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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

\textbf{ABSTRACT}

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

\textbf{Keywords} Pygmephoroidae; systematics; new genus; new species; fauna

\textbf{Zoobank} http://zoobank.org/4CC238AE-261B-432A-901D-490635B60695

\textbf{Introduction}

The superfamily Pygmephoroidae 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 pygmephorid mites are fungivorous (Khaustov 2008), but some species of the family Microdispidae might be parasitoids of insects (Kaliszewski et al. 1995). Most pygmephorid mites utilize various arthropods (mostly insects) for phoresy, however at least representatives of the genus \textit{Pygmephorus} (Pygmephoridae) are phoretic on small mammals (Kaliszewski et al. 1995).

Mites of the genus \textit{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: \textit{Bakerdania jonesi} Mahunka, 1975, \textit{B. plurisetosa} Mahunka, 1975, \textit{B. equisetosa} Cross, 1970, and \textit{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.

\textbf{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 chelicer setae follow those of Grandjean (1944, 1947), respectively. The systematics of Pygmephoroidea follows that of Khaustov (2004, 2008). All measurements are given in micrometers (μm) 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 AxiosImager 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

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 (*v1, sc2*); pair of clavate trichobothria (*sc1*) and small, round stigmata located just anteriorly to setae *v2*. Dorsal hysterosomal setae not modified, except wide and flat *v2*. Tergite C with two pairs of setae (*c1, c2*); 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 (*h1, h2*) 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 (*ps1–3*). 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 trochanter 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'*, *d* of tibia, *pl'*, *tc'*, and (*pv*) of tarsus of leg II, *pl'', *pv''* of tarsus III and *u'*, *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''*, *v'*, *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, a1, a2, φ, ρ2*); leg II: Tr 1 (*v*), Fe 3 (*d, l', v''*), Ge 3 (*l', l'', v''*), Ti 4(1) (*d, l', v', v'', φ*), Ta 6(1) (*tc', tc'', pl'', pv', pv'', u', ω*); leg III: Tr 1 (*v*), Fe 2 (*d, v'*, *v'', φ*), Ge 2 (*l', v''*), Ti 4(1) (*d, l', v', v'', φ*), Ta 6 (*tc', tc'', pl'', pv', pv'', u*, ω*); leg IV: Tr 1 (*v*), F 2 (*d, v'*, *v'', φ*), Ge 1 (*v*), Ti 4(1) (*d, l', v', v'', φ*), Ta 6 (*tc', tc'', pl', u', pv', pv'').

**Differential diagnosis** — The new genus is most similar to *Proto-bakerdania* 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 Neopygmephyridae 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 Neopygmephyrid 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
(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 socket thick and flat, other ventral setae distinctly barbed. Posterior part of tergite H slightly bent ventrally. Distances between setae: \(a_1 36 (35–55), b_1 37 (32–38), 2a_1 65 (58–71), 2b_1 64 (61–68), 3a_1 51 (43–54), 3b_1 61 (51–63), 3c_1 40 (35–41), 4a_1 76 (68–86), 4b_1 84 (81–96), 4c_1 62 (60–67), ps1 20 (17–24), ps2 8 (7–9), ps3 18 (14–19).

Legs (Figs 3, 4, 5F). Leg I (Fig. 3A). Lengths of solenidia \(a_1 10 (10–11), a_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 \(a_1 11 (11–12) and \varphi_7 7 (7–8) finger-shaped. All leg setae pointed and barbed. Leg III (Fig. 4A). Solenidion \(\varphi_5 5 (5–6) almost oval. All leg setae pointed and barbed. Leg IV (Fig.
4B). Solenidion φ 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.
Genus *Theriadania* gen. nov

Zoobank: 6D0CFA60-B3B1-42F6-8134-DC013C856FF1

*Type species:* *Theriadania 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 (*h₁, h₂*) 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
pairs of setae (4a, 4b, 4c). Pseudanal segment with three pairs of setae (ps1-3). Ap1 and ap2 well developed and joined with aprr, apeaj 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 ω2 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, te', tc", p", ft", ft", pv", pv", pl", pl", s, u, φ1, φ2); leg II: Tr 1 (v'), Fe 3 (d, l', v"), Ge 3 (l', l", v'), Ti 4(1) (d, l', v", v", φ), Ta 6(1) (tc", tc", pl", pv", pv", u", φ); leg III: Tr 1 (v'), Fe 2 (d, v'), Ge 2 (l', v'), Ti 4(1) (d, l", v"), Ta 6 (tc", tc", pl", pv", pv", u'); leg IV: Tr 1 (v'), F 2

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

**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.
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*  
(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  *Theriadania 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*₁ 317
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.

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), ps1 13 (13–14), ps2 12 (12–13), ps3 14 (14–15).

Legs (Figs 8, 9, 11C). Leg I (Figs 8A, 11C). Lengths of solenidia ω1 11 (11), φ1 9 (8–9), φ2 4 (4); solenidion φ3 finger-shaped, solenidion φ1 baculiform, solenidion φ2 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 ω 9 (9) and φ 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). Solenidion φ 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). Solenidion φ 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.
**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. *Theriadania 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 Theriadania 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 Theriadania 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. Theriodania 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 Pygmeophorus (Pygmeophoridae), 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 Pygmeophoridae (Pygmeophorus) independently as a result of phoresy on small mammals.

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**References**
