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Article

First record of the genus *Penthalodes* (Acari: Eupodoidea: Penthalodidae) from Russia, with description of a new species

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ABSTRACT
Penthalodes caucasicus **sp. nov.** (Acari: Penthalodidae) is described based on females collected from moss in Western Caucasus, Russia. Some morphological characters in the genus *Penthalodes* are discussed. The new species differs from closely related *P. ovalis* and *P. polonicus* in having three solenidia arranged in a longitudinal row on tarsus I.

KEYWORDS: Acarina, Acariformes, Caucasus, Eupodina, SEM microscopy, systematics.

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INTRODUCTION

Mites of the cosmopolitan superfamily Eupodoidea Koch, 1842 are mycophagous, phytophagous and predatory. Classification of the superfamily lacks stability (Baker and Lindquist 2002). The number of families in the superfamily Eupodoidea is still unclear as well as the number of genera in currently recognized families (Khaustov 2014, 2015; Szudarek-Trepto *et al.* 2020, 2021).

The family Penthalodidae includes six genera: *Penthalodes* Murray, 1877, *Stereotydeus* Berlese, 1901, *Hawaiieupodes* Strandtmann & Goff, 1978, *Callipenthalodes* Qin, 1998, *Protopenthalodes* Jesionowska, 1989 and *Halotydeus* Berlese, 1891 (Qin 1998; Jesionowska 2008; Khaustov 2015). The genus *Halotydeus* was previously placed in the family Penthaleidae, but Khaustov (2015) replaced it to the family Penthalodidae. The monotypic genus *Turanopenthalodes* Barilo, 1988, previously placed in the family Penthalodidae (Barilo 1988) was moved to Penthaleidae (Khaustov 2016). Probably all penthalodid mites are phytophagous. Species of the genus *Halotydeus* are important pests of crops in Southern Hemisphere (Baker 1995).

The genus *Penthalodes* currently comprises eight described species, namely: *P. ovalis* (Duges, 1834), *P. boneti* Baker, 1946, *P. oregonensis* Baker, 1946, *P. turneri* Baker, 1946, *P. carinatus* Shiba, 1978, *P. alaskaensis* Jesionowska, 2010, *P. hawaiiensis* Jesionowska, 2010, and *P. polonicus* Jesionowska, 2010 (Jesionowska 2010; Kontschan *et al.* 2018). *Penthalodes alaskaensis* and *P. hawaiiensis* were created based on original descriptions of *P. ovalis* sensu Strandtmann (1971) and Strandtmann and Goff (1978), respectively (Jesionowska 2010). All species of *Penthalodes* are

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currently known only from Northern Hemisphere. Mites of the genus *Penthalodes* have never been reported from Russia.

The junior author collected numerous specimens of *Penthalodes* from Western Caucasus. After detailed study of its morphology, we revealed that it is represents an undescribed species. The description of the new species is provided below.

MATERIAL AND METHODS

Mites were collected from moss using Berlese funnels. Most of collected mites were cleared in lactic acid and mounted in Hoyer's medium. Several specimens were preserved in 96% ethanol. Notations for the prodorsal and leg setae follow that of Lindquist and Zacharda (1987) and Baker (1995), and the remaining nomenclature is as applied to eupodoids by Baker (1990). All measurements are given in micrometers (μm) for the holotype and for five paratypes (in parentheses). In the descriptions of leg setation the number of solenidia and famuli are given in parentheses. For SEM microscopy several alcohol-preserved mites were dried in a JFD 320 freeze drying device (JEOL, Japan), dusted with gold and scanned with a JEOL–JSM-6510LV SEM microscope. Mite morphology was studied using a Carl Zeiss AxioImager A2 (Carl Zeiss, Germany) compound microscope with phase contrast and differential interference contrast (DIC) illumination.

SYSTEMATICS

Family Penthalodidae Thor, 1933
Genus *Penthalodes* Murray, 1877

Type species: *Megamerus ovalis* Dugés, 1834, by original designation.

Penthalodes caucasicus sp. nov. (Figs. 1–7)

http://zoobank.org/urn:lsid:zoobank.org:act:A7F6E478-5D29-45F9-8404-AFD18E7E49B3

Description (female, n = 6)

Idiosoma – Ovate, egg-shaped (Fig. 5F). Length of idiosoma including epirostrum 480 (445–490), greatest width 350 (330–370). Dorsum of idiosoma with characteristic Y-shaped impression (Fig. 4A). Dorsal integument with numerous pointed and hooked distally cuticular projections usually forming polygonal ornamentation (Figs. 4B, C; 5A). Naso small, ovate, located far from anterior margin of idiosoma and densely covered by tiny cuticular projections (Figs. 4B–D); in specimens mounted on slides naso usually hided under anterior part of prodorsum (Fig. 1A). Eyes ovoid, covered with numerous cuticular projections and located posteromesad setae *sc2* (Fig. 4B). Epirostrum trilobed, with numerous cuticular projections as on dorsal idiosoma (Fig. 4E); lateral lobes more than half as long as median one (Fig. 1A), in some specimens poorly visible; median lobe subtriangular in shape, with rounded distal end. Setae *v1* very small 5 (4–6), smooth and pointed, located on naso (Fig. 4D); their bases widely separated; trichobothria *sc1* 59 (59) pilose in basal part and with long sparsely distributed projections in distal part (Fig. 5A); setae *v2*, *sc2*, *c1*, *c2*, *d1*, *e1*, *f1*, *f2*, *h1*, and *h2* subequal (25–30), of complex shape, pilose in basal half and with 3–4 long and pointed branches (Figs. 4B, C, 5B, C). Lyrifissures *ia*, *im*, *ip*, and *ih* long, slit-like; *ia* located posterolaterad setae *c1*, *im* posterolaterad setae *d1*, *ip* anterolaterad *f1*, and *ih* anterolaterad *ps3*. Ventral idiosoma with short, simple cuticular projections (Figs. 5B, E, F). All ventral setae plumose. Genital valves with nine pairs of genital setae, one of which located laterally (Fig. 5E); 10 pairs of aggenital setae and one pair of pseudanal setae. Primary genital opening with seven pairs of

pilose eugenital setae and two pairs of large genital papillae (Fig. 5E). Epimeral formula: 2(*1b*, *1c*) –1(*2b*) –2(*3b*, *3c*) –2(*4b*, *4c*); three pairs of intercoxal setae (*1a*, *3a*, *4a*). Coxisternal fields I with characteristic tubercles.

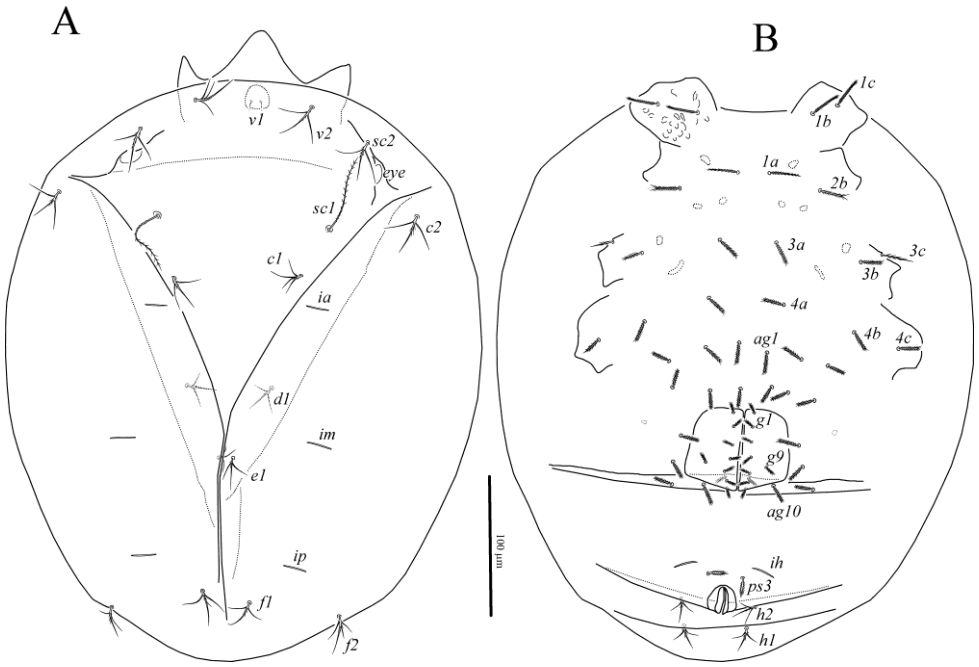

Figure 1. *Penthalodes caucasicus* **sp. nov.** (female) – **A.** Dorsum of idiosoma; **B.** Venter of idiosoma.

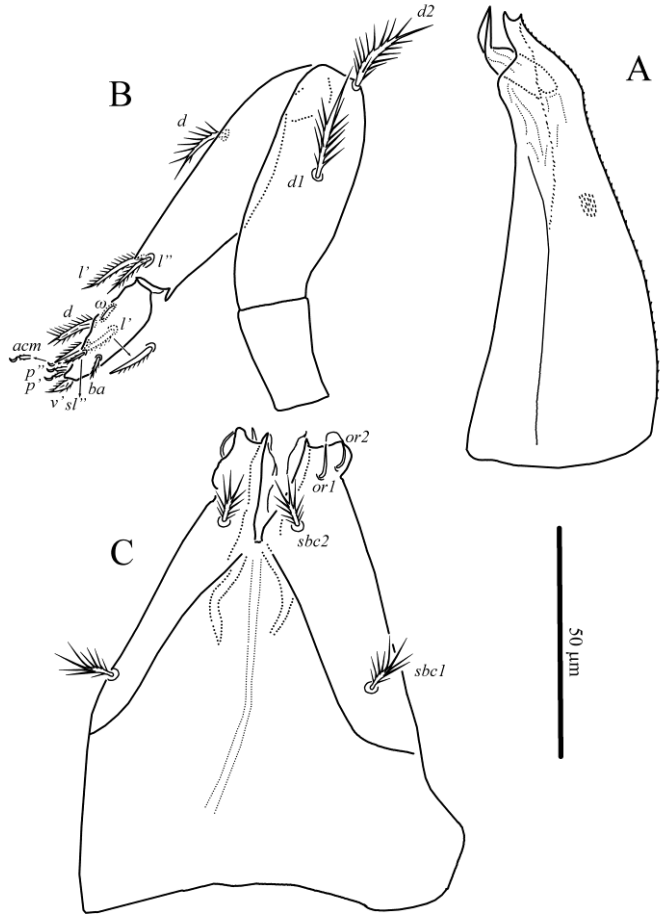

Figure 2. *Penthalodes caucasicus* **sp. nov.** (female) – **A.** Chelicera, lateral aspect; **B.** Palp, dorsolateral aspect; **C.** Subcapitulum.

Gnathosoma (Figs. 2, 6A–C) – Chelicerae without setae; dorsal surface with numerous tiny cuticular projections, ventral surface smooth; fixed digit bifid distally; movable digit (dm) strongly sclerotized and characteristically bent (Figs. 2A, 6A). Subcapitulum with short, smooth adoral setae or_1 and or_2, located subterminally on membranous malae (Figs. 6B, C); subcapitular setae *sbc1*and *sbc2* subequal, plumose. Palp (Figs. 2B, 6C) 155 (145–160) long; number of setae and solenidia on palp segments: 0–2–3–9(1); setae *p', p"* and *acm* of palptarsus pilose in basal half and with spoon-like distal half (Fig. 2B), other palpal setae plumose; solenidion *ω* 5 (4–5) on palptarsus located in depression (Fig. 6C); palptarsus about twice longer than its width. Palptibia with spiniform ventrodistal process. Coxal supracoxal seta not evident.

Legs (Figs. 3, 6C–F, 7) – Integument on leg segments with relatively big and tiny cuticular projections (Figs. 6C–F, 7A–F). Relative lengths of legs: I > IV > III > II. Lengths of legs: I 350 (345–355), II 270 (265–275), III 280 (275–285), IV 335 (330–340). Femora not divided. Leg I (Figs. 3A, B, 6C–F, 7A, F): supracoxal seta *el* smooth, setiform, hardly visible dorsally posteriad trochanter; setal formula: Tr–1 (*v'*), Fe–9 (*d, l', l", v', v", bv", d1, v1', l1'*), Ge–5(1+1*k*) (*d, l', l", v', v"*, 1 *σ*, 1 *k*), Ti–6(2+1) (*d, l', l", v', v", v1'*, 2 *φ*, 1 *k*), Ta–23(3+1) (*pd, ft', ft", tc', tc", it', it", p', p", u', u", pv', pv", pl', pl", v1', v1", v2', v2", v3', v3", v4', v4"*, 3 *ω*, 1 *ε*). Famulus *ε* 4 (3–4) smooth, short, blunt-tipped, located in depression anterolaterad setae *ft"* (Figs. 6C, E); famulus *k* on tibia very small, spiniform, located in depression together with solenidion *φ1* (Fig. 7A); famulus *k* on genu very short, spiniform, located dorsally near distal margin of segment; solenidia *φ2* 9 (8–9) on tibia and *σ* 12 (11–12) on genu short, baculiform. Rhagidial organ I consist of three semierect solenidia arranged in longitudinal line in one shallow depression (Figs. 6C, D); lengths of solenidia: *ω1* 9 (8–10), *ω2* 10 (8–10), *ω3* 10 (8–10). All setae of trochanter and femur, as well as setae *l'* and (*v*) of genu pointed, plumose in basal half and smooth in distal half (Fig. 7F); other leg setae plumose with short smooth blunt-ended tip (Fig. 6C). Leg II (Figs. 3C, D, 7B–E): setal formula: Tr–1 (*v'*), Fe–8(*d, l', l", v', bv", d1, v1', l1'*), Ge–5(1+1) (*d, l', l", v', v"*, 1 *σ*, 1 *k*), Ti–6(2) (*d, l', l", v', v", v1'*, 2 *φ*), Ta–16(3+1) (*pd, ft', tc', tc", it', it", p', p", u', u", pv', pv", v1', v1", v2', v2"*, 3 *ω*, 1 *ε*). Famulus *ε* 3 (3) smooth, short, blunt-tipped, semierect, located laterad solenidion *ω1* (Figs. 7B, C); famulus *k* on genu very short, spiniform, located dorsally near distal margin of segment; solenidion *φ1* on tibia situated in depression (Figs. 7D, E); solenidia *φ2* 9 (8–9) on tibia and *σ* 10 (9–10) on genu short, baculiform. Rhagidial organ II consist of three semierect solenidia arranged in longitudinal line in one shallow depression (Figs. 7B, C); lengths of solenidia: *ω1* 10 (8–10), *ω2* 9 (8–19), *ω3* 9 (8–10). All setae of trochanter and femur, as well as setae *l'* and (*v*) of genu pointed, plumose in basal half and smooth in distal half; other leg setae plumose with short smooth blunt-ended tip (Fig. 6C). Leg III setal formula: Tr–1 (*v'*), Fe–6(*d, l', v', ev', d1, l1'*), Ge–5(1) (*d, l', l", v', v"*, 1 *σ*), Ti–6(1) (*d, l', l", v', v", v1', φ*), Ta–15 (*ft', tc', tc", it', it", p', p", u', u", pv', pv", v1', v1", v2', v2"*). Solenidia *φ* 8 (7–9) on tibia and *σ* 9 (8–9) on genu short, baculiform. All setae of trochanter and femur, as well as setae *l'* and (*v*) of genu pointed, plumose in basal half and smooth in distal half; other leg setae plumose with short smooth blunt-ended tip. Leg IV (Figs. 3G, H): setal formula: Tr–1 (*v'*), Fe–4(*d, v', ev', d1*), Ge–4(1) (*d, l', v', v"*, 1 *σ*), Ti–6(1) (*d, l', l", v', v", v1', φ*), Ta–15 (*ft', tc', tc", it', it", p', p", u', u", pv', pv", v1', v1", v2', v2"*). Solenidia *φ* 9 (8–9) on tibia and *σ* 10 (8–10) on genu short, baculiform. All setae of trochanter and femur, as well as most setae of genu (except *d*) pointed, plumose in basal half and smooth in distal half; setae (*it*), (*p*) and (*u*) widened distally, plumose; other leg setae plumose.

Male and immatures unknown.

Type material

Female holotype, slide ZISP T-Eup-1, Russia, Krasnodar Krai, vicinity of Sochi, Khosta District, moss near the Agura River, 43° 32' 38" N, 39° 48' 26" E, 3 December 2022, coll. S.V. Kravchenko; paratypes: 16 females, same data.

Type deposition

The holotype and four female paratypes are deposited in the acarological collection of the Zoological Institute of RAS, Saint Petersburg, Russia; other paratypes are deposited in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

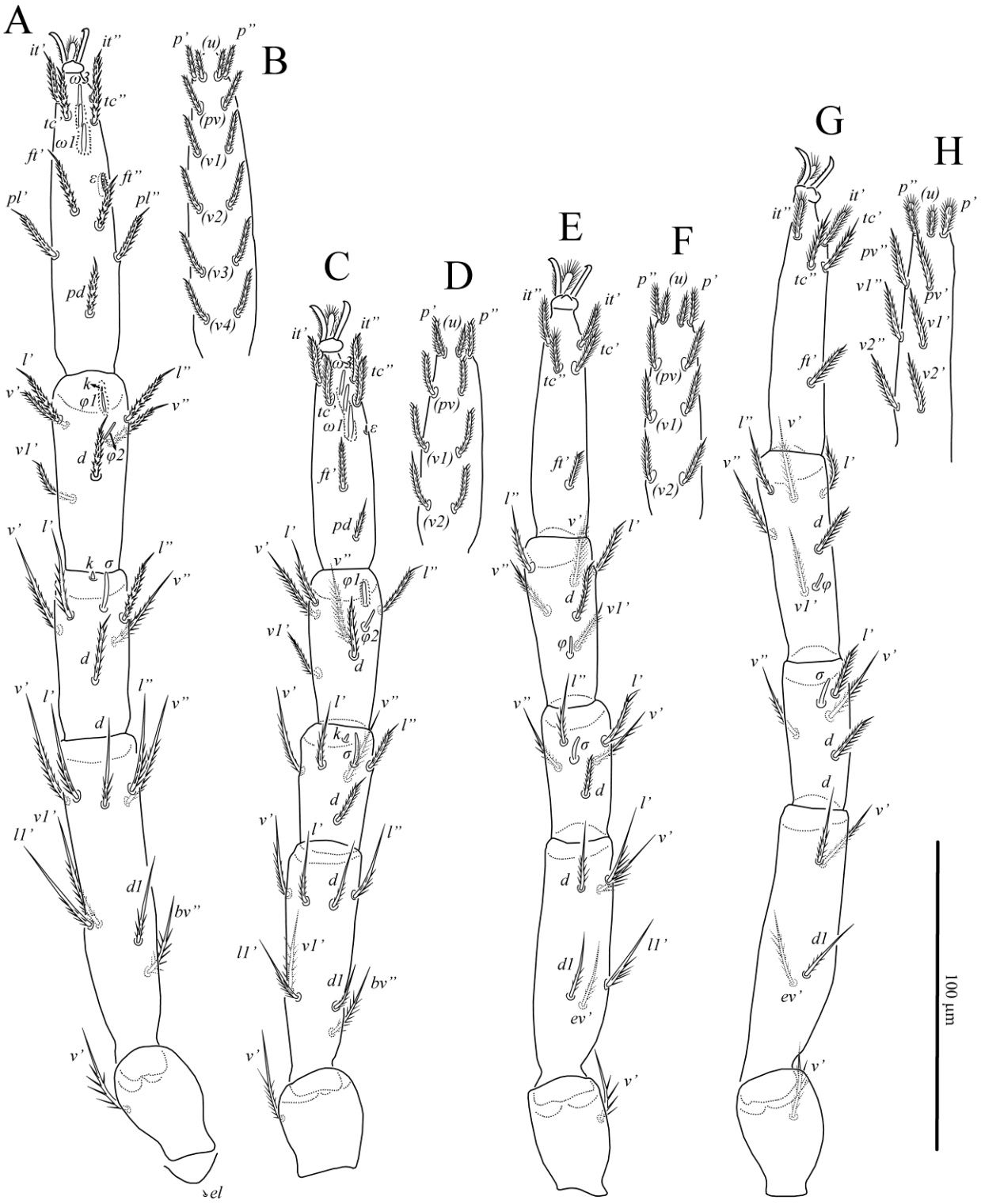

Figure 3. *Penthalodes caucasicus* **sp. nov.** (female) – **A.** Right leg I, dorsal aspect; **B.** Tarsus I, ventral aspect; **C.** Right leg II, dorsal aspect; **D.** Tarsus II, ventral aspect; **E.** Left leg III, dorsal aspect; **F.** Tarsus III, ventral aspect; **G.** Left leg IV, dorsal aspect; **H.** Tarsus IV, ventral aspect.

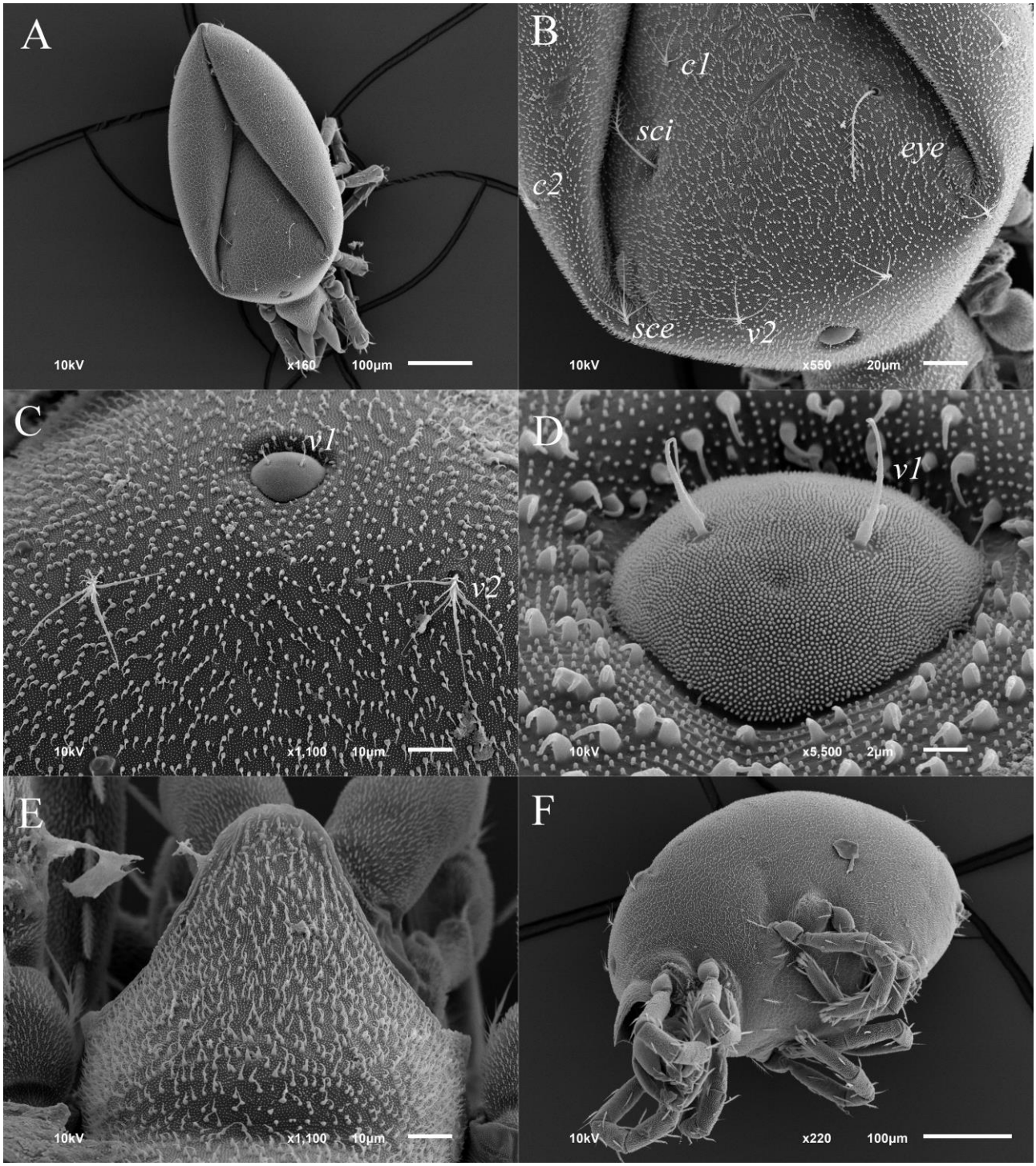

Figure 4. SEM micrographs of *Penthalodes caucasicus* **sp. nov.** (female) – **A.** Dorsum of body; **B.** Prodorsum; **C.** Anterior part of prodorsum; **D.** Naso; **E.** Epirostrum; **F.** General view, lateral aspect.

Differential diagnosis

The new species is most similar to *P. polonicus* in having all dorsal setae of similar complex shape with 3–4 long and pointed branches. In other described species at least setae *f1*, *f2* and *h1* pilose, without long branches. The new species differs from *P. polonicus* in having three solenidia in rhagidial organ I (vs. two in *P. polonicus*); bases of setae *v1* widely separated (vs. bases of setae *v1* almost contiguous in *P. polonicus*); and femoral formula 9–8–6–4 (vs. 9–7–5–7 in *P. polonicus*). The new species is also similar to *P. ovalis* sensu Kaluz, 2000 in having same chaetotaxy of legs

(except tarsi) and similar shape of setae *v2*, *sc2* and *c2*. The new species differs from *P. ovalis* by the shape of opisthosomal setae being multibranched (vs. plumose with fine distal filament in *P. ovalis* as illustrated in Fig. 10(d) in Baker (1990)); in having three solenidia in rhagidial organ I (vs. two in *P. ovalis*); and tarsal formula 23–16–15–15 (vs. 20–14–14–14 in *P. ovalis*).

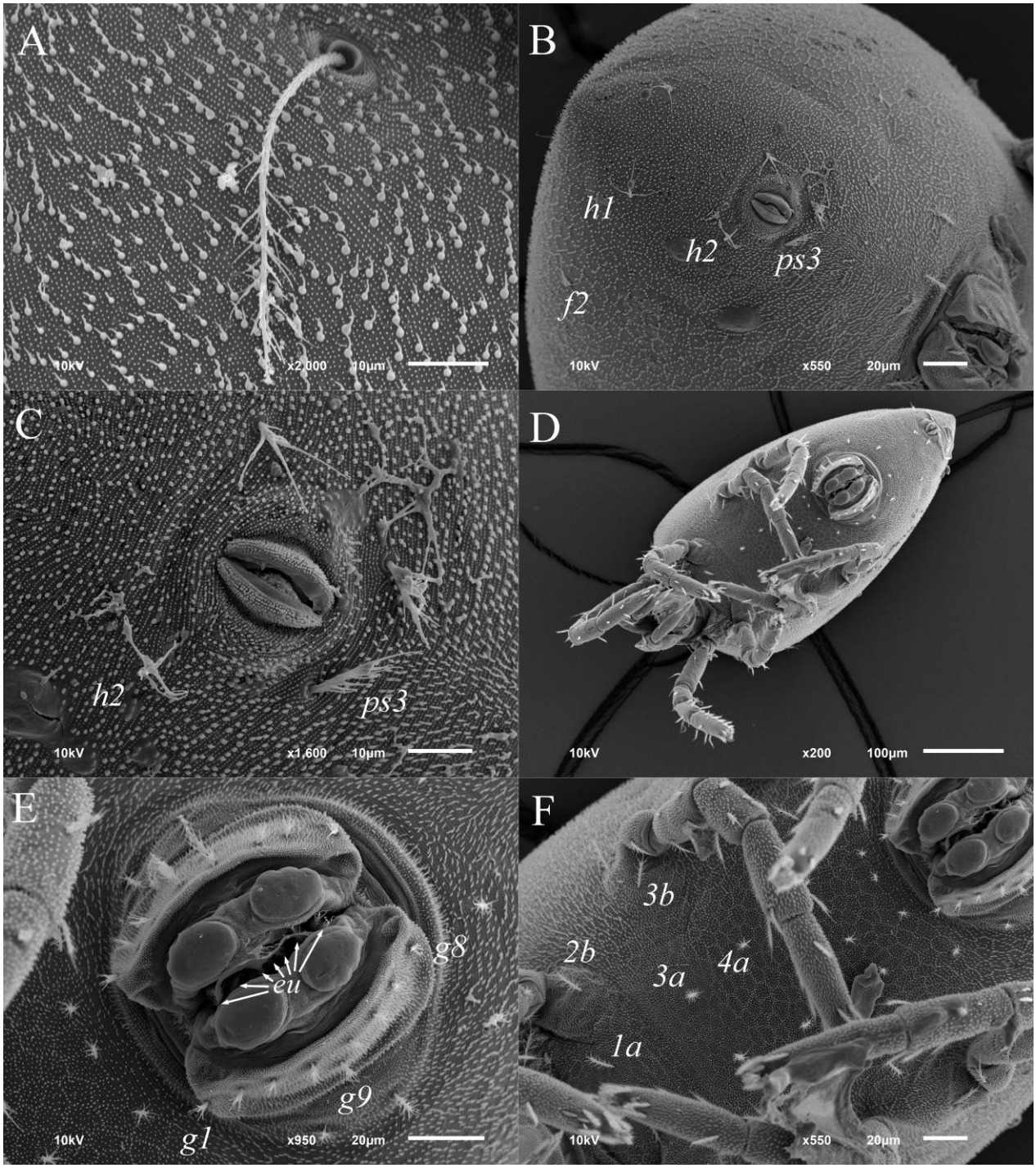

Figure 5. SEM micrographs of *Penthalodes caucasicus* **sp. nov.** (female) – **A.** Trichobothrium; **B.** Opisthosoma, posteroventral aspect; **C.** Anal area; **D.** General view, ventral aspect; **E.** Genital area, **F.** Metapodosomal, ventral aspect.

Etymology

The name of the new species refers to its geographical distribution in Caucasus.

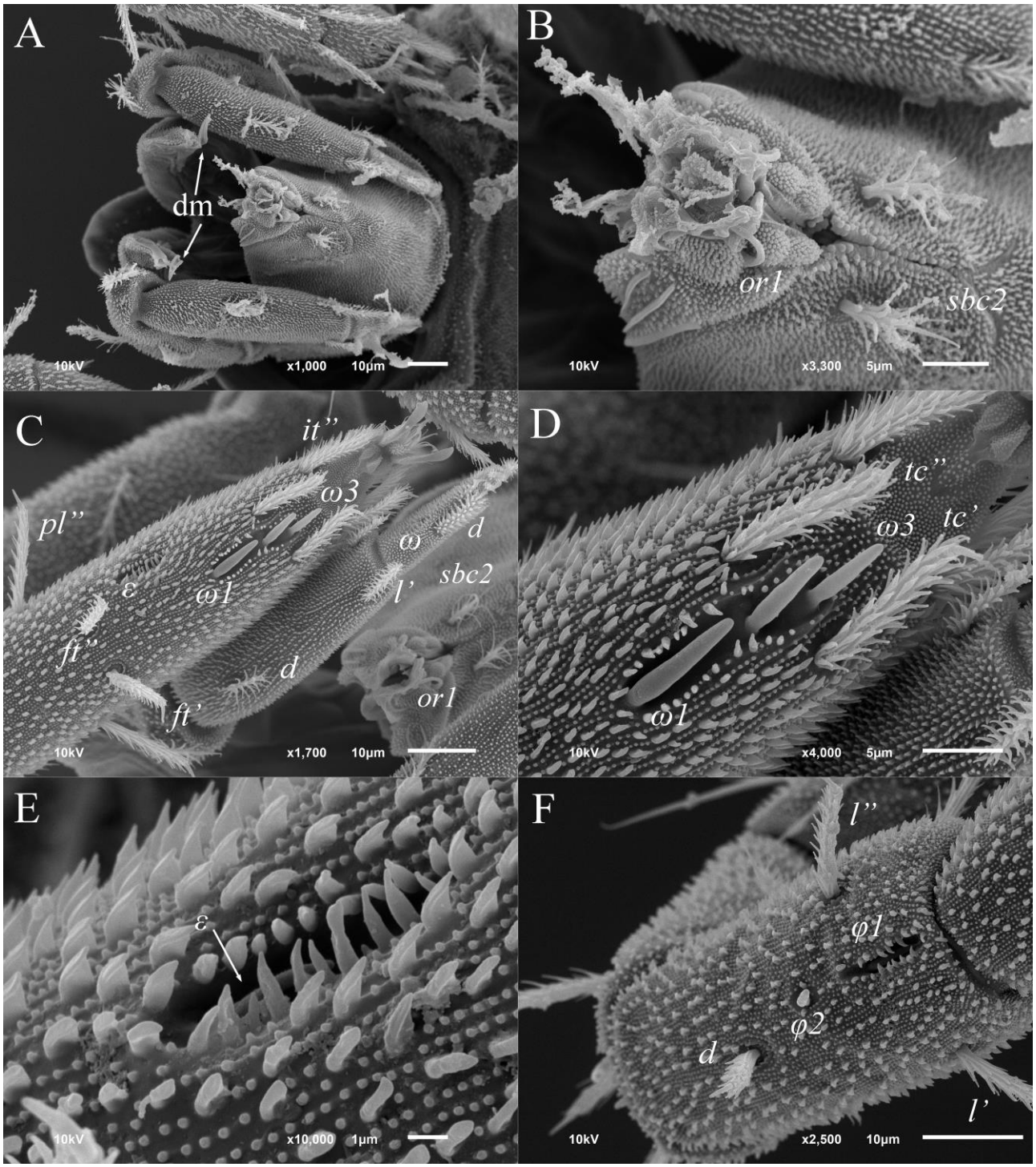

Figure 6. SEM micrographs of *Penthalodes caucasicus* **sp. nov.** (female) – **A.** Gnathosoma, ventral aspect; B. Distal part of subcapitulum; **C.** Tarsus I and palp, dorsal aspect, distal part of subcapitulum, ventral aspect; **D.** Rhagidial organ I, **E.** Famulus on tarsus I, **F.** Tibia I, dorsal aspect.

DISCUSSION

Famulus on tarsi I and II. Eupodoid mites are characterized by the presence of famulus (or stellate seta) on tarsus I in almost all representatives of the superfamily (Baker 1990). However, in *Penthalodes* species famulus on tarsus I was illustrated only for two species. In *P. carinatus* it

located just posteriad first rhagidial solenidion and illustrated as “stellate seta” typical for most eupodoid mites (Shiba 1978).

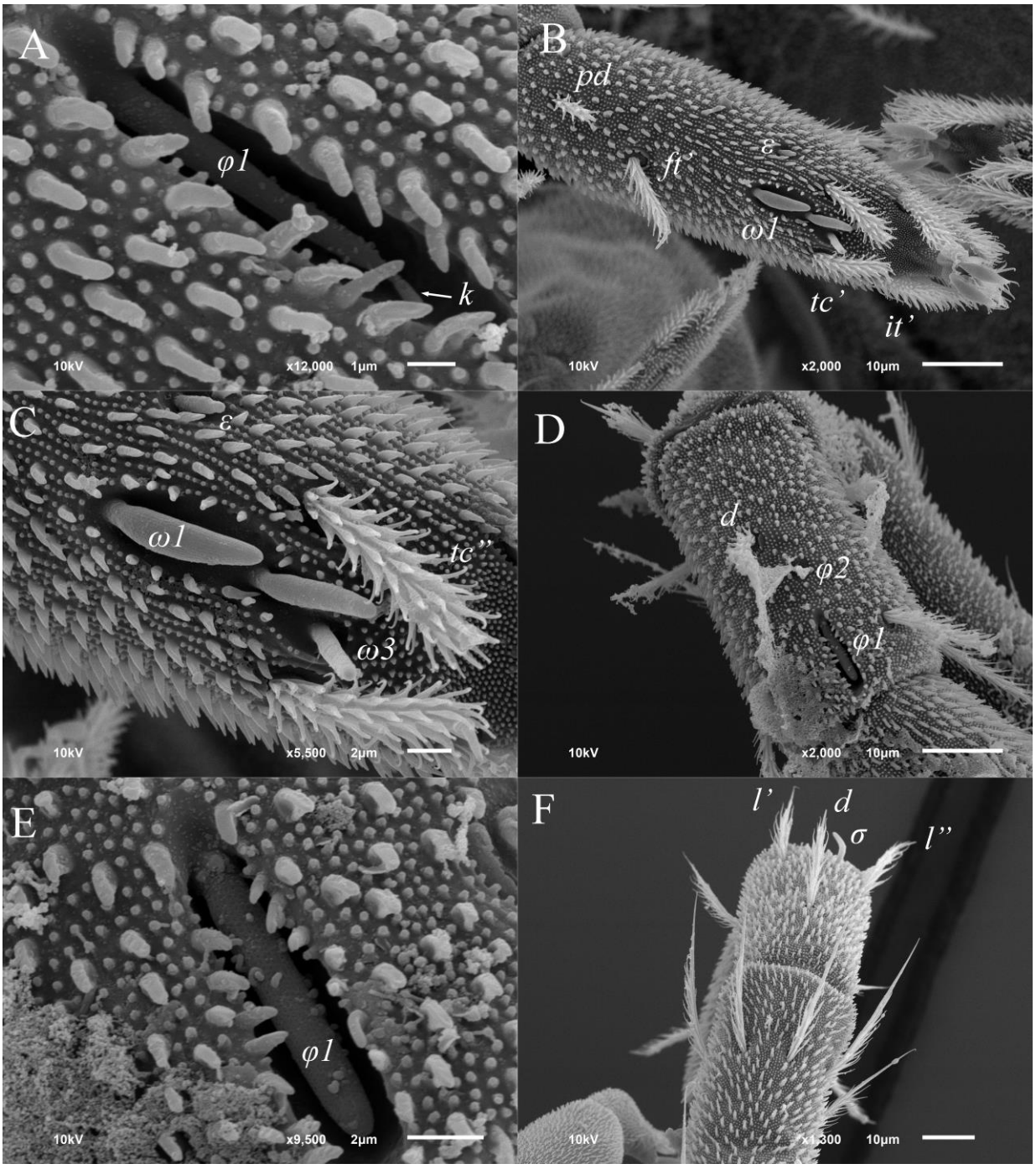

Figure 7. SEM micrographs of *Penthalodes caucasicus* **sp. nov.** (female) – **A.** Sensory cluster on tibia I; **B.** Tarsus II, dorsal aspect; **C.** Rhagidial organ II, **D.** Tibia II, dorsal aspect; **E.** Rhagidial solenidion on tibia II; **F.** Femur and genu I, dorsal aspect.

In *P. polonicus* famulus located posterolaterad seta *ft’* and illustrated as tiny knob (Jesionowska 2010). In other *Penthalodes* species famulus on tarsus I has never been found. On the other hand, in *P. polonicus*, *P. ovalis* and *P. hawaiiensis* there is a tiny “rhagidial solenidion” located in deep depression posterolaterad solenidion *ω1* on paraxial surface (Strandtmann and Goff 1978; Kaluz 2000; Jesionowska 2010; Kontschan *et al*. 2018). This “rhagidial solenidion” considerably differs

from other rhagidial solenidia by its very small size, shape and location in deep depression. In contrast to this "rhagidial solenidion", normal solenidia in rhagidial organ I distinctly larger, semierect and located in shallow depression (Fig. 13(a) in Baker (1990), Fig. 6D in our article). Using scanning electron microscope, we revealed that this "rhagidial solenidion" located posterolaterad rhagidial solenidion *ω1* on tarsus I sufficiently differs from normal solenidia by the structure of surface. In normal solenidia surface with numerous tiny pores (Figs. 6D, 7E), while lateral "rhagidial solenidion" in deep depression is smooth (Fig. 6E). Its shape and structure is very similar to baculiform famulus *ε* on tarsus II (Fig. 7C). In this study, we consider lateral "rhagidial solenidion" in deep depression on tarsus I as a famulus *ε*. The presence of "stellate seta" on tarsus I in *P. carinatus* is doubtful and needs reexamination of the type material. An unusual famulus on tarsus I illustrated in *P. polonicus* is most likely an artefact. The famulus *ε* on tarsus II was illustrated as a tiny spine only for *P. polonicus* (Jesionowska 2010). In our study, we found similar famulus on tarsus II (Figs. 7B, C). Most likely, it was not found in other *Penthalodes* species because of very small size.

Presence of famulus k on tibia I. In most eupodoid mites, tibia I has a sensory cluster which includes solenidion *φ1* and tiny famulus *k* (both usually located in depression). Famulus *k* on tibia I was not illustrated in any *Penthalodes* species. Using of SEM as well as DIC light microscopy, we found tiny spiniform famulus *k* on tibia I located in a common depression with solenidion *φ1* (Fig. 7A) for the first time in the genus *Penthalodes*.

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نخستین گزارش از جنس *Penthalodes* (Acari: Eupodoidea: Penthalodidae) از روسیه، همراه با توصیف گونه‌ای جدید

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چکیده

گونهٔ *Penthalodes caucasicus* **sp. nov.** (Acari: Penthalodidae) بر اساس ماده‌های جمع‌آوری شده از خزه در قفقاز غربی، روسیه توصیف می‌شود. برخی از ویژگی‌های ریخت‌شناسی در جنس *Penthalodes* مورد بحث قرار گرفته است. تفاوت گونهٔ جدید با گونه‌های نزدیکش *P. ovalis* و *P. polonicus* در داشتن سه سولنیدی است که در یک ردیف طولی روی پنجهٔ پای نخست قرار گرفته‌اند.

واژگان کلیدی: Acarina، Acariformes، قفقاز، Eupodina، میکروسکپی اسکن الکترونی، رده‌بندی.

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