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A new species of cave-dwelling *Neocarus* (Acari: Opilioacaridae) from Minas Gerais state, Brazil with a key to species of the genus

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Abstract

Neocarus jonasi **n.sp.** is described from three limestone caves of the Bambuí Group geomophological formation, Minas Gerais state, Brazil, with a combination of a higher number of palp genu and tibia *r* setae and palp tarsus *sm* and *d* setae. Its relationship to *Neocarus spelaion* and the importance of setae variation in Opilioacaridae is discussed. A key to the genus *Neocarus* is also provided.

Keywords: Opilioacarida, karst, hypogeic, Neotropical

Introduction

Opilioacaridae is a small family of soil mites, which is endemic and distributed on all continents, except Antarctica. They are known from 54 species distributed in 13 genera (Araújo *et al.* 2020; Moraza *et al.* 2021). Twenty percent of these species are from the New World. These can be divided into two groups according to their *d* type palpal tarsus setae: one composed of the genera *Amazonacarus* Vázquez, Araújo & Feres 2014, *Brasilacarus* Vázquez, Araújo & Feres 2015 and *Caribeacarus* Vázquez & Klompen 2009, with 8 to 12 setae pectinated, the other by *Neocarus* Chamberlin & Mulaik 1942, with 4 to 6 foliate setae.

The first group shares the pectinated setae character with an Asian genus, *Siamacarus* Leclerc 1989, from Thailand caves (Leclerc 1989); while *Neocarus* shares the form of the *d* type setae with other Old World genera (*e.g.*, Araújo *et al.* 2018b; Das & Bastawade 2007; Hammen 1977; Vázquez & Klompen 2010). In *Neocarus*, in addition to the characters of the palp, the *ζ1* (eupathidium) being small with a crown-like tip inserted close to sensilla group in the first pair of legs is a differential character in this combination that contributes to the diagnosis of *Neocarus.*

From the seven hypogeic species described from Brazil, one belongs to *Caribecarus* and six to *Neocarus*: *C. brasiliensis* Bernardi, Silva, Zacarias, Klompen & Ferreira (2013), *N. potiguar* Bernardi, Zacarias& Ferreira (2012), *N. proteus* Bernardi, Klompen, Zacarias & Ferreira (2013), *N. caipora* Bernardi, Klompen & Ferreira (2014), *N. coronatus* Araújo & Feres (2018), *N. spelaion* Bernardi & Borges-Filho (2018) and *N. simmonsi* Bernardi, Zampaulo & Oliveira (2020).

With 21 described taxa (Araújo *et al.* 2020), *Neocarus* is thus the most diverse Opilioacaridae genus, meriting a key to help identify species. Here, we present a detailed description of a new species of Opilioacaridae from Brazilian caves and a key to the *Neocarus* genus.

Material and Methods

Study Area (Figure 1A).

The material was recorded from three caves in the Monjolos region, Minas Gerais State, Brazil (Figure 1A). This region is located in the central-east part of the southern portion of the São Francisco Craton, Velhas river basin, with a mean altitude of approximately 600 meters, inserted in the Sete Lagoas Formation, Bambuí Group geomorphological unit (GMU), which has a relief typical of karst carbonate regions (Guimarães 2012; Stávale 2012). The Monjolos region is characterized by evident karst relief, marked by large limestone cliffs, karrens, dolines, sinks, and resurgences, representing the exokarst, and subterranean watercourses, diverse speleothems, and caves, representing the endokarst (Guimarães 2012). According to the Köppen-Geiger climatic classification, the region has a tropical climate with a dry season (Kottek *et al.* 2006) type Aw (Sá Júnior *et al.* 2012), with mean annual temperatures ranging between 20 and 21 °C. The vegetation is dominated by plants of the 'Cerrado' sensu strictu, Cerrado fields, and seasonal forests (Guimarães 2012). However, the vegetation surrounding the cave is under anthropogenic influence, such as pasture and agricultural activities.

Gruta Pau Ferro (Figure 1B). A limestone cave (18°19'4.28"S 44° 6'29.89"W, 544 MASL), with development of 701.8 meters in a southwest-northeast longitudinal direction, point Córrego Alegre, belonging to an agricultural property, is located up to half a slope of a hill with a smooth slope and concave shape, recovered by developed soil and occasional outcrops of limestone.

Toca do Geraldo (Figure 1C). A limestone cave (18°16'43.31"S 44° 6'10.97"W) which extends approximately 1.5 km, with one entrance in a crack and another in the ceiling and a subterranean stream, which extends at least 400 meters. This cave has guano piles and litter as the main food source for other cave arthropods such as crickets, cockroaches, mites, etc. Because of the perennial drainage, the humidity is high (higher than 70%), even during the dry season. The cave does not have dry galleries and/or conduits, showing high relative humidity of the air (ca. 80%) and a temperature amplitude between 22 and 24 °C.

Lapa do Santo Antônio. A limestone cave (18°19'7.66"S 44°7'3.32"W) ca. 4.6 km distant from Toca do Geraldo which also possess a subterranean stream. However, it is an impacted cave due to uncontrolled visitation. This cave has ca. of 300 meters of extension.

Material studied

Specimens were collected from the soil of the caves using a brush and preserved in vials with 70% ethanol.

Part of the specimens were cleared in lactic acid, washed in distilled water, and carefully dissected (Araújo *et al.* 2018a). The main structures (idiosoma, gnathosoma, legs, and gut content) were mounted on different slides in Hoyer's medium (Walter & Krantz 2009) and placed in an oven at 55° C for 2–3 days. Specimen habit images were taken with a Leica MZ16 stereomicroscope equipped with a Leica DFC320 camera. Identification, light microscope images, and drawings of the specimens were accomplished using a Leica DMR phase contrast and DIC microscope equipped with a drawing tube.

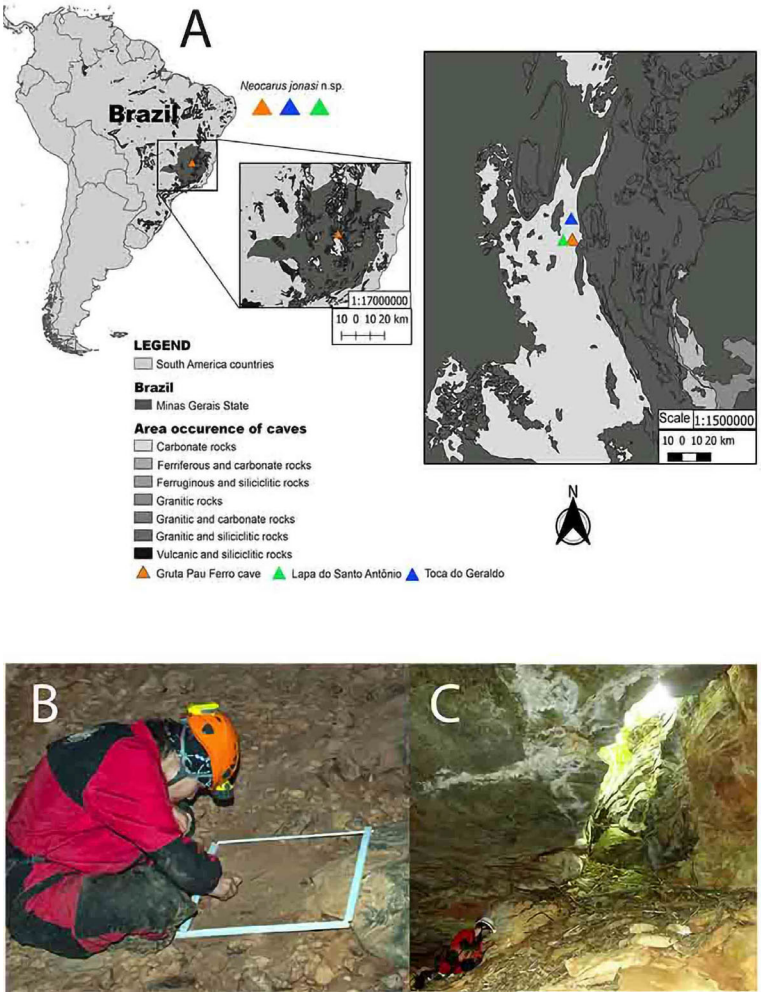

FIGURE 1. *Neocarus jonasi* **n. sp. (A)** collection sites in Minas Gerais state, Brazil; aspects of **(B)** Gruta Pau Ferro cave and **(C)** Toca do Geraldo cave (main gallery). Photos: M.E. Bichuette.

Measurements were taken of digitalized drawings using ImageJ (Schneider *et al.* 2012) and are presented in micrometers (μm). Final drawings were made in Adobe Illustrator®, using techniques outlined by Fisher & Dowling (2010).

The description of the adults was made using DELTA Editor (Open Delta Suite 1.02) (Dallwitz *et al.* 2013) and commands outlined in (Coleman *et al.* 2010). The character database used follows Araújo *et al.* (2018). The nomenclature follows different authors according to morphological characters: palps and legs (Araújo *et al.* 2018a; Grandjean 1936; Vázquez & Klompen 2002), subcapitulum and chelicera (Hammen 1966) and sternal area (Klompen *et al.* 2015).

The material studied is deposited in Departamento de Ecologia e Biologia Evolutiva (DEBE) Laboratório de Estudos Subterrâneos (LES), Federal University of São Carlos, São Carlos, São Paulo, Brazil.

Results

***Neocarus jonasi* Araújo & Duarte n. sp.**
(Figures 2–4)

Material examined

Holotype F (LES0026983), BRAZIL, Minas Gerais, Monjolos, Gruta Pau Ferro cave, 18°19'4.28"S 44° 6'29.89"W, coll. Bichuette, M.E.; Ferreira, R.F.; 31.OCT.2014.

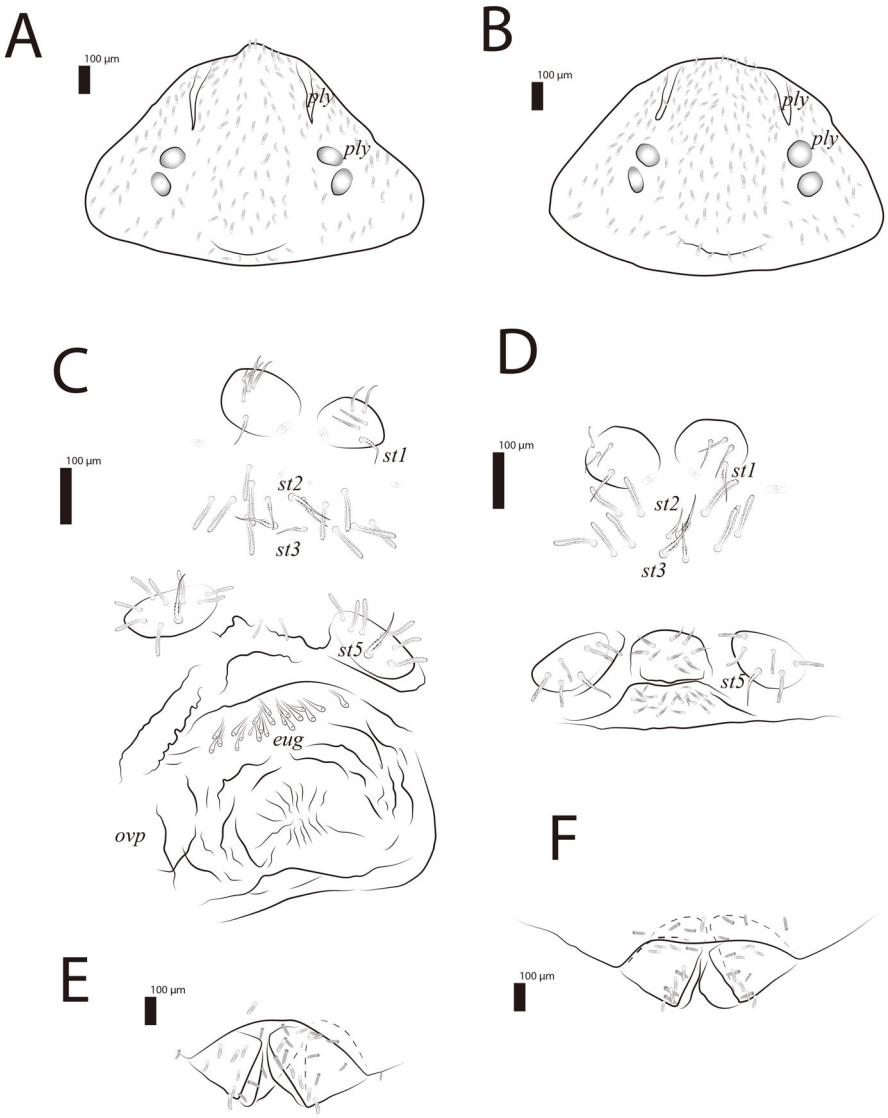

FIGURE 2. *Neocarus jonasi* **n. sp.** Prodorsal shield of **(A)** female and **(B)** male; sternitogenital view of **(C)** female (with invaginated ovipositor) and **(D)** male, and detail of eugenital seta; anal area of **(E)** female and **(F)** male.

Paratypes

Same data as for holotype: F (LES0027014), F (LES0027020), F (LES0027021), F (LES0027028), M (LES0026932), M (LES0026933), M (LES0026935), M (LES0026979), M

(LES0026980), M (LES0026981), M (LES0027009), M (LES0027010), M (LES0026985), coll. Bichuette, M.E.; Gallão, J.E.; Ferreira, R.F.; 11.SEP.2013; same data: F (LES-0026986), M (LES0026987); M (LES0027004), coll. Bichuette, M.E.; Ferreira, R.F.; 29.OCT.2014; same data: M (LES0027006), same data: F (LES0026988), coll. Ferreira, R.F.; Arnone, I.; Bichuette, M.E.; Gallão, J.E., 7.JUL.2014; same data: M (LES0026989), M (LES0026990), M (LES0019204), M (LES0026991); F (LES006581), Lapa do Santo Antônio cave, 18°19'7.66"S 44° 7'3.32"W, coll. Ferreira, R.F.; do Monte, B.G.O.; 21.FEB.2014; same data: F (LES006583); F (LES006577), Toca do Geraldo cave, 18°16'43.31"S 44°6'10.97"W, coll. Ferreira, R.F.; do Monte, B.G.O.; 22.FEB.2014; same data, coll. Ferreira, R.F.; Arnone, I.; Bichuette, M.E.; Gallão, J.E., 8.JUL.2014: M (LES0026994), F (LES0026995).

Etymology

Dedicated to the Brazilian arachnologist Jonas Eduardo Gallão, for his contributions to biospeleology and material collection.

Diagnosis

As a combination of characters of adults' palp tibia with 63–82 (female) and 53–83 (male) *r* setae; palp genu with 37–37 (female) and 29–54 (male) *r* setae; tarsus with 10–13 *sm* setae, 5–7 *d* foliate setae. Females with 14–21 smooth eugenital setae.

Description

Based on female (N= 11) and male (N= 17).

Idiosoma. Idiosoma with distinct segmentation; integument corniculate; dorsal segments between prodorsal shield and preanal segments without setae, but with numerous lyrifissures arranged in transverse rows; with four pairs of dorsal stigmata without peritremes; ventral suckers absent; posterior border without elongated setae. Idiosoma anus positioned terminally. Thon's organ absent. **Prodorsal shield.** With rounded area anteriorly; without dense patch; with 2 pairs of dorsolateral eyes; 2 pairs of lyrifissures, one close to the apical part and other smaller close to the first pair of eyes; female with 148–183 and male with 136–196 stout ribbed setae (Fig. 2A, B). **Preanal region.** Preanal segment (XVII) without dorsal and ventral setae; preanal segment (XVIII) with a single dorsal seta and a pair of ventrolateral setae. **Anal valves.** Anal valves (each) with 11–15 (female) and 8–20 (male) stout ribbed setae (Figs. 2E, F). **Tritosternum.** Each digitiform structure with 2 pairs of setae, 1 small at the tip and 1 long, barbed positioned more basally. **Sternal verrucae.** In both adults, each with a longer ribbed smooth tapering seta (*st1)*; female with 3–4 and male with 2 ribbed acute setae. **Sternal region (Figs. 2C, D).** With a pair of ventral and lateroventral lyrifissures; female *st2* and *st3* setae ribbed, smooth tapering, and 4–7 pairs of stout ribbed setae; male *st2* and *st3* ribbed tapering and 2–7 pairs of stout ribbed setae. **Pregenital area.** Female without setae. Male presenting setae shape variation, 7–12 acute ribbed and 2 stout ribbed setae. Each pregenital capsules in both adults with a ribbed, smooth tapering seate (*st5*); female with 5–7 and male with 4–8 stout ribbed setae. **Genital area.** Female without setae. Male genital area trapezoid with 9–19 acute smooth setae. Female with 10–21 smooth eugenital setae. **Ovipositor.** Consisting of tube-shaped structure; slightly striated without digitiform or seta-like projections; large basal structures absent; without terminal setae; gland-like structures or accessory glands absent. **Male glands.** 2 pairs, one larger and one smaller, without reel-like structures.

Gnathosoma. Chelicera (Figs. 3B, 4B). Female and male chelicera basal segment with denticulate paraxial surface and 1 seta (cht_1); and fixed digit with 3 dorsal setae (ch_1, ch_2, ch_3). Adult chelicera fixed digit with *id* and *iα* lyrifissures; well-developed hook; female with 2 and male with 1 ventral denticle; lateral denticle absent; *ogc* present. **Subcapitulum (Figs. 3A, 4A).** Subcapitulum

paralabial setae present; *pl1* conical, obtuse, inserted between cb_3 and cb_4; *pl2* (With's organ) discoid, marginally barbed; *pl3* (rutella) inserted dorsolaterally with a distinct row of 5 teeth; *pl4* tiny, conical, inserted dorsally near the base of *pl3*; all 4 pairs of circumbuccal setae (*cb*) with bifurcate tips; cb_4 equal size of other *cb* setae; female with 1–4 rounded tip setae, 7–9 pairs of pointed setae (*vm, lvm, vp, lvp*) and 1 *ldm* setae; male with 1 rounded tip seta; 7–11 pairs of pointed setae (*vm, lvm, vp, lvp*) and 1 *ldm* setae; both adults with lateral lips with distinct canals (*dl1*, *dl2*) and their orifices (*ogl1*, *ogl2*).

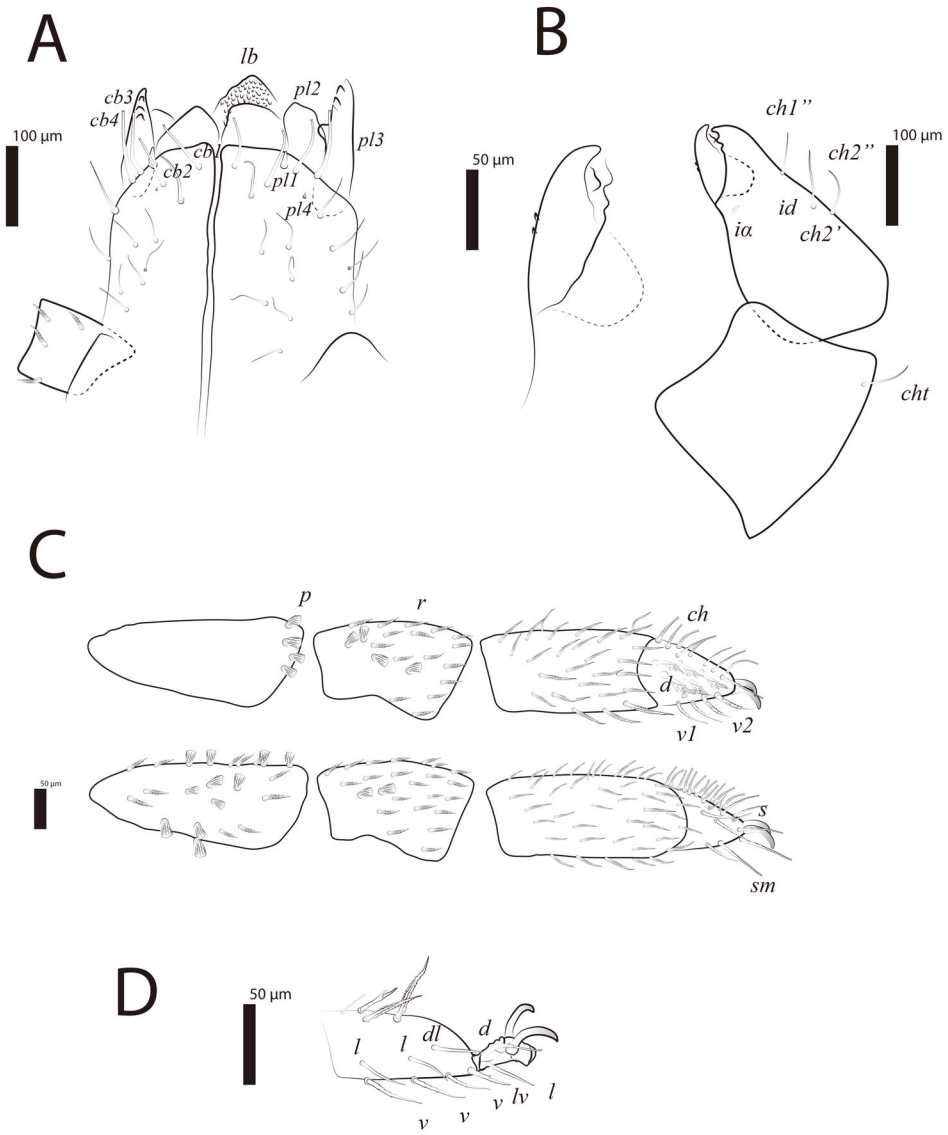

FIGURE 3. *Neocarus jonasi* **n. sp.** Female gnathosoma: **(A)** subcapitulum ventral view; **(B)** chelicera; **(C)** dorsal and ventral view of palptarsi. **(D)** Female leg II tarsus lateral view.

Palps (Figs. 3C, 4C). *Female* trochanter with 4–5 *r* setae. Femur with 12–19 *r* and 12–19 *p* setae. Spike-like setae absent. Genu with 37–47 *r* and 4–11 *p* setae. Tibia with subequal length setae, 63–82 *r* and 3 *s*. Tarsus with *iα* and *iπ* lyrifissures; 6-7 *d1* foliate; stout pointed setae with 4–5

lobules; 5–6 *v1*; 2–6 *v2*; *v3* absent; 3 *s*; 10–13 *sm1* and 14–23 *ch* setae. Tarsus apotele distal; ventral margin smooth.

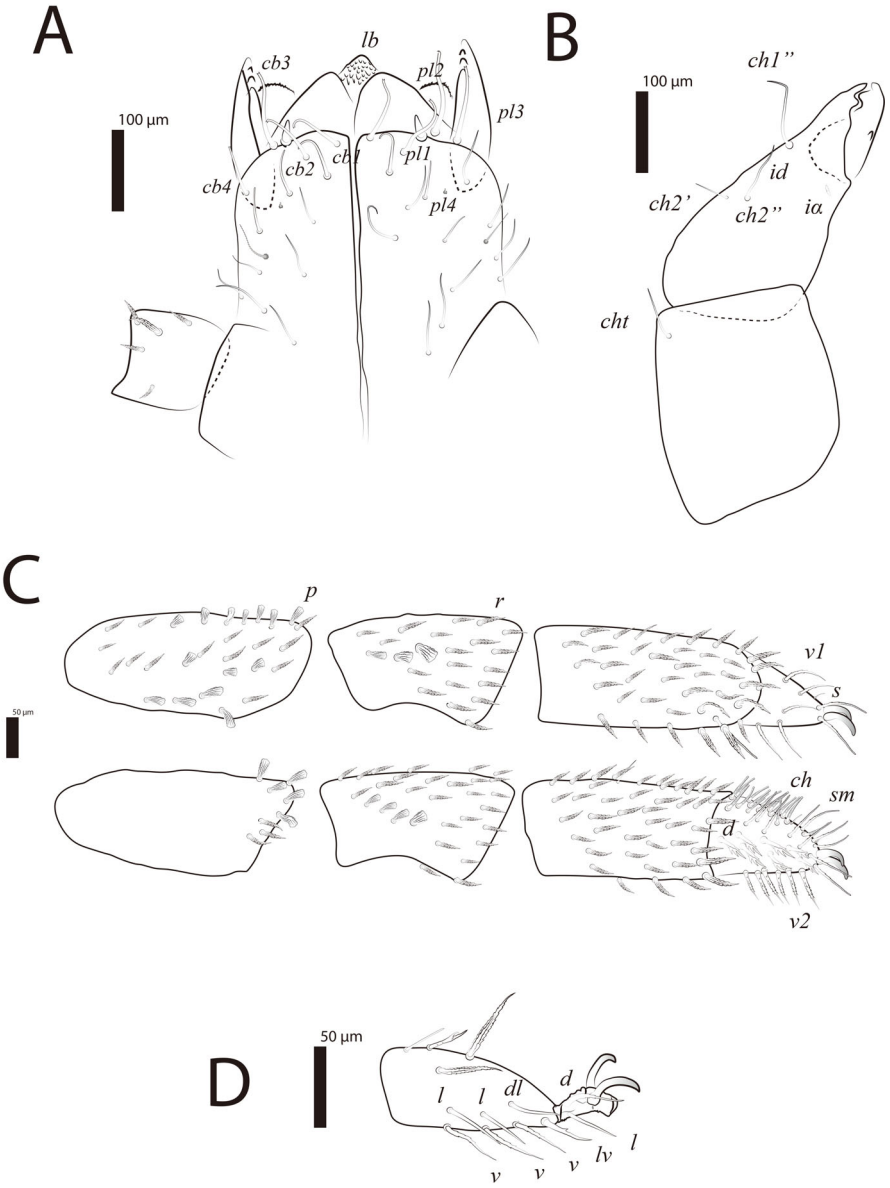

FIGURE 4. *Neocarus jonasi* **n. sp.** Male gnathosoma: **(A)** subcapitulum ventral view; **(B)** chelicera; **(C)** dorsal and ventral view of palptarsi. **(D)** Male leg II tarsus lateral view.

Male. Trochanter with 4–6 *r* setae. Femur with 11–24 *r* and 7–15 *p* setae. Spike-like setae absent. Genu with 29–54 *r* and 1–6 *p* setae. Tibia with subequal length, 53–83 *r* and 3 *s* setae. Tarsus with *ia* and *iπ* lyrifissures; 6-7 *d1* foliate, stout pointed setae with 4–5 lobules; 3 *s*; 3–6 *v1*; 3–7 *v2*; *v3* absent; 10–11 *sm1*; *sm3* absent and 14–20 *ch* setae. Apotele distal with ventral margin smooth.

LEGS. Papilliform setae longer than broad. Legs I–IV thin; papiliform setae present. **Legs I:** legs I longer than others; tibia I distal long setae absent; basitarsus I proximal long setae absent; telotarsus I with a highly modified group of dorsal distal setae in a depression; *ω1* conical, *ω2*

ligulate, *ω3* subulate acuminate, *ω4* acicular; *ζ1* small with crown-like tip inserted close to sensilla group and a *ζ2* filiform with bifid tip. **Legs II (Fig. 3D, 4D):** acrotarsus II with a bifid seta longer than wide and a smooth dorsal seta and *ωa* solenidion. **Legs IV:** tibia IV without coronidia. **Legs I–IV:** all other leg segments with 3 types of setae arranged in distal to basal lines: 1) tapering and barbed, 2) papilliform and 3) smooth setae. **Legs II–III:** tibia II–III without coronidia. Genu II–III without coronidia. **Legs II–IV:** femur II–IV without ventral trichobothria. Basitarsus II–IV with coronidia. Acrotarsus II–IV with 3 ventral setae pairs *v*; 3 lateral setae pairs *l/dl*, a pair of long serrated dorsolateral setae, and a pair of distal lightly bifid *lv* setae. Pretarsi II–IV with 1 pair of well-developed sessile claws and 2 pairs of setae, 1 setal pair long and curved, other pair smaller and apically pectinate; ambulacrum rounded and smooth; with a pair of well-developed sessile claws. **Legs III–IV:** acrotarsi III–IV with a long dorsal serrated seta.

Measurements. Female. Idiosoma: length 2308–2691;width at level of ocelli 426–486, palp: trochanter 118–143, femur 240–329, genu 211–334, tibiotarsus 344–374; chelicera length: basal segment 223–299, fixed digit 305–387; **leg I:** trochanter 525–633, basifemur 98–112, telofemur 1334–1692, genu 1083–1365, basitibia 846–992, telotibia 635–718, basitarsus 596–744, telotarsus 516–580; **leg II:** trochanter 265–321, femur 703–956, genu 354–476, tibia 402–534, basitarsus 478–659, telotarsus 417–529, acrotarsus 87–122; **leg III:** basitrochanter 231–291, telotrochanter 195–266, femur 601-823, genu 368–492, tibia 415–546, basitarsus 479–650, telotarsus 423–536, acrotarsus 95–130; **leg IV:** basitrochanter 371–425, telotrochanter 338–440, femur 901–1185, genu 546–691, tibia 692–879, basitarsus 668–931, telotarsus 534–692, acrotarsus 103–124. **Male. Idiosoma:** length 2111–2549, width at level of ocelli 386–487; palp: trochanter 109–152, femur 242–318, genu 182–228, tibiotarsus 285–359; chelicera length: basal segment 230–278, fixed digit 288–342; **leg I:** trochanter 371–626, basifemur 72–126, telofemur 783–1702, genu 632–1383, basitibia 792–1172, telotibia 583–672, basitarsus 399–721, telotarsus 392–595; **leg II:** trochanter 213–326, femur 578–947, genu 304–499, tibia 327–551, basitarsus 367–646, telotarsus 367–554, acrotarsus 89–121; **leg III:** basitrochanter 181–294, telotrochanter 176–301, femur 526–779, genu 312–453, tibia 338–539, basitarsus 425–660, telotarsus 372–533, acrotarsus 85–110; **leg IV:** basitrochanter 322–465, telotrochanter 270–436, femur 745–1208, genu 469–705, tibia 620–883, basitarsus 104–897, telotarsus 469–696, acrotarsus 95–138.

Key to species of *Neocarus* Chamberlin & Mulaik, 1942
(based on adult specimens)

1 Female ovipositor presenting projections or terminal setae 2
- Female ovipositor without projections or terminal setae 8
2 Female ovipositor presenting digitiform projections 3
- Female ovipositor presenting terminal setae 4
3 Female ovipositor presenting 4 pairs of smooth digitiform projections . . . . . *N. coronatus*
- Female ovipositor presenting 3 pairs of barbed digitiform projections . . . . . *N. entrerios*
- Female ovipositor presenting a single pair of barbed digitiform projection . . . . . *N. belizensis*
4 Female ovipositor with less than 30 terminal setae 5
- Female ovipositor with 40 or more terminal setae . . . . . *N. comalensis*
5 Female ovipositor with 14 to 27 terminal setae 6
- Female ovipositor with 13 or less terminal setae 7
6 Male genital area with 7–11 acute smooth setae . . . . . *N. bajacalifornicus bajacalifornicus*
- Male genital area with 4–6 stout ribbed setae . . . . . *N. bajacalifornicus chamelaensis*
7 Male palp tarsus presenting *sm3* type setae . . . . . *N. nohbecanus*
- Male palp tarsus lacking *sm3* type setae . . . . . *N. chactemalensis*

8 Female with eugenital setae 9
- Female with no eugenital setae 11
9 Male pregenital area with acute ribbed setae 10
- Male pregenital area with stout ribbed setae 16
10 Female palp femur with 4–6 *p* setae, palp genu with 16–29 *r* setae, palp tibia with 32–57 r setae, palp tarsus with 7–8 *sm* setae . . . . . *N. spelaion*
- Female palp femur with 12–19 *p* setae, palp genu with 37–47 *r* setae, palp tibia with 63–82 *r* setae, palp tarsus with 9–10 *sm* setae . . . . . *N. jonasi* **n. sp.**
11 Male palp tarsus lacking *sm3* type setae 12
- Male palp tarsus presenting *sm3* type setae . . . . . *N. orghidani*
12 Male palp tarsus with 10–11 *sm1* and 11–16 *ch* setae 13
- Male palp tarsus with 8 *sm1* and 19 *ch* setae . . . . . *N. veracruzensis*
13 Female subcapitulum with 6–8 pointed setae; male genital area with stout ribbed setae 14
- Female subcapitulum with 10–11 pointed setae; male genital area with acute smooth setae . . . . . *N. texanus*
14 Female pregenital area with stout ribbed setae 15
- Female pregenital area with no setae . . . . . *N. siankaanensis*
15 Female dorsal shield with 131 setae, anal valves with 12–13 setae, ovipositor slightly striated, palp tarsus with 18–22 *ch*; male with 121 setae, anal valves with 8 setae, palp tarsus with 16 *ch* setae . . . . . *N. nicaraguensis*
- Female dorsal shield with 99 setae, anal valves with 8 setae, ovipositor strongly striated, palp tarsus with 15–17 *ch* setae; male dorsal shield with 58 setae, anal valves with 6–7 setae, palp tarsus with 11 *ch* setae . . . . . *N. calakmulensis*
16 Female dorsal shield with less than 170 setae; male dorsal shield with less than 142 setae 17
- Female dorsal shield with 186–204 setae, male dorsal shield with 218–242 setae . . . . . *N. simmonsi*
17 Male palp tarsus with 19 or less *ch* setae 18
- Male palp tarsus 25–27 *ch* setae . . . . . *N. potiguar*
18 Female pregenital area with no setae 19
- Female pregenital area with 2–5 stout ribbed setae . . . . . *N. proteus*
19 Female ovipositor with 9 or more eugenital setae 20
- Female ovipositor with 4–8 eugenital setae . . . . . *N. platensis*
20 Female anal valves with 9–10 setae; male palp femur with 2–4 *r* setae, genu with 7–12 setae, tibia with 21–31 *r* setae . . . . . *N. caipora*
- Female anal valves with 11–16 setae; male palp femur with 15 *r* setae, genu with 29 *r* setae, tibia 57 *r* setae . . . . . *N. misiones*

Discussion

Variation in the chaetotaxy of Opilioacaridae is often found, either in the same species or specimen, mainly for structures in pairs such as sternal verrucae, genital capsules, anal valves. Also, the variation in the shape of pregenital setae is not rare, being previously reported (e.g., Araújo *et al.* 2018a; Bernardi *et al.* 2013; Bernardi & Borges-Filho 2018), indicating a development during molting (Araújo *et al.* 2018b).

This perception of variation often includes specimens divided by geographical barriers in the same valid species. Despite being considered an endemic group (Bernardi *et al.* 2012; Vázquez *et al.* 2015; Vázquez & Klompen 2015), Opilioacaridae also present distributions considered extensive for the group such as for *N. potiguar* with 150km of extension in the game GMU (Bernardi *et al.* 2012), *N. texanus* around 1500km crossing the southern USA and northern Mexico (Vázquez & Klompen 2015), as for aquatic geographic barriers as in *O. brignolii* with 600km between the island of Sardinia and the Italian mainland (Araújo *et al.* 2018b).

Diagnoses in Opilioacaridae are usually focused on the palpal *d* type, pregenital and genital setae, but some species also include the tibia *r* setae shape or number as a diagnostic character

(Vázquez *et al.* 2015, 2018). The tibia hypertichy of *N. jonasi* **n. sp.** is partially shared with *N. belizensis, N. coronatus, N. texanus* and *N. veracruzensis* and also with *Caribeacarus* species, *C. armasi* and *C. panamensis.* The 5 to 7 *d* type foliate setae, is only shared with other undescribed hypogeic species in Brazil (MSA, *pers. obs.*).

An unpublished phylogeny reveals the close relationship between *N. jonasi* **n. sp.** and *N. spelaion*. This relationship is corroborated by the proximity of their collection sites (around 135 km) and the same GMU, the Bambuí group.

Despite the similarity, *N. jonasi* **n. sp.** has a greater number of palp setae when compared to *N. spelaion*: genu with 37–47 (female) and 29–54 (male) to 16–29 *r* setae; tibia with 63–82 (female) and 53–83 (male) to 16–27 *r* setae (32-57 in total with *s* barbed setae); tarsus with 10–13 (female) and 10–11 (male) *sm* setae to 7–8 *sm*; and 5–7 to 5–6 *d* type setae. The separate description of males and females (e.g., Araújo *et al.* 2018a; b), even when overlapping occurs, is extremely important for more specific comparisons.

The 10-12 smooth genital setae of *N. spelaion* correspond to the 10–15 eugenital setae of *N. jonasi* **n. sp.**, as different interpretations of the nomenclature have been addressed. The pregenital and genital setae are situated at the exterior part, on plates, the eugenital setae are inside and under genital opening (Vázquez *et al.* 2015), while ovipositor setae do not present a clear base (Vázquez & Klompen 2009). This is a rare condition, but is present in *Indiacarus pratyushi* Das & Bastawade 2007, and *Paracarus hexophthalmus* Redikorzev 1937 as presented by Hammen (1968).

As for *N. spelaion, N. jonasi* **n. sp.** in the Bambuí GMU region is under intense pressure from mining activities, allied to the deforestation in the cave surroundings. It impacts the immediate environment, threatening both epigean (Simões *et al.* 2014) and hypogean species (Pinto-da-Rocha *et al.* 2015).

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References

Araújo, M.S., Bichuette, M.E., Bauchan, G.R., Ochoa, R. & Feres, R.J.F. (2018a) A new species of cave dwelling *Neocarus* (Acari: Opilioacaridae) from Bahia state, Brazil, with remarks on taxonomic characters. *Zootaxa*, 4402, 303–322.
https://doi.org/10.11646/zootaxa.4402.2.4

Araújo, M.S., Di Palma, A. & Feres, R.J.F. (2018b) A new species of *Opilioacarus* With, 1902 (Acari: Opilioacaridae) from Italy, and a new diagnosis of the genus. *Zootaxa*, 4500, 135–145.
https://doi.org/https://doi.org/10.11646/zootaxa.4500.1.9

Araújo, M.S., Di Palma, A. & Feres, R.J.F. (2020) Catalog of the Opilioacarida (Acari: Parasitiformes). *Zootaxa*, 4895, 332–356.
https://doi.org/https://doi.org/10.11646/zootaxa.4895.3.2

Bernardi, L.F. de O. & Borges-Filho, E.L. (2018) *Neocarus spelaion* sp. n. (Parasitiformes, Opilioacaridae), a

new species of cave dwelling *Neocarus* from Minas Gerais state, Brazil. *Subterranean Biology*, 27, 1–16. https://doi.org/10.3897/subtbiol.27.25777

Bernardi, L.F.O., Klompen, H. & Ferreira, R.L. (2014) *Neocarus caipora*, a new mite species (Parasitiformes: Opilioacarida: Opilioacaridae) from Brazilian amazon caves. *Acarologia*, 54, 47–56. https://doi.org/10.1051/acarologia/20142113

Bernardi, L.F.O., Klompen, H., Zacarias, M.S. & Ferreira, R.L. (2013a) A new species of *Neocarus* Chamberlin & Mulaik, 1942 (Opilioacarida, Opilioacaridae) from Brazil, with remarks on its postlarval development. *ZooKeys*, 358, 69–89. https://doi.org/10.3897/zookeys.358.6384

Bernardi, L.F.O., Silva, F.A.B., Zacarias, M.S., Klompen, H. & Ferreira, R.L. (2013b) Phylogenetic and biogeographic analysis of the genus *Caribeacarus* (Acari: Opilioacarida), with description of new South American species. *Invertebrate Systematics*, 27, 294–306.

Bernardi, L.F.O., Zacarias, M.S. & Ferreira, R.L. (2012) A new species of *Neocarus* Chamberlin & Mulaik, 1942 (Acari: Opilioacarida) from Brazilian caves of karst area. *Zootaxa*, 68, 53–68.

Bernardi, L.F.O., Zampaulo, R.A. & Oliveira, M.P.A. (2020) A new species of *Neocarus* (Opilioacaridae) from a Brazilian ferruginous geosystem and notes on natural history. *Subterranean Biology*, 33, 11–33. https://doi.org/10.3897/subtbiol.36.54034

Chamberlin, R.V. & Mulaik, S. (1942) On a new family in the Notostigmata. *Proceedings of the Biological Society of Washington*, 55, 125–132.

Coleman, C.O., Lowry, J.K. & Macfarlane, T. (2010) DELTA for Beginners: An introduction into the taxonomy software package DELTA. *ZooKeys*, 45, 1–75. https://doi.org/10.3897/zookeys.45.263

Dallwitz, M.J., Paine, T.A. & Zurcher, E.J. (2013) User's guide to the DELTA Editor. Available from: http://delta-intkey.com

Das, N.P.I. & Bastawade, D.B. (2007) The first report of the acarine suborder Opilioacarida from India, with description of new genus, *Indiacarus*, and a new species, Indiacarus pratyushi. *Acarologia*, 47, 3–11.

Fisher, J.R. & Dowling, A.P.G. (2010) Modern methods and technology for doing classical taxonomy. *Acarologia*, 50, 395–409. https://doi.org/10.1051/acarologia/20101981

Grandjean, F. (1936) Un acarien synthétique: *Opilioacarus segmentatus* With. *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord*, 27, 413–444.

Guimarães, R.L. (2012) Mapeamento geomorfológico do carste da região de Monjolos, Minas Gerais. Pontificia Universidade Católica de Minas Gerais, Belo Horizonte, Brazil.

van der Hammen, L. (1966) Studies on Opilioacarida (Arachnida) I. Description of *Opilioacarus texanus* (Chamberlin & Mulaik) and revised classification of the genera. *Zoologische Verhandelingen*, 86, 3–80.

van der Hammen, L. (1968) Studies on Opilioacarida (Arachnida) II. Redescription of *Paracarus hexophthalmus* (Redikorzev). *Zoologische Mededelingen*, 43, 57–76.

van der Hammen, L. (1977) Studies on Opilioacarida (Arachnidea) IV. The genera Panchaetes Naudo and *Salfacarus* gen. nov. *Zoologische Mededelingen*, 51, 43–78.

Klompen, H., Vázquez, M.M. & Bernardi, L.F.O. (2015) Post-embryonic development in the mite suborder Opilioacarida, with notes on segmental homology in Parasitiformes (Arachnida). *Experimental and Applied Acarology*, 67, 183–207. https://doi.org/10.1007/s10493-015-9939-7

Kottek, M., Grieser, J., Beck, C., Rudolf, B. & Rubel, F. (2006) World map of the Köppen-Geiger climate classification updated. *Meteorologische Zeitschrift*, 15, 259–263. https://doi.org/10.1127/0941-2948/2006/0130

Leclerc, P. (1989) Considérations paléobiogéographiques à propos de la découverte en Thaïlande d'opilioacariens nouveaux (Acari - Notostigmata). *Compte Rendu des Séances de la Société de Biogéographie*, 65, 162–174.

Moraza, M.L., Prieto, C.E. & Balanzategui, I. (2021) A new species of the genus *Opilioacarus* With, 1902 (Acari: Opilioacarida) for the Iberian Peninsula. *Acarologia*, 1902, 1–26. https://doi.org/10.24349/acarologia/20214422

Pinto-da-Rocha, R., Fonseca-Ferreira, R. & Bichuette, M.E. (2015) A new highly specialized cave harvestman from Brazil and the first blind species of the genus: *Iandumoema smeagol* sp. n. (Arachnida, Opiliones, Gonyleptidae). *ZooKeys*, 537, 79–95.

https://doi.org/10.3897/zookeys.537.6073
Redikorzev, V. (1937) Eine neue Opilioacarus-Art. *Zoologischer Anzeiger*, 118, 10–12.
Sá Júnior, A., Carvalho, L.G., Silva, F.F. & Alves, M.C. (2012) Application of the Köppen classification for climatic zoning in the state of Minas Gerais, Brazil. *Theoretical and Applied Climatology*, 108, 1–7. https://doi.org/10.1007/s00704-011-0507-8
Schneider, C.A., Rasband, W.S. & Eliceiri, K.W. (2012) NIH Image to ImageJ: 25 years of image analysis. *Nature Methods*, 9, 671–675.
Simões, M.H., Souza-Silva, M. & Ferreira, R.L. (2014) Cave invertebrates in northwestern Minas Gerais state, Brazil: endemism, threats and conservation priorities. *Acta Carsologica*, 43, 159–174.
Stávale, Y.O. (2012) Espacialização do patrimônio espeleológico da Reserva da Biosfera da Serra do Espinhaço: geossítios selecionados e sua importância para a geoconservação. Universidade Federal de Minas Gerais, Belo Horizonte, Brasil.
Vázquez, M.M., De Araújo, M.S. & Feres, R.J.F. (2014) A new genus and two new species of Opilioacaridae (Acari: Parasitiformes) from Amazonia, Brazil with a key to world genera. *Zootaxa*, 3814, 151–176. https://doi.org/10.11646/zootaxa.3814.2.1
Vázquez, M.M., De Araújo, M.S. & Feres, R.J.F. (2015) *Brasilacarus cocaris* (Acari: Opilioacaridae), a new genus and species from Amazonia, Brazil. *Zootaxa*, 3915, 375–389. https://doi.org/10.11646/zootaxa.3915.3.3
Vázquez, M.M. & Klompen, H. (2002) The family Opilioacaridae (Acari: Parasitiformes) in North and Central America, with description of four new species. *Acarologia*, 42, 299–322.
Vázquez, M.M. & Klompen, H. (2009) New species of New World Opilioacaridae (Acari: Parasitiformes) with the description of a new genus from the Caribbean region. *Zootaxa*, 2061, 23–44. https://doi.org/10.11646/zootaxa.2061.1.2
Vázquez, M.M. & Klompen, H. (2010) The genus *Salfacarus* (Acari: Opilioacarida) in Madagascar. *Zootaxa,* 2482, 1–21. https://doi.org/10.11646/zootaxa.2482.1.1
Vázquez, M.M. & Klompen, H. (2015) The family Opilioacaridae (Parasitiformes: Opilioacarida) in Mexico, description of two new species and notes on biology and geographical distribution. *Zootaxa*, 3957, 535–552. https://doi.org/10.11646/zootaxa.3957.5.3
Vázquez, M.M., May, D., Alamilla, E. & Klompen, H. (2018) A new species of Opilioacaridae (Parasitiformes: Opilioacarida) from Belize with some observations on life history and behavior. *Systematic & Applied Acarology*, 23, 132–142. https://doi.org/10.11158/saa.23.1.11
Walter, D.E. & Krantz, G.W. (2009) Collecting, Rearing, and Preparing Specimens. *In*: Krantz, G.W. & Walter, D.E. (Eds.), *Manual of acarology*. Lubbock Texas, Texas Tech University Press, pp. 83–96.

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