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# Two new genera and two new species of the mite family Neopygmephoridae (Acari: Heterostigmata) associated with small mammals from USA

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## Original research

### ABSTRACT

Two new monotypic genera and two new species of the mite family Neopygmephoridae (Acari: Pygmephoroida) associated with small mammals are described from USA: *Crossdania* **gen. nov.** with the type species *Crossdania tubulosa* **sp. nov.** associated with Northern grasshopper mouse, *Onychomys leucogaster* (Rodentia: Cricetidae) and Great Basin pocket mouse, *Perognathus parvus* (Rodentia: Heteromyidae), and *Theriodania* **gen. nov.** with the type species *Theriodania venusta* **sp. nov.** associated with Merriam's kangaroo rat, *Dipodomys merriami* (Rodentia: Heteromyidae).

**Keywords** Pygmephoroida; systematics; new genus; new species; fauna

**Zoobank** <http://zoobank.org/4CC238AE-261B-432A-901D-490635B60695>

## Introduction

The superfamily Pygmephoroida Cross, 1965 includes four families, Pygmephoridae Cross, 1965, Neopygmephoridae Cross, 1965, Microdispidae Cross, 1965, and Scutacaridae Oudemans, 1916, and more than 1400 species worldwide (Zhang et al. 2011). Probably all pygmephoroid mites are fungivorous (Khaustov 2008), but some species of the family Microdispidae might be parasitoids of insects (Kaliszewski et al. 1995). Most pygmephoroid mites utilize various arthropods (mostly insects) for phoresy, however at least representatives of the genus *Pygmephorus* (Pygmephoridae) are phoretic on small mammals (Kaliszewski et al. 1995).

Mites of the genus *Pygmephorus* are well studied in North America (Mahunka 1973, 1974, 1975; Smiley 1978; Smiley and Whitaker 1979, 1984), while mites of the family Neopygmephoridae are poorly studied and only four species have been reported in association with small mammals: *Bakerdania jonesi* Mahunka, 1975, *B. plurisetosa* Mahunka, 1975, *B. equisetosa* Cross, 1970, and *Kerdabania quadrata* (Ewing, 1917) (Mahunka 1975). During the study of Neopygmephorid mites collected on small mammals by the junior author and associates, two new remarkable new genera were found and are described below.

## Materials and methods

Mites were collected directly from small mammals by combing through the fur using dissecting needles with a dissecting microscope and mounted in Hoyer's medium. The terminology of the idiosoma and legs follows that of Lindquist (1986); the nomenclature of subcapitular setae

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and the designation of cheliceral setae follow those of Grandjean (1944, 1947), respectively. The systematics of Pygmephoroida follows that of Khaustov (2004, 2008). All measurements are given in micrometers ( $\mu\text{m}$ ) for the holotype and paratypes (in parentheses). For leg chaetotaxy, the number of solenidia is given in parentheses. Mite morphology was studied using a Carl Zeiss AxioImager A2 compound microscope with phase contrast and DIC objectives. Photomicrographs were taken with Hitachi KP-HD20A and AxioCam 506 color digital cameras.

## Systematics

### Family Neopygmephoridae Cross, 1965

#### Genus *Crossdania* gen. nov.

Zoobank: [BC02375D-4CFF-4338-8DE7-12E55D2D3203](https://zoobank.org/BC02375D-4CFF-4338-8DE7-12E55D2D3203)

Type species: *Crossdania tubulosa* sp. nov.

**Diagnosis** — Female. Body oval. Gnathosomal capsule slightly elongate, its length slightly longer than width, dorsally with two pairs of cheliceral setae (*cha*, *chb*); postpalpal setae not evident; palps prominent, with two pairs of dorsolateral setae (*dFe*, *dGe*), tiny distal seta-like structure and distinct tibial claw distally. Subcapitulum with one pair of setae *m*; palps ventrally with accessory setigenous structure (*ass*) and small solenidion (*sol*). Pharyngeal pumps tripartite, connected to each other. Prodorsum and tergite C separated by soft cuticle. Prodorsum with two pairs of setae ( $v_2$ ,  $sc_2$ ), pair of clavate trichobothria ( $sc_1$ ) and small, round stigmata located just anteriorly to setae  $v_2$ . Dorsal hysterosomal setae not modified, except wide and flat  $v_2$ . Tergite C with two pairs of setae ( $c_1$ ,  $c_2$ ); tergite D with one pair of setae (*d*) and pair of round cupules *ia*; tergite EF with two pairs of setae (*e*, *f*); tergite H with two pairs of setae ( $h_1$ ,  $h_2$ ) and pair of round cupules *ih*. A pair of tube-like sclerotized structures located under tergite H (Fig. 5C). Coxal fields I with two pairs of setae (*1a*, *1b*); coxal fields II with two pairs of setae (*2a*, *2b*); coxal fields III with three pairs of setae (*3a*, *3b*, *3c*); coxal fields IV with three pairs of setae (*4a*, *4b*, *4c*). Pseudanal segment with three pairs of setae ( $ps_{1-3}$ ). Apodemes 1 (*ap1*) and apodemes 2 (*ap2*) well developed and joined with prosternal apodeme (*appr*), sejugal apodeme (*apsej*) well developed and joined with *appr*; apodemes 3 (*ap3*) weak, diffuse, apodemes 4 (*ap4*) long, reaching beyond bases of setae *3b*. Apodemes 5 (*ap5*) short, located near the bases of trochanters IV. Secondary transverse apodeme absent. Coxal fields I separated from coxal fields II by slightly curved and almost connected medially lines. Posterior margin of posterior sternal plate entire, slightly convex in middle part. Anterior genital sclerite (*ags*) small, cup-shaped, posterior genital sclerite (*pgs*) small, triangular. Median genital sclerite absent. Ventral idiosomal setae not modified. Legs I slightly shorter than legs II. Tibiotarsus I cylindrical, with slightly thickened claw situated on short pretarsus; seta *d* of femur I hook-like, seta *k* short, blunt-ended, eupathidium-like. Claws on tarsi II and III thickened basally (padded). Claws on pretarsus IV absent. Femora III–IV divided into basi- and telofemur. Setae *l''* of genu, *d* of tibia, *pl''*, *tc'*, and (*pv*) of tarsus of leg II, *pl''*, (*pv*) of tarsus III and *u'* of tarsus IV modified, thickened and usually with “crown” of hooked barbs (Fig. 5F). Empodia on tarsi II and III distinctly elongate; empodium on tarsus IV very long and narrow. An unpaired slightly thickened seta-like structure (modified unguinal seta *u*) located near the base of pretarsal claw. Leg setation: leg I; Tr 1 ( $v'$ ), Fe 3 ( $d$ ,  $l'$ ,  $v''$ ), Ge 4 ( $l'$ ,  $l''$ ,  $v'$ ,  $v''$ ), TiTa 17(4) ( $d$ ,  $l'$ ,  $l''$ ,  $v'$ ,  $v''$ , *k*, *tc'*, *tc''*, *p''*, *ft'*, *ft''*, *pv'*, *pv''*, *pl'*, *pl''*, *s*, *u*,  $\omega_1$ ,  $\omega_2$ ,  $\phi_1$ ,  $\phi_2$ ); leg II: Tr 1 ( $v'$ ), fe 3 ( $d$ ,  $l'$ ,  $v''$ ), Ge 3 ( $l'$ ,  $l''$ ,  $v'$ ), Ti 4(1) ( $d$ ,  $l'$ ,  $v'$ ,  $v''$ ,  $\phi$ ), Ta 6(1) (*tc'*, *tc''*, *pl''*, *pv'*, *pv''*, *u'*,  $\omega$ ); leg III: Tr 1 ( $v'$ ), Fe 2 ( $d$ ,  $v'$ ), Ge 2 ( $l'$ ,  $v'$ ), Ti 4(1) ( $d$ ,  $l'$ ,  $v'$ ,  $v''$ ,  $\phi$ ), Ta 6 (*tc'*, *tc''*, *pl''*, *pv'*, *pv''*, *u'*); leg IV: Tr 1 ( $v'$ ), F 2 ( $d$ ,  $v'$ ), Ge 1 ( $v'$ ), Ti 4(1) ( $d$ ,  $l'$ ,  $v'$ ,  $v''$ ,  $\phi$ ), Ta 6 (*tc'*, *tc''*, *pl''*, *u'*, *pv'*, *pv''*).

**Differential diagnosis** — The new genus is most similar to *Protobakerdania* Khaustov and Minor, 2018 by the absence of a median genital sclerite, hook-like setae *d* of femur I, the same leg setation, and entire posterior margin of the posterior sternal plate. The new

genus differs from *Protobakerdania* by the long and narrow empodia on tarsi II and III and very long empodium on tarsus IV (vs not elongate, flipper-like in *Protobakerdania*), by the characteristically modified setae *l''* of genu, *d* of tibia, *pl''*, *tc''*, and (*pv*) of tarsus of leg II (vs. not modified in *Protobakerdania*). From all known genera of Neopygmephoridae the new genus differs by the presence of sclerotized tube-like structures under tergite H (vs absent in all other genera) and by the absence of claws on tarsus IV (vs present in all other genera).

**Species included** — The genus *Crossdania* includes only one species, *Crossdania tubulosa* sp. nov.

**Distribution and habitats** — *Crossdania tubulosa* sp. nov. was collected on the Northern grasshopper mouse, *Onychomys leucogaster* (Rodentia: Cricetidae) and Great Basin pocket mouse, *Perognathus parvus* (Rodentia: Heteromyidae) in USA.

**Etymology** — The generic name is a combination of two words: Cross, the family name of late American acarologist Earl Cross, and *dania*, the common ending of many Neopygmephorid genera. The new genus is named after Earl Cross for his contributions in the study of heterostigmatic mites.

### ***Crossdania tubulosa* sp. nov.**

Zoobank: [B5FA2A5E-BF1B-488D-B960-B2614985FD72](https://zoobank.org/B5FA2A5E-BF1B-488D-B960-B2614985FD72)

(Figs 1–5)

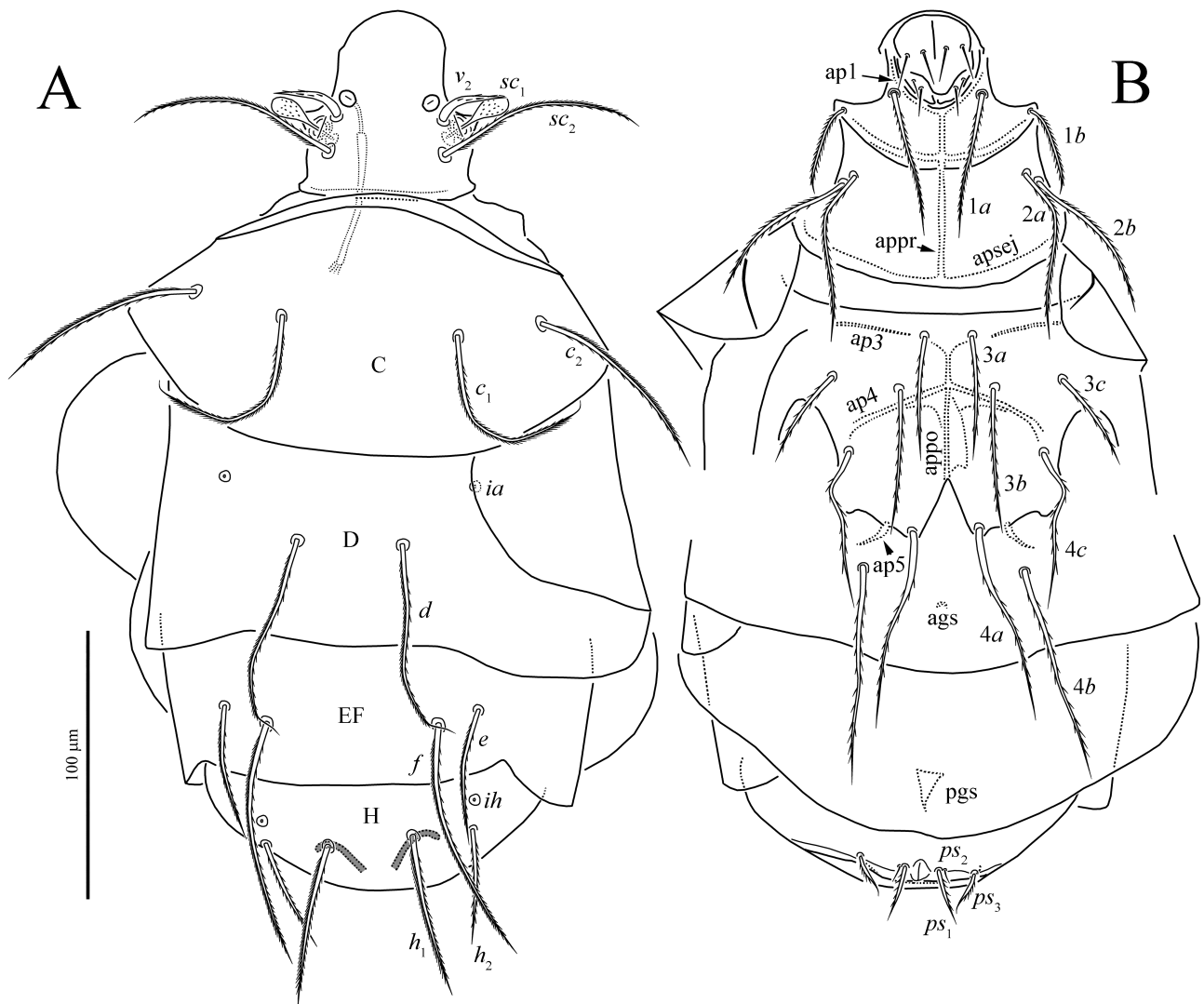
#### **Description**

**Female** (Figs 1–5) — With the character states of the genus as described above. Length of idiosoma 350 (265–355), width 180 (155–190). *Gnathosoma* (Fig. 2). Length of gnathosoma 33 (31–35), width 30 (29–31). Dorsal median apodeme well developed, thick. Cheliceral setae smooth and pointed. Setae *cha* 15 (15–16), *chb* 18 (18–19). Setae *dFe* slightly shorter than *dGe*, both smooth and pointed. Subcapitular setae *m* (not visible in holotype due to folded gnathosoma) (14–19) smooth and pointed. All pharyngeal pumps distinctly transversely striated. Pharyngeal pump 1 (*php1*) small, bow-shaped subequal to oval pharyngeal pump 3 (*php3*); pharyngeal pump 2 (*php2*) long, subrectangular, more than five times longer than *php3*.

**Idiosomal dorsum** (Figs 1A, 5A–C). All dorsal shields with numerous small round dimples (Figs 5A, B). All dorsal setae pointed and distinctly barbed. Setae  $v_2$  thick and flat, other dorsal setae not modified. Trichobothria with long stem, clavate, sparsely barbed, with rounded apex. Cupules *ia* on tergite D situated anterolaterally to bases of setae *d*; cupules *ih* on tergite H situated anteriorly to bases of setae  $h_2$ . Posterior part of tergite H slightly bent ventrally. Lengths of dorsal setae:  $v_2$  28 (22–26),  $sc_2$  81 (71–82),  $c_1$  80 (72–82),  $c_2$  81 (72–85), *d* 81 (72–80), *e* 51 (45–53), *f* 89 (82–91),  $h_1$  62 (59–68),  $h_2$  41 (38–43). Distances between setae:  $v_2$ – $v_2$  39 (37–41),  $sc_2$ – $sc_2$  43 (39–41),  $c_1$ – $c_1$  67 (59–72),  $c_1$ – $c_2$  34 (26–33), *d*–*d* 39 (31–39), *e*–*f* 17 (15–19), *f*–*f* 64 (55–66),  $h_1$ – $h_1$  32 (31–34),  $h_1$ – $h_2$  22(20–24).

**Idiosomal venter** (Figs 1B, 5D, E). Ventral plates with numerous small dimples (Figs 5D, E), dimples on anterior half of coxal fields II slightly larger than others (Fig. 5D). All ventral setae pointed. Setae  $ps_2$  smooth, other ventral setae distinctly barbed. Posterior margin of aggenital plate weakly concave. Bases of setae *4a* connected with posterior end of appo by distinct ridges (Fig. 5E) forming inverted v-shaped structure. Lengths of ventral setae: *1a* 36 (35–55), *1b* 37 (32–38), *2a* 65 (58–71), *2b* 64 (61–68), *3a* 51 (43–54), *3b* 61 (51–63), *3c* 40 (35–41), *4a* 76 (68–86), *4b* 84 (81–96), *4c* 62 (60–67),  $ps_1$  20 (17–24),  $ps_2$  8 (7–9),  $ps_3$  18 (14–19).

**Legs** (Figs 3, 4, 5F). Leg I (Fig. 3A). Lengths of solenidia  $\omega_1$  10 (10–11),  $\omega_2$  8 (7–9),  $\varphi_1$  9 (9–10),  $\varphi_2$  7 (6–7); all solenidia finger-shaped. Seta *l'* of femur blunt-ended; other leg setae (except eupathidia) pointed. All leg setae (except eupathidia) barbed. Leg II (Figs 3B, 5F). Solenidia  $\omega$  11 (11–12) and  $\varphi$  7 (7–8) finger-shaped. All leg setae pointed and barbed. Leg III (Fig. 4A). Solenidium  $\varphi$  5 (5–6) almost oval. All leg setae pointed and barbed. Leg IV (Fig.



**Figure 1** *Crossdania tubulosa* sp. nov., female: A – dorsum of the body, B – venter of the body. Legs omitted.

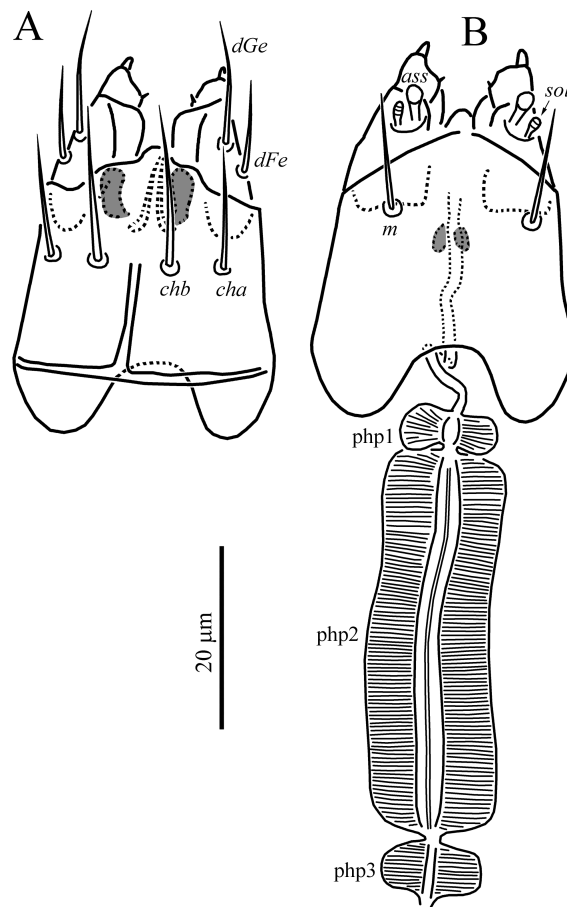
4B). Solenidion  $\phi$  4 (4) weakly clavate. All leg setae distinctly barbed. Seta  $v''$  of tibia weakly blunt-ended; other leg setae pointed.

Male and larva unknown.

**Type material** — Holotype (female) and 17 paratypes (females): USA, Oregon, Malheur County, 10.5 km to SE from White-horse ranch, on Northern grasshopper mouse, *Onychomys leucogaster*, 29 August 1976 (J. Whitaker). Other paratypes: 3 females, USA, Oregon, Malheur County, Jordan crater RNA, on Great Basin pocket mouse, *Perognathus parvus*, 29 August 1976 (J. Whitaker).

**Type deposition** — The holotype and 4 paratypes are deposited in the United States National Museum, Washington, USA; other paratypes are deposited in the mite collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

**Etymology** — The name of the new species is derived from Latin *tubulosa* meaning tubular, and refers to the presence of unusual tube-like structures under tergite H.



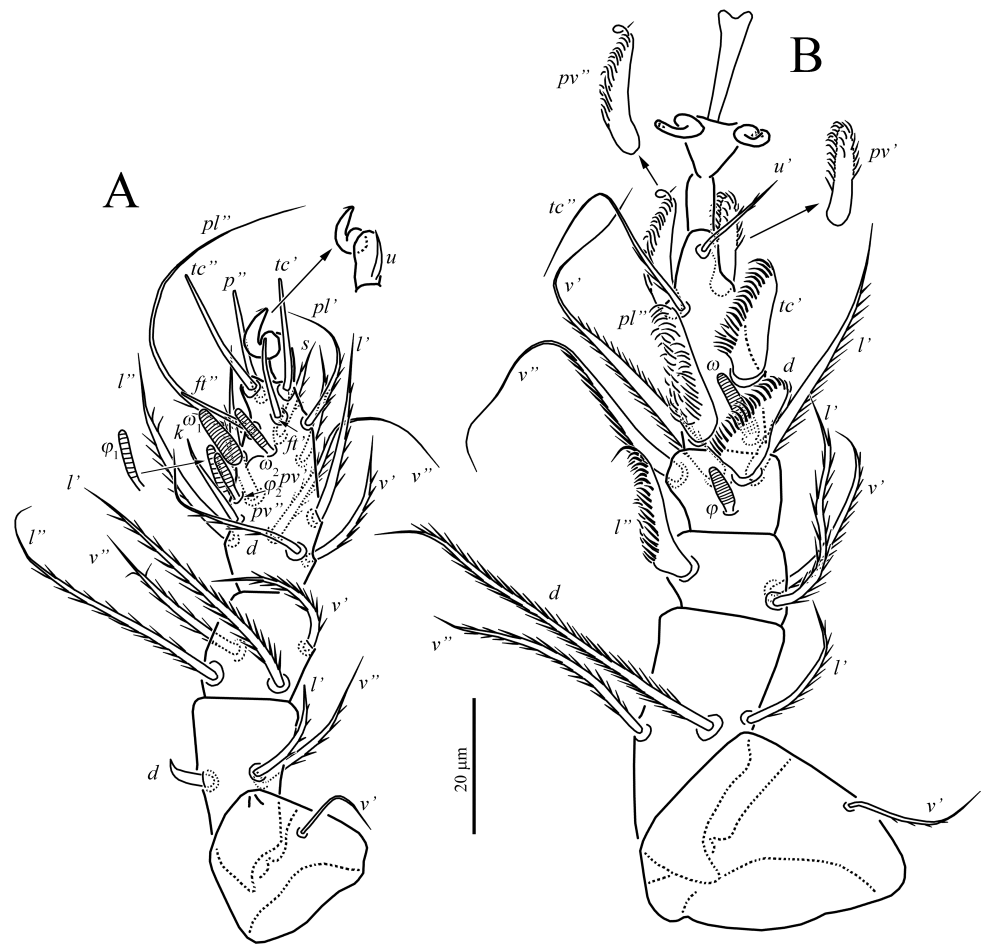
**Figure 2** *Crossdania tubulosa* sp. nov., female: A – gnathosoma in dorsal view, B – gnathosoma and pharyngeal pumps in ventral view.

### Genus *Theridania* gen. nov

Zoobank: [6D0CFA60-B3B1-42F6-8134-DC013C856FF1](https://zoobank.org/6D0CFA60-B3B1-42F6-8134-DC013C856FF1)

Type species: *Theridania venusta* sp. nov.

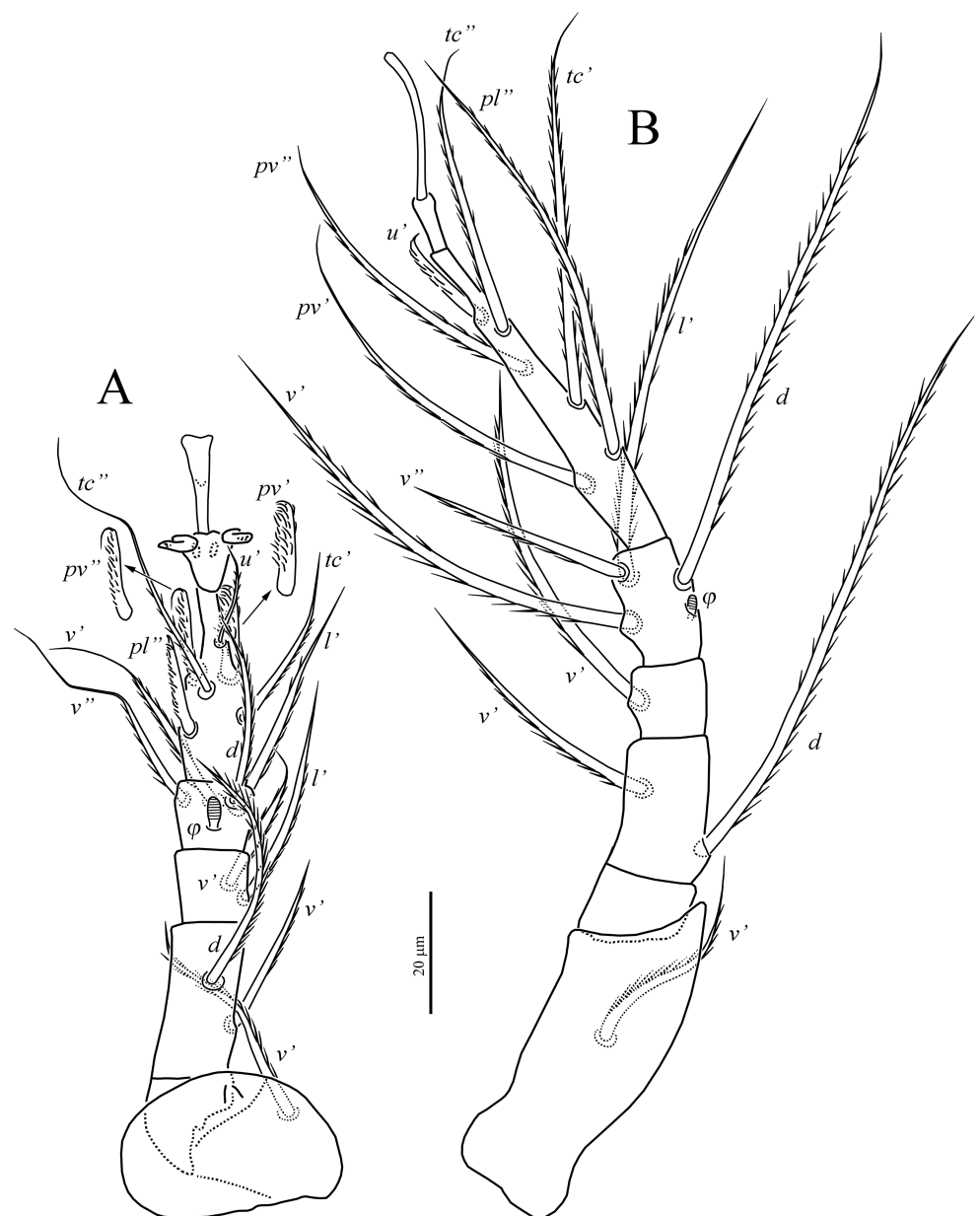
**Diagnosis** — Female. Body oval. Gnathosomal capsule distinctly elongate, its length almost two times longer than width, dorsally with one pair of cheliceral setae (*cha*); setae *chb* absent, postpalpal setae not evident; palps prominent, with two pairs of setae (*dFe*, *dGe*), tiny distal seta-like structure and small tibial claw distally. Subcapitulum with one pair of setae *m* and large round alveolar pits *n*; palps ventrally with accessory setigenous structure (*ass*), palpal solenidion not evident. Pharyngeal pumps tripartite, pharyngeal pump 1 very small, vestigial separated from pumps 2 and 3. Prodorsum and tergite C separated by soft cuticle. Prodorsum with two pairs of setae ( $v_2$ ,  $sc_2$ ), pair of clavate trichobothria ( $sc_1$ ) and elongate 2-chambered stigmata located dorsolaterally and partly covered by lateral projections of prodorsal shield (Figs 7C, 11A). Dorsal hysterosomal setae modified, flat, wide and strongly barbed. Tergite C with two pairs of setae ( $c_1$ ,  $c_2$ ), setae  $c_1$  located near anterior margin of tergite; tergite D with one pair of setae (*d*) and pair of elongate, rhombic cupules *ia* (Fig. 11B); tergite EF with two pairs of setae (*e*, *f*); tergite H with two pairs of setae ( $h_1$ ,  $h_2$ ) and pair of inverse drop-shaped cupules *ih*. Coxal fields I with two pairs of setae ( $1a$ ,  $1b$ ); coxal fields II with two pairs of setae ( $2a$ ,  $2b$ ); coxal fields III with three pairs of setae ( $3a$ ,  $3b$ ,  $3c$ ); coxal fields IV with three



**Figure 3** *Crossdania tubulosa* sp. nov., female: A – left leg I in dorsal view, B – left leg II in dorsal view.

pairs of setae (4a, 4b, 4c). Pseudanal segment with three pairs of setae ( $ps_{1-3}$ ). Ap1 and ap2 well developed and joined with appr, apsej well developed and joined with appr; ap3 weak, diffuse, ap4 long, reaching beyond bases of setae 3b. Ap5 short, located near the bases of trochanters IV. Secondary transverse apodeme absent. Coxal fields I separated from coxal fields II by u-shaped line. Posterior margin of posterior sternal plate entire, slightly convex in middle part. Anterior genital sclerite (ags) small, bell-shaped, posterior genital sclerite (pgs) small, triangular. Median genital sclerite absent. Ventral idiosomal setae thick and flat. Legs I distinctly shorter than legs II. Tibiotarsus I cylindrical, with simple hooked claw situated on short pretarsus; seta *d* of femur I wide and flat, fan-shaped (Fig. 11C), seta *k* short, lanceolate, eupathidium-like. Solenidion  $\omega_2$  absent. Claws on tarsi II and III simple, hooked. Claws on pretarsus IV simple, slightly curved. Femora III–IV divided into basi- and telofemur. Setae *d* of tibia, *pl''*, *tc'*, and (*pv*) of tarsus of leg II, and *pv'* of tarsus III modified, thickened and usually with “crown” of hooked barbs. Empodia on tarsi II and III tongue-shaped; empodium on tarsus IV very long and narrow. An unpaired simple seta (*u*) located near the base of pretarsal claw. Leg setation: leg I; Tr 1 (*v'*), Fe 3 (*d, l', v''*), Ge 4 (*l', l'', v', v''*), TiTa 17(3) (*d, l', l'', v', v'', k, tc', tc'', p'', ft', ft'', pv', pv'', pl', pl'', s, u, \omega\_1, \phi\_1, \phi\_2*); leg II: Tr 1 (*v'*), fe 3 (*d, l', v''*), Ge 3 (*l', l'', v'*), Ti 4(1) (*d, l', v', v'', \phi*), Ta 6(1) (*tc', tc'', pl'', pv', pv'', u, \omega*); leg III: Tr 1 (*v'*), Fe 2 (*d, v'*), Ge 2 (*l', v'*), Ti 4(1) (*d, l', v', v'', \phi*), Ta 6 (*tc', tc'', pl'', pv', pv'', u'*); leg IV: Tr 1 (*v'*), F 2





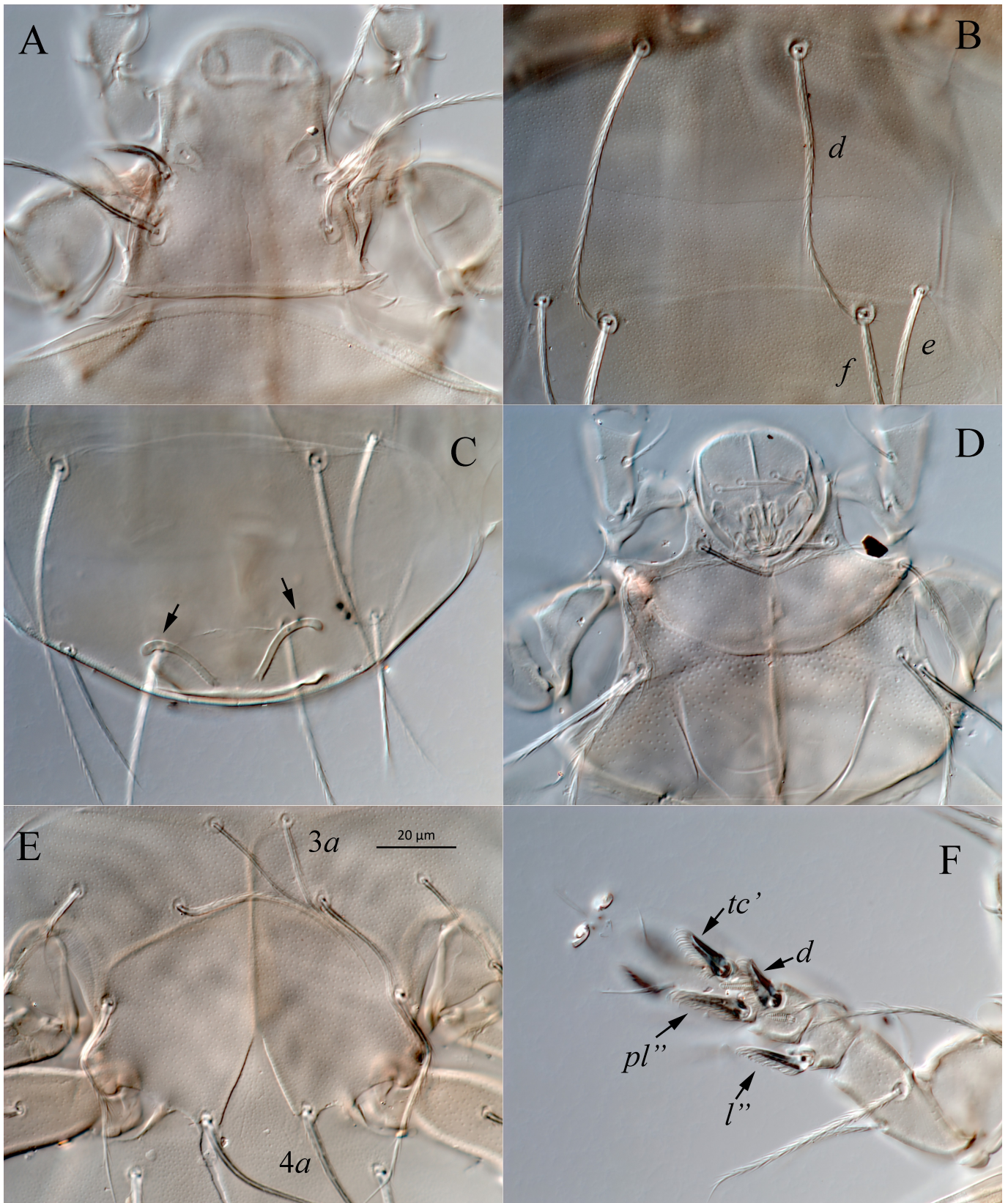
**Figure 4** *Crossdania tubulosa* sp. nov., female: A – left leg III in dorsal view, B – left leg IV in dorsal view.

(*d*, *v'*), Ge 1 (*v'*), Ti 4(1) (*d*, *l'*, *v'*, *v''*,  $\phi$ ), Ta 6 (*tc'*, *tc''*, *pl''*, *u'*, *pv'*, *pv''*).

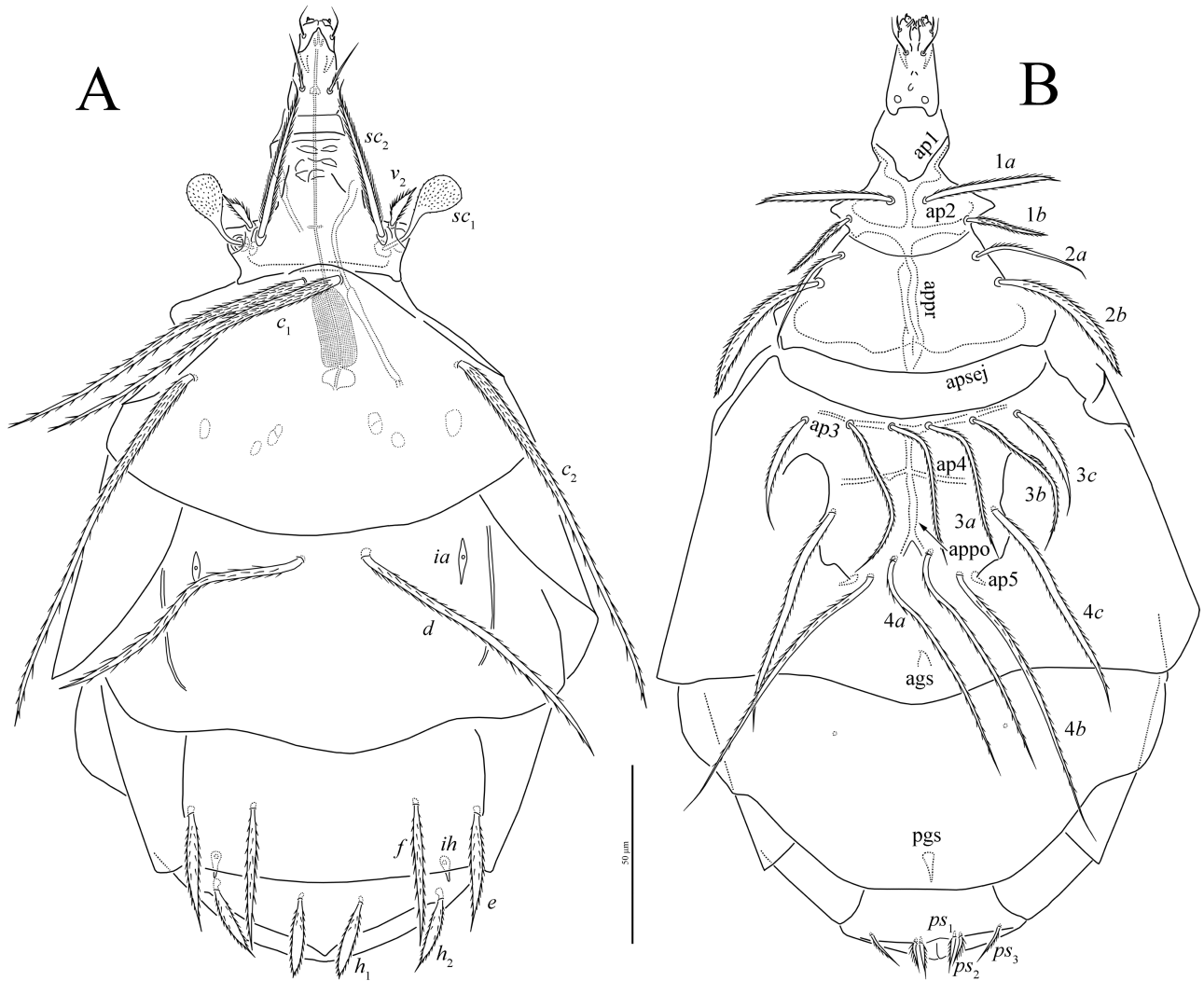
**Differential diagnosis** — The new genus is most similar to *Crossdania* gen. nov. by the presence of modified setae on leg II and very long empodium on tarsus IV. The new genus differs from *Crossdania* gen. nov. by the presence of claws on tarsus IV (vs absent in *Crossdania*), by the fan-shaped seta *d* of femur I (vs. hook-like in *Crossdania*), by the absence of solenidion  $\omega_2$  (vs. present in *Crossdania*), and by unusual elongate 2-chambered stigmata (vs. round, 1-chambered in *Crossdania*).

**Species included** — The genus *Theriadania* includes only one species *Theriadania venusta* sp. nov.

**Distribution and habitats** — *Theriadania venusta* sp. nov. was collected on Merriam's



**Figure 5** DIC micrographs (AxioCam 506 color) of *Crossdania tubulosa* sp. nov., female: A – prodorsum, B – tergites D and EF, C – tube-like structures (arrowed) under tergite H, D – prosoma in ventral view, E – posterior sternal plate, F – leg II in dorsal view.



**Figure 6** *Theriadania venusta* sp. nov., female: A – dorsum of the body, B – venter of the body. Legs omitted.

kangaroo rat, *Dipodomys merriami* (Rodentia: Heteromyidae) in USA.

**Etymology** — The generic name is a combination of two words: Ancient Greek *θηρίον* (*theria*) meaning, wild beast and *dania*, the common ending of many Neopygmephorid genera and refers to association of mites with small mammals.

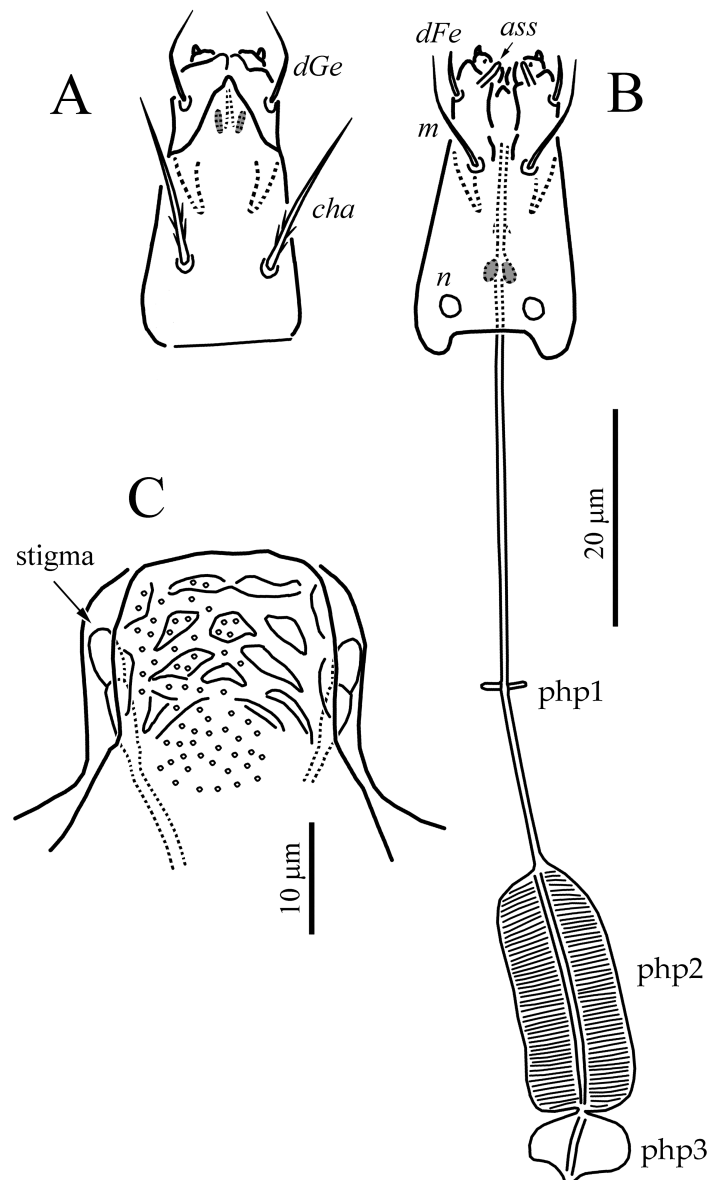
***Theriadania venusta* sp. nov.**

Zoobank: [728BAA7F-660C-455A-80A7-BA63F332DECA](https://zoobank.org/728BAA7F-660C-455A-80A7-BA63F332DECA)

(Figs 6–11)

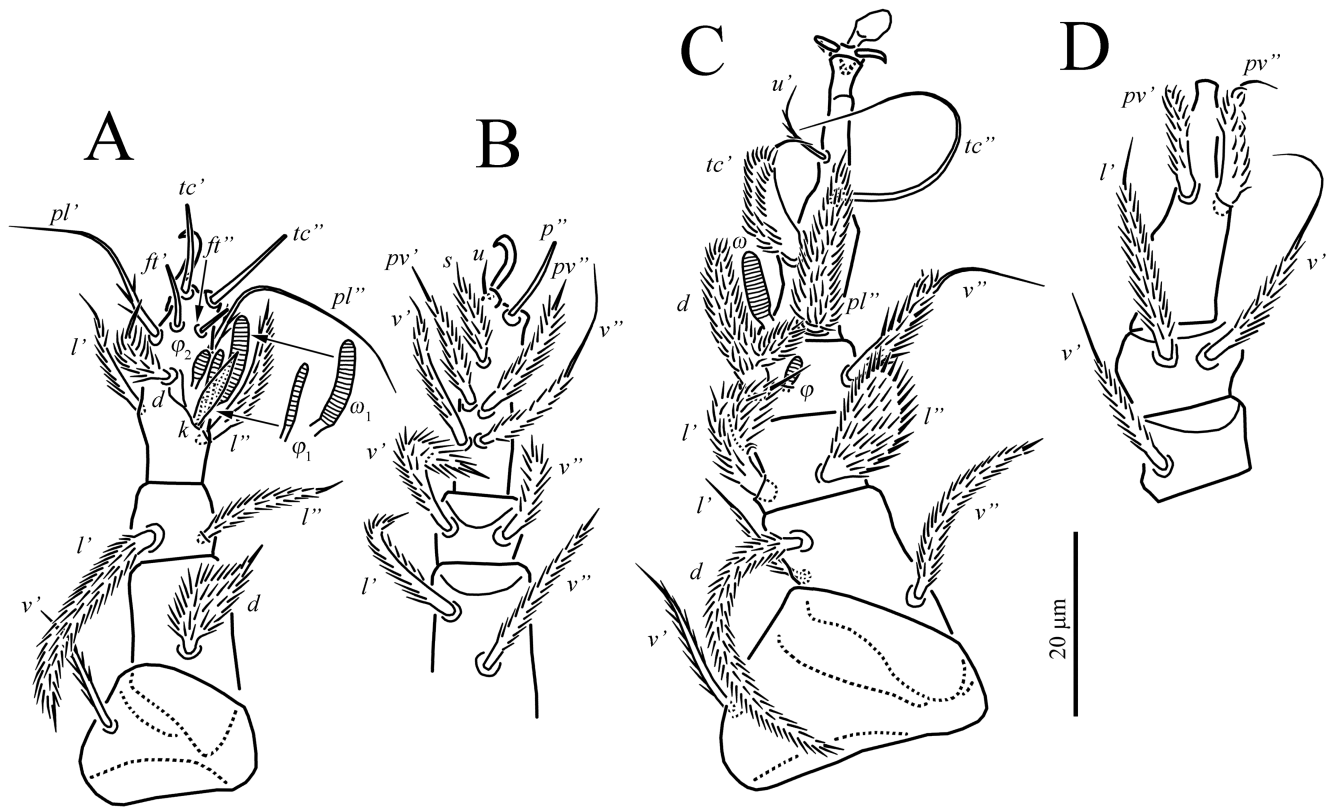
**Description**

**Female** (Figs 6–11) — With the character states of the genus as described above. Length of idiosoma 235 (220–225), width 155 (125–135). *Gnathosoma* (Figs 7A, B). Length of gnathosoma 26 (24–26), width 15 (14–15). Dorsal median apodeme absent. Cheliceral setae *cha* 17 (15–17) weakly barbed in basal part and pointed. Setae *dFe* located ventrolaterally, blunt-ended and distinctly shorter than dorsolateral pointed *dGe*. Subcapitular setae *m* 10 (10)



**Figure 7** *Theriadiania venusta* sp. nov., female: A – gnathosoma in dorsal view, B – gnathosoma and pharyngeal pumps in ventral view, C – anterior part of prodorsum.

smooth and pointed. Php1 very small, smooth, distinctly separated from transversely striated subrectangular php2 and smooth oval php3, which is about three times shorter than php2 (Fig. 7B). Accessory setigenous structure (*ass*) rod-shaped. *Idiosomal dorsum* (Figs 6A, 10A–C, 11A, B). All dorsal shields with numerous small round dimples (Figs 10A–C, 11A, B). Anterior part of prodorsum with distinct sculpture lines forming polygonal cells (Figs 7C, 11A). Tergite C with three pairs of oval porous areas (Fig 6A). All dorsal setae pointed and distinctly barbed. Setae  $v_2$ ,  $e$ ,  $h_1$ ,  $h_2$  distinctly lanceolate. Setae  $sc_2$  and  $f$  narrowly lanceolate; other dorsal setae long and slightly thickened. Trichobothria with long stem, clavate, sparsely barbed, with rounded apex. Cupules *ia* on tergite D situated laterally to bases of setae  $d$ ; cupules *ih* on tergite H situated anteriorly to bases of setae  $h_2$ . Lengths of dorsal setae:  $v_2$  13 (13–16),  $sc_2$  50 (49–51),  $c_1$  95 (90–98),  $c_2$  115 (115–125),  $d$  80 (74–83),  $e$  37 (35–42),  $f$  41 (43–48),  $h_1$



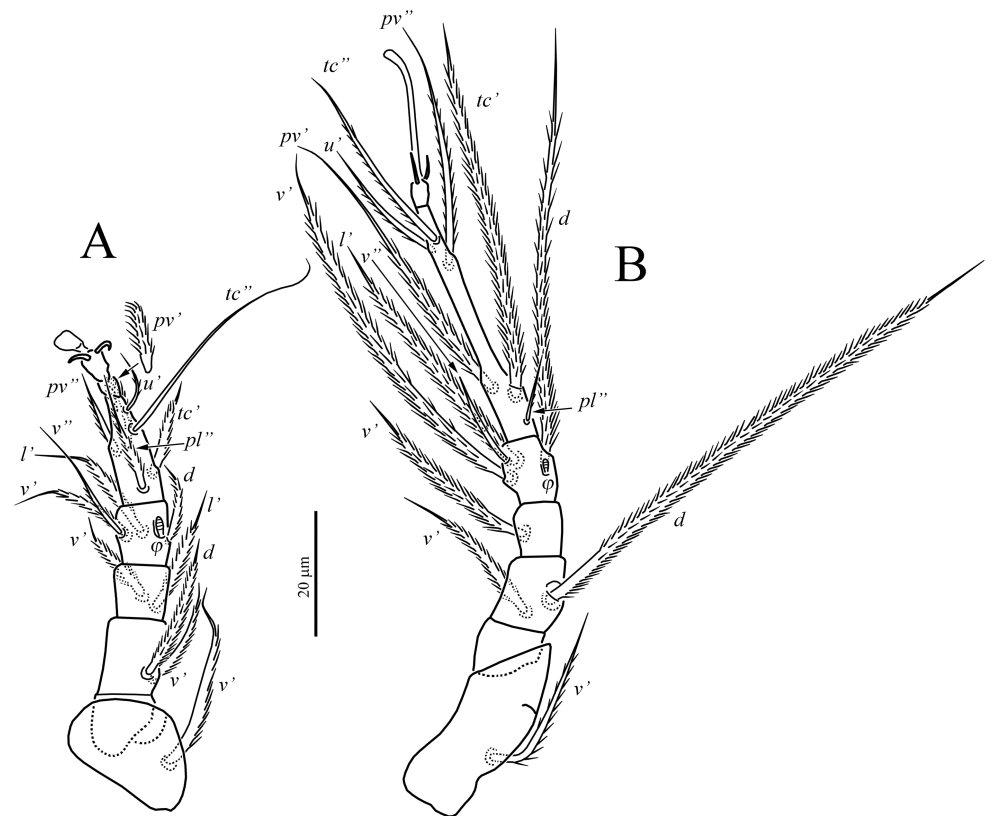
**Figure 8** *Theriadania venusta* sp. nov., female: A – right leg I in dorsal view, B – right leg I in ventral view, C – right leg II in dorsal view, D – genu, tibia and tarsus of right leg II in ventral view.

23 (23–26),  $h_2$  25 (25–26). Distances between setae:  $v_2-v_2$  39 (39–40),  $sc_2-sc_2$  33 (33–34),  $c_1-c_1$  10 (9–11),  $c_1-c_2$  39 (38–39),  $d-d$  18 (16–18),  $e-f$  18 (16–18),  $f-f$  45 (47–48),  $h_1-h_1$  16 (16–17),  $h_1-h_2$  24 (24–25).

*Idiosomal venter* (Figs 6B, 10D–E). Ventral plates with numerous small dimples (Figs 10D–F), dimples on anterior half of coxal fields II slightly larger than others (Fig. 10D). Lateral plates lateral to legs II and IV and lateral parts of aggenital plate with weak longitudinal striation (Fig. 10F). All ventral setae distinctly barbed and pointed. Posterior margin of aggenital plate straight. Setae 3a, 3b, 3c located in transverse row. Lengths of ventral setae: 1a 41 (37–43), 1b 25 (23–26), 2a 32 (32–34), 2b 47 (46–48), 3a 48 (46–49), 3b 60 (56–61), 3c 35 (33–36), 4a 75 (73–78), 4b 85 (89–99), 4c 66 (65–74),  $ps_1$  13 (13–14),  $ps_2$  12 (12–13),  $ps_3$  14 (14–15).

*Legs* (Figs 8, 9, 11C). Leg I (Figs 8A, 11C). Lengths of solenidia  $\omega_1$  11 (11),  $\phi_1$  9 (8–9),  $\phi_2$  4 (4); solenidium  $\omega_1$  finger-shaped, solenidium  $\phi_1$  baculiform, solenidium  $\phi_2$  clavate. Setae  $v'$  of trochanter and ( $pl$ ) of tarsus slightly thickened basally, pointed and barbed; other leg setae (except eupathidia and  $u$ ) strongly barbed, flattened and widened with pointed tips. Leg II (Fig. 8B). Solenidia  $\omega$  9 (9) and  $\phi$  4 (4) finger-shaped. Seta  $tc''$  smooth, other leg setae distinctly barbed. Setae  $tc''$  and  $u'$  not thickened; seta  $v'$  of trochanter slightly thickened; other leg setae distinctly thickened and flattened; seta  $d$  of tibia distinctly bifurcate; seta  $l''$  of genu fan-shaped. Leg III (Fig. 9A). Solenidium  $\phi$  3 (3) weakly clavate. All leg setae pointed; seta  $tc''$  smooth, other leg setae distinctly barbed. Setae  $tc''$  and  $u'$  not thickened, other leg setae distinctly thickened and flattened. Leg IV (Fig. 9B). Solenidium  $\phi$  2 (2–3) weakly clavate. All leg setae distinctly barbed. Seta  $v''$  of tibia weakly blunt-ended; other leg setae pointed.

Male and larva unknown.



**Figure 9** *Theriadanania venusta* sp. nov., female: A – left leg III in dorsal view, B – left leg IV in dorsal view.

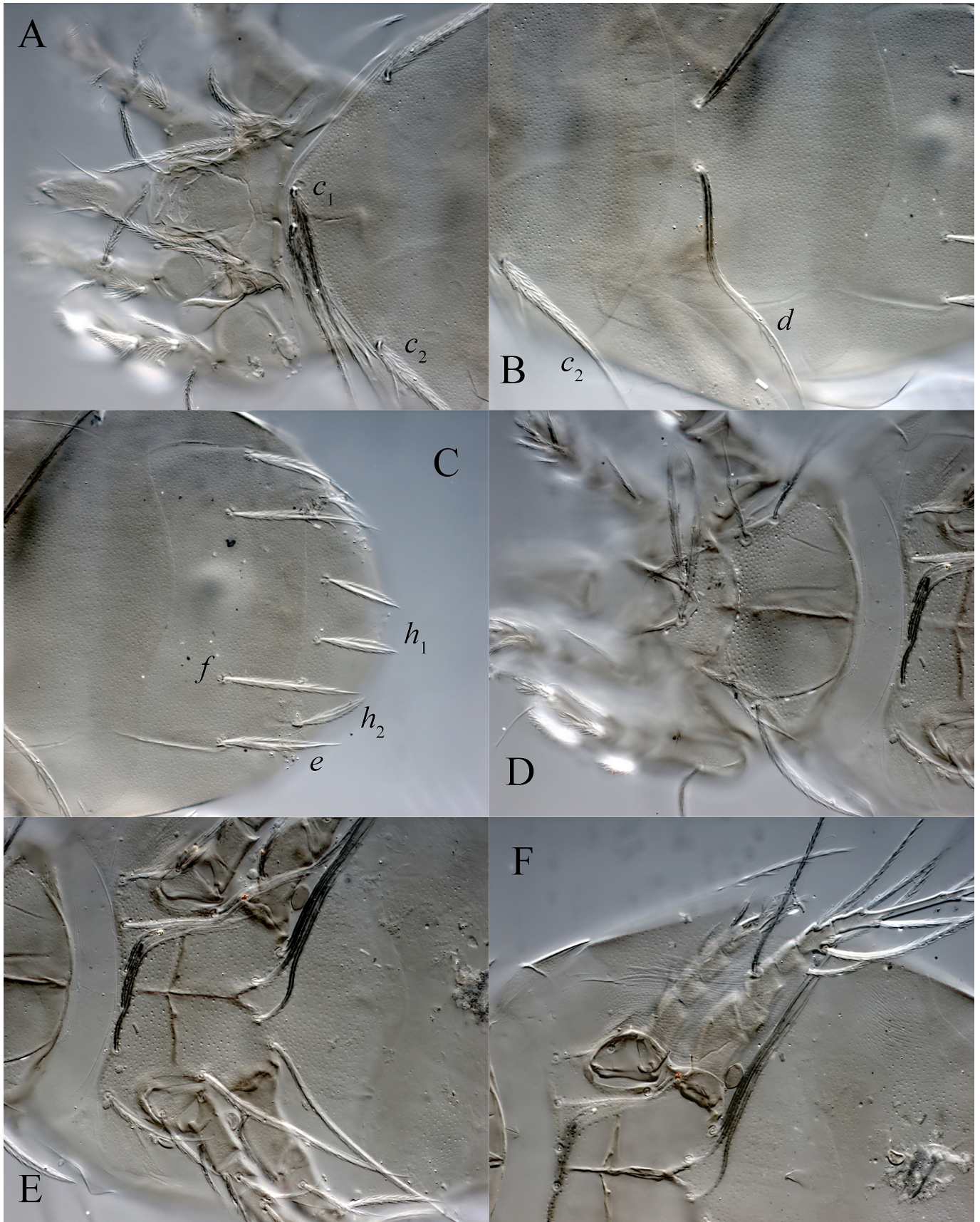
**Type material** — Holotype (female) and 3 paratypes (females): USA, Texas, Culberson County, on Merriam's kangaroo rat, *Dipodomys merriami*, 19 June 1976 (J. Whitaker).

**Type deposition** — The holotype and 1 paratype are deposited in the United States National Museum, Washington, USA; other paratypes are deposited in the mite collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

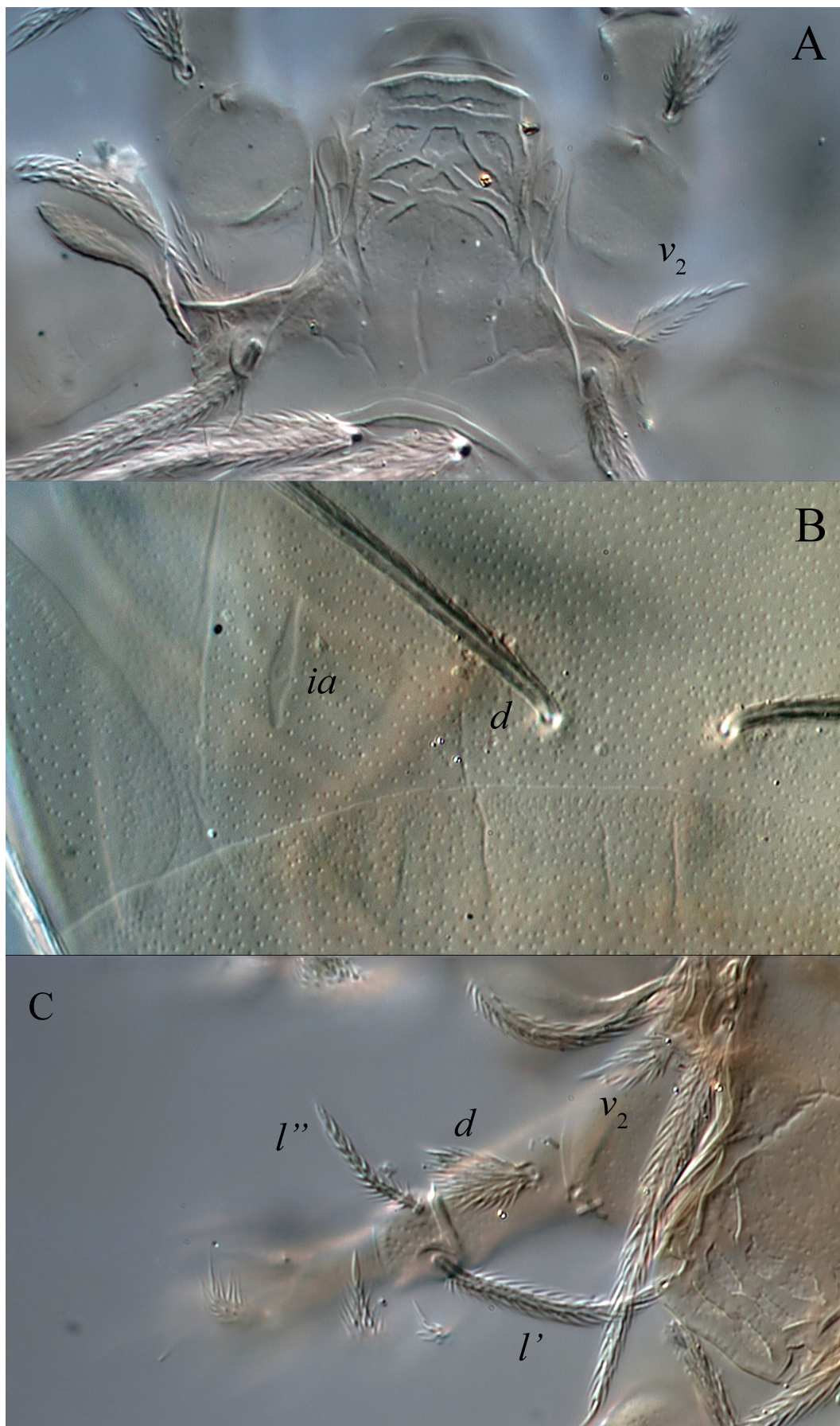
**Etymology** — The name of the new species is derived from Latin *venustus* meaning beautiful, and refers to the presence of many modified setae on idiosoma and legs.

## Discussion

Both newly described monotypic genera are characterized by a remarkable combination of characters. *Crossdania tubulosa* sp. nov. has unusual well sclerotized paired tube-like structures under tergite H (Fig.5C). Similar structures were not previously recorded in neopygmephorid and other heterostigmatic mites. These structures most likely represent part of insemination system, like spermathecae in astigmatid and mesostigmatid mites. However, these tube-like structures are located near the anal opening and could also be sclerotized ducts of glands. Another unusual character of *C. tubulosa* sp. nov. is the complete absence of claws on tarsus IV. The complete absence of claws on tarsus IV is unknown in all previously described neopygmephorid mites, however in some genera (for example *Petalomium*) the claws are very small and have a tendency to reduction and one species, *Zambedania argentiniana* has only one claw on tarsus IV. *Theriadanania venusta* sp. nov. has an unusual fan-like shape of seta *d* of femur I. In most neopygmephorid genera this seta is hook-like, relatively short, setiform



**Figure 10** DIC micrographs (AxioCam 506 color) of *Theriadanania venusta* sp. nov., female: A – prosoma and tergite C, B – tergites C and D, C – tergites EF and H, D – prosoma in ventral view, E – posterior sternal plate, F – lateral and aggenital plates in ventral view.



**Figure 11** DIC micrographs (Hitachi KP-HD20A) of *Theriadanina venusta* sp. nov., female: A – prodorsum, B – part of tergite D, C – right part of prodorsum and leg I in dorsal view.



in *Singhalophorus* and *Nipponophorus*, and very long and strongly barbed in *Zambedania*. *Theriadania venusta* **sp. nov.** is also characterized by the absence of the solenidion  $\omega_2$ . The absence of solenidion  $\omega_2$  in Neopygmephoridae is currently known only in *Zambedania*. Both *C. tubulosa* **sp. nov.** and *T. venusta* **sp. nov.** are characterized by an unusually long and thin empodium on tarsus IV and modification of some leg setae, especially *d* of tibia, *tc'* and *pl''* of tarsus on leg II. These characters are unknown in all other neopygmephorid mites. However, similar modification of the setae on leg II and a very long and narrow empodium is known in some species of *Pygmephorus* (Pygmephoridae), which also associated with small mammals (see Fig. 3 in Smiley and Whitaker, 1984). There is no doubt that these characters appeared in Neopygmephoridae (*Crossdania* and *Theriodania*) and Pygmephoridae (*Pygmephorus*) independently as a result of phoresy on small mammals.

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## References

- Cross E.A. 1965. The generic relationships of the family Pyemotidae (Acarina, Trombidiformes). Univ. Kans. Sci. Bull., 45: 29-215.
- Cross E.A. 1970. Acarina: Prostigmata: Tarsonemoidea: Pyemotidae of South Georgia. Pacif. Ins. Mon., 23: 115-120.
- Ewing H.L. 1917. New Acarina. Part II - Descriptions of new species and varieties from Iowa, Missouri, Illinois, Indiana, and Ohio. Bull. Amer. Mus. Nat. Hist., 37: 166.
- Grandjean F. 1944. Observations sur les Acariens de la famille des Stigmaeidae. Arch. Sci. Phys. Natur., 26: 103-131.
- Grandjean F. 1947. L'origine pileuse des mors et la chaetotaxie de la mandibule chez les Acariens ac-tinochitineux. C. rend. Séanc. Acad. Sci., 224, 1251-1254.
- 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
- Kaliszewski M., Athias-Binche F., Lindquist E.E. 1995. Parasitism and parasitoidism in Tarsonemina (Acari: Heterostigmata) and evolutionary considerations. Adv. Parasit., 35: 335-367. doi:10.1016/S0065-308X(08)60074-3
- Khaustov A.A. 2004. Mites of the family Neopygmephoridae Cross, 1965 stat. n. and their position in Heterostigmata. In: Balashov Y.S. (Ed.), VIII Russian Acarological Conference, St.Petersburg. Zoological Institute of RAS, St.Petersburg, p. 137. [in Russian]
- Khaustov A.A. 2008. Mites of the family Scutacaridae of Eastern Palaearctic. Akademperiodyka, Kiev, 291 pp.
- Khaustov A.A., Minor M.A. 2018. New taxa of the mite family Neopygmephoridae (Acari: Heterostigmata) from alpine New Zealand. Zootaxa, 4115: 276-296. doi:10.11646/zootaxa.4415.2.3
- Mahunka S. 1973. *Pygmephorus* species (Acari: Tarsonemida) from North American small mammals. Parasitol. Hung., 6: 247-259.
- Mahunka S. 1974. New data to the knowledge of *Pygmephorus* species (Acari: Tarsonemida) living on small mammals in North America. Parasitol. Hung., 7: 197-200.
- Mahunka S. 1975. Further data to the knowledge of Tarsonemida (Acari) living on small mammals in North America. Parasitol. Hung., 8: 85-94.
- Oudemans A.C. 1916. Acarologische Aanteekeningen LX. Entomol. Ber., 4: 308-316.
- Smiley R.L. 1978. Taxonomic studies of *Pygmephorus* species from the Western hemisphere, with a key to females and an overview of the current problems for classification (Acari: Pyemotidae and Pygmephoridae). Int. J. Acarol., 4: 125-160. doi:10.1080/01647957808684032
- Smiley R.L., Whitaker J.O. 1979. Mites of the genus *Pygmephorus* (Acari: Pygmephoridae) on small mammals in North America. Acta Zool. Acad. Sci. Hung., 25 (2-4): 383-408.
- Smiley R.L., Whitaker J.O. 1984. Key to New and Old world *Pygmephorus* species and description of six new species (Acari: Pygmephoridae). Int.J. Acarol., 10 (2): 59-73. doi:10.1080/01647958408683355
- Zhang Z.-Q., Fan Q.-H., Pesic V., Smit H., Bochkov A.V., Khaustov A.A., Baker A., Wohltmann A., Wen T.-H., Amrine J.W., Beron P., Lin J.-Z., Gabrys G., Husband, R. 2011. Order Trombidiformes Reuter, 1909. In: Zhang Z.-Q. (ed.) Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness. Zootaxa, 3148: 129-138. doi:10.11646/zootaxa.3148.1.24