



The family Opilioacaridae (Parasitiformes: Opilioacarida) in Mexico, description of two new species, new records, and geographical distribution

MA. MAGDALENA VÁZQUEZ^{1,3}, GABRIELA CASTAÑO-MENESES² & ABRAHAM RODRÍGUEZ²

¹División de Desarrollo Sustentable, Universidad Autónoma del Estado de Quintana Roo, Mexico.

M.M. Vázquez: [✉ marvazqu@uqroo.mx](mailto:marvazqu@uqroo.mx), [ORCID](https://orcid.org/0000-0001-6283-1887) <https://orcid.org/0000-0001-6283-1887>

²Ecología de Artrópodos en Ambientes Extremos, Unidad Multidisciplinaria de Docencia e Investigación, Facultad de Ciencias, Campus Juriquilla, Boulevard Juriquilla 3001, Col. Jurica La Mesa 76230, Juriquilla, Querétaro, Mexico.

G. Castaño-Meneses: [✉ gcastanom@ciencias.unam.mx](mailto:gcastanom@ciencias.unam.mx), [ORCID](https://orcid.org/0000-0002-5405-5221) <https://orcid.org/0000-0002-5405-5221>

A. Rodríguez: [✉ abrrodalv@hotmail.com](mailto:abrrodalv@hotmail.com), [ORCID](https://orcid.org/0000-0002-9536-7256) <https://orcid.org/0000-0002-9536-7256>

³Corresponding author

Abstract

Two new species of *Neocarus* (Opilioacarida: Opilioacaridae), *N. haicolous* n. sp. and *N. queretanus* n. sp., are described from mesophyll and pine-oak forests in the state of Querétaro, central Mexico. One species was described from adults and tritonymphs. Distribution and habitat preferences of all known collections of Opilioacarida are reviewed. In Mexico, they have been collected in all habitats, from semideserts areas to tropical forest and from to sea level in dunes to high temperate and cloud forest.

Key words: *Neocarus*, Central Mexico, litter, soil, species richness, habitat distribution

Introduction

The family Opilioacaridae is represented in Mexico by the genera *Neocarus* and *Caribeacarus* (Vázquez & Klompen 2015). At a global level, *Neocarus* is the most diverse genus with 22 species (Araújo *et al.* 2021). In Mexico, *Neocarus* is represented by seven species and one subspecies: *N. bajacalifornicus* (Vázquez & Klompen, 2002); *N. bajacalifornicus chamelaensis* Vázquez & Klompen, 2009; *N. nohbecanus* (Vázquez & Klompen, 2002); *N. veracruzensis* Vázquez & Klompen, 2009; *N. calakmulensis* Vázquez & Klompen, 2009; *N. siankaanensis* (Vázquez & Klompen, 2002); *N. chactemalensis* Vázquez & Klompen, 2015; and *N. comalensis* Vázquez & Klompen, 2015.

These species inhabit a variety of terrestrial habitats, from dunes at sea level to pine-oak forest at altitudes of 2,200 m, and in several biotopes such as litter, sand, under rocks, in mangrove soils and in logs (Vázquez & Klompen 2002, 2009, 2015). The main goal of this study was to describe two new species of Opilioacaridae from high temperate and cloud forests of Mexico.

Study area

Specimens were collected in Jalpan de Serra municipality in the state of Querétaro, Mexico (Fig. 1). The area is located in the Sierra Gorda Biosphere Reserve, which has a high ecosystem diversity (de la Llanta Gómez *et al.* 2006). The sampling area (21°27'40.80"N, 99°10'45.00"W) belongs to the Huasteco Karst physiographic province (Cervantes-Zamorano *et al.* 1990) in the Pánuco river watershed (Priego *et al.* 2007). According to the Köppen classification modified by García (2004) the area's climate is (A)C(w1), with an annual average precipitation of 1500–2000 mm and temperature range between 20 to 22°C (Vidal-Zepeda 1990). One species was in the mountain mesophyll forest in Ojo de Agua de San Francisco village, and the other in pine-oak forest in San Juan de los Duran locality (Fig. 1-C). The general vegetation in the area is shown in Fig. 1-D.

(Fig. 1) (Map and study area).

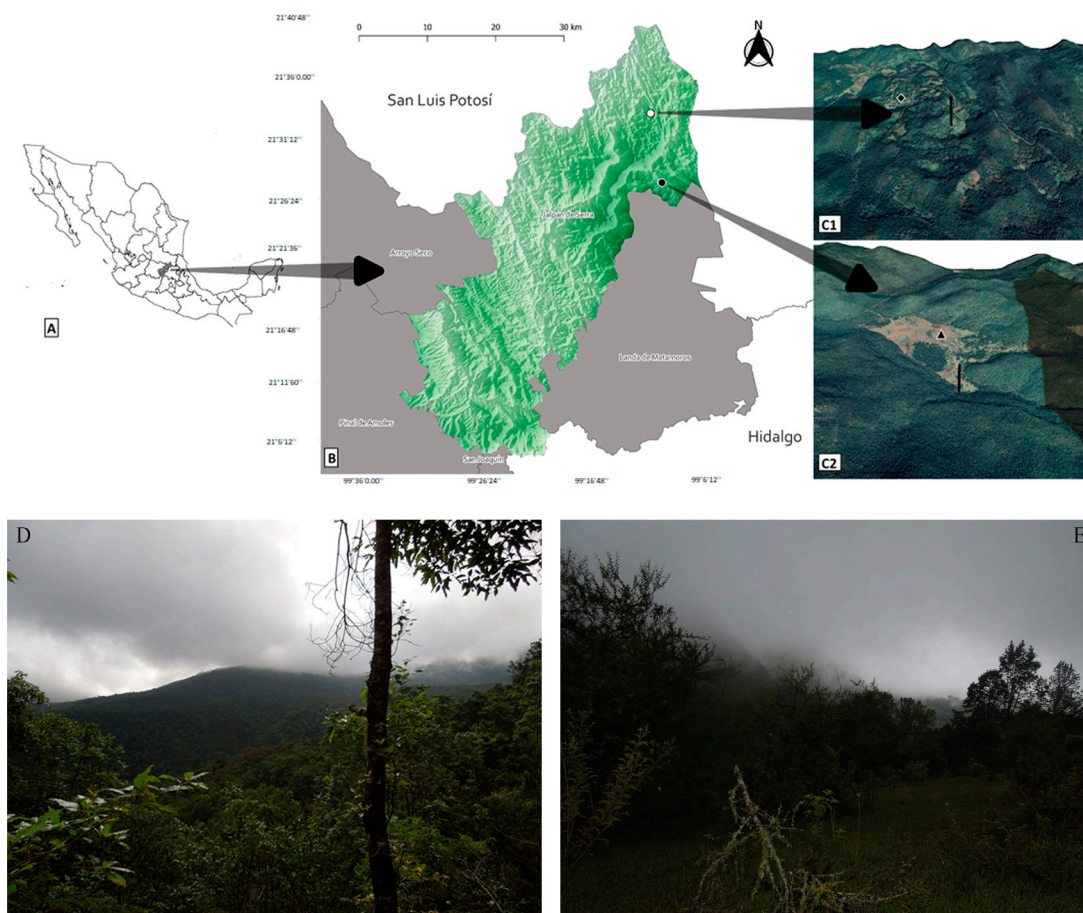


FIGURE 1. A–E. Study area. **A.** State of Querétaro in Mexico, **B.** Jalpan de Serra municipality in the state of Querétaro, **C1.** Collecting area of *Neoacarus queretanus* in San Juan de los Durán (21° 27' 40.799"N, 99° 10' 45"W; 1311 m asl), **C2.** Collecting area of *Neoacarus haicolous* Ojo de Agua de San Francisco (21° 33' 10.289"N, 99° 11' 43.49" W, 1145 m asl), **D.** Mesophyll forest, Ojo de Agua de San Francisco village, **E.** Pine-oak forest, San Juan de los Durán, State of Querétaro.

Material and methods

Most specimens were examined as slide-mounts although others were examined using temporary preparations in cavity slides. Terminology for the palp tarsal sensilla follows Grandjean (1936) as modified by Vázquez & Klompen (2002). Terminology for the palp tarsal sensilla follows Grandjean (1936) as modified by Vázquez and Klompen (2002), for the sternitogenital region we follow Klompen *et al.* (2015), and for the leg sensory structures Grandjean (1936), Van der Hammen (1966), and Araújo *et al.* (2018).

The measurements are presented with some caveats. They are based on slide-mounted specimens, which means that measurements of soft structures, e. g. total length and total width, are almost certainly distorted. All measurements are in micrometers (μm) and are presented in Table 1.

Collection information. The specimens were collected in litter processed by Berlese funnels, some of them collected by hand. Most of the material studied for the description of both new species will form part of the new collection of the Laboratorio de Ecología de Artrópodos en Ambientes Extremos (LEAEx) which is housed at Unidad Multidisciplinaria de Docencia e Investigación, Facultad de Ciencias, Campus Juriquilla, Universidad Nacional Autónoma de México (UNAM). The other material is deposited at Laboratorio de Microatropodos Edáficos, Departamento de Ciencias, Universidad Autónoma del Estado de Quintana Roo (UAEQROO).

TABLE 1. Comparative measurements for new species of *Neocarus* from Mexico.

* Ovipositor inside of the female.

Δ Ovipositor everted

n.a information not available

	sex	N	Lengthbody	Width body	Length ovip	Width ovip	Length male glands	Width male glands
<i>N. haicolous</i>	♀	3	1830	1030	200 *	150 *		
	♂	2	1930	1000			n.a	n.a
	Tn	1	1150	8000				
<i>N. queretanus</i>	♀	1	1600	200	300 Δ	200 Δ		
	♂	1	2040	1000			1550	650

Taxonomic section

Neocarus Chamberlin & Mulaik 1942

Diagnosis

With 2 pairs of eyes and With's organ membranous and discoid in form, main opisthosomal segments in adults without setae, penultimate segment of idiosoma in adults with 3 setae, palp-tarsus in adults with 4–6 *d*-type foliate setae, tarsus I sensillum with “crown like” tip in main group of sensory sensilla.

Neocarus haicolous Vázquez & Castaño-Meneses n. sp. (Fig. 2)

(Figs. 1–12)

Diagnosis. Palp tarsus with 5 *d*-type foliate setae. With 3 large and pointed lobes each. Area between sternal and genital verrucae with 2 pairs of long tapering *St* setae and 5–6 pairs of long stout, blunt, serrated *St* setae. Female with 2 short, blunt serrated setae in pregenital area, male with 7 setae on pregenital area; 2 of them ending acutely and 5 more or less blunt or acute and 5 short acute setae on genital area. Ovipositor with 2 pairs of glands-like and 2 channels and 6 thin acutely tipped eugenital setae. Males with a group of large serrated setae on tarsus.

Description. Based on observations of 3 females, 2 males, and 1 Tn.

Gnathosoma. Chelicera (Fig. 3. A–B). Basal segment in adults with 1 seta (*cht*), fixed digit with 3, one of which (*chl'*) larger, thick. Seta *cht* on basal segment of male chelicera shorter than seta *chl''* on fixed digit. Setae *ch2'*, *ch2''* and *cht* in female and males simple. Fixed digit with 1 tooth, movable digit with 2 teeth and well-developed terminal hook. Movable digit in adults and tritonymph with 1 large and 2 small ventral denticles (Fig. 3 A–B).

Subcapitulum (Fig. 3. C–D). All 4 pairs of parlabial setae present in adults; *pl1* small, conical; With's organ (*pl2*) membranous, discoid; rutellum (*pl3*) with 1 row of 5 teeth, inserted dorso-laterally; *pl4* small but distinct inserted dorsal on subcapitulum. In addition, 4 circumbuccal (*cb*), and in females 6, in males 8 median and subcapitular (*vm*, *lvm*, *ldm*, *vp*, *lvp*) setae. Lateral lips with distinct canals.

Palp. Adults (Fig. 4 A–D). Trochanter with 5 large, ribbed tapering setae (=r-type) in female and male; femur with 5 papilliform (=p-type) setae in female, 6 in male and 18–14 r-type setae, the lower number in female, genu with only 2–1 p-type setae and 42–37 r-type setae, the lower number in female. Tibia and tarsus partially fused. Tibia with 35 large lightly serrated setae in female and 29 r-type setae, 37 lightly serrated and pointed setae in male and 40–42 r-type. Small group of 6 thick, serrated and mostly large setae within r-type setae, on lateroventral border almost at border of tibia and tarsus (Fig. 5-B) only in males). Tarsus with lyrifissures *it* and *ia*. Tarsus with 5 foliate (*d*-type), *3s*, *5v* in male, *6v* in female; male with 5 *v*-2 on lateroventral side of tibia, most thicker than *v* setae on

dorsal side (Fig. 5-A and 6-A), 9–13 *ch* setae, lowest number in female, 5–7 *m* setae. Pretarsus in shape of a pair of well-developed sessile claws. Sexual dimorphism: male with 6 thick serrated and acutely tipped setae in between *r*-type setae on tibia, female without. Male with 2 pairs of big glands or testes.

Idiosoma. Color light blue-violet. Stripes on both body and legs.

Dorsum. Prodorsal shield in adults with small stout puffy setae (152–158) and a pair of eyes on dark patch (Fig. 7-A). Dorsal idiosoma between shield and preanal segment without setae, but with numerous lyrifissures arranged in transverse rows. Preanal segment with 1 dorsal and 2 ventral setae; anal plates with 8–9 stout ribbed setae in females and males (Fig. 8 A–B).

Stigmata. Stigma 1 close to lateral border of body, stigmas 2 and 4 at same distance and stigma 3 towards body axis female and male (Fig. 7 B–C).

Sternitogenital region (Fig. 8 C–D). Sternal verrucae each with 1 long, barbed, tapering seta and 2–3 smaller barbed setae. Remaining sternal area with 2 pairs of long, tapering *St* setae in both sexes, 5–6 pairs of stout, ribbed *St* setae and 3 pairs of lyrifissures very large and obvious. Pregenital capsules each with 1 long tapering and 4 (females) or 5 (males) stout ribbed setae. Pregenital area with 7 setae, 3 of them ribbed and slightly pointed, 4 of them ribbed and stout. Genital area with 5 ribbed pointed large setae. Pregenital area in female with 2 short, stout ribbed setae; genital area without setae and 6–7 thin, acute, pointed eugenital setae. Ovipositor (Fig. 9-A) of simple type, without spines, but with a single pair of gland-like structures and a pair of large channels or ducts.

Legs. Legs relatively long. Ratio of legs I to idiosoma approximately 2.5, legs IV to idiosoma about 2. Broad sensillum with “crown-like” tip (Fig. 9 B–C) in main sensillar field. Pretarsus I with well-developed sessile claws without setae.

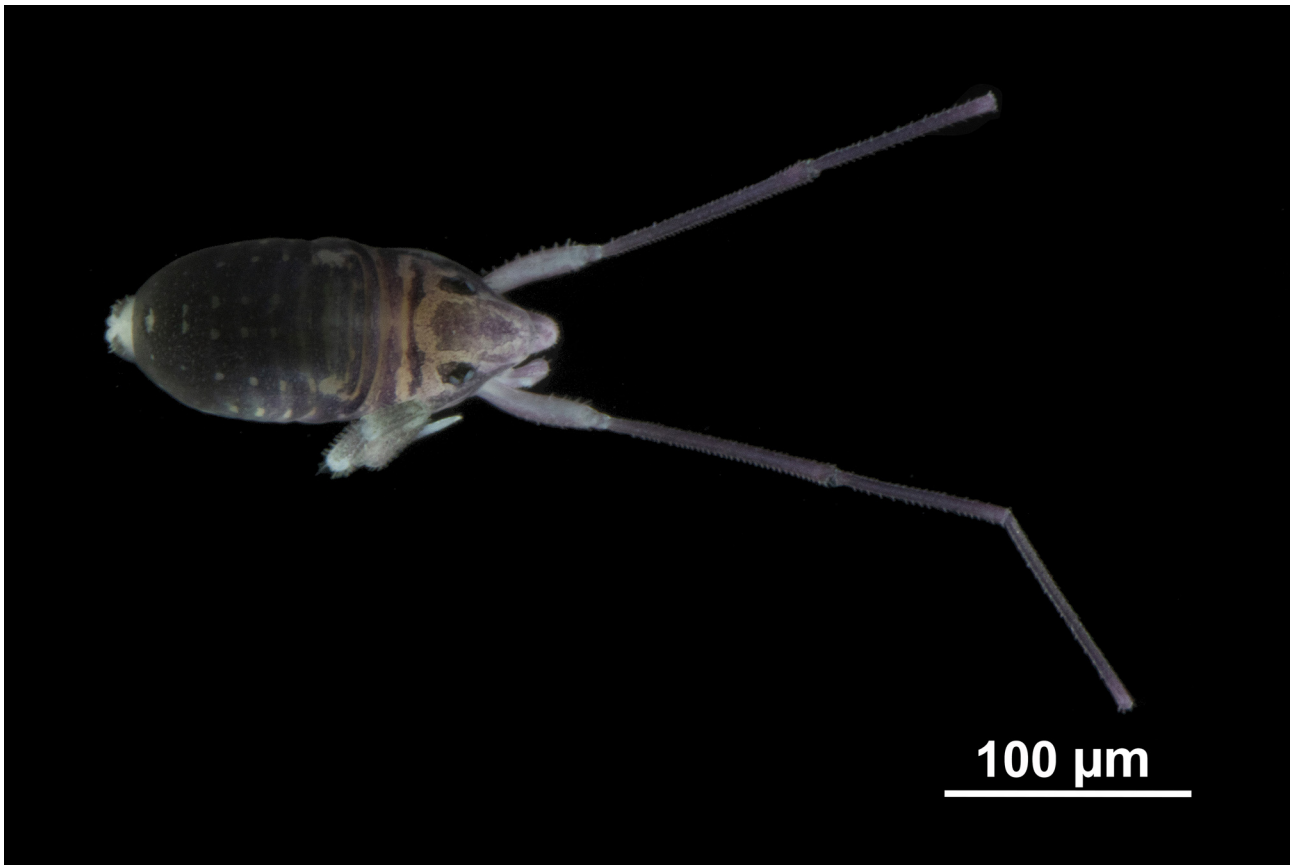


FIGURE 2. *Neocarus haicolous* n. sp. Habitus female, dorsal view (specimen photographed by L. Ibarra).

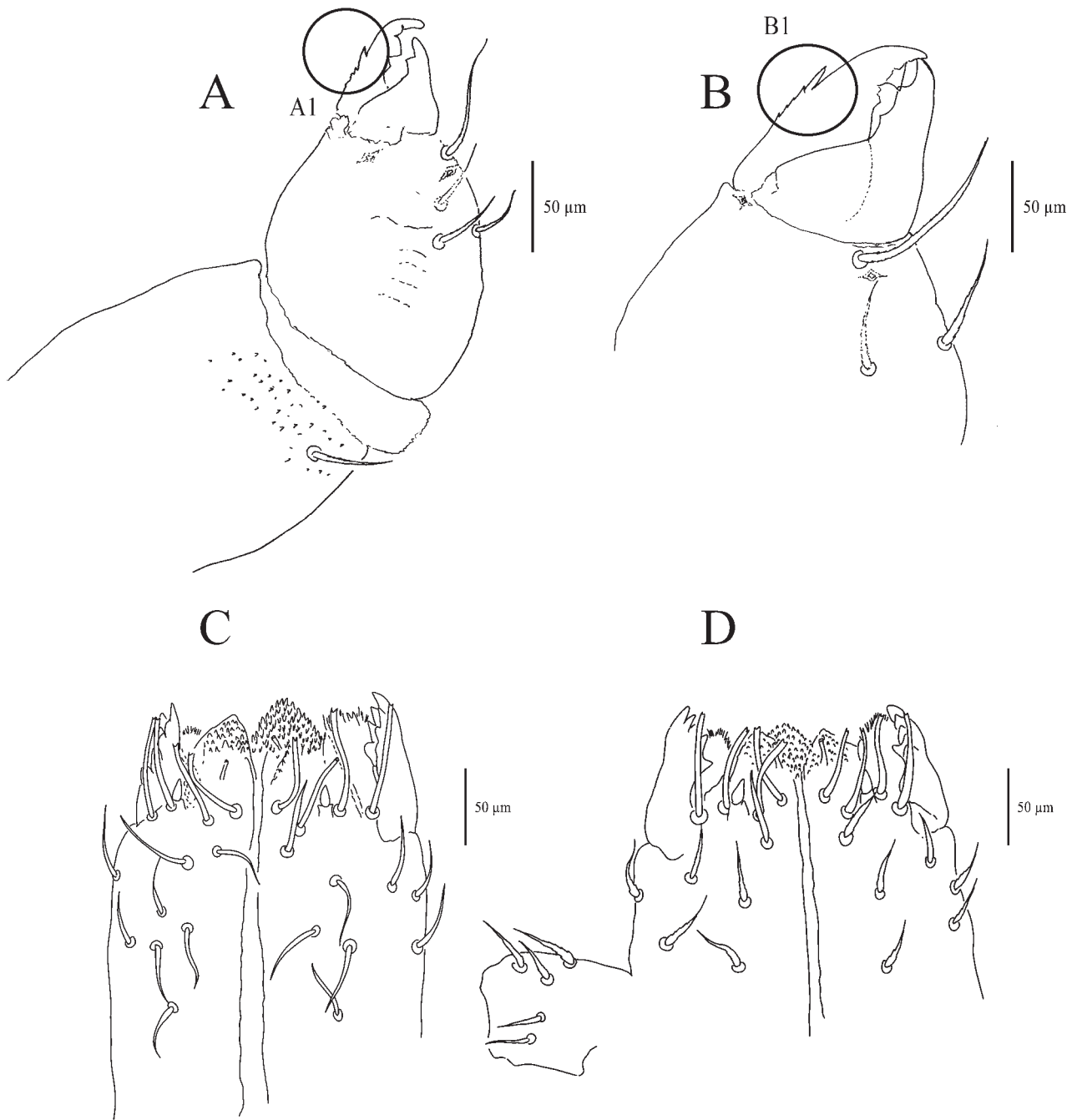


FIGURE 3. *Neocarus haicolous* n. sp. **A.** Lateral view of female chelicerae, **B.** Male chelicerae and details of denticles, ventral view of hypostome. **C.** Female, **D.** Male. A1–B1. (Circle: detail of ventral denticles).

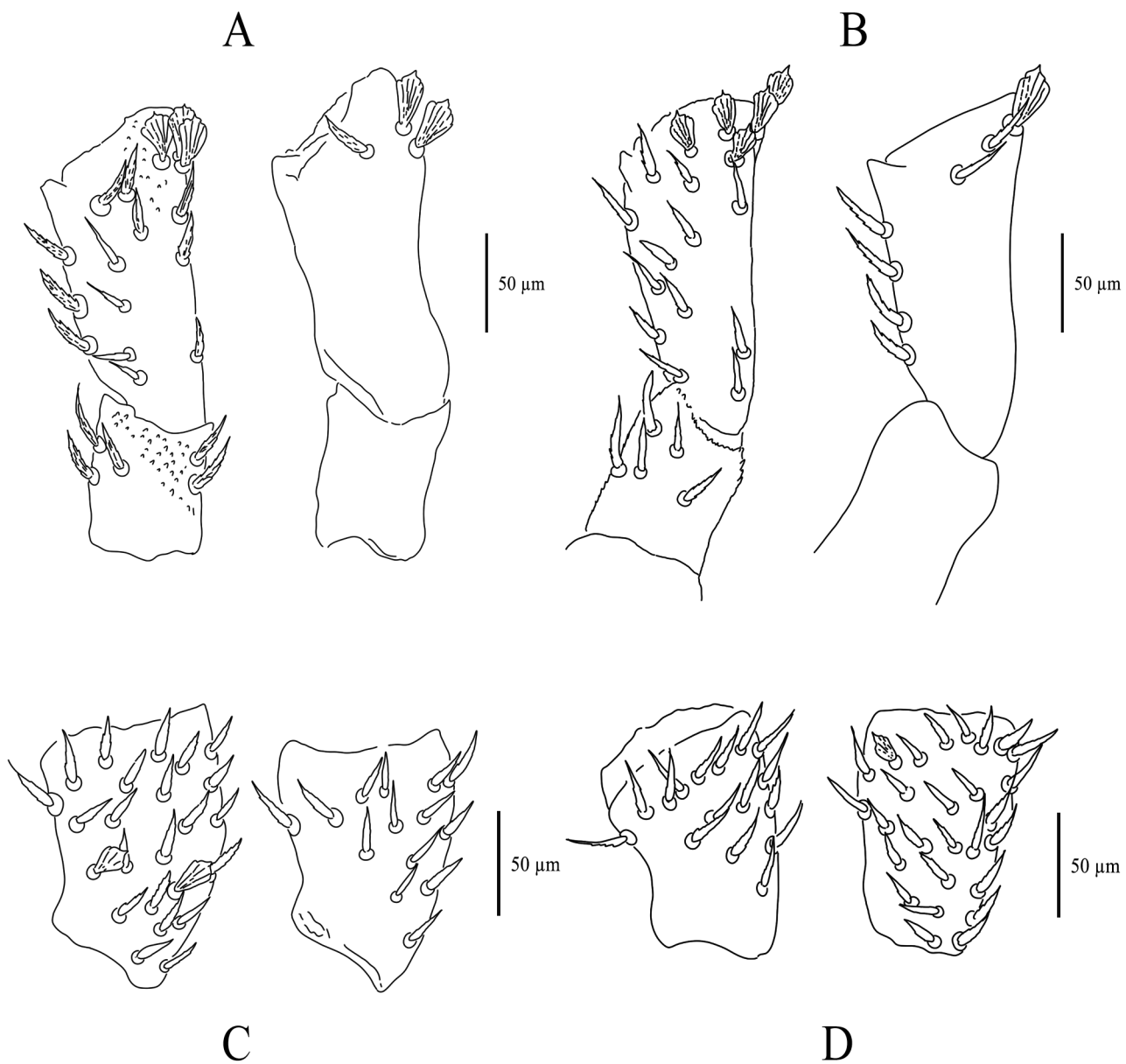


FIGURE 4. *Neocarus haicolous* n. sp. Pals. **A–B.** Dorsal and ventral view of trochanter and femur, female and male. **C–D.** Dorsal and ventral view of genu, female and male.

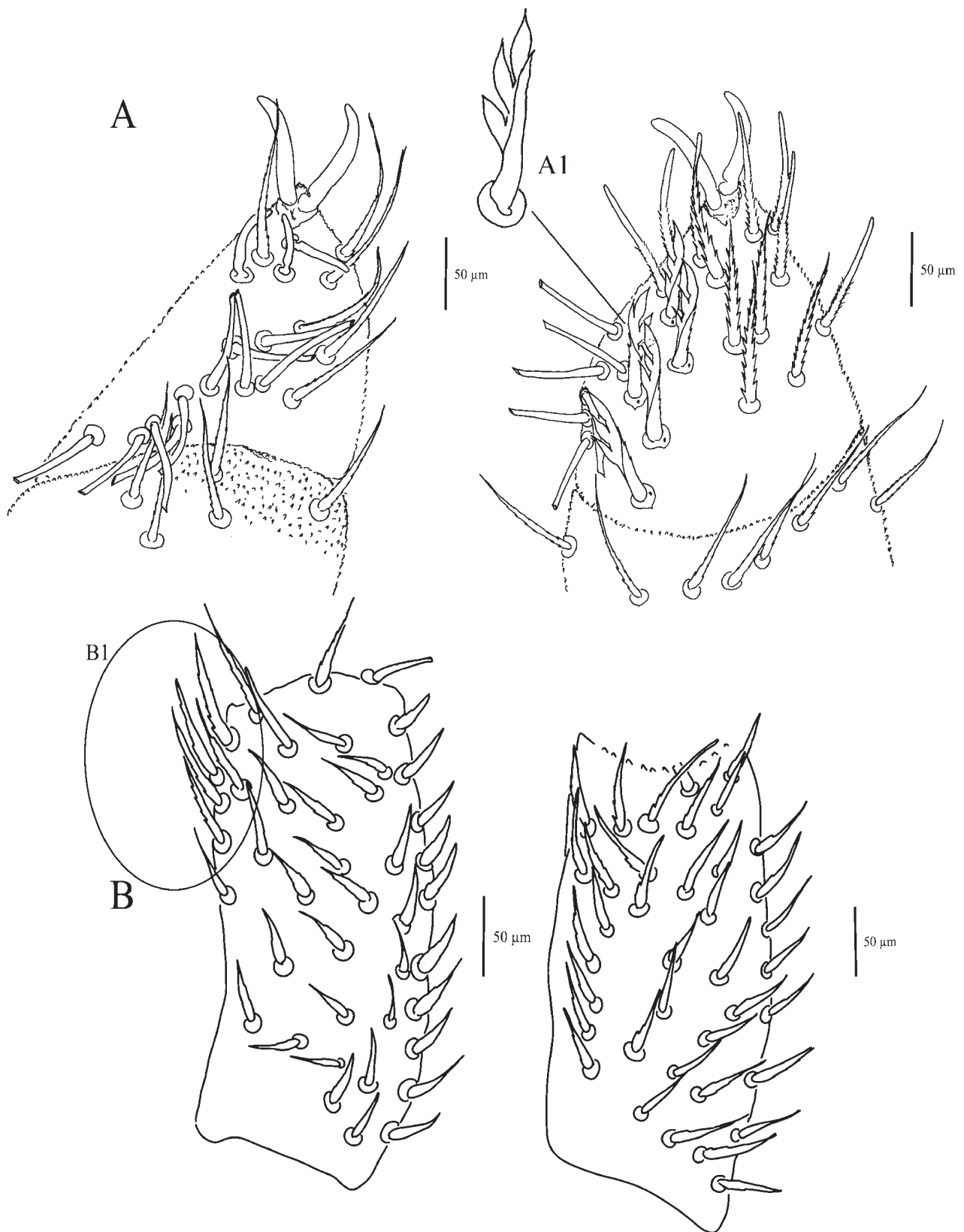


FIGURE 5. *Neocarus haicolous* n. sp. Palp. **A.** Male, ventral and dorsal view of tibiotarsus, **A1.** Detail of setae (d-type) of the palp-tibiotarsus, **B.** Tibia, **B1.** Detail of serrated setae (6) on the tibia.

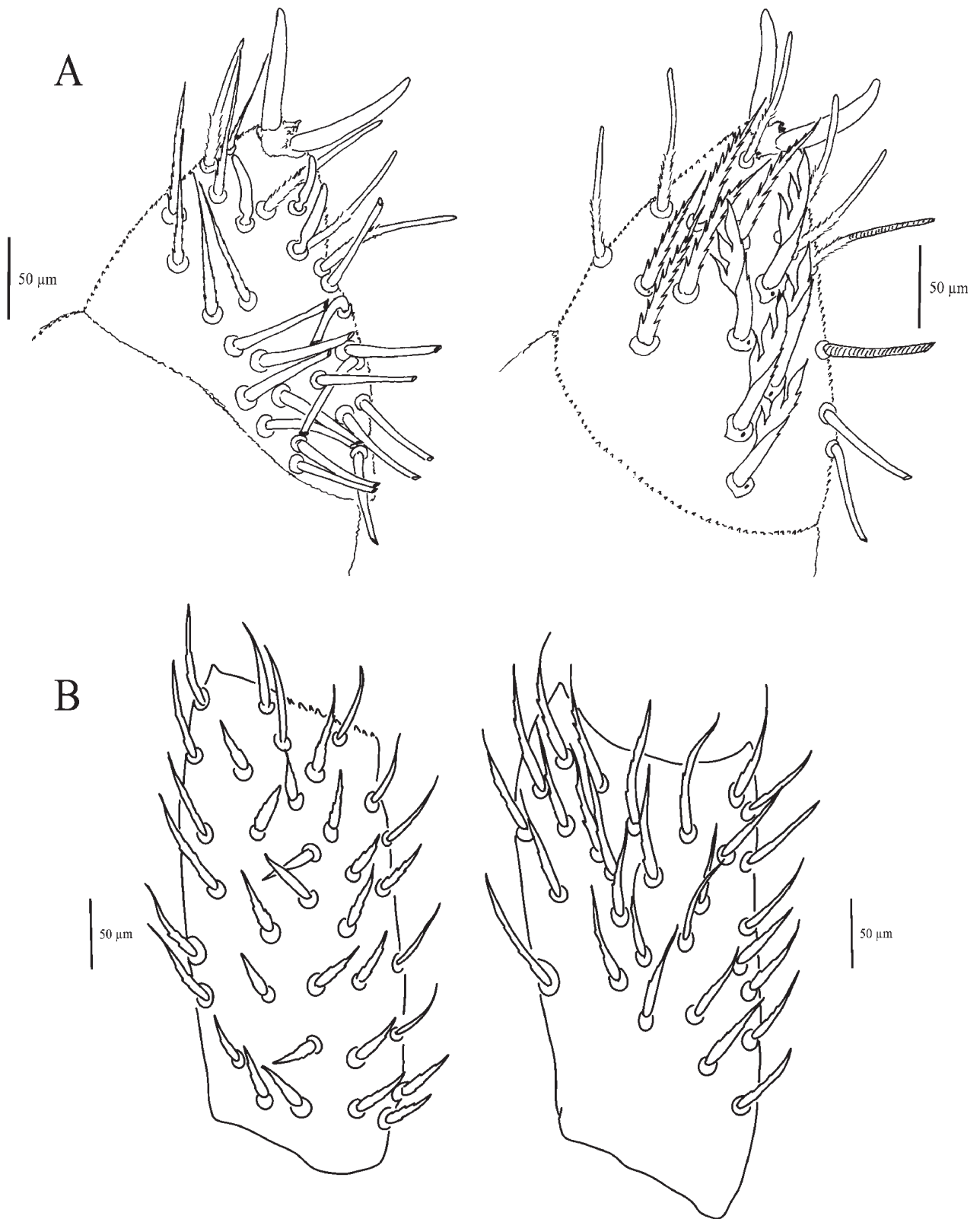


FIGURE 6. *Neocarus haicolous* n. sp. Female. **A.** Ventral and dorsal view of tibiotarsus, **B.** Tibia.

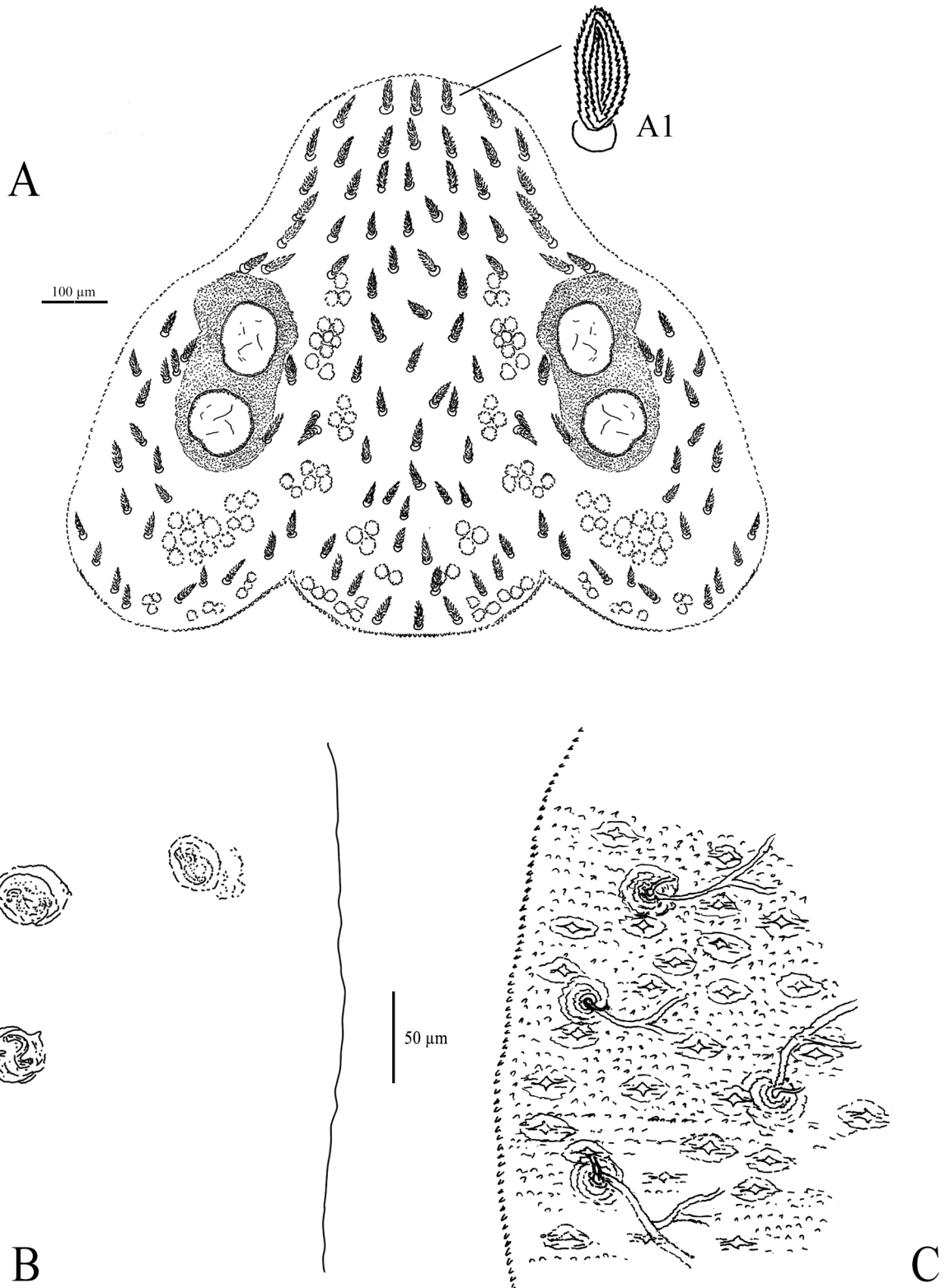


FIGURE 7. *Neocarus haicolous* n. sp. **A.** Dorsal shield male, **A1.** Detail of puffy antero-dorsal setae, **B.** Stigmata female, **C.** Stigmata male.

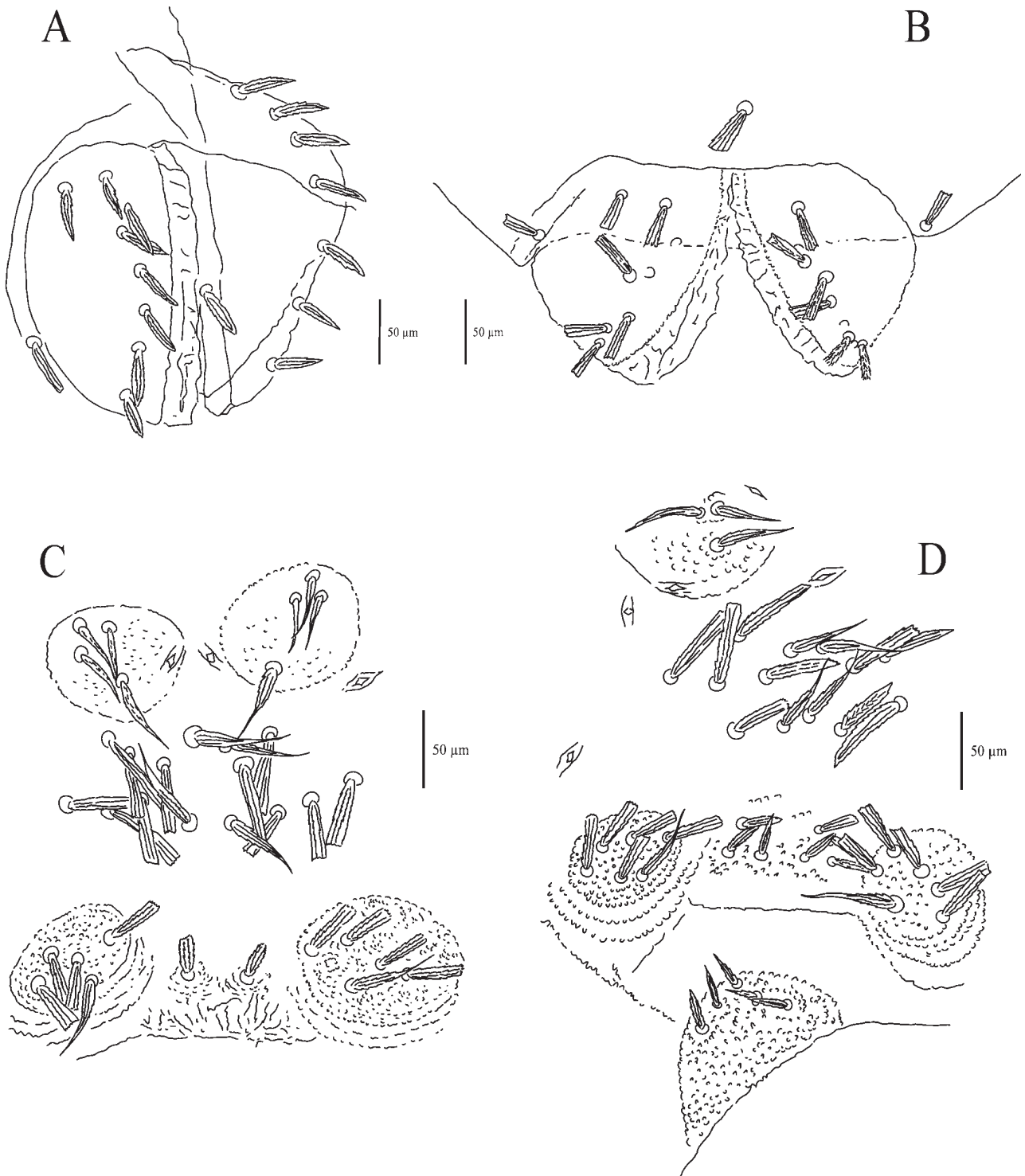


FIGURE 8. *Neocarus haicolous* n. sp. A–B. Anal plate female and male, C–D. Sternitogenital region female and male.

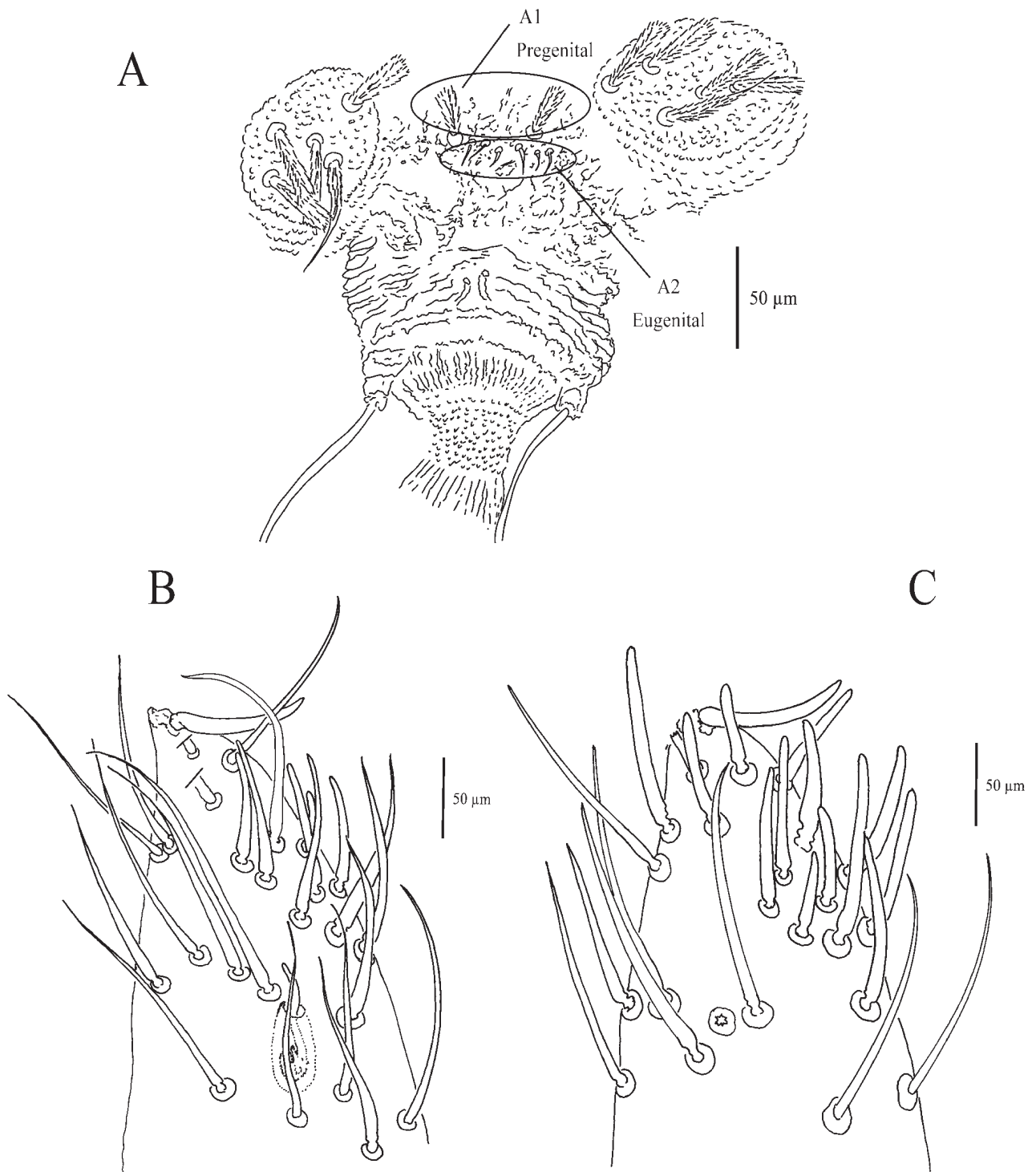


FIGURE 9. *Neocarus haicolous* n. sp. A. Ovipositor female, A1. Pregenital setae, A2. Eugenital setae, B–C. Tip of leg I.

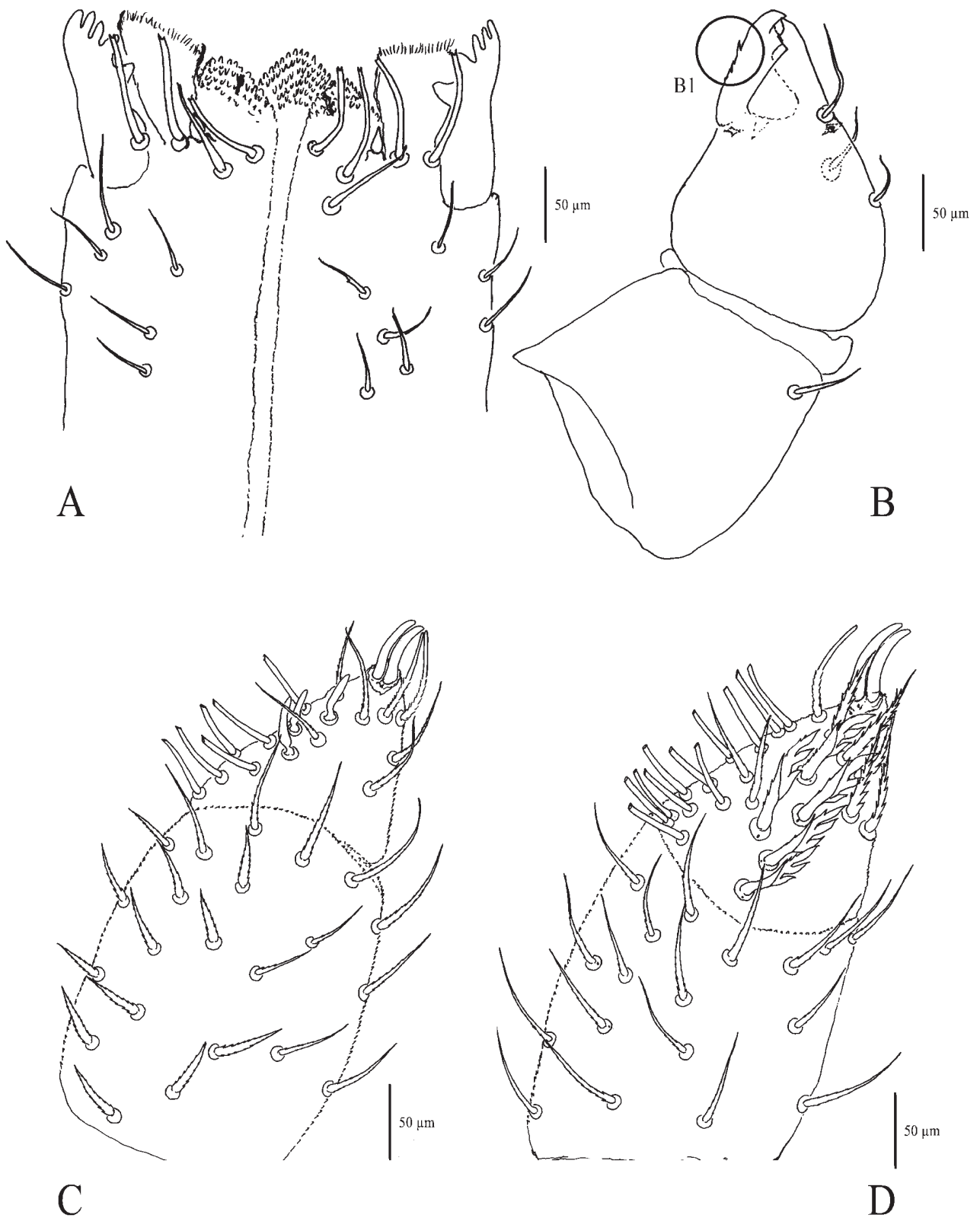
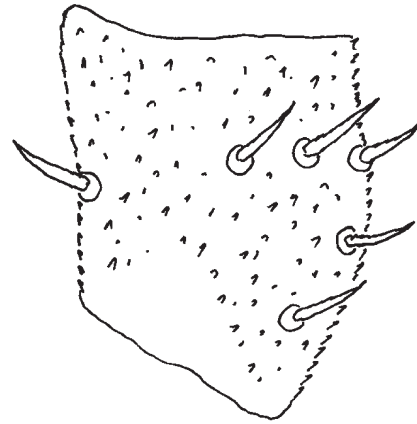


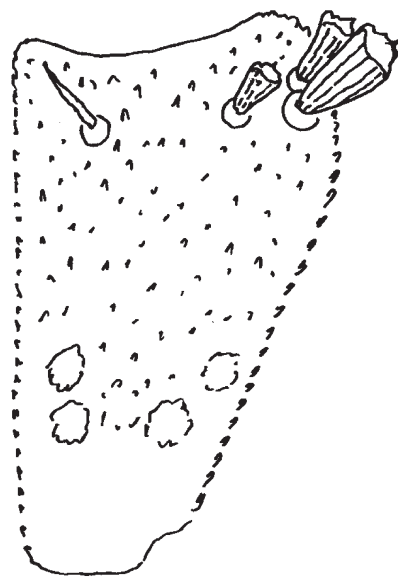
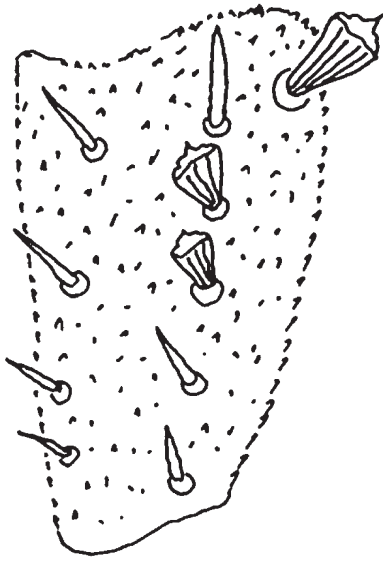
FIGURE 10. *Neocarus haicolous* n. sp. Tn. **A.** Subcapitulum, **B.** Chelicera, **B1.** Detail of denticles, **C–D.** Palp, tibia-tarsus both sides.

A



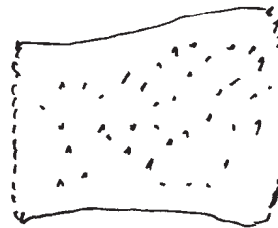
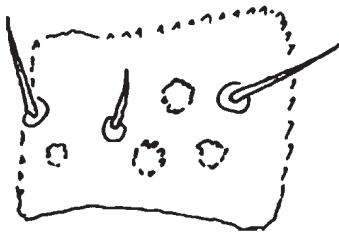
50 μ m

B



50 μ m

C



50 μ m

FIGURE 11. *Neocarus haicolous* n. sp. Tn. A. Palp-genu, B. Palp- femur, C. Trochanter.

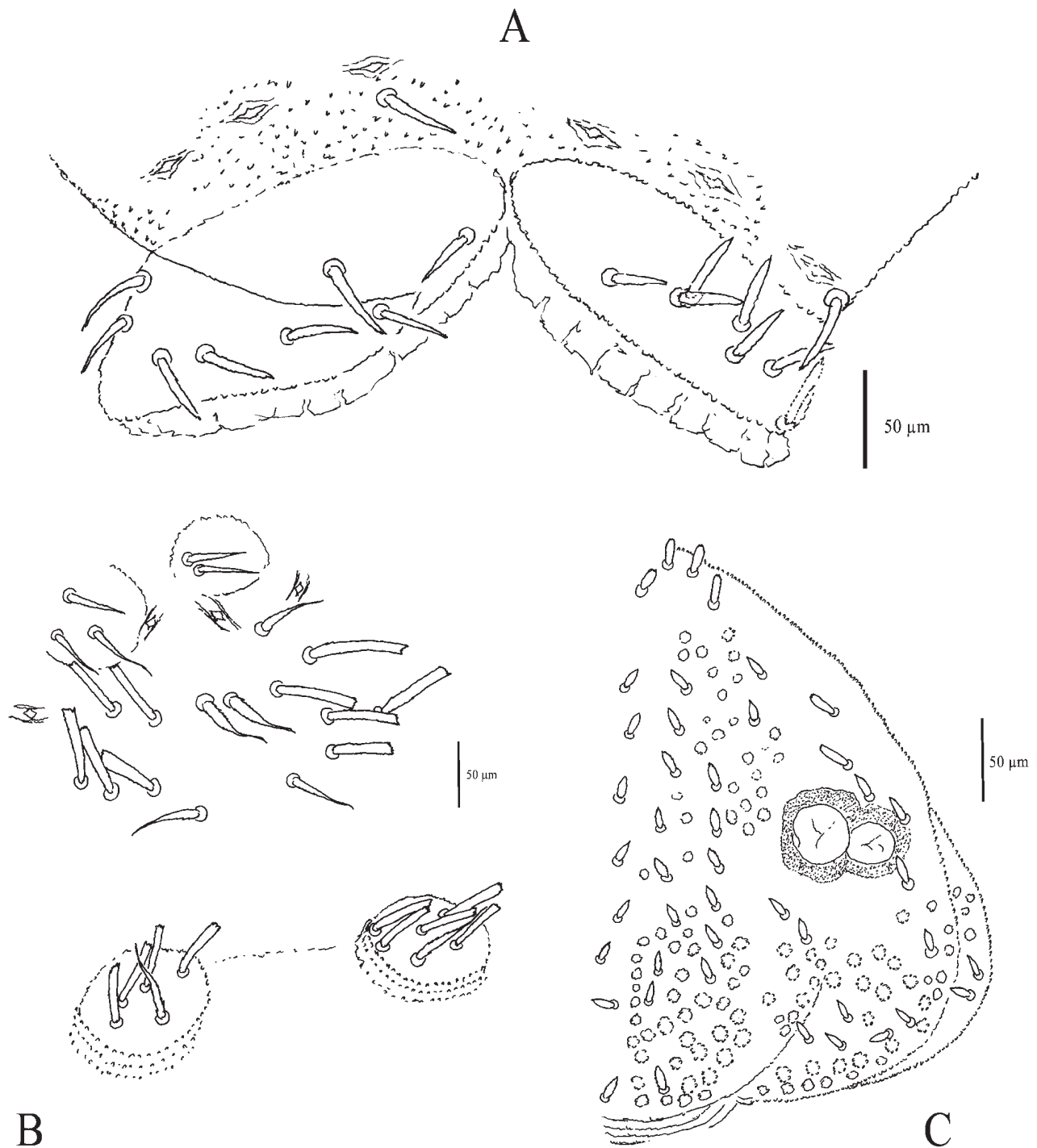


FIGURE 12. *Neocarus haicolous* n. sp. Tn. A. Anal plate, B. Sternitogenital area, C. Antero-dorsal shield of Tn.

Tritonymph

Diagnosis. Palp tarsus with 5 *d*-type foliate setae. Area between sternal and genital verrucae with 2 pairs of long tapering *St* setae and 5–6 pairs of long stout, blunt, serrated *St* setae. Without setae in pregenital or genital area, without genital opening.

Description. Based on observations of 1 specimen.

Gnathosoma. Chelicera (Fig. 10-B). Basal segment in adults with 1 seta (*cht*), fixed digit with 3, one of those (*ch1'*) large, thick. Seta *cht* on basal segment of male chelicera shorter than seta *ch1''* on fixed digit. Setae *ch2'*, *ch2''* and *cht* in female and males simple. Dorsal and antiaxial lyrifissures present. Fixed digit with 1 tooth, movable

digit with 2 teeth and a well-developed terminal hook. Movable digit with 2 small denticles and 1 large denticle on ventral margin.

Subcapitulum (Fig. 10-A). All 4 pairs of paralabial setae present: *p1* relatively, small, conical; With's organ (*p2*) membranous and discoid; rutellum (*p3*) with 1 row of 5 teeth, inserted dorso-laterally; *p4* small but distinct inserted dorsal on subcapitulum. In addition, 4 circumbuccal (*cb*), and 6–8 median and subcapitular (*vm*, *lvm*, *ldm*, *vp*, *lvp*) setae. Lateral lips with distinct canals (*og1* and *og2*).

Palp. Tn (Fig. 11 A–C). Trochanter with only 3 small lightly serrated setae instead 5 in adults. Femur with 5 papilliform (= *p*-type) and 8 *r*-type setae, genu with only 1 *p*-type seta and 16 *r*-type setae.

Tibia and tarsus partially fused. Tibia with 24 large lightly serrated setae and 17 *r*-type setae. Tarsus with lyrifissures *ix* and *ia*. Setation includes *3s*, *5d-4v* on lateroventral side, 14 *ch* setae, 5 *sm* setae. Pretarsus in shape of a pair of well-developed sessile claws (Fig. 10 C–D).

Idiosoma. Color light blue-violet. Stripes on both body and legs.

Dorsum. Prodorsal shield in Tn with 68 small stout puffy setae and a pair of eyes on dark patch (Fig. 12-C). Preanal segment with 1 dorsal seta and 2 lateroventral setae; anal plates with 6–7 stout ribbed setae (Fig. 12-A).

Stigmata. Same arrangement as in adults.

Sternitogenital region (Fig. 12-B). Sternal verrucae each with 1 long, barbed and tapering seta and 2 smaller barbed setae. Remaining sternal area with 2 pairs of long, tapering *St* setae, 5–6 pairs of stout, ribbed *St* setae and 3 pairs of lyrifissures very large and obvious. Pregenital capsules each with 1 long tapering seta and 4–5 stout ribbed setae. Pregenital and genital area without setae. Pregenital capsules each with 1 long tapering seta and 4–5 stout ribbed setae.

Tn without genital opening (Fig. 12-B).

Legs not studied.

Differential diagnosis

N. haicolous **sp. nov.** is similar to *N. bajacalifornicus*, *N. bajacalifornicus chamelaensis*, *N. calakmulensis*, and *N. veracruzensis* in that all present 5 *d* setae on the palp. The new species differs by the group of 6 thick, serrated, pointed setae on the tibia between the *r*-type setae, which is unique for Mexican species of *Neocarus*. This group of setae resembles the group of setae in *Brasilacarus cocaris* Vázquez, Araújo & Feres, 2015, which has 11–12 of these setae, which are also larger. In contrast, *N. haicolous* has only 6 of these setae. *N. haicolous* also differs from all other American *Neocarus* by having thicker and more numerous setae *v1*. The ovipositor, even though it is of the simple type, has an obvious pair of canals or ducts in the inferior part of the ovipositor connected to an unknown type of gland. This pair of ducts or channels has been observed in several species like *C. panamensis* (Vázquez & Klompen 2009), *N. veracruzensis* (Vázquez & Klompen 2009), *O. nobecanus* (Vázquez & Klompen 2009) and *O. thaleri* (Vázquez *et al.* 2021). Thus, these structures are not unique but are either not always visible or not present in all species.

Deposition of types. Holotype female (specimen number LEAEx00001) and allotype male (LEAEx00002) deposited at UNAM. Paratypes at UQROO (1F) and LEAEx1F,1TN).

Material examined. Holotype female 3 slides. Mexico, Queretaro, Ojo de agua de San Francisco, Jalpan de Serra, mountain mesophyll forest in litter 21° 33' 10.289"N, 99° 11' 43.49" W, 1145 m asl, Rodriguez, A., col. 14-IX-19. Paratypes 2 males (LEAEx 00002), 1 Tn. (LEAEx; 00003), same data as holotype.

Etymology. The specific name is derived from “hai” hñähñu “lenguaje” which means soil.

Neocarus queretanus Vázquez & Castaño-Meneses **n. sp.** (Figs. 13–22).

Diagnosis. Palp tarsus of male with 6 pairs of foliate setae. With 3 large and pointed lobes each, female with 5. Area between sternal and genital verrucae with 2 pairs of long tapering *St* setae and 4 pairs of long stout, blunt, serrated *St* setae in female, on male 2 pairs of long tapering *St* setae and 6 long stout blunt serrated *St* setae. Female with 2 short, blunt serrated setae in pregenital area, male with 8 short thick and lightly pointed setae on pregenital area, plus 10 thin, acute, and lightly serrated setae in genital area. Male with 2 pairs of gland or testes, female without eugenital setae. Ovipositor with 2 pairs of gland-like structures and 2 channels.

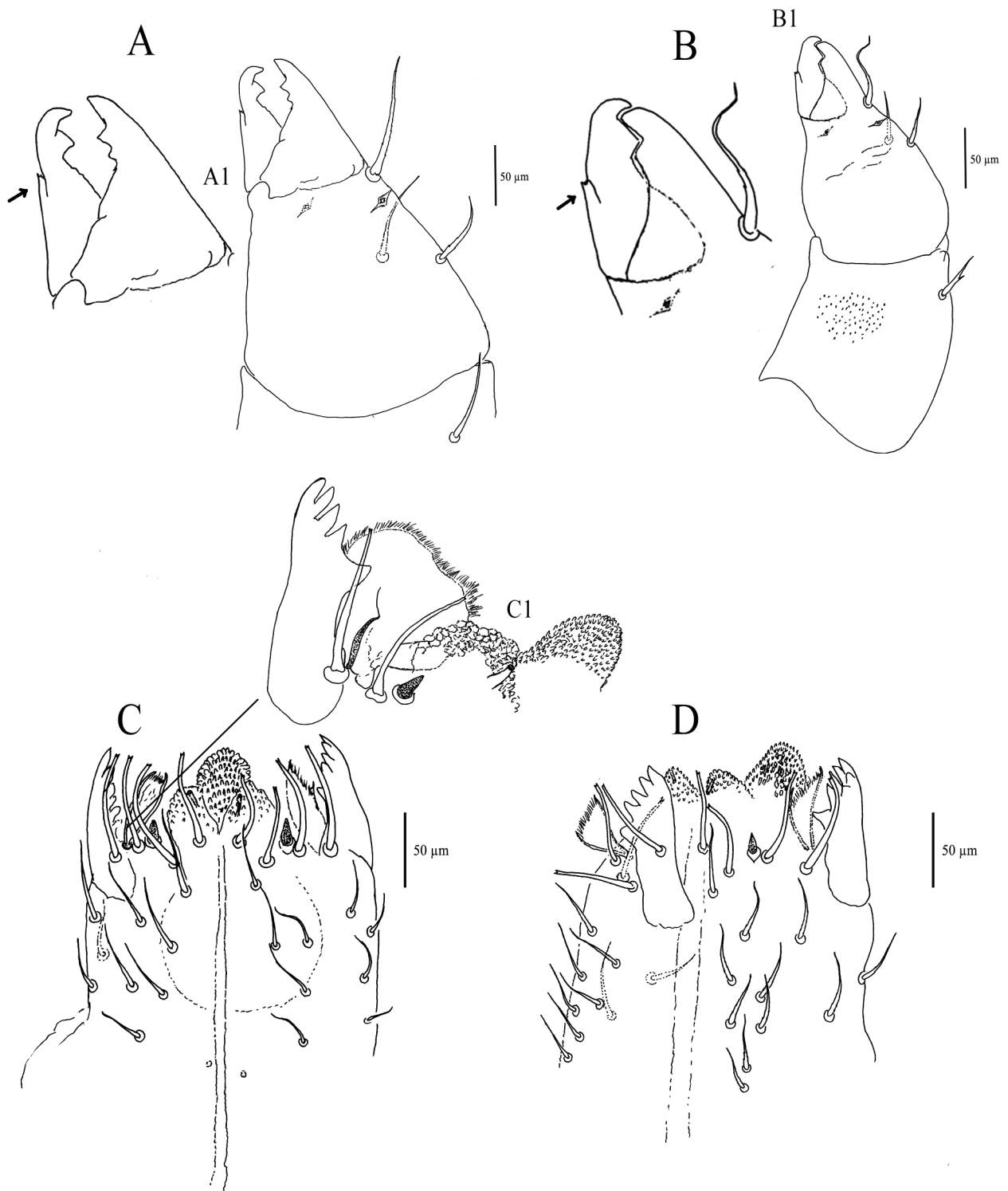


FIGURE 13. *Neocarus queretanus* n. sp. **A.** Chelicera female, **A1.** Denticle, **B.** Chelicera male, **B1.** Denticle, **C.** Subcapitulum, female, **C1.** Detail of some paralabial setae, **D.** Subcapitulum, male.

Description. Based on observations on 1 female and 1 male. No juveniles were collected.

Gnathosoma. Chelicera (Fig. 13 A–B). Basal segment in adults with 1 lightly barbed and acutely tipped seta (*cht*), fixed digit with 3, one of those (*chl'*) large, thick. Seta *cht* on basal segment of male chelicera shorter than seta *chl''* on fixed digit. Setae *ch2'*, *ch2''* and *cht* in female and males lightly barbed. Dorsal and antiaxial lyrifissures present. Fixed digit with 1 tooth, movable digit with 2 teeth and a well-developed terminal hook. Movable digit with 1 large flat denticle (Fig. 13 A–B).

Subcapitulum (Fig. 13 C–D). All 4 pairs of parolabial setae present in adults; *pl1* small, conical; With's organ (*pl2*) membranous, hyaline and barbulated, discoid; rutellum (*pl3*) with 1 row of 5 teeth, inserted dorso-laterally; *pl4* small but distinct inserted dorsal on subcapitulum. In addition, 4 circumbuccal (*cb*), setae, and in females 9 medium, subcapitular (*vm*, *lvm*, *ldm*, *vp*, *lvp*) setae; in male 10. Lateral lips with distinct canals.

Palp. Adults (Fig. 14 A–D). Trochanter female with 4 large, ribbed tapering setae (= *r*-type) in male 5 setae; femur with 7 papilliform (= *p*-type) setae in female and male and 15 *r*-type setae in female and male, genu (Fig. 14 C–D) with only 1 *p*-type seta in female and 10 in male. Tibia and tarsus partially fused. Tibia with 25 large, lightly serrated setae in female and 16 *r*-type setae, plus 3 sensilla (*ss*), in male 25 *r*-type setae and 41 lightly serrated setae, plus 3 sensilla (*ss*), these 3 setae very thin, large and acutely tipped between *r*-type setae (Fig. 15 A–D). Tarsus with lyrifissures *ix* and *ia*. Setation includes 3 *s*, 5 *d*, 6 *v* in female; in male 3 *s*, 6 *d*, 6 *v*, female with 5 *v2* on lateroventral side, 12 *ch* setae and 6 *m* setae, in male 3 *V2* setae 18 *ch* setae and 6 *m* setae. Pretarsus in shape of a pair of well-developed sessile claws (Fig. 16 A–D, and 17-B). Sexual dimorphism: male with 6 *d*-type setae on the tarsus, female with 5.

Idiosoma. Color dark blue-violet. Stripes on both body and legs (Fig. 17-C)

Dorsum. Prodorsal shield in adults with medium size stout puffy setae; 84 in male, 92 in female. A pair of eyes on dark patch (Fig. 18 A–B). Dorsal idiosoma between shield and preanal segment without setae, but with numerous lyrifissures arranged in transverse rows. Preanal segment with 1 dorsal and 2 ventral setae; and anal plates with 6–8 setae stout ribbed in male and 6–9 in female (Fig. 21 A–B).

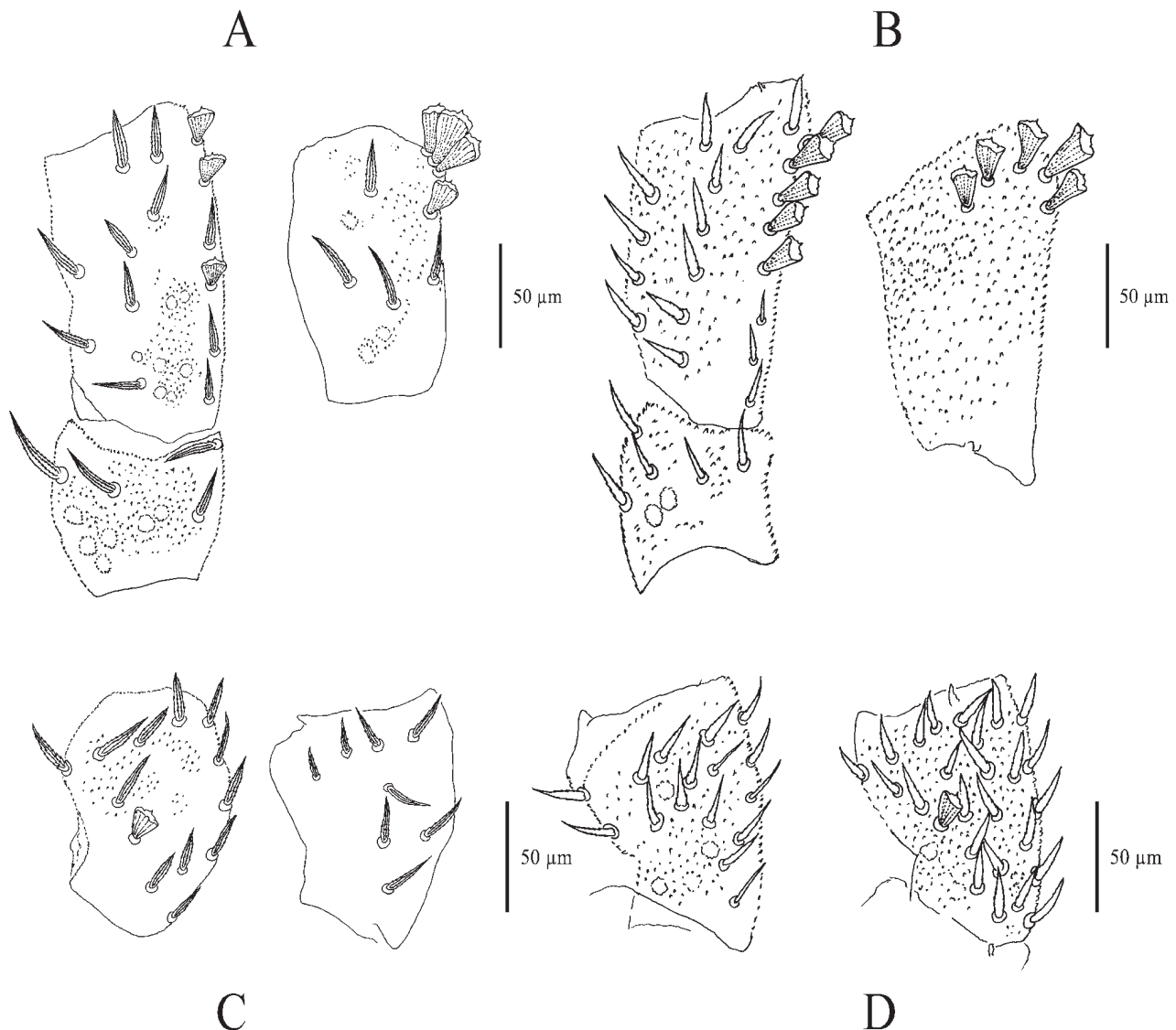


FIGURE 14. *Neocarus queretanus* n. sp. Palp. A–B. Trochanter and femur female and male, C–D. Genu, female and male.

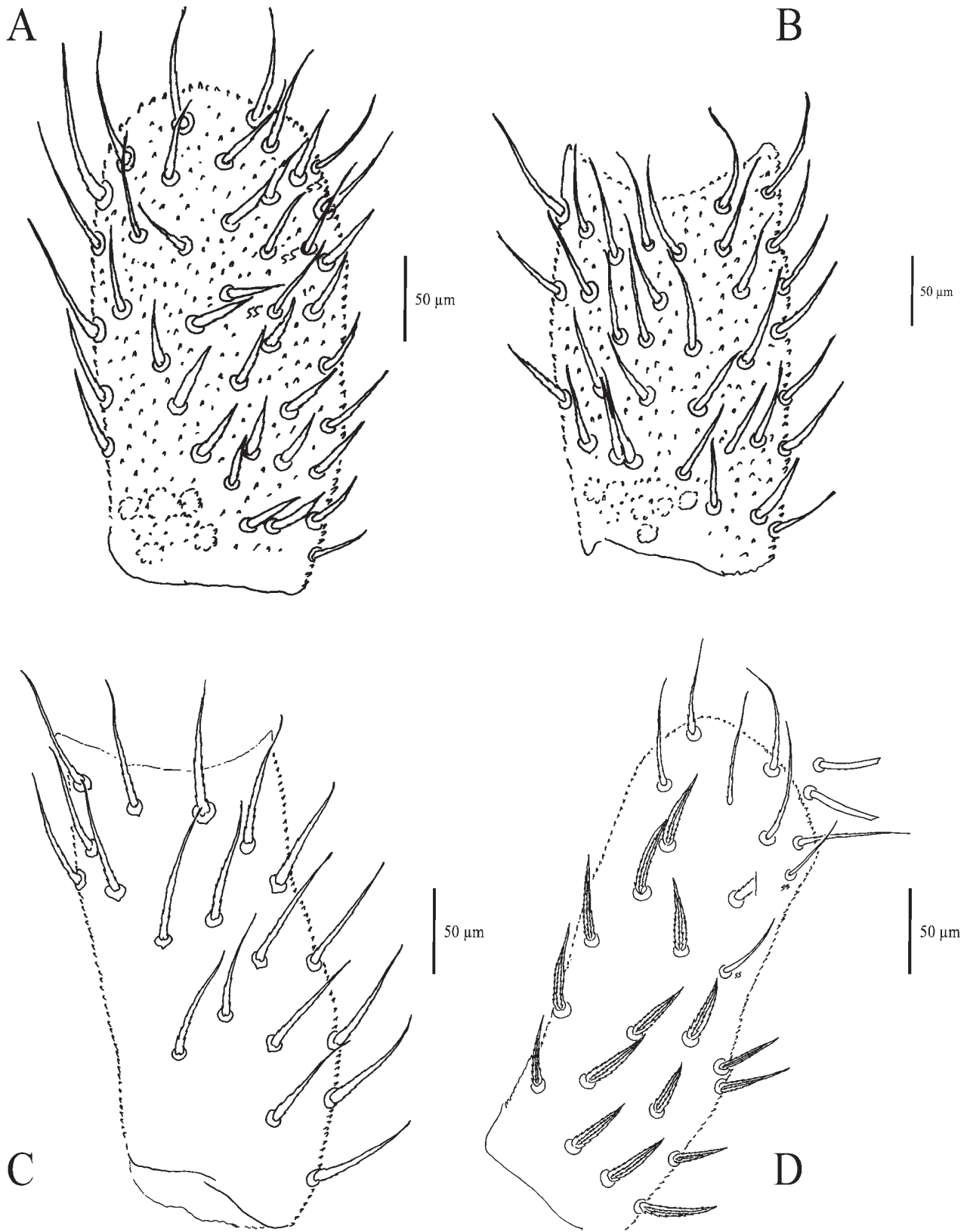


FIGURE 15. *Neocarus queretanus* n. sp. Palp. A–B. Tibia, male, C–D. Tibia, female.

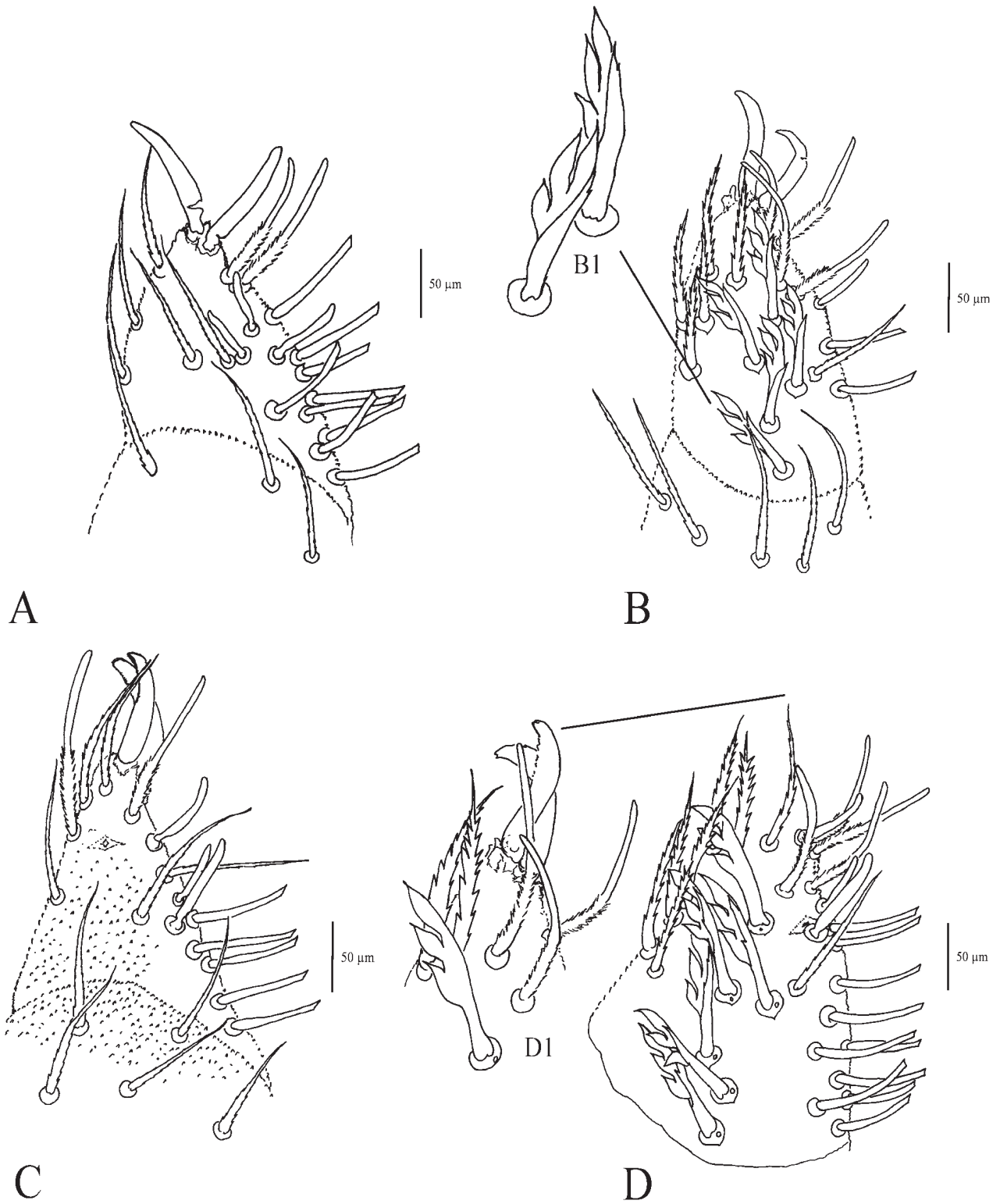


FIGURE 16. *Neocarus queretanus* n. sp. **A–B.** Palp tibiotarsus, female, **B1.** Detail of setae (d-type) in female. **C–D.** Palp tibiotarsus, male, **D1.** Detail of the tip of the tibiotarsus male.

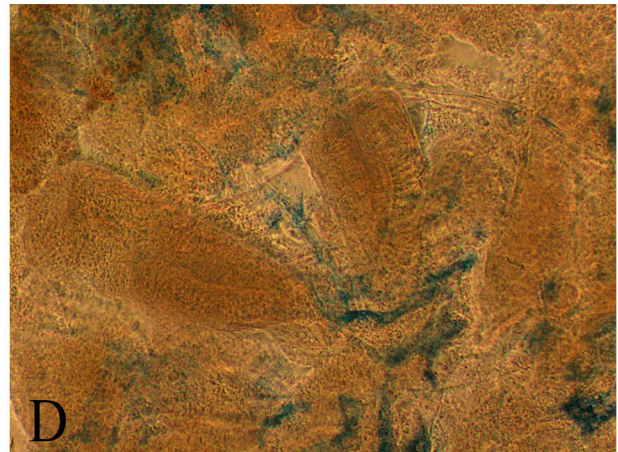
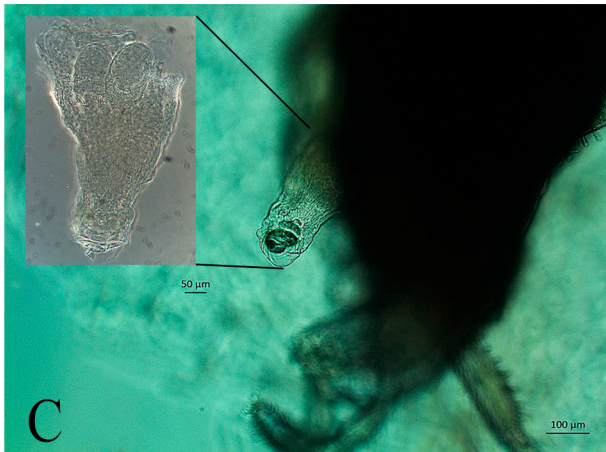
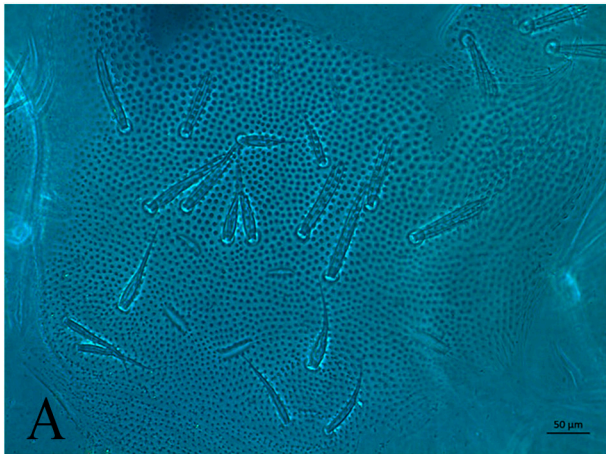


FIGURE 17. Photos of *Neocarus queretanus* n. sp. **A.** Female sternitogenital area, setation, **B.** Female tibiotarsus, leaf setae, **C.** Female body with ovipositor evaginated, **D.** Male glands or testes, **E.** Female antero-dorsal shield, **F.** Habitus photo of *Neocarus queretanus* n. sp. (specimen photographed by D. May).

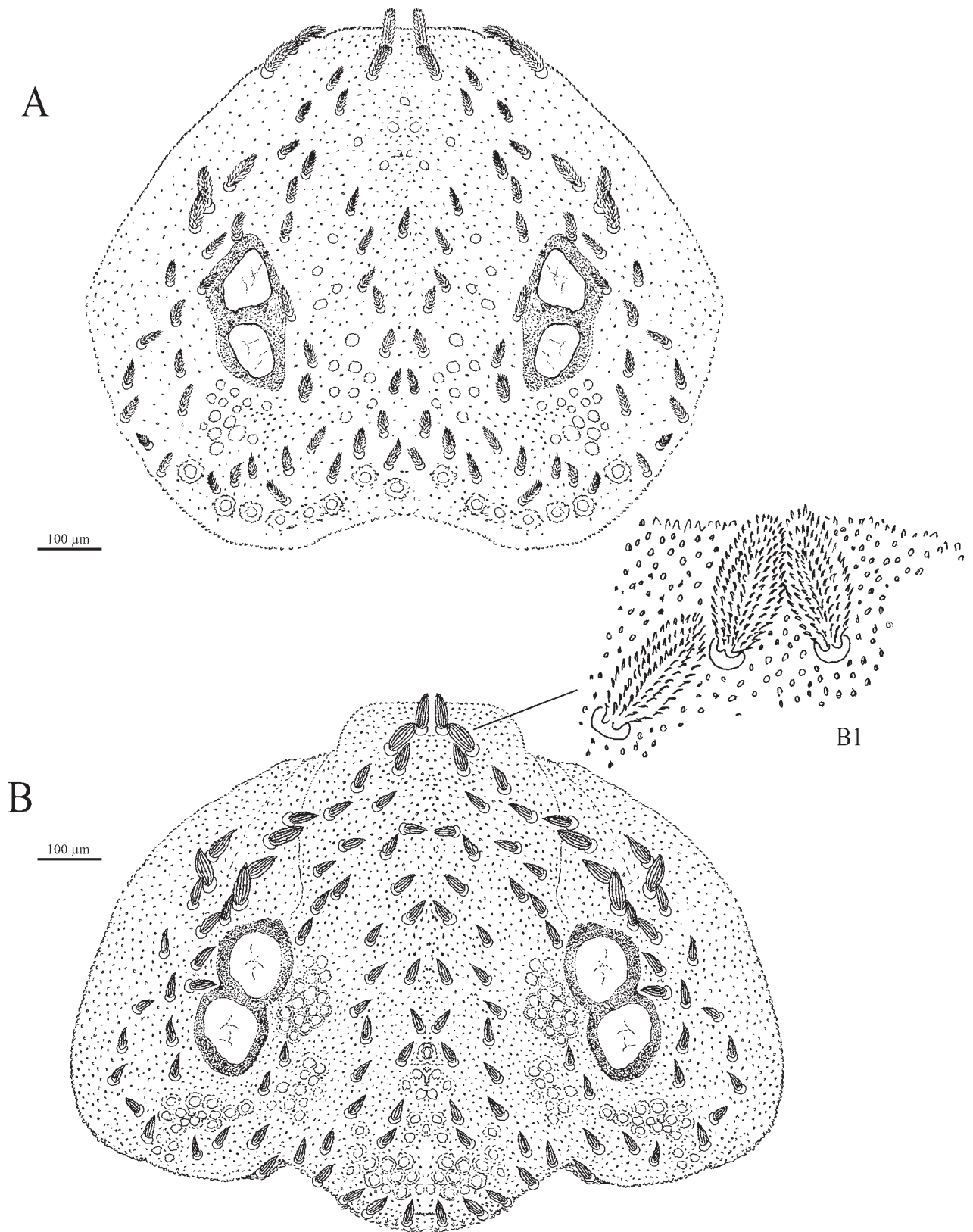
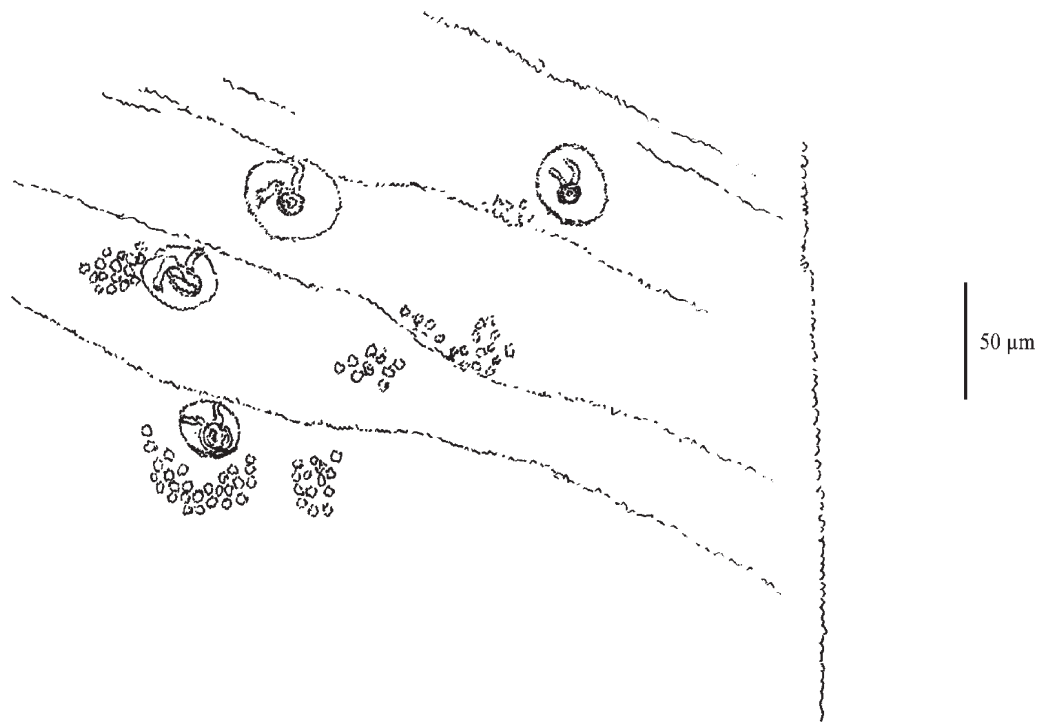


FIGURE 18. *Neocarus queretanus* n. sp. Prodorsal shield, A–B. Male and female, B1. Detail of puffy antero-dorsal setae in female.

A



B

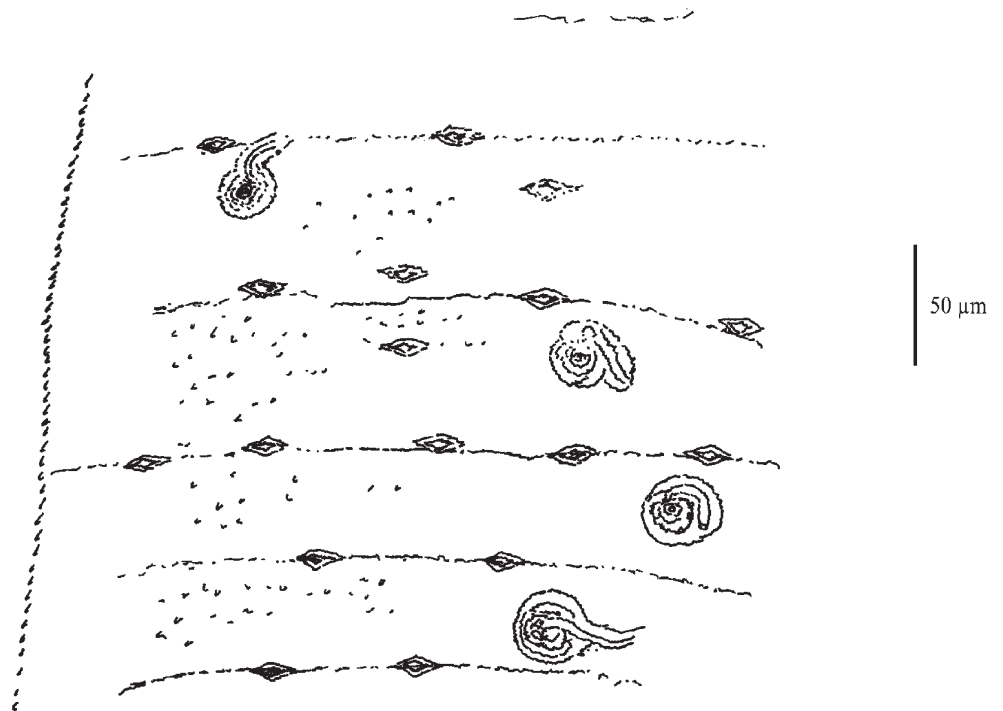


FIGURE 19. *Neocarus queretanus* n. sp. Stigmata, A. Axis right side female, B. Male axis left side.

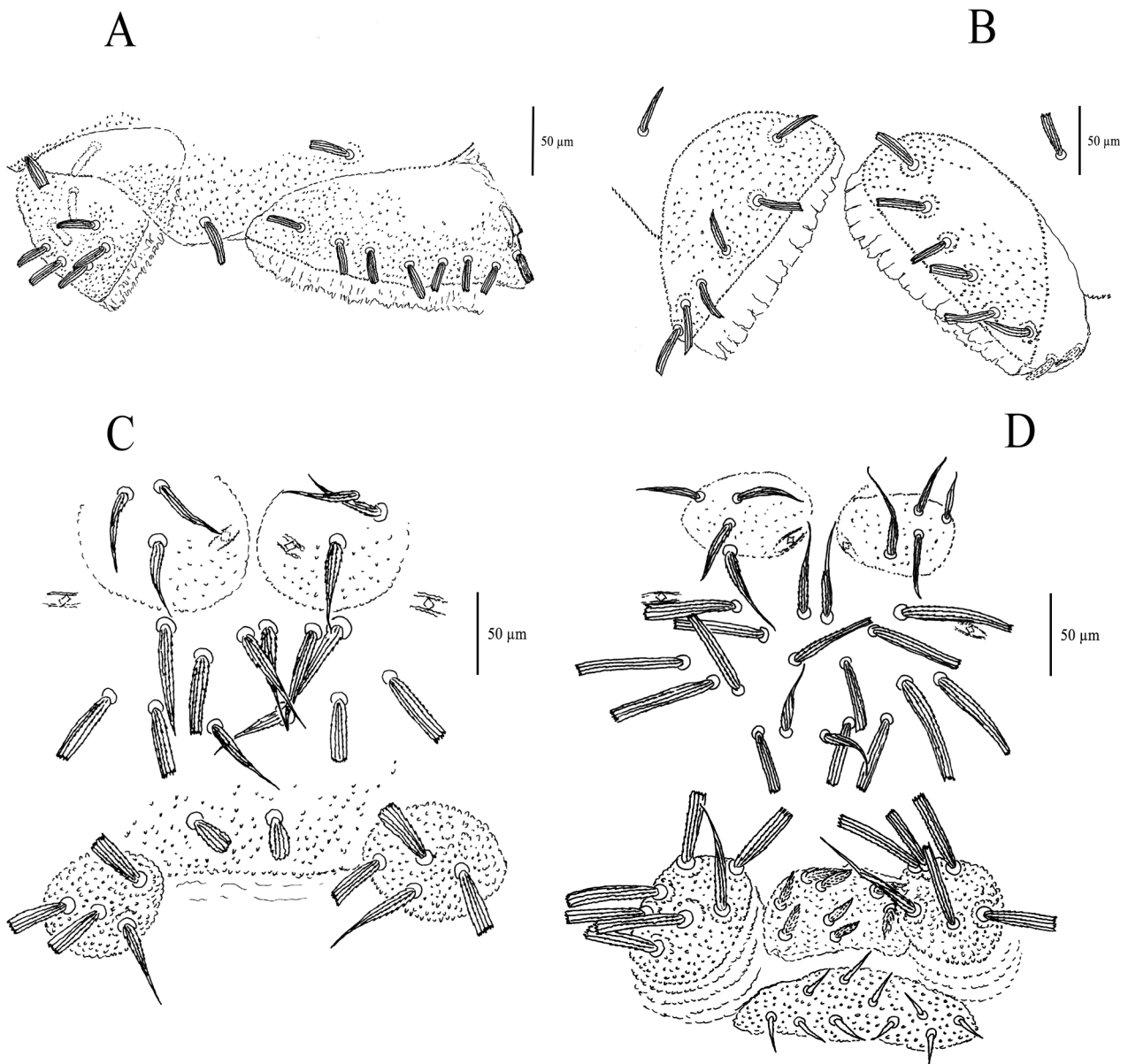


FIGURE 20. *Neocarus queretanus* n. sp. A–B. Anal plate female and male, C–D. Sternitogenital region, female and male.

Stigmata. Arrangement in female and male similar. Stigma 1 close to lateral border of body, stigmata 2 and 4 at same distance and stigma 3 towards body axis. (Fig. 19 A–B).

Sternitogenital region (Fig. 20 C–D; Fig. 17-A). Sternal verrucae each with 1 long, barbed and tapering seta plus 3 long barbed setae in male, while in female only 2 thin lightly serrated setae and 1 long barbed and tapering seta. Remaining sternal area with 2 pairs of long, tapering *St* setae in both female and male, plus 7 pairs of large stout ribbed *St* setae. In female only 4–5 stout, ribbed *St* setae and 3 pairs of lyrifissures very large and obvious. Pregenital capsules each with 1 long tapering and 5–6 stout ribbed setae in male, in female 1 long tapering setae and 3 pairs of stout ribbed setae. Pregenital and genital areas in male with 8 short puffy setae and 10 tiny, pointed, lightly serrated setae, respectively. Male with 2 pairs of bigger glands or testes (Fig. 17-D and Fig. 21-C). In female 2 puffy short setae on pregenital area, without eugenital setae. Ovipositor large, everted with 3 lobules at tip, 2 pairs of glands-like and a pair of channels (Fig. 21-B), (Fig. 21-A).

Legs. Legs relatively long. Ratio of legs I to idiosoma approximately 2.5, legs IV to idiosoma about 2. Broad sensillum with “crown-like” tip (Fig. 22 A–B) in main sensillar field. Pretarsi I with well-developed sessile claws without setae.

Deposition of types. Holotype female (LEAEx00007) and 1 paratype male (LEAEx00008).

Material examined. Holotype female 1 slides. Mexico, Queretaro, San Juan de los Durán locality, in Jalpan de Serra. Vegetation in the area is pine-oak forest 21° 27' 40.799"N, 99° 10' 45"W; 1311 m asl Rodriguez, A. col. 29-II-20. Paratype 1 male (LEAEx00008).

Etymology. This species is named after the state, Querétaro, where the material was collected.

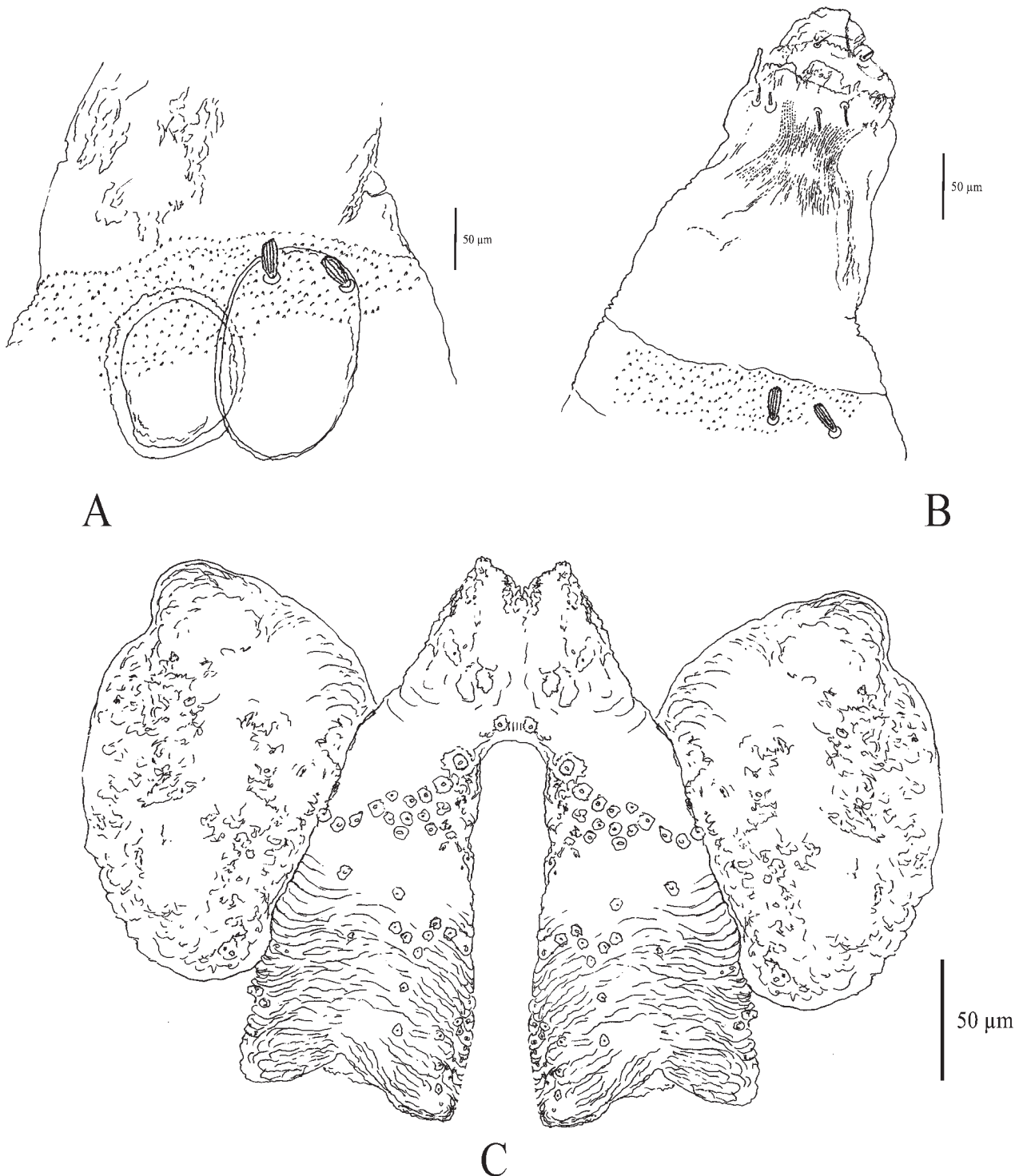


FIGURE 21. *Neocarus queretanus* n. sp. **A.** Eggs at the basis of ovipositor of female, **B.** Ovipositor everted, **C.** Glands or testes in male.

TABLE 2. Records of *Neocarus* species described and undescribed from Mexico (modified from Vazquez & Klompen, 2015).

No ¹	Species	Depository ²	Locality	General habitat	Specific habitat	Climate
1	<i>Neocarus</i> (unidentified)	UQRoo	Baja California Sur, Presa de la Buena Mujer, Mpio. La Paz, 385 m asl. 24.0838N 110.1905W	semi-desert	soil under shrubs	
2	<i>N. bajacalifornicus</i>		Baja California Sur, Sierra de La Laguna, 2000 m asl.pine-oak forest 23.593611N 109.9686W	under bark		temperate
3	<i>Neocarus</i> (unidentified)	CNAC	Nuevo León, Sierra de Apanco, 2027m asl 23.9171N 99.9798W	high elevation		temperate
4	<i>Neocarus</i> (unidentified)	CNAC	Querétaro, San Joaquin, km 14.5, 2381m asl 20.9892N 99.6581W	high elevation pine-oak forest	under bark	temperate
5	<i>Neocarus</i> (unidentified)	CNAC	Hidalgo , El Cardenal, 2301 m asl 20.6713N 99.1042W	high elevation pine forest		temperate
6	<i>N. bajacalifornicus</i> <i>chamelaensis</i>		Jalisco, Estación de Biología de Chamela, 150 m asl 19.5333N 105.0833W	medium-high temperate forest	soil and litter	
7	<i>Neocarus</i> (unidentified)	CNAC	Colima, Cueva (Fuera), 8km S Coguatlán, 230 m asl 19.2983N 104.1018W	entrance cave	under stones	warm-tropical
8	<i>Neocarus</i> (unidentified)	CNAC	México, Mpio Tonatico, 1614 m asl 18.7721N 99.5660W	grassland with acacia		temperate
9	<i>N. comalensis</i>	CNAC	Guerrero, El Comal, Mpio. Buenavista de Cuellar, 1749 m asl 18.4600N 99.4100W	medium-high temperate forest	under stones	temperate
10	<i>N. veracruzensis</i>	CNAC	Guerrero, Jalitla, Mpio Tepecoacuilco, 580 m asl 18.1527N 99.5395W	low-high tropical forest	under stones	warm-tropical
11	<i>N. texanus</i>	OSAL	Guerrero, Cumbre de Llano Largo, Puerto Marquez, nr coast nr Acapulco, 371 m asl 16.8287N 99.8489W	low dry tropical forest	under stones and rocks	warm-tropical
12	<i>N. veracruzensis</i>		Veracruz, El Morro de la Mancha, 8 m asl 19.8432N 96.4533W	coastal dunes	on soil under shrubs	warm-tropical
13	<i>Neocarus</i> (unidentified)	OSAL	Veracruz, Veracruz, ~15km SSW, 13 m asl 19.0372N 96.1763W			
14	<i>Neocarus</i> (unidentified)	OSAL	Veracruz, Catemaco, Playa Azul, 358 m asl 18.4215N 95.1111W			
15	<i>Neocarus</i> (unidentified)	CNAC	Oaxaca, San Melchor Betaza, Distrito Villa Alta, 1432 m asl 17.2514N 96.1538W	mid-elevation low dry tropical forest	under stones	warm-dry

.....Continued on the next page

TABLE 2. (Continued)

No ¹	Species	Depository ²	Locality	General habitat	Specific habitat	Climate
16	<i>Neocarus</i> (unidentified)	CNAC	Oaxaca, San Juan Tabaá, Diaz Ordaz, Villa Alto, 1354 m asl 17.3048N 96.2064W	low dry tropical forest	under stones	warm-dry
17	<i>Neocarus</i> (unidentified)	CNAC	Chiapas, E of Ocosingo, 888 m asl 16.7146N 90.9055W	high tropical forest		warm-tropical
18	<i>N. calakmulensis</i>		Campeche, Calakmul Biosphere Reserve 200 m asl 18.1083N 89.8000W	high tropical forest	litter, under bark & stones	warm-tropical
19	<i>Neocarus</i> (unidentified)	UQRoo	Campeche, Calakmul Biosphere Reserve, 5km from Arroyo Negro, ~160 m asl 17.8241N 89.2815W			warm-tropical
20	<i>N. calakmulensis</i>		Campeche, Calakmul Biosphere Reserve, Bel-Ha, ~150 m asl 18.9473N 89.3155W	high tropical forest	litter	warm-tropical
21	<i>N. calakmulensis</i>	UQRoo	Quintana Roo, Cenote “Cocodrilo dorado”, La unión, 13 m asl 17.9000N 88.8833W	medium-high tropical forest	litter	warm-tropical
22	<i>N. chactemalensis</i>	UQRoo	Quintana Roo, Campus UQRoo, Chetumal, 8 m asl 18.5229N -88.2703W	medium-high tropical forest	under stones, in litter	warm-tropical
23	<i>Neocarus</i> (unidentified)	UQRoo	Quintana Roo, Peninsula, ~8 m asl; 18.8314N 88.2267W			warm-tropical
24	<i>Neocarus</i> (unidentified)	UQRoo	Quintana Roo, Chacchoben, ~22 m asl; 19.0261N 88.2540W			warm-tropical
25	<i>N. nohbecanus</i>		Quintana Roo, Noh Bec, 8 m asl 19.1234N 88.3390W	high hardwood tropical forest	litter	warm-tropical
26	<i>N. siankaanensis</i>		Quintana Roo, Sian Ka'an Biosphere Reserve, 10 m asl 19.6833N 87.8833W	low tropical forest	under stones	warm-tropical
27	<i>N. siankaanensis</i>		Quintana Roo, Lol Beh restaurant, 2 km from road Tulum to Cobá, 26 m asl; 20.4239 N 87.6499W	medium-high tropical forest	under stones	warm-tropical
28	<i>Neocarus</i> (unidentified)	UQRoo	Quintana Roo, Laguna Colombia, Cozumel Island, 11 m asl. 20.4638N 86.8788W	mangrove forest	in litter and sandy soil	warm-tropical
29	<i>Neocarus</i> (unidentified)	UQRoo	Quintana Roo, Puerto Morelos, Botanical Garden, 5 m asl. 20.8442N 86.8807W	botanical garden	litter	warm-tropical
30	<i>Neocarus</i> (unidentified)	UQRoo	Yucatan, Muná, 29 m asl; 20.9000N 89.2500W		litter	warm-tropical

....Continued on the next page

TABLE 2. (Continued)

No ¹	Species	Depository ²	Locality	General habitat	Specific habitat	Climate
31	<i>Neocarus haicolous</i>	LEAEx UQRoo	Querétaro, Sierra Gorda Biosphere Reserve, San de los Durán, Jalpan de Serra, 1311 m asl, 21°33'18.10"N, 99°11'40.08"W 1145 m.a.s.l	mountain mesophyll forest	litter	subtropical
32	<i>Neocarus queretanus</i>	LEAEx UQRoo	Querétaro, Sierra, Gorda Biosphere Reserve, San Juan de los Durán, Jalpan de Serra 1311 m.a.s.l 21°27'680 N, 99°10.45.750 W	pine- oak forest	litter	temperate
33	<i>Neocarus</i> (unidentified)	UQRoo	Q.Roo Reserve Biosphere “del manati”	mangrove at sea level	litter	warm tropical
34	<i>Neocarus</i> (unidentified)	UQRoo	Q.Roo, Puerto Morelos, Botanic Garden	high medium tropical forest	litter, under bark	warm tropical
35	<i>Neocarus</i> (unidentified)	UQRoo	Q.Roo, Cozumel, Punta Sur	mangrove	litter	warm tropical
36	<i>Neocarus</i> (unidentified)	UQRoo	Tamaulipas “El cielo” Reserve Biosphere	mountain mesophyll forest	litter under stones	warm tropical
37	<i>Neocarus</i> (unidentified)	UQRoo	Morelos	high medium tropical forest	litter	subtropical

Differential Diagnosis.

N. queretanus sp. nov. differs from all other Mexican *Neocarus* by having 6 *d*-setae on the palp of the male versus 5 *d* setae on the palp of male *N. bajacalifornicus bajacalifornicus* (Vázquez & Klompen, 2002), *N. bajacalifornicus chamelaensis* (Vázquez & Klompen, 2009), *N. calakmulensis* Vázquez & Klompen, 2009, *N. comalensis* Vázquez & Klompen, 2015, *N. siankaanensis* (Vázquez & Klompen, 2002), *N. texanus* Chamberlin & Mulaik, 1942, and *N. veracruzensis* Vázquez & Klompen, 2009. Males also differ in the number of setae on the pregenital and genital area: 8/10 in *N. queretanus* sp. nov. versus 4–6 and 5–7 setae in all other Mexican species (Table 3). Males of some Brazilian species have a similar number of setae in this area, i.e., *N. caipora* (Bernardi et al. 2014), *N. entrerios* (Vázquez et al. 2020), *N. platensis* (Silvestri, 1905), *N. simmonsii* (Bernardi et al. 2018) and *N. spelaion* (Bernardi et al. 2018), and also the single *p*-seta on the palp genu (versus more than 1 in all other species). The other Brazilian species, *N. proteus*, has fewer pregenital and genital setae (Bernardi et al. 2013).

The male of *N. queretanus* **n. sp** is probably a “super adult” due to: 1) the presence of a bigger pair of glands or testes, 2) the higher number of pregenital and genital setae, 3) and the higher number of *d* setae on the palp.

Habitat description and geographic distribution of Mexican species.

The Opilioacaridae were first collected in Mexico in 1986 in a pine-oak forest at 2000 m asl in Sierra de la Laguna Reserve Biosphere, later described as *N. bajacalifornicus* (Vázquez & Klompen, 2002). Since this time, opilioacarid mites have been found in an extraordinary variety of habitats from sea level to mountainous regions (Table 2). Across Mexico, most collections are from central and southern regions but, even within a state, these mites are found in numerous macrohabitats. For example, in Quintana Roo, opilioacarids occur in coastal dunes, mangrove, low flooded tropical forest, high medium tropical forest, and high tropical forest (Vázquez & Klompen 2002, 2009, 2015). In terms of microhabitats, most collections are from under stones and in litter, but several new collections are from under bark and moss (Table 2, Fig. 24).

TABLE 3. Comparative setal patterns and shape for the pregenital and genital region, ovipositor and palp of *Neocarus* adults (Modified from Bernardi *et al.* 2020).

OCCURENCE	SPECIES/SUBSPECIES	FEMALE		MALE		PALP	
		Pregenital region	Genital/Eugenital region	Pregenital region	Genital region	<i>c/h</i> -type	<i>d</i> -type
		No. And type of setae	No. and type of setae	No. and type of setae	No. and type of setae		
North America							
USA	<i>Neocarus texanus</i>	2 st/r	nude	4/6 st/r	8-9 sh	10-12(21)	5
Mexico	<i>Neocarus nohbecanus</i>	nude	nude	4-5 st/r	5-7 ^{*/r}	17-19	4
Mexico	<i>Neocarus siankaanensis</i>	nude	nude	2 st/r	4st/r	14-15	5
Mexico	<i>Neocarus bajacalifornicus bajacalifornicus</i>	2 st/r	nude	5-8(13a) st/r	7-8(11a) st/r	14-18 (21*)	5
Mexico	<i>Neocarus bajacalifornicus chamelaensis</i>	2-3 st/r	nude	4-5 st/r	4-6 st/r	16	5
Mexico	<i>Neocarus calakmulensis</i>	2-3 st/r	nude	2-6 st/r	3-8 st/r	17	5
Mexico	<i>Neocarus veracruzensis</i>	2 st/r	nude	6-8 st/r, 0-1 s	6-8 st/r	13	5
Mexico	<i>Neocarus comalensis</i>	5-7 st/r	3st/r			14-18	5
Mexico	<i>Neocarus chactemalensis</i>	nude	nude	4-6 st/r	a-6 st/r	11-13	4
Mexico	<i>Neocarus haicolous</i>	0	6-7	6	7	9-13	5
Mexico	<i>Neocarus queretanus</i>	2	0	8	10	18	6
South America							
Brazil	<i>Neocarus proteus</i>	2-5 st/r	4-6 wb	2-5 st/r	3-5 sh	12 or 13	5 or 6
Brazil	<i>Neocarus potiguar</i>	1 tp/r	4-8 sh	5 st/r	7-10 st/r	25-27	5 or 6
Brazil	<i>Neocarus coronatus</i>	nude	6 pb/b	1-7/r	5-15 tp/r	18-25	4
Brazil	<i>Neocarus caipora</i>	nude	8-12 sh	1-7 st/r	5-8 tp/r	15-16	6
Brazil	<i>Neocarus spelaion</i>	nude	10-12 sh	4-8 st/r	7-11 sh and/or tp/r	14-18	5 or 6
Brazil	<i>Neocarus simmonsii</i>	nude	6-12 st/b or tp/b	9-12 sh or tp/r	4-10 sh or tp/r or st/r	15-17	6
Brazil/Argentina/Uruguay	<i>Neocarus platensis</i>	0-2 st/r	6-9 sh	6-10 st/r	5-10 sh	14	5 or 6
Argentina	<i>Neocarus misiones</i>	nude	12-13 tp/b	7-9 st/r and/or tp/b	12-13 tb/b	15	6
Argentina	<i>Neocarus entrerrios</i>	nude	6-12 sh	6-10 st/r	8-10 tp/r	20	6

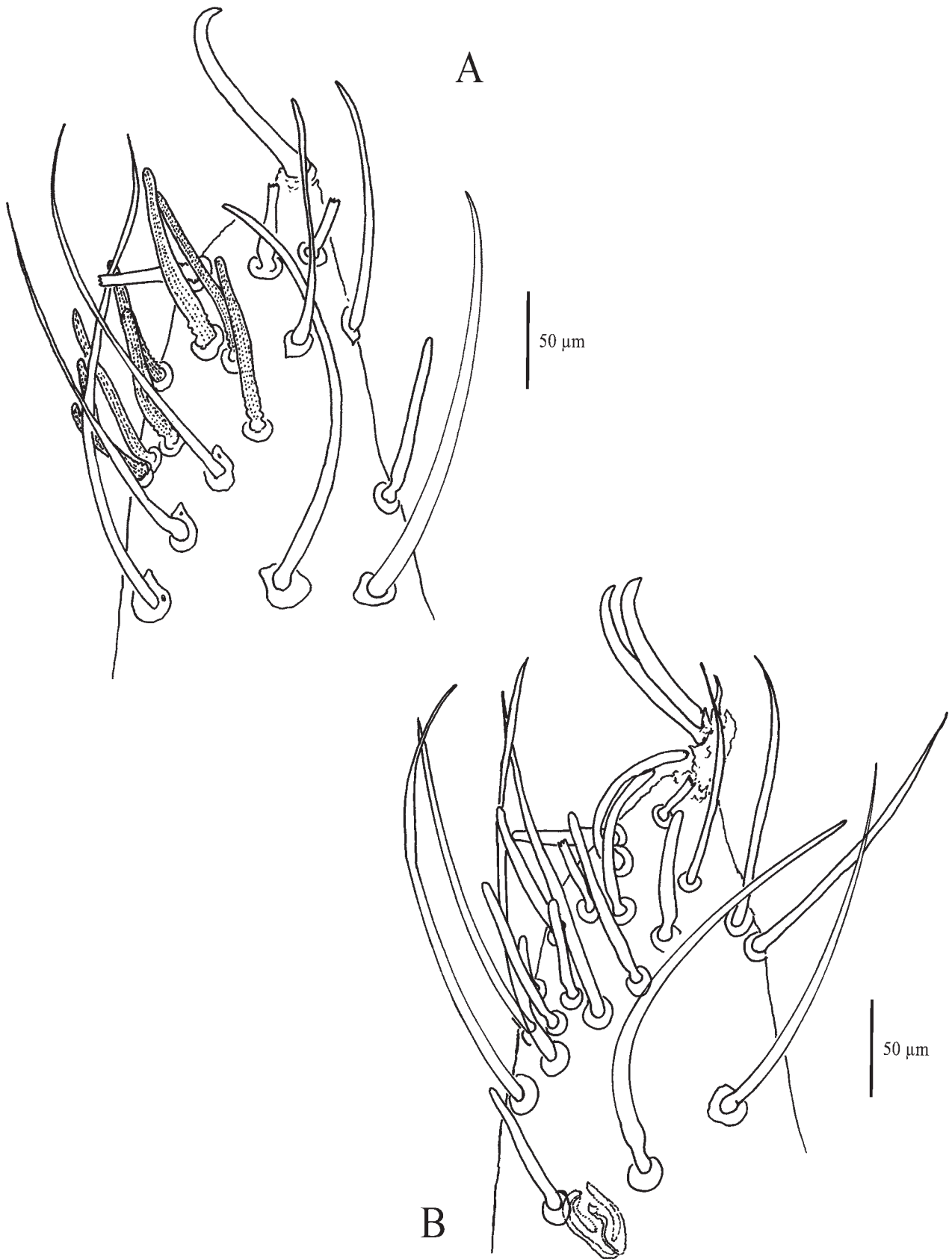


FIGURE 22. *Neocarus queretanus* n. sp. A–B. Tip of leg I, male.

Opilioacarids are found in numerous vegetation types although, so far, seem to be associated with forests, except for two instances in coastal dune systems:

1. Pine-oak Forest—Baja California Sur, Querétaro, Nuevo León.
2. *Quercus* Forest—Baja California Sur
3. Mesophyll Forest—Querétaro, Tamaulipas.
4. Cloud Forest—Chiapas.
5. Xerophyll shrubs—Guerrero, Baja California Sur, Oaxaca.
6. Deciduous Forest— Jalisco, Colima, Morelos.
7. Medium high Tropical Forest—Quintana Roo, Veracruz.
8. Perennial Tropical Forest—Campeche, Quintana Roo
9. Coastal dunes—Veracruz, Quintana Roo.
10. Mangrove Forest—Quintana Roo
11. Liquidambar Forest—Chiapas

Mexico is the second country in species richness of *Neocarulus*, after Brazil, where most species have been found in caves (Araújo *et al.* 2021; Bernardi *et al.* 2020). Mexico has a high diversity but is notable that there are no records of *Neocarulus* species in cave environments. Therefore, in Mexico, Opilioacaridae may not be tied closely to soil type but are widely distributed in forests and, possibly, coastal ecosystems.

Acknowledgements

Field work was supported by PAPIME-DGAPA-UNAM PE201919. Hmunts'a Hem'i-Centro de Documentación y Asesoría Hñähñu, helped name the species.

We thank Oscar Francke, Héctor Montaña, Griselda Montiel, José G. Palacios Vargas, all from Universidad Autónoma de México, Mexico City, for making specimens available and for permission to include unpublished records of material in the CNAC collection and José Irving Monjaras Barrera, Universidad Autónoma de Baja California. Dr. Owen Seeman gave invaluable suggestions to improve the manuscript. We thank Dr. Leopoldo Ferreira de Oliveira Bernardi and an anonymous reviewer for their detailed comments which significantly improved this study.

References

- Araújo, M.S., Bichuette, M.E., Bauchan, G.R., Ochoa, R. & Feres, R.J.F. (2018) A new species of cave dwelling *Neocarulus* (Acari: Opilioacaridae) from Bahia state, Brazil, with remarks on taxonomic characters. *Zootaxa*, 4402 (2), 303–322. <https://doi.org/10.11646/zootaxa.4402.2.4>
- Araújo, M.S., Durarte, M.V.D.S.A. & Bichuette, M.E. (2021) A new species of cave-dwelling *Neocarulus* (Acari: Opilioacaridae) from Minas Gerais state, Brazil with a key to species of the genus. *Systematic and Applied Acarology*, 26 (7), 1229–1240. <https://doi.org/10.11158/saa.26.7.4>
- Bautista, F., Palacio-Aponte, G., Quintana, P. & Zinck, J.A. (2011) Spatial distribution and development of soils in tropical karst areas from the Peninsula of Yucatán, Mexico. *Geomorphology*, 135, 308–321. <https://doi.org/10.1016/j.geomorph.2011.02.014>
- Bernardi, L.F.O. & Borges-Filho, E.L. (2018) *Neocarulus spelaion* sp. n. (Parasitiformes, Opilioacaridae), a new species of cave dwelling *Neocarulus* from Minas Gerais state, Brazil. *Subterranean Biology*, 27, 1–16. <https://doi.org/10.3897/subtiol.27.25777>
- Bernardi, L.F.O., Klompen, H. & Ferreira, R.L. (2014) *Neocarulus 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. (2013) A new species of *Neocarulus* Chamberlin & Mulaik, 1942 (Opilioacarida: Opilioacaridae) from Brazil, with remarks on postembryonic development. *ZooKeys*, 358, 69–89. <https://doi.org/10.3897/zookeys.358.6384>
- Bernardi, L.F.O., Zampaulo, R.A. & Oliveira, M.P.A. (2020) A new species of *Neocarulus* (Opilioacaridae) from a Brazilian ferruginous geosystem and notes on natural history. *Subterranean Biology*, 36, 11–33. <https://doi.org/10.3897/subtiol.36.54034>
- Cervantes-Zamora, Y., Cornejo-Olgín, S.L., Lucero-Márquez, R., Espinoza-Rodríguez, J.M., Miranda-Viquez, E. & Pineda-Velázquez, A. (1990) *Provincias Fisiográficas de México. Datos vectoriales*. Instituto de Geografía, UNAM. México City.

Available from: http://conabio.gob.mx/informacion/metadatos/gis/rfisio4mgw.xml?_xsl=/db/metadatos/xsl/fgdc_html.xsl&_indent%20=%20no (accessed 11 October 2022)

- Chamberlin, R.V. & Mulaik, S. (1942) On a new family of Notostigmata. *Proceedings of the Biological Society of Washington*, 55, 125–132.
- de la Llanta Gómez, R., Bayona Celis, A., Rivera Sánchez, E., Valtierra, J. G., Martínez Resendiz, W.E. & Montoya Martínez, A. (2006) *Caracterización de los Ecosistemas, Cambios en el Uso del Suelo y Unidades Paisajísticas en la Reserva de la Biosfera “Sierra Gorda” de Querétaro. Vol. XII.* CONCYTEQ, Santiago de Querétaro. [unknown pagination]
- García, E. (2004) *Modificaciones al sistema de clasificación climática de Köppen. Serie Libros. Núm. 6.* Instituto de Geografía, Universidad Nacional Autónoma de México, México, D.F. [unknown pagination]
- Grandjean, F. (1936) Un acarien synthétique: *Opilioacarus segmentatus* With. *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord*, 27, 413–444.
- Hammen L., van der (1966) Studies on Opilioacarida (Arachnida). I. Description of *Opilioacarus texanus* (Chamberlin & Mulaik) and revised classification of the genera. *Zoologische Verhandelingen, Leiden*, 86, 3–80.
- Klompen, H., Vázquez, M.M. & Bernardi, L.F. de O. (2015) Post-embryonic development in the mite suborder Opilioacarida, with notes on segmental homology in Parasitiformes. *Experimental & Applied Acarology*, 67, 183–207.
<https://doi.org/10.1007/s10493-015-9939-7>
- Morrone, J.J. (2005) Hacia una síntesis biogeográfica de México. *Revista Mexicana de Biodiversidad*, 76, 207–252.
<https://doi.org/10.22201/ib.20078706e.2005.002.303>
- Priego, A.G., Isunza, E., Luna, N. & Pérez, J.L. (2007) *Cuenca hidrográficas de México.* Instituto Nacional de Estadística, Geografía e Informática (INEGI), Instituto Nacional de Ecología (INE), Comisión Nacional de Agua (CONAGUA). Available from: <https://www.conabio.gob.mx/> (accessed 23 August 2021)
- Vázquez, M.M. & Klompen, H. (2002) The family Opilioacaridae (Acari: Parasitiformes) in North and Central America, with description of four new species. *Acarologia*, 42 (4), 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 (1), 23–44.
<https://doi.org/10.11646/zootaxa.2061.1.2>
- 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 (5), 535–552.
<https://doi.org/10.11646/zootaxa.3957.5.3>
- Vázquez, M.M., Araújo, M.S. & Feres, R.J.F. (2015) *Brasilacarus cocaris* (Acari: Opilioacaridae), a new genus and species from Amazonia, Brazil. *Zootaxa*, 3915 (3), 375–389.
<https://doi.org/10.11646/zootaxa.3915.3.3>
- Vázquez, M.M., Bernardi, L.F.O. & Klompen, H. (2020) The family Opilioacaridae (Acari: Parasitiformes) in Argentina, with description of two new species. *Acarologia*, 60 (3), 505–519.
<https://doi.org/10.24349/acarologia/20204380>
- Vázquez, M.M., Uicab, D.A.M. & Pastrana, E.B.A. (2016) Riqueza específica y biodiversidad de Cozumel, Quintana Roo, México. *Teoría y Praxis*, 19, 137–171.
- Vidal Zepeda, R. (1990) *Precipitación media anual. Atlas Nacional de México. Vol. II. escala 1:400 000.* Instituto de Geografía, UNAM, México City. [unknown pagination]