2019; ISLA 61306 • 1 juv.; N4W_023; RESCUE; 6°2'2"S, 50°10'8"W; 15.I.2018; ISLA 48884 • 1 ♀; N4WS_010; RESCUE; 6°5'22"S, 50°11'42"W; 21-31.X.2018; ISLA 61679 • 1 ♂; N4WS_018; 6°4'34"S, 50°11'37"W; 21-30.VII.2020; ISLA 61308 • 1 juv.; N4WS_036; 6°5'50"S, 50°11'8"W; 10-17.IV.2017; ISLA 95917 • 1 ♂; N4WS_036; 10-17.IV.2017; ISLA 95920 • 1 ♂; N4WS_036; 10-17.IV.2017; ISLA 95924 • 1 ♂; N4WS_036; 10-17.IV.2017; ISLA 95928 • 1 ♂, 4 ♀; N4WS_039; RESCUE; 6°3'59"S, 50°11'36"W; 21-31.X.2020; ISLA 61681 • 1 ♂, 1 ♀; N4WS_055; 6°4'51"S, 50°11'46"W; 21-30.VII.2018; ISLA 61316 • 1 ♀; N4WS_064; 6°4'53"S, 50°11'44"W; 21-30.VII.2021; ISLA 61312 • 1 ♂, 1 ♀; N4WS_064; 21-30.VII.2021; ISLA 61313.

Brazil. Pará state, Parauapebas municipality, Serra do Tarzan plateau, E.M.B. Silva leg. • 1 ♂; ST_0002 cave; 6°19'32"S, 50°7'7"W; 21.I.2016; ISLA44232 • 1 ♀; ST_0003 cave; 6°19'38"S, 50°6'50"W; 2.II.2016; ISLA44233 • 1 ♂; ST_0026, 21.I.2016; ISLA44234 • 1 ♀; ST_0022 cave; 6°19'11"S, 50°7'55"W; 2.II.2016; ISLA43714 • 1 ♀; ST_0045 cave; 6°19'4"S, 50°7'35"W; 3.VIII.2016; ISLA96369 • 2 ♀; ST_0018 cave; 6°19'49"S, 50°7'21"W; 4.VIII.2016; ISLA96374 • 1 ♂, 4 ♀; ST_0020 cave; 6°18'59"S, 50°7'13"W; 4.II.2016; ISLA96373 • 1 ♀; ST_0017 cave; 6°18'54"S, 50°6'20"W; 3.II.2016; ISLA96378 • 1 ♀; ST_0030 cave; 6°18'59"S, 50°7'13"W; 21.VII.2016; ISLA96752 • 1 ♀; ST_0031 cave; 6°18'37"S, 50°5'58"W; 13.VII.2016; ISLA96753 • 2 ♀, 1 juv.; ST_0030 cave; 6°18'59"S, 50°7'13"W; 21.VII.2016; ISLA96388 • 1 ♀; ST_0044 cave; 6°18'59"S, 50°7'39"W; 2.II.2016; ISLA96399 • 3 ♀; ST_0048 cave; 6°19'5"S, 50°7'39"W; 26.I.2016; ISLA96400 • 1 ♀; ST_0054 cave; 6°19'16"S, 50°8'21"W; 29.I.2016; ISLA96754 • 1 ♀; ST_0040 cave; 6°19'46"S, 50°9'51"W; 25.I.2016; ISLA96405 • 1 ♂, 1 ♀; ST_0020 cave; 6°18'57"S, 50°7'22"W; 21.I.2016; ISLA96410 • 2 ♀; ST_0016 cave; 6°19'10"S, 50°7'33"W; 4.III.2016; ISLA96413 • 1 ♀; ST_0026 cave; 6°19'32"S, 50°7'13"W; 18.VII.2016; ISLA96415 • 1 ♂; ST_0010 cave; 6°12'51"S, 50°6'32"W; 12.VII.2016; ISLA96412 • 1 ♀; ST_0030 cave; 6°18'59"S, 50°7'13"W; 4.II.2016; ISLA96419 • 1 ♂, 2 ♀; ST_0064 cave; 6°18'43"S, 50°8'35"W; 7.I.2016; ISLA96420 • 1 ♂; ST_0053 cave; 6°19'16"S, 50°8'21"W; 29.I.2016; ISLA96424 • 2 ♂, 1 ♀; ST_0049 cave; 6°19'10"S, 50°7'38"W; 26.I.2016; ISLA96425 • 1 ♂, 1 ♀; ST_0061 cave; 6°18'46"S, 50°8'30"W; 27.I.2016; ISLA96426 • 1 ♂, 1 ♀; ST_0013 cave; 6°19'1"S, 50°6'24"W; 3.II.2016; ISLA96427 • 1 ♂; ST_0070 cave; 6°19'0"S, 50°7'16"W; 2.VIII.2016; ISLA96431 • 1 ♀; ST_0017 cave; 6°18'54"S, 50°6'20"W; 14.VII.2016; ISLA96433 • 1 ♀; ST_0016 cave; 6°19'10"S, 50°7'33"W; 4.VIII.2016; ISLA96435 • 3 ♂, 5 ♀; ST_0030 cave; 6°18'59"S, 50°7'13"W; 4.II.2016; ISLA96436 • 2 ♂, 2 ♀; ST_0026 cave; 6°19'32"S, 50°7'13"W; 21.I.2016; ISLA96437 • 2 ♀; ST_0056 cave; 6°19'39"S, 50°8'23"W; 20.VII.2016; ISLA96438 • 1 ♀; ST_0009 cave; 6°19'28"S, 50°6'32"W; 12.VII.2016; ISLA96440 • 1 ♂; ST_0038 cave; 6°18'47"S, 50°5'50"W; 3.II.2016; ISLA96755 • 4 ♀; ST_0030 cave; 6°18'59"S, 50°7'13"W; 21.VII.2016; ISLA96756.

DISTRIBUTION. — Carajás National Forest, Pará State.

HABITAT

Ctenorillo ferrarai were originally found in two caves in the Carajás region, located in eastern Pará state, in the Amazon Forest. Unfortunately, data on their habitats were not pro-

vided in the original description (Campos-Filho *et al.* 2014). Herein we add additional occurrences for this species and some notes on their habitats, along with the first photographs of living specimens (Fig. 1). The Carajás region presents massive iron ore reserves (among other metals) thus being strategically important for the Brazilian economy. However, due to the accelerated growth of iron ore exploitation, the natural landscapes, including both external (forests) and subterranean (caves) components are under unprecedented threat. A considerable part of the iron ore plateaus in the Carajás region is located in the conservation unit of the Carajás National Forest. This National Forest embraces parts of the municipalities of Parauapebas, Canaã dos Carajás, and Água Azul do Norte and is composed by a mosaic of protected areas that adds up to 1.31 million hectares of preserved forests (Rolim *et al.* 2006) surrounded by severely impacted areas especially covered by pastures (Campos & Castilho 2012; Martins *et al.* 2012). This conservation unit preserves ombrophilous or seasonal forest formations (Fig. 1A), with 5% consisting of laterite plateaus, which outcrops on the high areas of the region (Campos & Castilho 2012). Despite the status of a conservation unit, the Carajás National Forest, is highly altered by mining, farming and illegal deforestation (Mertens *et al.* 2002; Souza-Filho *et al.* 2016; Oliveira *et al.* 2020; Rizzo *et al.* 2020). The current climate classification of the region is Aw according to Köppen's system (Alvares *et al.* 2013). It is characterized by a high annual precipitation, which follows a unimodal pattern, with the rainy season peaking between January and March. The region receives an annual total precipitation of approximately 2.033 millimeters, with three-quarters of this occurring during the three wettest months. Monthly average temperatures range from 25.1°C to 26.3°C, with minimums between 15.6°C and 18.3°C (from July to October) and maximums between 34.3°C and 38.1°C, in the remaining months. The region maintains consistently high humidity levels throughout the year, with monthly average relative air humidity varying between 76.8% and 88.5%.

In Serra Norte Mountain Range samples were made in around 900 iron ore caves. Specimens of *C. ferrarai* (Fig. 1D) were found in 114 caves (which corresponds to approximately 12.7% of the caves in the area). Additionally, specimens were also found in 34 caves in the Serra do Tarzan region, in an area close to the Serra Sul complex (Fig. 1B, C). Hence, its wide distribution in caves located at different iron ore plateaus indicates that this species certainly occurs outside caves, and is considered a troglomorphic species. The caves where the specimens were found are extremely variable in their geological traits, such as the number and size of their entrances, the total length, and the position on the plateaus, among other characteristics, thus indicating that the species seems to be a generalist cave inhabitant, apparently not demanding specific habitat traits. It is important to mention, however, that the quarries expansion in the last years may represent a significant threat, thus monitoring plans should include this species to evaluate any changes in its distributional patterns and population attributes.

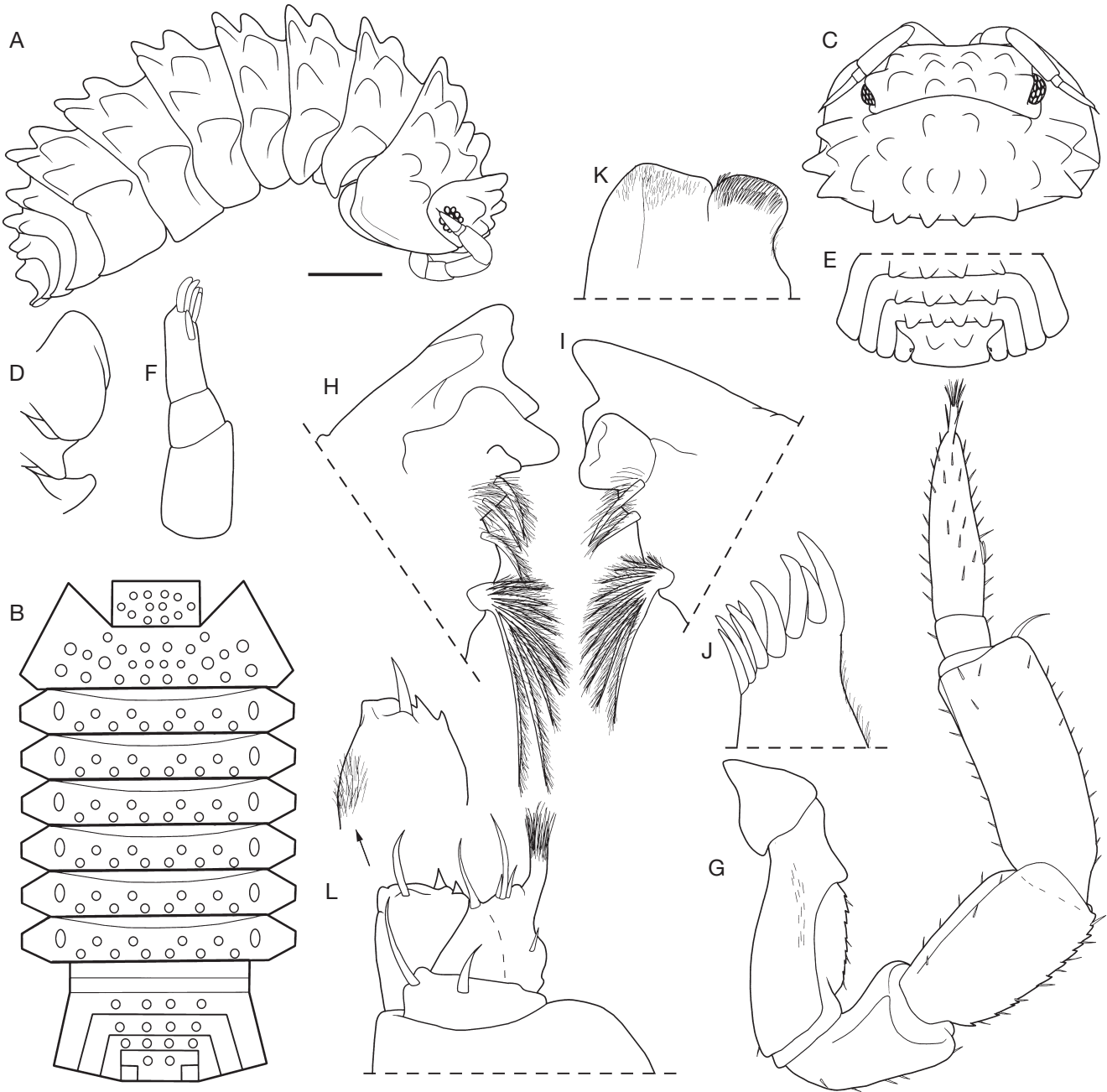


FIG. 2. — *Ctenorillo pelado* Cardoso & Ferreira, n. sp. paratype (male, 5 mm, ISLA96774): **A**, habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon and pereonite 1, dorsal view; **D**, epimera 1-3 ventral view; **E**, pleonites 3-5, uropods and telson, dorsal view; **F**, antennula; **G**, antenna; **H**, right mandible; **I**, left mandible; **J**, maxillula; **K**, maxilla; **L**, maxilliped. Scale bar: 0.5 mm.

REMARKS

Ctenorillo ferrarai was initially documented in two distinct locations of Serra Norte within the Carajás National Forest. Additional surveys conducted in both Serra Norte and Serra do Tarzan provided evidence of similar configurations of dorsal tubercles, which suggests that these specimens are conspecific with the initial discovery. *Ctenorillo ferrarai* is distinguished by its well-defined tubercles present on both the pereon and pleon segments, as well as a singular rib comprising the first lateral tubercle on epimeron 1 (Fig. 1D-G). This trait is of particular interest and will be further examined in other species within this genus.

Ctenorillo pelado Cardoso & Ferreira, n. sp. (Figs 2-4; 27B; 28A-D)

[urn:lsid:zoobank.org:act:B55B71C4-84ED-4DF5-AF0E-6B8356376022](https://doi.org/10.21203/rs.3.rs-3111111/v1)

nec *Ctenorillo ferrarai* – Campos-Filho *et al.* 2023: 560, figs 22, 23.

TYPE MATERIAL. — **Holotype.** Brazil. Pará state; Curionópolis municipality; Serra Leste plateau • ♂ (4.5 mm); SL_0001 cave; 5°57'58"S, 49°38'57"W; 14.I.2011; ISLA96773.

Paratypes. Brazil • 1 ♂ (parts in slide); same data as holotype; ISLA96774 • 4 ♂, 3 ♀; SL_0001 cave; same data as holotype; ISLA15135 • 2 juv.; same data as holotype; 4.VII.2010; ISLA15926 • 5 ♂, 5 ♀; same data as holotype; 4.VII.2010; ISLA15969.

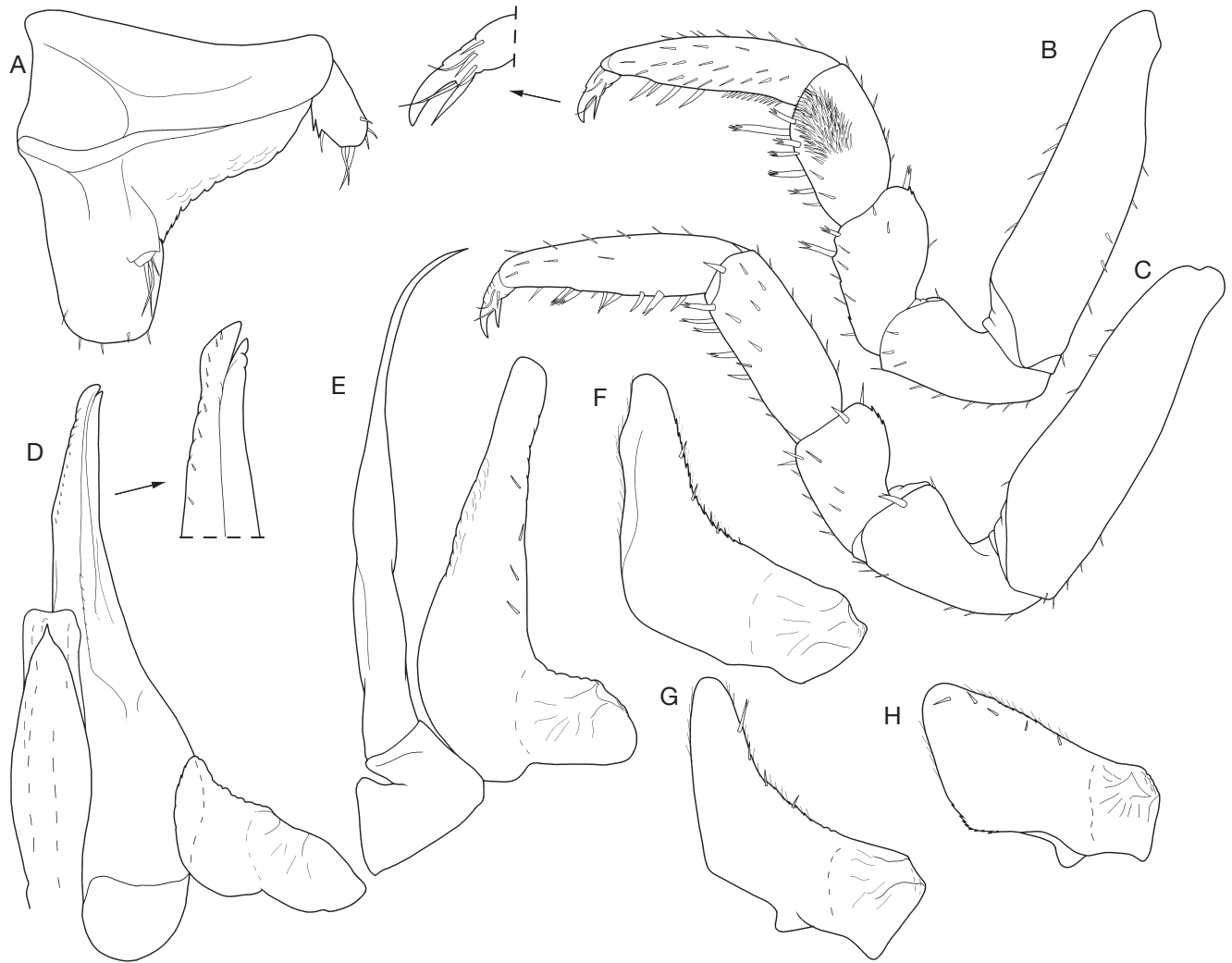


FIG. 3. — *Ctenorillo pelado* Cardoso & Ferreira, n. sp. paratype (male, 5 mm, ISLA96774): **A**, uropod; **B**, pereopod 1; **C**, pereopod 7; **D**, pleopod 1 and genital papilla; **E**, pleopod 2; **F**, pleopod 3 exopod; **G**, pleopod 4 exopod; **H**, pleopod 5 exopod.

OTHER MATERIAL. — **Brazil**. Pará; Curionópolis municipality; Serra Leste plateau • 4 ♂, 5 ♀; SL_0002 cave; 5°52'57"S, 49°38'57"W; 13.I.2011; ISLA15136 • 8 ♂, 2 ♀; SL_0002 cave; 3.VII.2010; ISLA15970 • 2 ♂; SL_0003 cave; 3.VII.2010; ISLA15971 • 2 ♂, 5 ♀; SL_0004 cave; 5°57'49"S, 49°38'59"W; 13.I.2011; ISLA15137 • 2 ♂, 2 ♀; SL_0004 cave; 3.VII.2010; ISLA15972 • 1 ♂, 2 ♀; SL_0006 cave; 5°57'48"S, 49°38'59"W; 13.I.2011; ISLA15138 • 3 ♀; SL_0006 cave; 28.VI.2010; ISLA15902 • 1 ♂, 6 ♀; SL_0007 cave; 5°57'58"S, 49°38'58"W; 3.XII.-2011; ISLA15872 • 1 ♂, 2 ♀; SL_0007 cave; 4.VII.2010; ISLA15939 • 3 ♀, 3 juv.; SL_0008 cave; 5°58'3"S, 49°38'58"W; 14.I.2012; ISLA15139 • 4 ♂, 3 ♀; SL_0008 cave; 5.VII.2010; ISLA15973 • 1 ♀, 1 juv.; SL_0011 cave; 5°58'4"S, 49°38'59"W; 14.I.2011; ISLA15140 • 1 ♀; SL_0012 cave; 5°57'52"S, 49°38'59"W; 4.VII.2016; ISLA15974 • 2 ♀; SL_0013 cave; 5°57'47"S, 49°38'59"W; 13.I.2011; ISLA15141 • 1 ♀; SL_0014 cave; 5°57'46"S, 49°39'0"W; 13.I.2011; ISLA15878 • 1 ♀; SL_0015 cave; 5°57'44"S, 49°39'0"W; 2.II.2011; ISLA15142 • 1 ♂; SL_0016 cave; 5°58'12"S, 49°38'51"W; 12.I.2011; ISLA6211 • 2 ♂, 6 ♀; SL_0016 cave; 12.I.2011; ISLA15143 • 1 ♀; SL_0016 cave; 6.VI.2010; ISLA16588 • 1 ♂; SL_0017 cave; 5°58'16"S, 49°38'48"W; 8.I.2011; ISLA15144 • 3 ♀; SL_0019 cave; 5°58'15"S, 49°38'47"W; 12.I.2011; ISLA15145 • 1 juv.; SL_0020 cave; 5°58'15"S, 49°38'47"W; 12.I.2011; ISLA15146 • 2 ♀; SL_0022 cave; 5°58'17"S, 49°38'46"W; 29.I.2011; ISLA15147 • 1 ♀, 3 juv.;

SL_0023 cave; 5°58'18"S, 49°38'46"W; 12.I.2011; ISLA15985 • 3 ♂, 6 ♀; SL_0024 cave; 5°58'19"S, 49°38'41"W; 9.VI.2010; ISLA15929 • 2 ♂, 4 ♀; SL_0026 cave; 5°58'21"S, 49°38'41"W; 12.I.2011; ISLA15976 • 2 ♂, 1 ♀; SL_0026 cave; 9.VI.2010; ISLA16589 • 2 ♂; SL_0030 cave; 5°58'20"S, 49°38'37"W; 8.VI.2010; ISLA15954 • 1 ♀; SL_0032 cave; 5°58'7"S, 49°38'40"W; 27.VII.2010; ISLA15942 • 1 ♂, 3 ♀; SL_0035 cave; 5°58'32"S, 49°38'16"W; 31.I.2011; ISLA15148 • 1 ♂, 2 ♀; SL_0036 cave; 5°58'31"S, 49°38'15"W; 23.VII.2010; ISLA15931 • 1 ♀; SL_0037 cave; 5°58'40"S, 49°37'54"W; 27.I.2011; ISLA15855 • 1 ♀; SL_0037 cave; 8.VII.2010; ISLA15935 • 1 ♂; SL_0042 cave; 5°58'14"S, 49°38'47"W; 2.II.2011; ISLA15149 • 2 ♂; SL_0042 cave; 8.VII.2010; ISLA16590 • 1 ♀; SL_0047; 30.VI.2010; ISLA16591 • 1 ♀; SL_0048 cave; 5°58'58"S, 49°37'52"W; 29.I.2011; ISLA15860 • 2 ♂, 1 ♀; SL_0049 cave; 5°58'58"S, 49°37'51"W; 29.I.2011; ISLA15980 • 2 ♂, 1 ♀; SL_0049; 27.VI.2010; ISLA16592 • 1 ♂, 2 ♀; SL_0057 cave; 5°58'36"S, 49°37'32"W; 11.I.2011; ISLA15151 • 1 ♀; SL_0058 cave; 5°58'34"S, 49°37'28"W; 29.I.2011; ISLA15150 • 1 ♂, 3 ♀; SL_0058 cave; 27.VI.2010; ISLA16593 • 3 ♂, 5 ♀; SL_0060 cave; 5°58'46"S, 49°37'22"W; 10.I.2011; ISLA15152 • 4 ♂, 5 ♀; SL_0060 cave; 10.VI.2010; ISLA16594 • 1 ♂; SL_0064 cave; 5°58'44"S, 49°37'17"W; 10.VI.2010; ISLA15924 • 1 ♀; SL_0065 cave; 5°58'53"S, 49°37'11"W; 2.XII.-2011; ISLA15154 • 2 ♂, 1 ♀; SL_0065; 2.XII.-2011; ISLA15155 • 2 ♂, 8 ♀; SL_0065 cave;

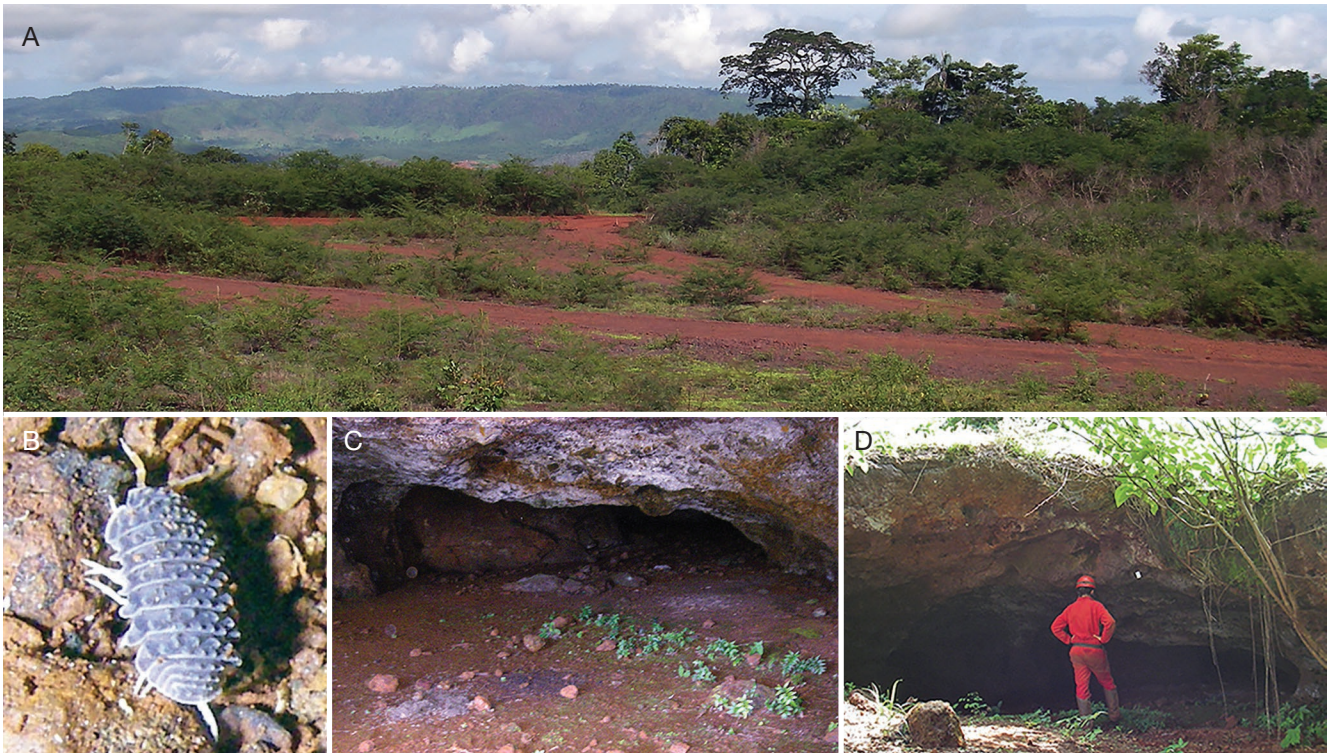


FIG. 4. — *Ctenorillo pelado* Cardoso & Ferreira, n. sp.: **A**, Serra Leste Mountain range; **B**, habitus in natural condition; **C**, inner portion of an iron ore cave where specimens are found; **D**, entrance of an iron ore cave in the Serra Norte region where specimens are found.

5.VI.2010; ISLA16595 • 1 ♀; SL_0066 cave; 5°58'52"S, 49°37'12"W; 2.XII.-2011; ISLA15153 • 1 ♀; SL_0066; 8.VII.2010; ISLA16596 • 1 ♂, 1 ♀; SL_0067 cave; 5°58'51"S, 49°37'12"W; 5.VI.2010; ISLA16597 • 1 ♂, 3 ♀; SL_0067 cave; 3.III.2011; ISLA15156 • 3 ♂, 5 ♀; SL_0069 cave; 5°59'2"S, 49°37'14"W; 3.XII.-2011; ISLA15157 • 1 ♂, 3 ♀; SL_0069 cave; 11.VI.2010; ISLA16598 • 1 juv.; SL_0072 cave; 7.I.2011; ISLA15158 • 2 ♂, 1 ♀; SL_0072 cave; 5°58'21"S, 49°37'28"W; 23.VII.2010; ISLA15909 • 3 ♂, 2 ♀; SL_0074 cave; 5°57'57"S, 49°37'55"W; 11.I.2010; ISLA15965 • 4 ♀; SL_0074 cave; 24.VI.2010; ISLA16599 • 1 ♂, 1 ♀; SL_0075 cave; 5°57'55"S, 49°37'56"W; 12.I.2011; ISLA15966 • 2 ♂, 1 ♀; SL_0076 cave; 5°58'0"S, 49°38'32"W; 31.I.2011; ISLA15110 • 2 ♀; SL_0077 cave; 5°58'0"S, 49°38'33"W; 29.VI.2010; ISLA16600 • 1 ♂, 1 ♀; SL_0082 cave; 5°57'30"S, 49°38'15"W; 7.VII.2010; ISLA15911 • 1 ♀; SL_0083 cave; 5°57'29"S, 49°38'11"W; 7.VII.2010; ISLA15945 • 2 ♀; SL_0085 cave; 5°57'30"S, 49°38'10"W; 18.I.2011; ISLA15099 • 1 ♀; SL_0085 cave; 21.VII.2010; ISLA15894 • 1 juv.; SL_0086 cave; 5°57'31"S, 49°38'10"W; 18.I.2011; ISLA15990 • 2 ♂, 2 ♀; SL_0087 cave; 5°57'31"S, 49°38'9"W; 2.II.2011; ISLA15111 • 5 ♂, 8 ♀; SL_0087 cave; 21.VII.2010; ISLA15913 • 1 ♀; SL_0088 cave; 5°57'31"S, 49°38'9"W; 22.VII.2010; ISLA21127 • 1 ♀; SL_0089 cave; 5°57'31"S, 49°38'8"W; 2.II.2011; ISLA15967 • 2 ♂; SL_0089 cave; 2.II.2011; ISLA21128 • 1 ♀; SL_0091 cave; 5°57'32"S, 49°38'7"W; 2.II.2011; ISLA15906 • 1 ♀; SL_0092 cave; 5°57'33"S, 49°38'7"W; 2.II.2011; ISLA15885 • 1 ♀; SL_0092 cave; ISLA15904 • 1 ♂, 2 ♀; SL_0099 cave; 5°58'33"S, 49°37'28"W; 7.I.2011; ISLA15968 • 2 ♂, 5 ♀; SL_0100 cave; 5°58'45"S, 49°37'21"W; 10.I.2011; ISLA15964 • 3 ♂, 2 ♀; SL_0100 cave; ISLA21129 • 3 ♂, 10 ♀; SL_0101 cave; ISLA6178 • 1 ♀; SL_0102; ISLA6182 • 1 ♀; SL_cm-t4b; 5°58'36"S, 49°37'33"W; 17.IV.2018; ISLA21130 • 1 ♂, 3 ♀; SL_cm-t4c; 5°58'35"S, 49°37'35"W; 17.IV.2017; ISLA21131 • 1 ♂, 1 ♀; SL_as-t4d; 5°58'34"S, 49°37'37"W; 26.IV.2018; ISLA21132 • 1 ♀; SL_as-t4b; 5°58'36"S, 49°37'33"W; 26.IV.2017; ISLA21133 • 1 ♀; SL_as-t4c; 5°58'35"S, 49°37'35"W; 26.IV.2017; ISLA21134 • 1 ♂; SL_as-t1b; 5°58'23"S, 49°38'32"W; 29.IV.2017;

ISLA21135 • 1 ♀; SL_cm-t4d; 5°58'34"S, 49°37'37"W; 17.II.2017; ISLA21136 • 1 ♂, 1 ♀; SL_apl-t4c; 5°58'35"S, 49°37'35"W; 17.II.2017; ISLA21137.

ETYMOLOGY. — The new species name is a noun in apposition that refers to the region where the species was collected, also known as “Serra Pelada”, which means “naked mountains”, in reference to the presence of the metallophilic vegetation, that is considerably reduced (in size) when compared to the surrounding Amazon Forest.

DIAGNOSIS. — Dorsum covered with conical tubercles and lateral ribs with three rows on cephalon (4, 2, 6); three rows on pereonite 1 (6, 10, 8); two rows on pereonites 2-7 (6 + 6); one row of four tubercles on pleonites 3-5; two paramedian tubercles on telson. Pleopod 1 exopod wider than long, triangular with protruding distal portion, outer margin concave and crenulate; endopod with distal portion straight, slightly swollen, four times longer than exopod.

DISTRIBUTION. — Carajás National Forest, Pará State.

DESCRIPTION

Maximum size: ♂, 4.5 mm, ♀, 6 mm. Color grey in nature, brownish in ethanol (Figs 4B; 27B). Dorsum covered with conical tubercles and lateral ribs (Figs 2A-C; 28A, B); cephalon with three rows (4, 2, and 6 from front to back of vertex); pereonite 1 with 24 in three rows (6, 10 and 8); pereonites 2-7 with 12 (6 + 6); pleonites 3-5 with one row of four tubercles; telson with two paramedian tubercles. Dorsal cuticle (Fig. 28B) with short triangular scale setae; pereonites 1-7 bearing one line of *noduli lateralis* per side on outer surface of posterior tubercle of second line of tubercles. Cephalon with frontal shield slightly protruding above vertex; eye consisting of 11 ommatidia (Figs 2C; 28A). Pereonite 1 with posterior

margin distinctly sinuous at sides; inner lobe of schisma rounded, extending beyond posterior margin of outer lobe; pereonite 2 with triangular ventral tooth reaching epimeron posterior margin (Figs 2A, D; 28D). Pereonites 2-7 (Figs 2A; 28B) with wide quadrangular epimera slightly bent outwards. Telson (Fig. 2E) hourglass-shaped, proximal portion broader than distal portion. Antennula (Fig. 2F) of three articles, second article much shorter than first and third, third article with two apical and four subapical aesthetascs. Antenna (Fig. 2G) short and stout, flagellum shorter than fifth article of peduncle; second article of flagellum about three times as long as first. Mandibles (Fig. 2H, I) with molar penicil semidichotomised, consisting of several plumose setae from common stem; right mandible with 1 + 1 and left mandible with 2 + 1 free penicils. Maxillula (Fig. 2J) with outer branch bearing 4 + 5 simple teeth. Maxilla (Fig. 2K) distally setose and bilobate, with inner lobe narrower than outer lobe. Maxilliped (Fig. 2L) endite with subapical large seta and two triangular setae on apical margin; palp with two setae on basal article. All pleopod exopods with monospiracular covered lungs (Fig. 28C). Uropod (Fig. 3A) protopod flattened, enlarged on basal portion; exopod very short, inserted dorsally close to medial margin of protopod.

Male

Pereopods without particular modifications (Fig. 3B, C). Pleopod 1 exopod (Fig. 3D) wider than long, triangular with protruding distal portion, outer margin concave and crenulate; endopod four times longer than exopod, distal portion straight, slightly swollen. Pleopod 2 endopod longer than exopod (Fig. 3E). Pleopods 3-5 exopods as in Figure 3F-H.

HABITAT

Specimens of *C. pelado* Cardoso & Ferreira, n. sp. were found in several caves in the Serra Leste Mountain Range (also known as Serra Pelada) which is part of the geological complex of the Carajás region, in the Carajás National Forest (Fig. 4A). The specimens were found in caves, and also in the external habitats, during external surveys (Fig. 4B). The regional climate is also classified as Aw according to the Köppen system, characterized by the same patterns of precipitation and temperature as described for the previous species (*C. ferrarai*). Nevertheless, given the regularity with which specimens have been observed within cave systems, it is plausible to classify this species as troglophilic. Of the approximately 120 iron ore caves surveyed in the region, *C. pelado* Cardoso & Ferreira, n. sp. was identified in 63 of these caves (roughly 52.5% of the total caves in the area), indicating an even broader distribution within Serra Leste than *C. ferrarai* within the Serra Norte complex (Fig. 4C, D). It should be noted that Serra Leste is primarily comprised of a single, extensive plateau, as opposed to the multiple plateaus present in the Serra Norte complex. As with *C. ferrarai*, the geological characteristics of caves inhabited by *C. pelado* Cardoso & Ferreira, n. sp. vary significantly, suggesting that this species is not strongly reliant on specific habitat traits. Despite the wide distribution of this species in the caves of the area, a large quarry is rapidly expanding in the region, posing a significant threat to the

species. Therefore, monitoring plans should include *C. pelado* Cardoso & Ferreira, n. sp. to assess any potential changes to its distributional patterns and population characteristics.

REMARKS

As mentioned previously, the *Ctenorillo* species are distinguished mainly by the shape, number, and disposition of dorsal tubercles. The morphology of *C. pelado* Cardoso & Ferreira, n. sp. and *C. ferrarai* is very similar, the species differ in the number of tubercles on pereonite 1 with *C. pelado* Cardoso & Ferreira, n. sp. presenting 24 tubercles and *C. ferrarai* presenting 22; this seems to be related to the prominent lateral rib in *C. ferrarai* while in *C. pelado* Cardoso & Ferreira, n. sp. the lateral rib is present from pereonite 2 to 7 with two tubercles (instead of one rib) on pereonite 1. The disposition of tubercles on pereonite 1 differ with 6 + 10 + 8 on *C. pelado* Cardoso & Ferreira, n. sp. and 4 + 12 + 6 on *C. ferrarai*. The specimen presented by Campos-Filho *et al.* (2023) were also collected in the Serra Leste plateau and resembles the morphology of *C. pelado* Cardoso & Ferreira, n. sp. presented here; therefore, we can consider them as the same species.

Comparing *C. pelado* Cardoso & Ferreira, n. sp. with other *Ctenorillo* species, on pleon, the presence of four tubercles on pleonites 3-5 is similar to *C. guinensis* (Schmalfuss & Ferrara, 1983), *C. legai* (Arcangeli, 1941), *C. mineri* and *C. ferrarai* from which it differs by the shape of male pleopod 1 exopod.

Ctenorillo araguaia Cardoso & Ferreira, n. sp. (Figs 5-7; 27C; 28E)

[urn:lsid:zoobank.org:act:4F19B81C-879D-43EC-A3BF-0AFBB1D908EF](https://www.zoobank.org/act:4F19B81C-879D-43EC-A3BF-0AFBB1D908EF)

TYPE MATERIAL. — **Holotype.** Brazil • 1 ♂ (5 mm); Pará state; São Geraldo do Araguaia municipality; Serra das Andorinhas cave; 6°16'55"S, 48°32'34"W; sector 4; 17-20.II.2018; V.F. Sperandei leg.; ISLA96775.

Paratypes. Brazil • 1 ♂ in slide; same data as holotype; ISLA96784 • 6 ♀; sector 1; same data as holotype; ISLA96776 • 1 ♀; sector 1; same data as holotype; ISLA96777 • 1 ♀; sector 3; same data as holotype; ISLA96778 • 3 ♂, 8 ♀; sector 4; same data as holotype; ISLA96779 • 5 ♂; sector 5; same data as holotype; ISLA96780 • 3 ♂, 5 ♀ sector 6; same data as holotype; ISLA96781 • 1 ♂; sector 7; same data as holotype; ISLA96782 • 1 ♂, 3 ♀; same data as holotype; ISLA96783.

OTHER MATERIAL. — **Brazil** • 4 ♂; Pará state; São Geraldo do Araguaia municipality; Remanso dos Botos cave; 6°22'6"S, 48°23'38"W; V. F. Sperandei leg.; 20.II.2018; ISLA96785.

ETYMOLOGY. — The new species name is a noun in apposition that refers to the Araguaia River, a Brazilian environmental heritage: the type locality is within the hydrographic basin of the Araguaia river. The word Araguaia comes from the indigenous Amazonian language term arauay (or araguaí), which designates a type of macaw species.

DIAGNOSIS. — Dorsum covered with conical tubercles and lateral ribs with three rows on cephalon (6, 2, 6); four rows on pereonite 1 (4, 7, 10, 6); two rows on pereonites 2-6 (10 + 8) and on pereonite 7 (6 + 8); one row of four tubercles on pleonites 3-5; and two paramedian tubercles on telson. Pleopod 1 exopod distal portion round, outer margin straight; endopod with distal portion slightly bent outward, slightly swollen, four times longer than exopod.

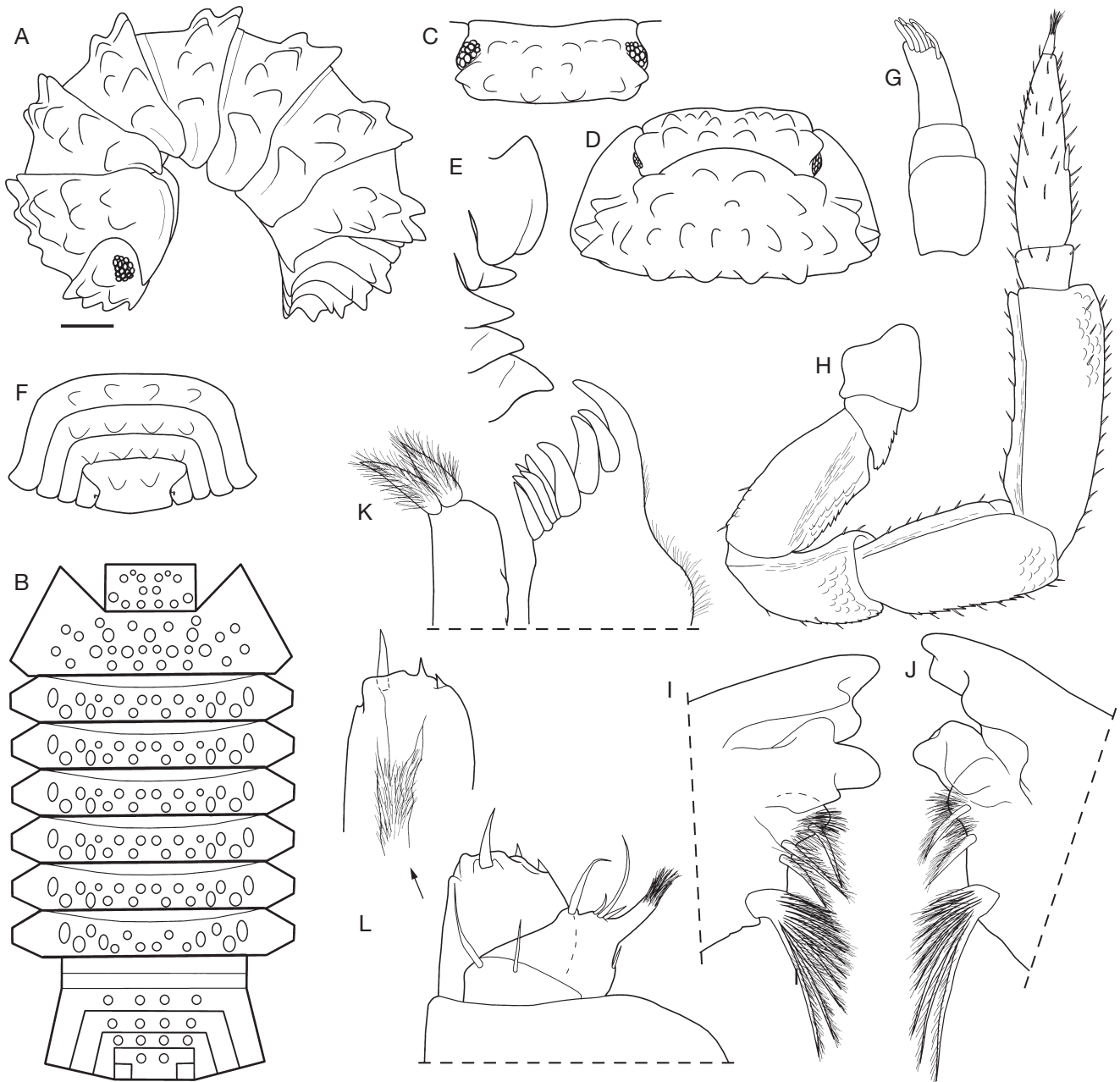


FIG. 5. — *Ctenorillo araguaia* Cardoso & Ferreira, n. sp. paratype (male, 5 mm, ISLA96784): **A**, habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon, dorsal view; **D**, cephalon and pereonite 1, dorsal view; **E**, epimera 1-5 ventral view; **F**, pleonites 3-5, uropods and telson, dorsal view; **G**, antennula; **H**, antenna; **I**, right mandible; **J**, left mandible; **K**, maxillula; **L**, maxilliped. Scale bar: 0.5 mm.

DISTRIBUTION.— Serra dos Martírios/Andorinhas State Park in São Geraldo do Araguaia municipality, Pará state.

DESCRIPTION

Maximum size: ♂, 5 mm, ♀, 6 mm. Color grey with lateral margins depigmented (Fig. 27C). Dorsum covered with conical tubercles and lateral ribs (Figs 5A, B; 28E); cephalon with three rows (6, 2, and 6 from front to back of vertex); pereonite 1 with 27 in four rows (4, 7, 10 and 6); pereonites 2-6 with 18 (10+8); pereonite 7 with 14 (6+8); pleonites 3-5 with one row of four tubercles; telson with two paramedian tubercles. Dorsal cuticle (Fig. 28E) with short triangular

scale setae; pereonites 1-7 bearing one line of *noduli lateralis* per side on outer surface of posterior tubercle of second line of tubercle. Cephalon with frontal shield directed upward; eye consisting of 16 ommatidia (Fig. 5C, D). Pereonite 1 with posterior margin sinuous at sides; inner lobe of schisma rounded, extending beyond posterior margin of outer lobe; pereonite 2 with triangular ventral tooth reaching epimeron posterior margin (Fig. 5E). Pereonites 2-7 (Fig. 5A) with wide quadrangular epimera slightly bent outwards. Telson (Fig. 5F) hourglass-shaped, proximal portion broader than distal portion. Antennula (Fig. 5G) of three articles, second article

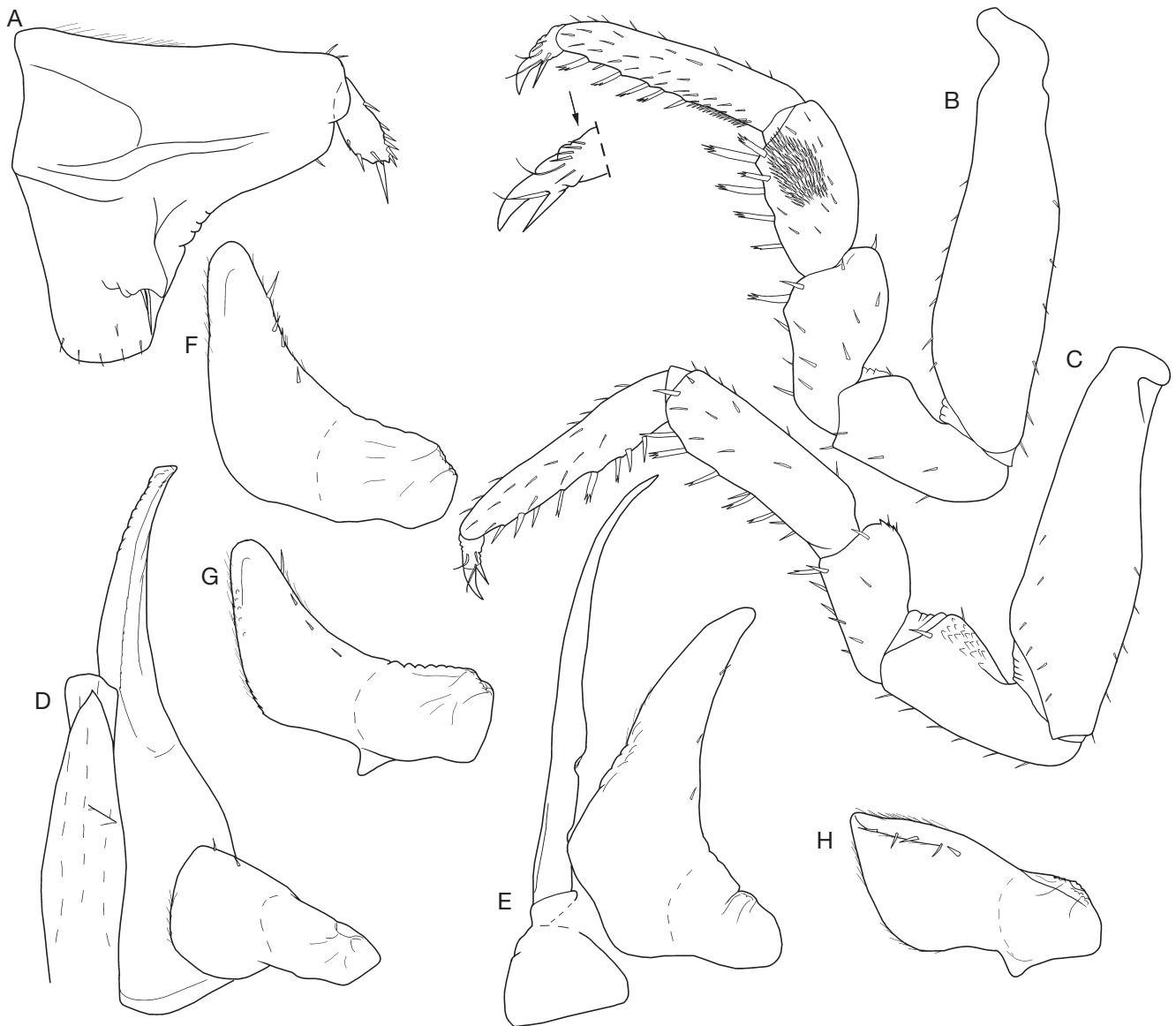


FIG. 6. — *Ctenorillo araguaia* Cardoso & Ferreira, n. sp. paratype (male, 5 mm, ISLA96784): **A**, uropod, **B**, pereopod 1; **C**, pereopod 7; **D**, pleopod 1 and genital papilla; **E**, pleopod 2; **F**, pleopod 3 exopod; **G**, pleopod 4 exopod; **H**, pleopod 5 exopod.

shorter than first and third, third article with six apical and one subapical aesthetascs. Antenna (Fig. 5H) short and stout, flagellum shorter than fifth article of peduncle; second article of flagellum about four times as long as first. Buccal pieces as *C. pelado* Cardoso & Ferreira, n. sp. (Fig. 5I-L). All pleopod exopods with monospiracular covered lungs. Uropod (Fig. 6A) protopod flattened, enlarged on basal portion; exopod very short, inserted dorsally close to medial margin of protopod.

Male

Pereopods without particular modifications (Fig. 6B, C). Pleopod 1 exopod (Fig. 6D) wider than long, distal portion round, outer margin straight; endopod four times longer than exopod, distal portion slightly bent outwards, slightly swollen. Pleopod 2 endopod longer than exopod (Fig. 6E). Pleopods 3-5 exopods as in Figure 6F-H.

HABITAT

Specimens of *C. araguaia* Cardoso & Ferreira, n. sp. were found in the Andorinhas cave and in Remanso dos Botos cave which are quartzite caves located in the Serra das Andorinhas Mountain Range (also known as Serra dos Martírios). The regional climate is classified, according to Köppen, as Aw5 (Tropical climate with dry season or Humid Equatorial), with annual rainfall between 1000 mm and 1500 mm and an average annual temperature of 26°C (22°-32°C). The relative humidity is high and varies from 25% to 90% with an average of 78% (Alvares *et al.* 2013).

The Andorinhas cave is 1 km long, featuring entrances on both the side cliffs covered by Amazonian Forest and the mountaintop covered by savannah vegetation (Fig. 7A, B). During the rainy season, an intermittent drainage flows through the cave. A large colony of insectivorous bats (*Pter-*



FIG. 7. — *Ctenorillo araguaia* Cardoso & Ferreira, n. sp.: **A**, quartzite outcrops on the Serra das Andorinhas mountain range; **B**, entrance of the Andorinhas cave, where specimens are found; **C**, inner portion of the Andorinhas cave; **D**, habitus in natural condition.

onotus sp.) inhabits some inner and isolated parts of the cave, producing a massive guano piles that cover the floor of several conduits and chambers. In upper areas of the cave conduit (Fig. 7C) away from the bat colony, specimens of *C. araguaia* Cardoso & Ferreira, n. sp. were found under rocks (Fig. 7D). Given the lack of bat guano in that part of the cave, it is probable that the new species feeds on plant debris carried by floods and deposited along this conduit. In contrast, the Remanso dos Botos cave is smaller (125 m) and located at a lower altimetric level of the hill. The main organic deposits in this cave are guano produced by bats with distinct feeding habits, such as frugivory (*Carollia* sp.) and insectivory (*Peropteryx* sp. and *Natalus* sp.). Moreover, seeds transported by the bats germinate, resulting in sprouts that were also consumed by some invertebrates. Specimens of *C. araguaia* Cardoso & Ferreira, n. sp. were observed on the cave floor in deeper areas of the cave, as in the Andorinhas cave.

The caves are located in the Serra dos Martírios/Andorinhas State Park, which preserves the mountain top and cliffs.

However, the surrounding landscape has been significantly impacted, particularly by deforestation for agriculture. The Andorinhas cave receives sporadic visitors, likely due to the difficult access to the cave. It is worth noting that the occurrence of *C. araguaia* Cardoso & Ferreira, n. sp. in these caves does not imply that the species is restricted to this habitat, especially considering the absence of any obvious troglomorphic traits. Therefore, further studies, including external samplings, are needed to better understand the distribution of the species.

REMARK

Ctenorillo araguaia Cardoso & Ferreira, n. sp. is similar to *C. pelado* Cardoso & Ferreira, n. sp., presenting two tubercles on pereonite 1 and lateral ribs from pereonites 2 to 7, but differs in the number of tubercles on pereonite 1 (27 vs 24 in *C. pelado* Cardoso & Ferreira, n. sp.), in the number of tubercles on pereonites 2 to 7 (18 tubercles on pereonites 2 to 6 and 14 on pereonite 7 vs *C. pelado* Cardoso & Ferreira, n. sp. with 12 tubercles on pereonites 2 to 7).

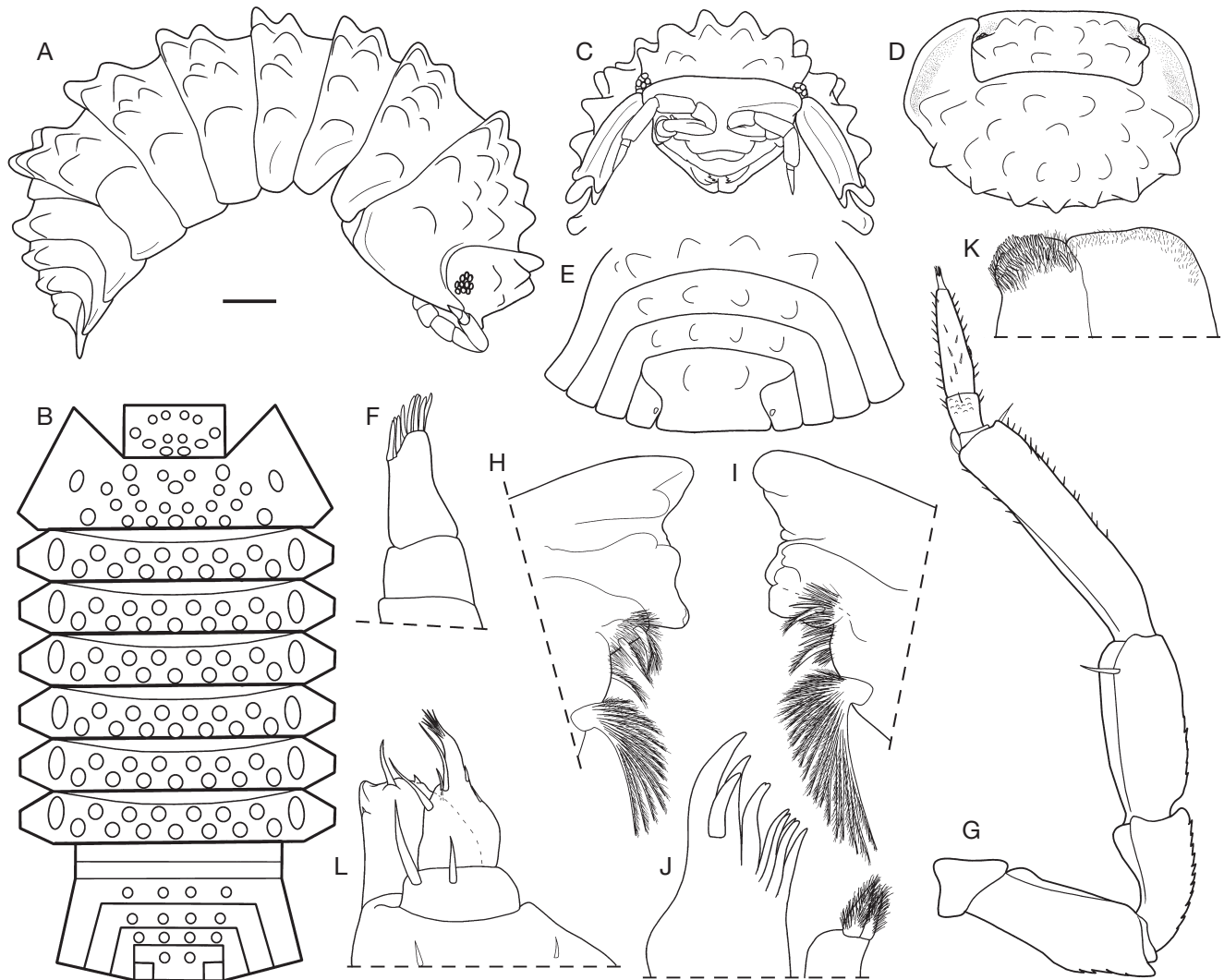


FIG. 8. — *Ctenorillo intertidalis* Cardoso & Ferreira, n. sp., paratype (male, 7.5 mm, ISLA96786): **A**, habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon and pereonite 1, frontal view; **D**, cephalon and pereonite 1, dorsal view; **E**, pleonites 3-5, uropods and telson, dorsal view; **F**, antennula; **G**, antenna; **H**, right mandible; **I**, left mandible; **J**, maxillula; **K**, maxilla; **L**, maxilliped. Scale bar: 0.5 mm.

Ctenorillo intertidalis Cardoso & Ferreira, n. sp.
(Figs 8-10; 27D; 28F, G)

[urn:lsid:zoobank.org:act:B61E5142-E53A-4AD7-AF85-B24944928069](https://zoobank.org/act:B61E5142-E53A-4AD7-AF85-B24944928069)

TYPE MATERIAL.— **Holotype.** Brazil • 1 ♂ (6 mm; parts in slide); Ceará state; Jijoca de Jericoacoara municipality; Jeri_10 cave; 2°47'12"S, 40°30'12"W; 25.IX.2019; R.L. Ferreira leg.; ISLA96786.
Paratypes. Brazil • 2 ♂, 9 ♀; same data as holotype; ISLA96787.

OTHER MATERIAL. — **Brazil.** Ceará state; Jijoca de Jericoacoara municipality • 10 ♂, 12 ♀; Jeri_4 cave; 2°47'18"S, 40°30'42"W; 25.IX.2019; R.L. Ferreira leg.; ISLA96788 1 ♂ in slide. Jeri_4 cave; ISLA96789 • 10 ♂, 11 ♀; Jeri_7 cave; 2°47'16"S, 40°30'34"W; 24.IX.2019; R.L. Ferreira leg.; ISLA96790 • 11 ♂, 7 ♀; Jeri_8; 2°47'17"S, 40°30'32"W; 24.IX.2019; R.L. Ferreira leg.; ISLA96791 • 1 ♂ in slide; Jeri_8; 24.IX.2019; R.L. Ferreira leg.; ISLA96792 • 7 ♂, 1 ♀; Duas bocas cave; 2°47'16"S, 40°30'33"W; 24.IX.2019; R.L. Ferreira leg.; ISLA96793 • 1 juv.; Jeri Novo cave; 2°47'15"S, 40°30'33"W; 25.IX.2019; R.L. Ferreira leg.; ISLA 96800.

ETYMOLOGY. — The new species name is a noun in apposition that refers to area in where the caves are located, close to the beach, in an intertidal area.

DIAGNOSIS.— Dorsum covered with conical tubercles and lateral ribs with three rows on cephalon (4, 2, 6); four rows on pereonite 1 (4, 7, 6, 7); two rows on pereonites 2-7 (8 + 7); one row of four tubercles on pleonites 3-5; and two paramedian tubercles on telson. Pleopod 1 exopod distal portion round, sinuous outer margin; endopod with distal portion slightly bent outward, three times longer than exopod.

DISTRIBUTION. — Jericoacoara National Park, municipality of Jijoca de Jericoacoara, North of Ceará state.

DESCRIPTION

Maximum size: ♂ and ♀, 7.5 mm. Color grey with lateral margins depigmented. Dorsum covered with conical tubercles and lateral ribs (Figs 8A, B; 28F, G); cephalon with three rows (4, 2, and 6 from front to back of vertex); pereonite 1 with 24 in four rows (4, 7, 6 and 7); pereonites 2-7

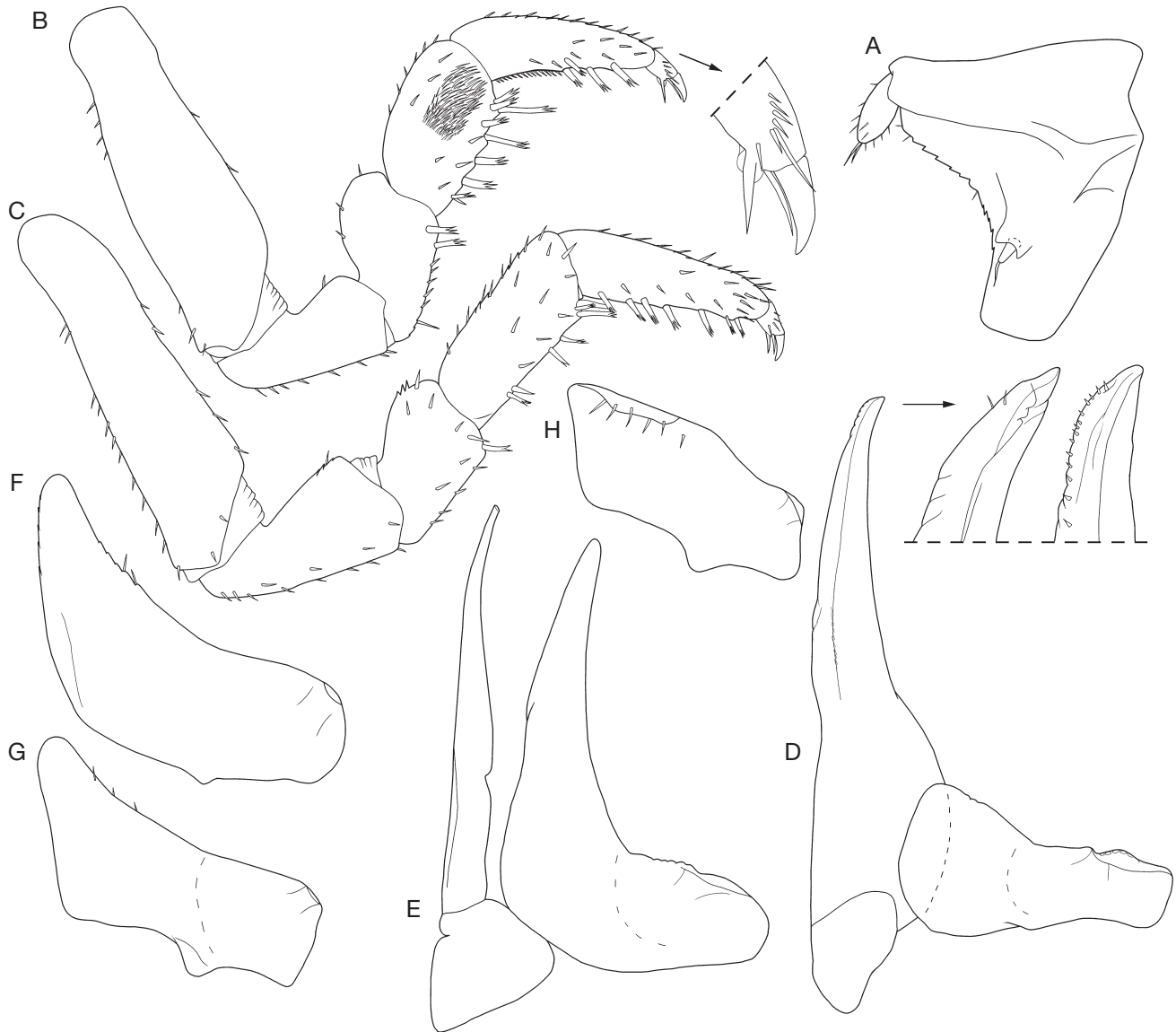


FIG. 9. — *Ctenorillo intertidalis* Cardoso & Ferreira, n. sp. paratype (male, 7.5 mm, ISLA96786): A, uropod, B, pereopod 1; C, pereopod 7; D, pleopod 1 and genital papilla; E, pleopod 2; F, pleopod 3 exopod; G, pleopod 4 exopod; H, pleopod 5 exopod.

with 15 (8 + 7); pleonites 3-5 with one row of four tubercles; telson with two paramedian tubercles. Dorsal cuticle (Fig. 28G) with short triangular scale setae, pereonites 1-7 bearing one line of *noduli lateralis* per side on outer surface of posterior tubercle of second tubercle. Cephalon with frontal shield protruding above vertex; eye consisting of 10 ommatidia (Figs 8A, C, D; 28F). Pereonite 1 with posterior margin sinuous at sides; inner lobe of schisma rounded, extending beyond posterior margin of outer lobe; pereonite 2 with triangular ventral tooth reaching epimeron posterior margin (Fig. 8C). Pereonites 2-7 (Fig. 8A) with wide quadrangular epimera slightly bent outwards. Telson (Fig. 8E) hourglass-shaped, proximal portion broader than distal portion. Antennula (Fig. 8F) of three articles, second article shorter than first and third, third article with four apical and five subapical aesthetascs. Antenna (Fig. 8G)

short and stout, flagellum shorter than fifth article of peduncle; second article of flagellum about twice as long as first. Buccal pieces as *C. pelado* Cardoso & Ferreira, n. sp. (Fig. 8H-L), except maxillula (Fig. 8J) with 4 + 6 simple teeth. All pleopod exopods with monospiracular covered lungs. Uropod (Fig. 9A) protopod flattened, enlarged on basal portion; exopod outward, short, inserted dorsally close to medial margin of protopod.

Male

Pereopods without particular modifications (Fig. 9B, C). Pleopod 1 exopod (Fig. 9D) wider than long, distal portion round, sinuous outer margin; endopod three times longer than exopod, distal portion slightly bent outwards. Pleopod 2 endopod longer than exopod (Fig. 9E). Pleopods 3-5 exopods as in Figure 9F-H.



Fig. 10. — *Ctenorillo intertidalis* Cardoso & Ferreira, n. sp.: **A**, quartzite outcrops on the shoreline of Jericoacoara, with a cave entrance (**yellow star**); **B**, inner portion of a cave where specimens are found; **C**, *Ctenorillo intertidalis* Cardoso & Ferreira, n. sp. specimen; **D**, habitus in natural condition sharing the habitat (under rocks) with other isopods.

HABITAT

Specimens of *C. intertidalis* Cardoso & Ferreira, n. sp. were found in six caves in quartzite outcrops on the shoreline (Fig. 10A, B), near the village of Jericoacoara, in the municipality of Jijoca de Jericoacoara. The climate is classified as hot and humid (Aw'sg, Köppen), with summer rains from January to July. Temperatures range from 25°C to 35°C, and the dry season lasts about six months and is often interrupted by heavy rains in October or September (Alvares *et al.* 2013).

The new species was found in six out of eight sampled caves in the area. The caves are quite small presenting, on average, 14.48 (± 7.48) meters of horizontal projection. Thus, most of them were devoid of aphotic zones. Specimens of *C. intertidalis* Cardoso & Ferreira, n. sp. were observed under rocks, sheltered from the wind off the coast (Fig. 10C). The organic matter inside the caves consisted of plant debris (brought by the wind or the tides, in caves closer to the sea) and bat guano in some caves (produced by the piscivorous *Noctilio leporinus* (Linnaeus, 1758)). In some caves, individuals of *C. intertidalis* Cardoso & Ferreira, n. sp. were observed co-occurring with another isopod species (Fig. 10D). The external environment comprises a

“restinga” ecosystem dominated by herbaceous vegetation, which grows along the dunes. Thus, there are few external shelters for these organisms. As the samplings that resulted in the discovery of this new species focused specifically on caves, the actual extent of *C. intertidalis* Cardoso & Ferreira, n. sp. habitat is currently unknown, but their distribution may be much wider than that observed in this work, especially considering the lack of troglomorphic traits in this species.

The region is inserted in the Jericoacoara National Park, so the area and the caves are currently protected. Nonetheless, it is noteworthy that there is no regulation of visitor access to these caves, and due to the region's popularity as a tourist destination, uncontrolled foot traffic may inadvertently pose a threat to the invertebrate populations, including those of the newly discovered species.

REMARK

Ctenorillo intertidalis Cardoso & Ferreira, n. sp. resembles *C. pelado* Cardoso & Ferreira, n. sp. in the number of tubercles on pereonite 1 (24), however the disposition with the presence of a lateral rib is similar to *C. ferrarai*, differing from both by the number of tubercles on pereonites 2 to 7 (15).

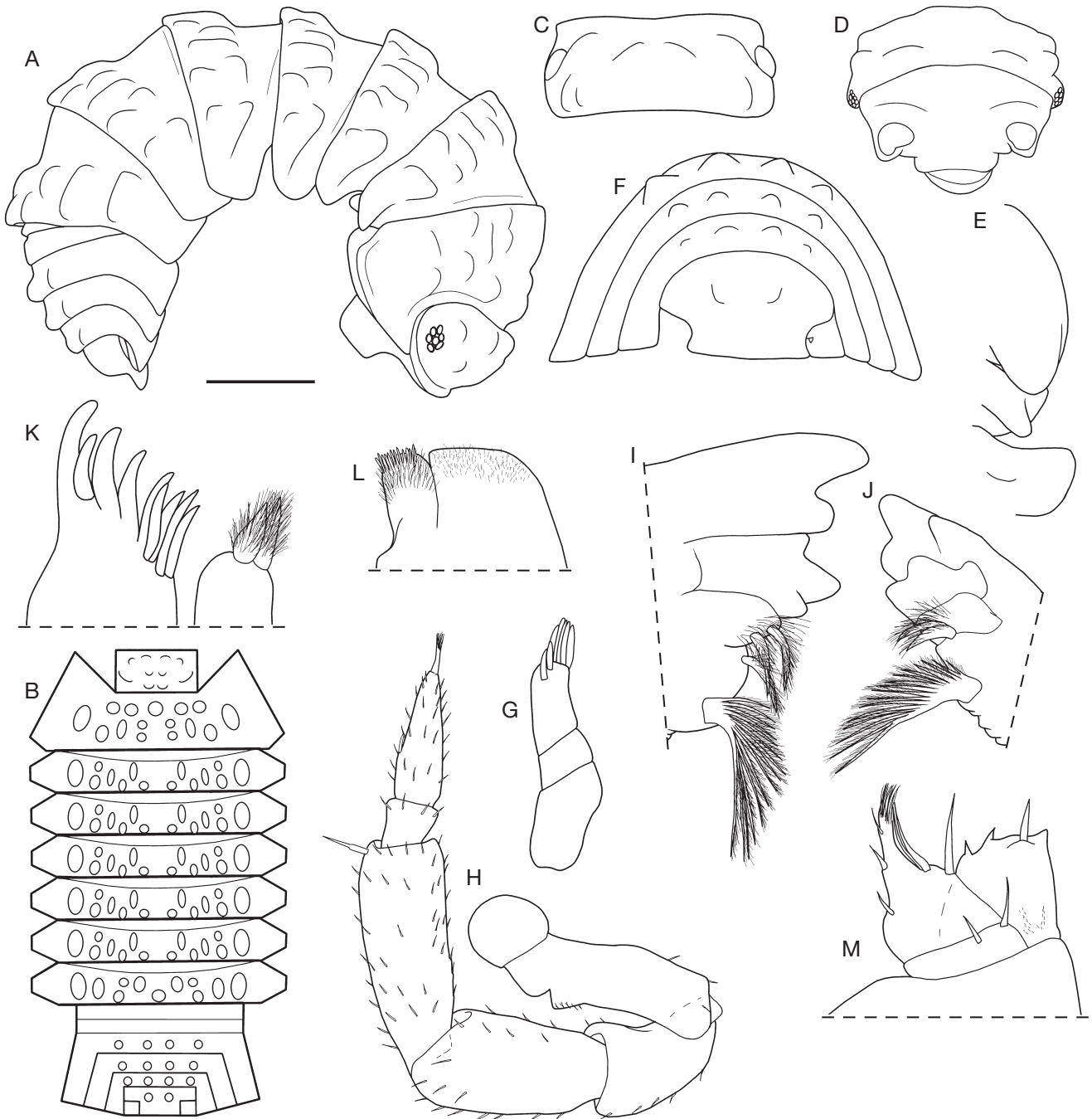


FIG. 11. — *Ctenorillo ubajarensis* Cardoso & Ferreira, n. sp., paratype (male, 6.5 mm, ISLA96794): **A**, habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon, dorsal view; **D**, cephalon, frontal view; **E**, epimera 1-3 ventral view; **F**, pleonites 3-5, uropod and telson, dorsal view; **G**, antennula; **H**, antenna; **I**, right mandible; **J**, left mandible; **K**, maxillula; **L**, maxilla; **M**, maxilliped. Scale bar: 0.5 mm.

Ctenorillo ubajarensis Cardoso & Ferreira, n. sp.
(Figs 11-13; 27E; 28H)

urn:lsid:zoobank.org:act:4C100618-9E25-499A-8078-F462716289C2

TYPE MATERIAL. — **Holotype.** Brazil • 1 ♂ (4 mm); Ceará state; Ubajara municipality; Urso Fóssil cave; 3°49'59"S, 40°53'32"W; 22.I.2019; R.L. Ferreira leg.; ISLA96794.

Paratypes. Brazil • 4 ♂, 5 ♀; same data as holotype; ISLA96795.

OTHER MATERIAL. — Brazil • 1 ♀; Ceará state; Ubajara municipality; Macaco Fóssil cave; 3°49'45"S, 40°54'6"W; 24.I.2019; R.L. Ferreira leg.; ISLA96796 • 1 ♀; Ubajara municipality; Pendurado cave; 3°50'4"S, 40°53'35"W; 25.I.2019; R.L. Ferreira leg.; ISLA96797.

ETYMOLOGY. — The new species name is a noun that refers to the type locality (the Ubajara National Park).

DIAGNOSIS. — Dorsum covered by bosses, more developed posteriorly with three rows on cephalon (4, 2, 4); three rows on pereonite 1 (5, 2, 8); two rows on pereonites 2-6 (6+6) and on pereonite 7 (6+5);



FIG. 12. — *Ctenorillo ubajarensis* Cardoso & Ferreira, n. sp., paratype (male, 6.5 mm, ISLA96794): **A**, uropod; **B**, pereopod 1; **C**, pereopod 7; **D**, pleopod 1 and genital papilla; **E**, pleopod 2; **F**, pleopod 3 exopod; **G**, pleopod 4 exopod; **H**, pleopod 5 exopod.

one row of four tubercles on pleonites 3-5; and two paramedian tubercles on telson. Pleopod 1 exopod with protruding distal portion, triangular, outer margin concave and crenulate; endopod with distal portion straight, slightly swollen, five times longer than exopod.

DISTRIBUTION. — Ubajara National Park, Ubajara municipality, Ceará state.

DESCRIPTION

Maximum size: ♂, 5 mm, ♀, 6.5 mm. Color brown in nature (Figs 13C; 27E). Dorsum covered by bosses, more developed posteriorly (Figs 11A, B; 28H): cephalon with three rows (4, 2, and 4 from front to back of vertex); pereonite 1 with 15 in three rows (5, 2 and 8); pereonites 2-6 with 14 (6+6); pereonite 7 with 11 (6+5); pleonites 3-5 with one row of four tubercles; telson with two paramedian tubercles. Dorsal

cuticle with short triangular scale setae; pereonites 1-7 bearing one line of *noduli lateralis* per side on the outer surface of posterior boss of second line (Fig. 28H). Cephalon with frontal shield protruding above vertex; eye consisting of eight ommatidia (Figs 11C; 28H). Pereonite 1 inner lobe of schisma rounded, extending beyond posterior margin of outer lobe; pereonite 2 with triangular ventral tooth reaching epimeron posterior margin (Fig. 11E); pereonites 2-7 with wide quadrangular epimera (Fig. 11A). Telson (Fig. 11F) hourglass-shaped, proximal portion broader than distal portion. Antennula (Fig. 11G) of three articles, second article shorter than first and third, third article with five apical and two subapical aesthetascs. Antenna (Fig. 11H) short and stout, flagellum shorter than fifth article of peduncle; second article of flagellum about twice as long as first. Buccal



FIG. 13. — *Ctenorillo ubajarensis* Cardoso & Ferreira, n. sp.: **A**, limestone outcrops at the Ubajara National Park; **B**, entrance of the Urso Fossil cave, where specimens are found; **C**, habitus in natural condition.

pieces as *C. pelado* Cardoso & Ferreira, n. sp. (Fig. 11I-M). All pleopod exopods with monospiracular covered lungs. Uropod (Fig. 12A) protopod flattened, enlarged on basal portion; exopod outward, short, inserted dorsally close to medial margin of protopod.

Male

Pereopods without particular modifications (Fig. 12B, C). Pleopod 1 exopod (Fig. 12D) wider than long, protruding distal portion, triangular, outer margin concave and crenulate; endopod with distal portion straight, slightly swollen, five times longer than exopod. Pleopod 2 endopod longer than exopod (Fig. 12E). Pleopods 3-5 exopods as in Figure 12F-H.

HABITAT

Specimens of *C. ubajarensis* Cardoso & Ferreira, n. sp. were found in three caves located at the Ubajara National Park (Fig. 13A). These caves are associated with limestones from the Frecheirinha Formation, Ubajara karst Group (Neoproterozoic). This region experiences two distinct climatic seasons: the rainy period when 94% of rainfall occurs (from January to June), and the dry period that is practically without rain (from July to December). The average annual temperature ranges from 20°C to 22°C in Serra da Ibiapaba and around

24°C to 26°C in the peripheral depression. June and July are typically the warmest months, while October and November are the hottest (Alvares *et al.* 2013).

The Urso Fossil cave, in which most of the specimens were found, extends up to 195 meters in length and has four entrances located along the cave main conduit (Fig. 13B). Most parts of the cave receive some light from the external environment, and aphotic areas are relatively few. Although this cave is located within the limits of the National Park, in which caves are important touristic attractions, tourists do not regularly visit this cave. However, it has been the target of several paleontological excavations in recent decades, which, on the one hand, revealed the great fossiliferous importance of this cave but, on the other hand, ended up altering several of its microhabitats.

Most specimens of *C. ubajarensis* Cardoso & Ferreira, n. sp. (Fig. 13C) were found in Urso Fossil cave, beneath fallen rocks or blocks on the cave floor. Additional specimens were observed in two other nearby caves (Pendurado and Macaco caves), with only one specimen found in each of these caves. Since external inventories were not conducted during our visit to the area, it is not possible to determine the actual distribution of this species, but it certainly occurs in external habitats in the caves' surroundings. Since the area is legally protected, the species is apparently not under any threat.

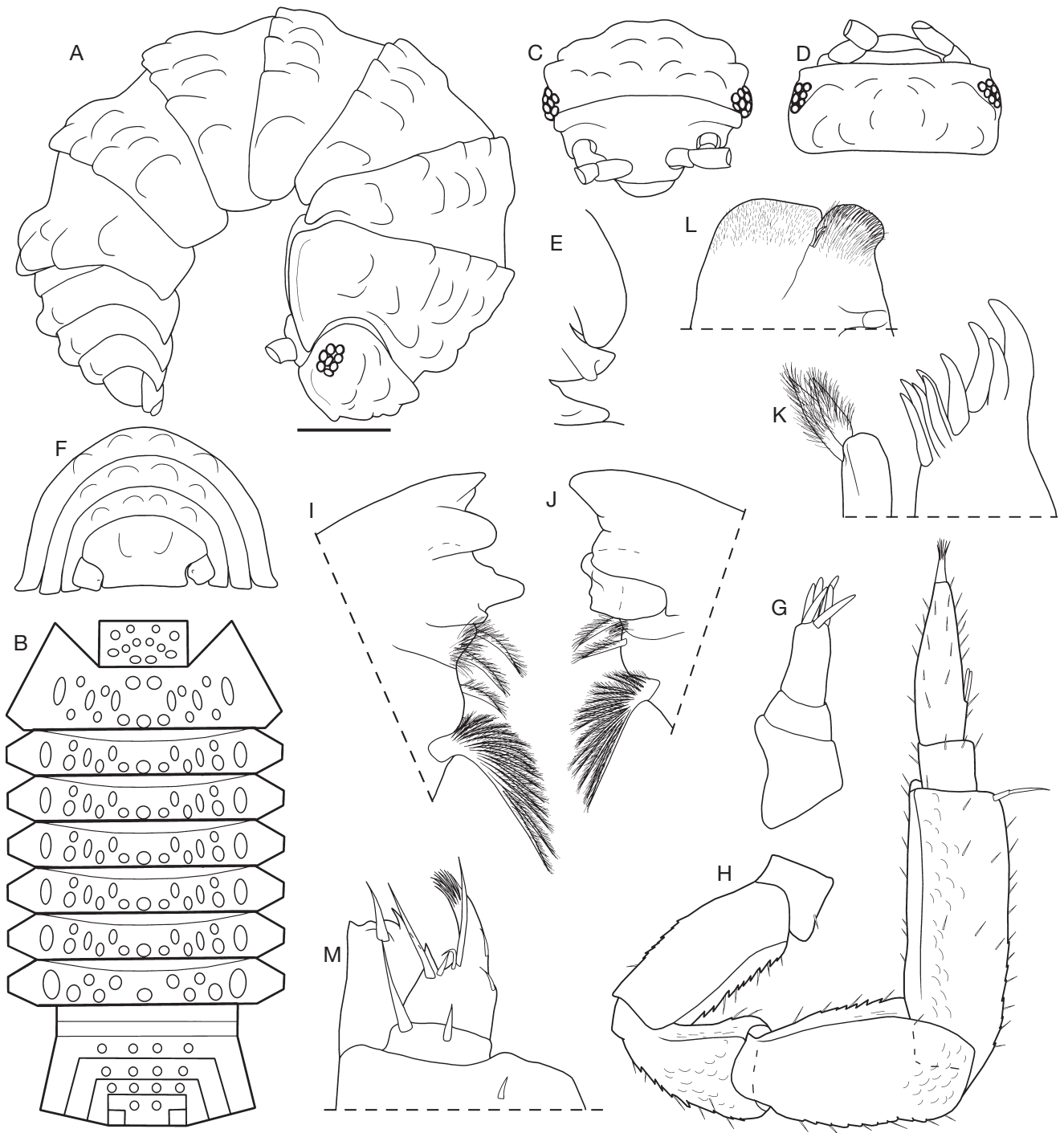


FIG. 14. — *Ctenorillo cearensis* Cardoso & Ferreira, n. sp., holotype (male, 4 mm, ISLA96021): **A**, habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon, frontal view; **D**, cephalon, dorsal view; **E**, epimera 1-3 ventral view; **F**, pleonites 3-5, uropods and telson, dorsal view; **G**, antennula; **H**, antenna; **I**, right mandible; **J**, left mandible; **K**, maxillula; **L**, maxilla; **M**, maxilliped. Scale bar: 0.5 mm.

REMARK

Ctenorillo ubajarensis Cardoso & Ferreira, n. sp., like *C. kenyensis* Schmölzer, 1974, differ from the congeneric species by the less developed tubercles, however in *C. ubajarensis* Cardoso & Ferreira, n. sp. the tubercles are more like bosses and are slightly more developed on pereonite 7, while on *C. kenyensis* they are granulated and densely distributed dorsally.

Ctenorillo cearensis Cardoso & Ferreira, n. sp.
(Figs 14; 15; 27F)

<https://doi.org/10.21203/rs.3.rs-2998881/v1>
<https://zoobank.org/act:29FFBB09-6896-4C9B-97BE-E50E44C7C180>

TYPE MATERIAL. — **Holotype**. Brazil • 1 ♂ (4 mm; parts in slide); Ceará state; Santa Quitéria municipality; W_04 cave; 4°33'53"S, 39°46'36"W; Carste leg.; 10-18.III.2021; ISLA96021.

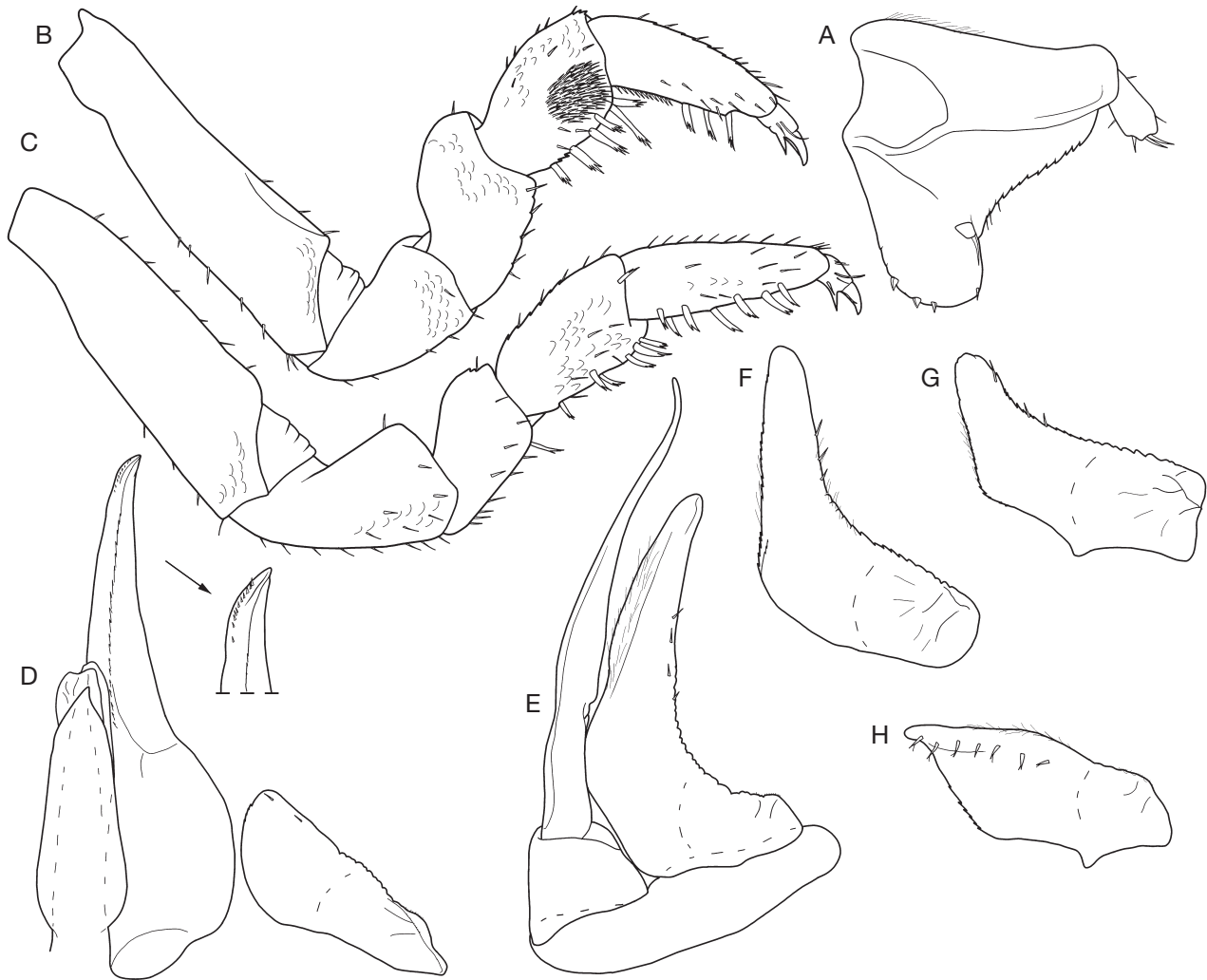


FIG. 15. — *Ctenorillo cearensis* Cardoso & Ferreira, n. sp., paratype (male, 4 mm, ISLA96021): A, uropod; B, pereopod 1; C, pereopod 7; D, pleopod 1 and genital papilla; E, pleopod 2; F, pleopod 3 exopod; G, pleopod 4 exopod; H, pleopod 5 exopod.

OTHER MATERIAL. — **Brazil** • 1 ♂; SQ_26 cave; 4°33'38"S, 39°46'51"W; Carste leg.; 10-18.III.2021; ISLA96020 • 1 ♀; W_16 cave; 4°33'43"S, 39°46'44"W; Carste leg.; 10-18.III.2021; ISLA96026 • 1 ♀; SQ_03 cave; 4°33'53"S, 39°46'40"W; Carste leg.; 10-18.III.2021; ISLA96033 • 2 ♂; SQ_P2 cave; 4°33'37"S, 39°45'57"W; Carste leg.; 10-18.III.2021; ISLA96962 • 3 ♀; SQ_03 cave; 4°34'4"S, 39°47'0"W; Carste leg.; 10-18.III.2021; ISLA96025.

ETYMOLOGY. — The new species name, “cearensis”, refers to the people who are born in the State of Ceará, Brazil. The word Ceará comes from the tupy language that means the macaw’s singing (o canto dajanaia in Portuguese).

DIAGNOSIS. — Dorsum covered by weakly developed tubercles and ribs with three rows on cephalon (4, 4, 4); three rows on pereonite 1 (2, 8, 9); two rows on pereonites 2-6 (4 + 11) and on pereonite 7 (4 + 7); one row of four tubercles on pleonites 3-5; and two paramedian tubercles on telson. Pleopod 1 exopod with round distal portion, outer margin straight; endopod with distal portion straight, four times longer than exopod.

DISTRIBUTION. — Santa Quitéria municipality, Ceará state.

DESCRIPTION

Maximum size: ♂ and ♀, 4 mm. Color grey (Fig. 27F). Dorsum covered by weakly developed tubercles and ribs (Fig. 14A, B): cephalon with three rows (4, 4, and 4 from front to back of vertex); pereonite 1 with 15 in three rows (2, 8 and 9); pereonites 2-6 with 15 (4 + 11); pereonite 7 with 11 (4 + 7); pleonites 3-5 with one row of four tubercles; telson with two paramedian tubercles. Dorsal cuticle with short triangular scale setae; pereonites 1-7 bearing one line of *noduli lateralis* per side on outer surface of posterior tubercle of second line of tubercle. Cephalon with frontal shield protruding above vertex; eye consisting of eight ommatidia (Fig. 14C, D). Pereonite 1 inner lobe of schisma rounded, extending beyond posterior margin of outer lobe; pereonite 2 with triangular ventral tooth reaching posterior margin of epimera (Fig. 14E); pereonites 2-7 with wide quadrangular epimera (Fig. 14A). Telson (Fig. 14F) hourglass-shaped, proximal portion broader than distal portion. Antennula (Fig. 14G) of three articles, second article shorter than first and third, third article with six apical aesthetascs. Antenna (Fig. 14H) short and stout,

flagellum shorter than fifth article of peduncle; second article of flagellum about three times as long as first. Buccal pieces as *C. pelado* Cardoso & Ferreira, n. sp. (Fig. 14I-M). All pleopod exopods with monospiracular covered lungs. Uropod (Fig. 15A) protopod flattened, enlarged on basal portion; exopod outward, short, inserted dorsally close to medial margin of protopod.

Male

Pereopods without particular modifications (Fig. 15B, C). Pleopod 1 exopod (Fig. 15D) wider than long, round distal portion, outer margin straight; endopod with distal portion straight, four times longer than exopod. Pleopod 2 endopod longer than exopod (Fig. 15E). Pleopods 3-5 exopods as in Figure 15F-H.

HABITAT

Specimens of *C. cearensis* Cardoso & Ferreira, n. sp. were found in six limestone caves inserted in the caatinga biome in northern Ceará state. The region experiences a Tropical Hot Semi-arid climate (BSH according to Koppen), with an average annual rainfall of 799.8 mm concentrated between February and April (Álvares *et al.* 2013). Average temperatures in the region hover around 27°C, with approximately 3°C of thermal amplitude (IPECE 2011). The area features three types of vegetation: Tropical Steppe, located in both the residual massifs and dissected areas of the Sertaneja Depression; Thorny Deciduous Forest and Tropical Rainforest. Unfortunately, the biologists who collected the specimens did not provide any data on the caves or the conservation status of the surrounding region. However, at least 74 caves were inventoried in the region, and specimens of *C. cearensis* Cardoso & Ferreira, n. sp. were found only in six of them. As mentioned for other species herein described, external inventories were not conducted, hence it is not possible to determine the actual distribution of this species. Nonetheless, the species does not present any troglomorphic traits, which would suggest its restriction to subterranean habitats. Importantly, the cave inventories were conducted to rank the importance of the caves in the area, as required by Brazilian environmental agencies for evaluating projects that may impact the environment. The potential installation of quarries in the area is a cause for concern since the limestone caves in the region are located close to uranium deposits (Júnior & de Souza 2012), and such enterprises could destroy the caves where the species occurs and severely alter the surrounding external habitats.

REMARKS

As *C. ubajarensis* Cardoso & Ferreira, n. sp., *C. cearensis* Cardoso & Ferreira, n. sp. presents the less developed tubercles, however the tubercles are more prominent than in *C. cearensis* Cardoso & Ferreira, n. sp. As the other Brazilian species, *C. cearensis* Cardoso & Ferreira, n. sp. presents the pleonites 3-5 with four tubercles each and differs from them by the number of tubercles on pereon, with 19 tubercles on pereonite 1, 15 on pereonites 2-6, and 11 on pereonite 7.

Ctenorillo quiteriensis Cardoso & Ferreira, n. sp. (Figs 16; 17; 27G)

[urn:lsid:zoobank.org:act:660D19DD-C840-4D69-A90B-F85FA9E916E8](https://doi.org/10.21203/rs.3.rs-2120312/v1)

TYPE MATERIAL. — **Holotype**. Brazil • 1 ♂ (7 mm) (part in slide); Ceará state; Santa Quitéria municipality; SQ_39; 4°33'42"S, 39°46'46"W; 10-18.III.2021; Carste leg.; ISLA96038.

OTHER MATERIAL. — **Brazil** • 1 ♀; Ceará state; Santa Quitéria municipality; SQ_P12; 4°33'39"S, 39°45'48"W; 10-18.III.2021; Carste leg.; ISLA96059.

ETYMOLOGY. — The new species name is a noun in apposition that refers to the people who are born in the municipality where the specimens were found (Santa Quitéria).

DIAGNOSIS. — Dorsum covered with conical tubercles and lateral ribs with three rows on cephalon (4, 2, 6); four rows on pereonite 1 (4, 5, 10, 7); two rows on pereonites 2-4 (8+7) and on pereonites 5-7 (10+7); one row of four tubercles on pleonites 3-5; and two paramedian tubercles telson. Pleopod 1 exopod with protruding distal portion, triangular, outer margin straight; endopod with distal portion straight, slightly swollen, three times longer than exopod.

DISTRIBUTION. — Santa Quitéria municipality, Ceará state.

DESCRIPTION

Maximum size: ♂ and ♀, 7 mm. Color brown with lateral margin depigmented (Fig. 27G). Dorsum covered with conical tubercles and lateral ribs (Fig. 16A-C): cephalon with three rows (4, 2, and 6 from front to back of vertex); pereonite 1 with 26 in four rows (4, 5, 10 and 7); pereonites 2-4 with 15 (8+7); pereonites 5-7 with 17 (10+7); pleonites 3-5 with one row of four tubercles; telson with two paramedian tubercles. Dorsal cuticle with short triangular scale setae; pereonites 1-7 bearing one line of *noduli lateralis* per side on outer surface of posterior tubercle of second line of tubercles. Cephalon with frontal shield protruding above vertex; eye consisting of eight ommatidia (Fig. 16A, D). Pereonite 1 with posterior margin distinctly sinuous at sides; inner lobe of schisma rounded, extending beyond posterior margin of outer lobe; pereonite 2 with triangular ventral tooth reaching posterior margin of epimera (Fig. 16E). Pereonites 2-7 (Fig. 16A) with wide quadrangular epimera slightly bent outwards. Telson (Fig. 16F) hourglass-shaped, proximal portion broader than distal portion. Antennula (Fig. 16G) of three articles, second article shorter than first and third, third article with three apical and five subapical aesthetascs. Antenna (Fig. 16H) short and stout, flagellum shorter than fifth article of peduncle; second article of flagellum about three times as long as first. Buccal pieces as *C. pelado* Cardoso & Ferreira, n. sp. (Fig. 16I-K). All pleopod exopods with monospiracular covered lungs. Uropod (Fig. 17A) protopod flattened, enlarged on basal portion; exopod very short, inserted dorsally close to medial margin of protopod.

Male

Pereopods without particular modifications (Fig. 17B, C). Pleopod 1 exopod (Fig. 17D) wider than long, protruding distal portion, triangular, outer margin straight; endopod with

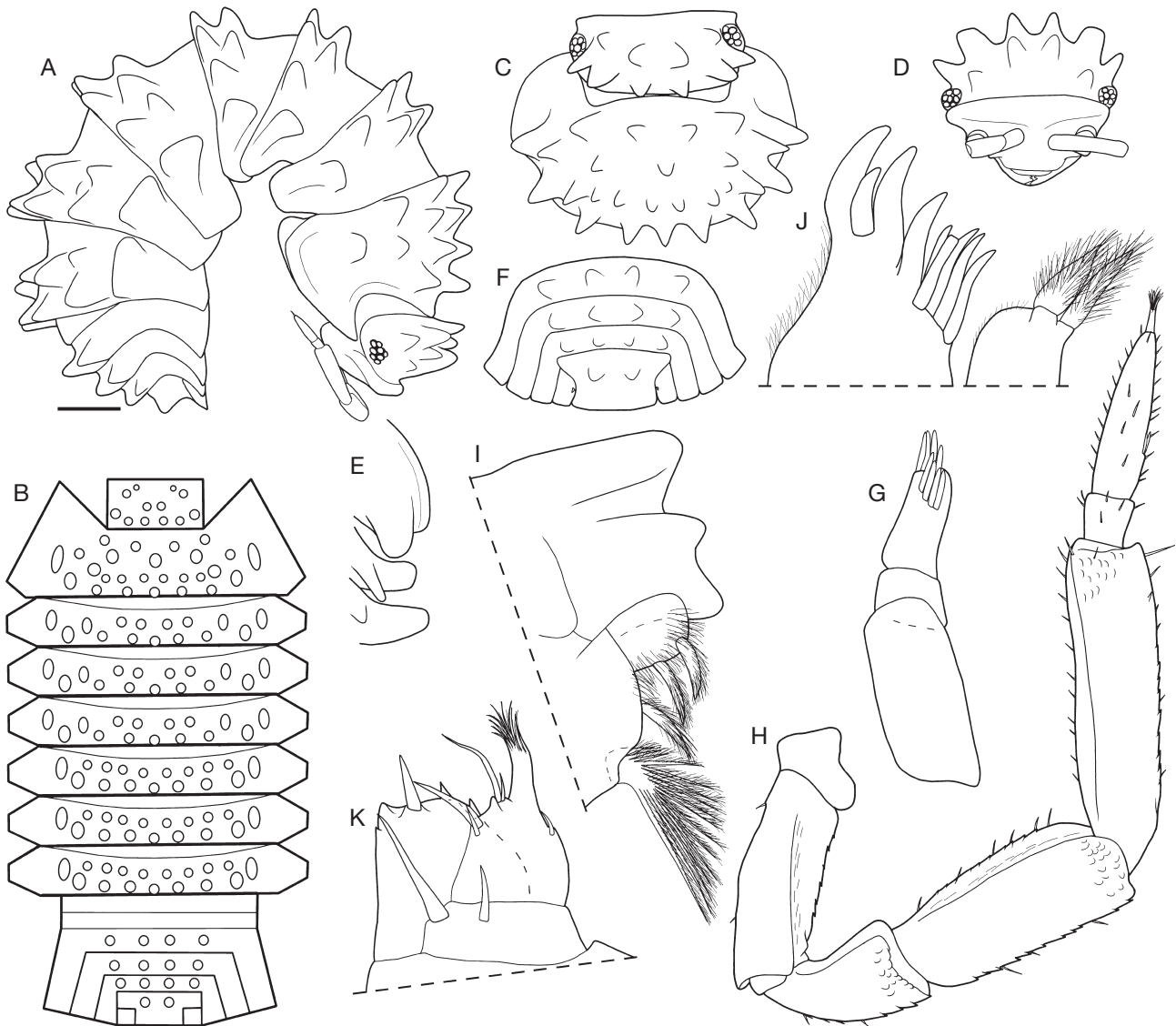


FIG. 16. — *Ctenorillo quiteriensis* Cardoso & Ferreira, n. sp., holotype (male, 7 mm, ISLA96038): **A**, habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon and epimeron 1, dorsal view; **D**, cephalon, frontal view; **E**, epimera 1-3 ventral view; **F**, pleonites 3-5, uropods and telson, dorsal view; **G**, antenna; **H**, antenna; **I**, right mandible; **J**, maxillula; **K**, maxilliped. Scale bar: 0.5 mm.

distal portion straight, slightly swollen, three times longer than exopod. Pleopod 2 endopod longer than exopod (Fig. 17E). Pleopods 3-5 exopods as in Figure 17F-H.

HABITAT

Specimens of *C. quiteriensis* Cardoso & Ferreira, n. sp. were found in two limestone caves inserted in the caatinga biome in northern Ceará state. The regional climate is also classified as BSh according to the Köppen system, characterized by the same patterns of precipitation and temperature as described for *C. cearensis* Cardoso & Ferreira, n. sp. Also, no data were available about the caves or the conservation status of the surrounding region. Regrettably, external inventories were not conducted during the sampling process in the area, making it difficult to determine the precise distribution of this species. It is likely that *C. quiteriensis* Cardoso & Ferreira, n. sp. occurs in external habitats surrounding the caves, as

observed in other species described here. As with *C. cearensis* Cardoso & Ferreira, n. sp., the establishment of quarries for uranium extraction in the future could pose a significant threat to the habitats of this newly discovered species. It is essential to undertake further studies to determine the extent of its distribution and the potential impacts of anthropogenic activities in the region to develop conservation strategies to safeguard this species.

REMARKS

Ctenorillo quiteriensis Cardoso & Ferreira, n. sp. occur in the same region as *C. cearensis* Cardoso & Ferreira, n. sp. and they clearly differ in the shape and number of tubercles, being more developed in *C. quiteriensis* Cardoso & Ferreira, n. sp. On pereonite 1, *C. quiteriensis* Cardoso & Ferreira, n. sp. presents 26 tubercles, resembling *C. ferrarai* in the presence of a lateral rib on the pereonites that are more developed posteriorly.



FIG. 17. — *Ctenorillo quiteriensis* Cardoso & Ferreira, n. sp., holotype (male, 7 mm, ISLA96038): **A**, uropod; **B**, pereopod 1; **C**, pereopod 7; **D**, pleopod 1 and genital papilla; **E**, pleopod 2; **F**, pleopod 3 exopod; **G**, pleopod 4 exopod; **H**, pleopod 5 exopod.

Ctenorillo potiguar Cardoso & Ferreira, n. sp.
(Figs 18-20; 27H; 28I)

urn:lsid:zoobank.org:act:53D58AC8-70BA-48E8-A228-4F455E72B475

TYPE MATERIAL. — **Holotype.** Brazil • 1 ♂ (3 mm, parts in slide); Rio Grande do Norte state; Baraúna municipality; Furna Nova cave; 5°2'3"S, 37°34'16"W; 12.VI.2008; D.M. Bento leg.; ISLA96798. **Paratypes.** Brazil • 2 ♀; same data as holotype; ISLA96799.

OTHER MATERIAL. — **Brazil.** Rio Grande do Norte; Baraúna municipality • 1 ♂, 2 ♀; Furna Feia cave; 5°2'12"S, 37°33'36"W; 31.VII.2010; D.M. Bento leg.; ISLA59267 • 2 ♂; Esquecida cave; 5°2'16"S, 37°33'40"W; 12.VI.2010; D.M. Bento leg.; ISLA59283 • 1 ♀; same collection data as for preceding; ISLA59333 • 1 ♀; Briador cave; 11.VI.2010; D.M. Bento leg.; ISLA59263.

Brazil. Rio Grande do Norte; Felipe Guerra municipality • 1 ♂, 1 ♀; Crotes cave; 5°33'37"S, 37°39'30"W; 4.VI.2010; D.M. Bento leg.; ISLA59330 • 2 ♀; same collection data as for preceding; ISLA59282 • 1 ♂; Trapiá cave; 5°33'45"S, 37°37'15"W; 4.VIII.2010; D.M. Bento leg.; ISLA59270.

ETYMOLOGY. — The new species name is a noun in reference to people who are born in the State of Rio Grande do Norte, Brazil.

DIAGNOSIS. — Dorsum covered with round tubercles and ribs with three rows on cephalon (4, 4, 6); four rows on pereonite 1 (4, 5, 8, 9); two rows on pereonites 2-7 (8 + 7); one row of four tubercles on pleonites 3-5 with; two paramedian tubercles on telson. Pleopod 1 exopod with round distal portion, outer margin straight; endopod with distal portion bent outward, four times longer than exopod.

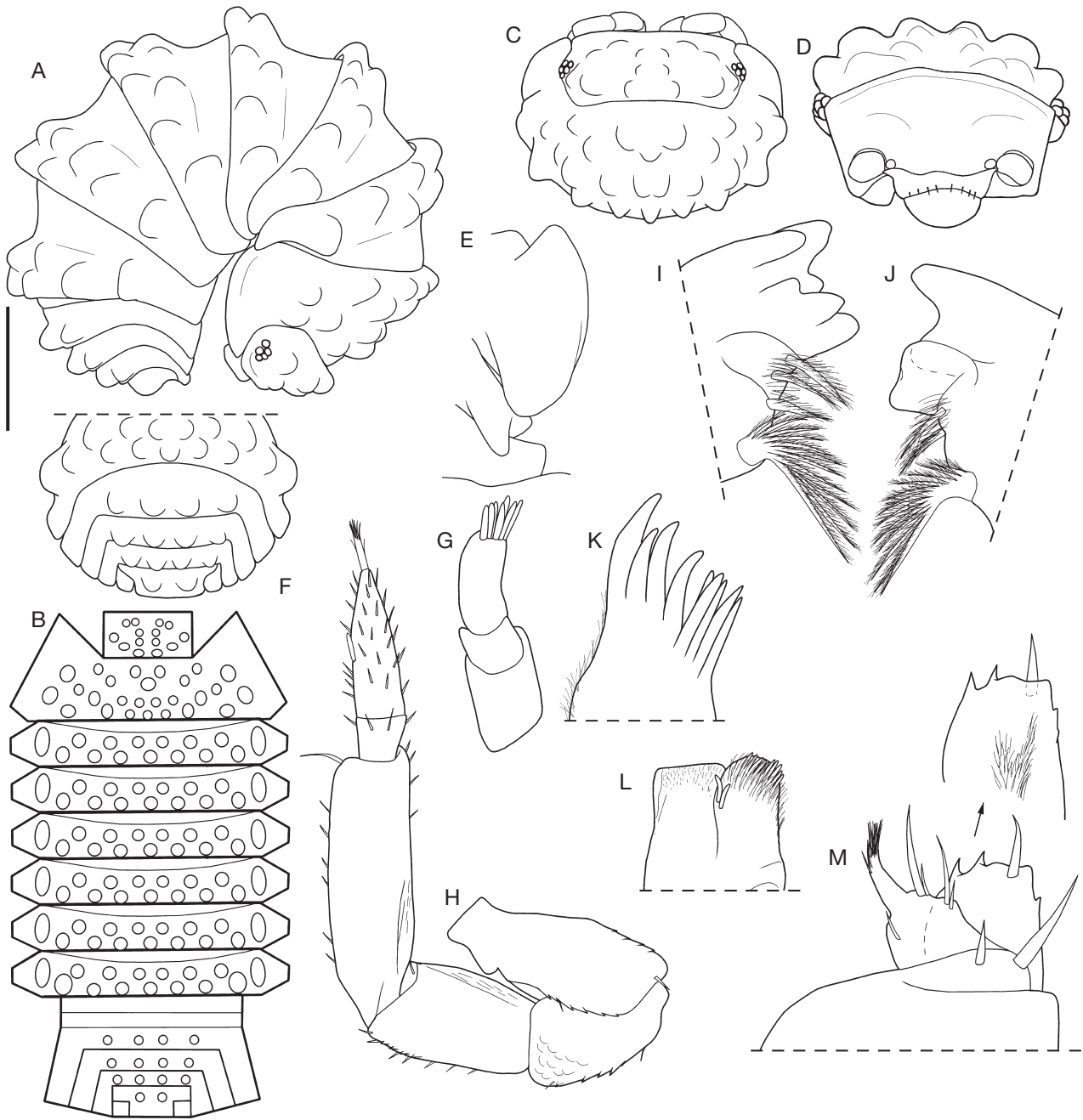


FIG. 18. — *Ctenorillo potiguar* Cardoso & Ferreira, n. sp., paratype (male, 3 mm, ISLA96798): **A**, habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon and epimeron 1, dorsal view; **D**, cephalon, frontal view; **E**, epimera 1-3, ventral view; **F**, epimeron 7, pleonites 3-5, uropods and telson, dorsal view; **G**, antennula; **H**, antenna; **I**, right mandible; **J**, left mandible; **K**, maxillula; **L**, maxilla; **M**, maxilliped. Scale bar: 0.5 mm.

DISTRIBUTION. — Baraúna and Felipe Guerra municipalities, west of the Rio Grande do Norte state.

DESCRIPTION

Maximum size: ♂, 3 mm, ♀, 4 mm. Color brown with lateral margins depigmented in nature (Figs 20D; 27H). Dorsum covered with round tubercles and ribs (Fig. 18A, B); cephalon with three rows (4, 4, and 6 from front to back of vertex); pereonite 1 with 26 in four rows (4, 5, 8 and 9); pereonites 2-7 with 15 (8 + 7); pleonites 3-5 with one row of four tubercles; telson with two paramedian tubercles. Dorsal

cuticle with short triangular scale setae; pereonites 1-7 bearing one line of *noduli lateralis* per side on outer surface of posterior tubercle of second tubercles (Fig. 28I). Cephalon with frontal shield protruding above vertex; eye consisting of five ommatidia (Figs 18C, D; 28I). Pereonite 1 with posterior margin sinuous at sides; inner lobe of schisma rounded, extending beyond posterior margin of outer lobe; pereonite 2 with triangular ventral tooth reaching posterior margin of epimera (Fig. 18E). Pereonites 2-7 (Fig. 18A) with wide quadrangular epimera slightly bent outwards. Telson (Fig. 18F) hourglass-shaped, proximal portion broader than

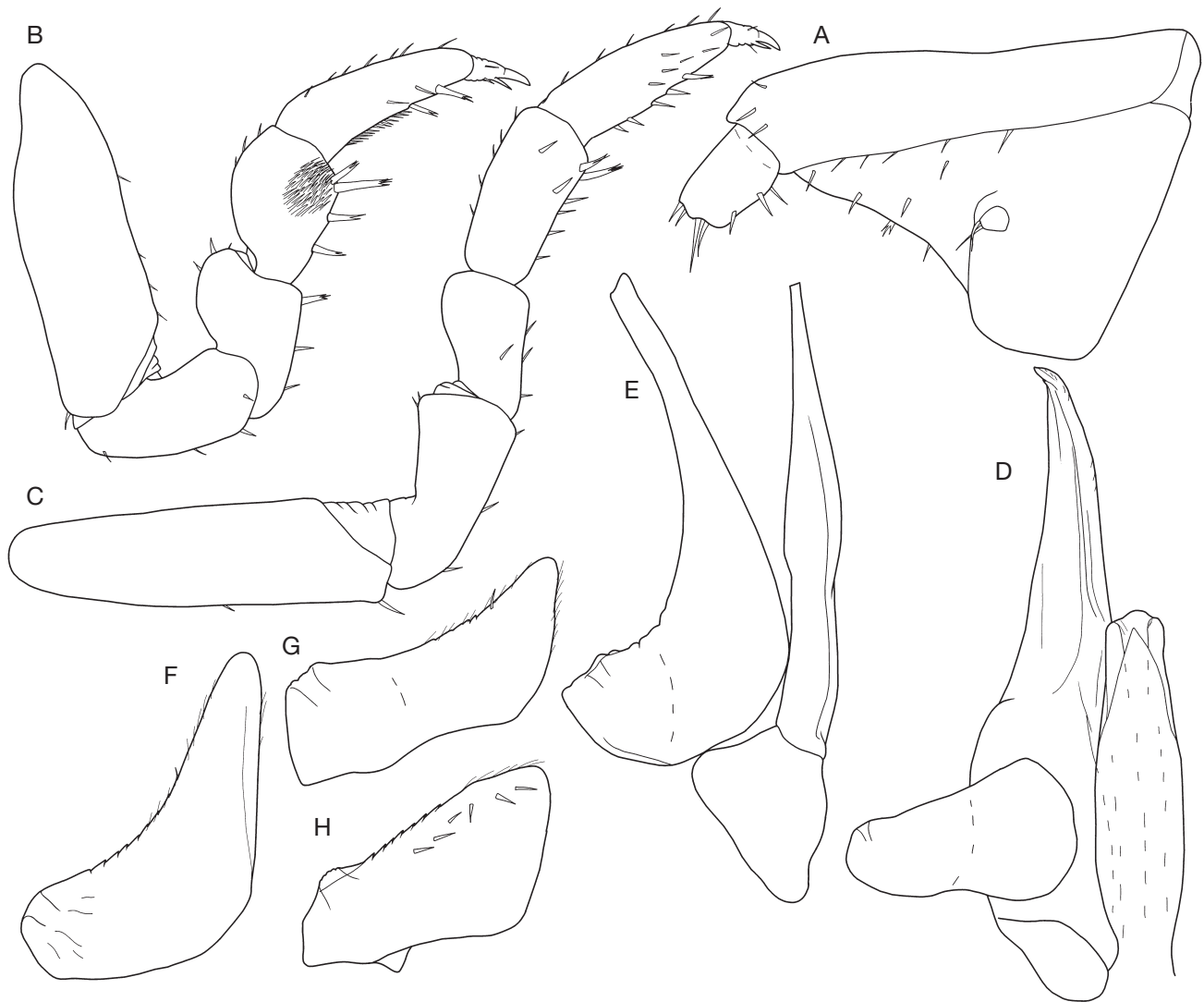


FIG. 19. — *Ctenorillo potiguar* Cardoso & Ferreira, n. sp., paratype (male, 3 mm, ISLA96798): **A**, uropod; **B**, pereopod 1; **C**, pereopod 7; **D**, pleopod 1 and genital papilla; **E**, pleopod 2; **F**, pleopod 3 exopod; **G**, pleopod 4 exopod; **H**, pleopod 5 exopod.

distal portion. Antennula (Fig. 18G) of three articles, second article shorter than first and third, third article with seven apical aesthetascs. Antenna (Fig. 18H) short and stout, flagellum shorter than fifth article of peduncle; second article of flagellum about three times as long as first. Buccal pieces as *C. pelado* Cardoso & Ferreira, n. sp. (Fig. 18I-M). All pleopod exopods with monospiracular covered lungs. Uropod (Fig. 19A) protopod flattened, enlarged on basal portion; exopod outward, short, inserted dorsally close to medial margin of protopod.

Male

Pereopods without particular modifications (Fig. 19B, C). Pleopod 1 exopod (Fig. 19D) wider than long, round distal portion, outer margin straight; endopod with distal portion bent outward, four times longer than exopod. Pleopod 2 endopod longer than exopod (Fig. 19E). Pleopods 3-5 exopods as in Figure 19F-H.

HABITAT

Specimens of *Ctenorillo potiguar* Cardoso & Ferreira, n. sp. were found in six caves located in the west of the Rio Grande do Norte state. This region has more than 1000 currently known caves (CANIE/CECAV 2022), but only about 48 have been inventoried (Ferreira *et al.* 2010; Bento *et al.* 2021). The caves are inserted in the limestones of the Janaína Formation, deposited during the Upper Cretaceous, which corresponds to a carbonate ramp that emerged along the emersed portion of the Potiguar Basin (Bezerra *et al.* 2007). The region is in the Caatinga Biome, with a hot and semiarid climate (BSH on the Köppen climate classification) (Alvares *et al.* 2013). The average temperature is constant over the year, ranging from 25° to 30°C, with average annual precipitation around 800 mm (concentrated from February to June, but 70% can fall in a single month) (Silva *et al.* 2017).

Three caves, Furna Feia (Fig. 20A, B), Furna Nova (Fig. 20C) and Macacos/Esquecida, are located in the Furna Feia Na-

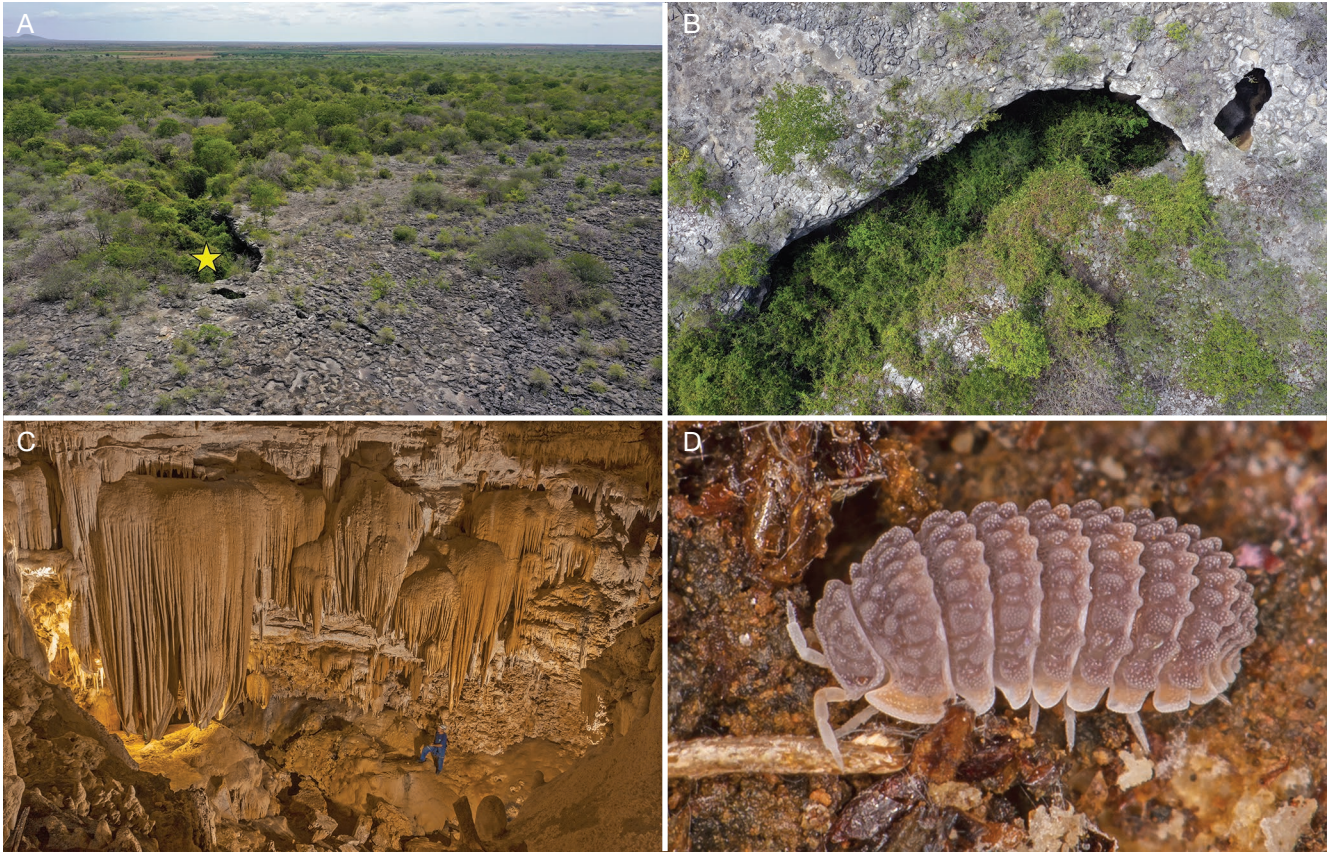


FIG. 20. — *Ctenorillo potiguar* Cardoso & Ferreira, n. sp.: **A**, limestone outcrops at the Furna Feia National Park, with the entrance of the Furna Feia cave (**yellow star**); **B**, detail of the Furna Feia cave entrance; **C**, inner portion of the Furna Nova cave, where specimens are found; **D**, habitus in natural condition.

tional Park (FFNP) in the municipality of Baraúna. Specimens were also found in the Britador cave, near FFNP, in Baraúna. Other specimens were found in Trapiá and Crotas caves, in the municipality of Felipe Guerra (RN), 60 km from the first ones. These caves exhibit varied morphology, dimensions, and environmental conditions, ranging from small photic caves spanning a few tens of meters (e.g. Britador cave) to large aphotic caves covering hundreds of meters and characterized by more stable climatic conditions (e.g. Furna Feia, Furna Nova, and Trapiá caves). Despite this distribution, individuals (Fig. 20D) were mainly found in aphotic and humid areas within the caves, often sheltered under rocks. This observation suggests that the species may have a specific habitat preference.

No samplings were conducted outside caves in the area, and it is likely that the species also occurs in surface habitats (especially considering the absence of any obvious troglomorphic traits). Therefore, further studies including external samplings are needed to better understand the species distribution. Although only part of the distribution of the new species occurs within a conservation unit, the other caves are found in relatively conserved areas, without direct anthropic impacts. Three caves (Furna Feia, Furna Nova, and Crotas Caves) are visited by tourists in an orderly manner. Thus, the conservation status of the species can be considered of less concern.

REMARK

Ctenorillo potiguar Cardoso & Ferreira, n. sp. resembles *C. ubajarensis* Cardoso & Ferreira, n. sp. by the less developed tubercles, however they are more prominent on *Ctenorillo potiguar* Cardoso & Ferreira, n. sp. By the number of tubercles on pereonite 1, *Ctenorillo potiguar* Cardoso & Ferreira, n. sp. resembles *C. quiteriensis* Cardoso & Ferreira, n. sp. with 26 tubercles, differing by the shape.

Ctenorillo iuiuensis Cardoso & Ferreira, n. sp. (Figs 21-23; 27I)

[urn:lsid:zoobank.org:act:0E0AFF4F-6924-438E-82A7-970FF1D1FD76](https://doi.org/10.21203/rs.3.rs-3120000/v1)

TYPE MATERIAL. — **Holotype.** Brazil • 1 ♂ (4 mm, parts in slide), Bahia state, Iuiu municipality, Lapa do Matias cave; 14°28'46"S, 43°36'50"W; R.L. Ferreira leg., 22.VII.2022; ISLA96802.

Paratypes. Brazil • 2 ♀; same data as holotype; ISLA96803.

ETYMOLOGY. — The new species name “*iuiuensis*” refers to the municipality where the species inhabits.

DIAGNOSIS. — Dorsum covered with conical tubercles three rows on cephalon (2, 2, 2); three rows on pereonite 1 (4, 4, 11); two rows on pereonites 2-6 (6+7) and on pereonite 7 (6+5); and two paramedian tubercles on pleonites 3-5 and on telson. Pleopod 1 exopod with round distal portion, outer margin straight; endopod with distal portion slightly bent outward, five times longer than exopod.

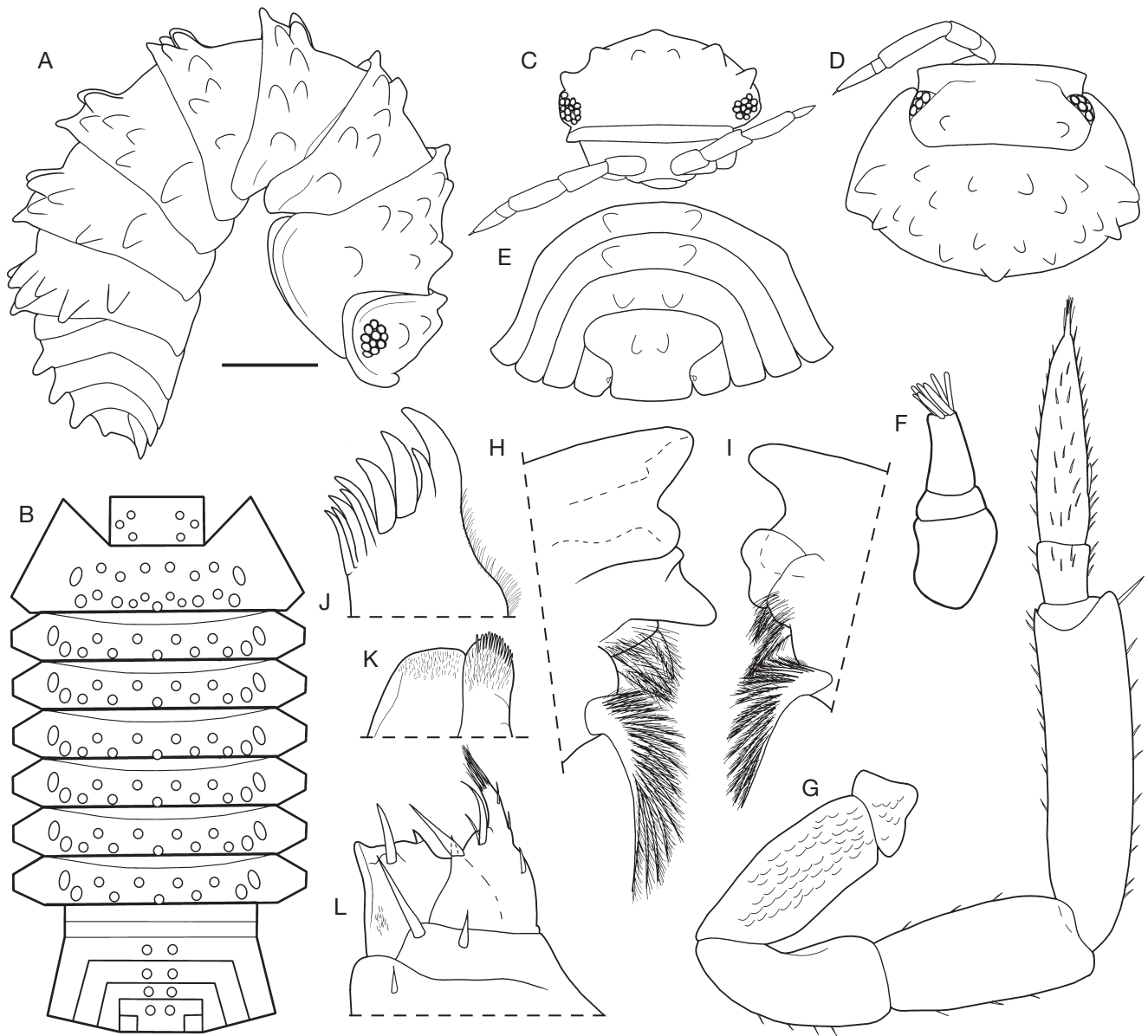


FIG. 21. — *Ctenorillo iuiuensis* Cardoso & Ferreira, n. sp., holotype (male, 4 mm, ISLA96802): **A**, habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon, frontal view; **D**, cephalon and pereonite 1, dorsal view; **E**, pleonites 3-5, uropods and telson, dorsal view; **F**, antennula; **G**, antenna; **H**, right mandible; **I**, left mandible; **J**, maxillula; **K**, maxilla; **L**, maxilliped. Scale bar: 0.5 mm.

DISTRIBUTION. — Serra do Iuiu mountain range, Iuiu municipality, Bahia state.

DESCRIPTION

Maximum size: ♂ and ♀, 4 mm. Color pale (Fig. 27I). Dorsum covered with conical tubercles (Fig. 21A, B); cephalon with three rows (2, 2, and 2 from front to back of vertex); pereonite 1 with 19 in three rows (4, 4 and 11); pereonites 2-6 with 13 (6+7); pereonite 7 with 11 (6+5); pleonites 3-5 and telson with two paramedian tubercles. Cephalon with frontal shield protruding above vertex; eye consisting of 11 ommatidia (Fig. 21C, D). Pereonite 1 with posterior margin sinuous at sides; inner lobe of schisma rounded, extending beyond posterior margin of outer lobe;

pereonite 2 with triangular ventral tooth reaching posterior margin epimera (Fig. 21A). Pereonites 2-7 (Fig. 21A) with wide quadrangular epimera slightly bent outwards. Telson (Fig. 21E) hourglass-shaped, proximal portion broader than distal portion. Antennula (Fig. 21F) of three articles, second article much shorter than first and third, third article with seven apical aesthetascs. Antenna (Fig. 21G) short and stout, flagellum shorter than fifth article of peduncle; second article of flagellum about three times as long as first. Buccal pieces as *C. pelado* Cardoso & Ferreira, n. sp. (Fig. 21H-L). All pleopod exopods with monospiracular covered lungs. Uropod (Fig. 22A) protopod flattened, enlarged on basal portion; exopod very short, inserted dorsally very close to medial margin of protopod.



FIG. 22. — *Ctenorillo iuiuensis* Cardoso & Ferreira, n. sp., holotype (male, 4 mm, ISLA96802): A, uropod, B, pereopod 1; C, pereopod 7; D, pleopod 1; E, pleopod 2; F, pleopod 3 exopod; G, pleopod 4 exopod; H, pleopod 5 exopod.

Male

Pereopods without particular modifications (Fig. 22B, C). Pleopod 1 exopod (Fig. 22D) wider than long, round distal portion, outer margin straight; endopod five times longer than exopod, distal portion slightly bent outward. Pleopod 2 endopod longer than exopod (Fig. 22E). Pleopods 3-5 exopods as in Figure 22F-H.

HABITAT

The Lapa do Matias cave, located in the Iuiú region, is the only place where specimens of *C. iuiuensis* Cardoso & Ferreira, n. sp. have been found, despite the extensive sampling of multiple caves in the region. The Iuiú region (northeastern Brazil) presents a significant karst area, known for its numerous caves and the occurrence of dozens of endemic species restricted to caves (Cardoso *et al.* 2021). This limestone formation is part of the Bambuí Group, the largest carbonate formation in

South America. The landscape is situated within the Caatinga domain, with a seasonally dry tropical forest mostly found in the limestone outcrops due to past intensive land use. As per the Köppen-Geiger classification system, the climate in the area is semi-arid tropical (Bsh), with an annual precipitation of 788 mm and an average temperature of 24°C. The rainy season is from November to February while the dry season lasts from March to October.

The Lapa do Matias cave is located at the top of the outcrop at Serra do Iuiú, in a quite anthropized region (Fig. 23A). The cave is in a heavily human-impacted area with pastures and exposed soil, which increases erosion. Despite its small single entrance (Fig. 23B), the cave is voluminous and has two main conduits (Fig. 23C, D). A thorough search was carried out but only three specimens of *C. iuiuensis* Cardoso & Ferreira, n. sp. were found under limestone blocks in aphotic areas (Fig. 23E). It is worth noting that *C. iuiuensis*



FIG. 23. — *Ctenorillo iuiuensis* Cardoso & Ferreira, n. sp.: **A**, limestone outcrops at the surroundings of the Lapa do Matias cave (cave entrance indicated by the yellow star); **B**, detail of the Lapa do Matias cave entrance; **C**, inner portion of the Lapa do Matias cave, where specimens are found.

Cardoso & Ferreira, n. sp. displays some troglomorphic traits, including a lack of pigmentation in both the body integument and eyes. As this condition was observed in all collected specimens, and none of them appeared to have a soft exoskeleton (teneral aspect), it is likely that this species is troglobitic. However, as no samplings were conducted outside caves in the area, future research is needed to confirm or refute this diagnosis.

The Iuíú karst area has been facing severe threats, particularly due to changes in the surrounding environments, which have intensified over the last few decades. According to Cardoso *et al.* (2022), the land cover and land use practices surrounding the caves in this region have significantly influenced the subterranean environments, affecting both microhabitat features and terrestrial invertebrate communities. The authors have demonstrated that deforested areas have had adverse effects on subterranean invertebrate richness, mainly by altering the fauna composition and reducing subterranean microhabitat diversity. Additionally, this region is home to several endemic cave species (Ratton *et al.* 2012; Souza *et al.* 2015; Hoch &

Ferreira 2016; Souza & Ferreira 2018; Cardoso *et al.* 2020), making it imperative for Brazilian environmental agencies to take urgent action to protect these caves in this important Brazilian karst area.

REMARK

Ctenorillo iuiuensis Cardoso & Ferreira, n. sp. differs from the Brazilian species by the presence of two paramedian tubercles on pleonites 3-5 and on telson.

Ctenorillo jequitinhonha Cardoso & Ferreira, n. sp.
(Figs 24-26; 27J; 28J, K)

[urn:lsid:zoobank.org:act:5CF8D003-88B7-465B-84EF-040FEC4FB7F2](https://doi.org/10.21203/rs.3.rs-3120003/v1)

TYPE MATERIAL. — **Holotype**. Brazil • 1 ♂ (7 mm, parts in slide), Minas Gerais state, Jequitinhonha municipality, Toca Juparaná cave; 16°25'3"S, 40°55'23"W; R.L. Ferreira leg., 7.IV.2017; ISLA96804. **Paratypes**. Brazil • 1 ♂ in slide; same data as holotype; ISLA96806 • 3 ♂, 8 ♀; same data as holotype; ISLA96805.

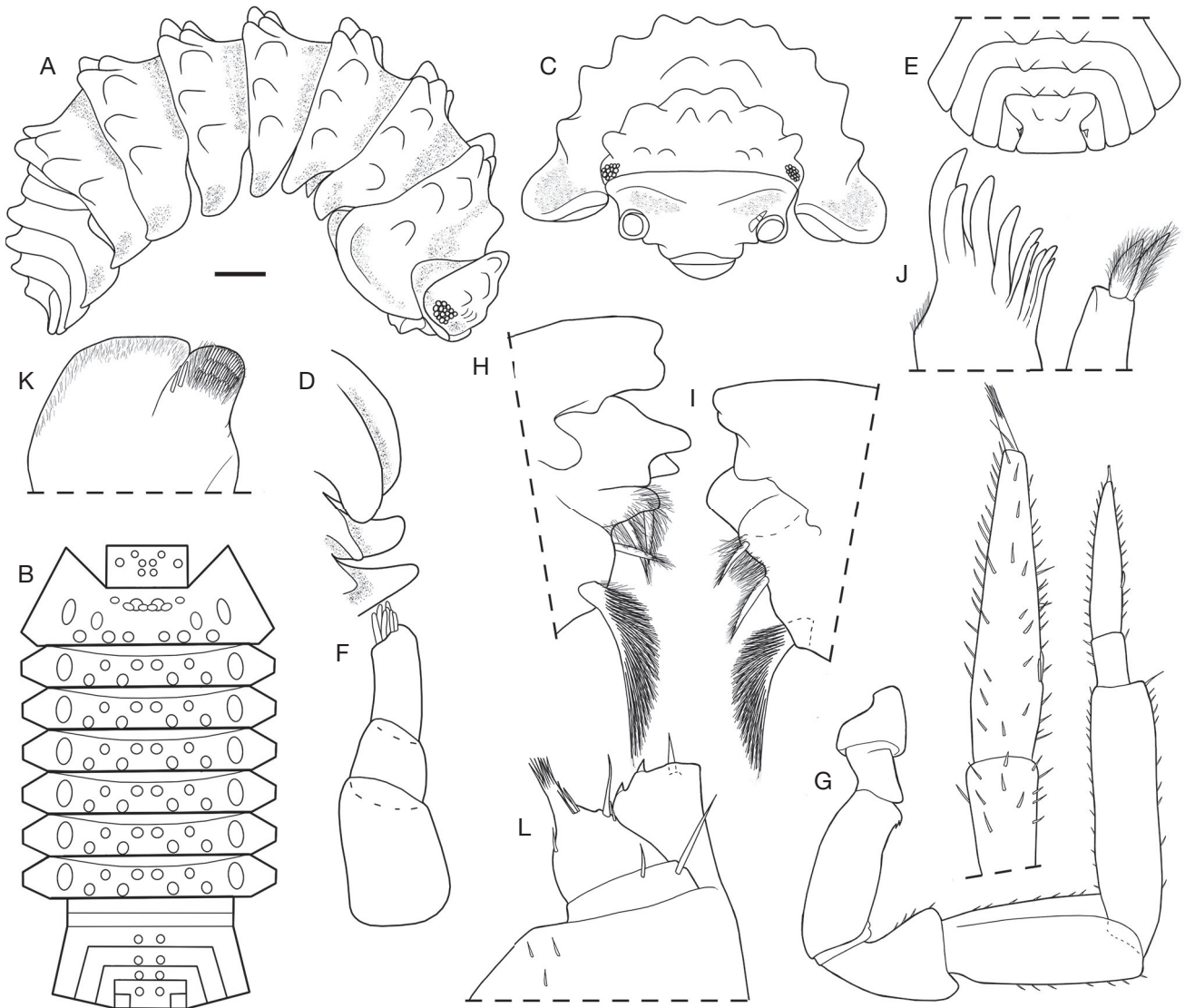


FIG. 24. — *Ctenorillo jequitinhonha* Cardoso & Ferreira, n. sp. paratype (male, 7 mm, ISLA96806): **A**, habitus, lateral view; **B**, disposition of dorsal tubercles; **C**, cephalon and epimeron 1, frontal view; **D**, epimera 1-3 ventral view; **E**, pleonites 3-5, uropods and telson, dorsal view; **F**, antennula; **G**, antenna; **H**, right mandible; **I**, left mandible; **J**, maxillula; **K**, maxilla; **L**, maxilliped. Scale bar: 0.5 mm.

ETYMOLOGY. — The new species name is a noun in apposition that refers to the city and the Jequitinhonha River, one of the most important rivers in the north of Minas Gerais state; the type locality is within the drainage basin of the Jequitinhonha river. The word Jequitinhonha is of indigenous origin and means “wide river full of fish”.

DIAGNOSIS. — Dorsum covered with round tubercles with three rows on cephalon (4, 4, 4); three rows on pereonite 1 (2, 4, 7); two rows on pereonites 2-7 (6+4); and two paramedian tubercles on pleonites 3-5 and on telson. Pleopod 1 exopod with protruding distal portion, triangular, outer margin sinuous; endopod distal portion straight, twice longer than exopod.

DISTRIBUTION. — Jequitinhonha municipality, Minas Gerais state.

DESCRIPTION

Maximum size: ♂, 7 mm, ♀, 9 mm. Color grey with lateral margins depigmented (Fig. 26C, D). Dorsum covered with round tubercles (Fig. 24A, B); cephalon with three

rows (4, 4, and 4 from front to back of vertex); pereonite 1 with 13 in three rows (2, 4 and 7); pereonites 2-7 with 10 (6+4); pleonites 3-5 and telson with two paramedian tubercles. Dorsal cuticle (Fig. 28J, K) with short triangular scale setae, pereonites 1-7 bearing one line of *noduli lateralis* per side on outer surface of posterior tubercle of second tubercle. Cephalon with frontal shield protruding above vertex; eye consisting of 16 ommatidia (Figs 24C; 28J). Pereonite 1 with posterior margin sinuous at sides; inner lobe of schisma rounded, extending beyond posterior margin of outer lobe; pereonite 2 with triangular ventral tooth reaching epimeron posterior margin (Fig. 24D). Pereonites 2-7 (Fig. 24A) with wide quadrangular epimera slightly bent outwards. Telson (Fig. 24E) hourglass-shaped, proximal portion broader than distal portion. Antennula (Fig. 24F) of three articles, second article shorter than

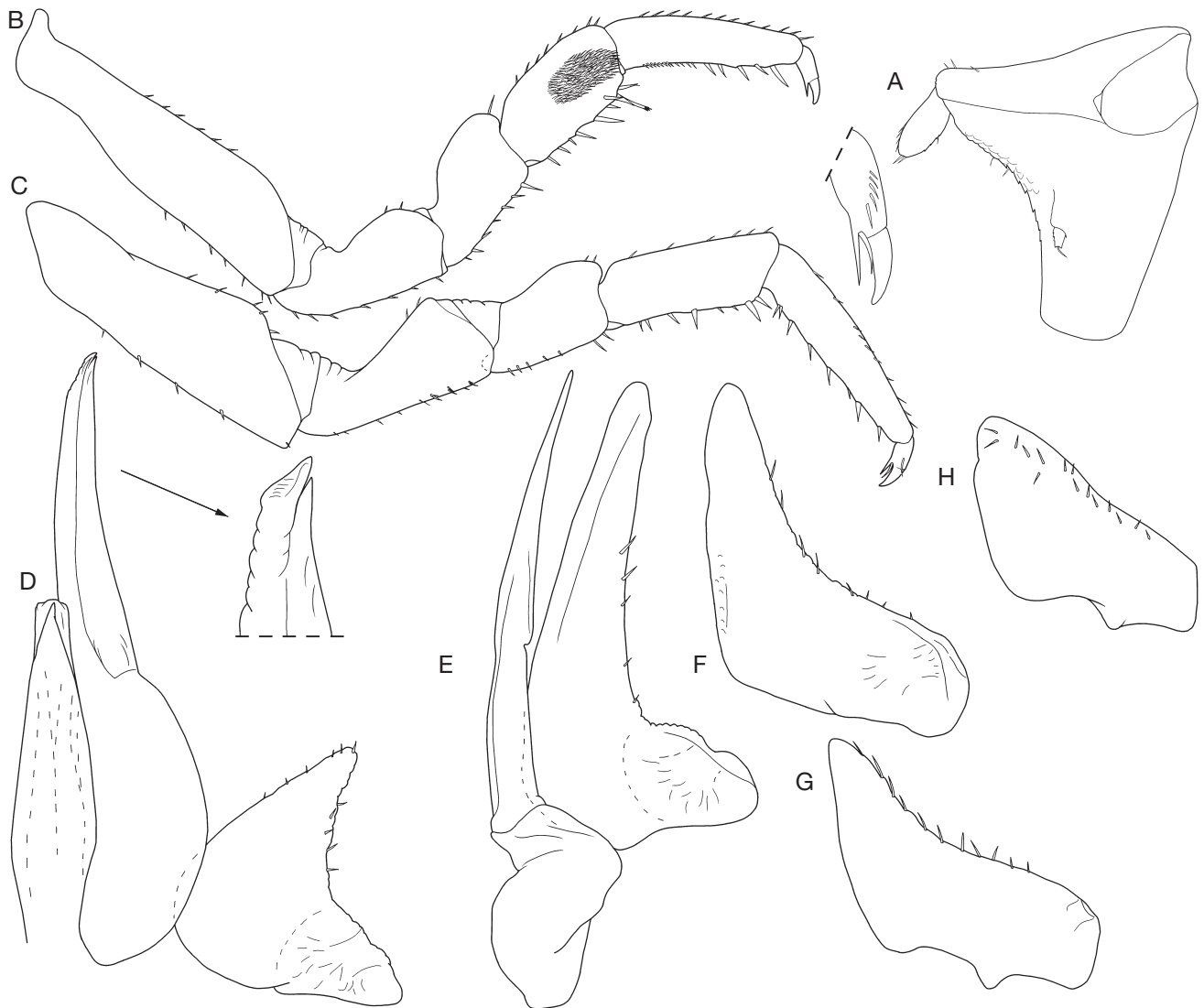


FIG. 25. — *Ctenorillo jequitinhonha* Cardoso & Ferreira, n. sp., paratype (male, 7 mm, ISLA96806): **A**, uropod; **B**, pereopod 1; **C**, pereopod 7; **D**, pleopod 1 and genital papilla; **E**, pleopod 2; **F**, pleopod 3 exopod; **G**, pleopod 4 exopod; **H**, pleopod 5 exopod.

first and third, third article with seven apical aesthetascs. Antenna (Fig. 24G) short and stout, flagellum shorter than fifth article of peduncle; second article of flagellum about three times as long as first. Buccal pieces as *C. pelado* Cardoso & Ferreira, n. sp. (Fig. 24H-L). All pleopod exopods with monospiracular covered lungs. Uropod (Fig. 25A) protopod flattened, enlarged on basal portion; exopod outward, short, inserted dorsally close to medial margin of protopod.

Male

Pereopods without particular modifications (Fig. 25B, C). Pleopod 1 exopod (Fig. 25D) as wide as long, protruding distal portion, triangular, outer margin sinuous; endopod twice longer than exopod, distal portion straight. Pleopod 2 endopod as long as exopod (Fig. 25E). Pleopods 3-5 exopods as in Figure 25F-H.

HABITAT

Specimens of *C. jequitinhonha* Cardoso & Ferreira, n. sp. were found in Toca Juparanã, a granite cave located in Jequitinhonha municipality, in northeastern Minas Gerais state, Brazil. The average annual temperature is around 25°C, with the minimum temperature of approximately 15°C and the maximum of 38°C. The rainy season lasts from October to April, with December being the wettest month (140 mm of precipitation). The dry season lasts from May to September, with July being the driest month (average of 3 mm of precipitation) (Álvares *et al.* 2013).

The Toca Juparanã cave is a granitic talus cave that was formed by water removal of smaller sediments between large collapsed granitic blocks. The cave has two entrances of irregular shape, delineated by the contact of boulders (Fig. 26A). The main chamber of the cave has an irregular floor made up of collapsed boulders (Fig. 26B) and is euphotic/disphotoc



FIG. 26. — *Ctenorillo jequitinhonha* Cardoso & Ferreira, n. sp.: **A**, detail of the Toca do Juparanã cave entrance; **B**, inner portion of the Toca do Juparanã cave; **C, D**, *Ctenorillo jequitinhonha* Cardoso & Ferreira, n. sp. habitus in natural habitat; **E**, landscape at the surroundings of the Toca do Juparanã cave, where the Jequitinhonha river can be seen.

due to the presence of two entrances located on either side of the chamber. There is a descending aphotic conduit from this chamber, which is crossed by a small hypogenic drainage. Specimens of *C. jequitinhonha* Cardoso & Ferreira, n. sp. were found under fallen rocks in this conduit trespassed by the small drainage, although the specimens were not observed close to the mainstream passage. The only visible organic resource in this area was plant debris brought by water, indicating that the isopods were likely feeding on this resource (Fig. 26 C, D).

The vegetation surrounding the cave represents a well-preserved secondary forest, although many areas in the region are deforested for pastures and monocultures, especially near the Jequitinhonha River floodplain (Fig. 26E). The cave receives

no visitors and is unknown to most of the local population. As for other *Ctenorillo* herein described, no samplings were conducted outside caves in the area, thus *C. jequitinhonha* Cardoso & Ferreira, n. sp. is likely to occur in external habitats. Therefore, it is advisable that further studies including external samplings be conducted to better understand the species distribution.

REMARK

Ctenorillo jequitinhonha Cardoso & Ferreira, n. sp. differs from the Brazilian species by the round shape of tubercles, resembling *C. iuiuensis* Cardoso & Ferreira, n. sp. by the presence of two paramedian tubercles on pleonites 3-5 and on telson.



FIG. 27. — Habitus of the species of the genus *Ctenorillo* Verhoeff, 1942 discussed in the present paper: **A**, *Ctenorillo ferrarai* Campos-Filho, Araujo & Taiti, 2014; **B**, *Ctenorillo pelado* Cardoso & Ferreira, n. sp.; **C**, *Ctenorillo araguaia* Cardoso & Ferreira, n. sp.; **D**, *Ctenorillo intertidalis* Cardoso & Ferreira, n. sp.; **E**, *Ctenorillo ubajarensis* Cardoso & Ferreira, n. sp.; **F**, *Ctenorillo cearensis* Cardoso & Ferreira, n. sp.; **G**, *Ctenorillo quiteriensis* Cardoso & Ferreira, n. sp.; **H**, *Ctenorillo potiguar* Cardoso & Ferreira, n. sp.; **I**, *Ctenorillo iuiuensis* n. sp.; **J**, *Ctenorillo jequitinhonha* Cardoso & Ferreira, n. sp. Scale bars: 1 mm.

DISCUSSION

TAXONOMY

Currently, the genus is composed by 22 species, 11 of which are from Africa, seven are from Colombia, three are from Brazil, and one is from the Democratic Republic of São Tomé and Príncipe (Taiti *et al.* 1998; Campos-Filho *et al.* 2014, 2017, 2018; Cifuentes & Da Silva 2023; Carpio-Díaz *et al.* 2023). Hence, the current manuscript contributes significantly to the knowledge of this genus, especially in Brazil, as nine new species are described, bringing the total number of species known in the country to 12 and the total number of species in the genus to 31.

As previously mentioned, *Ctenorillo* is typically identified by the shape, number, and arrangement of the dorsal tubercles. In this study, we have identified three distinct shapes of tubercles in the Brazilian species. The first group of species, including *C. ubajarensis* Cardoso & Ferreira, n. sp., *C. cearensis* Cardoso & Ferreira, n. sp. and *Ctenorillo potiguar* Cardoso & Ferreira, n. sp. display bosses or weakly developed tubercles. The second group of species, consisting of *C. pelado*

Cardoso & Ferreira, n. sp., *C. araguaia* Cardoso & Ferreira, n. sp., *C. intertidalis* Cardoso & Ferreira, n. sp., *C. quiteriensis* Cardoso & Ferreira, n. sp., *C. iuiuensis* Cardoso & Ferreira, n. sp., *C. mineri* and *C. tuberosus*, possess conical tubercles. Finally, the third group, represented by *C. jequitinhonha* Cardoso & Ferreira, n. sp. exhibits round tubercles.

The number and arrangement of tubercles differed significantly among the species, and each species displayed a unique combination of these features. In most species, except for *C. jequitinhonha* Cardoso & Ferreira, n. sp., the tubercles developed in a lateral rib, which became increasingly prominent towards the posterior end of the last pereonites. In *C. ferrarai*, the first epimeron presented a single lateral rib that appeared to be the result of the fusion of two tubercles, which could be observed separately in *C. tuberosus*, *C. mineri*, *C. pelado* Cardoso & Ferreira, n. sp., and *C. araguaia* Cardoso & Ferreira, n. sp. With respect to the pleon, there was little variation among species, with most species displaying four tubercles on pleonites 3 to 5. However, *C. tuberosus* exhibits four tubercles on pleonites 3 and 4, and two on pleonite 5, while *C. iuiuensis* Cardoso & Ferreira, n. sp. and *C. jequitinhonha*

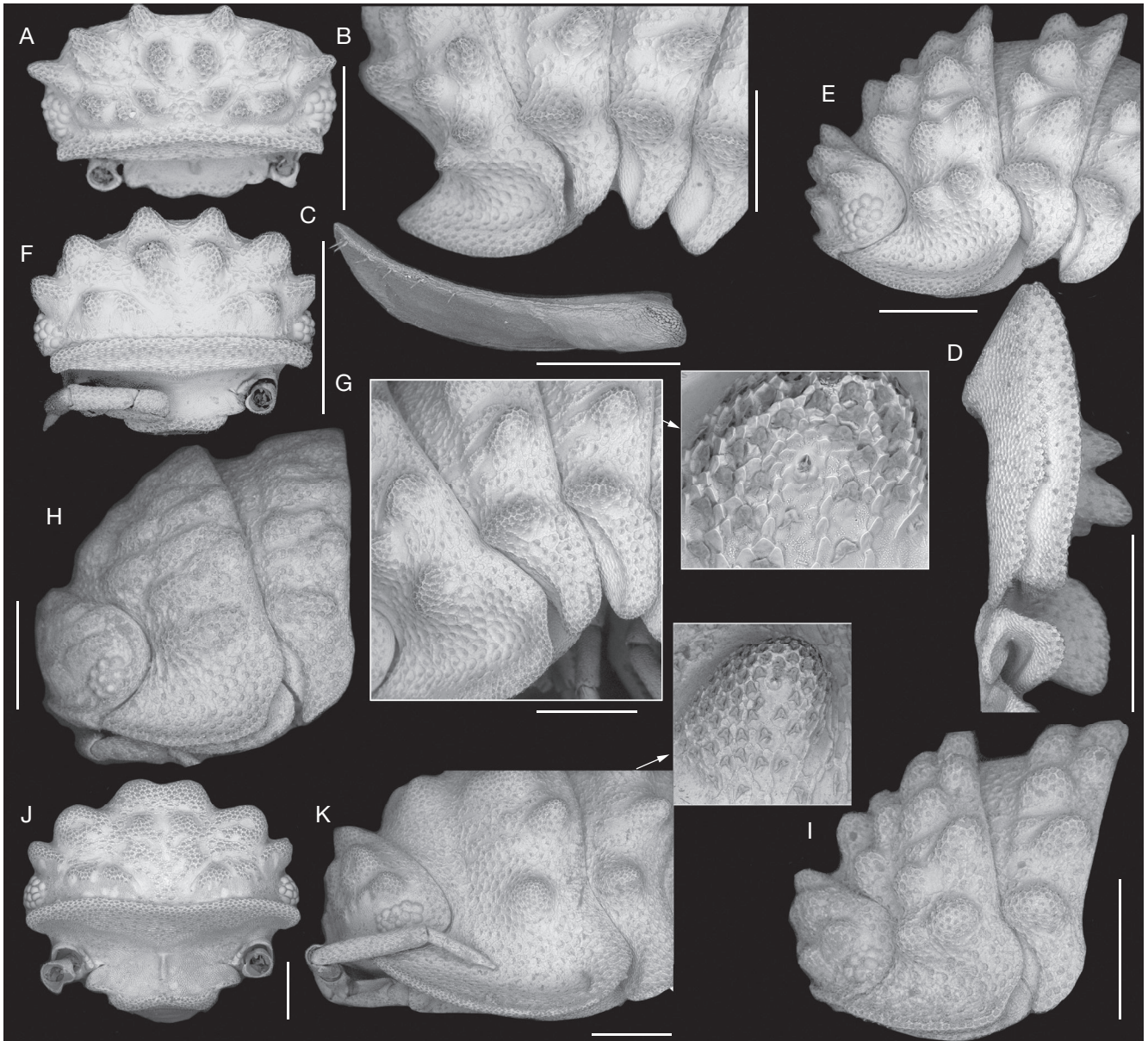


FIG. 28. — SEM images of *Ctenorillo* Verhoeff, 1942 new species: **A-D**, *Ctenorillo pelado* Cardoso & Ferreira, n. sp.: cephalon, dorsal view (**A**); epimera 1-3, lateral view (**B**); pleopod 3 exopod (**C**); epimera 1 and 2, ventral view (**D**); **E**, *Ctenorillo araguaia* Cardoso & Ferreira, n. sp.: cephalon and epimera 1-3, lateral view; **F**, **G**, *Ctenorillo intertidalis* Cardoso & Ferreira, n. sp.: cephalon, frontal view (**F**); epimera 1-3, lateral view (**G**); **H**, *Ctenorillo ubajarensis* Cardoso & Ferreira, n. sp.: cephalon and epimera 1-3, lateral view; **I**, *Ctenorillo potiguar* Cardoso & Ferreira, n. sp.: cephalon and epimera 1 and 2, lateral view; **J**, **K**, *Ctenorillo jequitinhonha* Cardoso & Ferreira, n. sp.: cephalon, frontal view (**J**); cephalon and epimera 1 and 2, lateral view (**K**). Scale bars: A, B, D-K, 0.5 mm; C, 0.2 mm.

Cardoso & Ferreira, n. sp. presented only two tubercles on pleonites 3 to 5.

Regarding the shape of the male pleopod 1, variations were observed in the presence of a distal projection on exopod, which is present in *C. tuberosus*, *C. ferrarai*, *C. pelado* Cardoso & Ferreira, n. sp., *C. quiteriensis* Cardoso & Ferreira, n. sp. and *C. jequitinhonha* Cardoso & Ferreira, n. sp.

The morphological similarities among the species are generally consistent with their geographical distribution. The state of Pará, in northern Brazil, host *C. ferrarai*, *C. pelado* Cardoso & Ferreira, n. sp. and *C. araguaia* Cardoso & Ferreira, n. sp., which exhibit well-developed, conical-shaped tubercles. In

contrast, the three species occurring in the northeast of Brazil, namely *C. ubajarensis* Cardoso & Ferreira, n. sp., *C. cearensis* Cardoso & Ferreira, n. sp. and *Ctenorillo potiguar* Cardoso & Ferreira, n. sp., display weakly developed tubercles. Notably, the most morphologically distinct species, *C. iuiuensis* Cardoso & Ferreira, n. sp. and *C. jequitinhonha* Cardoso & Ferreira, n. sp., inhabit Bahia and Minas Gerais states, respectively, the former being troglobitic, as previously mentioned.

CONSERVATION

The new species described here were found in highly heterogeneous regions, with some areas being well preserved while

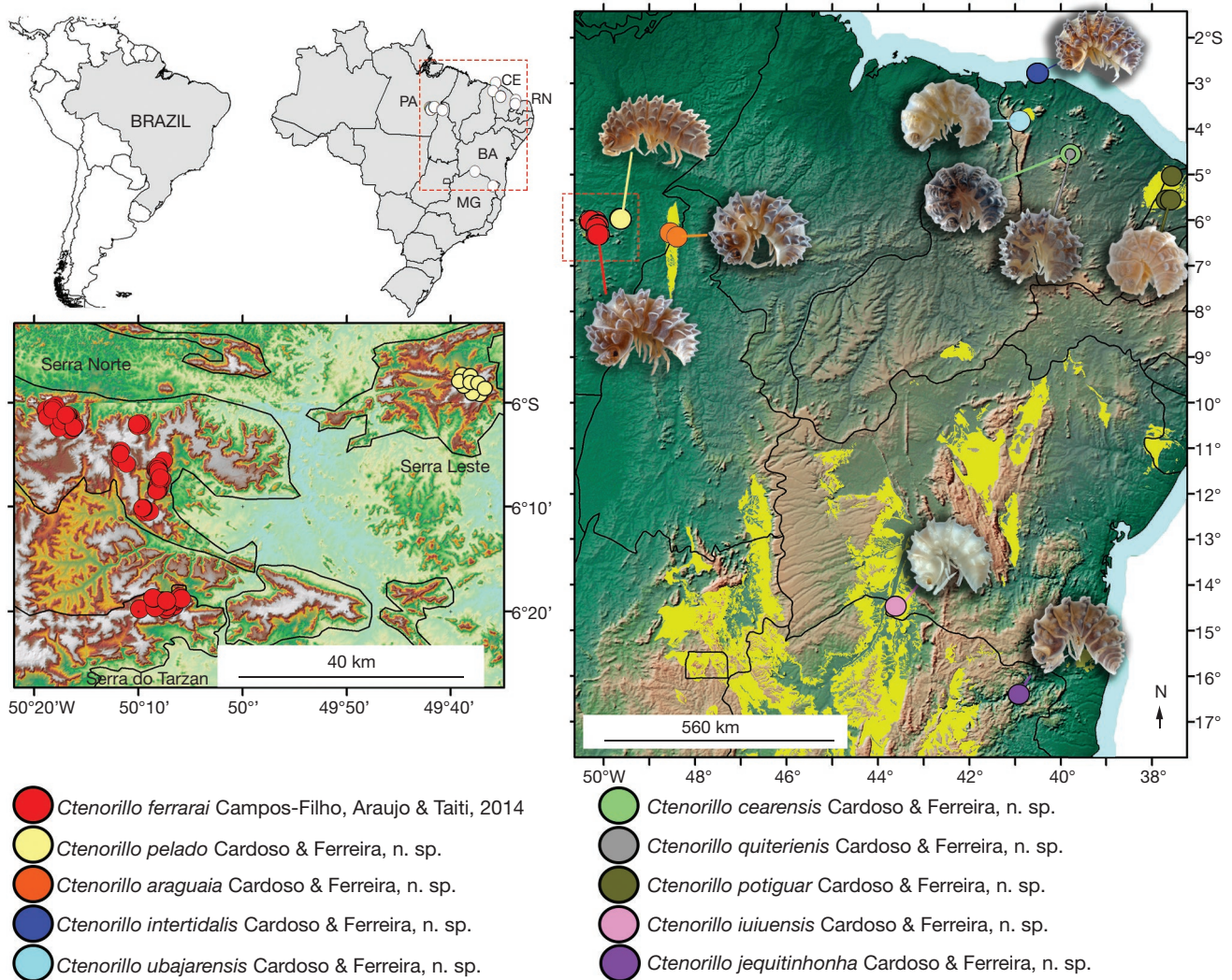


FIG. 29. — Distribution of *Ctenorillo* Verhoeff, 1942 species in Brazil, with the delimitation of the plateaus in Carajás Formation. Karstic areas marked in **yellow**. Abbreviations: **BA**, Bahia; **CE**, Ceará; **MG**, Minas Gerais; **PA**, Pará; **RN**, Rio Grande do Norte.

others significantly altered, leading to increased threats to the species. Notably, five out of the nine new species were found in conservation units: Carajás National Forest (*C. pelado* Cardoso & Ferreira, n. sp.); Serra dos Martírios/Andorinhas State Park (*C. araguaia* Cardoso & Ferreira, n. sp.); Jericoacoara National Park (*C. intertidalis* Cardoso & Ferreira, n. sp.); Ubajara National Park (*C. ubajarensis* Cardoso & Ferreira, n. sp.) and the Furna Feia National Park (FFNP) (*Ctenorillo potiguar* Cardoso & Ferreira, n. sp.). As such, these species could be considered relatively well protected. However, it is important to note that some of these protected areas, particularly the national parks, feature caves as a key tourist attraction, which may pose a potential threat to the species in the event of unregulated tourist activity.

From a conservation standpoint, the primary concern centers around species inhabiting regions lacking legal protection. Among the newly described species are *C. cearensis* Cardoso & Ferreira, n. sp., *C. quiterienis* Cardoso & Ferreira, n. sp., *C. iuiuensis* Cardoso & Ferreira, n. sp., and *C. jequitinhonha* Cardoso & Ferreira, n. sp. which are at a significant

risk due to deforestation caused by agricultural and livestock expansion. Since these species are not entirely reliant on caves, the loss of forest cover can severely impact critical parts of these species habitat ranges, except for *C. iuiuensis* Cardoso & Ferreira, n. sp., which is exclusively found in one cave. Moreover, while the fact that these species inhabit caves suggests the possibility of shelter in these environments, the caves themselves are facing an unprecedented threat in Brazil (Ferreira *et al.* 2022; Cardoso *et al.* 2023).

Finally, of all the newly described species, particular attention must be given to *C. iuiuensis* Cardoso & Ferreira, n. sp. due to its unique ecological characteristics. This species is not only troglitic but also confined to a single cave, making it especially vulnerable to habitat destruction. Furthermore, as previously mentioned, the landscape surrounding the cave where *C. iuiuensis* Cardoso & Ferreira, n. sp. is found has been significantly modified. Consequently, it is imperative that competent environmental agencies implement protective measures to guarantee the survival of this species.

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Authors' contributions

GMC performed the morphological description. All authors drafted the manuscript, read, and approved the final manuscript.

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