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Redescription of the female of bumblebee-associated gamasid mite *Proctolaelaps sibiriensis* (Davydova, 1988) (Acari: Mesostigmata: Melicharidae) from North Asia

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Original research

ABSTRACT

The female of *Proctolaelaps sibiriensis* (Davydova) (Acari: Mesostigmata: Melicharidae) is redescribed on the basis of type series and new materials collected from bumblebees (Hymenoptera: Apidae) in Tyumen Province, close to the type locality in Novosibirsk Province. A key to world bumblebee-associated species of the genus *Proctolaelaps* is presented.

Keywords Parasitiformes; Gamasina; morphology; *Bombus*; Russia
Zoobank http://zoobank.org/7C7C413D-EFF0-4B82-AAFB-25B7882B40A8

Introduction

Like other nest-making animals (e.g. birds, rodents, scarab beetles, wasps, ants and termites), bees, including bumblebees, are hosts to a wide diversity of gamasid mites (Eickwort, 1994). Members of the genera *Parasitellus* Willmann, 1939 (Parasitidae), *Pneumolaelaps* Berlese, 1920 (Laelapidae) and some species of *Proctolaelaps* Berlese, 1923 (Melicharidae) have a more intimate association with bumblebees (Westerboer, 1963; Bregetova, 1977b; Hyatt, 1980; Joharchi et al., 2019). The fauna of bumblebee-associated gamasid mites in North Asia has been well studied before (Davydova, 1976; Davydova and Bogdanov, 1976; Davydova and Nikolsky, 1986; Davydova, 1988; Davydova and Bogatyrev, 1990; Klimov, 1998; Joharchi et al., 2019). During a survey of bumblebee-associated gamasid mites in Western Siberia (Tyumen Region) *Proctolaelaps sibiriensis* (Davydova, 1988) was collected, a species known only from the type series. The aim of this article is to redescribe the female of *P. sibiriensis* based on type series and new material because the original description of this species is brief and both the description and illustrations lack many important details. Moreover, we provide a world key to bumblebee-associated species of the genus *Proctolaelaps*.

Materials and methods

Bumblebees were collected with a sweep net from flowers and placed individually in vials of 70% ethanol. Thereafter, alcohol sediments from the vials were inspected for phoretic mites with the aid of the stereomicroscope Discovery V8 (Carl Zeiss). Specimens were

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cleared in lactic acid solution and mounted in Hoyer's medium (Walter and Krantz, 2009). The morphology of mites was studied with the aid of an Axioskop 40 microscope (Carl Zeiss), and Axio Imager A2 microscope (Carl Zeiss) with DIC and phase-contrast objectives. Photomicrographs were taken with a M3CMOS 10000 camera (Sigeta).

The morphological terminology generally follows Evans and Till (1979). Dorsal and ventral setae were labelled according to the systems of Lindquist and Evans (1965), and Lindquist (1994). Palpal and leg chaetotaxy follows Evans (1963a, b). The notation for idiosomal pore-like structures follows Johnston and Moraza (1991). Lengths of shields were measured from the anterior to posterior shield margins along the midline. The length of the second cheliceral segment was measured from their base to the apex of the fixed digit. The length of legs was taken from the base of the coxa to the apex of the tarsus, excluding the ambulacrum. The measurements are given in micrometers (μm).

Proctolaelaps sibiriensis is redescribed based on type series (Novosibirsk Province) and specimens collected in Tyumen Province. The studied material is deposited in Zoological Museum of Institute of Systematics and Ecology of Animals (Novosibirsk, Russia) (type series of *P. sibiriensis*), the Zoological Museum of Tyumen State University (Tyumen, Russia), and the Department of Zoology of Odessa I. I. Mechnikov National University (Odessa, Ukraine).

Results

Family Melicharidae Hirschmann, 1962

Proctolaelaps Berlese, 1923

Type species: *Proctolaelaps productus* Berlese, 1923, by monotypy.

Diagnosis — the diagnosis of *Proctolaelaps* used here is based on that of Moraes et al. (2016).

Proctolaelaps sibiriensis (Davydova, 1988)

(Figs 1–4, 5A, B)

Material examined — Holotype female, Russia, Novosibirsk, arboretum, 55°05′N, 82°51′E, from nest of *Bombus hypnorum*, 1984, N.R. Bogatyrev coll.; two females, same data; four females, same geographical data, from nest of *Bombus agrorum*, 22 July 1985, N.R. Bogatyrev coll.; three females, same geographical data, from nest of *Bombus hypnorum*, 10 and 16 July 1987, N.R. Bogatyrev coll.; two females, Russia, Tyumen Province, Nizhnetavdinsky Region, vicinity of lake Kuchak, 57°21′N, 66°03′E, from *Bombus* sp., 27 April 2018, O. Joharchi coll.

Diagnosis — Dorsal shield with complex volumetric shape, harshly sclerotized with distinct reticulate ornamentation over whole surface except more poorly sclerotized regions in anterior extension and posterior; with 43 pairs of setae; dorsal setae simple, needle-like, except spindle-like setae *j1* and serrated setae *Z5*. Pre-sternal area transversely lineate, without platelets. Sternal shield completely reticulated except posteriorly where overlapped by hyaline flap of epigynal shield, with group of small rounded cells in centre of shield. Poroids *iv3* absent. Anterior membranous margin of epigynal shield subtriangular, elongate; posterior margin of shield slightly rounded; shield reticulated. Three pairs of postgenital platelets present. Anal shield subquadrate; reticulated; anus small, located in centre of shield. Soft opisthogastric cuticle with 11 pairs of setae. Epistome subtriangular with small blunt process distally and undulated laterally. Deutosternum with seven rows of denticles, rows 1–6 connected, 7th row free; rows with two lateral and 1–2 medial denticles. Corniculi with paraxial process. Fixed cheliceral digit with apical hook, two teeth on cutting surface and one small tooth on median line; subapical tooth with well-expressed membranous lobe instead of pilus dentilis. Movable digit with apical hook and one small tooth on cutting surface. Leg chaetotaxy formulae normal for genus, including tibia III with 9 setae; most leg setae thickened and born on small tubercles.

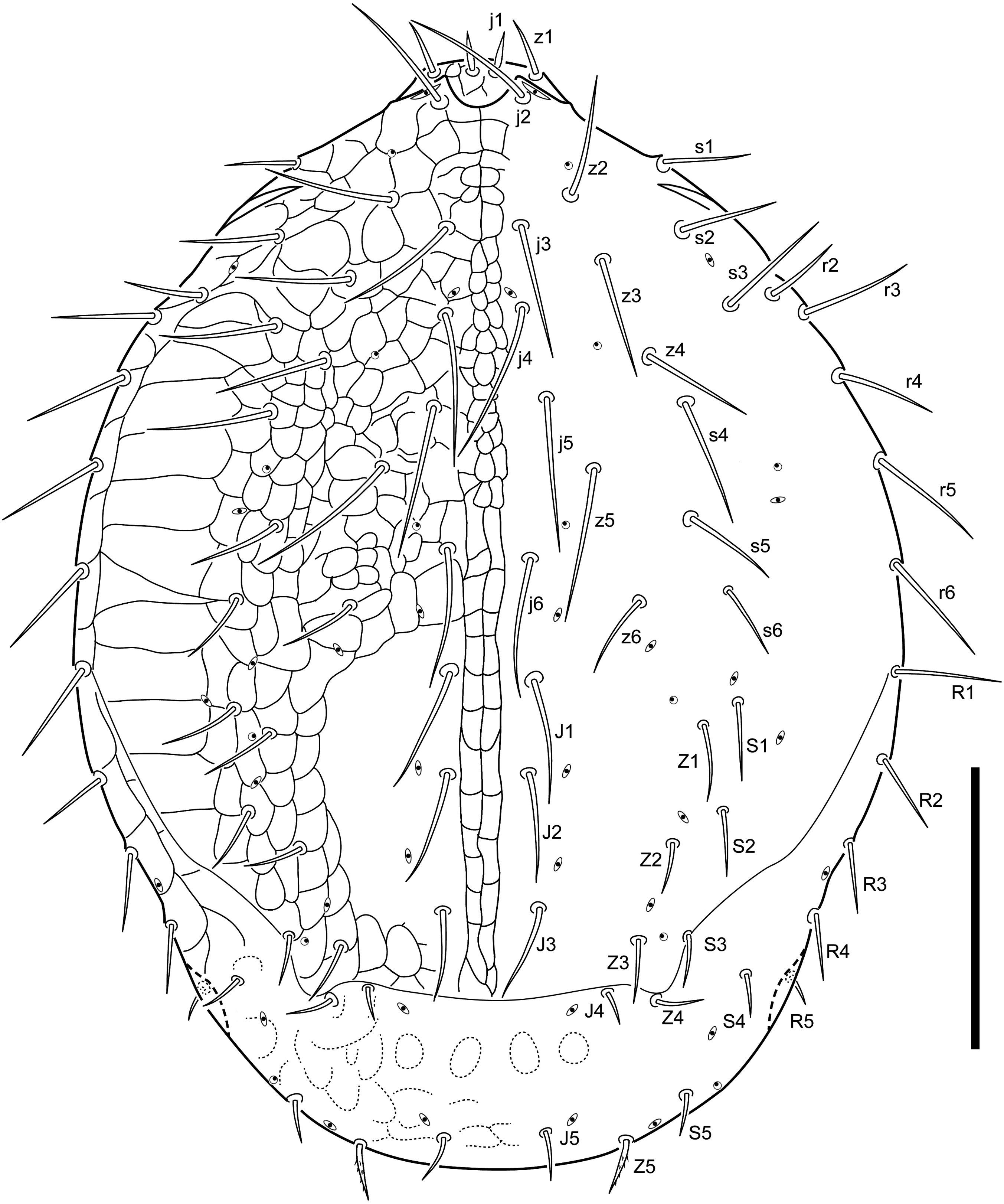

Figure 1 *Proctolaelaps sibiriensis* (Davydova, 1988), female: idiosoma, dorsal view. Scale bar: 100 µm.

Redescription of female (5 specimens measured)

Idiosomal dorsum (Figs 1, 5A) —Dorsal shield ovoid; 367–425 long and 275–300 maximum width at *R1* level; shield completely covers dorsum; shield strongly sclerotized and reticulate except lateral to *J1– J3* and posterior; cells transversally elongated near lateral margin, with a median ridge consisting of oval and rectangular reticulations; dorsum with 43 pairs of setae (*j1–j6*, *z1–z6*, *s1–s6*, *r2–r6*, *J1– J5*, *Z1– Z5*, *S1– S5*, *R1– R5*; base of setae *R5* visible ventrally) and 24 pairs of distinguishable pore-like structures (seven gland pores and 17 poroids). All dorsal setae simple, needle-like, except spindle-like setae *j1* and serrated setae *Z5*; lengths of setae: *j1* 10–17, *j2* 45–51, *j3* 40–50, *j4* 47–57, *j5* 51–63, *j6* 45–55, *z1* 18–21, *z2* 36–45, *z3* 38–50, *z4* 39–50, *z5* 46–56, *z6* 24–30, *s1* 25–31, *s2* 30–37, *s3* 35–41, *s4* 37–47, *s5* 26–36, *s6* 24–30, *r2* 25–28, *r3* 30–36, *r4* 29–37, *r5* 35–40, *r6* 28–40, *J1* 35–45, *J2* 33–42, *J3* 27–39, *J4* 10–20, *J5* 12–17, *Z1* 15–25, *Z2* 15–25, *Z3* 15–25, *Z4* 9–17, *Z5* 15–25, *S1* 18–30, *S2* 18–25, *S3* 13–17, *S4* 10–15, *S5* 9–15, *R1* 24–33, *R2* 22–27, *R3* 20–25, *R4* 17–25, *R5* 8–10.

Idiosomal venter (Figs 2, 5B) — Tritosternum with trapezoidal base, 11–13 long, 11–13 wide at base, laciniae pilose, fused for about fifth of total length 9–10, free parts 34–44 long. Pre-sternal area transversely lineate, without platelets. Sternal shield fused with endopodal elements of coxae I/II and coxae II/III; 57–65 long along midline, 94–125 wide at level of endopodal projections between coxae I/II, 135–160 wide at level of endopodal projections between coxae II/III, 76–95 wide at narrowest part between coxae II; with three pairs of setae (*st1–st3*) and two pairs of poroids (*iv1*, *iv2*); poroids *iv1* positioned posteriad of seta *st1*, poroids *iv2* positioned between setae *st2* and *st3*; posterior margin weakly concave, arched to level of bases of setae *st3*; reticulated except posteriorly where overlapped by hyaline flap of epigynal shield, with group of small rounded cells in centre of shield. Setae *st4* located on small metasternal platelets; poroids *iv3* absent. Anterior membranous margin of epigynal shield subtriangular, overlapping posterior margin of sternal shield, extending to level of setae *st2*, posterior margin of shield slightly rounded; epigynal shield reticulated; epigynal shield 142–146 long with hyaline membrane, 100–105 without membrane, with greatest width of hyaline flap 93–95, greatest width of posterior part 72–85; poroids *iv5* on soft cuticle, closely associated with shield. Three pairs of postgenital platelets present. Free endopodal plates between coxae III and IV. Anal shield subquadrate; reticulated; 95–100 long and 89–95 wide; anus small, located in centre of shield, anal opening 17–19 long; cribrum wide, reaching posterolateral corners of shield; one pair of gland pores (*gv3*) close to shield margin, at level of paranal setae. Posterior to coxae IV, two pairs of elongate metapodal platelets present; largest platelet 21–33 long, 5–9 wide; smaller platelet 4–6 long, 2–3 wide. Opisthogastric cuticle with 11 pairs of setae (*JV1– JV5*, *ZV1– ZV5*, *UR*) and three pairs of small poroids. Exopodal platelets fused, curved posteriorly around coxa IV , bearing gland pores *gv2* at posterior extremity. Peritrematal shields fused with dorsal shield at level of setae *s1*; with four pairs of distinguishable pore-like structures (poroids *ip2, ip3* and gland pores *gp2*, *gp3*); peritreme extending forward to level of *j2*. All ventral setae simple, needle-like; setae *JV5* and post-anal seta stout; lengths of setae: *st1* 38–43, *st2* 27–33, *st3* 21–28, *st4* 22–33, *st5* 19–25, *JV1* 15–20, *JV2* 16–20, *JV3* 14–17, *JV4* 12–13, *JV5* 16–22, *ZV1* 15–18, *ZV2* 13–17, *ZV3* 11–15, *ZV4* 9–13, *ZV5* 9–13, *UR* 9–13, para-anal setae 10–13, post-anal seta 19–23. Spermathecal apparatus not distinguishable.

Gnathosoma (Fig. 3) — Epistome subtriangular with small blunt process distally and undulated laterally (see Fig. 3A). Subcapitulum 65–72 wide at widest level. Deutosternum with seven rows of denticles, rows 1 to 6 connected by lateral margins, and row 7 free; rows with two lateral and 1–2 medial denticles (Fig. 3B). Hypostome with 4 pairs of simple setae; palpcoxal seta (*pc*) 18–25, *hp1* 15–20, *hp2* 12–15, *hp3* 24–26. Corniculi 20–25 long, 5–6 wide, horn-like, sclerotized, with small paraxial processes; internal malae slender, extending to paraxial processes of corniculi; salivary styli with blunt apices, reaching tips of corniculi. Palp length from trochanter to apex of tarsus 75–83; palpfemoral seta *al*, palpgenual setae *al1* and *al2* spatulate, other setae simple, palptarsal apotele 2-tined. Fixed cheliceral digit with short dorsal projection (dorsal mucro) over base; with apical hook, two teeth on cutting surface and

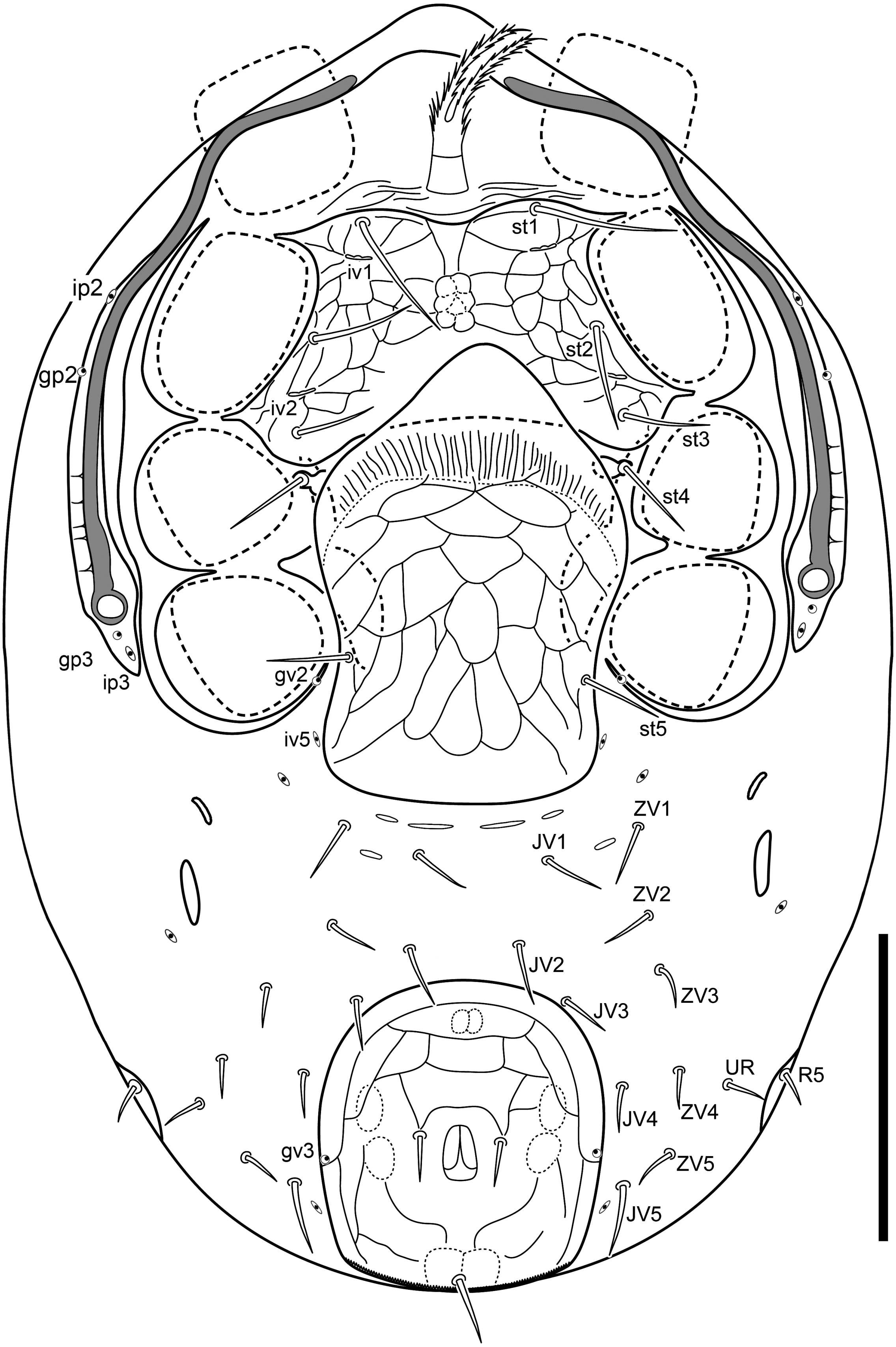

Figure 2 *Proctolaelaps sibiriensis* (Davydova, 1988), female: idiosoma, ventral view. Scale bar: 100 µm.

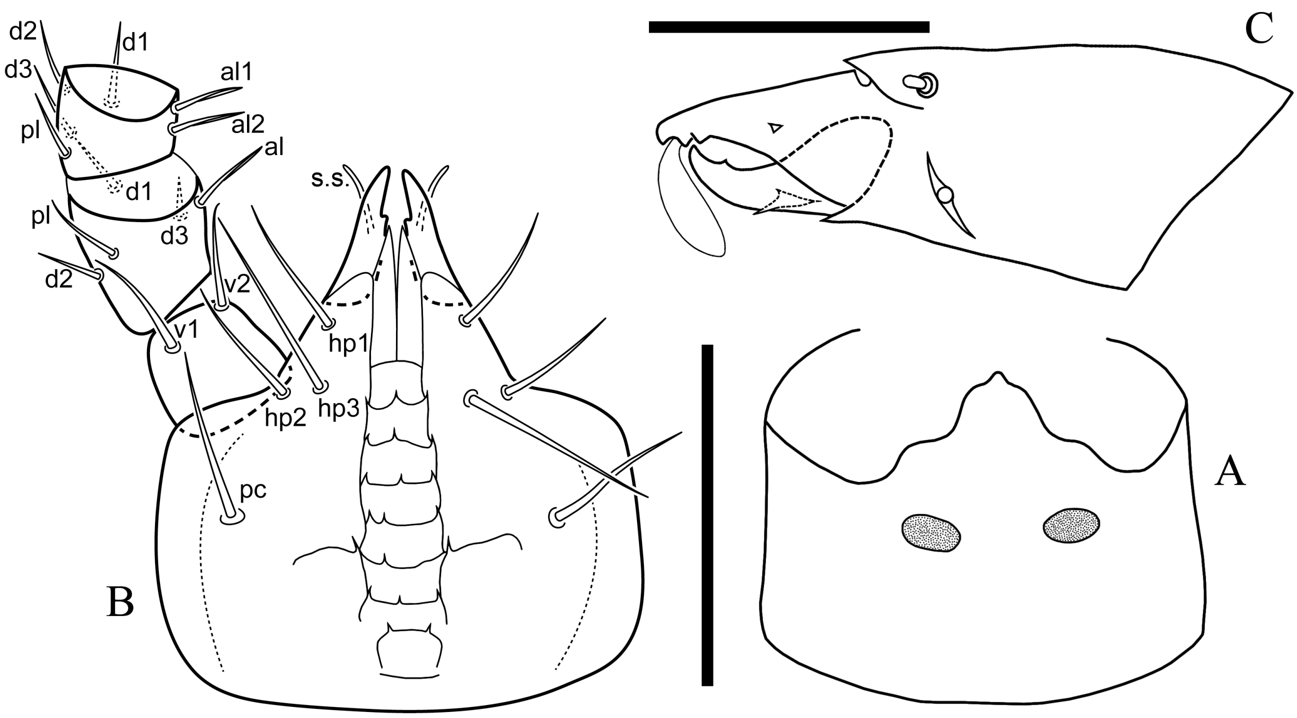

Figure 3 *Proctolaelaps sibiriensis* (Davydova, 1988), female: A – epistome; B – subcapitulum and palp (from trochanter to genu), ventral view; C – chelicera, antiaxial view. Scale bar: A, B 50 µm, C 25 µm.

one small tooth on median line (presumably for gripping hairs of bumblebee); subapical tooth with well-expressed membranous lobe instead of pilus dentilis, protrudes freely above the top of fixed digit or leans towards the movable digit of chelicera (at pressure on the slide as in Fig. 3c); dorsal and antiaxial lyrifissures present, dorsal seta blunt; second cheliceral segment length 56–60. Movable digit 17–18, with apical hook and one small tooth on cutting surface and with two ventral mucros: one strong spine-like in the middle of digit and second one small near base.

Legs (Fig. 4) — Lengths: I 274–313, II 231–243, III 216–236, IV 291–317. Leg chaetotaxy formulae normal for genus: leg I: coxa 2 (0 0/1 0/1 0), trochanter 6 (1 0/1 1/2 1), femur 12 (2 3/1 2/2 2), genu 13 (2 3/2 3/1 2), tibia 13 (2 3/2 3/1 2); leg II: coxa 2 (0 0/1 0/1 0), trochanter 5 (1 0/1 0/2 1), femur 11 (2 3/1 2/2 1), genu 11 (2 3/1 2/1 2), tibia 10 (2 2/1 2/1 2); leg III: coxa 2 (0 0/1 0/1 0), trochanter 5 (1 0/1 0/2 1), femur 6 (1 2/1 1/0 1), genu 9 (2 2/1 2/1 1), tibia 9 (2 1/1 2/1 2) *pl2* present; leg IV: coxa 1 (0 0/1 0/0 0), trochanter 5 (1 0/1 0/2 1), femur 6 (1 2/1 1/0 1), genu 9 (2 2/1 3/0 1), tibia 10 (2 1/1 3/1 2). Tarsi II-IV: 18 (3 3/2 1/1 3/2 3). Most leg setae stout and inserted on small tubercles. All legs with elongate pretarsi, bearing paired claws, paradactyli and three rounded pulvillae.

Discussion

Currently, fifteen species of the genus *Proctolaelaps* have been reported from North Asia: *P. arctorotundus* Nikolsky, 1984; *P. bickleyi* (Bram, 1956); *P. bombophilus* (Westerboer, 1963); *P. dendroctoni* Lindquist and Hunter, 1965; *P. fiseri* Samšiňák, 1960; *P. hystricoides* Lindquist and Hunter, 1965; *P. hystrix* (Vitzthum, 1923); *P. jueradeus* (Schweizer, 1949); *P. longisetosus* (Postner in Westerboer, 1963); *P. ornatus* (Postner in Westerboer, 1963); *P. parvanalis* (Thor,

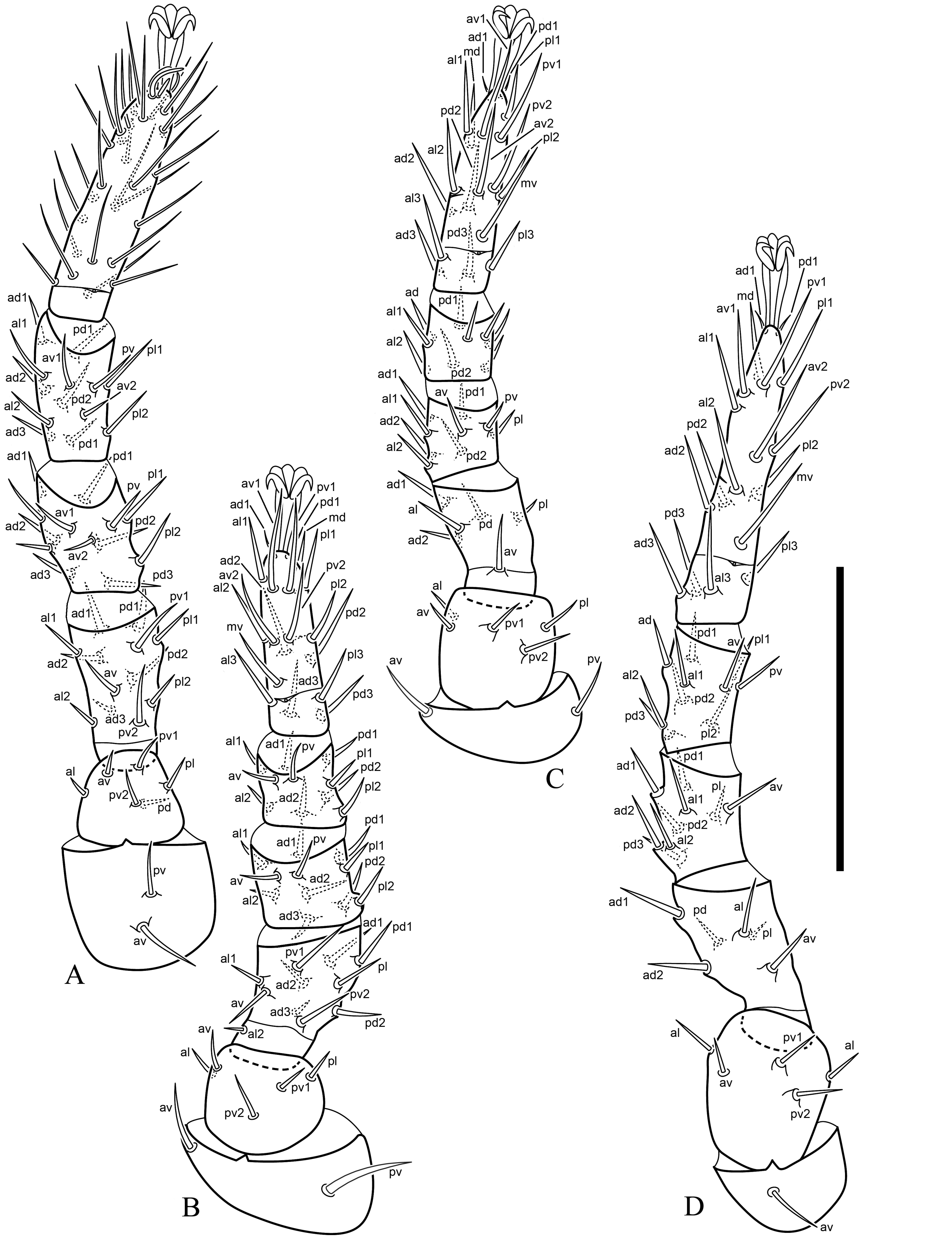

Figure 4 *Proctolaelaps sibiriensis* (Davydova, 1988), female: A – leg I, ventral view; B – leg II, ventral view; C – leg III, ventral view; D – leg IV, ventral view. Scale bar: 100 µm.

1930); *P. pseudofiseri* Nikolsky, 1984; *P. pygmaeus* (Müller, 1859); *P. scolyti* Evans (1958); *P. sibiriensis* (Davydova, 1988) (Bregetova 1977a; Nikolsky 1984; Davydova and Nikolsky 1986; Davydova 1988; Davydova and Bogatyrev, 1990; Klimov 1998; Makarova, 2012; Marchenko, 2010, 2012; Khaustov et al. 2016, 2018; Trach and Khaustov, 2017).

Genus *Proctolaelaps* Berlese, 1923 includes about 140 described species, but only five species are associated with bumblebees: *Proctolaelaps bombophilus* (Westerboer, 1963); *P. longanalis* (Westerboer, 1963); *P. longisetosus* (Postner, 1963); *P. ornatus* (Postner, 1963); *P. sibiriensis* (Davydova, 1988).

Their distribution is limited to the Holarctic (e.g. *P. sibiriensis* is known only from Western Siberia). Although the genus *Bombus* Latreille, 1802 is more widely distributed, and data on *Proctolaelaps* mites associated with bumblebees in the Neotropical and Indomalayan regions are not recorded at all (Williams, 1998; OConnor, Klimov, 2012).

Nothing is known about the feeding behavior of these mites or any other aspects of their biology. Females of these species of mites disperse and overwinter on adult queen bees (Klimov et al., 2016). OConnor and Klimov (2012) are of the opinion that *Proctolaelaps* mites could be harmful to their bee hosts by feeding on its eggs, larvae, and pupae. However, we agree with Halliday (2019) that the mites and the bees have a symbiotic relationship though these suggestions are still mere speculation and not yet confirmed.

The following key is based on published descriptions and illustrations, except for *P. ornatus* and *P. sibiriensis*.

Key to bumblebee-associated species of the genus *Proctolaelaps*

1. Dorsal shield strongly sculptured; setae *j1* and *z1* located on anterior extension of shield; anal shield subquadrate; setae of *JV*- and *ZV*-series short, never reaching base of consecutive seta 2

— Dorsal shield sculptured more lightly; anterior extension of shield absent; anal shield ovale or subrectangle; setae of *JV*- and *ZV*-series longer, mostly reaching base of next consecutive seta 3

2. Setae of dorsal shield shorter than distances to setae next behind (Fig. 5C); circum-anal setae subequal (Fig. 5D); epistome triangular, pointed distally (Holarctic) . . . . **P. ornatus** (Postner, 1963)

— Most setae of *j*-, *z*-, *s*-, and *r*-series reach base of seta next behind (Fig. 5A); post-anal seta 1.5–2 times as long as para-anal setae (Fig. 5B); epistome subtriangular with small blunt process distally and undulated laterally (Palaearctic: Western Siberia) . . . . **P. sibiriensis** (Davydova, 1988)

3. Epistomal margin denticulate; fixed digit of chelicera with numerous teeth (Holarctic) . . . . **P. longanalis** (Westerboer, 1963)

— Epistomal margin smooth; fixed digit of chelicera with one or two teeth 4

4. Setae of dorsal shield significantly longer than distances to setae next behind; deutosternum with rows of denticles 1 to 5 connected by lateral margins, and rows 6–7 free; movable cheliceral digit with one tooth (Holarctic) . . . . **P. longisetosus** (Postner, 1963)

— Setae of dorsal shield as long as distances to setae next behind; deutosternum with all 7 rows of denticles connected; movable cheliceral digit with two teeth (Holarctic) . . . . **P. bombophilus** (Westerboer, 1963)

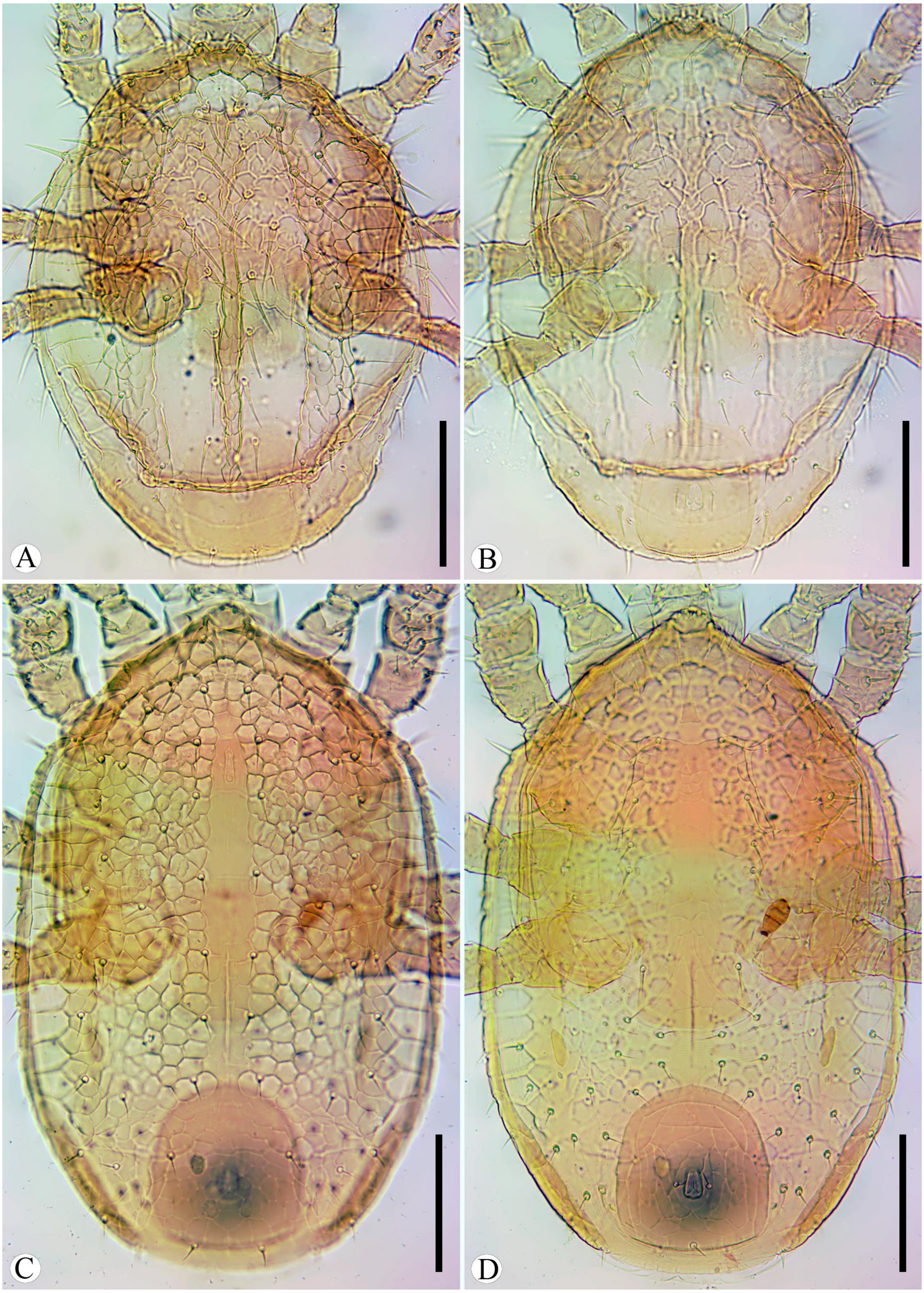

Figure 5 Micrographs of *Proctolaelaps* spp., females: A – *Proctolaelaps sibiriensis* (Davydova, 1988), dorsal view; B – *Proctolaelaps sibiriensis* (Davydova, 1988), ventral view; C – *Proctolaelaps ornatus* (Postner, 1963), dorsal view; D – *Proctolaelaps ornatus* (Postner, 1963), ventral view. Scale bar: 100 µm.

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