

A new species of *Paracarophenax* (Acari: Heterostigmata: Acarophenacidae) associated with *Triplax scutellaris* (Coleoptera: Erotylidae) from European Russia

Alexander A. Khaustov^a, Vladimir V. Abramov^b

^a Tyumen State University, Tyumen, Semakova 10, 625003 Russia.

^b Gagarin str. 12, Suvorov, Tula Province, 301430, Russia.

ABSTRACT

A new species, *Paracarophenax triplaxophilus* n. sp. (Acari: Acarophenacidae), is described based on phoretic females collected under the elytra of a mycophagous beetle *Triplax scutellaris* Charpentier, 1825 (Coleoptera: Erotylidae) in European Russia. An updated key to species of *Paracarophenax* is provided. Homologies of some gnathosomal structures of acarophenacid mites are re-evaluated.

Keywords Heterostigmata, Pyemotoidea, systematics, morphology, phoresy

Zoobank <http://zoobank.org/E23C6E9C-0E42-4DF8-B263-C0C9BCADB2AF>

Introduction

The family Acarophenacidae currently includes one fossil genus *Protophenax* Magowski, 1994 and six extant genera: *Acarophenax* Newstead and Duval, 1918, *Adactylidium* Cross, 1965, *Aegyptophenax* Rady, 1992, *Aethiophenax* Mahunka, 1981, *Paracarophenax* Cross, 1965 and *Paradactylidium* Mahunka, 1975 and about 36 described species (Magowski 1994; Ardjomandi *et al.* 2017; Walter & Seeman 2017). Members of the family are parasitoids of eggs of various insects, including beetles from the families Cerambycidae, Tenebrionidae, Nitidulidae, Dermestidae, Curculionidae, Mycetophagidae and thrips (Thysanoptera) (Goldarazena *et al.* 2001; Katlav *et al.* 2015; Ardjomandi *et al.* 2017; Walter & Seeman 2017). The genus *Paracarophenax* Cross, 1965 includes six described species: *P. dybasi* Cross, 1965 from USA (Cross 1965), *P. bambergensis* (Krczal, 1959) from Germany (Krczal 1959), *P. undosus* Mahunka, 1975 from New Guinea (Mahunka 1975), *P. paucisetosus* Mahunka and Rack, 1977 from Hungary (Mahunka & Rack 1977), *P. scolysi* Khaustov, 1999 from Crimea (Khaustov 1999), and *P. myzognathus* Walter and Seeman, 2017 from Canada (Walter & Seeman 1917). Katlav *et al.* (2015) discussed distribution and host range of *Paracarophenax* species and Walter & Seeman (2017) redefined the genus and described the phenomenon of pre-phoresy, when adult females of *P. myzognathus* attached to larvae of the host beetle.

During the study of insect associated mites, a new species of *Paracarophenax* was revealed from European Russia. This is the first record of a species of Acarophenacidae associated with fungus beetles of the family Erotylidae.

The aim of this article is to describe this new species associated with the mycophagous beetle *Triplax scutellaris* from European Russia and to re-evaluate homologies of some gnathosomal structures.

Received 11 October 2017
Accepted 17 October 2017
Published 22 February 2018

Corresponding author
Alexander A. Khaustov:
alex1973khaustov@gmail.com

Academic editor
Michel Bertrand

DOI
10.24349/acarologia/20184245

© Copyright
Khaustov A.A. and Abramov V.V.

Distributed under
Creative Commons CC-BY 4.0

Materials and methods

Mites were collected from under the elytra of a single specimen of *Triplax scutellaris* that was captured by the junior author on rotten oyster mushroom *Pleurotus* sp.. The mites were mounted in Hoyer's medium. The terminology follows that of Lindquist (1986). All measurements are given in micrometers (μm) for the holotype and five female paratypes (in parentheses). For leg chaetotaxy the number of solenidia is given in parentheses. DIC micrographs were taken using the Carl Zeiss Axio Imager A2 compound microscope and digital Cameras Hitachi KP-HD20A. For SEM microscopy, alcohol-preserved mites were dried in a freeze drying device JFD 320 (JEOL, Japan), dusted by silver and scanned with the aid of a JEOL-JSM-6510LV SEM microscope. The holotypes and most paratypes of the new species are deposited in the mite collection of the Tyumen State University Museum of Zoology, Tyumen, Russia; two female paratypes of the new species are deposited in the acarological collection of the Zoological Institute of RAS, St. Petersburg, Russia.

Results

Systematics

Family Acarophenacidae Cross, 1965

Genus *Paracarophenax* Cross, 1965

Type species: *Paracarophenax dybasi* Cross, 1965

Paracarophenax triplaxophilus n. sp. (Figures 1–5)

Zoobank: [73D3924C-5DEB-4F99-B151-3D9608B35095](https://doi.org/10.3896/73D3924C-5DEB-4F99-B151-3D9608B35095)

Diagnosis — Gnathosoma ventrally with pair of smooth membranous areas. Setae *e* and *ps* absent. Setae *h*₂ present. Aggenital setae present. Trochanter I with seta, trochanter II without seta. Apodemes 1 and 3 absent. Femur III with 2 setae, femur IV with 1 seta. Genua I and II with 2 setae each. Seta *pl*'' of tarsus II spine-like.

Description

Female — Length of idiosoma 260 (280–290), width 190 (195).

Gnathosoma (Figures 1B, 4C, F) — Concealed dorsally by prodorsum, indistinguishable ventrally from idiosoma; palps absent. One pair of setae laterally, probably representing postpalpal seta *pp* (Figure 5C) (see Discussion). Venter with mouth flanked by paired, semi-ovular smooth membranous area (Figure 4C); one pair of rod-like ventral setae 4 (3–4) of unknown homology situated at anterior ends of membranous areas. Pharynx large, narrowly oval, thin walled. One pair of very thin ducts leads from mouth into propodosoma above pharynx (Figure 4F).

Idiosomal dorsum (Figures 1A, 4A, B, 5A–D) — Ovate. Prodorsal shield delineated into primary plate and prodorsal projection encapsulating gnathosoma. Stigmata on prodorsal projection; tracheal trunks broad, expanding after ca. 15–25 μm (into cylindrical atrium), becoming obsolete ca. 30–50 μm into body. Prodorsal shield and plates C, D, EF, H weakly punctate (Figures 4A, B). Pits *sc*₁ situated anterolaterally to bases of setae *v*₂. Setae *e* absent. All dorsal setae weakly barbed and blunt-ended (Figures 4A, B, 5D). Cupules small, round; *ia* and *im* situated anterolaterad bases of setae *d* and *f* respectively; cupules *ih* situated just laterad bases of setae *h*₁. Lengths of dorsal setae: *v*₂ 37 (32–37), *sc*₂ 34 (30–34), *c*₁ 36 (34–37), *c*₂ 36 (33–36), *d* 40 (39–41), *f* 44 (39–44), *h*₁ 43 (39–43), *h*₂ 34 (28–34). Distances between setae: *v*₂–*v*₂ 30 (30–34), *sc*₂–*sc*₂ 99 (99–105), *v*₂–*sc*₂ 35 (35–39), *c*₁–*c*₁ 77 (69–77), *c*₁–*c*₂ 37 (37–39), *d*–*d* 100 (98–105), *f*–*f* 68 (65–67), *h*₁–*h*₁ 40 (32–36), *h*₂–*h*₂ 34 (29–34).

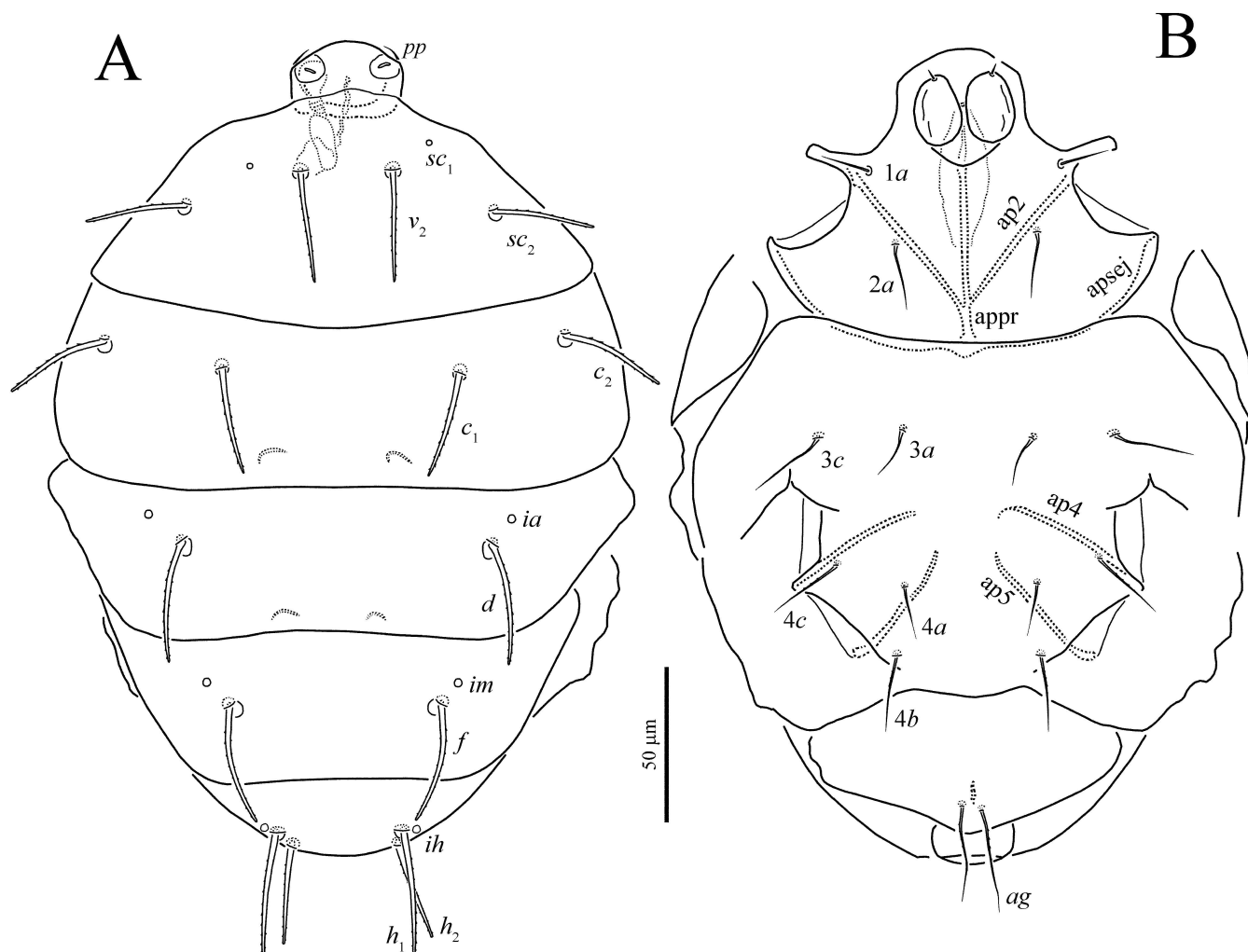


Figure 1 *Paracarophenax triplaxophilus* n. sp., female: A – dorsum of the body, B – venter of the body. Legs omitted.

Idiosomal venter (Figures 1B, 4C-E) — Ventral plates punctate (Figures 4C-E), punctations coarser than on dorsal shields. Ventral setae *4b*, *4c* and *ag* weakly barbed, attenuate; other ventral setae smooth and attenuate. Setae *2a*, *3a*, *3c*, and *4c* with slightly thickened base (Figures 4C, D). Pseudanal setae absent. Apodemes 1 absent, apodemes 2 (*ap2*) well developed, just reaching prosternal apodeme (*appr*); sejugal apodeme (*apsej*) well developed and joined with prosternal apodeme; apodemes 3 absent; apodemes 4 (*ap4*) and 5 (*ap5*) well developed, but not joining each other medially. Lengths of ventral setae: *1a* 12 (12–13), *2a* 26 (24–27), *3a* 21 (21–24), *3c* 28 (27–31), *4a* 19 (19–20), *4b* 26 (25–27), *4c* 29 (28–30), *ag* 38 (34–38).

Legs (Figures 2, 3, 5E, F) — Leg I (Figures 2A, 5E) much thicker than other legs. Leg setation: Tr 1, Fe 3, Ge 2, TiTa 17(2). Tibiotarsus with massive claw and structure opposing to claw. Solenidia ω 9 (7–9) and ϕ 8 (6–8) weakly clavate. Seta *k* thickened and flattened in middle part. Setae (*pl*), *d* and *v*'' of tibiotarsus very long, smooth; seta *l*' of femur slightly thickened, blunt-ended, smooth; seta *d* of femur blunt-ended and weakly barbed; seta *pv*'' blunt-ended and smooth; other leg setae (except eupathidia) pointed and weakly barbed. Leg II (Figures 2B, 5F). Leg setation: Tr 0, Fe 3, Ge 2, Ti 4(1), Ta 7(1). Solenidia ω 10 (8–10)

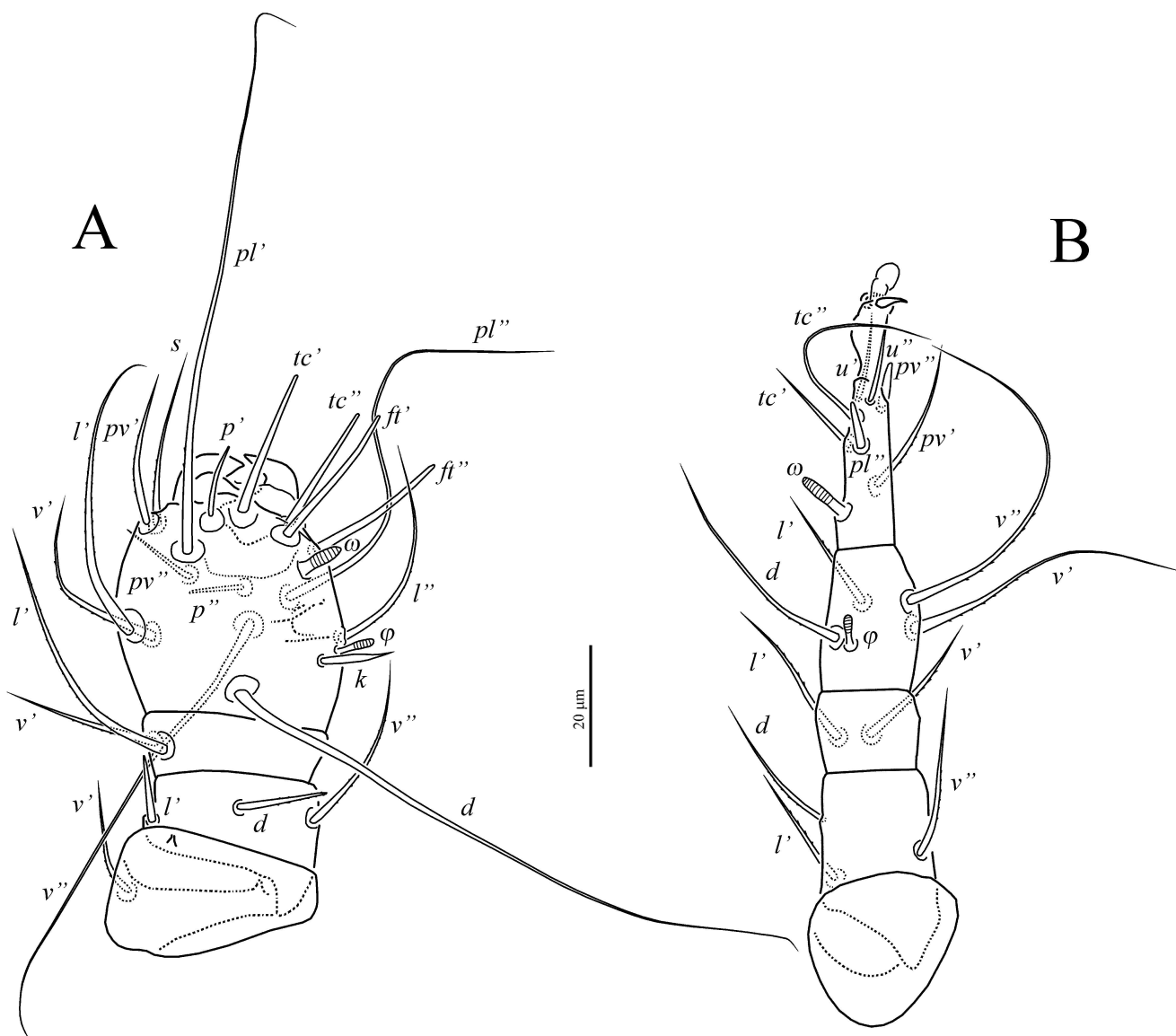


Figure 2 *Paracarophenax triplaxophilus* n. sp., female: A – right leg I in dorsal view, B – right leg II in dorsal view.

and ϕ 6 (5–6) weakly clavate. Tarsus with pair of simple claws and tongue-like empodium. Setae *pl''* and *p_{v''}* spine-like, smooth; setae (*tc*) and (*u*) smooth, pointed; other leg setae weakly barbed and pointed. Leg III (Figure 3A). Leg setation: Tr 1, Fe 2, Ge 2, Ti 4, Ta 6. Claws and empodium as on tarsus II. Seta *p_{v''}* spine-like, smooth; setae (*tc*) and (*u*) smooth, pointed; other leg setae weakly barbed and pointed. Leg IV (Figure 3B). Leg setation: Tr 1, Fe 1, Ge 1, Ti 4, Ta 5. Claws and empodium as on tarsus II. Seta *p_{v''}* spine-like, smooth; setae *tc''* and (*u*) smooth, pointed; other leg setae weakly barbed and pointed.

Male unknown.

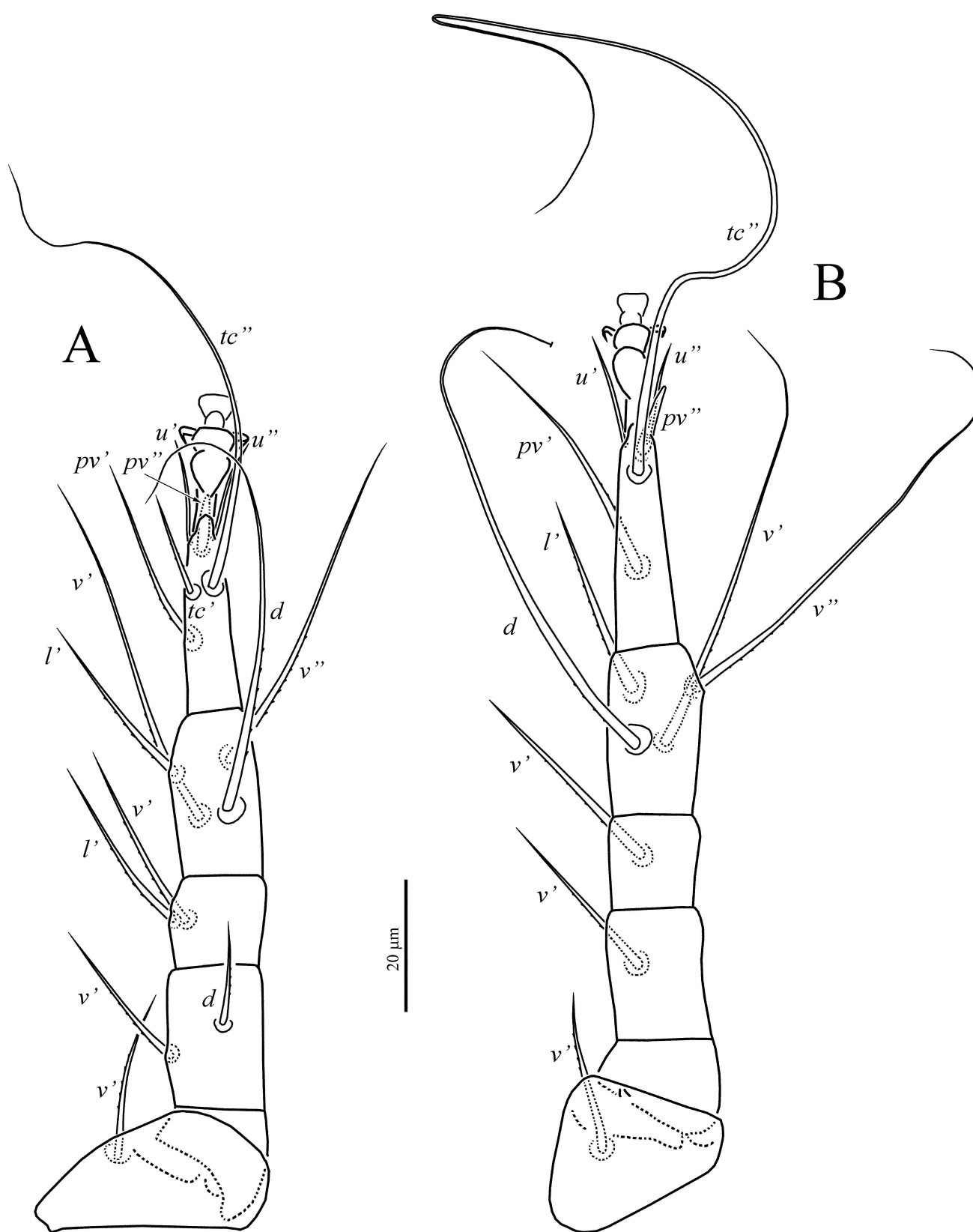


Figure 3 *Paracarophenax triplaxophilus* n. sp., female: A – right leg III in dorsal view, B – right leg IV in dorsal view.

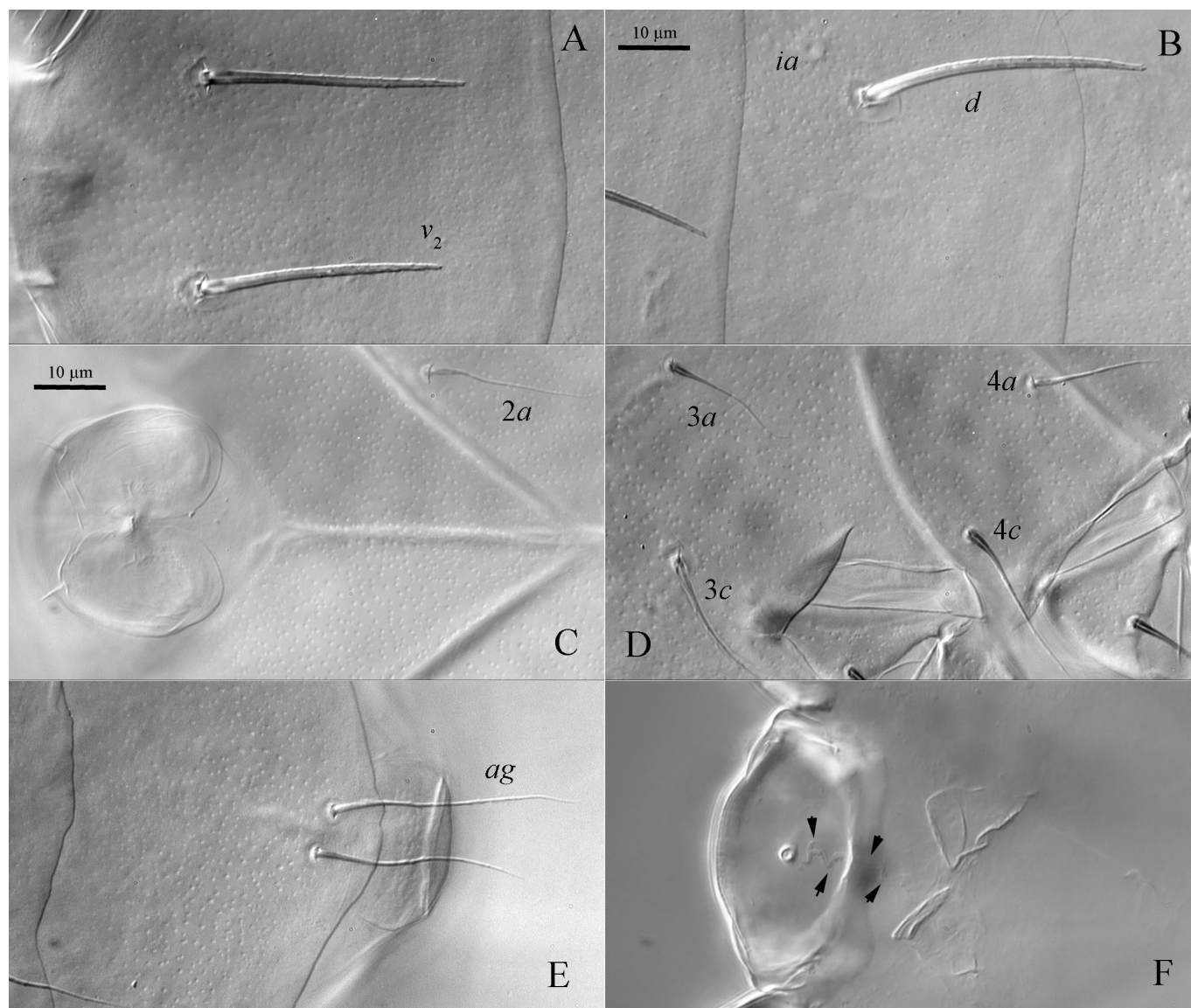


Figure 4 DIC micrographs of *Paracarophenax triplaxophilus* n. sp. female: A – central part of prodorsum, B – lateral part of tergite D, C – gnathosoma and anterior part of anterior sternal plate, D – lateral part of posterior sternal plate, E – opisthosoma in ventral view, F – ducts (arrows) of unknown homology located above pharynx.

Type material — Female holotype, slide VA140616, Tula Province, vicinity of Suvorov town, 13 April 2016, under elytra of *Triplax scutellaris* Charpentier, 1825, coll. V.A. Abramov. Paratypes: 9 females, same data.

Etymology — The specific epithet of the new species is derived from the name of its phoretic host genus *Triplax* and Greek *φιλία* (philia), meaning “friendship” or “fondness”.

Differential diagnosis — The female of the new species is most similar to *P. myzognathus* Walter and Seeman, 2017 described from Canada and *P. paucisetosus* Mahunka and Rack, 1977 described from Hungary because it lacks the body setae *e* and *ps* and also seta *v'* on trochanter II. It can be distinguished from both species by the presence of aggenital setae (vs. absent in both other species), presence of seta on trochanter I (vs. absent in both other species),

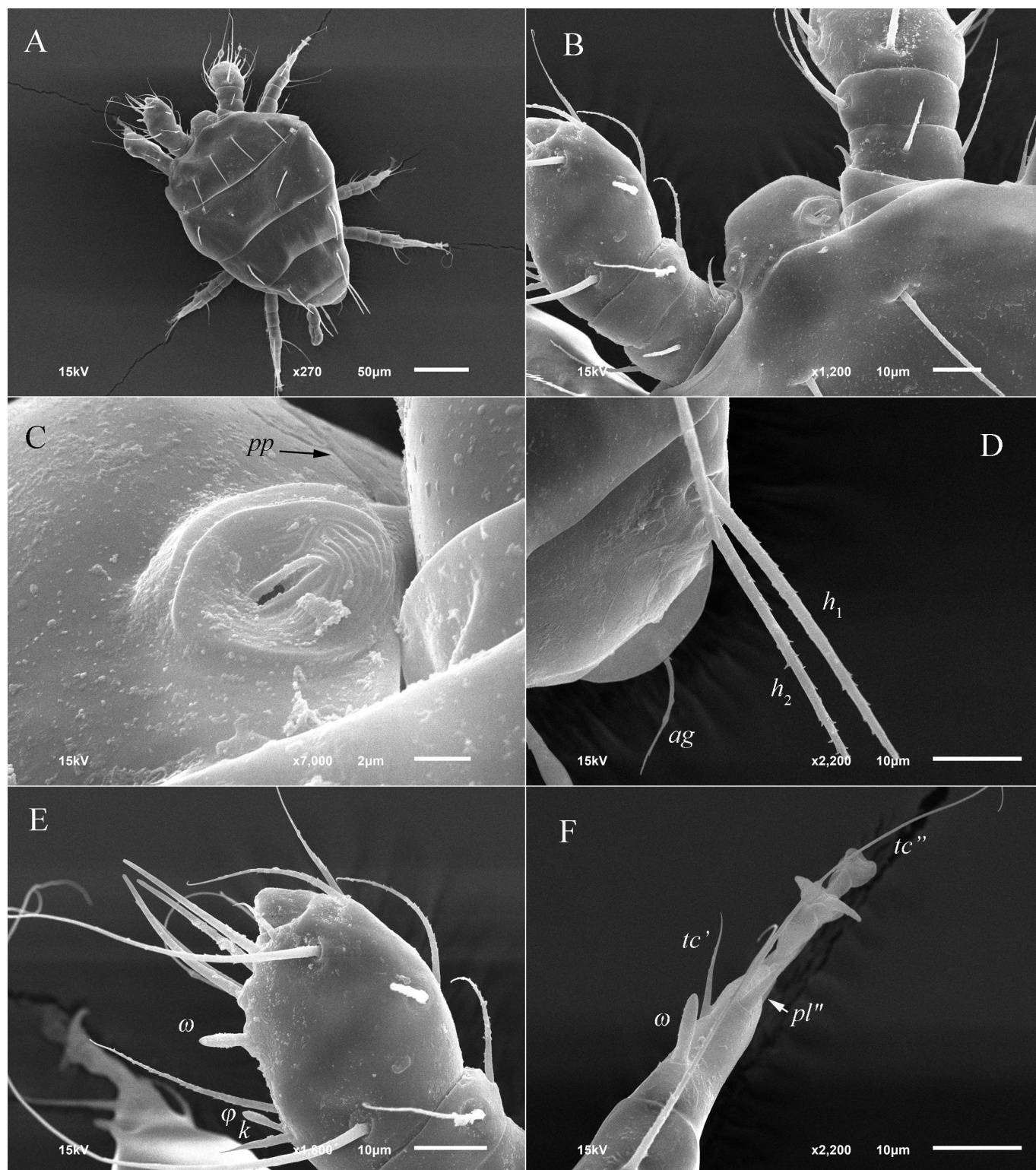


Figure 5 SEM micrographs of *Paracarophenax triplaxophilus* n. sp. female: A – general view, B – anterior part of prodorsum, C – stigma, D – setae of tergite H, E – left tibiotarsus I in dorsal view, F – right tarsus II in dorsal view.

absence of apodemes 3 (vs. present in both other species), and well developed medially sejugal apodeme (vs. weak medially in *P. myzognathus*, but well developed in *P. paucisetosus*).

Key to species of *Paracarophenax* (based on Walter & Seeman (2017) with modifications)

1. Setae *e* and *ps* absent; trochanter II without seta 2
— Setae *e* and *ps* present; trochanter II with seta 4
2. Trochanter I without seta, aggenital setae absent 3
— Trochanter I with seta, aggenital setae present *P. triplaxophilus* n. sp.
3. Tracheal atria bulbous, narrowing distally; sejugal apodeme fully developed; apodemes I moderately well developed *P. paucisetosus* Mahunka and Rack
— Tracheal atria cylindrical, not narrowing distally; sejugal apodeme weakly developed medially; apodemes I weakly developed or obsolete *P. myzognathus* Walter and Seeman
4. Setae *ag* absent, tegula present 5
— Setae *ag* present, tegula absent 6
5. Tracheae with atrium terminating in brush-like extensions; setae *h*₂ present
..... *P. scolysi* Khaustov
— Tracheae without obvious atrium extensions; setae *h*₂ absent *P. undosus* Mahunka
6. Prosternal and poststernal apodeme absent; setae *h*₂ as long as *h*₁ *P. dybasi* Cross
— Prosternal apodeme present; poststernal apodeme present as remnant; setae *h*₂ about twice as long as *h*₁ *P. bambergensis* (Krczal)

Discussion

Homologies of some gnathosomal structures. *Paracarophenax triplaxophilus* and some closely related species, such as *P. myzognathus*, retain two pairs of gnathosomal setae. One pair of setae is situated anterolaterally to stigmata, which Katlav *et al.* (2015) considered to be palpal femoral (*dFe*). Another pair of setae is located near to the anterior margin of the paired membranous areas. Walter & Seeman (2017) considered this pair of setae as subcapitular (*su*). We compared the gnathosomal structures of *P. triplaxophilus* with those of *Pyemotes dryas* (Vitzthum, 1923) (Figure 6), which is a representative of a closely related and more early-derivative family of the superfamily Pyemotoidea. In our opinion the ventrolateral pair of setae found in *P. triplaxophilus* is homologous to the gnathocoxal (or postpalpal) (*pp*) setae of *P. dryas*, because they are located in similar position and even have a similar shape (blade-like and appressed to the gnathosoma). A pair of membranous areas, which is located laterally to the mouth and is found in some *Paracarophenax* species is probably the remnants of the palps. In *Pyemotes dryas*, the palps are also weakly sclerotized, membranous and bearing setae *dGe* anteriorly (Figure 6). In our opinion the setae designated by Walter and Seeman (2017) as *su* could not be subcapitular because they are located anteriorly to mouth and on the anterior margin of the membranous areas (vestigial palps). Most probably this pair of setae is homologous with *dGe* of *P. dryas*, but it also could be cheliceral setae (*ch*) moved close to vestigial palps.

We also recorded paired thin ducts leading almost from the mouth to just above the pharynx (Figure 4F). These ducts are probably homologous to those recently found in females of some *Petalomium* (Pygmephoridea: Neopygmephoridae) species (Silva *et al.* 2017).

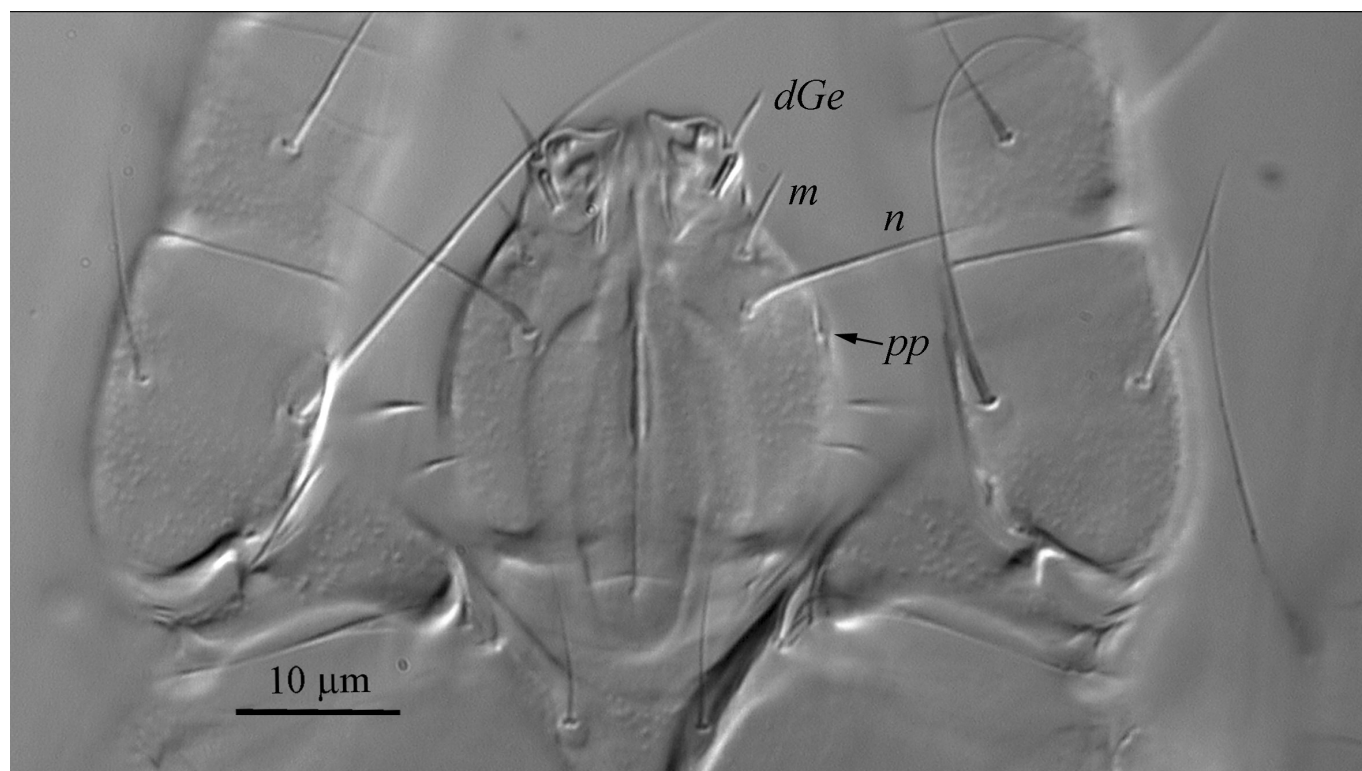


Figure 6 DIC micrograph of *Pyemotes dryas* (Vitzthum, 1923) female: gnathosoma in ventral view.

Notes on phylogenetic relationships among some species of *Aethiophenax* and *Paracarophenax*. At present three species of acarophenacid mites are known as associates of mycophagous beetles: *Paracarophenax myzognathus* and *Aethiophenax mycetophagi* are associated with *Mycetophagus* sp., (Mycetophagidae) (Walter and Seeman 2017; Arjomandi *et al.* 2017), and *Paracarophenax triplaxophilus* associated with *Triplax scutellaris* (Erotylidae) (present study). All host beetles were collected in oyster mushrooms. The above mentioned acarophenacid species are characterized by several synapomorphic characters: 1) absence of setae *e* on tergite EF, 2) absence of pseudanal setae, 3) spiniform setae *pl*'' on tarsus II. All of these synapomorphies are also known in *Paracarophenax paucisetosus* and *Aethiophenax luteoli* Katlav *et al.* 2015. Phylogenetic relationships among the species of the genera *Aethiophenax* and *Paracarophenax* are unknown. Synapomorphies 1 and 2 are setal reductions and could be a result of homoplasy; synapomorphy 3 potentially could be a good evidence of close relationships between some species of *Aethiophenax* and *Paracarophenax*. It is still not clear if this group of species represents a single generic-level taxon (*Aethiophenax* potential synonym of *Paracarophenax*) or synapomorphic characters independently appeared in the genera *Aethiophenax* and *Paracarophenax*. The phylogenetic analysis of the genera *Aethiophenax* and *Paracarophenax* is necessary to clarify this taxonomic problem.

Acknowledgements

The authors thank A.N. Bobylev (Tyumen State University) for preparing SEM photos.

References

- Arjomandi E., Hajiqaanbar H., Joharchi O. 2017. *Aethiophenax mycetophagi* sp. nov. (Acari: Trombidiformes: Acarophenacidae), an egg parasitoid of *Mycetophagus quadripustulatus* (Coleoptera: Mycetophagidae) from Iran. Syst. Appl. Acarol., 22(4): 541-549. doi:10.11158/saa.22.4.9
- Cross E.A. 1965. The generic relationships of the family Pyemotidae (Acarina, Trombidiformes). Univ. Kans. Sci. Bull., 45: 29-215.
- Goldarazena A., Ochoa R., Jordana R., OConnor B.M. 2001. Revision of the genus *Adactylidium* Cross (Acari: Heterostigmata: Acarophenacidae), mites associated with thrips (Thysanoptera). Proc. Entomol. Soc. Wash., 103: 473-516.
- Katlav A., Hajiqaanbar H., Talebi A.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. doi:10.1016/j.aspen.2015.03.011
- Khaustov A.A. 1999. Redescription of "*Pediculoides*" *ipidarius* Redikortsev, 1947, with description of the new species from the genus *Paracarophenax* (Acari: Heterostigmata: Acarophenacidae). Acarina, 7: 57-59.
- Katlav A., Hajiqaanbar H., Talebi A.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. doi:10.1016/j.aspen.2015.03.011
- 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. doi:10.4039/entm118136fv
- Magowski W.L. 1994. Discovery of the first representative of the mite subcohort Heterostigmata (Arachnida: Acari) in the Mesozoic Siberian amber. Acarologia, 35: 229-241.
- Mahunka S. 1975. Neue und auf Insekten lebende Milben aus Australien und Neu-Guinea (Acari: Acarida, Tarsonemida). Ann. Hist. Nat. Mus. Nat. Hung., 67: 317-325.
- Mahunka S., Rack G. 1977. Zwei neue Artender Familien Acarophenacidae und Pygmephoridae (Acarina, Tarsonemida). Ann. Hist.-nat. Mus. Nat. Hung., 69: 305-309.
- Silva R.A., Khaustov A.A., Lopes J.M.S., Delabie J.H.C., Oliveira A.L. 2017. A new species of *Petalomium* from Brazil with a redescription of *Petalomium gottrauxi* Mahunka 1977 (Acari: Heterostigmatina: Neopygmephoridae). Syst. Appl. Acarol., 22(11): 1800-1812. doi:10.11158/saa.22.11.2
- 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(4): 329-335. doi:10.1080/01647954.2017.1287216