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First record of Acarophenacidae (Acari: Heterostigmata) from Mexico, with description of a new species of *Paracarophenax* associated with Cerambycidae (Insecta: Coleoptera)

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Original research

ABSTRACT

Paracarophenax (Acari: Heterostigmata: Acarophenacidae) comprises eight distinct species of egg parasitoids associated mainly with various beetles, distributed across different global regions. In this study, a new species of *Paracarophenax* was found associated with cerambycid beetles' collection samples deposited in the Colección de Insectos de la Universidad de Morelos, Morelos, Mexico. The aim of this paper is to describe the ninth species of the *Paracarophenax*, and provide an updated taxonomic key of the genus. The new species can be separated from others congeners by the presence of one spiniform seta on genu II, the seta *l*' on femur I slightly spatulate, one seta on femur III, setae *e* slightly longer than *f*, and the distance between setae *e* and *f* slightly longer or equal to the distance between setae *h*₁ and *h*₂. This study reports the family Acarophenacidae for the first time from Mexico, and the genus *Paracarophenax* from the Neotropical Region.


Keywords female phoretic; geographical distribution; taxonomic key; Neotropical; mites; beetles; CIUM

Zoobank <http://zoobank.org/90BA285B-FE52-4C14-855E-9C7C507BBD91>

Introduction

Mites of the family Acarophenacidae Cross, 1965 include species with phoretic adult females and parasitoids of insect's eggs, and pre-phoretic attendance (Walter & Seeman 2017; Khaustov & Abramov 2019, 2021). The family comprises eight genera and about 40 described species (Khaustov & Abramov 2021; Khaustov *et al.* 2021). The genus *Paracarophenax* was established by Cross in 1965 with the description of the species *Paracarophenax dybasi* Cross, 1965, type species of the genus, and the taxonomic transference of *Acarophenax bambergensis* Krczal, 1959 to this new genus. Subsequently, six more species were described associated with decomposing organic matter and beetles of the families Cerambycidae, Curculionidae, Erotylidae, Mycetophagidae and Nitidulidae, and characterized by the presence

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of the prodorsum with two pairs of setae, the dorsal stigmatal openings with membranous atria, tibia and tarsus I fused, tarsi I-IV with claws and the absence of U-shaped apodeme in gnathosoma (Krczal 1959; Cross 1965; Mahunka 1975; Mahunka & Rack 1977; Khaustov 1999; Katlav *et al.* 2015; Walter & Seeman 2017; Khaustov & Abramov 2018; Xu *et al.* 2018; Khaustov *et al.* 2021). In addition, Cross (1965) refers to an undescribed species of *Paracarophenax* collected from an unidentified Cerambycidae from Panama, which to our knowledge has never been described. Before this study, there are no records of this genus and the family Acarophenacidae from Mexico.

In this study, following a taxonomic study of mites associated with Coleoptera deposited in Colección de Insectos de la Universidad de Morelos (CIUM), Morelos, Mexico, a new species is described based on phoretic females associated with Cerambycidae collected from Mexico. We also provide an updated key of the species of *Paracarophenax*.

Material and methods

Specimens of Cerambycidae family deposited in the CIUM from localities in Mexico were examined under a stereomicroscope Nikon C-LEDS (Tokyo, Japan) to collect phoretic mites. The mites were found ventrally between coxae I and II of the hosts, and were preserved in 70% ethanol for morphological identification, and were slide-mounted in Hoyer's medium following the protocol described by Walter & Krantz (2009) for their taxonomic identification according to the keys presented by Walter & Seeman (2017), Xu *et al.* (2018), and Khaustov *et al.* (2021). The mites were measured and microphotographed with a Nikon Eclipse 80i optical microscope (Nikon Japan Y-TV55), equipped with a Nikon DS-Ri2 camera. Measurement data are given in micrometers (μm) for the holotype and the ranges of paratypes are in parentheses. Drawings were made by superposition of vector art placed on the microphotographs in Adobe Illustrator CC 2017 software (Adobe Systems Inc., San Jose, California). The terminology follows the adaptation of Katlav *et al.* (2015) and Walter & Seeman (2017) from Lindquist (1986). Finally, one individual was used for scanning electron microscopy (SEM) study at Laboratorio de Microscopía Electrónica, Instituto de Biología (IB) of the Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico.

Results

Systematics

Family Acarophenacidae Cross, 1965

Genus *Paracarophenax* Cross, 1965

Type species: *Paracarophenax dybasi* Cross, 1965

Paracarophenax cerambycinus Trejo-Palacios n. sp.

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(Figures 1–3)

Description

Phoretic female — idiosoma length 212 (183–257), width 104 (90–151).

Gnathosoma — (Figures 1A, 1B, 3D). Rounded, partially concealed dorsally by prodorsum, posterior edge distinguishable ventrally from idiosoma; posterior ventral region with membranous-striate areas; palps fused with gnathosomal capsule; cheliceral stylets strong, and one pair of postpalpal setae (*pp*) 3 (3–6). Pharynx enlarged and almost elliptical.

Idiosomal dorsum — (Figures 1A, 3A). Ovate; prodorsal shield and tergites C, D, EF, H punctate. Prodorsal shield trapezoidal with two pairs of external vertical and external scapular

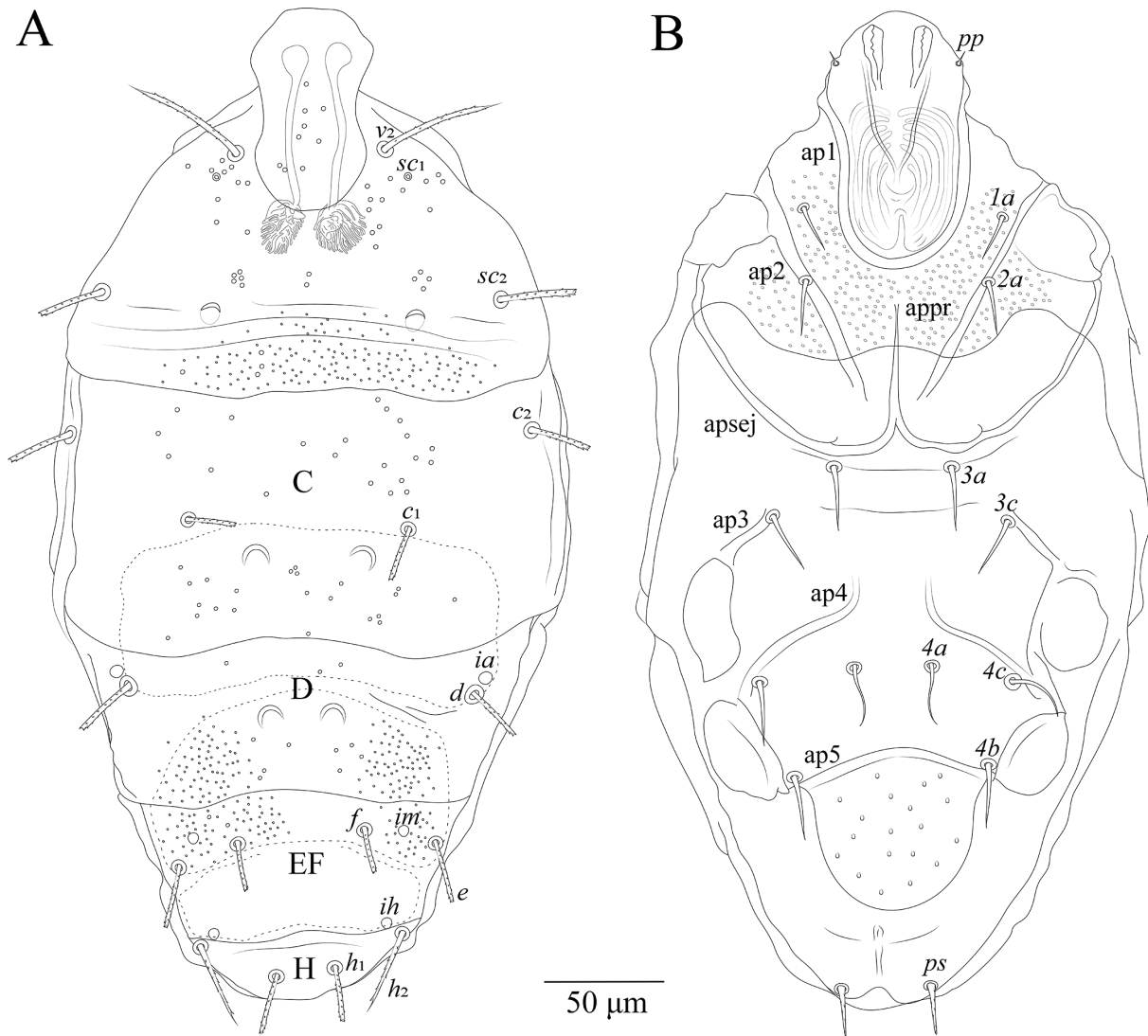


Figure 1 *Paracarophenax cerambycinus* n. sp., female: A – dorsum of the body (prodorsum with external vertical setae = v_2 , pits of internal scapular setae = sc_1 , external scapular setae = sc_2 ; tergite C with dorsal setae c_1 and c_2 , dorsal setae d on tergite D, dorsal setae e and f on tergite EF, setae h_1 and h_2 on tergite H, and cupules ia , im and ih); B – venter of the body (coxal setae $1a$, $2a$, $3a$, $3c$, $4a$, $4b$ and $4c$; pseudanal setae = ps , postpalpal setae = pp , apodemes 1 = $ap1$, apodemes 2 = $ap2$, sejugal apodeme = $apsej$, prosternal apodeme = $appr$ and apodeme 3 = $ap3$). Legs omitted.

setae (v_2 and sc_2) thickened and barbed. Setae v_2 longer than sc_2 . Stigmata on prodorsal projection, tracheal trunks with a brush-like atrium. Pits of internal scapular setae (sc_1) situated anterolaterally to bases of setae v_2 . Tergite C with two pairs of setae (c_1 and c_2). Tergite D with one pair of setae d ; tergite EF with two pairs of setae (e and f); tergite H with two pairs of setae (h_1 and h_2). One pair of crescent-shaped ornamentation located near posterior margin of tergite C, one pair near posterior margin of tergite D, and one pair near posterior margin of prodorsal shield. Cupules small, oval; cupules ia , im and ih situated anterior and lateral to bases of setae d , e and h_2 respectively. All setae of tergites C, D, EF and H with short barbs and shorter and slender than prodorsal setae; setae v_2 about two times longer than setae sc_2 ; setae e slightly longer than f ; setae h_2 located far from h_1 , and the distance between setae e and f subequal to distance between setae h_1 and h_2 . Lengths of dorsal setae: v_2 28 (19–28), sc_2 17 (13–20), c_1 11 (10–14), c_2 15 (12–18), d 14 (12–17), e 14 (12–15), f 11 (9–13), h_1 13 (11–14), h_2 19 (15–25). Distances between setae: v_2 – v_2 32 (26–35), sc_2 – sc_2 81 (69–85), v_2 – sc_2 24 (21–26),

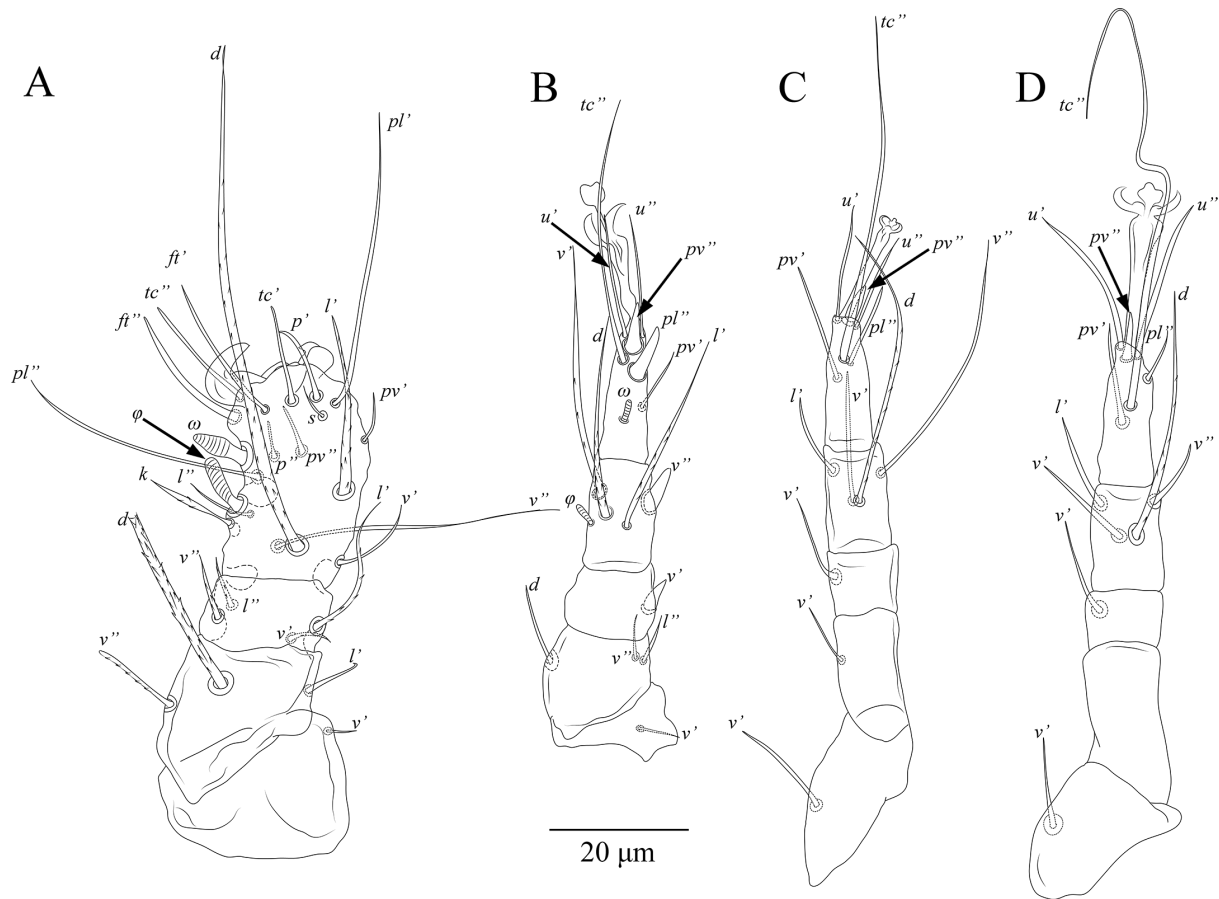


Figure 2 Leg chaetotaxy of *Paracarophenax cerambycinus* n. sp., female: A – leg I in dorsal view; B – leg II in dorsal view; C – leg III in dorsal view; D – leg IV in dorsal view.

c_1-c_1 46 (35–55), c_2-c_2 97 (86–113), c_1-c_2 28 (22–31), $d-d$ 73 (68–90), $f-f$ 27 (19–29), $e-f$ 13 (14–21), h_1-h_1 13 (12–20), h_2-h_2 42 (35–50), h_1-h_2 15 (11–18).

Idiosomal venter — (Figures 1B, 3B). Ventral plates punctate. All coxal setae of ventral plates (*1a*, *2a*, *3a*, *3c*, *4a*, *4b* and *4c*) thin and smooth. Apodemes 1 (ap1) fused, apodemes 2 (ap2) and sejugal apodeme (apsej) joined with prosternal apodeme (appr); apodeme 3 (ap3) restricted proximal femur III, apodemes 4 (ap4) well developed. Tegula well developed in the posterior edge of poststernal plate. Aggenital plate without setae *ag*. Plate PS with one pair of pseudanal setae *ps* weakly barbed and thicker than other ventral setae. Lengths of ventral setae: *1a* 7 (7–9), *2a* 11 (8–14), *3a* 13 (9–21), *3c* 13 (9–18), *4a* 12 (8–19), *4b* 9 (6–14), *4c* 10 (10–13), *ps* 8 (8–10). Distances between setae: *1a-1a* 40 (40–51), *2a-2a* 38 (36–48), *3a-3a* 28 (25–40), *4a-4a* 20 (15–27), *4b-4b* 35 (25–42), *4c-4c* 55 (42–66).

Legs — (Figures 2A–2D, 3C–3E). Lengths of legs I–IV: 63 (58–80), 62 (58–72), 81 (67–90), 79 (69–93). Tibiotarsus I length 31 (26–35), width 22 (16–22). Leg I — (Figures 2A, 3C). Setal formula Tr1–Fe3–Ge4–TiTa17(2). Trochanter with seta *v'* tiny, slender and smooth. Femur with seta *l'* spatulate and slightly thickened, seta *v''* slender and weakly barbed, seta *d* thickened and serrate. Genu with setae *l'*, *l''*, *v'* and *v''* slender and weakly barbed. Tibiotarsus with tarsal-claw complex, solenidion ϕ 9 (9–11) and solenidion ω 9 (7–10), seta *d* attenuated, whip-like and with short barbs, seta *v''* slender, smooth and whip-like, seta *k* weakly barbed and thickened in the middle part, setae *pv''* and *p''* pointed, seta *fi''* attenuated, *pl'* elongated and attenuated, *l'* weakly barbed, setae *v'*, *l''*, *pl''*, *pv'*, *s*, *p'*, *tc'*, *ft'* and *tc''* setiforms and smooth. Leg II — (Figure 2B, 3D). Setal formula Tr1–Fe3–Ge1–Ti4(1)–Ta6(1). Trochanter with seta

v' tiny and slender. Femur with setae *l''*, *v''* and *d* slender and smooth. Genu with seta *v'* spiniform. Tibia with solenidion φ 4 (4–5); setae *d*, *v'* and *l'* weakly barbed, elongated and attenuated, seta *v''* spiniform. Tarsus with two simple claws and empodium lobed similar to legs III and IV, solenidion ω 5 (3–5), setae *pl''* and *pv''* spiniform, seta *pv'* pointed, seta *tc''* elongated and attenuated, setae *u'* and *u''* slender. Leg III — (Figure 2C–3E). Setal formula: Tr1–Fe1–Ge1–Ti4–Ta6. Trochanter, femur and genu each one with one seta *v'* slender and pointed. Tibia with seta *d* weakly barbed, setae *v'*, *v''* and *l'* slender and attenuated. Tarsus with seta *tc''* attenuated and whip-like, setae *u'* and *u''* slender, seta *pv''* spiniform, seta *pl''* and *pv'* pointed. Leg IV — (Figure 2D). Setal formula: Tr1–Fe0–Ge1–Ti4–Ta6. Trochanter with seta *v'* slender and pointed. Femur without setae. Genu with seta *v'* slender and pointed. Tibia with setae *d* weakly barbed, setae *v'*, *v''* and *l'* slender and attenuated. Tarsus with seta *tc''* attenuated and whip-like, seta *pv''* spiniform, seta *pl''* pointed, setae *pv'*, *u'*, *u''* slender.

Other developmental stages — unknown.

Type material

Holotype (slide number CNAC012477) — Female, from Mexico, Chiapas, Ocozocoautla de Espinosa (16°53'31.5" N, 93°27'09.5" W, 956 m a.s.l.), ex. *Atrypanius implexus* Erichson, 1847.

Paratypes (n= 17; CNAC012478– CNAC012494) — Six females, same data as holotype. Five females from Mexico, Chiapas, Ocozocoautla de Espinosa (16°53'06.4" N, 93°27'29.4" W, 934 m a.s.l.; 16°53'31.5" N, 93°27'09.5" W, 956 m a.s.l.), ex. *Thryallis leucophaeus* (White, 1855). One female from Mexico, Tabasco, Teapa (17°32'11" N, 92°54'45" W, 158 m a.s.l.), ex. *Platyarthron bilineatum* Guérin-Méneville, 1844. Five females from Tabasco, Teapa (17°31'42" N, 92°55'44" W, 90 m a.s.l.), ex. *Taeniotes scalatus* (Gmelin, 1790).

Type deposition

The type series is deposited in the Colección Nacional de Ácaros (CNAC), Instituto de Biología (IB) of the Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico.

Differential diagnosis

Paracarophenax cerambycinus n. sp. is very close to *P. scolyti* Khaustov, 1999 and *P. alternatus* Xu & Zhang, 2018. The new species is similar to *P. scolyti* by presence of one seta on femur III, setae *e* slightly longer than *f* and the distance between setae *e* and *f* slightly longer or equal to the distance between setae h_1 and h_2 but differs by the presence of one spiniform seta on genu II. The last character is also present in *P. alternatus*, and both species are associated with Cerambycidae, however, *P. cerambycinus* n. sp. differs from *P. alternatus* in having femur III with one setae, and the seta *l'* on femur I spatulate and slightly thickened instead two setae on femur III, and seta *l'* setiform. Also, the new species differs of *P. alternatus* in having setae *e* slightly longer than *f*, setae h_2 located far to h_1 , and the distance between setae *e* and *f* slightly longer or equal to the distance between setae h_1 and h_2 , rather than setae *f* longer than *e*, setae h_2 located very close to h_1 , and the distance between setae h_1 and h_2 is about one fifth of the distance between setae *e* and *f* in *P. alternatus*.

Etymology

The new species name refers to Cerambycidae family, host of the new species.

Key to species of *Paracarophenax* (after Xu et al. 2018 with modifications)

1. Tergite EF with one pair of setae *f* (setae *e* absent); setae *ps* absent; trochanter II without setae 2
- Tergite EF with two pairs of setae *e* and *f*; setae *ps* present; trochanter II with seta *v'* 4

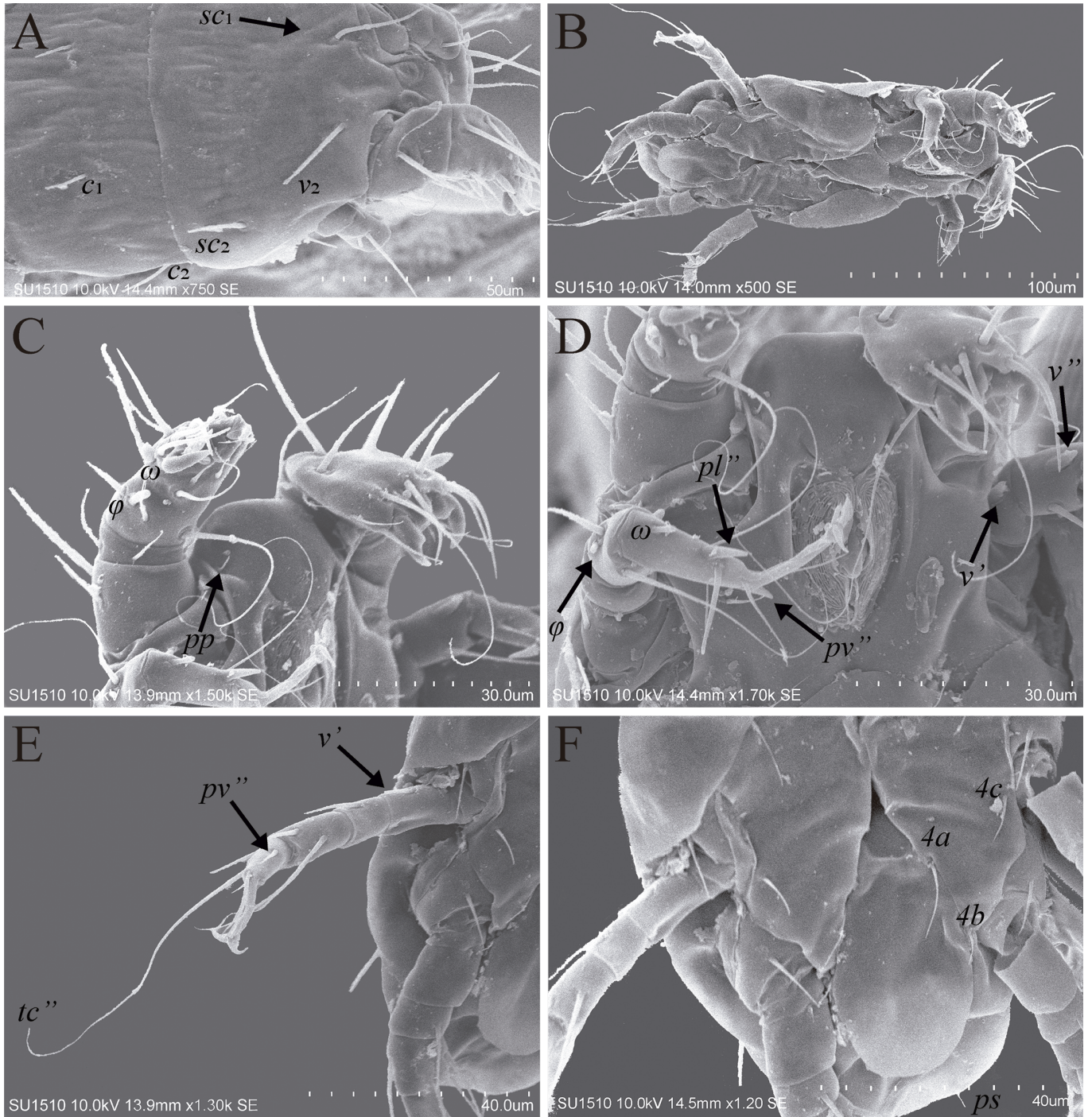


Figure 3 SEM micrographs of *Paracarophenax cerambycinus* n. sp., female: A – anterior part of prodorsum (external vertical setae = v_2 , pits of internal scapular setae = sc_1 , external scapular setae = sc_2 , and dorsal setae c_1 and c_2); B – general ventral view; C – legs I (solenidia ϕ and ω ; the arrow indicate postpalpal setae = pp); D – Legs II (solenidia ω and ϕ , spiniform setae pl'' and pv'' on tarsus, spiniform seta v'' on tibia, and spiniform seta v' on genu); E – Leg III (seta v' on femur, seta tc'' and spiniform seta pv'' on tarsus); F – anterior ventral view (coxal setae $4a$, $4b$, $4c$ and pseudanal setae = ps).

- 2. Aggenital setae ag present, trochanter I with seta v'
 *P. triplaxophilus* Khaustov & Abramov, 2018 – Russia
- Aggenital setae ag absent, trochanter I without setae 3

- 3. Tracheal atria bulbous, narrowing distally; sejugal apodeme fully developed; apodemes I moderately well developed *P. paucisetosus* Mahunka & Rack, 1977 – **Hungary**
 — Tracheal atria cylindrical, not narrowing distally; sejugal apodeme weakly developed medially; apodemes I weakly developed or obsolete
 *P. myzognathus* Walter & Seeman, 2017 – **Canada**
- 4. Opisthogaster without setae *ag* absent; tegula present 5
 — Opisthogaster with one pair of setae *ag* present; tegula absent 8
- 5. Setae *h*₂ present; tracheae with atrium terminating in brush-like extensions 6
 — Setae *h*₂ absent; tracheae without obvious atrium extensions
 *P. undosus* Mahunka, 1975 – **New Guinea**
- 6. Genu II with one setiform seta *P. scolyti* Khaustov, 1999 – **Crimea**
 — Genu II with one spiniform seta 7
- 7. Femur III with two setae; setae *f* about twice longer than *e*; setae *h*₂ located very close to *h*₁, and about one fifth of the distance between setae *e* and *f*
 *P. alternatus* Xu & Zhang, 2018 – **China**
 — Femur III with one seta; setae *e* slightly longer than *f*; setae *h*₂ located far to *h*₁, and the distance between setae *e* and *f* about equal to the distance between setae *h*₁ and *h*₂
 *P. cerambycinus* n. sp. – **Mexico**
- 8. Prosternal and poststernal apodemes absent; setae *h*₂ as long as *h*₁
 *P. dybasi* Cross, 1965 – **USA**
 — Prosternal apodeme present; poststernal apodeme present as remnant; setae *h*₂ about twice as long as *h*₁ *P. bambergensis* (Krczal, 1959) – **Germany, Russia**

Discussion

The host range of *Paracarophenax* is wide, mostly there are associations with beetles, and members of the family Cerambycidae appear to be potential hosts of these mites. The first record of the genus on cerambycid beetles was recorded in China (Xu *et al.* 2018), and in the present study *Paracarophenax* has been found associated with four new host species belonging to Cerambycidae (Table 1).

Paracarophenax is a genus distributed in America, Asia, Europe and Oceania. In the American continent species of this genus were described from Canada, USA and now from Mexico (Table 1). It also is the first record of the family Acarophenacidae from the country. The

Table 1 Localities and host / habitat of mites of the genus *Paracarophenax*.

Species	Host / habitat	Locality	Reference
<i>P. bambergensis</i> Krczal, 1959	Nitidulidae Gen. et sp.; <i>Amphottis marginata</i> (Fabricius, 1781) (Nitidulidae).	Germany; Russia	Krczal 1959; Khaustov & Abramov 2019.
<i>P. dybasi</i> Cross, 1965	In debris under decaying fruit.	USA	Cross 1965.
<i>P. undosus</i> Mahunka, 1975	Without habitat / host data.	New Guinea	Mahunka 1975.
<i>P. paucisetosus</i> Mahunka & Rack, 1977	Under tree bark.	Hungary	Mahunka & Rack 1977.
<i>P. scolyti</i> Khaustov, 1999	<i>Leperesinus fraxini</i> (Panzer, 1799) (Curculionidae); <i>Fraxinus</i> sp. (Oleaceae).	Crimea	Khaustov 1999.
<i>P. myzognathus</i> Walter & Seeman, 2017	<i>Mycetophagus</i> (Mycetophagidae) ex. rearing container of <i>Pleurotus ostreatus</i> (Jacq.) P. Kumm (1871).	Canada	Walter & Seeman 2017.
<i>P. triplaxophilus</i> Khaustov & Abramov, 2018	<i>Triplax scutellaris</i> Charpentier, 1825 (Erotylidae).	Russia	Khaustov & Abramov 2018.
<i>P. alternatus</i> Xu & Zhang, 2018	<i>Monochamus alternatus</i> Hope, 1843 (Cerambycidae).	China	Xu <i>et al.</i> 2018.
<i>P. cerambycinus</i> Trejo-Palacios n. sp.	<i>Atrypanius implexus</i> Erichson, 1847 (Cerambycidae); <i>Thryallis leucophaeus</i> (White, 1855) (Cerambycidae); <i>Platyarthron bilineatum</i> Guérin-Méneville, 1844 (Cerambycidae); <i>Taeniotes scalatus</i> (Gmelin, 1790) (Cerambycidae).	Mexico	Present study

new species, *P. cerambycinus* n. sp. is the 9th species assigned to this genus which contributes to expanding the range of geographical distribution of *Paracarophenax* in American continent with the first record for the Neotropical Region. Taking into account the current records of the genus in southern Mexico, and the possible record of *Paracarophenax* in South America (Cross 1965), it is possible to assume a wide distribution of this genus in other areas of the Neotropic, therefore it is imperative to continue studying these associations between Acari and Coleoptera in unexplored hosts and habitats.

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References

- Cross E. 1965. The generic relationships of the family Pyemotidae (Acarina, Trombidiformes). *Kans. Univ. Sci. Bull.*, 45: 29-215.
- Katlav A., Hajiqanbar H. Asghar-Talebi A. 2015. First record of the genus *Aethiophenax* (Acari: Acarophenacidae) from Asia, redefinition of the genus and description of a new species. *J. Asia-Pac. Entomol.*, 18: 389-395. <https://doi.org/10.1016/j.aspen.2015.03.011>
- Khaustov A.A. 1999. Redescription of *Pediculoides ipidarius* Redikortzev, 1947, and a description of a new species from the genus *Paracarophenax* (Acari: Heterostigmata: Acarophenacidae). *Acarina*, 7: 57-59.
- Khaustov A.A., Abramov V.V. 2018. A new species of *Paracarophenax* (Acari: Heterostigmata: Acarophenacidae) associated with *Triplax scutellaris* (Coleoptera: Erotylidae) from European Russia. *Acarologia*, 58: 332-341. <https://doi.org/10.24349/acarologia/20184245>
- Khaustov A.A., Abramov V.V. 2019. First record and redescription of *Paracarophenax bambergensis* (Acari: Heterostigmata: Acarophenacidae) associated with *Amphotis marginata* (Coleoptera: Nitidulidae) from European Russia. *Acarina*, 27: 45-51. <https://doi.org/10.21684/0132-8077-2019-27-1-45-51>
- Khaustov A.A., Abramov V.V. 2021. A new species of *Adactylidium* (Acari: Heterostigmata: Acarophenacidae) associated with *Phlaeothrips* sp. (Thysanoptera: Phlaeothripidae) from European Russia. *Acarologia*, 61: 356-364. <https://doi.org/10.24349/acarologia/20214435>
- Khaustov A.A., Vorontsov D.D., Perkovsky E.E. Lindquist E.E. 2021. Review of fossil heterostigmatic mites (Acari: Heterostigmata) from late Eocene Rovno Amber. I. Families Tarsocheylidae, Dolichocybidae and Acarophenacidae. *Syst. Appl. Acarol.*, 26: 33-61. <https://doi.org/10.11158/saa.26.1.3>
- Krczal H. 1959. Systematik und Ökologie der Pyemotiden. *Beitr. Syst. Ökol. Mitteleurop. Acarina*, 1: 385-625.
- Lindquist E.E. 1986. The world genera of Tarsonemidae (Acari: Heterostigmata): a morphological, phylogenetic, and systematic revision, with a reclassification of family-group taxa in the Heterostigmata. *Mem. Entomol. Soc. Can.*, 118: 1-517. <https://doi.org/10.4039/entm118136fv>
- Mahunka S. 1975. Neue und auf Insekten lebende Milben aus Australien und Neu-Guinea (Acari: Acarida, Tarsonemida). *Annl. Hist.-Nat. Mus. Natn. Hung.*, 67: 317-325.
- Mahunka S., Rack G. 1977. Zwei neue Artender Familien Acarophenacidae und Pygmephoridae (Acarina, Tarsonemida). *Annl. Hist.-Nat. Mus. Natn. Hung.*, 69: 305-309.

- Walter, D.E., Krantz, G.W. 2009. Collecting, rearing, and preparing specimens. In: Krantz, G.W., Walter, D.E. (Eds.). *A Manual of Acarology*. Third Edition. Texas Tech University Press, p. 83-96.
- Walter D.E., Seeman O.D. 2017. A new species of *Paracarophenax* (Acariformes: Acarophenacidae) with a new means of phoretic attachment. *Internat. J. Acarol.*, 43: 329-335. <https://doi.org/10.1080/01647954.2017.1287216>
- Xu Y., Li Y., Huang B., Cai M., Wu J., Wu S., Zhang F. 2018. First record of the genus *Paracarophenax* (Acari: Acarophenacidae) from China, with description of a new species. *Syst. Appl. Acarol.*, 23: 2411-2419. <https://doi.org/10.11158/saa.23.12.10>