

Two new feather mites of the genus *Proctophyllodes* (Acari: Proctophyllodidae) from passerines of China (Aves: Passeriformes)

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Abstract

Two new species of the feather mite genus *Proctophyllodes* (Analgoidea: Proctophyllodidae) are described from two passerine birds (Passeriformes) in China: *Proctophyllodes scleroticus* **sp. nov.** from the Brandt's Mountain Finch *Leucosticte brandti pallidior* (Fringillidae) and *P. micrurus* **sp. nov.** from the White-rumped Snow Finch *Onychostruthus taczanowskii* (Passeridae). *Proctophyllodes scleroticus* **sp. nov.** belongs to the *tricetratus* species-group, and differs from the most similar species *P. petroniae* Atyeo & Braasch, 1966 by the following characters: in male, the genital sheath is heavily sclerotized, peach shaped, and extending to the level of setae *g*, anal suckers are surrounded with a pair of membranes, and terminal lamella is relatively greater, and in female, lobar shield is divided into two independent shields by the anal opening and anal opening extends beyond the level of setae *ps1*, terminal appendage is long. *Proctophyllodes micrurus* **sp. nov.** belongs to the *musicus* species-group, and differs from the most similar species *P. saltatoris* Atyeo & Braasch, 1966 by the following characters: in male, genital arch and the anterior part of opisthogastric shield are about the same width, anal suckers are surrounded with a pair of membranes, genital organ extends to the anterior 1/3 of the level of setae *g* and setae *ps3*, terminal lamella are located closely to each other and slightly greater, and in female, lobar shields are medially divided into two halves, terminal appendages are small, about 1/10 of setae *h3*, edge of the cleft is almost horizontal.

Key words: Acari, feather mites, *Proctophyllodes*, new species, China

Introduction

Feather mites are permanent ectosymbionts living on the surface of birds. The genus *Proctophyllodes* (Analgoidea: Proctophyllodidae) is the most species-rich genus among all feather mite genera. Atyeo and Braasch (1966) made a comprehensive revision of this genus, recorded and described 123 species. Mironov (2012) updated the checklist with 162 recorded species of this genus. To date the genus *Proctophyllodes* includes about 179 species (Mironov 2019; Pedroso & Hernandez 2021). They are mainly distributed on the flight feathers, greater coverts of the wings, and tail feathers of host birds, among which passerines (Passeriformes) are the most common hosts (Aty eo & Braasch 1966; Dabert & Mironov 1999; Mironov 2012).

The taxonomic research on the genus *Proctophyllodes*, including species groups subdivision and species identification, is almost completely based on the morphologic characters of male opisthosoma and genital region, as well as the shapes and sizes of the terminal lamellae of males, while female characters are just as an additional supplement. In this genus male genital organs and

terminal membranes present various conformations (Atyeo & Braasch 1966; Gaud & Atyeo 1996; Mironov 2012; Klimov *et al.* 2017).

Currently, only nine species and one subspecies of *Proctophyllodes* from passerine birds in China were recorded (Wang & Fan 2010; Wang *et al.* 2014). In the present paper, two new species of *Proctophyllodes* are described with material collected from passerines birds in China.

Materials and methods

The material used in this study was collected from birds in Qinghai Province, China. Birds were captured by mist-nets, under the condition of not affecting the flight of birds, a few feathers with feather mites were cut off and stored in 96% alcohol, and the birds were subsequently released to the wild after identifying the species. A part of mites was picked up by means of a flattened needle or pincers and soaked in lactic acid for two weeks, and then slides were mounted with Hoyer's medium (Krantz & Walter 2009).

Specimens were observed with a Leica DM 2500 light microscope, and drawings were made with a camera lucida connected with this microscope, and inked with Photoshop.

Specimens for SEM observing were removed from alcohol and allowed to be dried, then sputter-coated with Leica EM SCD050. Microscopy was performed on a FEI Quanta 450.

The description of new species and measuring technique follow the modern standards used for proctophyllodine mites (Mironov 2012). General morphological terms, leg and idiosomal chaetotaxy follow Gaud & Atyeo (1996), with the coxal setae proposed by Norton (1998). All measurements are given in micrometers (μm). The full set of measurements for holotype and a range of measurements for corresponding paratypes were given in brackets. Latin names of birds and supraspecific classification of hosts followed by Zheng (2017).

Type specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences (IZAS).

Taxonomy

Family Proctophyllodidae

Subfamily Proctophyllodinae

Genus *Proctophyllodes*

Proctophyllodes scleroticus sp. nov. (Figs. 1–5)

Type-host: Brandt's Mountain Finch *Leucosticte brandti pallidior* (Passeriformes: Fringillidae).

Type-locality: Liuhuanggou (37°46'35"N, 101°21'17"E, 3840 m), Menyuan County, Qinghai Province, China.

Type-material: Holotype: male (IZAS-ZY-19-02601), 14.VIII.2019, coll. Ying Zhang. Paratypes: six males and 12 females (IZAS-ZY-19-02602–02619), same data as the holotype. Holotype and paratypes are all mounted in slides.

Etymology: The species is named according to the genital sheath heavily sclerotized.

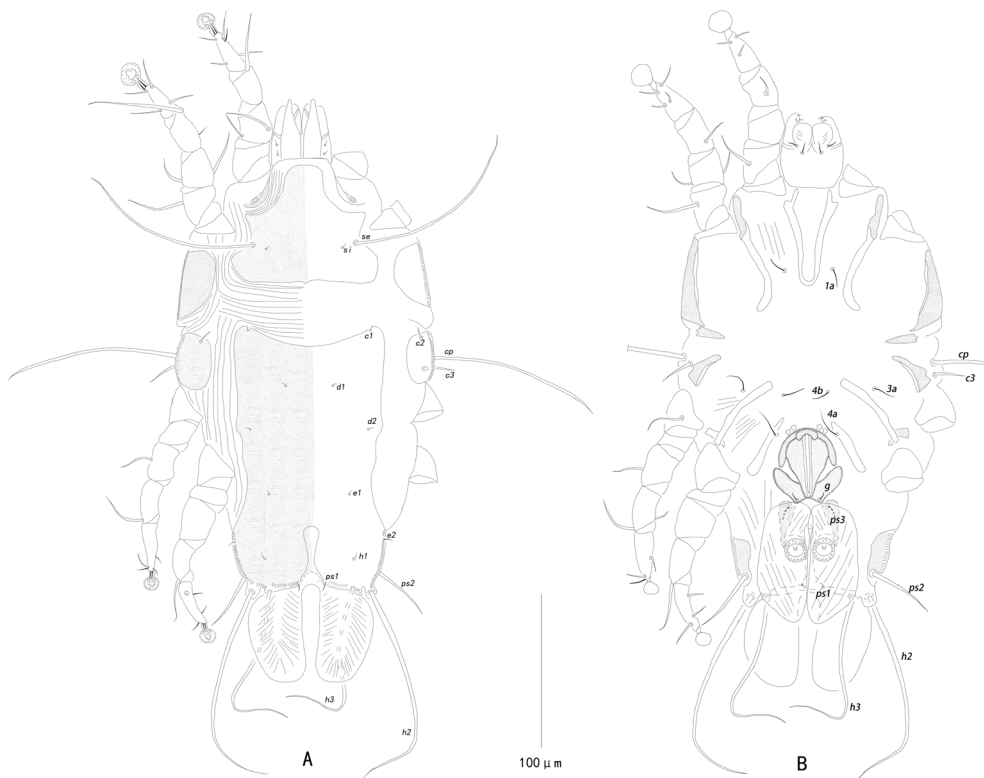


FIGURE 1. *Proctophylloides scleroticus* sp. nov., male. A—dorsal view, B—ventral view.

Description

Male [Based on the holotype and six paratypes.]. Idiosoma, 300 (290–310)×152 (152–175), length of hysterosoma 183 (168–187). Prodorsal shield: antero-lateral extensions obtuse angled, lateral margins entire, posterior margin slightly convex with minute median extension, posterior angles roughly rectangular, greatest length 75 (73–78), greatest width 92 (92–100), surface without ornamentation. Distance between bases of scapular setae *se* 74 (70–75). Scapular shields wide. Humeral shields well developed, not fused with epimerites III, not encompassing base of seta *cp*. Setae *c2* situated near anterior margin of humeral shields. Subhumeral setae *c3* lanceolate, 15 (15–20) in length and about 2 wide. Hysteronotal shield: length 190 (175–190), width at anterior margin 80 (80–100), surface without ornamentation. Anterior margin concave, anterior angles rounded. Supranal concavity open terminally, anterior end extending beyond level of setae *e2*, length from anterior end to base of seta *ps1* 38 (30–40). Posterior margin of opisthosoma between setae *h2* convex. Terminal lamellae big, oblong, with pennate venation; length of lamellae 70 (55–75), greatest width 43 (38–50). Distance between bases of lamellae 7 (5–7). Setae *ps1* minute. Distances between hysteronotal setae: *c2:d2* 57 (55–63), *d2:e2* 86 (70–87), *e2:h3* 32 (30–33), *d1:d2* 35 (30–35), *e1:e2* 25 (25–30), *h1:h3* 15 (15–20), *h2:h2* 74 (70–85), *h3:h3* 57 (50–60), *ps2:ps2* 90 (85–95).

Epimerites I fused into a narrow “U”, without lateral extensions. Setae *4a* located below epimerites IVa, *4b* situated behind inner tips of epimerites IIIa. Genital arch strongly curved and wide, 25 (20–25) in length, 40 (35–40) in width. Aedeagus short and thin wrapped in genital sheath, 30 (25–35) in length, with heavily sclerotized cyclic annular at base, genital sheath heavily sclerotized and peach shaped, extending to level of setae *g*. Genital arch crescent moon shaped. Opisthogastric shields fragmented into three shields of which anterior shield connects tips of genital arch and bears setae *g*,

posteriorly two leaf-shaped shields widely separated from each other, each bearing one seta *ps3*. Anal suckers cylindrical, 20 (20–23) in length, 18 (13–18) in width (at base), corolla with 14–20 small teeth. Anal suckers surrounded with a pair of membranes, which anterior margin extending to setae *g*, posterior exceeding setae *ps1*. Setae *g* and *ps3* situated on opisthogastric shields, slightly thickened basally, their bases arranged in low trapezium; distances between these setae: *g:g* 15 (15–20), *g:ps3* 6 (5–7), *ps3:ps3* 30 (27–35). Distance from genital arch apex to setae *ps1* 102 (93–102).

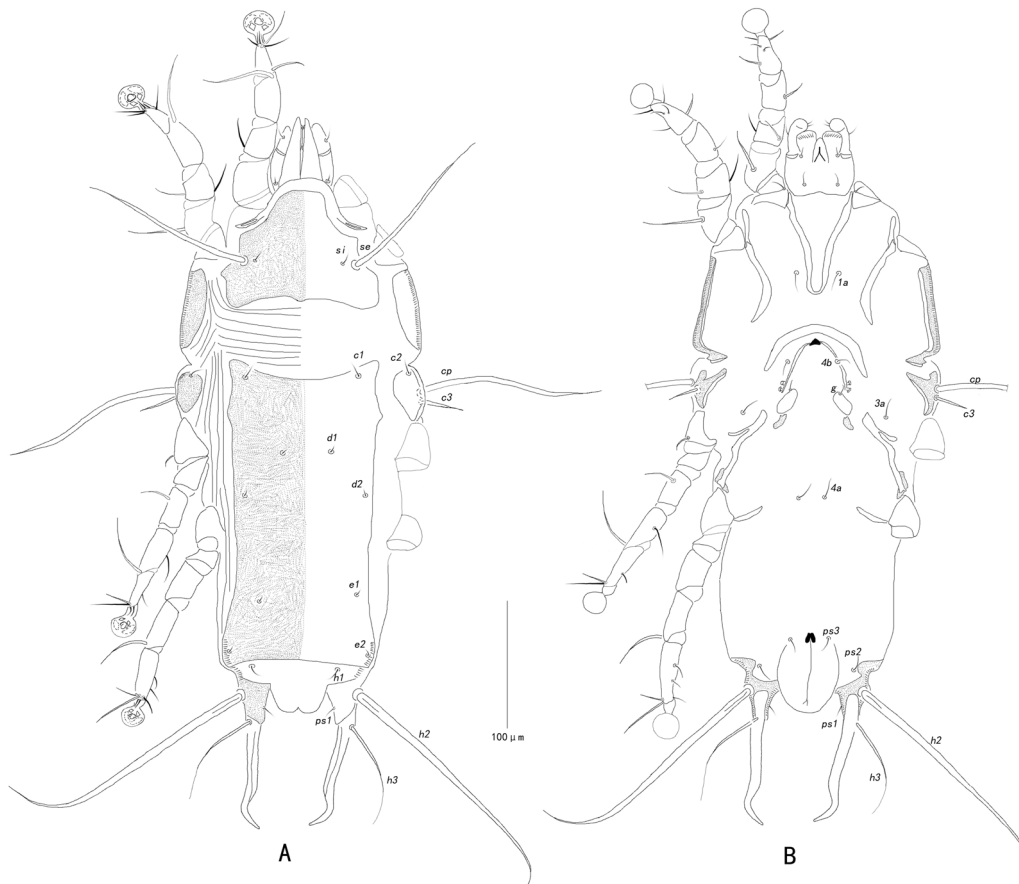


FIGURE 2. *Proctophyllodes scleroticus* sp. nov., female. A—dorsal view, B—ventral view.

Femora I, II without noticeable ventral crests. Genual solenidia σ I and σ III situated at midlevel of corresponding segment; tarsus IV 25 (25–30) long, setae *d* button-like and situated at the front half of this segment. Length of solenidia: σ I 25 (23–28), σ III 15 (13–18), ϕ IV 38 (32–38).

Female [Based on 12 paratypes.]. Length of idiosoma 388×420, width 170×190, length of hysterosoma 240–265. Prodorsal shield shaped as in males, length 85–100, width 110–122. Distance between scapular seta *se* 73–87. Scapular shields wide. Humeral shields not fused with epimerites III, not encompassing base of seta *cp*. Setae *c2* situated just behind anterior margin of humeral shield. Setae *c3* lanceolate, 18–22 long. Lobar region of opisthosoma distinctly separated from remaining part of hysterosoma, hysteronotal shield split into anterior and lobar parts by narrow transverse furrow. Anterior hysteronotal shield roughly rectangular, 210–225 in length, 93–110 in width, with anterior margin shallowly concave, and posterior margin approximately straight and slightly convex upward, surface without ornamentation. Lobar shield divided into two independent shield by anal opening, and anal opening extending beyond to level of setae *ps1*. Setae *h1* on narrow band of soft

tegument between anterior hysteronotal and lobar shields. Setae *h2* whip-shaped, monotonously attenuate to filiform apex, 165–195 long; setae *h3* filiform, 80–110 long, about the same length of terminal appendages (90–110). Distance between dorsal setae: *c2:d2* 80–90, *d2:e2* 107–115, *e2:h2* 30–37, *h2:h3* 15–20, *d1:d2* 28–35, *e1:e2* 38–40, *h1:h2* 15–20, *h2:ps1* 10–12, *h1:h1* 38–45, *h2:h2* 75–85.

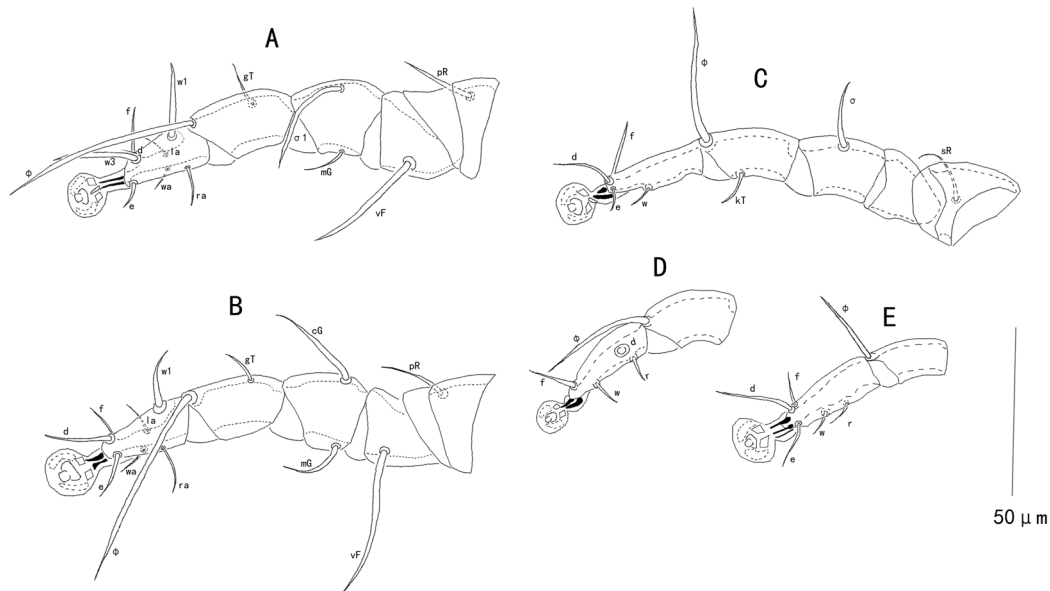


FIGURE 3. *Proctophyllodes scleroticus* sp. nov. Details. A–C—legs I–III of male, respectively, D—tibia and tarsus IV of male, E—tibia and tarsus IV of female.

Epimerites I shaped as in males. Epigynum short, nearly semicircular, tips extending posteriorly not to level of genital papillae, lateral extensions not developed, length 70–75, width 25–35. Copulatory opening situated immediately posterior to anal opening and covered with posterior ends of anal flaps. Setae *ps2* situated at level of posterior half of anal opening and widely separated from each other; distance between pseudanal setae: *ps2:ps2* 65–75, *ps3:ps3* 25–30, *ps2:ps3* 16–22. Genual solenidium σ III situated as in male. Solenidium ϕ of tibia IV similar in 2/3 length to tarsus IV. Length of genual solenidia: σ I 28–32, σ III 20–25.

Remarks

Proctophyllodes scleroticus sp. nov. belongs to the *tricetratus* species-group of which males are mainly characterized by having short genital organ and the reduced sclerotization of the opisthogastric region. The new species is most similar to *P. petroniae* Atyeo & Braasch, 1966 from *Petronia superciliaris* (Ploceidae) by having the following characters in males: genital discs separated, genital arch extending to anterior trochanter margin of leg IV, genital organ extending to level of anterior opisthogastric setae, opisthogastric setae locations in trapezoidal arrangement; opisthogastric shields fragmented into three shields of which anterior shield connecting tips of genital arch and bearing anterior pair of opisthogastric setae, and posteriorly two small shields each bearing one opisthogastric seta, terminal lamellae oblong. The diagnosis for distinguishing these two species are as follows: in *Proctophyllodes scleroticus* sp. nov., genital sheath heavily sclerotized and peach shaped, anal suckers surrounded with a pair of membranes, terminal lamellae much greater, 55–75 in length, 38–50 in width in male, lobar shield divided into two independent shield by anal opening, anal opening extending beyond to level of setae *ps1*, terminal appendages 90–110 in length

in female, while in *P. petroniae*, genital sheath sword shaped and completely enveloping the aedeagus, anal suckers without membranes surrounded, terminal lamellae relatively small, 29 in length, 15 in width in male, lobar shield slightly connected, anal opening extending to the anterior margin of lobar region cleft, and without terminal appendages in female.

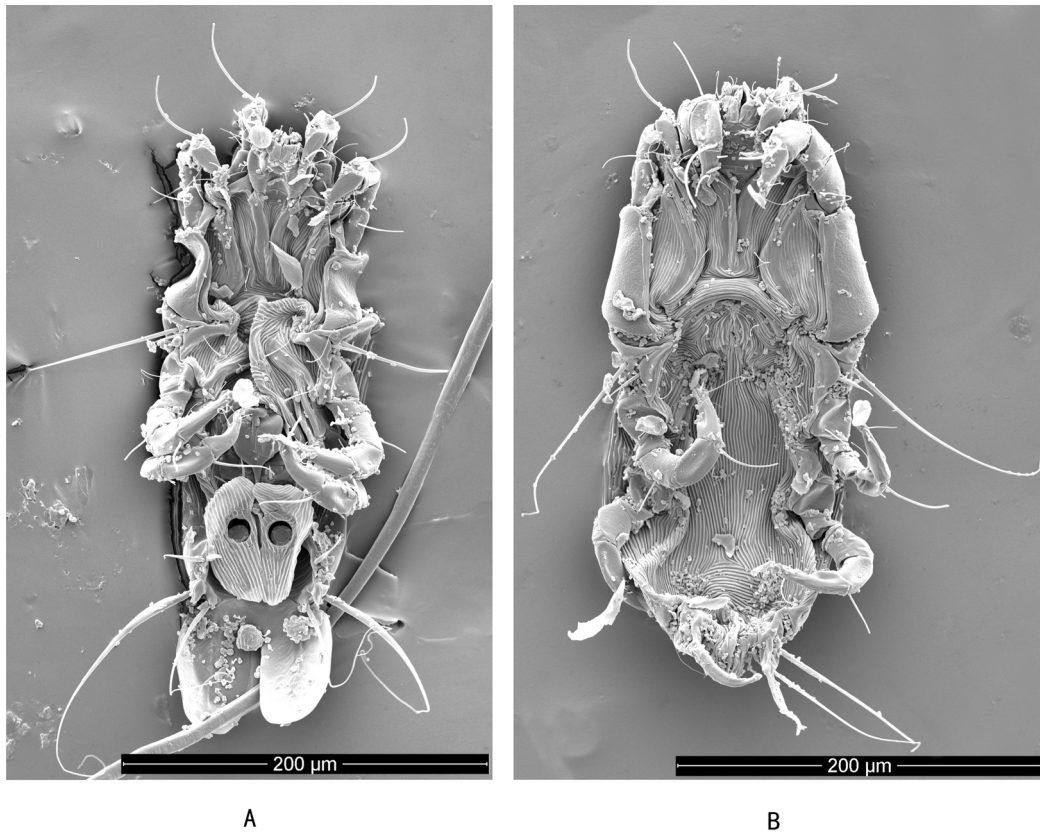


FIGURE 4. *Proctophyllodes scleroticus* sp. nov., SEM photo, ventral view, A—male, B—female.

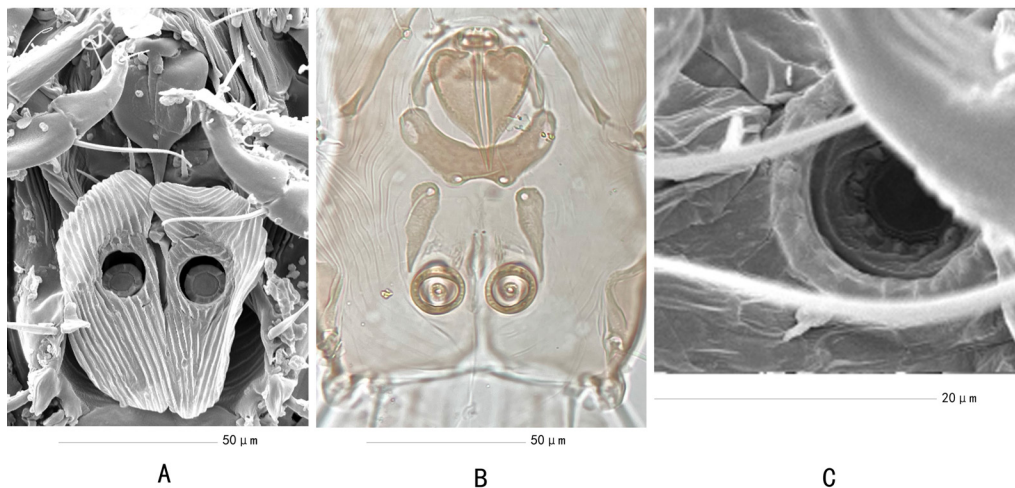


FIGURE 5. *Proctophyllodes scleroticus* sp. nov., male, ventral view, A—SEM photo, opisthosoma, B—Microscope photo, opisthosoma, C—SEM photo, anal sucker.

***Proctophyllodes micrurus* sp. nov.** (Figs. 6–10)

Type-host: White-rumped Snow Finch *Onychostruthus taczanowskii* (Passeriformes: Passeridae).

Type-locality: Liuhuanggou (37°46'38"N, 101°21'3"E, 3810 m), Menyuan County, Qinghai Province, China.

Type-material: Holotype: male (IZAS-ZY-20-01001), 27.VII.2020, coll. Ying Zhang. Paratypes: six males and eight females (IZAS-ZY-20-01002~01015), same data as the holotype.

Holotype and paratypes are all mounted in slides.

Etymology: The species is named according to the small terminal appendages in female.

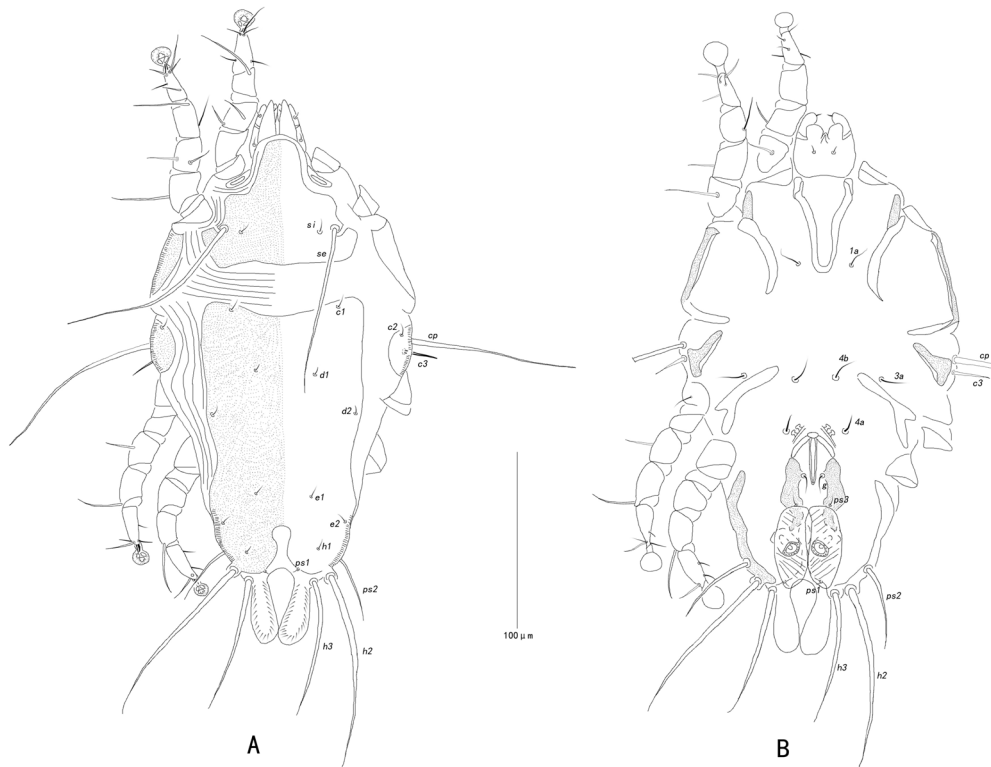


FIGURE 6. *Proctophyllodes micrurus* sp. nov., male. A—dorsal view, B—ventral view.

Description

Male [Based on holotype and six paratypes.]. Idiosoma, 250 (238–258) × 150 (148–155), length of hysterosoma 163 (155–167). Prodorsal shield: lateral margins entire; with a lacunae beside setae *se*, greatest length 65 (65–70), greatest width 88 (75–90), surface without ornamentation. Distance between bases of scapular setae *se* 62 (58–63). Scapular shields wide. Humeral shields well developed, not fused with epimerites III, not encompassing base of seta *cp*. Setae *c2* situated behind anterior margin of humeral shields. Setae *c3* lanceolate, 20 (15–20) long, about 2 wide. Hysteronotal shield: anterior margin slightly concave, anterior angle rounded, length 160 (145–160), width at anterior margin 80 (80–90), surface without ornamentation. Supranal concavity open terminally, anterior end extending above middle of setae *h1* and *e2*, length from anterior end to base of seta *ps1* 25 (20–25). Posterior margin of opisthosoma between setae *h2* convex. Terminal lamellae relatively short, long oblong, not overlapping, with pennate venation; length of lamellae 42 (38–45), greatest width 16 (15–22). Setae *ps1* minute. Distance between dorsal setae: *c2*:*d2* 60 (45–60), *d2*:*e2* 50 (50–

65), $e2:h3$ 42 (30–42), $d1:d2$ 25 (23–30), $e1:e2$ 8 (8–13), $h1:h3$ 15 (13–15), $h2:h3$ 60 (55–65), $h3:h3$ 41 (38–45), $ps2:ps2$ 72 (65–75).

Epimerites I fused into a narrow “U”, without lateral extensions. Setae $4b$ situated at level of inner tips of epimerites IIIa. Genital arch well developed, 30 (20–30) in length, 20 (20–25) in width. Aedeagus wrapped in genital sheath, 25 (25–32) in length, setae $4a$ situated at anterior margin of genital arch and above epimerites IVa. Opisthogastric shield represented by a pair of long longitudinal sclerites widely separated from each other. Anal suckers cylindrical, 7 (7–12) in length, 10 (10–12) in width, corolla with 14–16 small teeth. Anal suckers surrounded with a pair of membranes, which anterior margin extending to setae $ps3$, posterior exceeding setae $ps1$. Setae g and $ps3$ situated on opisthogastric shields, their bases arranged in trapezium; distances between these setae: $g:g$ 12 (10–12), $g:ps3$ 18 (15–20), $ps3:ps3$ 25 (25–30). Distance from genital arch apex to setae $ps1$ 85 (80–95).

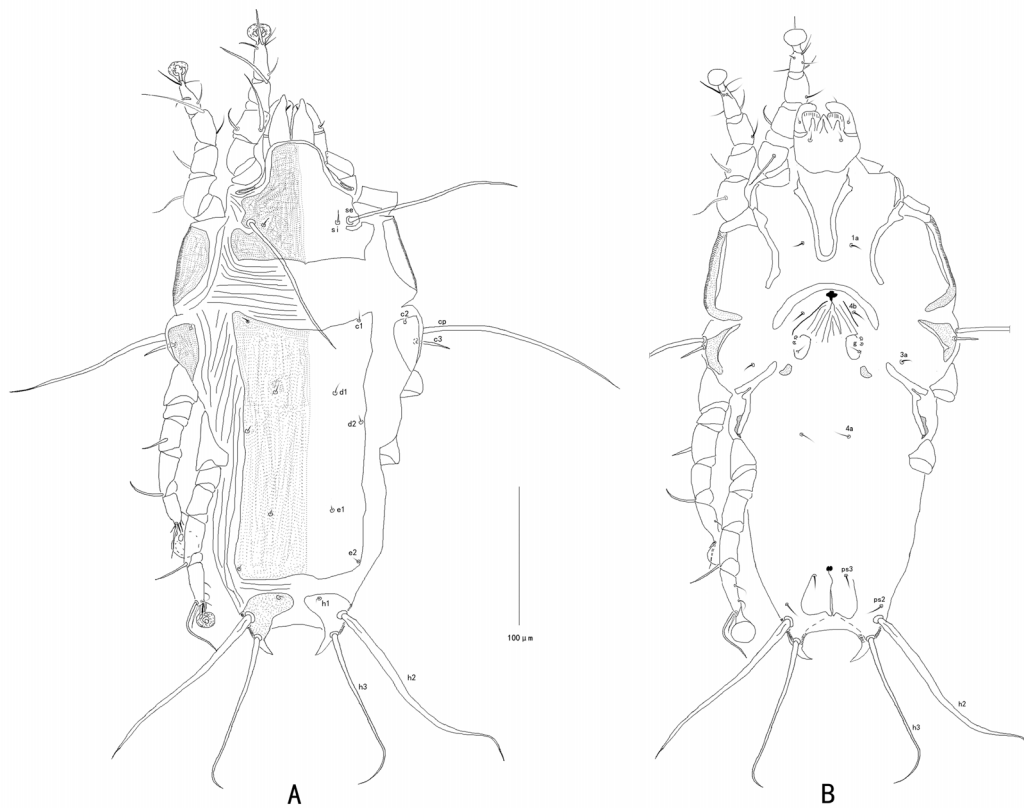


FIGURE 7. *Proctophyllodes micrurus* sp. nov., female. A—dorsal view, B—ventral view.

Femora I, II without noticeable ventral crests. Genual solenidia σ I and σ III situated at midlevel of corresponding segment. Tarsus IV 25 (25–30) long. Length of solenidia: σ I 20 (15–20), σ III 8 (8–13), ϕ IV 30 (30–40).

Female [Based on eight paratypes.]. Length of idiosoma 365–385, width 185–187, length of hysterosoma 230–240. Prodorsal shield shaped as in males, length 90–95, width 105–120. Distance between scapular setae se 75–85. Scapular shields wide. Humeral shield not fused with epimerites III, not encompassing base of seta cp . Setae $c2$ situated behind anterior margin of humeral shields. Setae $c3$ lanceolate, 23–28 long. Lobar region of opisthosoma distinctly separated from remaining part of hysterosoma, hysteronotal shield split into anterior and lobar parts by narrow transverse

furrow. Anterior hysteronotal shield roughly rectangular, 190–205 in length, 85–95 in width, with anterior margin shallowly concave, and posterior margin slightly convex, surface without ornamentation. Lobar shields medially divided into two halves, terminal appendages very small, 10–15 in length, about 1/10 of setae *h3*. Setae *h1* on edge of the lobar shield. Setae *h2* whip-shaped, monotonously attenuate to filiform apex, 150–190 long; setae *h3* filiform, 125–175 long. Distance between dorsal setae: *c2:d2* 75–80 *d2:e2* 100–105, *e2:h2* 30–37, *h2:h3* 12–15, *d1:d2* 25–33, *e1:e2* 30–38, *h1:h2* 10–15, *h1:h1* 28–35, *h2:h2* 62–65.

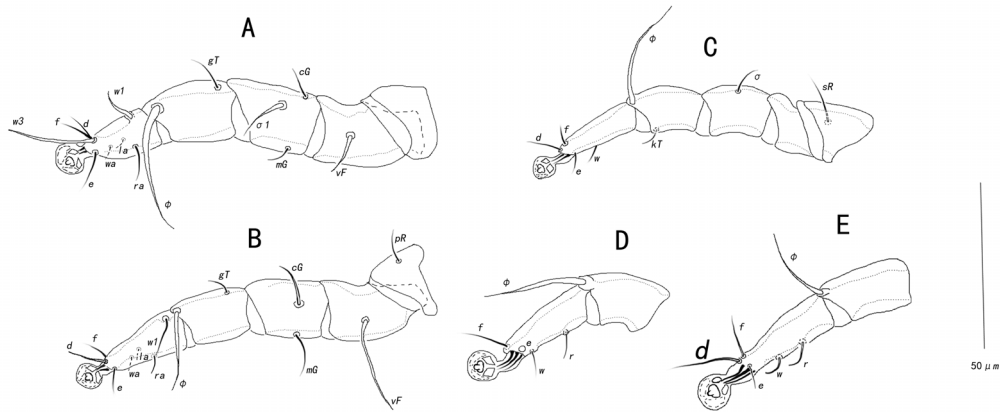


FIGURE 8. *Proctophylloides micrurus* sp. nov. Details. A–C—legs I–III of male, respectively, D—tibia and tarsus IV of male, E—tibiae and tarsi IV of female.

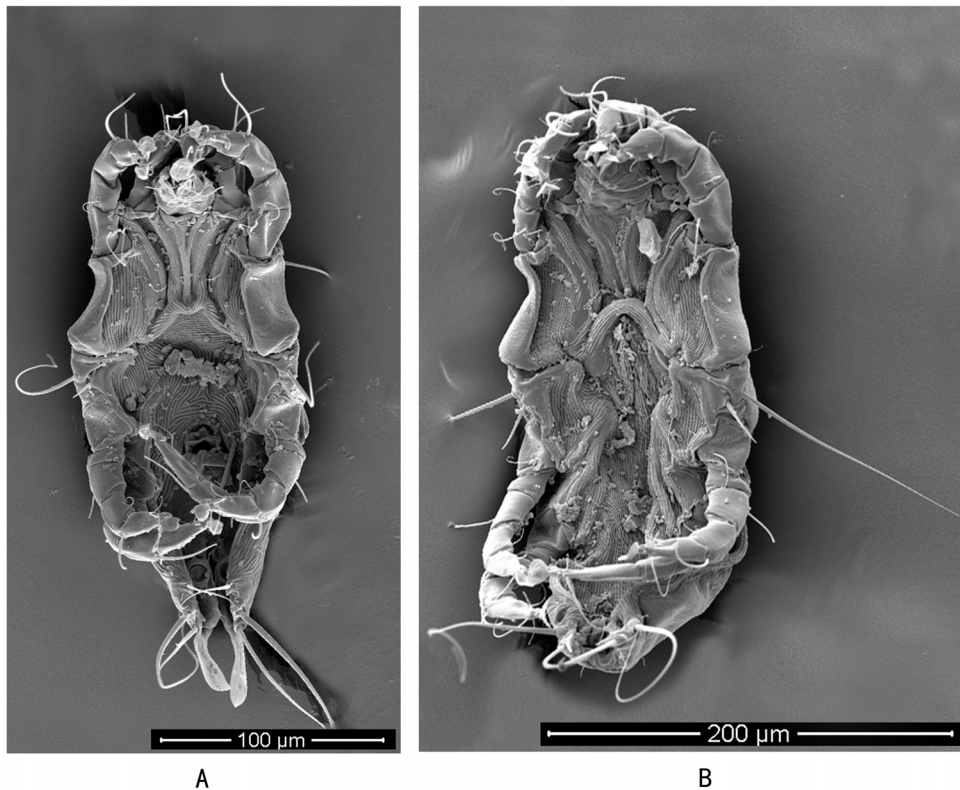


FIGURE 9. *Proctophylloides micrurus* sp. nov., SEM photo, ventral view, A—male, B—female.

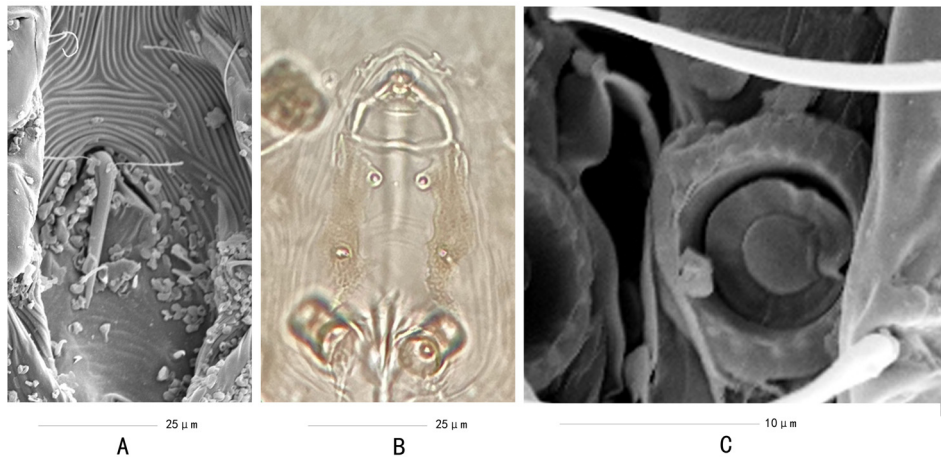


FIGURE 10. *Proctophyllodes micrurus* **sp. nov.**, male, ventral view, A—SEM photo, aedeagus, B—Microscope photo, opisthosoma, C—SEM photo, anal sucker.

Epimerites I shaped as in males. Epigynum thick, nearly semicircular, tips not extending to level of genital papillae, lateral extensions not developed, length 65–75, width 25–30. Copulatory opening situated immediately posterior to anal opening. Setae *ps2* situated at level of posterior half of anal opening and widely separated from each other; distance between pseudanal setae: *ps2:ps2* 50–56, *ps3:ps3* 16–20, *ps2:ps3* 15–20. Genual solenidion σ III situated as in male. Solenidion ϕ of tibia IV similar in length to tarsus IV. Length of solenidia: σ I 30–35, σ III 15–20, ϕ III 35–45, ϕ IV 30–38.

Remarks

Proctophyllodes micrurus **sp. nov.** belongs to the *musicus* species-group which males are mainly characterized by having divided or weakly connected opisthogastric shields. Within this group, the new species is close to *P. saltatoris* Atyeo & Braasch, 1966 from *Saltator coerulescens* (Fringillidae) (type-host) and *Saltator maximus* (Fringillidae) by having the following characters: opisthogastric shields separated by less than 10µm, and genital discs joined in males; lobar region incompletely fused with anterior shield in females. The diagnosis for distinguishing these two species are as follows: in *Proctophyllodes micrurus* **sp. nov.**, genital arch and anterior part of opisthogastric shield with about the same width, genital organ extending to the anterior 1/3 level of setae *g* and setae *ps3*, anal suckers surrounded with a pair of membranes, terminal lamellae slightly greater, 38–45 in length, 15–22 in width in male, lobar region 25–32 in length and with two separate shields, terminal appendages very small, 10–15 in length, about 1/10 of setae *h3*, edge of the cleft almost horizontal in female, while in *P. saltatoris*, genital arch about 2/3 of the anterior margin width of opisthogastric shield, genital organ extending slightly beyond setae *g*, anal suckers without membranes surrounded, terminal lamellae 22 in length, 10 in width in male, lobar region 39 in length, lobar shield entire, lobes short, cleft arched, setae *h3* 1/2 length of terminal appendages in female.

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References

- Atyeo, W.T. & Braasch, N.L. (1966) The feather mite genus *Proctophyllodes* (Sarcoptiformes: Proctophyllodidae). *Bulletin of the University of Nebraska State Museum*, 5, 1–354.
- Dabert, J. & Mironov, S.V. (1999) Origin and evolution of feather mites (Astigmata). *Experimental and Applied Acarology*, 23, 437–454.
<https://doi.org/10.1023/A:1006180705101>
- Gaud, J. & Atyeo, W.T. (1996) Feather mites of the world (Acarina, Astigmata): the supraspecific taxa. *Annales du Musée Royal de l'Afrique Centrale, Sciences Zoologiques*, 277(Part 1 & 2), 1–193 (text) & 1–436 (illustrations).
- Klimov, P.B., Mironov, S.V. & OConnor, B.M. (2017) Convergent and unidirectional evolution of extremely long aedeagi in the largest feather mite genus, *Proctophyllodes* (Acari: Proctophyllodidae): evidence from comparative molecular and morphological phylogenetics. *Molecular Phylogenetics and Evolution*, 114, 212–224.
<https://doi.org/10.1016/j.ympev.2017.06.008>
- Krantz, G. & Walter, D. (2009) *A Manual of Acarology (3rd edition)*. Lubbock, Texas Tech University Press, 807 pp.
- Mironov, S.V. (2012) New species of the feather mite genus *Proctophyllodes* Robin, 1877 (Acari: Analgoidea: Proctophyllodidae) from European passerines (Aves: Passeriformes), with an updated checklist of the genus. *Acarina*, 20, 130–158.
- Mironov, S.V. (2019) Two new feather mites of the genus *Proctophyllodes* Robin, 1868 (Acari: Proctophyllodidae) associated with passerines (Aves: Passeriformes) in the Russian Far East. *Acarina*, 27(2), 151–164.
<https://doi.org/10.21684/0132-8077-2019-27-2-151-164>
- Norton, R.A. (1998) Morphological evidence for the evolutionary origin of Astigmata (Acari: Acariformes). *Experimental and Applied Acarology*, 22, 559–594.
<https://doi.org/10.1023/A:1006135509248>
- Pedroso, L.G.A. & Hernandez, F.A. (2021) Two new feather mites of the genus *Proctophyllodes* Robin (Acari: Proctophyllodidae) from passerines in Brazil. *Systematic & Applied Acarology*, 26(6), 1081–1096.
<https://doi.org/10.11158/saa.26.6.6>
- Wang, Z.Y. & Fan, Q.H. (2010) Psoroptidia (Acari: Astigmatina) of China: a review of research and progress. *Zoosymposia*, 4, 260–271.
<https://doi.org/10.11646/zoosymposia.4.1.16>
- Wang, Z.Y., Wang, J.J. & Su, X.H. (2014) Four new feather mite species of the genus *Proctophyllodes* Robin (Astigmata: Proctophyllodidae) from China. *Zoological Systematics*, 39, 248–258.
- Zheng, G. (2017) *A Checklist on the Classification and Distribution of the Birds of China (Third Edition)*. Beijing, The Science Publishing Company, 492 pp.

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