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The first species of Calabozoidae from iron-ore caves and their importance for the Amazon biome (Crustacea: Isopoda), Brazil

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Abstract. Three new calabozoid species are described from iron-ore caves in the Carajás Mineral Province, Pará State, north of Brazil. The species are allocated in a new genus, *Kaaetecarcinia* gen. nov., and found in two different mountain ranges: Serra Leste and Serra Norte. *Kaaetecarcinia apina* gen. et sp. nov. is found in four caves in the Serra Leste Mountain Range. In Serra Norte Mountain Range, *K. amazonica* gen. et sp. nov. is found in two caves of the N1 plateau, while *K. karaja* gen. et sp. nov. is found in two caves of the N5 plateau and one cave in the N4 plateau. These records represent the first species associated with iron-ore caves in the Amazon forest. A taxonomic key to the Calabozoidae genera is provided.

Keywords. Stygofauna, troglobitic, Carajás National Forest, Pará State.

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Introduction

In recent decades, several new isopod species belonging to the suborder Calabozoidea Van Lieshout, 1983 have been described from Brazil. To date, only one species of this group has been recorded outside this country: *Calabozoa pellucida* Van Lieshout, 1983, from Venezuela, which was also the first member of the suborder discovered in subterranean waters, collected from wells (Van Lieshout 1983).

In Brazil, species of Calabozoidea are known from two families, Calabozoidae and Brasileirinidae, Prevorčnik, Ferreira & Sket, 2012 with occurrences concentrated in the northeastern region, mainly within the Caatinga, the country's only semi-arid biome. The family Brasileirinidae includes two species: *Brasileirinho cavaticus* Prevorčnik, Ferreira & Sket, 2012, described from Bahia State, and *Brasileirinho sergipanus* Cardoso, Bento & Ferreira, 2025, from Sergipe State (Prevorčnik *et al.* 2012; Cardoso *et al.* 2025a). The family Calabozoidae is represented by *Pongycarcinia xiphidiourus* Messana, Baratti & Benvenuti, 2002, from Bahia State, and three species recorded in Rio Grande do Norte State: *Oiticicarcinia epikarstica* Cardoso, Bento & Ferreira, 2025, *Itararecarcinia yapyra* Cardoso, Bento & Ferreira, 2025, and *Poicarcinia jandairensis* Cardoso, Bento & Ferreira, 2025 (Messana *et al.* 2002; Cardoso *et al.* 2025b). Recently, three new calabozoid species have been discovered in the state of Pará, the first found in iron-ore caves within the Amazon forest. This represents a distinct lithology and biome compared to the caves where previously known species were recorded, increasing the likelihood of discovering additional species in other regions of Brazil. Additionally, we provide ecological notes, a habitat description, and the conservation status for the newly described species.

Material and methods

Study area

Specimens were discovered in iron-ore caves within the Carajás Mineral Province, located in the Carajás National Forest (Floresta Nacional de Carajás or FLONA de Carajás) in the Amazon biome, in the state of Pará, northern Brazil (Fig. 1). This mineral province is globally recognized for its vast deposits of iron, nickel, copper, and gold, contributing approximately 49% of Brazil's mineral production (ANM 2022). The Carajás region is also a hotspot of subterranean biodiversity, home to numerous cave-restricted species, many of which remain undescribed (Ferreira *et al.* 2018; Trevelin *et al.* 2019).

The species were found in two distinct areas: the Serra Norte Mountain Range complex, which is undergoing intense iron ore exploitation, and the Serra Leste Mountain Range (also known as Serra Pelada), which comprises a single extensive plateau, in contrast to the multiple plateaus of the Serra Norte (Fig. 1A).

The climate in this region is continental equatorial below 350 m above sea level and equatorial mesothermal above 700 m, with average temperatures ranging from 23 to 25°C (Piló *et al.* 2015). Rainfall varies seasonally, with a dry season from June to September (10–90 mm/month) and a rainy season from October to April (160–340 mm/month) (Sahoo *et al.* 2016). The average annual precipitation is approximately 2400 mm (Piló *et al.* 2015).

Collection

The material was collected by private consultancy companies conducting faunal inventories for environmental assessments of these caves. The specimens are stored at the Center of Studies on Subterranean Biology (CEBS/UFLA), Federal University of Lavras, Brazil. Specimens were measured and photographed using a ZEISS Axio Zoom V16 stereo microscope equipped with an Axio Cam 506 Color camera. Some were stained with Rose Bengal, dissected, and mounted on slides with Hoyer's medium. Illustrations were created using a camera lucida attached to a Leica DM750 microscope, then digitized with GIMP software (ver. 2.8) (Montesanto 2015, 2016) and a Wacom Cintiq drawing tablet. Additionally, some specimens were analyzed using a Hitachi TM4000 Scanning Electron Microscope (SEM), which employs low-vacuum imaging to scan non-conductive samples without metal coating.

The holotypes and paratypes have been deposited in the Collection of Subterranean Invertebrates of Lavras (ISLA), housed at the Ecology and Conservation Department, Federal University of Lavras, Minas Gerais, Brazil.

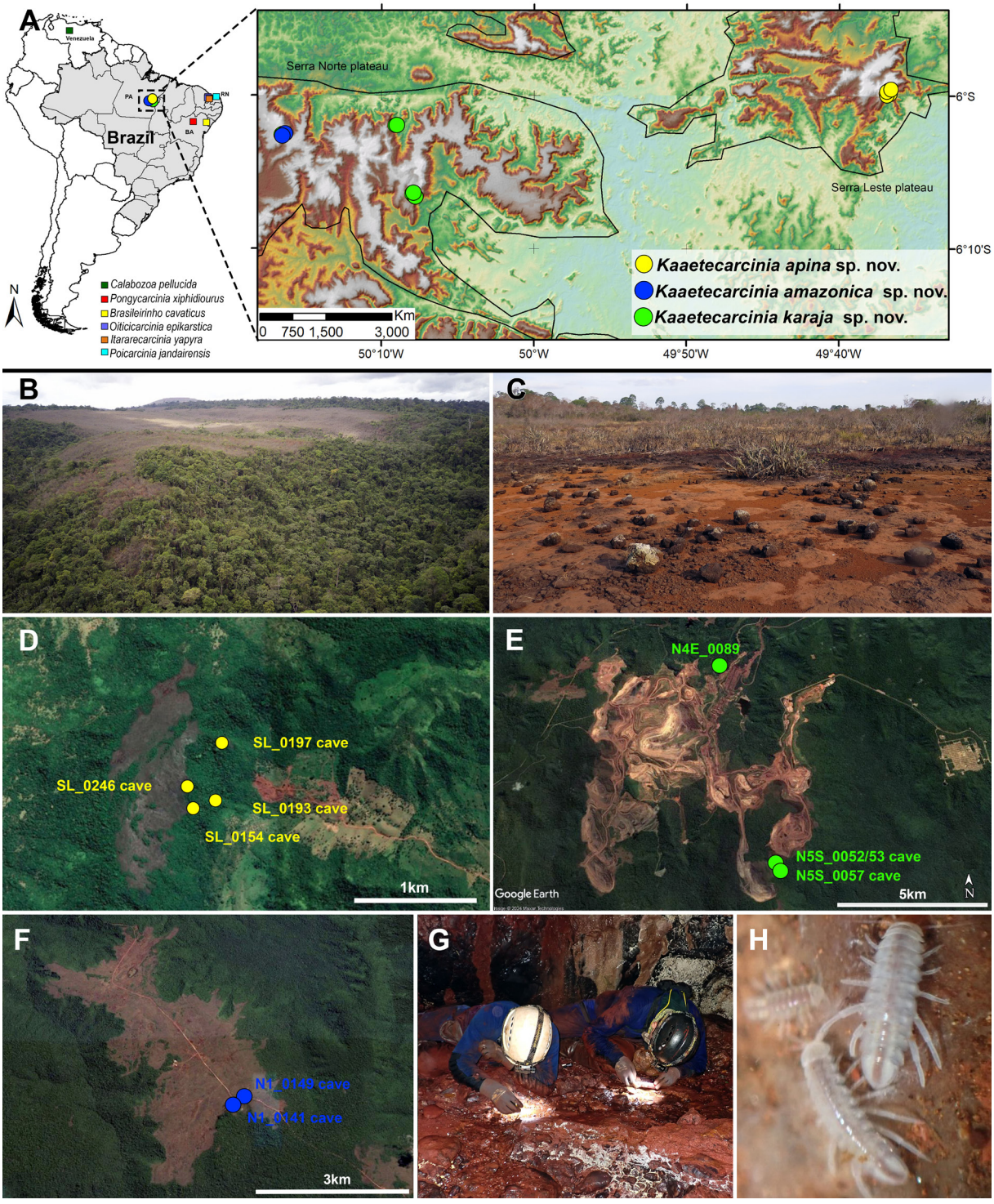

Fig. 1. A. Distribution of species of Calabozoidea Van Lieshout, 1983 in South America, with emphasis on the distribution of new species in the state of Pará. **B**. Overview of a canga formation. **C**. Typical canga vegetation. **D**. Distribution of *Kaaetecarcinia apina* gen. et sp. nov. on Serra Leste Mountain Range. **E**. Distribution of *K. karaja* gen. et sp. nov. on N5 plateau. **F**. Distribution of *K. amazonica* gen. et sp. nov. on N1 plateau. **G**. Travertine puddles in SL-0197 cave. **H**. Live specimens of *K. apina* in SL-0197 cave. Photos G and H by M.P. Oliveira.

Results

Taxonomy

Class Malacostraca Latreille, 1802
Superorder Peracarida Calman, 1904
Order Isopoda Latreille, 1816
Suborder Calabozoidea Van Lieshout, 1983
Family Calabozoidae Van Lieshout, 1983

Kaaetecarcinia gen. nov.
urn:lsid:zoobank.org:act:B448108B-C680-4C91-8E70-E5176C033DF3

Type species

Kaaetecarcinia apina gen. et sp. nov.

Diagnosis

Head shield rectangular, wider than long, wider than pleotelson. Pleon in a continuous line with pereon; pleonite I reduced to sternal part; pleonite II visible dorsally on middle. Mandibles without palp. Pereopod I stocky; propodus 3 × as long as carpus, dactylus reaching distal margin of carpus. Pleopods III–V oval-shaped, biramous, with respiratory function. Uropods shorter than pleotelson apex.

Etymology

The name '*Kaaetecarcinia*' is derived from the Brazilian indigenous Tupi-Guarani word 'KAÃ-ETÉ', which means 'native forest' and is combined with the Greek word 'carcinia', meaning 'shrimp'.

Remarks

As highlighted in previous studies, pleon and pleotelson morphology are key features in the taxon phylogeny (Van Lieshout 1983; Messana *et al.* 2002; Prevorčnik *et al.* 2012; Tabacaru & Danielopol 1999; Tabacaru & Giurginca 2019, 2021a, 2021b). In the newly discovered species, these characteristics are also crucial for defining both family and species levels within the Calabozoidea suborder (Van Lieshout 1983; Messana *et al.* 2002; Prevorčnik *et al.* 2012; Tabacaru & Danielopol 1999; Tabacaru and Giurginca 2019, 2021; Cardoso *et al.* 2025a, 2025b). In the species of Calabozoidae, the pleotelson is notably large, being around 30% of the body length in *Calabozoa* Van Lieshout, 1983 and *Pongycarcinia* Messana, Baratti & Benvenuti, 2002, and 20% of the body length in *Oiticicarcinia* Cardoso, Bento & Ferreira, 2025, *Itararecarcinia* Kury & Villarreal, 2015, *Poicarcinia* Cardoso, Bento & Ferreira, 2025, and *Kaaetecarcinia* gen. nov. Relative to the pleon length, the pleotelson is also longer in *Calabozoa* and *Pongycarcinia*, being around 75% of the pleon length, and 50–60% in *Oiticicarcinia*, *Itararecarcinia*, *Poicarcinia* and *Kaaetecarcinia* gen. nov. (Van Lieshout 1983; Messana *et al.* 2002; Cardoso *et al.* 2025a, 2025b).

Kaaetecarcinia gen. nov. is morphologically similar to *Calabozoa* due to the reduction of pleonites I and II and the shape of the pleopods. In *Calabozoa*, pleonites I and II are not visible dorsally, being reduced to the sternal part (Van Lieshout 1983; Tabacaru & Giurginca 2019). In *Kaaetecarcinia* gen. nov., pleonite I is reduced to the sternal part, while only a small portion of pleonite II is visible dorsally. The pleopods III–V in *Kaaetecarcinia* gen. nov. have respiratory endopods, and their oval-shaped exopods may serve natatory functions, similar to *Calabozoa*. This contrasts with the round pleopods in *Pongycarcinia*, *Itararecarcinia*, and *Poicarcinia*, and the subrectangular ones in *Oiticicarcinia*. As mentioned by Van Lieshout (1983), monomorphic pereopods are only found in Oniscidea, whereas other taxa may exhibit specialization in the first or additional pereopods. In Calabozoidea, the pereopod I differs slightly from

the others due to modifications in the carpus and propodus. In *Kaaetecarcinia*, pereopod I is stocky, with a long dactylus reaching the distal margin of the carpus, resembling a subchelae structure.

Kaaetecarcinia apina gen. et sp. nov.
urn:lsid:zoobank.org:act:3568D564-1BCD-4066-AB18-F1181E080909
Figs 1–4, 11A, 12

Diagnosis

Male pleopod I biramous, with inner ramus conical and shorter than outer ramus, exopod longer than wide, with two pappose setae plus one long seta; male pleopod II biramous, with endopod as long as base and apex with four setae; exopod basal part wider than apex, with one acute spine.

Etymology

The term '*apina*' originates from the Brazilian indigenous Tupi language, meaning 'naked' in reference to the place where the species was collected. Serra Leste Mountain Range, also known as Serra Pelada, means 'naked mountains', due to the presence of the metallophilic vegetation on top of the plateau, which is reduced (in size) when compared to the surrounding Amazon Forest.

Type material

Holotype

BRAZIL – **Pará State** • ♂ (in slide); Parauapebas municipality, Serra Leste plateau, SL-0193 cave; 5.9982° S, 49.6129° W; 1–19 Mar. 2016; Spelayon leg; ISLA, ISLA96925.

Paratypes

BRAZIL – **Pará State** • 1 ♀, same data as for holotype; ISLA, ISLA39610 • 1 ♂ (in slide), 2 ♀♀; same data as for holotype; ISLA39615 • 1 ♀; SL-0154 cave; 5.9989° S, 49.6146° W; 1–19 Mar. 2016; Spelayon leg.; ISLA, ISLA39611 • 2 immature ♂♂, 5 ♀♀; same locality as for holotype; 11 Apr. 2024; Bioespeleo leg.; ISLA, ISLA96956 • 10 ♀♀, 5 immature ♂♂; SL-0197 cave; 5.9938° S, 49.6123° W; 15 Apr. 2024; Bioespeleo leg.; same data as for holotype; ISLA, ISLA96957 • 2 ♀♀; SL-0246 cave; 5.9974° S, 49.6152° W; 12 Apr. 2024; Bioespeleo leg.; ISLA, ISLA96958.

Description

Maximum body length 3 mm, approximately 3 × as long as wide (Figs 2A, 3A). Pereonites subtrapezoidal, with rounded posterior margins, 8–11 setae on lateral margins (Fig. 2A, C). Pleonite II slender than pleonite III, pleonite III width about 90% of pereonite VII length, pleonites III–V with three setae laterally (Fig. 2A). Pleotelson (Figs 2A, 3C) length 20% of body length, similar to pleon length, as wide as long, with 8–10 setae laterally, apex with two sets of setae. Antennula (Fig. 2B) longer than peduncle of antenna, peduncle of three articles, flagellum of one article with one aesthetasc, as long as flagellum length. Antenna (Fig. 2B) long, about 50% of body length, reaching pereonite V, peduncle of five articles, flagellum with 13–15 articles. Mandibles (Fig. 2D) lacinia mobilis with denticulate apex, right and left incisor with three to four teeth, spine row reduced to one plumose seta, pars molaris as tuft of setae with 4–5 branches. Maxillula (Fig. 2E) endite with two simple setae and two robust pappose setae; exite with one robust seta plus four robust serrate setae and four robust cuspidate setae. Maxilla (Fig. 2F) endite with two plumose (one medial and one distal) and one simple setae on medial margin, apex setose with one serrate seta; exite medial and lateral rami with 12 and 13 serrate setae respectively. Maxilliped (Fig. 2G) endite proximal lobe with seven pappose setae, apex with two pappose setae, medial margin with two pappose setae; palp of five articles, first article fused with maxilliped body, articles with long simple setae, article 5 smallest, with tuft of simple setae distally. Pereopod I (Figs 3D, 4A) stocky; propodus 2.5 × as long as carpus, medial margin with three stout setae, some with accessory

seta; carpus reduced to ½ of propodus length, with serrate setae on inferior margin; dactylus shorter than propodus, closing over propodus and reaching distal margin of carpus, unguis shorter than dactylus length; propodus and dactylus inferior margin with scales. Pereopod II–IV (Figs 3E, 4B) carpus with similar length as propodus; dactylus shorter than propodus. Pereopods V–VII (Figs 3F–H, 4D) merus, carpus and propodus which progressively lengthen, merus with one serrate seta on distal margin longer than merus length. Pereopod VII (Figs 3H, 4C) 2 × as long as pereopod I, propodus longer than carpus, dactylus ½ of propodus length, unguis as long as dactylus length.

Mature male (Fig. 4D–G)

Pereonites with 11 setae on lateral margins. Pleotelson with 9–10 setae on lateral margin. Antennal flagellum with 13 articles. Genital papilla with one lobe, on articulating membrane between pereonite VII and pleonite I. Pleopod I (Fig. 4D–E) biramous, base rectangular, endopod conical and short, exopod longer than wide, with two pappose setae plus one long seta. Pleopod II (Fig. 4D, F) biramous, base rectangular, endopod as long as base, apex with four setae; exopod basal part wider than apex, with one spine with acute apex. Pleopods III–IV (Fig. 4D, G) biramous endopod respiratory, bladder-shaped, smaller than exopod; exopod ovoid, progressively longer than wide, with 4–5 plumose setae distally.

Immature male (Fig. 4H–J)

Pereonites with 10–12 setae on lateral margins. Pleotelson with 7–9 setae on lateral margin. Antennal flagellum with 15–19 articles. Pleopod I (Fig. 4H–I) base rectangular, longer than wide; endopod short, with one long seta; exopod longer than wide, with 3–4 plumose setae on apex. Pleopod II (Fig. 4J) base rectangular, endopod as wide as base, apex tapering; exopod ovoid, distal margin with five plumose setae.

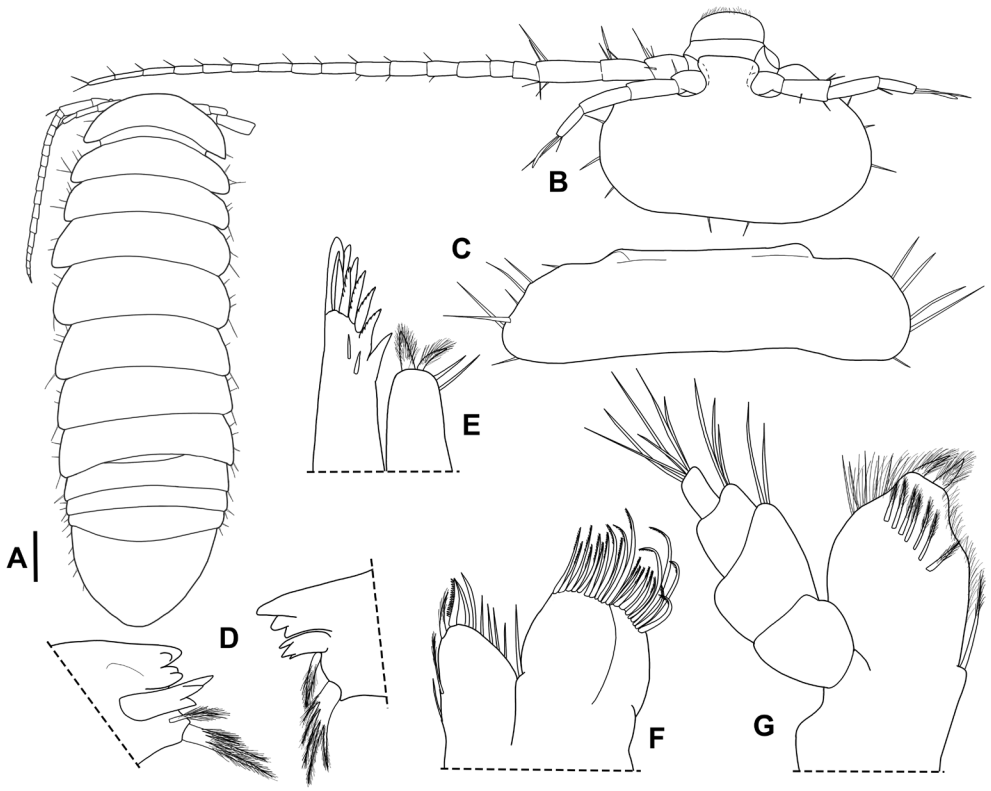

Fig. 2. *Kaaetecarcinia apina* gen. et sp. nov. **A**. Paratype, ♂ (ISLA39615), habitus, dorsal view. **B–G**. Holotype, ♂ (ISLA96925). **B**. Head shield dorsal view, with antennula and antenna. **C**. Epimeron I, dorsal view. **D**. Left and right mandibles. **E**. Maxillula. **F**. Maxilla. **G**. Maxilliped. Scale bar: A = 0.2 mm.

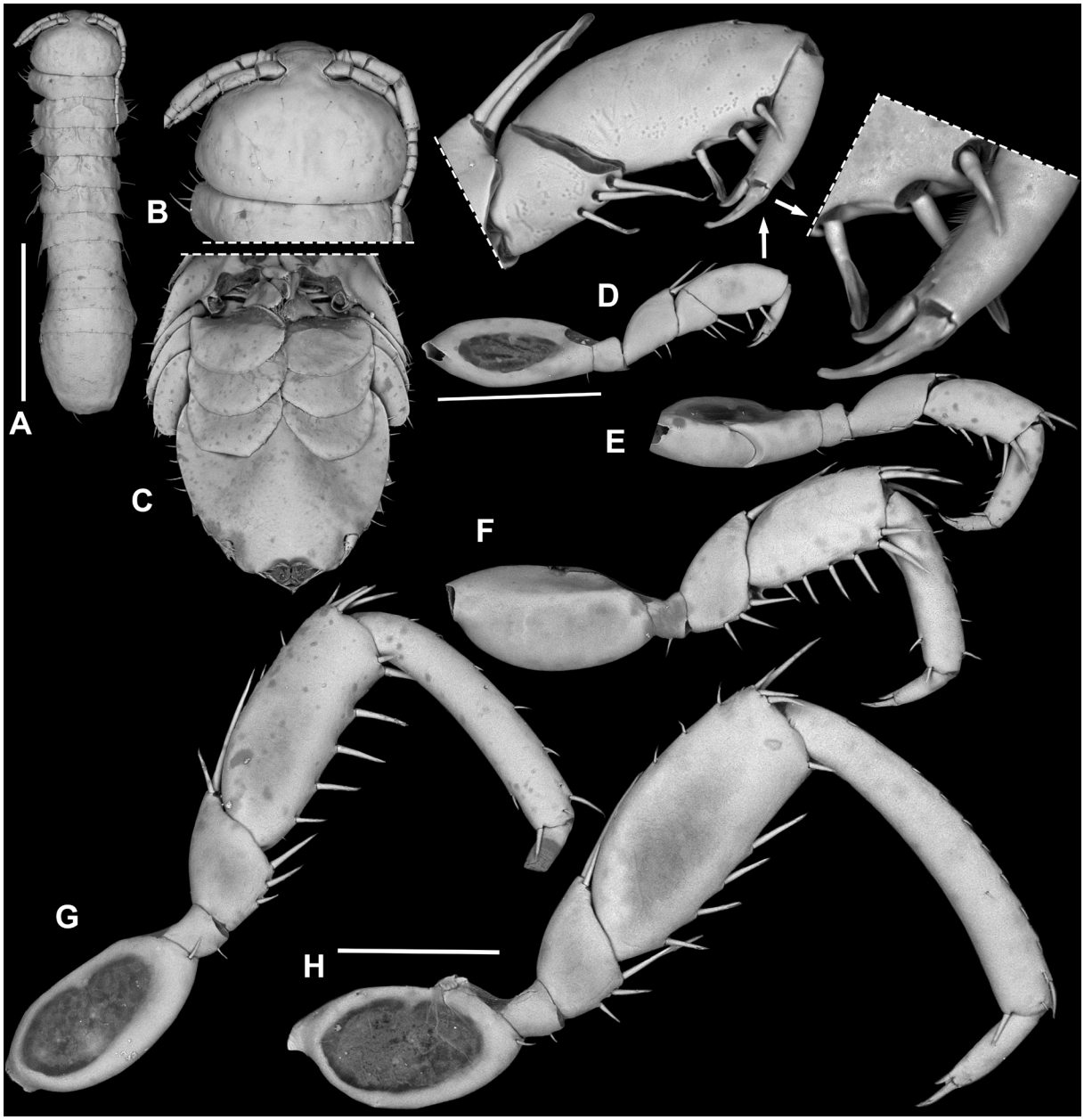

Fig. 3. *Kaaetecarcinia apina* gen. et sp. nov., paratype, ♀ (ISLA96957). **A**. Habitus, dorsal view. **B**. Head shield and epimeron I, dorsal view. **C**. Pleon with pleonites, pleotelson and uropods, ventral view. **D**. Pereopod I with emphasis on carpus, propodus and dactylus. **E**. Pereopod II. **F**. Pereopod V. **G**. Pereopod VI. **H**. Pereopod VII. Scale bars: A, D, H = 1 mm.

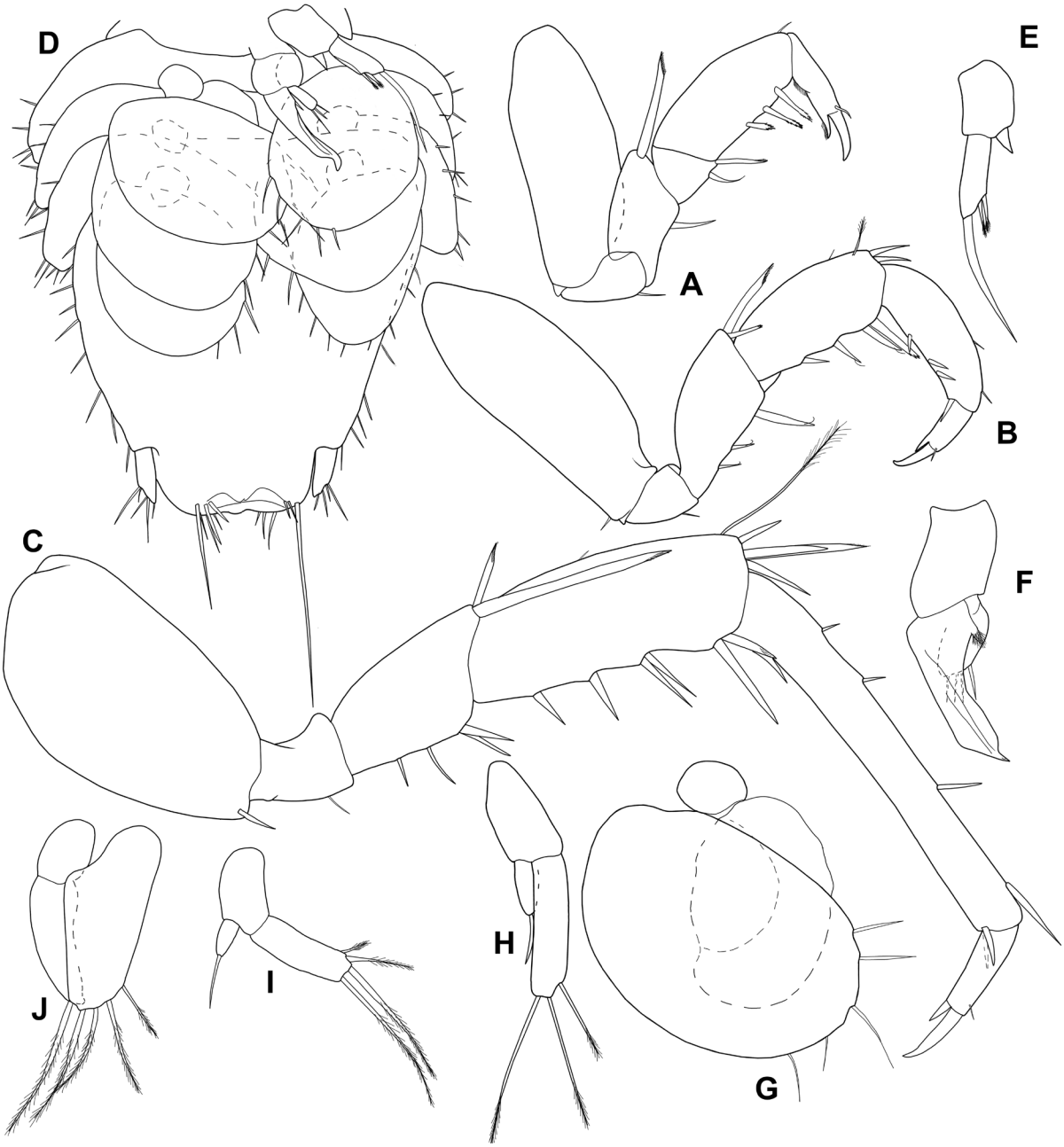

Fig. 4. *Kaaetecarcinia apina* gen. et sp. nov. **A–G**. Holotype, ♂ (ISLA96925). **A**. Pereopod I. **B**. Pereopod I carpus, propodus and dactylus. **C**. Pereopod VII. **D**. Pleon with pleonites, pleotelson and uropods, ventral view. **E**. Pleopod I. **F**. Pleopod II. **G**. Pleopod III. **H**. Immature paratype of SL_0193 cave (ISLA39615), pleopod I. **I–J**. Immature paratype (ISLA96957) of SL_0197 cave. **I**. Pleopod I. **J**. Pleopod II.

Kaaetecarcinia amazonica gen. et sp. nov.
urn:lsid:zoobank.org:act:ED87C3B2-978E-4F08-B520-60F3F9AD038A
Figs 1, 5–7, 8A–D, 11B

Diagnosis

Male pleopod I biramous with endopod long and styliform, exopod short, with two plumose setae on apex; pleopod II biramous with endopod simple, robust and long; exopod ovoid.

Etymology

The specific epithet '*amazonica*' refers to the Amazon rainforest where the species has been found.

Type material

Holotype

BRAZIL – **Pará State** • ♂ (in slide); Parauapebas municipality, Serra Norte plateau, N1-0149 cave; 6.0423° S, 50.2749° W; 24 Feb.–13 Mar. 2015; Carste (iso)1129 leg.; ISLA, ISLA96925.

Paratypes

BRAZIL – **Pará State** • 2 ovigerous ♀♀; same data as for holotype; Carste iso(1128) leg.; ISLA, ISLA30922 • 2 immature ♂♂ (one in slide), 2 ♀♀; same data as for holotype; ISLA, ISLA30923 • 1 ♀; N1-0141 cave; 6.04317° S, 50.2761° W; 7–28 Jan 2015; Carste iso(1125) leg.; ISLA, ISLA30919 • 1 ♂ immature (in slide), 2 ♀♀; same data as for preceding; Carste iso(1126) leg.; ISLA, ISLA30920 • 4 ♀♀; same data as for preceding; Carste iso(1127) leg.; ISLA, ISLA30921.

Description

Maximum body length approximately 2.5 mm, 2.5 × as long as wide (Fig. 5A). Pereonites (Figs 5A, C, 8A) subtrapezoidal, with rounded posterior margins, 9–12 setae on lateral margins, pereonite IV widest. Pleonite II visible dorsally on middle, smaller than pleonite III, length of pleonites II and III about 56% and 98% of pereonite VII, pleonites III–V with three setae on lateral margins. Pleotelson (Figs 5A, 6C) 20% of body length and about 60% longer than pleon, slightly wider than long, with 10 setae laterally, apex with two sets of three setae. Antennula. (Fig. 5B) as long as peduncle of antenna, peduncle of three articles, flagellum of one article with two terminal simple setae and one aesthetasc, shorter than flagellum. Antenna (Fig. 5B) long, about 40% of body length, reaching pereonite V, peduncle of five articles, flagellum with 15–18 articles. Mandibles (Fig. 5D) lacinia mobilis with denticulate apex, right and left incisor with four teeth, spine row reduced to one seta on right mandible, and two setae on left mandible; pars molaris as tuft of setae. Maxillula (Fig. 5E) endite with two simple setae and two robust pappose setae; exite with one robust seta, four robust serrate setae and four cuspidate setae. Maxilla (Fig. 5F) endite with two medial serrate setae, apex setose with two serrate setae, one pappose seta; exite medial and lateral rami with more than ten serrate setae each. Maxilliped (Fig. 5G) endite proximal lobe with six pappose setae, apex with two pappose setae, medial margin with two pappose setae; palp of five articles, first article fused with maxilliped body, articles with long simple setae, article 5 smallest, with distal tuft of setae. Pereopod I (Figs 6A–B, 7A) haptorial, stocky; merus with serrate setae on anterodistal angle; carpus with three cuspidate setae on lateral margin, reduced to ⅓ of propodus length, whose inner margin bears three serrate setae; dactylus shorter than propodus, reaching distal margin of carpus, unguis shorter than dactylus length; propodus and dactylus inner margin with scales. Pereopod II (Fig. 7B) merus with cuspidate setae with accessory seta on lateral margin and serrate setae on anterodistal angle; carpus as long as propodus, cuspidate setae on lateral margin; dactylus shorter than propodus. Pereopod IV (Fig. 7C) merus with cuspidate setae on lateral margin; carpus as long as propodus, anterodistal angle with serrate setae and one plumose seta; dactylus shorter than propodus. Pereopods V–VII (Fig. 7D–F) merus with cuspidate setae with accessory seta on lateral margin, anterodistal angle with one long serrate

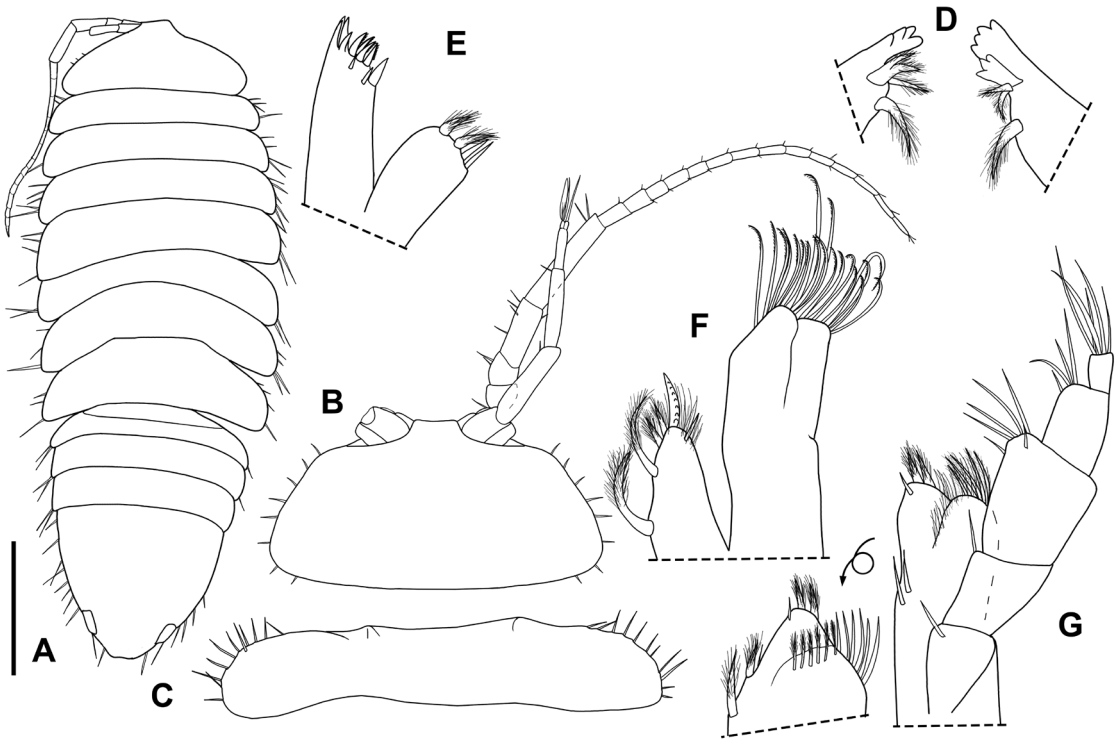

Fig. 5. *Kaaetecarcinia amazonica* gen. et sp. nov. **A**. Paratype, ♂ (ISLA30923), habitus, dorsal view. **B–G**. Holotype, ♂ (ISLA96925). **B**. Head shield dorsal view, with antennula and antenna. **C**. Epimeron I dorsal view. **D**. Left and right mandibles. **E**. Maxillula. **F**. Maxilla. **G**. Maxilliped. Scale bar: A = 0.2 mm.

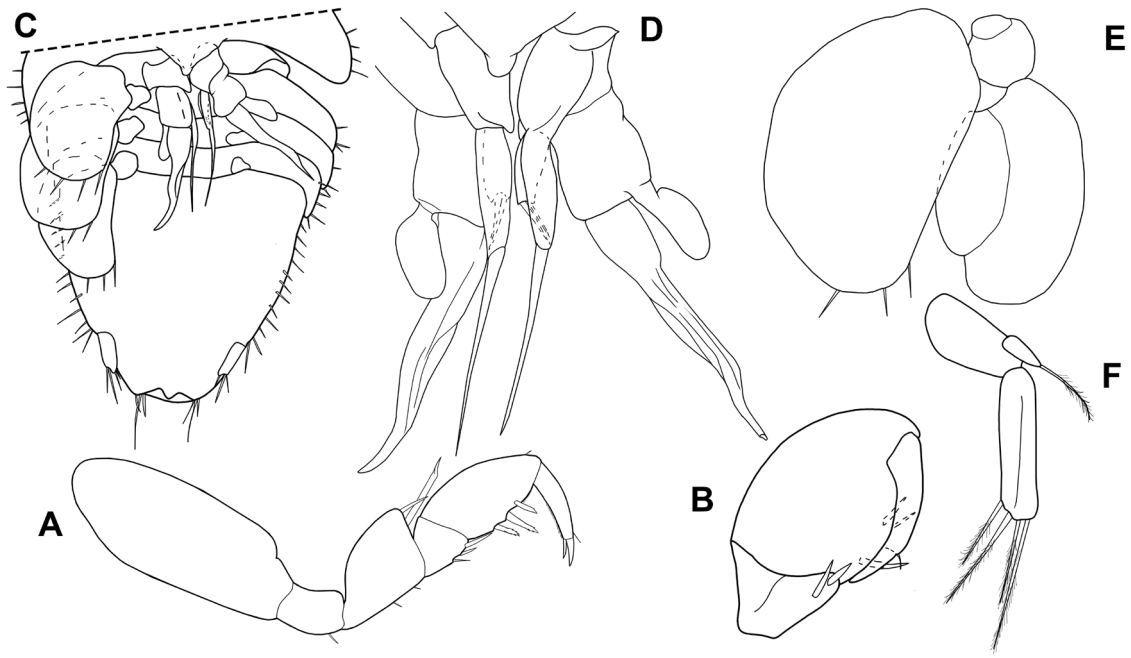

Fig. 6. *Kaaetecarcinia amazonica* gen. et sp. nov. **A–E**. Holotype, ♂ (ISLA96925). **A**. Pereopod I. **B**. Second pair of pereopod I carpus, propodus and dactylus. **C**. Pleon with pleonites, pleotelson and uropods, ventral view. **D**. Genital papilla, pleopods I and II. **E**. Pleopod V. **F**. Immature ♂ (ISLA30923), pleopod I.

seta, as long as carpus; carpus anterodistal angle with serrate setae and one plumose seta; propodus progressively lengthen; dactylus shorter than propodus.

Mature male (Fig. 6A–E)

Genital papilla (Fig. 6C–D) with one lobe, on articulating membrane between pereonite VII and pleonite I. Pleopod I (Fig. 6C–D) base rectangular, biramous, inner ramus long, styliform, outer ramus short, with two plumose setae on apex. Pleopod II biramous (Fig. 6C–D), protopodite trapezoidal, inner ramus simple, robust and long reaching ¼ of pleotelson; outer ramus ovoid. Pleopods III–IV (Fig. 6C, E) exopod ovoid with four plumose setae distally, similar in shape.

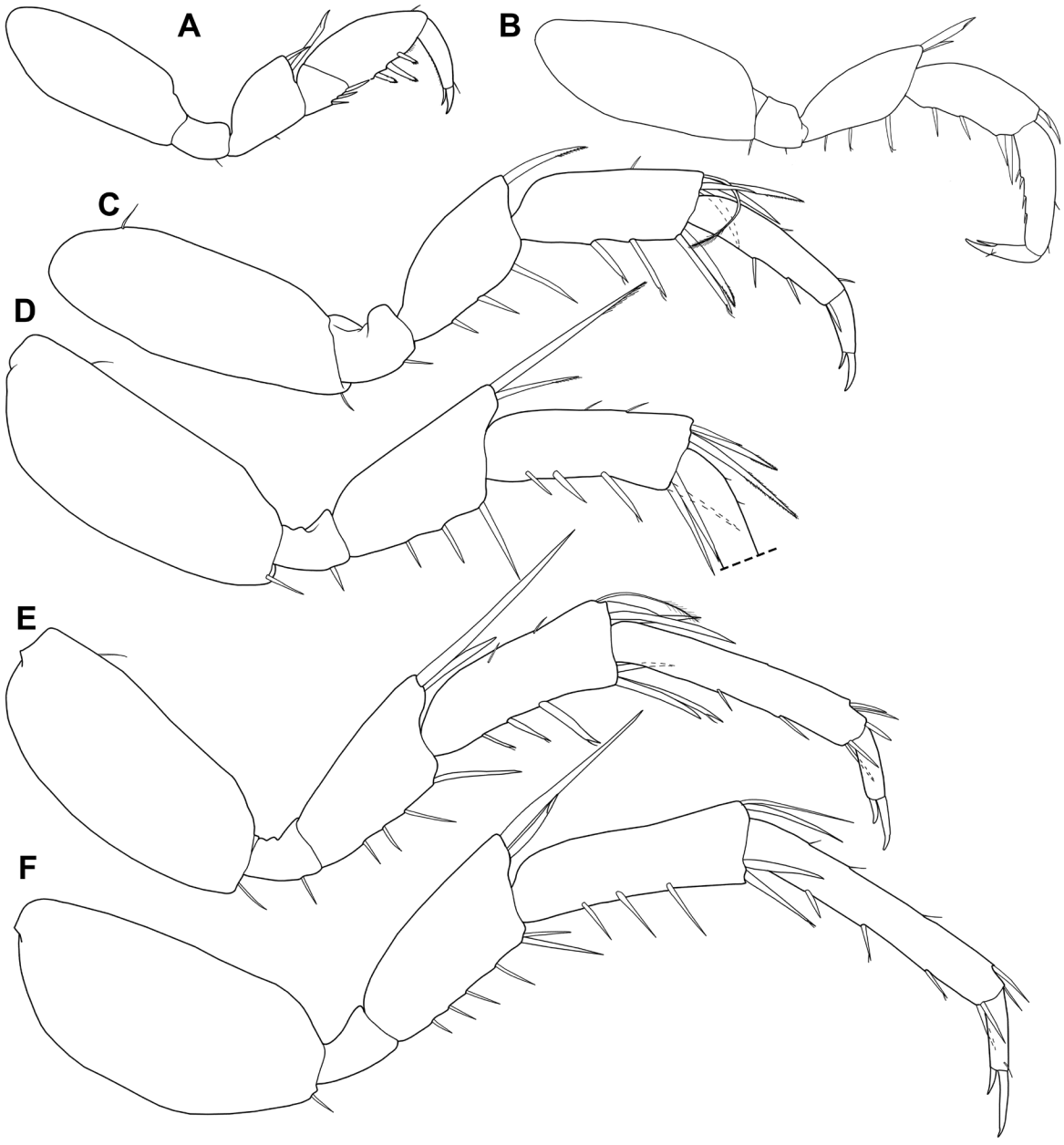

Fig. 7. *Kaaetecarcinia amazonica* gen. et sp. nov., holotype, ♂ (ISLA96925). **A**. Pereopod I. **B**. Pereopod II. **C**. Pereopod IV. **D**. Pereopod V. **E**. Pereopod VI. **F**. Pereopod VII.

Immature male (Fig. 6F)

Pereonites with nine setae on lateral margins. Pleotelson with 10 setae on lateral margin. Antennal flagellum with 17–19 articles. Pereopod I similar to holotype. Pereopods II–IV progressively long; carpus with similar length as propodus; dactylus shorter than propodus. Pereopods V–VII merus, carpus and propodus progressively long, merus with one serrate seta on distal margin longer than merus length. Pereopod VII 2 ×as long as pereopod I, propodus longer than carpus, dactylus haft propodus length, unguis as long as dactylus length. Pleopod I (Fig. 6F) base rectangular, longer than wide; inner ramus short, with one long plumose seta; outer ramus longer than wide, with four plumose setae on apex. Pleopod II base rectangular, biramous, inner ramus as wide as base, apex tapering; outer ramus ovoid, distal margin with plumose setae. Pleopods III–V similar to holotype.

Kaaetecarcinia karaja gen. et sp. nov.

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Figs 1, 8E–G, 9–11C

Diagnosis

Male pleopod I uniramous with ramus long, styliform, longer than pleopod II; male pleopod II uniramous with ramus robust, ramus basal part as wide as apex, with one seta, apex with one acute lobe directed inward.

Etymology

The specific epithet '*karaja*' refers to the indigenous tribe that inhabits the region that bears the same name, Serra de Carajás (Carajás Mountain Range).

Type material

Holotype

BRAZIL – **Pará State** • ♂; Parauapebas municipality, Serra Norte plateau, N5S_057 cave; 6.1084° S, 50.1325° W; 25 Aug.–3 Sep. 2009; R Andrade leg.; ISLA, ISLA96902.

Paratypes

BRAZIL – **Pará State** • 1 ♂; same data as for holotype; ISLA, ISLA96901 • 2 ♀♀; same data as for holotype; N5S52/53 cave; 6.1074° S, 50.1332° W; 25 Aug.–3 Sep. 2009; R Andrade leg.; ISLA, ISLA96903 • 1 ♀; same data as for holotype; N4E89 cave; 6.0330° S, 50.1517° W; 19 Feb.–4 Mar. 2010; R Andrade leg.; ISLA, ISLA96904.

Description

Maximum body length of 2 mm, approximately 3 × as long as wide (Figs 8E, 9A). Pereonites subtrapezoidal, with rounded posterior margins, seven setae on lateral margins, pereonite IV widest (Fig. 9A, C). Pleonites II and III about 50% and 90% of pereonite VII length, respectively, pleonites III–V with three setae laterally (Fig. 9A). Pleotelson (Figs 8F, 9A) length 20% of body length and about 60% longer than pleon, as wide as long, with 13 setae laterally, apex with two sets of four setae. Antennula (Fig. 9B) longer than peduncle of antenna, peduncle of three articles, flagellum of one article with one simple seta and aesthetasc, shorter than flagellum. Antenna (Fig. 9B) long, about 50% of body length, reaching pereonite VI, peduncle of five articles, flagellum with 16–19 articles. Mandibles (Fig. 9D) lacinia mobilis with denticulate apex, right and left incisor with four teeth, spine row reduced to one seta, pars molaris as tuft of setae with five branches. Maxillula (Fig. 9E) endite with two robust simple setae and two robust pappose setae; exite margin with one robust seta plus four robust serrate setae and three robust simple setae. Maxilla (Fig. 9F) endite, apex setose with one serrate seta; exite medial and lateral rami with 12 and 13 serrate setae respectively. Maxilliped (Fig. 9G) endite proximal

lobe with eight pappose setae, apex with two pappose setae, medial margin with two pappose setae and four pappose on lateral margin; palp of five articles, first article fused with maxilliped body, articles with long simple setae, article 5 smallest, with tuft of setae distally. Pereopod I (Fig. 10A) stocky; propodus 2.5 × as long as carpus, inferior margin with three serrate setae; carpus with serrate setae on inferior margin and on anterodistal angle; dactylus ½ of propodus length, reaching distal margin of carpus, unguis shorter than dactylus length. Pereopod II (Fig. 10B) carpus longer than propodus, anterodistal angle with one plumose seta; dactylus shorter than propodus. Pereopod VII (Fig. 10C) 2 × as long as pereopod I, merus with cuspidate setae with accessory seta; propodus longer than carpus with cuspidate setae with accessory seta; unguis as long as dactylus length.

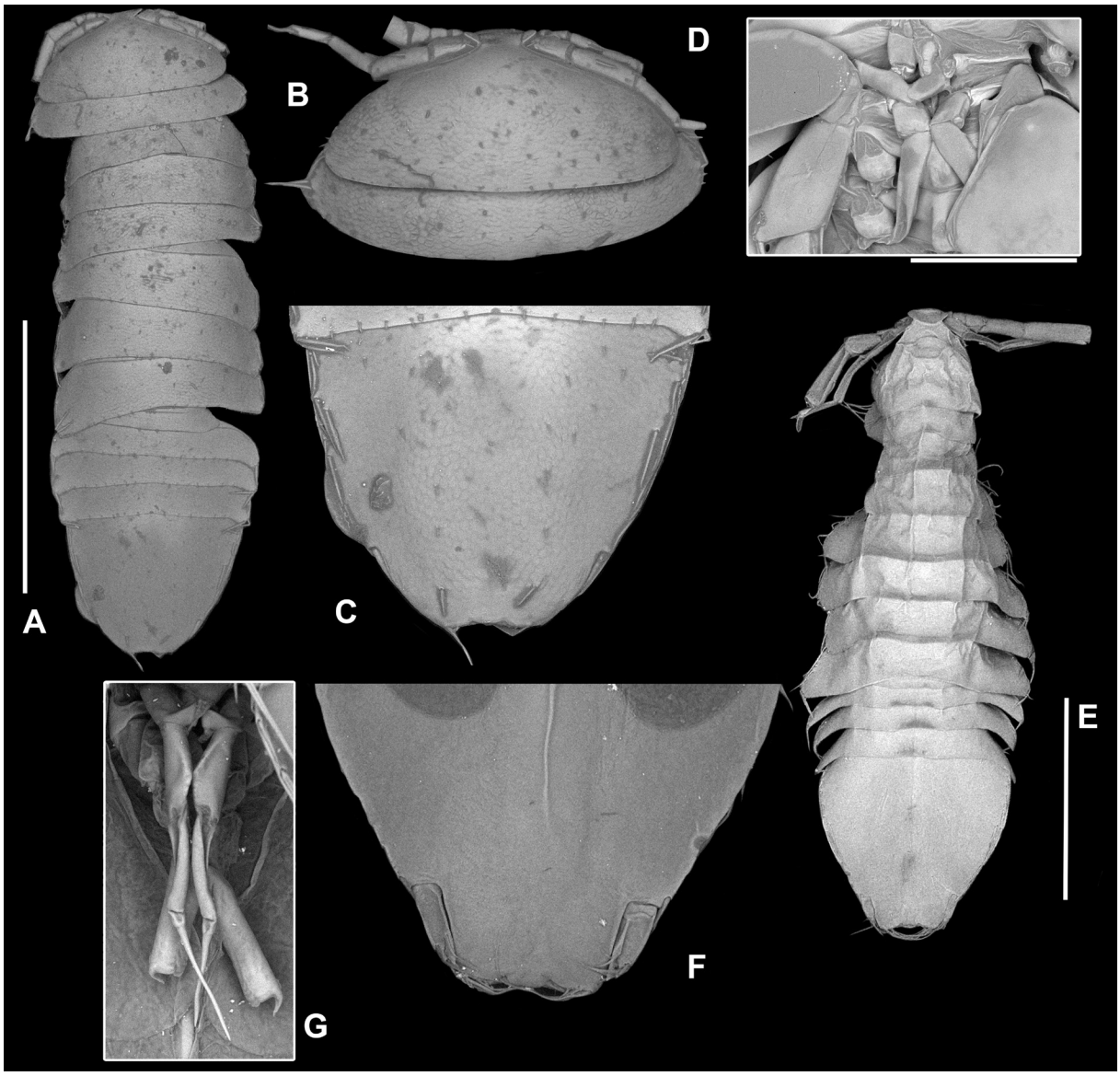

Fig. 8. A–D. *Kaaetecarcinia amazonica* gen. et sp. nov., holotype, ♂ (ISLA30923). **A**. Habitus, dorsal view. **B**. Head shield and epimeron I, dorsal view. **C**. Pleotelson and uropods, dorsal view. **D**. Pleopods, ventral view. **E–G**. *Kaaetecarcinia karaja* gen. et sp. nov., paratype, ♂ (ISLA96901). **E**. Habitus, dorsal view. **F**. Pleotelson and uropods, ventral view. **G**. Pleopods, ventral view. Scale bars: A, E= 1 mm

Mature male (Figs 8G, 10D–E)

Body length of 1.6 mm. Antennal flagellum with 16–17 articles. Genital papilla (Fig. 10D) with one lobe on articulating membrane between pereonite VII and pleonite I. Pleopod I (Figs 8G, 10D) uniramous, base rectangular, endopod long, styliform, longer than pleopod II. Pleopod II (Figs 8G, 10D–E) uniramous, protopodite rectangular; endopod robust, basal part as wide as apex, with one medial seta, apex with one acute lobe directed inward. Pleopods III–IV exopods ovoid, progressively longer than wide, with 4–5 plumose setae distally.

Immature male (Fig. 10F–H)

Body length of 2 mm. Antennal flagellum with 19 articles. Pleopod I (Fig. 10F) base rectangular, longer than wide, biramous; inner ramus short, with one plumose seta; exopod longer than wide, with four plumose setae on apex. Pleopod II (Fig. 10G) base rectangular, biramous; endopod short, with one plumose seta; exopod ovoid, distal margin with four plumose setae. Pleopods III–V (Fig. 10G) exopods ovoid, progressively longer than wide, with 4–5 plumose setae distally.

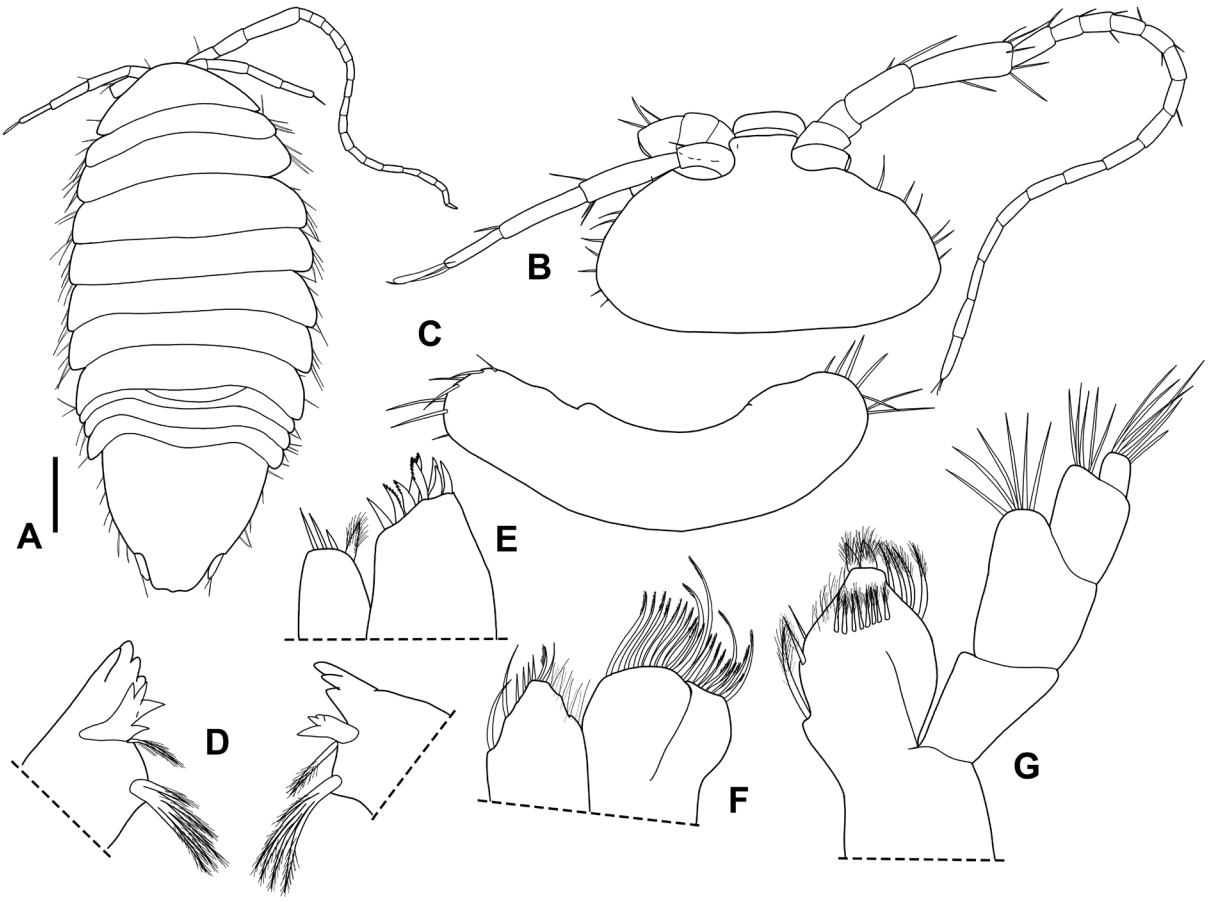

Fig. 9. *Kaaetecarcinia karaja* gen. et sp. nov., paratype, ♂ (ISLA96902). **A**. Habitus, dorsal view. **B**. Head shield, dorsal view, with antennule and antenna. **C**. Epimeron I, dorsal view. **D**. Left and right mandibles. **E**. Maxillula. **F**. Maxilla. **G**. Maxilliped. Scale bar: 0.2 mm. Scale bar: A = 0.2 mm.

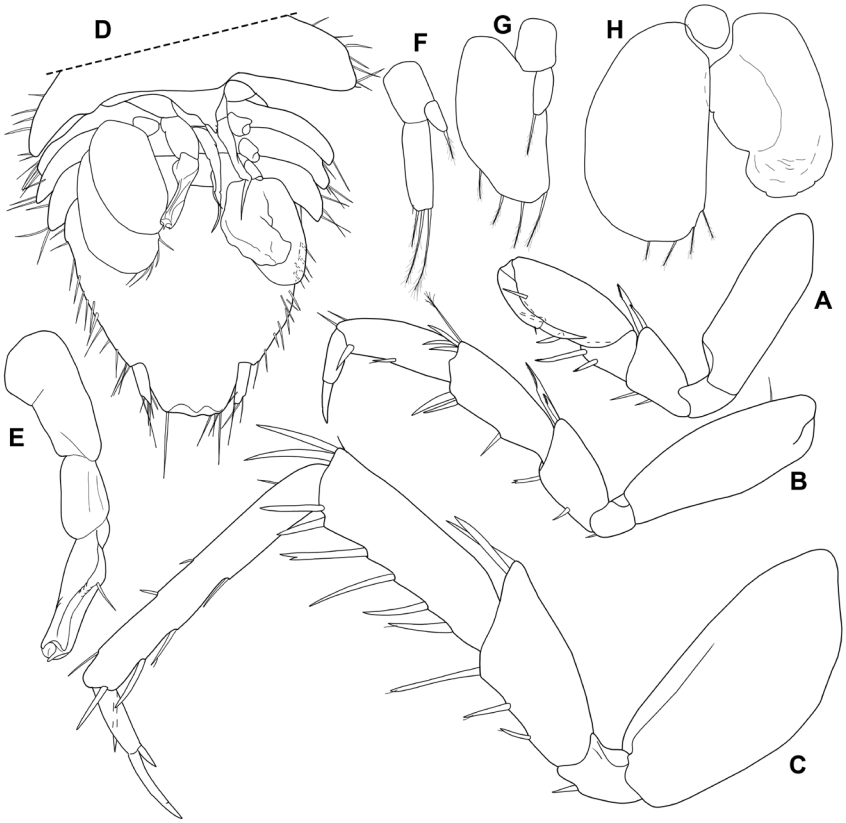

Fig. 10. *Kaaetecarcinia karaja* gen. et sp. nov. **A–E**. Paratype, ♂ (ISLA96902). **A**. Pereopod I. **B**. Pereopod II. **C**. Pereopod VII. **D**. Pleon with pleonites, pleotelson and uropods, ventral view. **E**. Pleopod I. **F–H**. Paratype, ♀ (ISLA96903). **F**. Pleopod I. **G**. Pleopod II. **H**. Pleopod V.

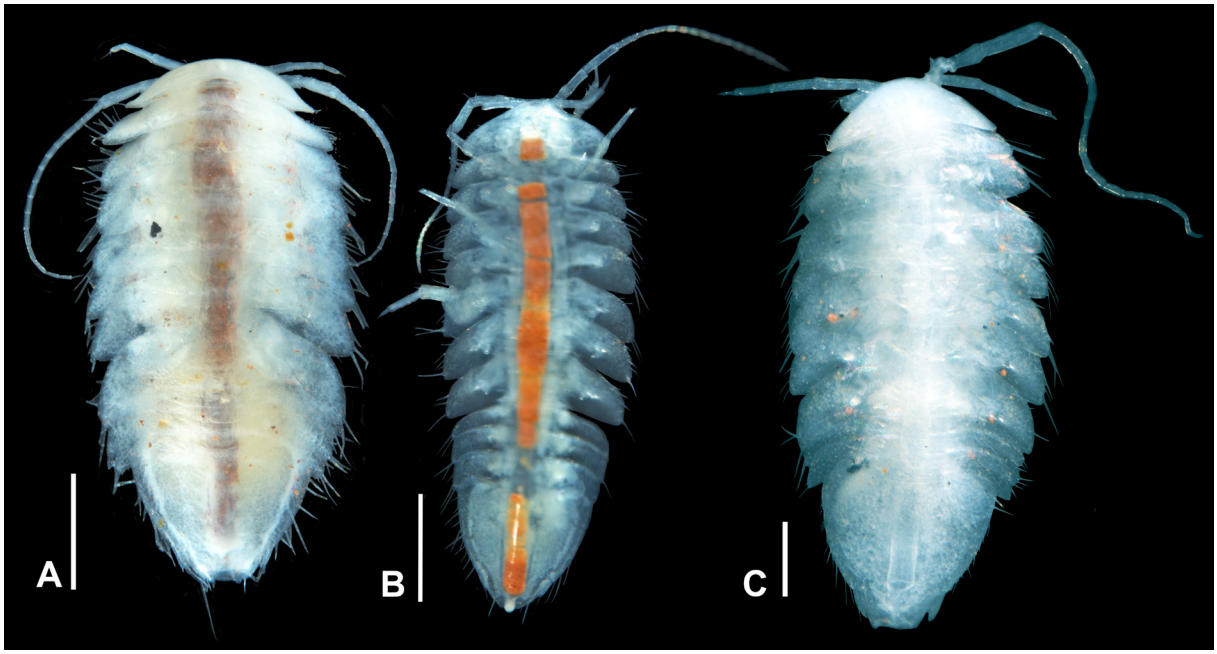

Fig. 11. A. *Kaaetecarcinia apina* gen. et sp. nov. **B**. *K. amazonica* gen. et sp. nov. **C**. *K. karaja* gen. et sp. nov. Scale bars: A–C = 0.2 mm.

Taxonomic key to the genera of Calabozoidae Van Lieshout, 1983

1. Pleotelson ≈ 75% of pleon length (≈ 30% of body lengt) 2
– Pleotelson ≈ 50−60% of pleon length (≈ 20% of body length) 3

2. Pleonites I and II not visible dorsally (reduced to the sternal part) ..... ***Calabazoa*** Van Lieshout, 1983
– Pleonites I and II are very small, but visible dorsally. Pleopods III–V exopods round, with natatory functions ..... ***Pongycarcinia*** Messana, Baratti & Benvenuti, 2002

3. Pleonite I reduced to sternal part, only a small portion of pleonite II is visible dorsally ..... ***Kaaetecarcinia*** gen. nov.
– Both pleonites I and II are visible dorsally 4

4. Pleopods III–V exopods subrectangular. Head shield wider than pleotelson ..... ***Oiticicarcinia*** Cardoso, Bento & Ferreira, 2025
– Pleopods III–V exopods round. Head shield slender/narrower than pleotelson 5

5. Pleon in a continuous line with pereon, forming a gap ..... ***Itararecarcinia*** Cardoso, Bento & Ferreira, 2025
– Pleon with body outline not continuous ..... ***Poicarcinia*** Cardoso, Bento & Ferreira, 2025

Discussion

Morphology

The most distinct variation among the new species is the shape of male pleopods, being biramous in *K. apina* gen. et sp. nov. and *K. amazonica* gen. et sp. nov.; and uniramous in *K. karaja* gen. et sp. nov. The shape appears to be simplified in *K. amazonica* and more complex in *K. karaja*.

Habitat and ecology

In the Serra Leste Mountain Range, *K. apina* gen. et sp. nov. was collected from four caves that vary significantly in morphology, dimensions, and matrix rock. Cave dimensions range from 20.5 meters (SL-0154, with an area of 67 m²) to 125 meters (SL-0246, with an area of 483 m²). The matrix rock also differs: SL-0154 is associated with jaspilite, SL-0193 and SL-0246 with both jaspilite and canga, and SL-0197 exclusively with canga formation.

In SL-0193 and SL-0246 caves, the ponds are perennial, fed by percolating water (Fig. 12A–B). In SL-0154 and SL-0197, the ponds are temporary and dry out during the dry season (Fig. 12C–E). In the Serra Norte Mountain Range, *K. amazonica* gen. et sp. nov. was found in two caves with less pronounced variation than those of *K. apina* gen. et sp. nov. Cave dimensions range from 67.5 meters (N1-0149, 405 m²) to 84.5 meters (N1-0141, 453 m²). The matrix rock differs: N1-0141 is associated with canga formation, while N1-0149 contains both jaspilite and canga. The intermittent ponds in N1-0149 suggest a similar ecological strategy to *K. apina*, but further research is needed.

Regarding *K. karaja* gen. et sp. nov., it is the second species found in the Serra Norte, but on a different plateau. Cave dimensions range from 30 meters (N5S57, 192 m²) to 90 meters (N5S52/53, 435 m²). The matrix rock also varies: N5S52/53 and N4E89 are associated with canga, while N5S57 contains both jaspilite and canga. Notably, all caves in this area have only intermittent ponds, strongly suggesting a reliance on connection between water bodies. Given that all newly described species have robust pereopods, they may actively migrate between habitats during dry and rainy periods.

Conservation

Given that the Carajás Mineral Province is a major mining hub, all the caves housing the species described herein face severe threats, similar to many other Brazilian caves (Ferreira *et al.* 2022). Ongoing mining activities near their habitats pose a significant risk to the long-term survival of all three species.

For *K. apina* gen. et sp. nov., the distance between their habitats and the quarries ranges from 1752 to 2106 meters. For *K. amazonica* gen. et sp. nov., the distance is approximately 3350 meters. However,

Fig. 12. A. Percolating water in SL-0193 cave. **B**. Percolating water and pond in SL-0154 cave. **C**. Temporary ponds in SL-0197 cave where the specimens of *Kaaetecarcinia apina* gen. et sp. nov. were collected. Photo by M.P. Oliveira.

for *K. karaja* gen. et sp. nov., the distance ranges from only 155 to 452 meters, indicating a concerning proximity to mining activities.

This becomes even clearer when using the International Union for Conservation of Nature (IUCN 2022) method of categories and criteria to conduct an exercise assessing the extinction risk of the newly described species. The IUCN criteria classify species as threatened if they meet one of five criteria designed to evaluate the level of extinction risk. These criteria encompass A) population reduction (past, present, and/or projected); B) restricted geographic distribution with evidence of fragmentation, decline, or fluctuations; C) small population size with evidence of fragmentation, decline, or fluctuations; D) very small population size or highly restricted distribution; and E) quantitative extinction risk analysis. Each criterion often includes subcriteria to further determine a species' placement within a specific category.

Population data for criteria A, C, and E are currently unavailable for these species; however, criteria B and D can be assessed. This involves calculating the Extent of Occurrence (EOO) and/or the Area of Occupancy (AOO), as well as determining the number of locations. The EOO, which encompasses all current presence sites, is calculated using a Minimum Convex Polygon (MCP). The AOO, representing the total area occupied within the EOO, is determined by summing the species' areas across 2 km × 2 km grid cells. The number of locations is calculated based on the number of distinct areas where an impact would need to occur to affect the entire species (IUCN 2022).

As mentioned, all caves where the new species occur are in mining areas. However, the caves where *K. apina* gen. et sp. nov. and *K. amazonica* gen. et sp. nov. are found are relatively far from the limits of the mining areas, and it is not known whether these activities affect the species. However, these caves are located in mining polygons with mining concessions (SIGMINE 2024), indicating the potential for mining operations in the coming years. Considering mining as the main potential threat and that, in the case of both species, the caves are very close and constitute a single location with an EOO and AOO of 4 km², *K. apina* and *K. amazonica* could be categorized as Vulnerable according to criterion D2.

For *K. karaja* gen. et sp. nov., however, the situation is different. The caves where this species is found are in operational areas, very close to mining fronts, resulting in a continuous decline in habitat quality. Considering mining as the main threat, with two locations and an AOO of 8 km² (which was equalized to the EOO), the species could be categorized as Endangered (EN) according to the criteria B1ab(iii)+2ab(iii).

Given this situation, it is crucial to implement a monitoring program to assess the population status and variations of each species. These species represent ancient, unique lineages of an important, basal, and enigmatic group of isopods, and their conservation is imperative.

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