



A new species and first record of *Gabunillo* Schmalzfuss & Ferrara, 1983 (Isopoda, Oniscidea, Armadillidae) from the Neotropics

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Abstract

A new species of terrestrial isopod, *Gabunillo aridicola* **sp. nov.**, is described from Ceará and Rio Grande do Norte States, in Karstic formations in the Brazilian semi-arid (caatinga). This genus, hitherto monotypic, was known only from Gabon. This occurrence is remarkable because very few genera of Armadillidae are known from both Afrotropics and Neotropics, and because it offers evidence of a tropical Gondwana biogeographical component.

Key words: Malacostraca, terrestrial crustaceans, semi-arid, cave life, Karst, caatinga, Brazil

Introduction

Terrestrial isopods (suborder Oniscidea) include 38 families, most of them occurring in the Neotropics. The family Armadillidae is composed of 80 genera and 703 species (Schotte *et al.* 2008 onwards) which form a clade, sister group to the Eubelidae (Schmidt 2008). Four genera and seven species have been recorded from Brazil (Souza-Kury 1998; Leistikow & Wägele 1999). The study of material collected in the vicinity of caves in the municipalities of Aiuaba, Ceará State and Apodi, Rio Grande do Norte State, in the caatinga biome, revealed a new species of Armadillidae of the monotypic genus *Gabunillo* Schmalzfuss & Ferrara, 1983, hitherto known only from Gabon, West Africa.

Gabunillo makes part of a group of genera that has the pleotelson triangular (or T-shaped) as opposed to the hourglass-shaped found in the groundplan of the Armadillidae. According to Schmalzfuss & Ferrara (1983), *Gabunillo* is akin to *Synarmadillo* Dollfus, 1892, a genus with 26 species distributed in western and eastern Africa (Schmidt & Leistikow 2004) and one species in Colombia (found in the zone of the coffee plantations), one in Costa Rica (Schmalzfuss 2003) and one in Venezuela (Leistikow & Wägele 1999).

According to Schmalzfuss & Ferrara (1983) *Gabunillo* differs from *Synarmadillo* by the cephalic structure (frontal margin interrupted medially), absence of teeth in pereonites 2 and 3, and shape of the pleotelson (although roughly triangular in both) and uropods. *Gabunillo* also does not have pleopodal lungs while *Synarmadillo* has lungs on the five pairs of pleopods (Ferrara & Schmalzfuss 1976). The new species presents all the characters of the genus diagnosis, except for the uropod exopods attached dorsally and the presence of eyes, such as in *Synarmadillo*.

Material and methods

The material examined was collected from the municipality of Aiuaba, Ceará State, on July 12th, 2002, and the municipality of Apodi, Rio Grande do Norte State, on August 28th, 2007, both from karstic environments. One male paratype specimen was dehydrated using gradual ethanol series and dried to the critical point with carbon dioxide for scanning electron microscopy (SEM). Dry specimens were mounted on metal specimen

stubs, coated with a gold-palladium mixture, and examined with a SEM JEOL 6390 series. All the remaining material is preserved in 75% ethanol and it is housed on the Crustacea collection of the Museu Nacional, Universidade Federal do Rio de Janeiro (MNRJ). Appendages and mouthparts were mounted in glass slides with gelatin-glycerol. The illustrations were drawn under optic microscope with camera lucida and digitally prepared as described by Coleman (2003, 2006).

The following abbreviations were used: A2: Antenna; Cp: Cephalon; Hb: Habitus; Md: Mandible; Mp: Maxilliped; Mx1–2: Maxillae 1–2; Pn1–2: Pereonites 1–2; PE1–3: Pereon-epimera 1–3; P1–7: Pereopods 1–7; GP: Genital papilla; St7: Sternite 7; P11–5: Pleopods 1–5; Ur: Uropod; T: Telson; r: right; l: left; v: ventral.

Taxonomy

Order Isopoda Latreille, 1817

Suborder Oniscidea Latreille, 1829

Family Armadillidae Brandt & Ratzeburg, 1831

Genus *Gabunillo* Schmalfuss & Ferrara, 1983

Type species: *Gabunillo coecus* Schmalfuss & Ferrara, 1983

Diagnosis. Animals able to conglobate, faintly brown pigmented or depigmented; cephalon with frontal margin interrupted medially; pereonite 1 with a tiny groove along its margin; both outer and inner lobes of the schisma rounded; pereonites 2 and 3 each with transverse ridge ventrally; epimeral plates overlapping; back without granulations, ribs or tubercles, armed with scale-setae; pleopodal exopods without respiratory structures; uropodal protopod rectangular with exopodite subterminally or dorsally attached; pleotelson triangular (or T-shaped).

Composition of the genus. The genus *Gabunillo* contains two species: *Gabunillo aridicola* **sp. nov.** and *G. coecus* Schmalfuss & Ferrara, 1983. Species known to occur in caves or near cave entrances.

Gabunillo aridicola **sp. nov.**

(Figs 1–7)

Material examined. Holotype: ♂ (MNRJ 21800), 6.0 mm long, 2.8 mm wide, in glycerin gel slides, dissected and drawn, around Gruta do Sobradinho, Sítio Pé Queimado, Aiuaba, Ceará State, Brazil, 12.vii.2002, L.A. Souza leg.

Paratypes: 1 ♀ (MNRJ 21801) 4.0 mm long, 1.6 mm wide, in 75% ethanol, around Gruta do Sobradinho, Sítio Pé Queimado, Aiuaba, Ceará State, 12.vii.2002, L.A. Souza leg.; 1 ♂ (MNRJ 21802) 4.5 mm long, 2.1 mm wide, coated with gold-palladium, Lajedo da Soledade, Apodi, Rio Grande do Norte State, 28.viii.2007, M.S. Silva leg.; 1 ♂ (MNRJ 21803) 6.0 mm long, 2.3 mm wide, in 75% ethanol, dissected and drawn, Lajedo da Soledade, Apodi, Rio Grande do Norte State, 28.viii.2007, M.S. Silva leg.; 1 ♀, 6.9 mm long, 2.4 mm wide and 1 juvenile, 3.3 mm long, 1.4 mm wide (MNRJ 21804), in 75% ethanol, Lajedo da Soledade, Apodi, Rio Grande do Norte State, 28.viii.2007, M.S. Silva leg.

Diagnosis. Species of *Gabunillo* distinguished by the eyes formed by 13 ommatidia, posterior margin of pereonite 1 smoothly arched, forming an attenuate semi-circle, outer lobe of schisma longer and wider than inner lobe, and uropod exopod dorsally attached.

Description. Holotype, male (figure references also of male paratype MNRJ 21802). Body length 5 mm. Color light-brown, posterior margins of cephalon, pereonites and pleonites dark-brown. *Habitus* (Figs 1B–D, 4A–B) body convex; volvational ability partial. Tergites (Figs 1A–D, 4A) smooth, without granulations,

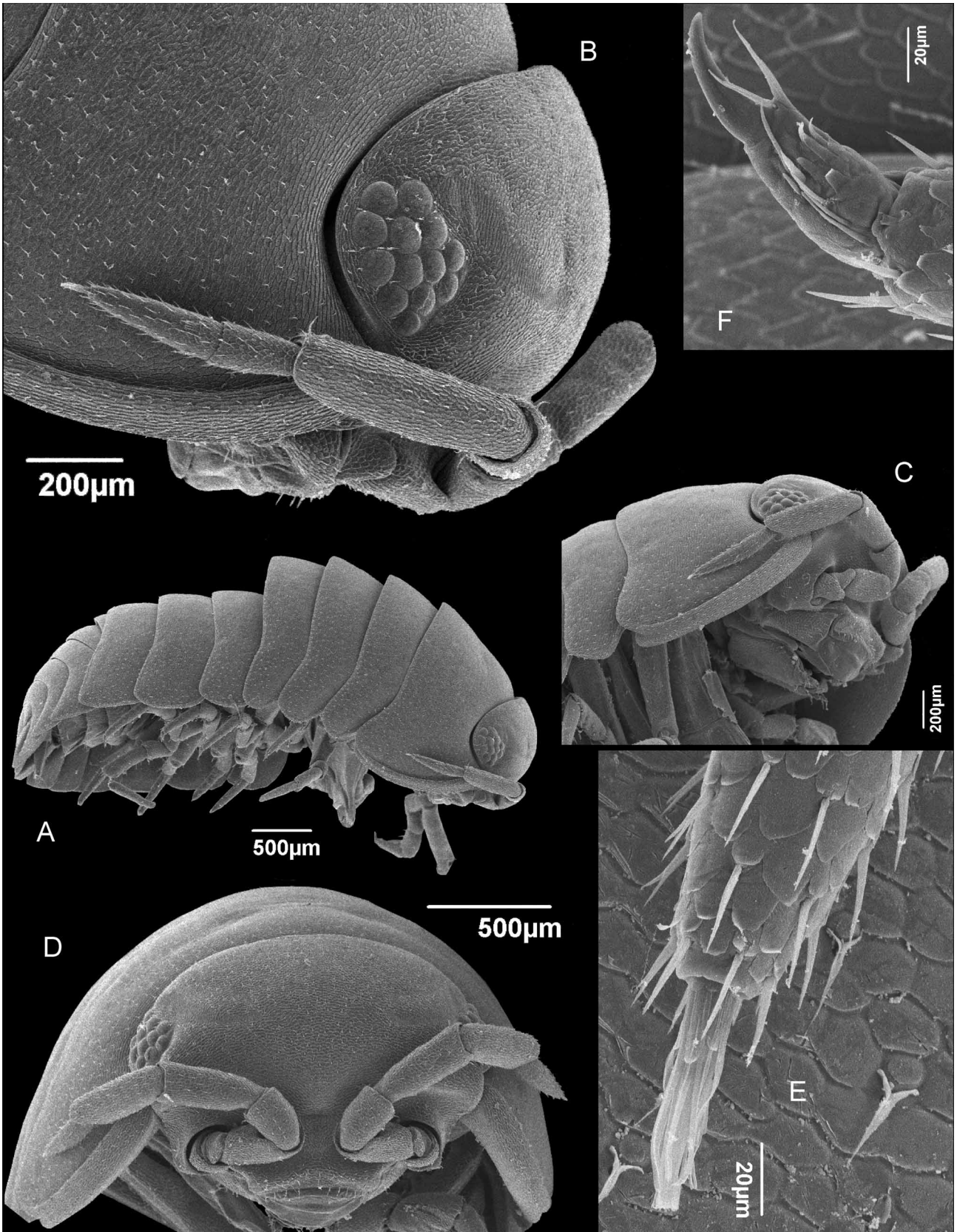


FIGURE 1. *Gabunillo aridicola* **sp. nov.** Paratype, male, Lajedo da Soledade, Apodi, Rio Grande do Norte, Brazil, 28 August 2007, MNRJ 21802. A: Hb, lateral view; B–D: Cp+Pn1, lateral view; ventro-lateral view; frontal view; E: A2, apex, lateral view; F: P7, apex, lateral view.

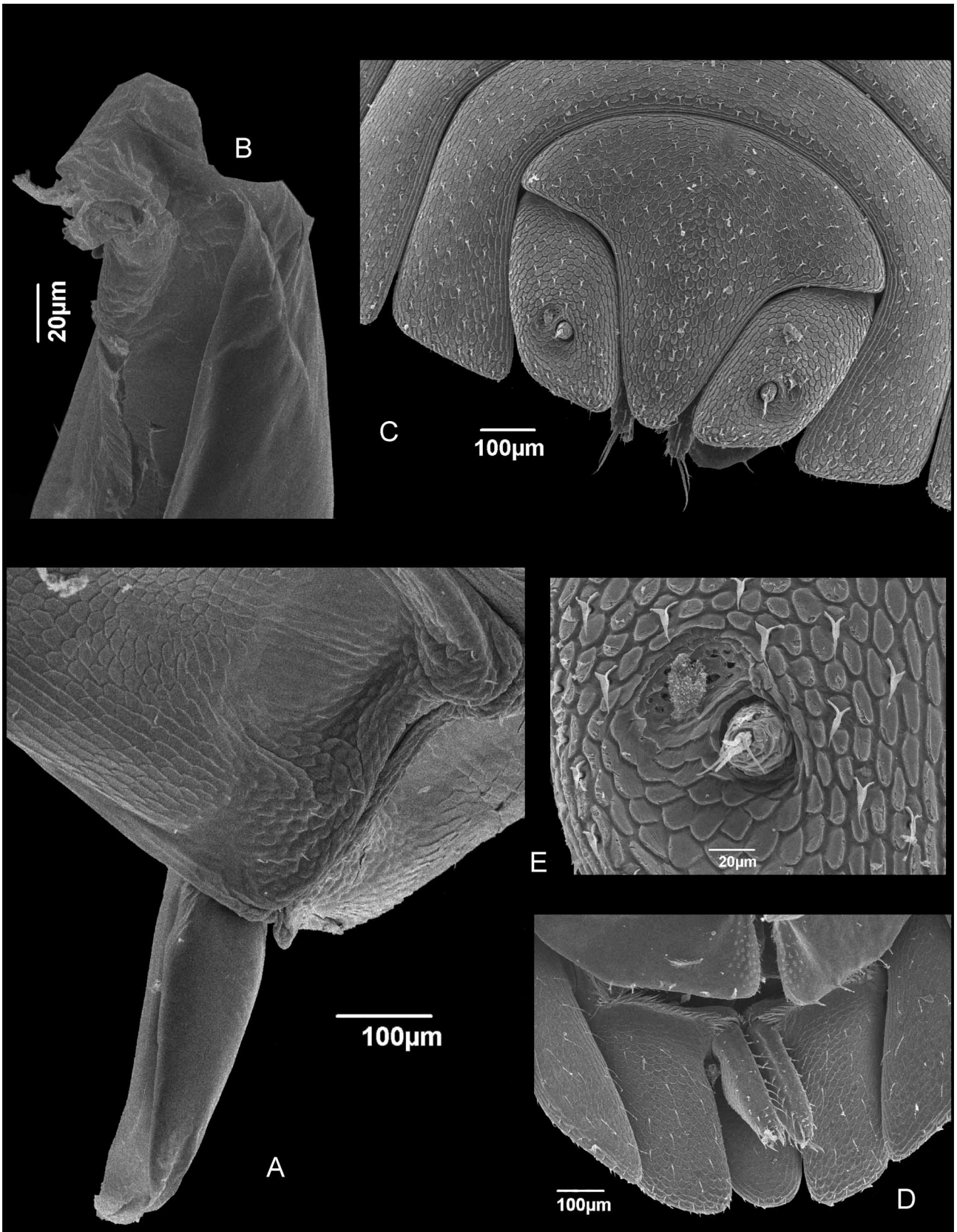


FIGURE 2. *Gabunillo aridicola* **sp. nov.** Paratype, male, Lajedo da Soledade, Apodi, Rio Grande do Norte, Brazil, 28 August 2007, MNRJ 21802. A: St 7 + GP, partial, lateral view; B: GP, detail; C: T + Ur, dorsal view; D: Ur, ventral view; E: Ur, detail, dorsal view.

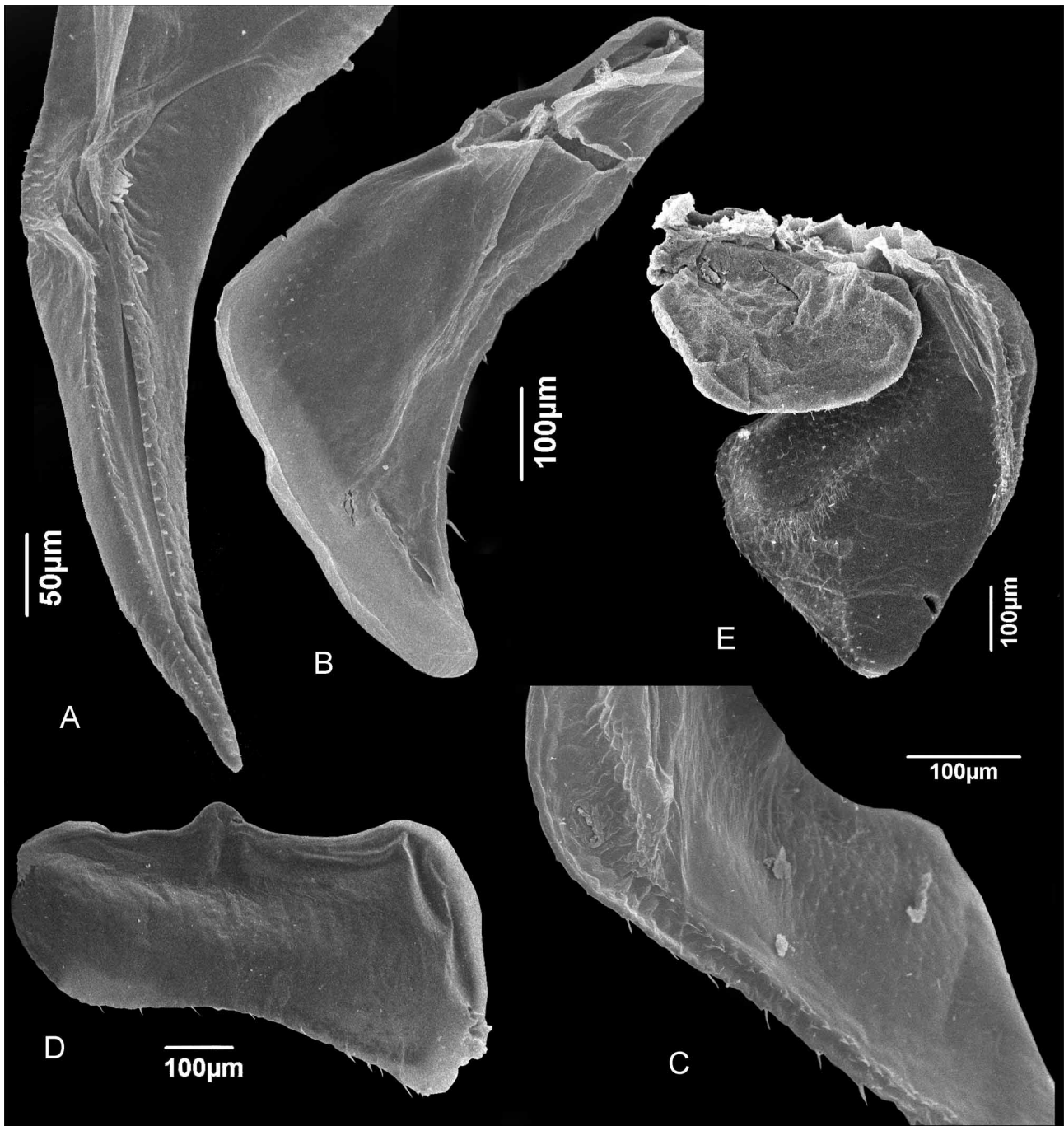


FIGURE 3. *Gabunillo aridicola* sp. nov. Paratype, male, Lajedo da Soledade, Apodi, Rio Grande do Norte, Brazil, 28 August 2007, MNRJ 21802. A: P11; B: P12; C: P13; D: P14; E: P15.

tubercles or ribs, covered with scale-setae. *Cephalon* (Figs 1B–D, 4A–B) frontal shield folded continuous with vertex, boundary between frontal shield and vertex marked by faint line starting at the eyes and interrupted in the middle. Lateral lobes weakly developed, median lobe absent. Eyes (Figs 1A–D; 4A–B) with 13 well-pigmented ommatidia. *Pereon* (Figs 1A, 4A, C–D) with schisma on pereonite I. Pereonites II and III (Figs 4C–D) with transverse ridge on ventral surface (more developed in II). Epimera of pereonites II–IV very narrow. Male pereonite VII sternite with bilobed lamellar process, which is a synapomorphy for the family Armadillidae. *Pleon* (Figs 1A, 4A) without ventral grooves or locking devices. *Pleotelson* (Figs 2C, 4A, E) T-shaped, instead of hourglass-shaped, distal part much narrower than proximal, apex *in situ* reaching posterior margin of uropodal protopods.

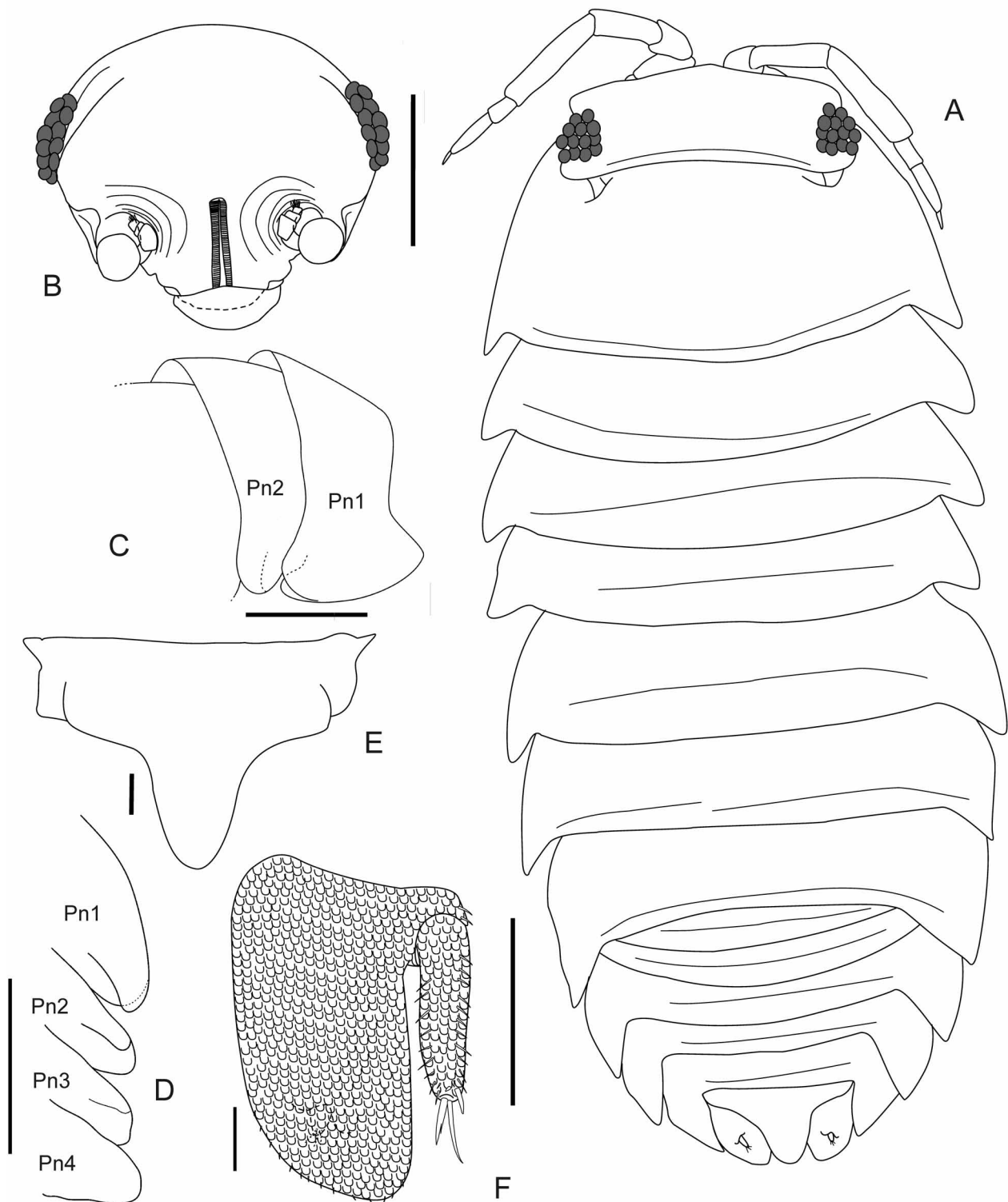


FIGURE 4. *Gabunillo aridicola* sp. nov. Holotype, male, 5.0 mm, Gruta do Sobradinho, Aiuaba, Ceará, Brazil, 12 July 2002, MNRJ 21800. A: Hb, dorsal view; B: Cp, frontal view; C: Pn1–2, lateral view; D: Pn1–4, ventral view; E: T, ventral view; F: Ur, ventral view. Scale bars: 1.0 mm for A, C–D; 0.5 mm for B; 0.1 mm for the remainder.

Antennule (Fig. 4B) with 3 articles, intermediate much shorter, distal article with a groups of at least 5 distal aesthetascs on inner (medial) latero-distal margin.

Antenna (Figs 1A–E, 4A) short, reaching posterior margin of pereonite I. Last article of peduncle with conspicuous sensorial spine. Flagellum with 2 articles, distal one with row of few aesthetascs on proximal region. Distal cone short, about 1/5 as long as last article of flagellum, with free bristles, without sheath.

Mandibles (Fig. 5A–B). Left mandible with 2 penicils on pilous lobe and 1 penicil between pilous lobe and molar process, this represented by a tuft of pilous bristles inserted on a socket. Right mandible with an intermediary penicil between pilous lobe and molar process.

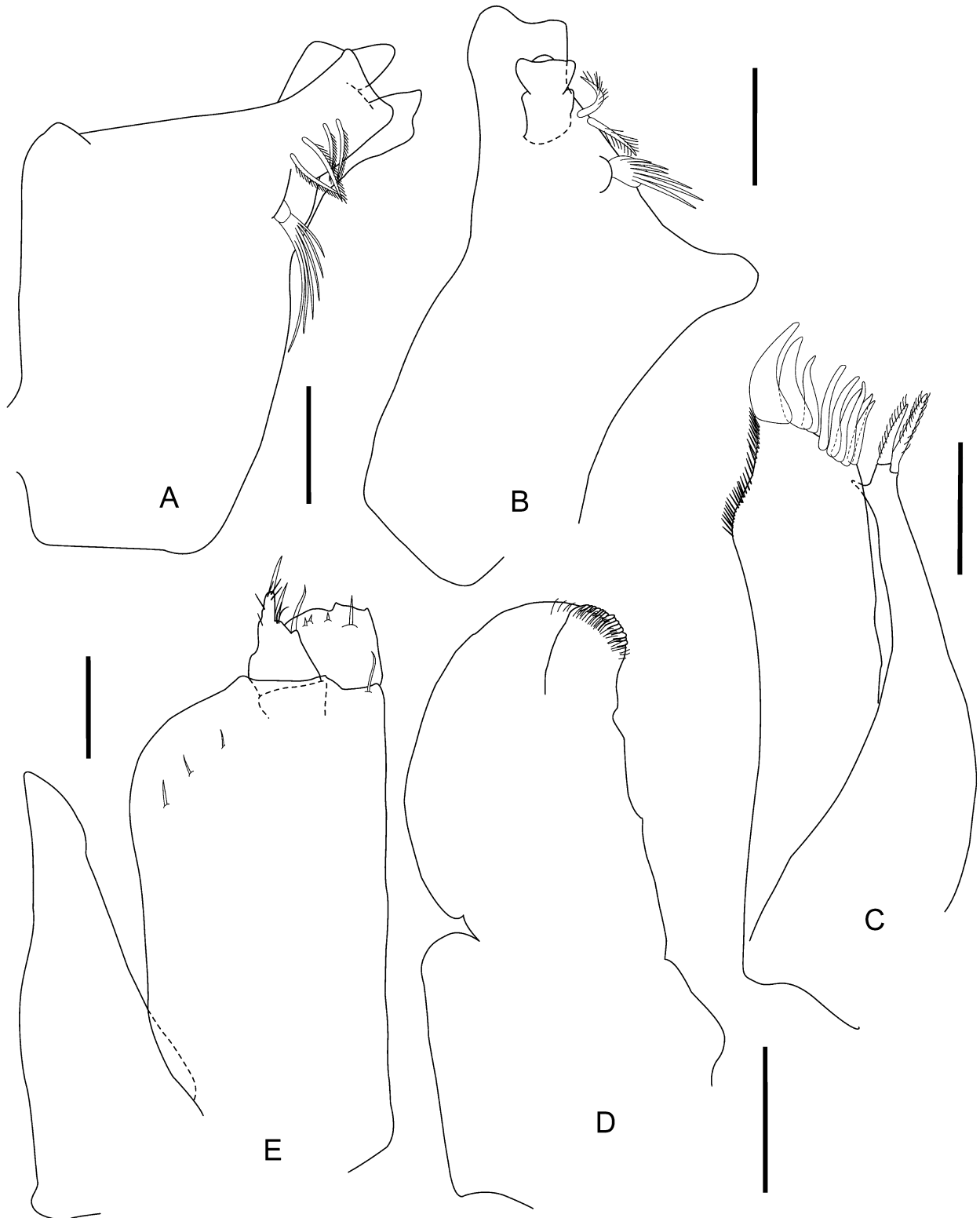


FIGURE 5. *Gabunillo aridicola* sp. nov. Holotype, male, 5.0 mm, Gruta do Sobradinho, Aiuaba, Ceará, Brazil, 12 July 2002, MNRJ 21800. A: lMd; B: rMd; C: Mx1; D: Mx2; E: Mp. Scale bars: 0.1 mm.

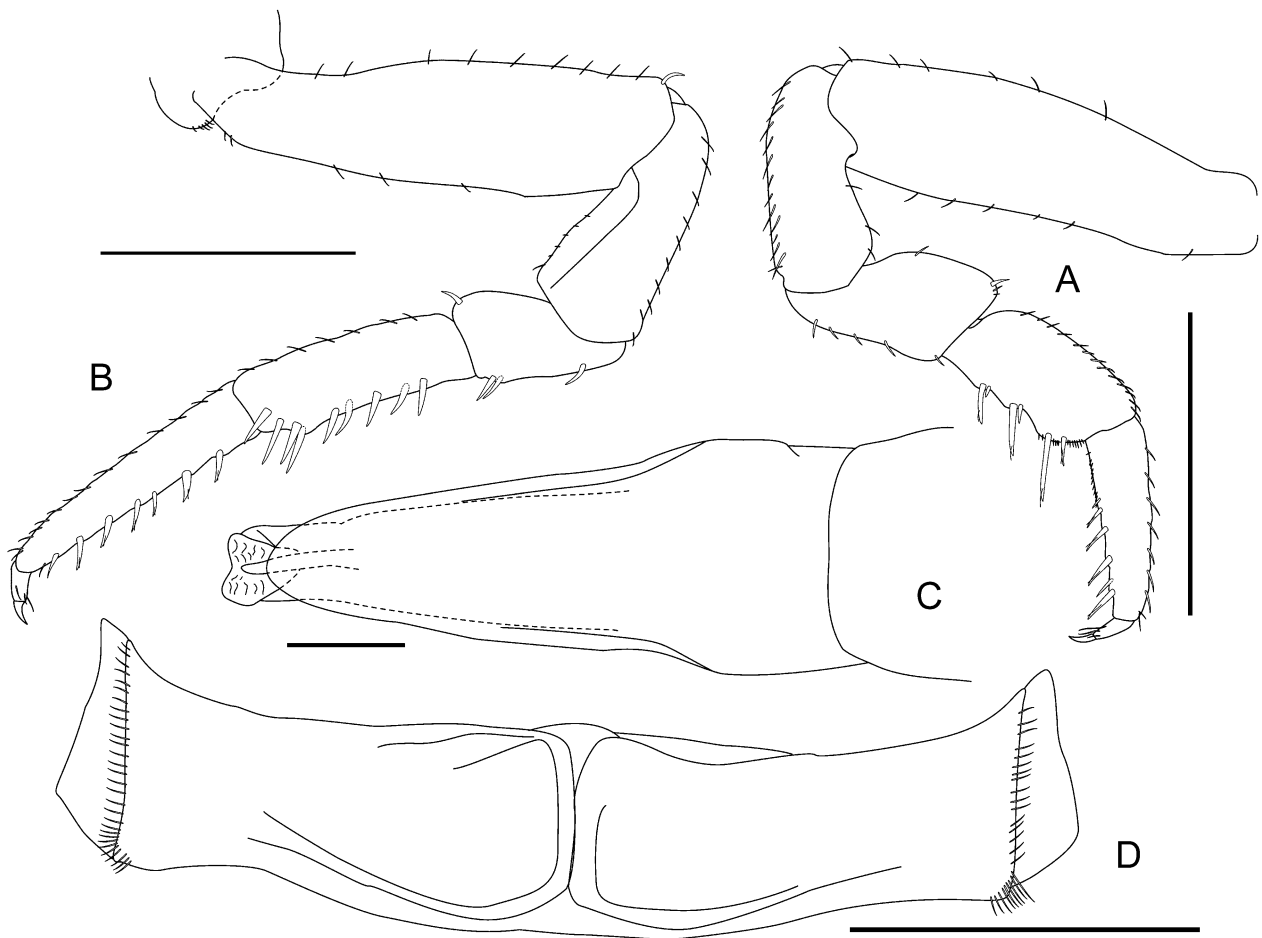


FIGURE 6. *Gabunillo aridicola* sp. nov. Holotype, male, 5.0 mm, Gruta do Sobradinho, Aiuaba, Ceará, Brazil, 12 July 2002, MNRJ 21800. A: P1; B: P7; C: GP; D: St7. Scale bars: 0.1 for C; 0.5 mm for the remainder.

Maxillule (Fig. 5C) inner endite with 2 long hairy subequal penicils; latero-distal border ending in acuminate point. Outer endite with 4 teeth in outer group and 4 in inner group, of which at least 2 with small supplementary points.

Maxilla (Fig. 5D) bilobed, both lobes densely setose on outer latero-distal margin, at least the seta closest to inner margin as a scale-seta; inner margin with thin setae on distal portion.

Maxilliped (Fig. 5E) endite with outer latero-distal margin widely rounded. Endite with 3 small spines: 1 at inner distal angle, 2 below distal margin and 1 bristle.

Pereopods (Figs 1F, 6A–B) of males and females similar, scarcely spined, most spines simple-pointed; dactylus with inner claw slightly smaller than outer claw; dactylar and unguis setae simple.

Genital papilla (Figs 2A–B, 6C) with ventral shield surpassed by a lobe.

Male pleopods (Figs 3, 7). Pleopods 1 and 2 similar to those of *G. coecus*. Endopod of pleopod 1 with grooved distal half, row of short, thick setae along medial side of dorsal groove. Pleopod 2 exopod with distal portion shorter and more acuminate than in *G. coecus*; endopod thin, narrow, tapering. Male pleopod 5 with subtriangular exopod with at least 5 spines on outer latero-distal margin, at least the first one (scale-seta) closer to inner margin; inner margin finely setose on distal portion. No perceptible respiratory fields are present.

Uropods (Figs 2C–E, 4A, F) with semi-rectangular protopods; endopods roughly cylindrical, ventral surface flattened, visible only in ventral view, reaching distal third of protopod; exopods conical, with conspicuous apical bristles, inserted dorsally on distal third of protopod.

Etymology. The species name is a noun in apposition (“dweller in the arid”) and refers to the semi-arid environment where this species is found.

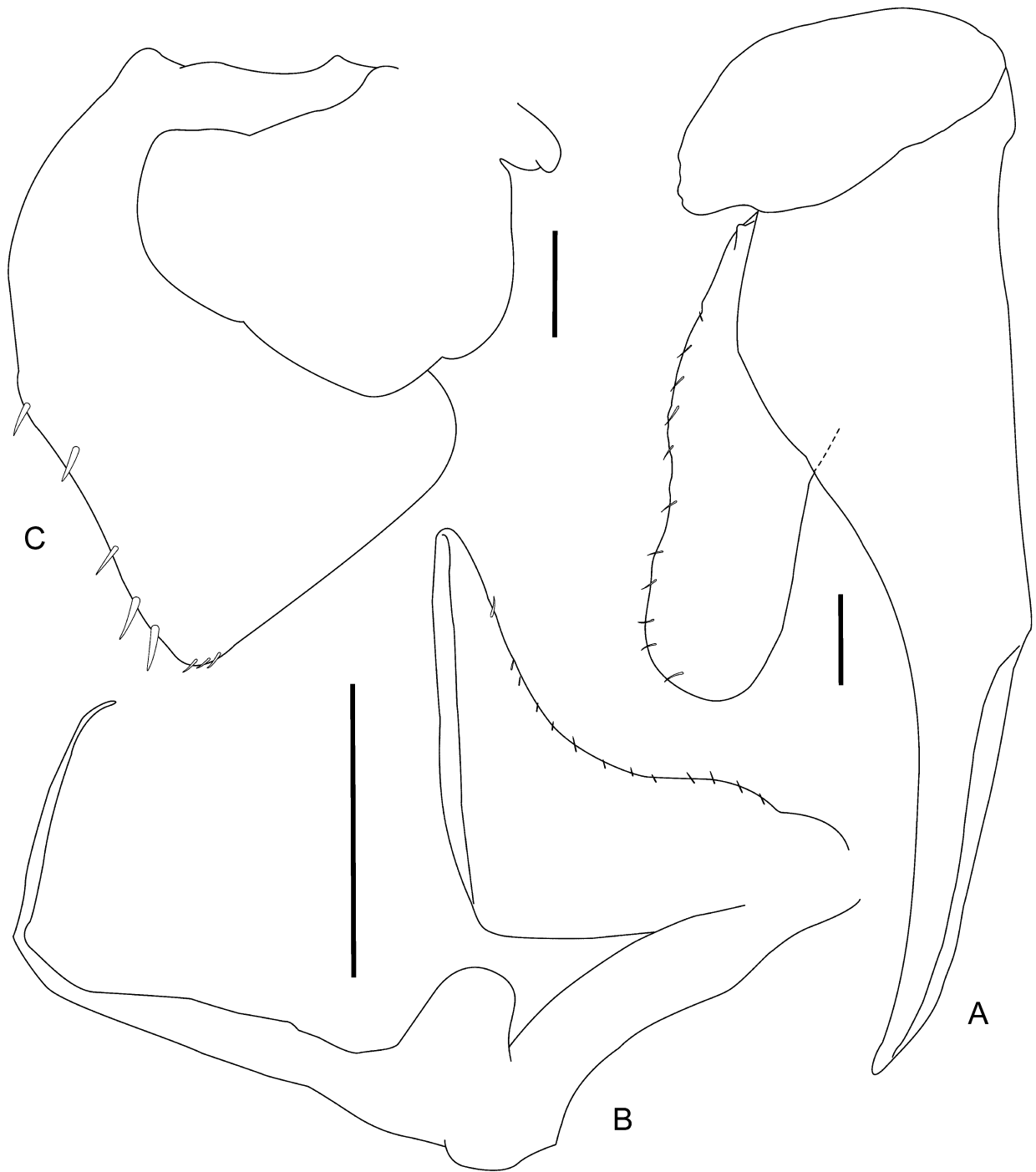


FIGURE 7. *Gabunillo aridicola* sp. nov. Holotype, male, 5.0 mm, Gruta do Sobradinho, Aiuaba, Ceará, Brazil, 12 July 2002, MNRJ 21800. A: P11; B: P12; C: P15. Scale bars: 0.5 mm for P12; 0.1 mm for the remainder.

Remarks. In the same way as happens with our sample, Schmalfuss & Ferrara (1983) have not reported females with marsupium, but considering that our animals are ca. 4–7 mm long and theirs only 3 mm, there is a good chance of ours being adults as well.

Gabunillo aridicola differs from *G. coecus* by: 1. Well developed eyes with 13 dark pigmented ommatidia (as opposed to anophthalmy); 2. Body pigmentation light brown with dark-brown areas (as opposed to unpigmented); 3. Uropodal exopods inserted dorsally on protopods (as opposed to inserted distally); 4. Pereonite I with incomplete tiny groove along its margin (as opposed to complete); 5. Uropodal endopods *in situ* covered by telson in dorsal view (as opposed to extremities visible); 6. Dorsal tegument covered by scale-

setae (or tricorns) that have a vertical stem arising from a cuticular depression and a Y-shaped scale overlying the stem (as opposed to scale-setae [“scale-spine” in Schmalfuss and Ferrara, 1983] with a serrate margin). Character states 1–3 are possibly plesiomorphic and 4–6 possibly apomorphic for the new species. It is not possible to compare the maxillula because it has not been described for *G. coecus*.

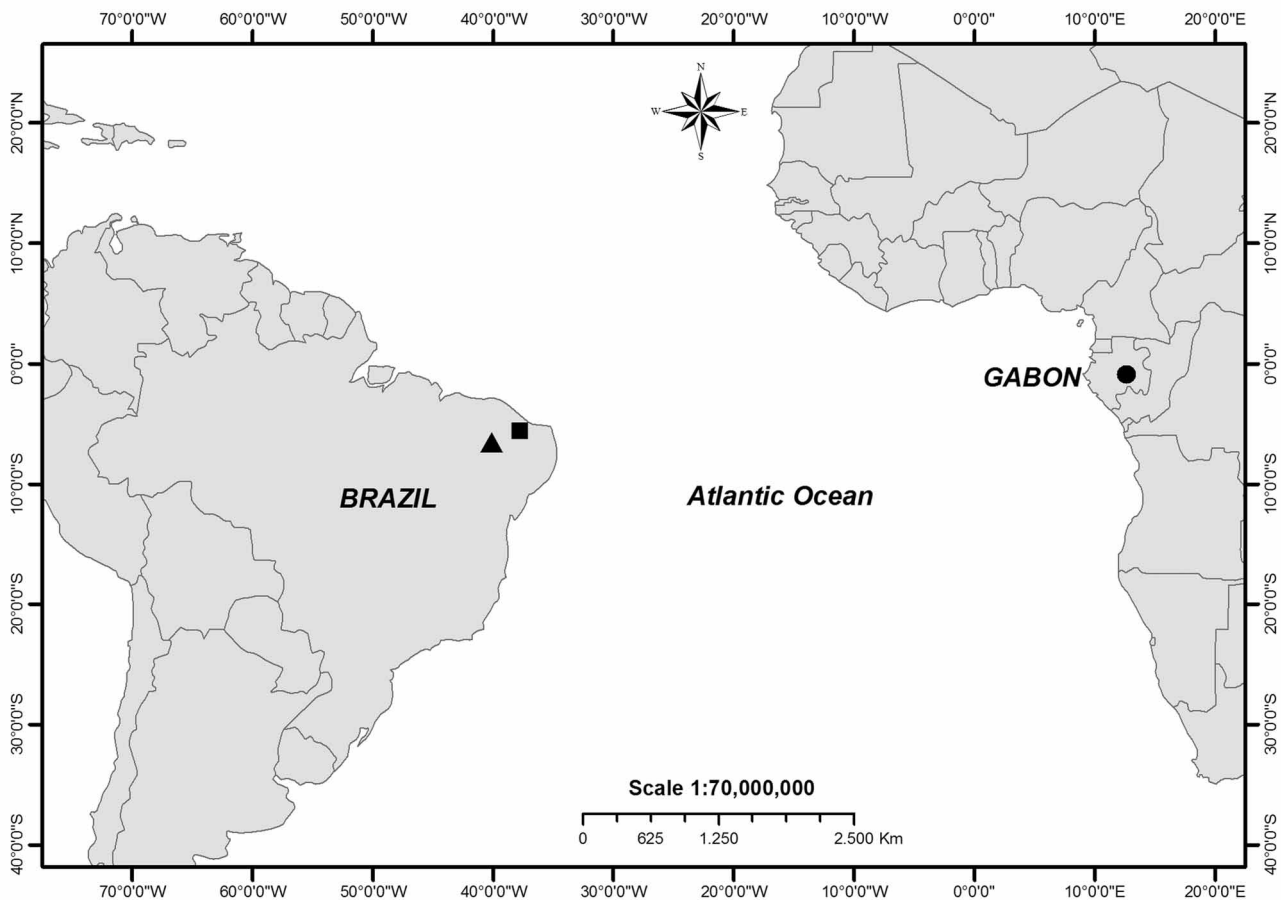


FIGURE 8. Distribution of *Gabunillo* species. Triangle (▲), type-locality of *G. aridicola* **sp. nov.**, Gruta do Sobradinho, Aiuaba, Ceará, Brazil, 6°34'S, 40°07'W. Square (■), occurrence of remainder paratypes of *G. aridicola* **sp. nov.**, Lajedo da Soledade, Apodi, Rio Grande do Norte, Brazil, 5°35'S, 37°48'W. Circle (●), Type locality of *G. coecus*, Grotte de Pahau, Lastourville, Gabon, 0°55'S, 12°38'E. Distribution map by Danielle P. Cintra.

Variation. The population of Apodi, RN is much lighter in color, almost unpigmented.

Geographic distribution. Brazil: Gruta do Sobradinho, municipality of Aiuaba, 6°34'S, 40°07'W, Ceará State (type locality), and Lajedo da Soledade, municipality of Apodi, 5°35'S, 37°48'W, Rio Grande do Norte State (Figs 8–9). Epigeal, in the semi-arid, near entrances of caves.

Discussion

A critical review of *Gabunillo coecus* from West Africa shows that the species could also be considered an aberrant cave-adapted member of the genus *Synarmadillo* instead of representing a separate genus. We use here a conservative view and keep *Gabunillo* as a distinct genus, in the absence of studies of phylogenetic relationships.

Relationships of *Gabunillo* – volvation. Verhoeff (1926, 1937) and Vandel (1973a, b, c) used the body shape and the presence of locking devices related to volvation/conglobation (rolling) in the definition of subfamilies of Armadillidae. Vandel (1973c) recognized 10 subfamilies of Armadillidae. Verhoeff called “endolobi” the tooth-like projections on ventral surface of the first pereon epimera, which serve to the locking



FIGURE 9. Collection sites of *G. aridicola* **sp. nov.** A, Gruta do Sobradinho, Aiuaba, Ceará, Brazil, 6°34'S, 40°07'W (Type-locality). B, Lajedo da Soledade, Apodi, Rio Grande do Norte, Brazil, 5°35'S, 37°48'W. Photos by Rodrigo Lopes Ferreira.

by conglobation. Vandel (1973b) separated from Cubarinae from Merulaninae, both with a "primitive locking system" based on the presence of 2 endolobi (on epimera 1–2) in the former and up to 3 endolobi in the latter (epimera 1–2/3), but considered Akermaniinae "more evolved" as a result of having suffered an unfolding and flattening the body with the epimera of pereon and pleon having become foliaceous. Vandel (1973a) considered Australiodillinae as the "most primitive", because they are not volvational. Dalens (1990) followed this guidance and described 5 new species of "primitive Armadillidae" (not volvational). Schmidt (2003), taking into account only Vandel (1973a), stated that Vandel considered non-volvational species as primitive and that today the opposite view is the most likely, being the non-volvational condition a secondary development. But actually Vandel interpreted the evolution of Armadillidae starting with "primitive" non-volvational types that gradually became volvational and perfected this ability up to *Armadillo* — considered "a perfect volvational kind", which after that, through numerous regressions, through Reductoniscinae, lost the volvational ability (Vandel, 1973a, b).

Relationships of *Gabunillo* – pleotelson and uropods. The shape of pleotelson, the corresponding shape of uropods and sometimes the position of insertion of uropodal exopods have all been used in the characterization of genera of Armadillidae. *Cosmeodillo*, for example, has the pleotelson hourglass-shaped, the "classical form" of the pleotelson in Armadillidae, as stated by Vandel (1973c). The outline of the pleotelson can vary greatly in Armadillidae, although Schmidt (2003) recognized only two basic shapes: hourglass and triangular. In *Schismadillo* and *Australiodillo* the pleotelson is cleft in the distal region to a greater extent in the first and less in the second; *Hybodillo* has short triangular pleotelson, with rounded end, in *Sphaerillo* and *Trogdillo* the pleotelson is almost hourglass-shaped, but with a large post-constriction portion, tongue-like, elongate and rounded. *Laureola* has a very atypical pleotelson with lateral margins sometimes sinuous with point elongate and acute, or rectangular. The pleotelson is triangular, for example, in *Leucodillo* and the "*Synarmadillo*-group" of armadillids, which also includes *Ethelumoris*, *Togarmadillo* and *Gabunillo*. *Gabunillo aridicola* **sp. nov.** resembles the species of *Synarmadillo*, *Ethelumoris* and *Togarmadillo* in having the uropodal exopod inserted distally on the protopod.

Relationships of *Gabunillo* – locking devices. The *sulcus arcuatus* ("a complete groove on lateral margin of pereonite I") has been proposed by Schmalzfuss & Ferrara (1983) as a synapomorphy for the Eubelidae, causing the transfer by these authors of *Synarmadillo* and related genera from Eubelidae to Armadillidae, because these possess "a tiny lateral margin slightly grooved along its length".

As noted by Schmidt (2003), Vandel (1963) classified *Pudeoniscus birabeni* (Pudeoniscidae) as "Eubelidae of uncertain position" because of the dorsal lateral furrow of the first coxal plate. But Schmidt believes that he "did not take account that the furrow is of different shape and accomodates the second antennae during conglobation in *Pudeoniscus*, while in the Eubelidae, which are endoantennal conglobators, their function is different and not yet understood". An alternative interpretation would be that all these structures are steps in a transformation series. The distinction between endo- and exoantennate volvation/conglobation only by observing features such as accommodation of antennae on the specimens preserved in alcohol can be misleading. This is why the presence of furrows in the cephalothorax and pereonite I is taken into account, in spite of the difficulty of an accurate establishment of relations between shape and function of different structures considered together.

Schmidt (2002, 2007) aptly did not separate different types of "schismata" describing them as a single state: "coxal plate 1 with hind corner cleft", calling attention to the fact that there is great variation in shape and extent of this structure.

World distribution of the Armadillidae. The genera of Armadillidae may not form phylogenetic units, as their monophyly has not been established in analyses. Therefore, the present discussion is based on the traditional diagnosis of the genera, with all drawbacks it may include. According to numbers from Schotte *et al.* (2008 onwards), out of the 80 genera in the family, one half is either monotypic (22 genera) or has only 2 species (21), which isolates the genera in individual capsules, decreasing their utility to establish relationships. On the other hand, only 4 genera detain 56% (392 species) of the diversity of the family, and these surely artificial assemblages are too large to be of some use in the discussion of distribution. The bulk of the family is Paleotropical: 42 genera come from the Australasia + Pacific Islands (27 endemic to this region).

A significant number of 34 genera occur in Afrotropical region (including an expressive diversity in the southern temperate part and Madagascar). Twenty-three genera occur in Indo-Malaya (only 11 endemic). Only eight genera occur in the Neotropics, of which five (including *Gabunillo*) also occur in the Afrotropics. Of the other three, *Cosmeodillo* Vandel, 1972 has a peculiar distribution in Cuba and Thailand.

Gabunillo and/or *Synarmadillo* are essentially Afrotropical, with only three Tropical American species, which may be introduced from Africa. Only *Pseudodiploexochus* Arcangeli, 1934 and *Venezillo* Verhoeff, 1928 show a tropical Gondwanan distribution (because they have numerous species in tropical South America as well as in West Africa, so they cannot all be introduced) as opposed to seven other genera of the family which represent a temperate Gondwanan component (they are present in South Africa and Australia and some also in India or Madagascar).

Afrotropical vs. Neotropical occurrence of *Gabunillo*. The occurrence of a new species of *Gabunillo* in the Brazilian caatinga, in the epigeal milieu, contrasting to *G. coecus*, which occurs in a cave in Lastourville which is a forested region in Gabon, can be interpreted taking various aspects into account. The Armadillidae have great ecological plasticity and include species adapted to life in deserts, which adopt different strategies to save water as well as presenting integumental features that prevent desiccation. These species also have pleopodal lungs for aerial respiration in the exopods of the five pairs of pleopods. But examination of the exopods I–V of the new species confirmed the absence of lungs, characteristic of the genus, indicating the need for branchial respiration on the endopods through the film of water that is kept on them.

The hypotheses for the presence of this species — initially not adapted to life in arid or out of moist caves by the absence of lungs — in the region of savanna in Ceará and Rio Grande do Norte are: (1) aggregation of individuals (to reduce evaporation) in the interstices of rocks containing residual water of the rainy season (situation found in specimens of Apodi) and (2) occurrence within the caves (hitherto not detected), where there is constant humidity and water is available in micro-spaces.

The caatinga lies northeast of the cerrado and is analogous to the African savannah. *G. coecus* occurs in a cave in an area of dense forest interrupted by savannah patches. The population of *G. aridicola* from Aiuaba occurs in a region of caatinga with the presence of a cave (Sobradinho) in an area that was forested in the past, represented by the continuity of the Amazon and Atlantic forests. The climate in the region of occurrence of *G. coecus* and the new species is typically hot equatorial, and in the region of occurrence of *G. coecus* there is a long dry season from mid May to September and the dry season in Aiuaba, and throughout southern Ceará, lasts from May to December.

The presence of *Gabunillo* in Brazil is either: 1) an introduction from the Afrotropics; 2) evidence of a former Tropical Gondwanan distribution. Furthermore, the relictual habitat of the known species should be explained on the basis of climatic fluctuations of ice ages, whose effect seems to have collapsed the distribution of these species of forest around core areas of refuge, including caves.

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