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A new species of *Neocarus* Chamberlin & Mulaik, 1942 (Acari: Opilioacarida) from Brazilian caves and karst areas

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Abstract

A new species of the genus *Neocarus*, *Neocarus potiguar* **n. sp.**, is described from caves and the epigeal environment of the Apodi Carbonatic Group, northeast Brazil. This new species is distinguished by the presence of smooth setae on the basal portion of the evaginated ovipositor, 25–27 *ch-type* setae on the palp tarsus and one (rarely two) setae on the pregenital area of the adult female.

Key words: Parasitiformes, Opilioacaridae, Brazil, Taxonomy.

Introduction

The order Opilioacarida conserves many morphological aspects that make it the most primitive group among the living Acari (Grandjean 1936; Walter & Harvey 2009). This order is one of the smallest of the acarine goups, yet is widely distributed throughout tropical and temperate zones of the world. Eight of its ten known genera are present in the Old World, and only two, the genera *Neocarus* and *Caribeacarus*, are found in the Americas (Vázquez & Klompen 2002; Vázquez & Klompen 2009).

In South America, two species are recorded: *Neocarus ojastii* Lehtinen, 1980 from Venezuela, and *Neocarus platensis* (Silvestri 1905) from southern Brazil, Uruguay and Northern Argentina (Silvestri 1905; Van der Hammen 1969; Lehtinen 1980; Leclerc 1989). However, the genus *Neocarus* in Brazil is represented by numerous undescribed species, distributed throughout all regions of the country (Vázquez & Klompen 2002; Bernardi *et al.* 2009). Herein, we take a step towards improved knowledge of the Brazilian *Neoacarus* fauna, by describing a species from northeastern Brazil.

Material and methods

Study area. The specimens examined in this work came from collections conducted in karst areas (epigean and hypogean environments) located in Rio Grande do Norte state (Fig. 1). All collection localities are from a limestone formation called the Apodi group. Most of the area is covered by limestone outcrops locally called “lajedos”. Such formations embrace several caves, with an extraordinary subterranean biodiversity (Ferreira *et al.* 2010).

The region is under the domain of an exclusively Brazilian biome, called Caatinga. It is a warm area, characterized by a semi–arid climate, where rainfall is concentrated in a few months of the year, resulting in long drought periods (Rizzini 1976). Its average annual precipitation is around 800 mm, concentrated mainly between the months of October and May, and the average annual temperature is 28 ºC (Fig. 1).

Methods. All specimens were collected with the aid of a brush and stored in vials of 70% alcohol. Most material was studied as slide–mounted specimens. For this purpose, specimens were cleared in Nesbitt’s solution, dis-

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sected (due to their large size and in order to better see some structures) and mounted on slides in Hoyer's medium (Walter & Krantz 2009).

All of the drawings and measurements presented are based on adult specimens (five males and eight females). The drawings of the new species were made with the aid of a Leica MDLS phase contrast microscope connected to a drawing tube. The measurements of the new species are given in micrometers (µm) and list the range of values found.

Ultrastructural analyses were also conducted through use of a scanning electron microscopy. A female was placed on an aluminum support stub covered with a film of aluminum foil with carbon tape, sputter–covered with gold (Baltec SCD 050), and observed in a LEO EVO 40 XVP scanning electron microscope (Leo Electron Microscopy).

Specimens are deposited at the Mite Reference Collection, Department of Entomology and Acarology, Escola Superior de Agricultura "Luiz de Queiroz" (**MZLQ**), Universidade de São Paulo, Piracicaba–SP, Brazil; and Collection of Subterrean Invertebrates (**ISLA**), Section of Zoology de Zoologia, Department of Biology, Universidade Federal de Lavras, Lavras–MG, Brazil.

FIGURE 1. Typical habitat where *Neocarus potiguar* **n. sp**. specimens were collected.

Results and discussion

Taxonomic section

Family Opilioacaridae With, 1911

Neocarus Chamberlin & Mulaik, 1942

***Neocarus potiguar* n. sp. Bernardi *et al.* 2012**

Description. All descriptions are based on adult (males and females) observations only.

Gnathosoma. Chelicera; movable digit 82–84 µm, anterior portion of fixed digit 57–75 µm, entire fixed digit 220–235 µm. Basal segment with one seta in dorsal part, fixed digit with three setae. Dorsal and antiaxial lyrifissures present. Fixed and movable digits with one distinct tooth with a small medial groove, and a well developed terminal hook. Movable digit with two small denticles on ventral surface observed only in female (Fig. 2).

Subcapitulum; four pairs of paralabial setae present in adults: *pl1* small, conical; With's organ (*pl2*) membranous and discoid: rutellum (*pl3*) (110–120 µm) with five teeth, inserted dorso–laterally; *pl4* small, conical and inserted dorsally on subcapitulum (Fig. 3).

In the holotype (female) a series of subcuticular channels in the lateral lips were observed that culminate in a small opening located in the median portion, on the side facing the rutella. Furthermore, With's organ has a group of ramifications laid out longitudinally on this structure, extending from its basal portion to the anterior part where a small setiform protuberance is formed (Fig. 4). This group of structures, which is probably related to sensorial functions, was only observed with clarity in the holotype. The other individuals presented wrinkled lateral lips and With's organ, the observation of all these structures being difficult.

Palp (Figs 5–6); tibia/tarsus 222–230 µm, genua 137–145 µm, femur 180–210 µm and trochanter 87–92 µm.

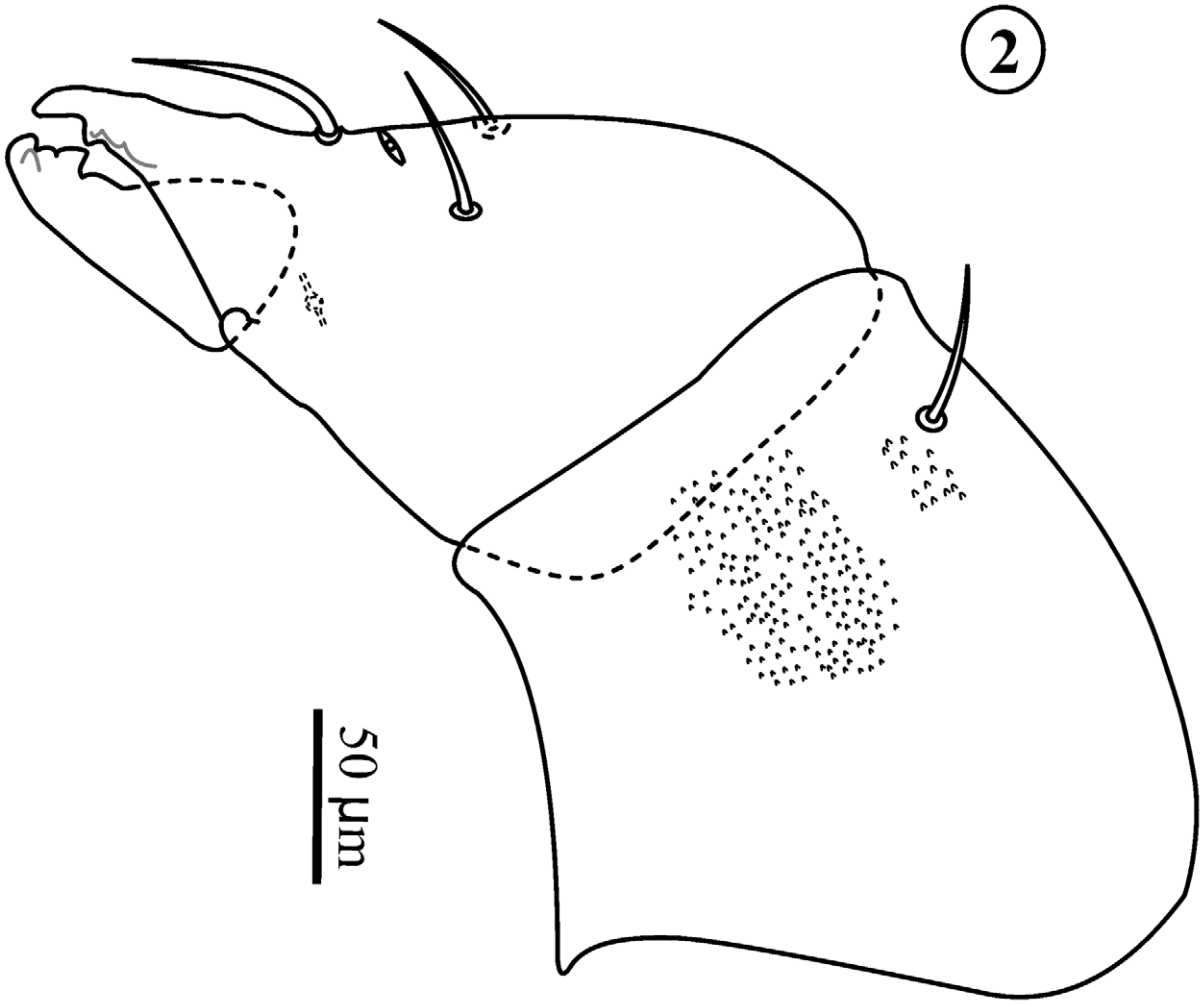


FIGURE 2. *Neocarus potiguar* **n. sp.**, male adult, paratype III. Lateral view of chelicerae.

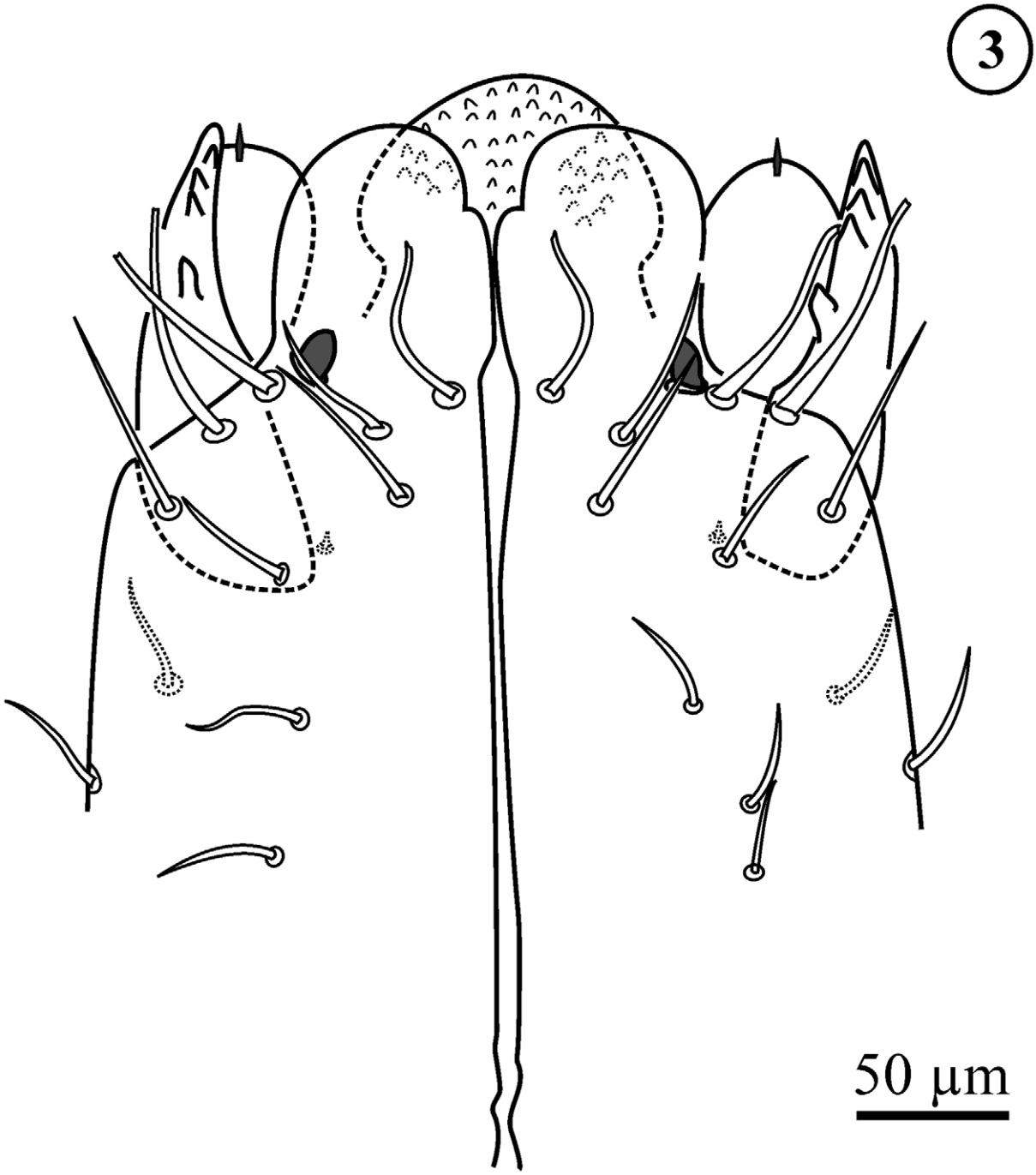


FIGURE 3. *Neocarus potiguar* **n. sp.**, female adult, holotype. Ventral view of subcapitulum. All the details present in With´s Organ are not shown in this figure.

Trochanter with three to four ribbed, tapering sensilla (*r*–type); femur with 9–18 papilliform (*p*–type) and 8–10 *r*–type sensilla; genu with 10–13 *p*–type and 22–29 *r*–type sensilla. Tibia and tarsus partially fused. Tibia with 9–10 smooth and 45–50 *r*–type setae. Palp tarsus with lyrifissures *i*π and *i*α. Setation includes two smooth and long rod shaped setae, 13 smooth sensilla with fine tips, three *s*–type, five or six *d*–type, five *v*–type, 25–27 *ch*–type, and nine *sm*–type setae (Fig. 4). Pretarsus with a pair of well developed sessile claws. No distinct sexual differentiation observed.

Idiosoma. Longer (1.29–1.25 mm) than wide (0.80–0.78 mm) and oval. The body light in color with dark blue patches. Some segments of the legs, mainly the tarsus and tibia, have a violet coloration. Body often with brownish background reflecting ingested food (Figs. 7–8).

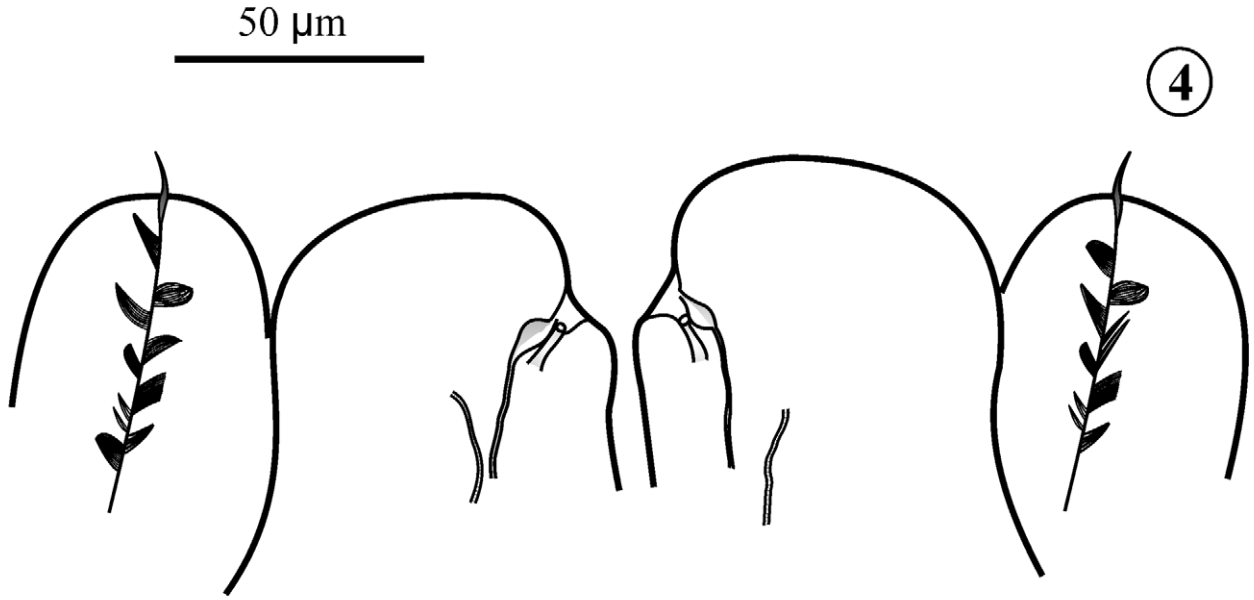
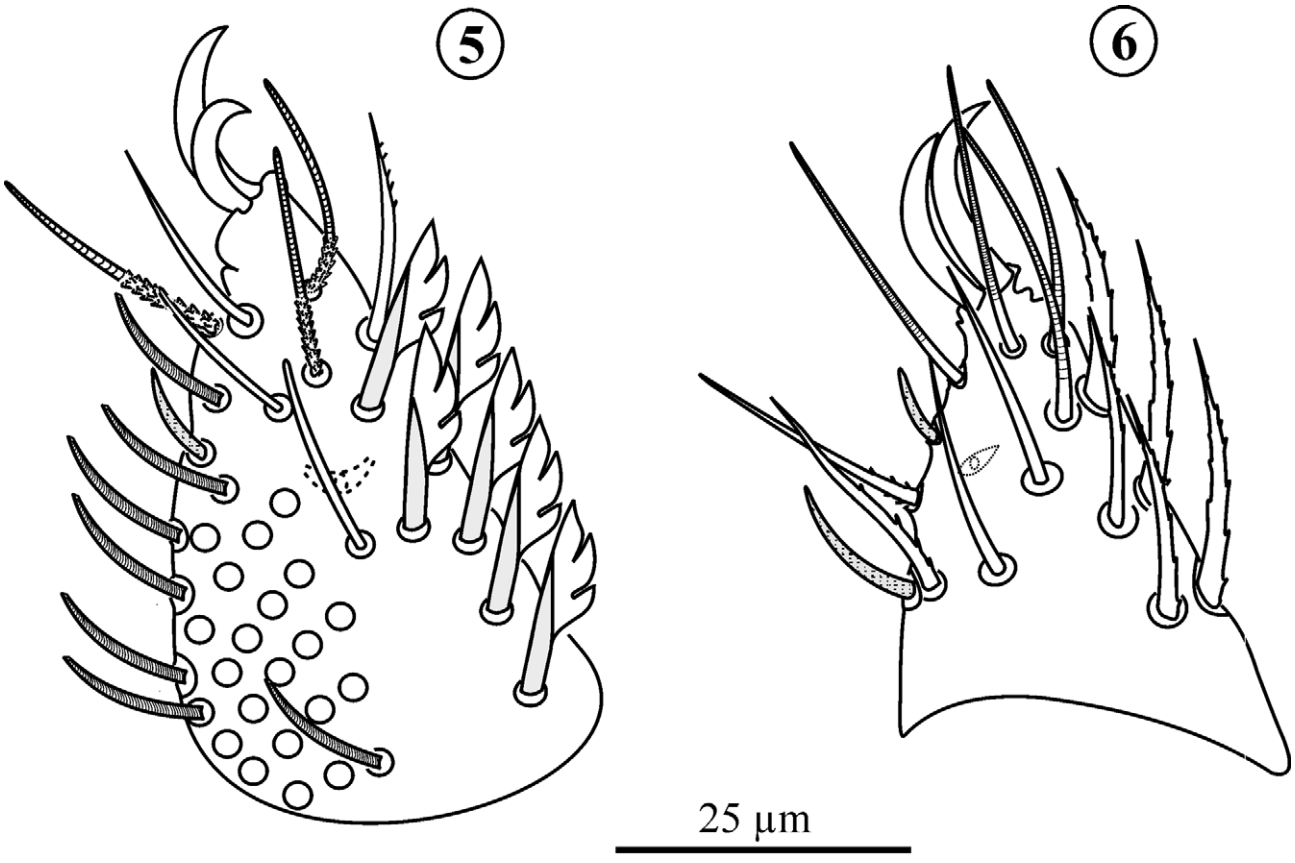
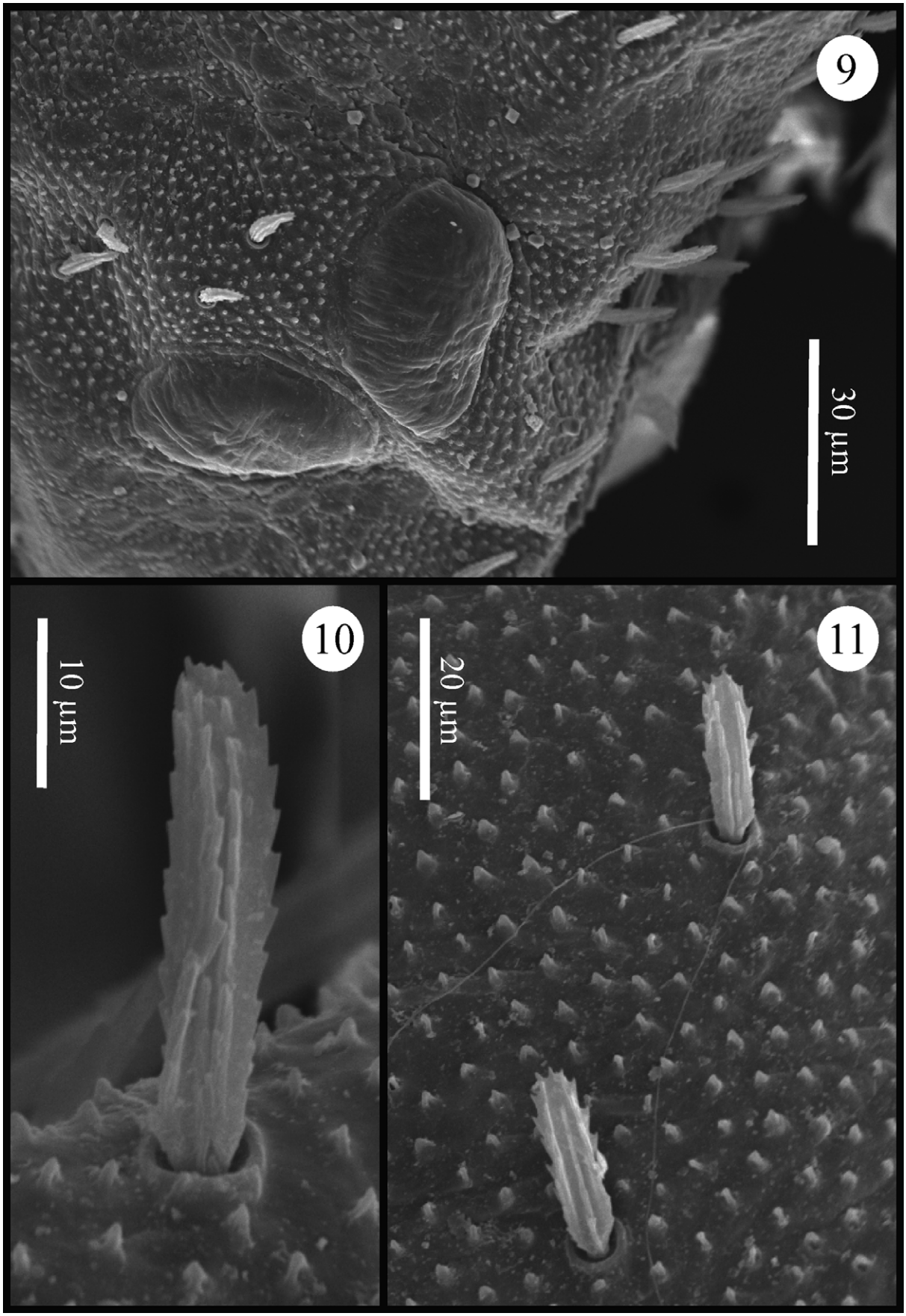


FIGURE 4. *Neocarus potiguar* **n. sp.**, female adult, holotype. Detailed view of the ventral of lateral lips and With's organ.

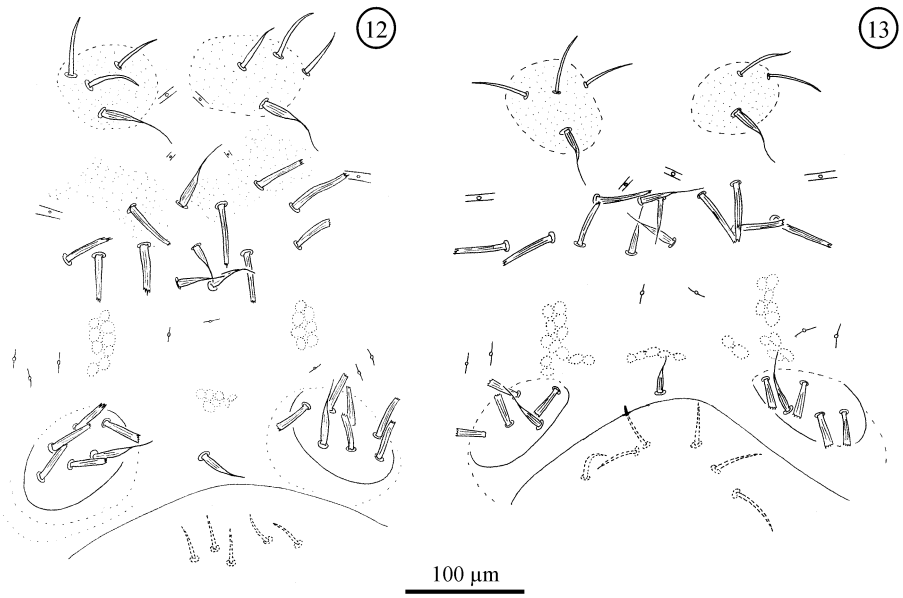


FIGURES 5–6. *Neocarus potiguar* **n. sp.**, female adult, holotype. Palp tarsus, dorsal (Fig.5) and ventral (Fig. 6) view. On dorsal view, empty circles represent the *ch type* setae insertion.

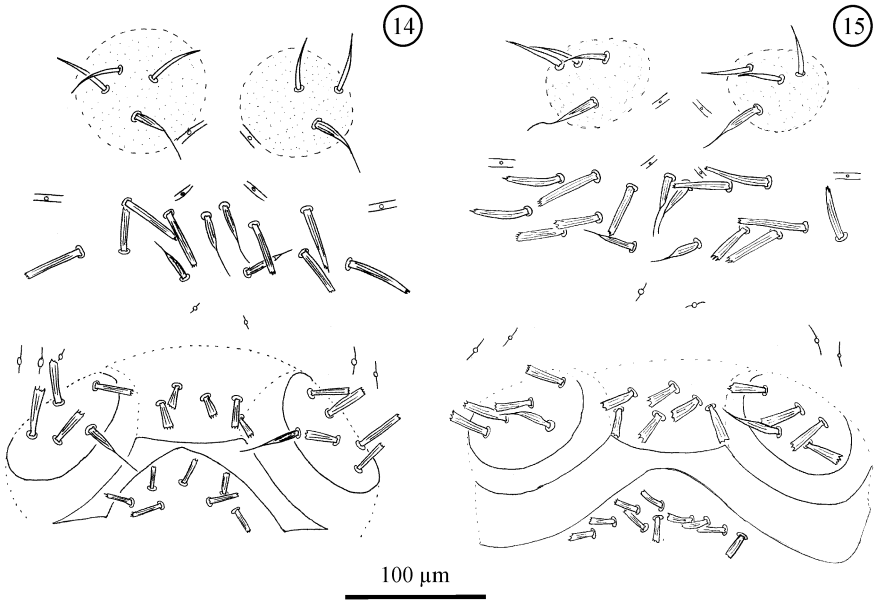
FIGURES 7–8. *Neocarus potiguar* **n. sp.**, female adult. Dorsal view.



FIGURES 9–11. *Neocarus potiguar* **n. sp.**, female adult. Scanning electron photographs of the dorsal podosoma, details of the eyes and stout ribbed setae located in this region.



FIGURES 12–13. *Neocarus potiguar* **n. sp.**, adult. View of the sternogenital and pregenital region of the female; 12, holotype; 13, paratype I.



FIGURES 14–15. *Neocarus potiguar* **n. sp.**, adult. View of the sternogenital and pregenital region of the male; 14, paratype III; 15, paratype IV.

Dorsum; anterior dorsal shield in adults with two pairs of eyes, and 114–120 stout, ribbed setae (Figs. 9–11). Dorsal idiosoma, between the shield and the preanal segment without setae, but with numerous lyrifissures arranged in transverse rows. Preanal segment with one dorsal and two ventral stout, ribbed setae; anal plates in adults each with 11–14 stout, ribbed setae.

Sternogenital region: sternal verrucae in adults each with one long, barbed and tapering seta and two to four smaller barbed and tapering setae. Sternal area with two pairs of long and tapering setae. With four to six pairs of stout and ribbed setae, and three pairs of lyrifissures (two very large pairs and the third smaller) (Figs. 12–13).

Pregenital area in female with one pair of capsules, each one presenting one long and tapering seta and four to six stout, ribbed setae. One (rarely two) small and tapering seta located between the pregenital capsules. The

genital area presents a group of four to eight small, smooth and tapering setae. These setae are positioned in an invagination, and thus not directly exposed. They are only exposed during partial or total evagination of the ovipositor (Figs. 12–13), situated at the base of that structure (Figs. 17).

Pregenital area in males with one pair of capsules each with one long tapering and four to six stout, ribbed setae. Five or six stout, ribbed setae located between pregenital capsules. Genital area with 7–11 stout and ribbed setae (Figs. 14–15).

Ovipositor; only four females presented an evaginated ovipositor, of which three ovipositors were mounted separately. The ovipositor comprises a tube like structure, in its median portion a single pair of gland-like structures can usually be found, and in the studied specimens the apex of the ovipositor has a convex form (Fig. 17).

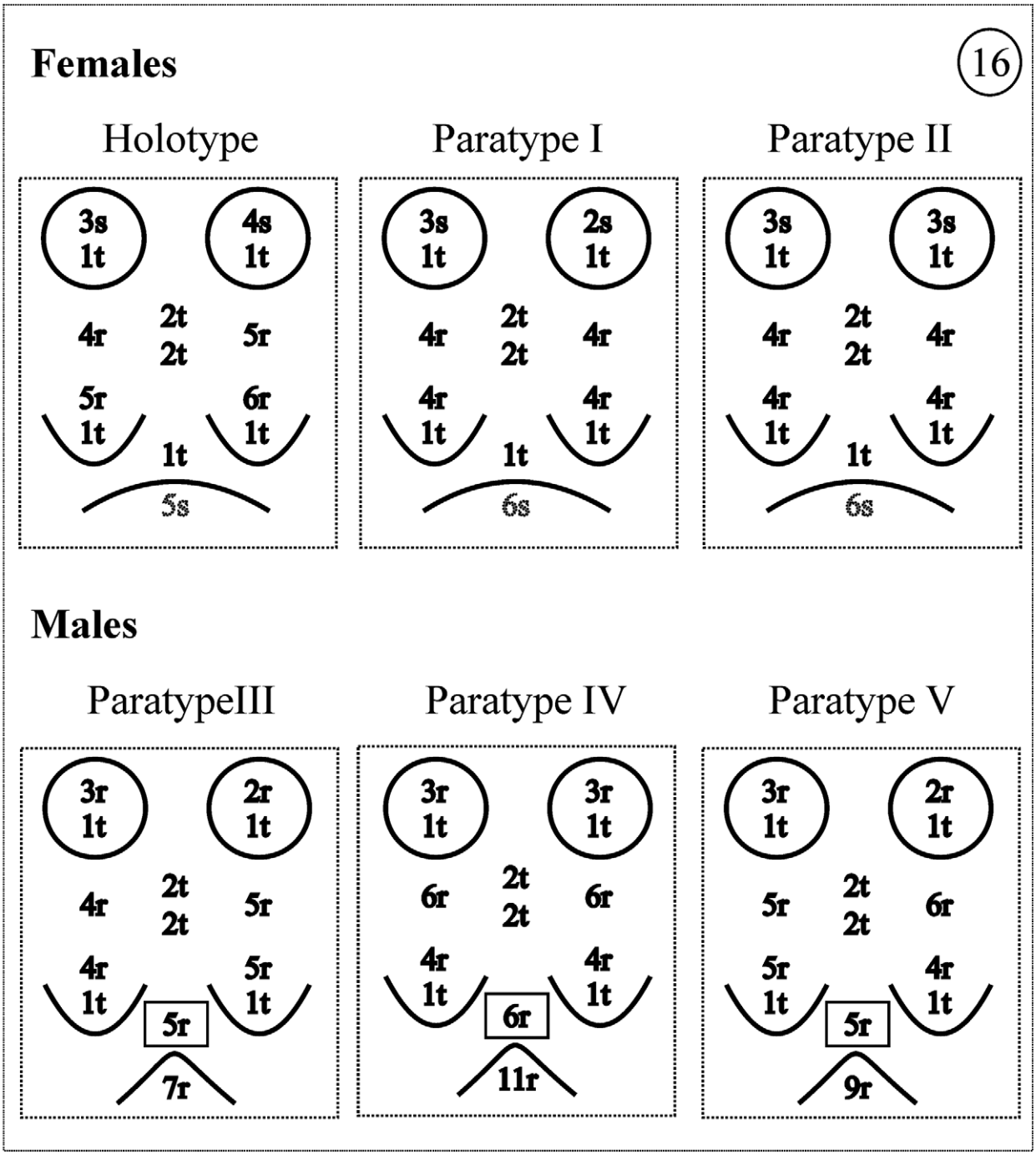


FIGURE 16. *Neocarus potiguar* **n. sp.**, adult. Schematic representation of the variation in the numbers of setae observed in the genital area of the females and males; s, smooth setae; r, ribbed and stout setae; t, tapering and ribbed setae.

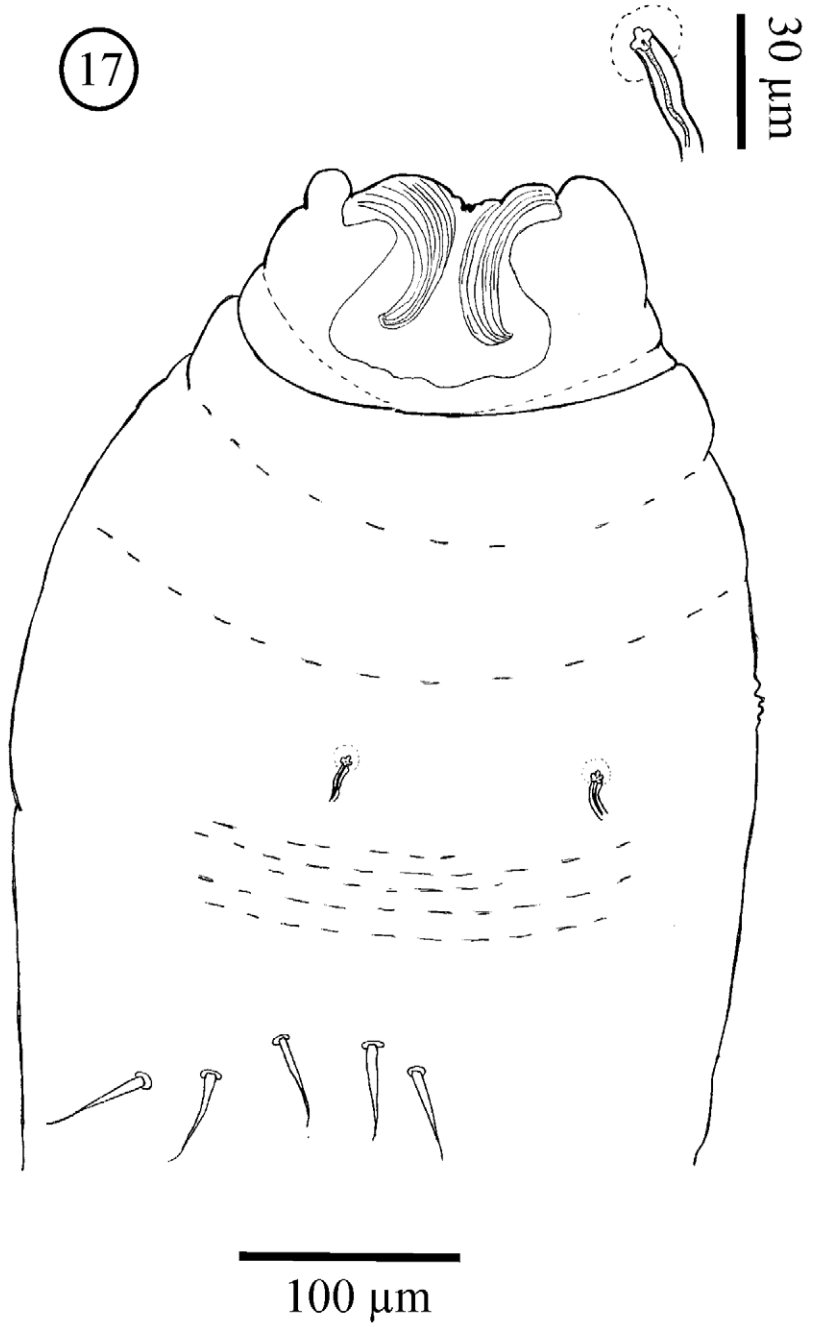


FIGURE 17. *Neocarus potiguar* **n. sp.**, View of the ovipositor evaginated and mounted in slide.

Legs. Leg I, basitarsus 340–350 µm, telotarsus 340–380 µm, tibia 880–1060 µm, genu 600–700 µm, basifemur 790–980 µm, telofemur 90–100 µm, trochanter 360–410 µm.

Leg II, acrotarsus 60–90 µm, basitarsus 215–270 µm, telotarsus 250–325 µm, tíbia 230–290 µm, genu 210–280 µm, femur 350–450 µm, trochanter 145–215 µm.

Leg III, acrotarsus 60–75 µm, basitarsus 220–280 µm, telotarsus 250–330 µm, tíbia 225–330 µm, genu 210–275 µm, femur 290–375 µm, basitrochanter 85–140 µm, telotrochanter 105–155 µm.

Leg IV, acrotarsus 75–85 µm, basitarsus 300–360 µm, telotarsus 355–445 µm, tíbia 450–510 µm, genu 430–470 µm, femur 580–650 µm, basitrochanter 180–240 µm, telotrochanter 225–250 µm.

Leg I longer than others. Tarsi I without acrotarsus, but with a distinct basitarsus and telotarsus. Acrotarsus present in legs II, III and IV.

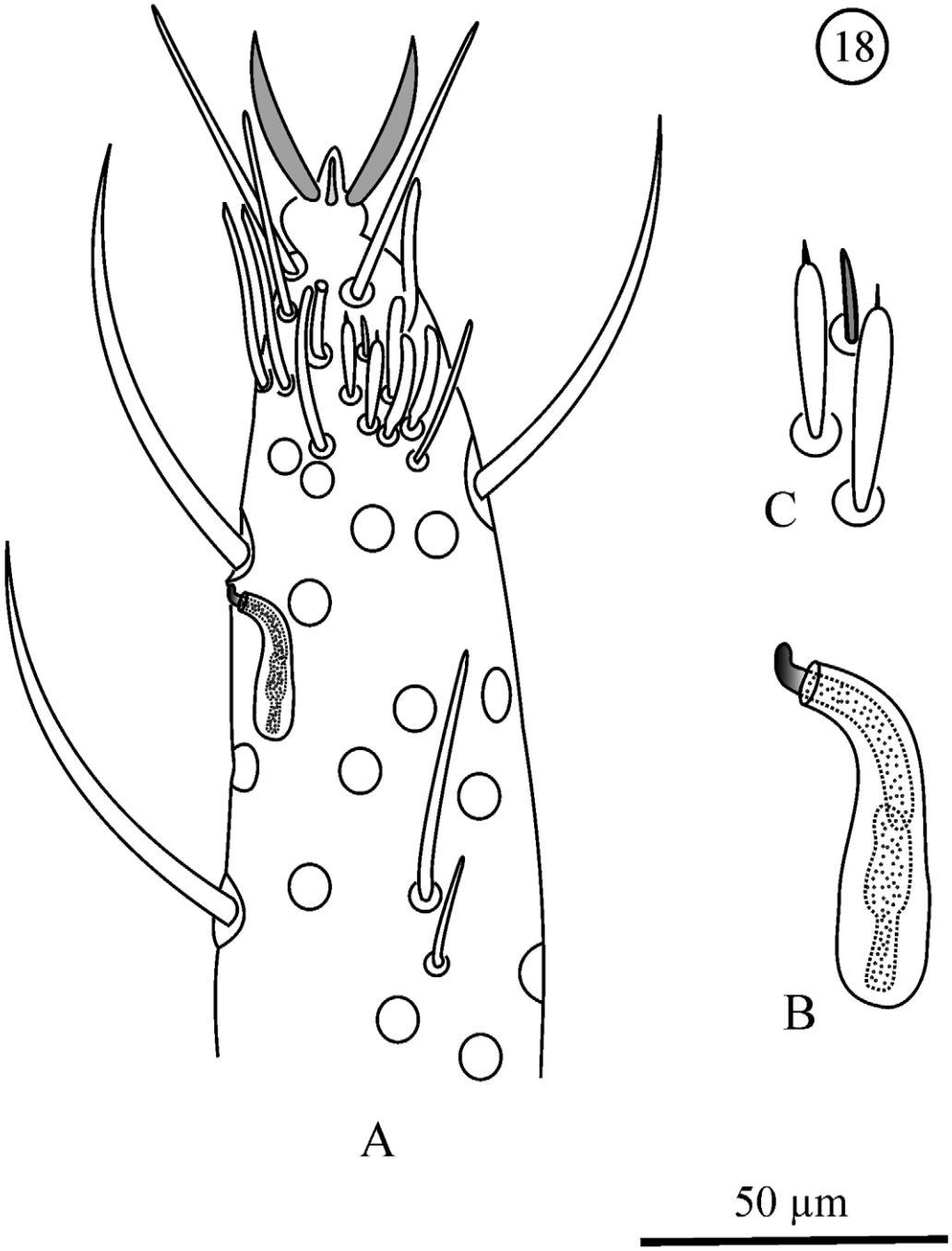
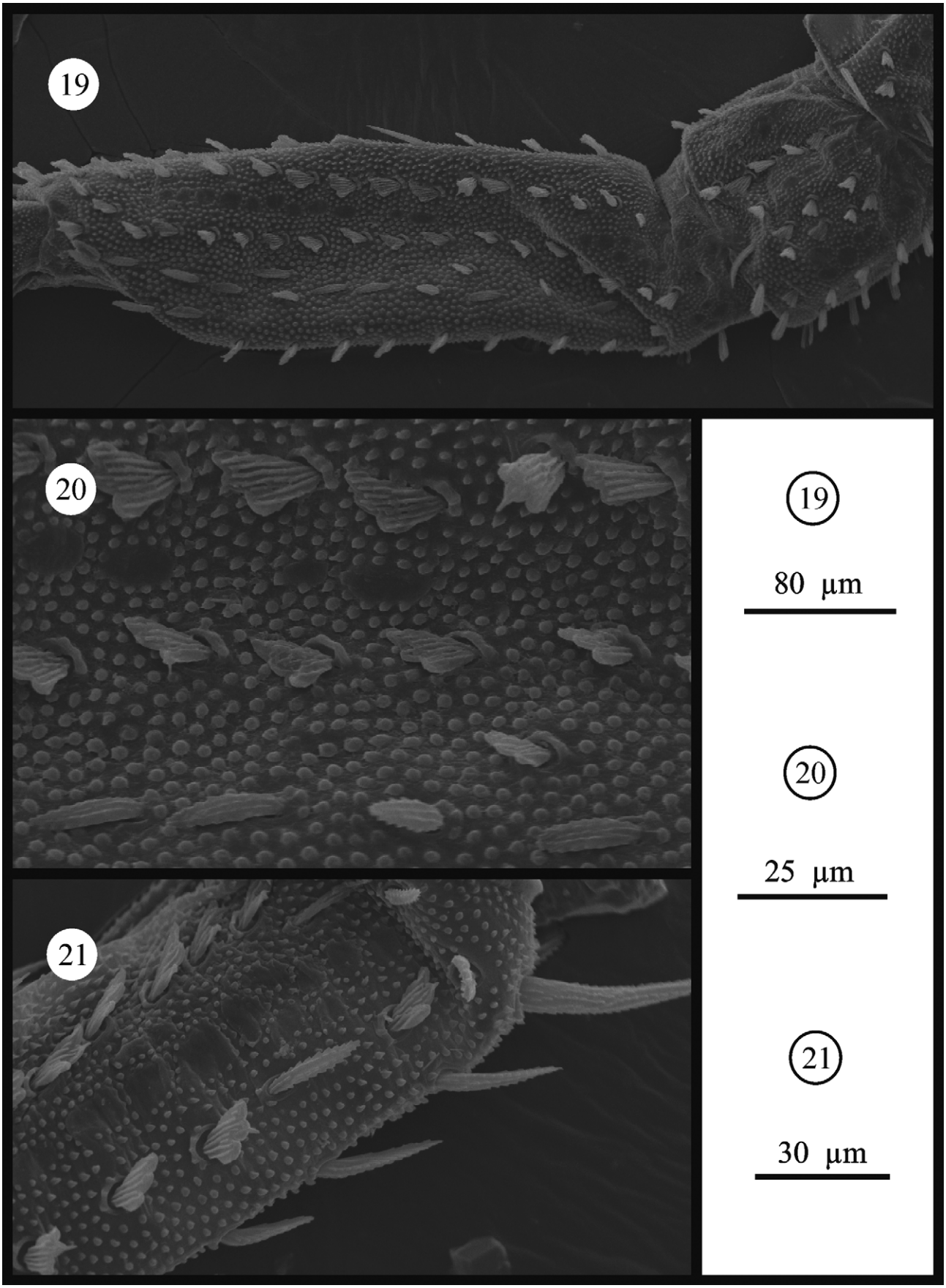


FIGURE 18. *Neocarus potiguar* **n. sp.,** female adult, holotype. Dorsal partial view of tarsal I. The empty spaces represent insertions equal to those that are represented in the posterolateral portion and anterolateral face.

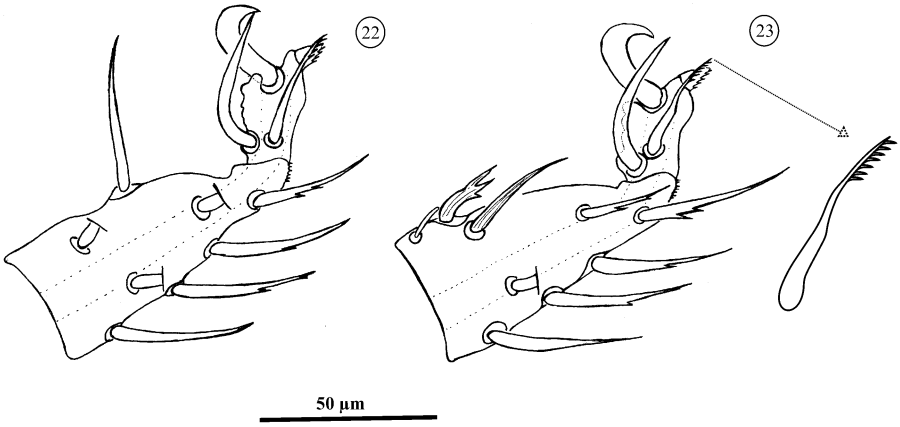
The telotarsus I has a joint complex of setae exclusive to leg I, located in the apical portion, close to the tarsal claws. In spite of the still unknown function of this group of setae, some authors speculate that it can have a sensorial function being homologous to Haller´s organ (Klompen 2000; Van der Hammen 1966) (Fig. 18A). Among the setae present in this group an exclusive type can be observed, that presents a small rod–like shape, round, smooth, with a sharp portion at the apex. Two of these setae in this group are present in the present species (Fig. 18C).

All legs have many setae of varied types, such as papiliform setae (*p*–type), small tapering and ribbed setae (like *r*–type), long tapering, and ribbed setae (Figs. 19–21).



FIGURES 19–21. *Neocarus potiguar* **n. sp.**, female adult. 19, Femur and trochanter; 20, Detail of femur; 21, Anterior portion of tibia.

The dorsal part of the leg II acrotarsus has one forked seta and one smooth seta, three pairs of slightly barbed basal setae and the strongly barbed anterior setae. Two smooth setae and one barbed setae are found on the antero-lateral portions as well as on the posterolateral. Close to the tarsal claws there are a pair of smooth setae and a pair of modified setae that have a pectinated apical portion. The tarsal ambulacrum is triangular and also has a pectinated base (Figs. 22–23).



FIGURES 22–23. *Neocarus potiguar* **n. sp.**, female adult, holotype. Antero and posterolateral view of acrotarsus II.

Differential diagnosis. The male of *N. potiguar* has stout and ribbed setae on the pregenital and genital area. This characteristic is shared with most other species of *Neocarus*, except for *Neocarus texanus* (six to nine tapering setae in genital region). However, the number and the type of setae on the pregenital and genital area of the female of *N. potiguar* are unique to this species. Females have only one (rarely two) tapering, ribbed seta in the pregenital area. The most common characteristic of other *Neocarus* spp. is the presence of either stout and ribbed setae, or the complete absence of the setae in this area. Moreover, the female of the new species has four to eight smooth setae in the genital region, a type of setae not present in other species, except in *N. platensis* (six to nine smooth setae in genital region). The pregenital and genital setal patterns for all *Neocarus* species are shown in the Table 1.

TABLE 1. Comparative setal pattern for the pregenital and genital region of *Neocarus* adults.

	FEMALE		MALE	
	Pregenital region	Genital region	Pregenital region	Genital region
	Number and type of setae	Number and type of setae	Number and type of setae	Number and type of setae
N. nohbecanus	0	0	4–5 st/r	5–7 st/r
N. siankaanensis	0	0	2 st/r	4 st/r
N. nicaraguensis	2–5 st/r	0	2–7 st/r	3–6 st/r
N. bajacalifornicus	2 st/r	0	5–8(13[a]) st/r	7–8(11[a]) st/r
N. bajacalifornicus chamelaensis	2–3 st/r	0	4–5 st/r	4–6 st/r
N. texanus	2 st/r	0	4–5 st/r	8–9 sh
N. plantensis	0–2 st/r	6–9 sh	6–10 st/r	5–10 sh
N. orghidani	0	0	6–9 ?	13 st/r
N. calakmulensis	2–3 st/r	0	2–6 st/r	3–8 st/r
N. veracruzensis	2 st/r	0	6–8 st/r , 0–1 s	6–8 st/r
N. potiguar	1 tp/r	4–8 sh[b]	5 st/r	7–10 st/r

[a] — number of setae in super adults

[b] —located in a tissue fold.

st/r—stout and ribbed setae; sh: smooth setae: tp/r: tapering and ribbed setae.

Besides the characteristics mentioned above, *N. potiguar* presents six d-type setae on the palp, which is uncommon among species of *Neocarus*. Of the 12 species currently described only three (*N. nicaraguensis* (Vázquez & Klompen 2002), *N. platensis* and *N. potiguar*) present six d-type setae on the palp tarsus, the other nine species only have four or five d-type setae. Similarly, the number of setae ch-type present on the palp of *N. potiguar* (25–27) is higher when compared to most of the other species already described. *Neocarus orhidani* (Juvara-Bals & Baltac 1977) is the closest, with up to 24 setae.

The wide variation of setae observed on the sternogenital and genital areas, in the male and females, is somewhat commonly observed in other *Neocarus* species. Similar variations were reported from species of *Neocarus* and *Caribeacarus* described by Vázquez and Klompen (2009).

Type material. Holotype, female (MZLQ2814), collected in Gruta do Pinga cave, municipality of Baraúna, Rio Grande do Norte State, Brazil. coll. Bento D., 29 Sep 2010. Paratype I, female (ISLA1918) collected in Baraúna municipality (outside caves), Rio Grande do Norte State, Brazil. coll. Bernardi L.F.O., 12 Jun 2008. Paratype II, female (ISLA1916) collected in Gruta do Pinga cave, municipality of Baraúna, Rio Grande do Norte State, Brazil. coll. Bento D., 29 Sep 2010. Paratype III, male (ISLA1907) collected in Baraúna municipality (outside caves), Rio Grande do Norte State, Brazil. coll. Bernardi L.F.O., 12 Jun 2008. Paratype IV, male (MZLQ2815) collected from Furna Feia cave, municipality of Baraúna, Rio Grande do Norte State, Brazil. coll. Ferreira R.L., 31 Sep 2010. Paratype V, male (MZLQ2815) collected in Governador Dix Sept Rosado municipality (outside caves), Rio Grande do Norte State, Brazil. coll. Bernardi L.F.O., 31.Jun 2010

Other material examined. One male (ISLA1912), five females (ISLA1908, ISLA1909, ISLA1910, ISLA1911, ISLA1913), 2 protonymphs (ISLA1917, ISLA1919), one deutonymph (ISLA1920), one tritonymph (ISLA1921) collected in Baraúna municipality (outside caves), Rio Grande do Norte State, Brazil. coll. Bernardi L.F.O., 12 Jun 2008. One female (ISLA1915), one tritonymph (ISLA1914) collected in Gruta Apertar da Hora cave, municipality of Jandaíra, Rio Grande do Norte State, Brazil. coll. Ferreira R.L., 22 Jul 2009.

Etymology. The specific epithet is an adjective used in Brazil to designate the natives from the state of Rio Grande do Norte.

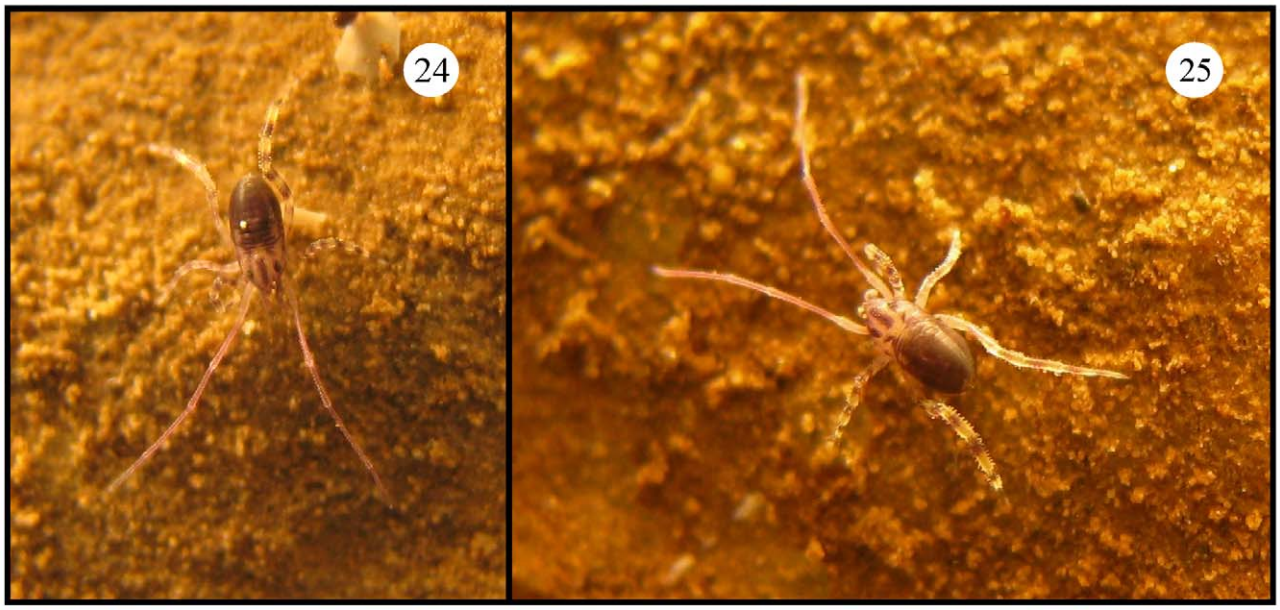
Ecology and distribution remarks. Four males, eight females and two protonymphs, one deutonymph and two tritonymphs were collected in the epigeal environment of karstic areas in the municipal districts of Baraúna, Felipe Guerra, Governador Dix–Sept Rosado, Jandaíra e Mossoró (Figs. 24–25). Furthermore, a female was collected in the Furna Feia (Baraúna), another in the Abrigo do Pinga (Baraúna), and 2 females in the Gruta da Aroeira and Gruta Apertar da Hora (Jandaíra). All these places are located within the Apodi Carbonatic Group, that encompasses a large part of the area to the north of the state of Rio Grande do Norte (Table 2) (Fig. 26).

TABLE 2. Records of *Neocarus potiguar* **n. sp.** in caves of Rio Grande do Norte State, Brazil.

Municipally	Locality	Latitude (S)*	Longitude (W)*
Baraúna	Epigean environment	05º02’09’’	37º34’14’’
Baraúna	Furna Feia cave	05º02’10.08’’	37º33’35.45’’
Baraúna	Pinga cave	05º03’06.5’’	37º32’21.7’’
Governador Dix Sept Rosado	Epigean environment	05º30’55’’	37º31’40’’
Governador Dix Sept Rosado	Epigean environment	05º29’41.9’’	37º32’42.1’’
Jandaíra	Aroeira cave	05º19’57.8’’	36º08’18.6’’
Jandaíra	Apertar da Hora cave	05º20’20’’	36º08’30’’

*****SAD 69, South America Datum.

In spite of some specimens having been found in caves, it is most probable that the subterranean environment is a habitat colonized occasionally by *N. potiguar*. Collections were made in 40 caves located in the Apodi Carbonatic Group, state of Rio Grande do Norte, however in only three caves a total of just five specimens of this species were found. In the epigeal environment, external, sporadic collections were undertaken in only three places, however a total of 32 specimens in these places were observed. As such, we believe that the main habitat of *N. potiguar* is the external environment, being found mainly under rocks.



FIGURES 24–25. *Neocarus potiguar* **n. sp.,** female adult. Specimens collected in the Gruta da Arueira, municipality of Janda-íra.

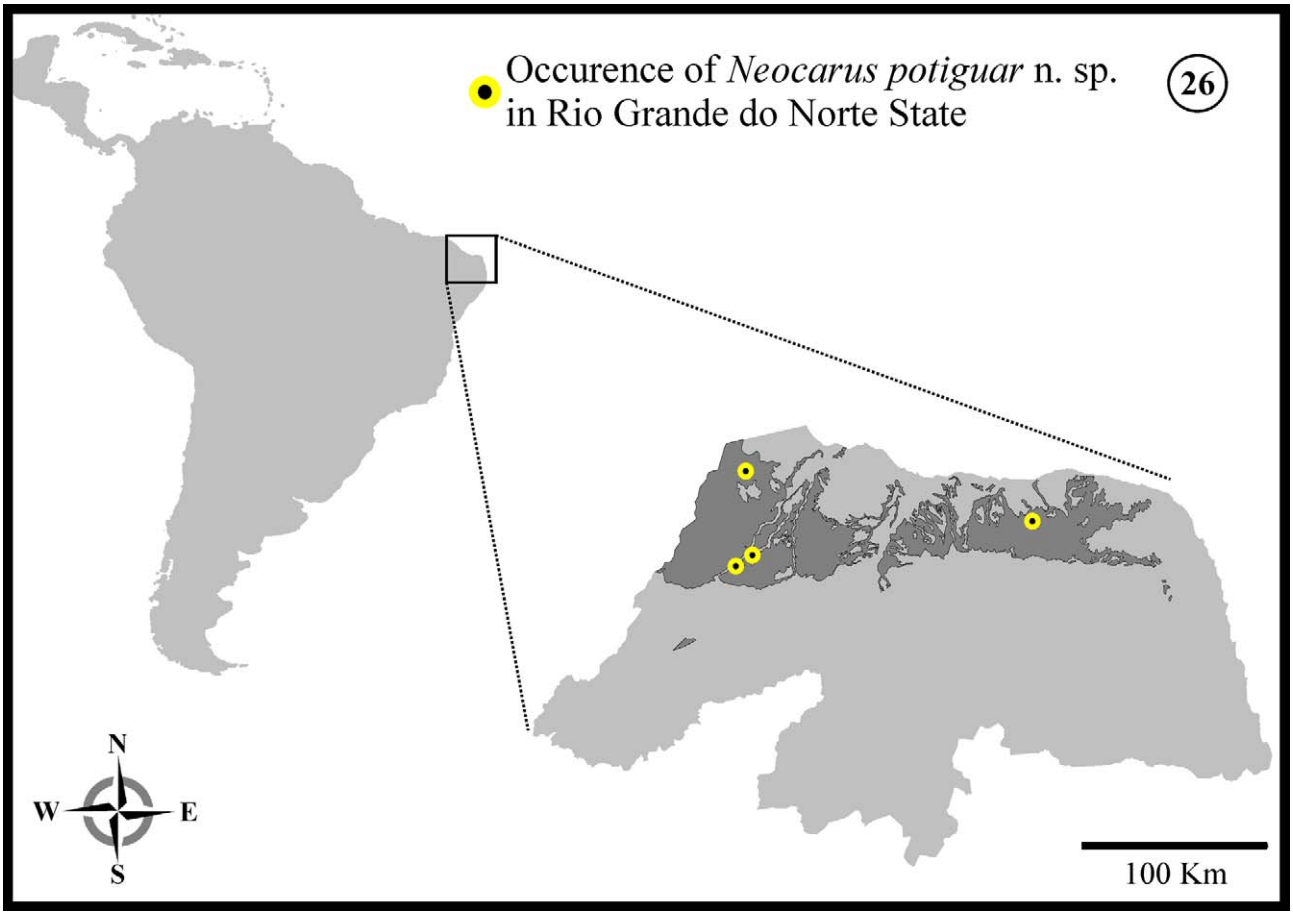


FIGURE 26. Occurrences sites of the *Neocarus potiguar* **n. sp.** in the Rio Grande do Norte State, Brazil. Highlights show the extension of the limestone rock of the Apodi Group.

The specimens observed in the epigeal environment as well as in the hypogeal environment were found under rocks and were solitary, except those observed in the municipal district of Mossoró, in the area known locally as Maysa`s Farm (05º02'09''S 37º34'14''W, Datum SAD69). In this locality, they were observed under small rocks in groups of three to six specimens, and these individuals were found intimately close.

The Caatinga is a unique biome, being found exclusively in Brazilian territory, and includes a large number of endemic species, which makes it an area of great importance for conservation (Silva *et al.*, 2003). But this fact does not protect these areas, such as the Apodi Carbonatic Group, from strong anthropic pressure such as mining (limestone extraction), petroleum extraction, deforestation and a high presence of trash.

The presence of specimens of the order Opilioacarida in some locales of the Caatinga biome reinforce the importance of the area and the need for the elaboration of conservation plans for this area. So doing would be a great step towards avoiding the destruction of the environment, the epigeal, as well as hypogeal, resulting in great loss of biodiversity, besides the extinction of *N. potiguar* which is likely endemic to this area.

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