

ORIGINAL ARTICLE

Four new feather mite species of the genus *Proctophyllodes* Robin (Astigmata: Proctophyllodidae) from China

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Abstract Four new species of the feather mite genus *Proctophyllodes* are described from the birds of the order Passeriformes in China: *P. flexuosa* **sp. nov.** from *Eophona migratoria* Hartert (Chongqing), *P. brevis* **sp. nov.** from *Passer montanus* (Linnaeus) (Anhui and Chongqing), *P. garrula* **sp. nov.** from *Garrulax poecilorhynchus* Gould (Anhui), *P. canora* **sp. nov.** from *Garrulax canorus* (Linnaeus) (Guizhou).

Key words Astigmata, feather mites, *Proctophyllodes*, new species, China.

1 Introduction

Feather mites are ectoparasitic or commensal mites which live on almost all recent orders of birds. They occur on flight feathers and large coverts of the wings, sometimes in the down, layer and on the skin (Gaud and Atyeo, 1996; Dabert & Mironov, 1999; Mironov, 2003; Proctor, 2003). There are over 2500 known species in 450 genera of 34–38 families and 2 superfamilies (OConnor, 2009; Mironov and Proctor, 2011). *Proctophyllodes* Robin, 1877 (Astigmata: Analgoidea: Proctophyllodidae: Proctophyllodinae) is the largest genus of feather mites (Gaud and Atyeo, 1996) and contains about 159 species (Aty eo & Braasch, 1966; Gaud & Fain, 1990; Mironov & Kopij, 1996; Mironov & Galloway, 2002; OConnor, 2005; Badek *et al.*, 2008; Burdejnaja & Kivganov, 2009, 2011; Mironov *et al.*, 2012). These species are arranged into twelve species groups, of which ten groups were established by Atyeo and Braasch (1966), the other two groups were created by Gaud and Fain (1990), Mironov and Kopij (1996) respectively.

Mites of the genus *Proctophyllodes* were recorded from birds of the orders Anseriformes, Charadriiformes, Strigiformes, Apodiformes, Piciformes and Passeriformes (Aty eo & Braasch, 1966), but numerous species of *Proctophyllodes* are distributed on the birds of the order Passeriformes. Currently, only 5 species and 1 subspecies of *Proctophyllodes* from hosts of the order Passeriformes in China were recorded (Wang & Fan, 2010). In this paper, four new species of *Proctophyllodes* are described from passerines hosts.

2 Material and methods

The mites were cleared in lactic acid, slide-mounted in polyvinyl lactophenol medium, and dried for 4 days at 40°C. Drawings were made at 200× using a 1× drawing tube attached to an Olympus BX51 with differential interference contrast (DIC) lighting. All measurements were given in micrometres (µm). Idiosomal length was measured from the anterior margin of prodorsum to the posterior end of opisthosomal lobes. Widths of idiosoma and hysteronotal shields were

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measured at the level of setae *c2*. Width of prodorsal shield was measured at its widest part posterior to setae *se*. Distances between pairs of setae were taken from the centre of insertion. The measurements were given for the holotype male followed by the measurements range for paratypes.

The terminology of idiosoma and chaetotaxy follows Gaud and Atyeo (1996). Holotype (male) and paratypes are deposited in the Institute of Entomology, College of Plant Protection, Southwest University.

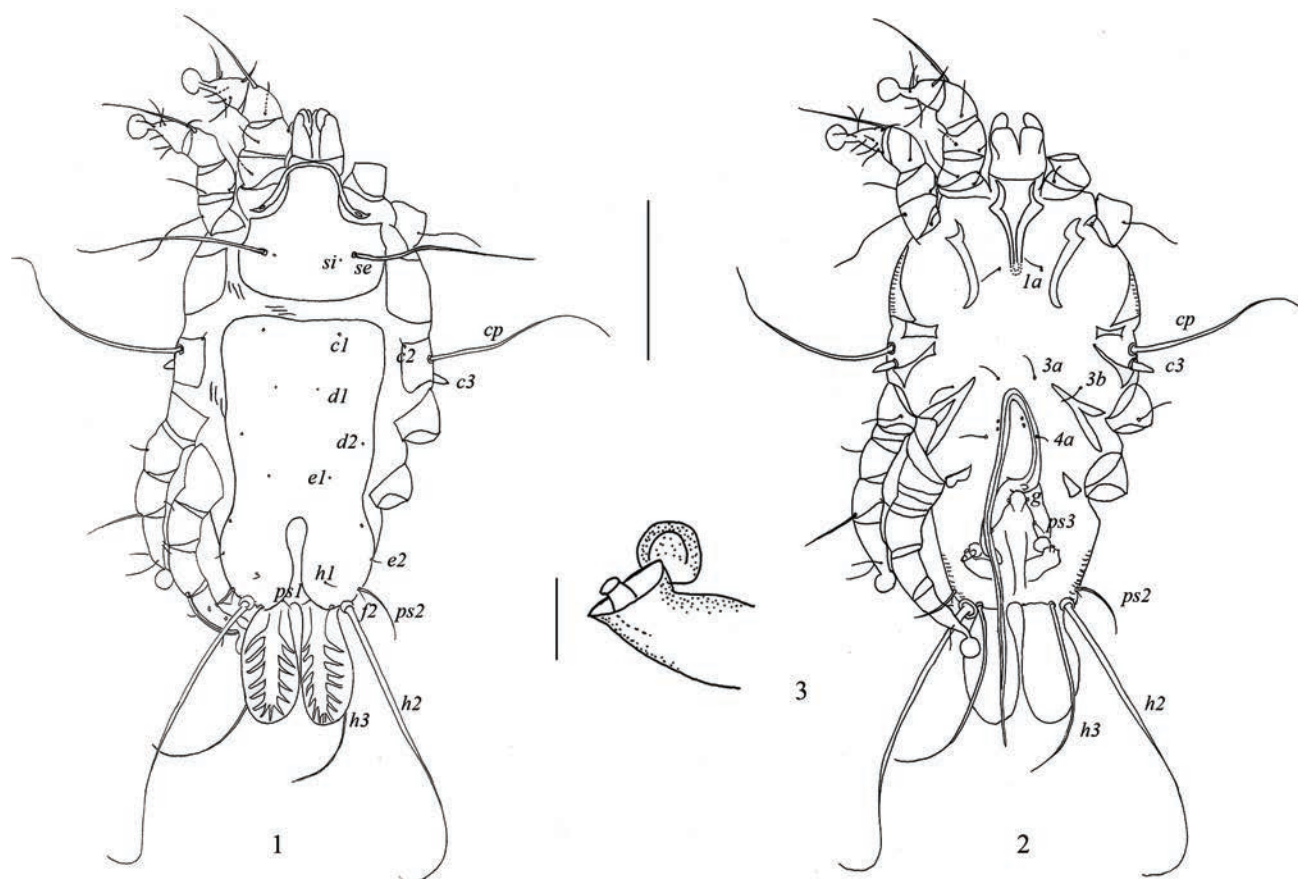
3 Taxonomy

Proctophyllodidae Mégnin & Trouessart, 1884

Proctophyllodes Robin, 1877

Proctophyllodes flexuosa sp. nov. (Figs 1–9)

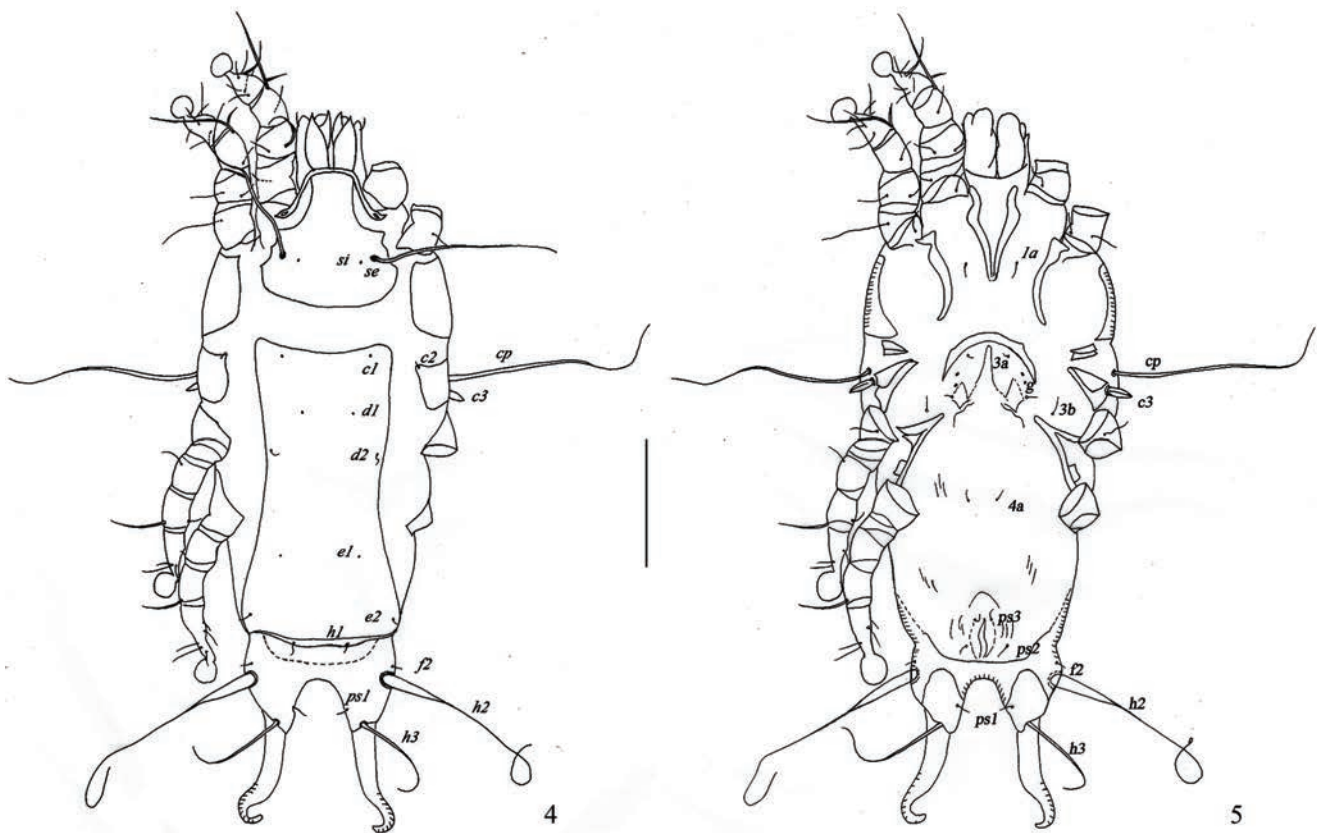
Holotype male, from *Eophona migratoria* Hartert (Passeriformes: Fringillidae), Beibei (29°48'N, 106°23'E), Chongqing, China, 22 August 2008, coll. Zi-Ying Wang. Paratypes 2 males and 6 females, same data as holotype.



Figs 1–3. *Proctophyllodes flexuosa* sp. nov., male. 1. Dorsal view. 2. Ventral view. 3. Anal sucker. Scale bars: 1–2 = 100 μ m, 3 = 10 μ m.

Male. Idiosoma length (not include lobar) 276 (271, 283), width 150 (105, 176). Prodorsal shield: greatest length 84 (72, 84), greatest width 86 (79, 86); Distances between scapular setae (*se-se*) 57 (57, 58); lateral margins entire. Setae *ve* absent. Scapular shields well developed. Setae *c2* in tip of humeral shield. Subhumeral setae *c3* lanceolate, 19 (18, 19) in length, 4.2 (4.1, 5.7) width. Hysteronotal shield length 177 (171, 177), width 105 (92, 105) at anterior margin, anterior

margin straight. Interval between prodorsal shields and hysteronotal shields 14.5 (14.5, 31.0). Supranal concavity opened from the posterior margin, anterior end extending beyond level of setae *e2*, and to midlevel between *e1* and *e2*. Terminal lamellae ovate, with pennate venation, length of lamellae 71 (67, 71), maximal width 36.6 (33.7, 35.8), not overlapping. Epimerites I fused into a narrow U with weak connection, without lateral extensions. Paragenital apodemes absent. Genital discs separate; genital arch in small size, reflexed to opisthosoma; aedeagus reflexing almost at level of setae *3a*, terminal beyond lamellae, full-length of aedeagus 280 (278, 280); genital sheath without distal bifurcation. Opisthogastric setae arranged in a trapezoid. Opisthogastric shield adjoining, bearing setae *g*, *ps3*, Opisthogastric shield with deep cleft at the level of setae *g*. Anal suckers cylindrical, 19.4 (15.5, 19.4) in length, 8.7 (7.8, 9.3) in width, with reniform accessory glands. Distances between hysteronotal setae: *c1-c1* 68 (64–68), *c1-d1* 14.9 (14.9, 27.8), *d1-d2* 21.2 (21.2, 35.1), *e1-e1* 27.8 (27.8, 40.8), *h1-h1* 50.8 (46.4, 51.7), *d2-e1* 70.4 (58.4, 70.4), *c2-d2* 39.2 (30.8, 40.1), *d2-e2* 97.0 (71, 90), *e1-h1* 30.9 (32.2, 40.7), *e2-h2* 37 (30, 37), *g-g* 12.6 (12.4, 15.7), *ps3-ps3* 25.2 (15.2, 30.3), *g-ps3* 12.5 (11.4, 12.5). Tarsus IV 34 (30, 32) long, seta *d* at near midlevel of this segment. Genual solenidion σ III situated at midlevel of segment. Length of genual solenidia: σ I 27 (29, 32), σ III 11 (13, 14).



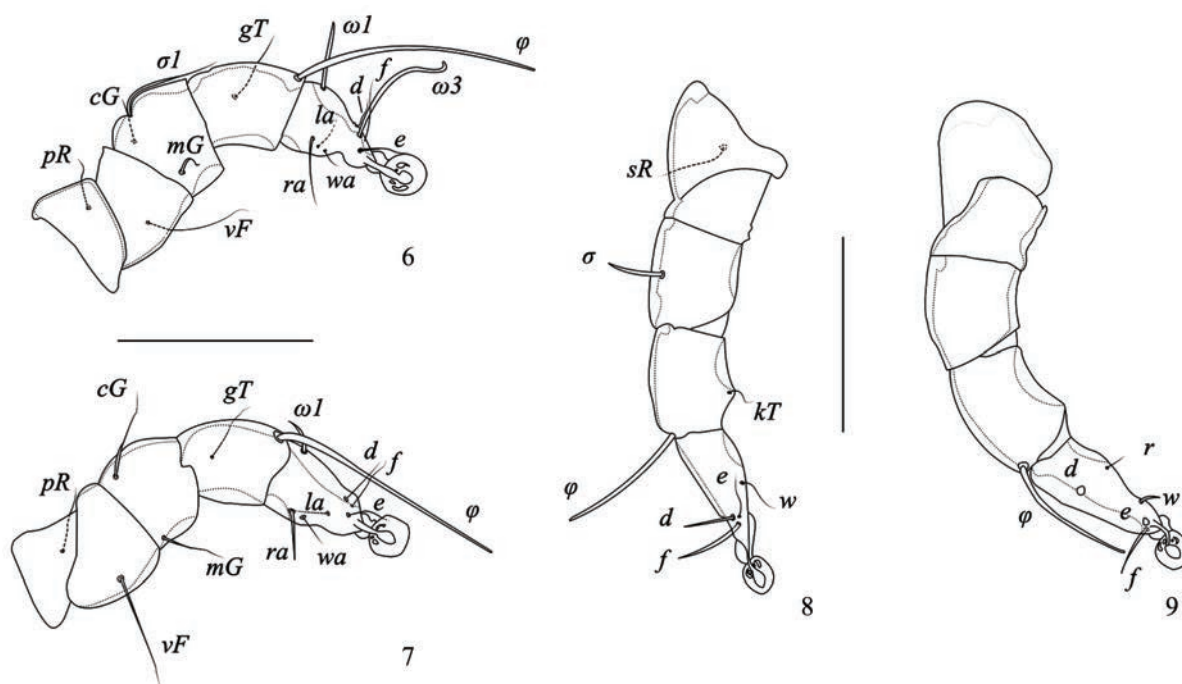
Figs 4–5. *Proctophyllodes flexuosa* sp. nov., female. 4. Dorsal view. 5. Ventral view. Scale bar = 100 μ m.

Female. Length of idiosoma 333–429, width 143–198. Prodorsal shield shaped as in males, length 80–102, width 96–108, setae *ve* absent. Distances between scapular setae (*se-se*) 41–78. The arrangement of *c1* and *c2* as in males. Subhumeral setae *c3* lanceolate, 18–24 in length, 6.3–6.9 in width. Hysterosoma shield large and roughly rectangular, with the lobar region, anterior margin shallowly concaved, greatest length 210–230, width at anterior margin 93–112. Interval between prodorsal and hysteronotal shields 29.2–38.8. Setae *h1* on anterior margin of lobar shield. Without supranal concavity. Opisthosomal lobes slightly attenuated apically, terminal cleft trapezoid shaped, parallel-sided, 36–39 in length, 33–44 in width. Epimerites I fused into a narrow U, without lateral extensions. Distance between dorsal setae: *c1-c1* 58–71, *c1-d1* 34–48, *d1-d2* 32–49, *e1-e2* 55–62, *h1-h1* 26–31, *d2-e1* 55–73, *c1-d2* 71–88, *d2-e2* 105–123, *e2-h2* 24–54. Genual solenidion σ III situated at posterior segment. Length of genual solenidia: σ I 33–40, σ III 12–15.

Diagnosis. The new species, *Proctophyllodes flexuosa* **sp. nov.**, belongs to the *glandarinus* species group, which have the aedeagus extending to or beyond the lamellar origins. *P. flexuosa* **sp. nov.** significantly differs from all other species of this group by the arched male genital, which bends towards opisthosoma and the folded aedeagus.

As for other features, the new species is close to *P. glandarinus* (Koch, 1841) from *Garrulus glandarius* (Linnaeus, 1758) (Corvidae). In the new species, however, the opisthogastric shield of the male is deeply concaved at the level of setae *g*, and the internal margins of the ovoid lamellae are not overlapping; in females, the lateral margins of propodosomal shield are entire. In males of *P. glandarinus*, the opisthogastric shield is shallowly concaved at the level of setae *g*, and the internal margins of the ovoid lamellae are overlapping; in females, the lateral margins of propodosomal shield are incised behind external scapular setae.

Etymology. The specific name, *flexuosa*, derives from *flexuosus* (flexural, Lat.), referring to the extraordinarily flexural aedeagus in male.



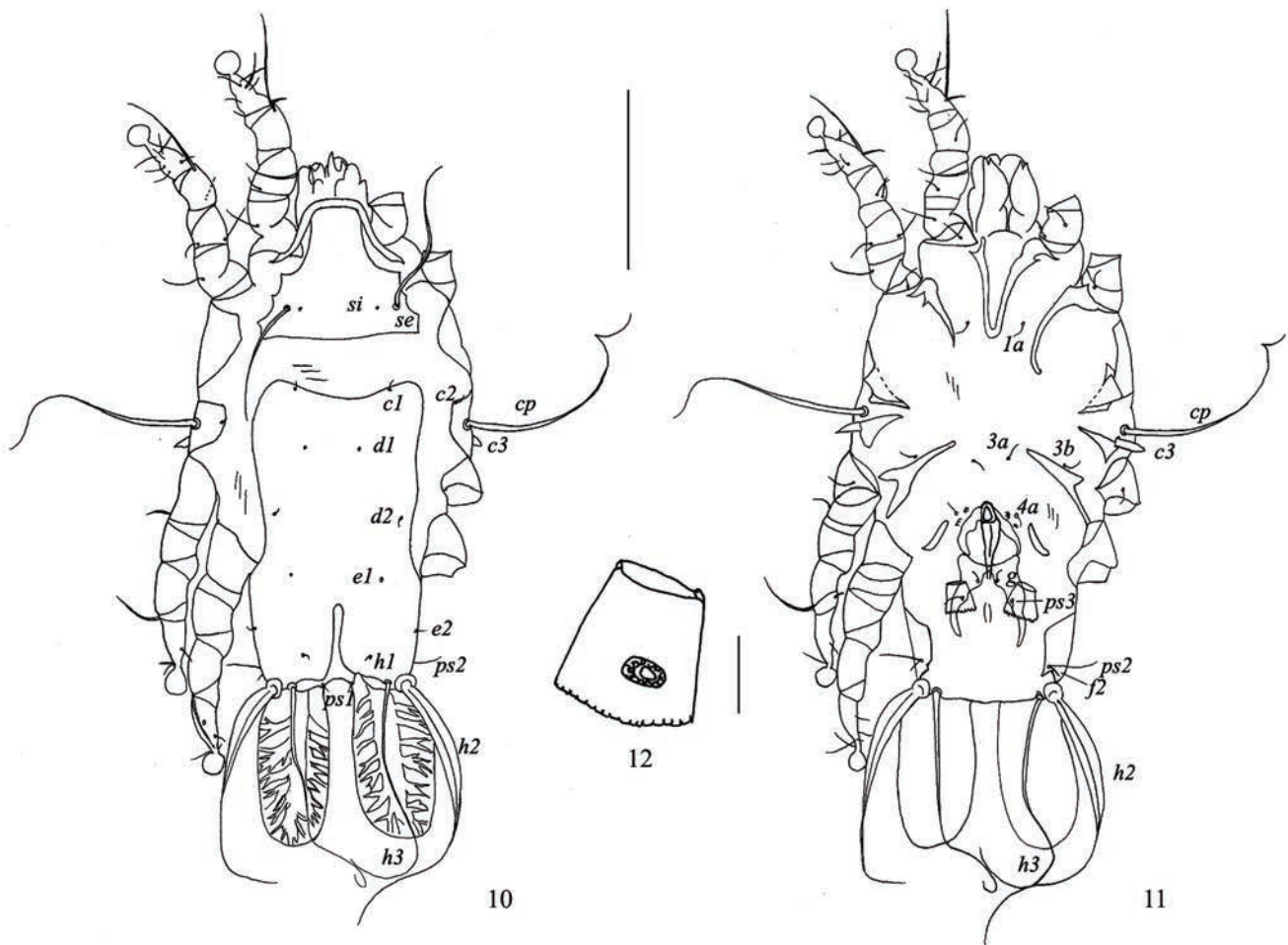
Figs 6–9. *Proctophyllodes flexuosa* **sp. nov.**, male. 6. Leg I. 7. Leg II. 8. Leg III. 9. Leg IV. Scale bars = 50 μ m.

***Proctophyllodes brevis* sp. nov.** (Figs 10–14, 25, 28)

Holotype male, from *Passer montanus* (Linnaeus) (Passeriformes: Passeridae), Beibei (29°49'N, 106°25'E), Chongqing, China, 17 May 2007, coll. Zi-Ying Wang. Paratypes 1 male and 2 females, same data as holotype; 2 males and 2 females from *Passer montanus* (Linnaeus) (Passeriformes: Passeridae), Huangshan (29°54'N, 117°43'E), Anhui, China, 24 May 2008, coll. Zi-Ying Wang.

Male. Idiosoma length (not include lobar) 276 (276–283), width 172 (167–168). Prodorsal shield greatest length 75 (72–81), greatest width 85 (81–95); distances between scapular setae (*se-se*) 64 (64–66); lateral margins entire. Setae *ve* absent. Scapular shields well developed. Setae *c2* in antero-mesal angle of humeral shield. Subhumeral setae *c3* lanceolate, 17.2 (14.6–15.8) in length, 4.3 (3.6–4.1) in width. Hysteronotal shield length 166 (163–167), width 94 (91–99) at anterior margin; posterior margin slightly concaved; posterior angles rounded. Interval between prodorsal and hysteronotal shield 40(29–31). Supranal concavity opened from the posterior margin, anterior end extending beyond the midlevel between *e1* and *e2*. Setae *h2* expanded at posterior parts, greatest width 9 (9–11). Terminal lamellae oblong, with pennate venation, length of lamellae 86 (80–84), maximal width 43 (37–40), not overlapping. Epimerites I fused into a narrow U with obvious connection, without lateral extensions. Paragenital apodemes absent. Genital arch advanced in size. Genital discs

separate. Aedeagus sword-shaped, with heavily sclerotized at the base, 42 (29–37) in length, not beyond setae *g*. Opisthogastric shield adjoining, in shape of H, bearing setae *g*, *ps3*, opisthogastric setae arranged in trapezoidal arrangement. Anal suckers cylindrical, 21(20–17) in length, 16(16–18) in width. Distances between hysteronotal setae: *c1-c1* 67(57–68), *c1-d1* 32(35–37), *d1-d2* 26(21–33), *e1-e1* 51(34–46), *h1-h1* 24(31–36), *d2-e1* 50(46–59), *c2-d2* 44(57–63), *d2-e2* 89(80–90), *e1-h1* 50(52–54), *e2-h2* 15(15–17), *g-g* 9.6(9.0–9.5), *ps3-ps3* 28(28–29), *g-ps3* 10(8.9–9.4). Tarsus IV 26(25–27) long, with ventral membrane, seta *d* near midlevel of this segment. Genual solenidion σ III situated at posterior segment. Length of genual solenidia: σ I 30 (29–32), σ III 9 (12–14).

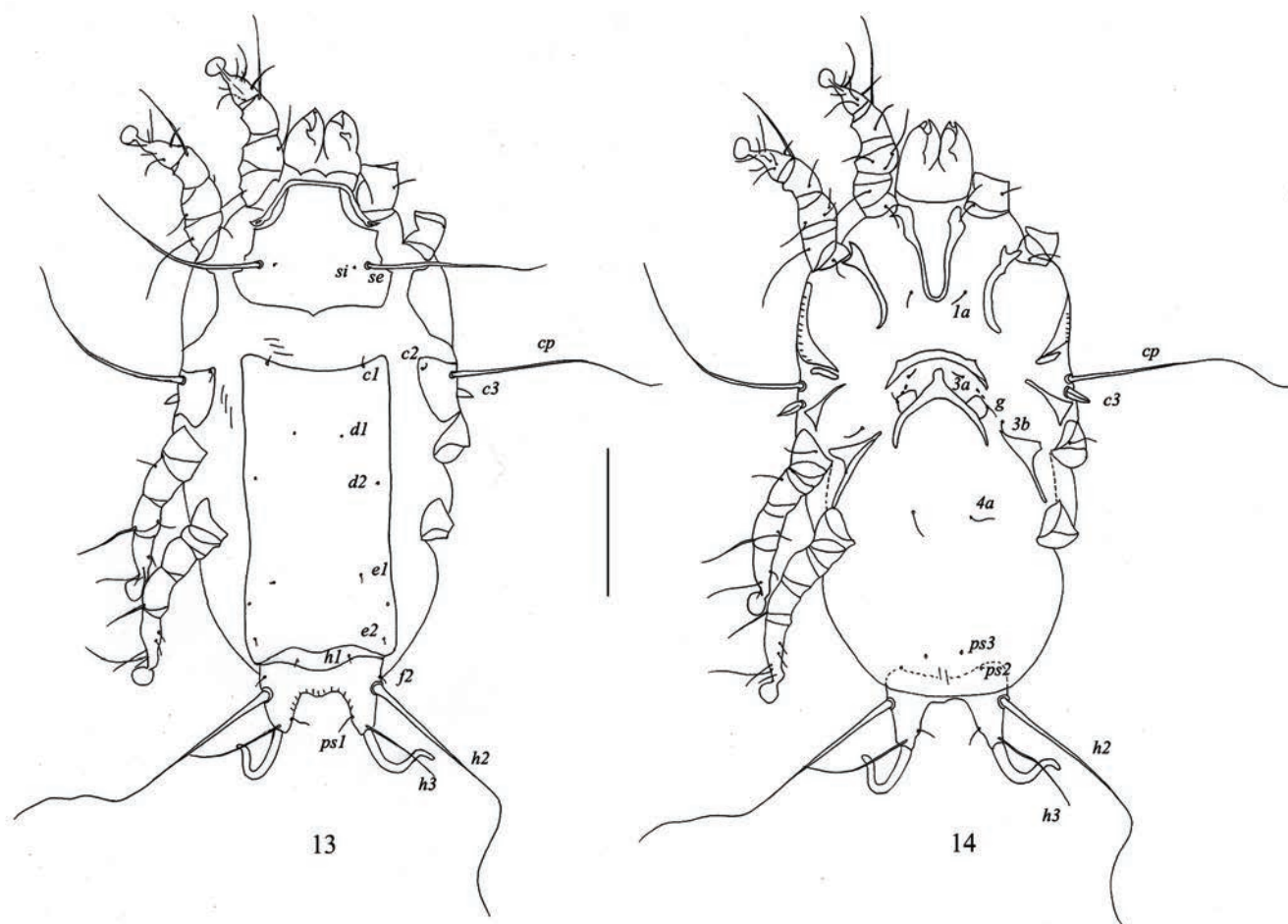


Figs 10–12. *Proctophyllodes brevis* sp. nov., male. 10. Dorsal view. 11. Ventral view. 12. Anal sucker. Scale bars: 10–11 = 100 μ m, 12 = 10 μ m.

Female. Length of idiosoma 335–389, width 178–190. Prodorsal shield without lacunae, 91–111 in length, 104–116 in width. Setae *ve* absent. Distances between scapular setae (*se-se*) 75–78. Scapular shields well developed. The arrangement of *c1* and *c2* as in males. Subhumeral setae *c3* lanceolate, 15–17 in length, 4.5–6.1 in width. Hysterosoma shield large and roughly rectangular, with lobar region, anterior margin shallowly concaved, greatest length 184–217, width 97–109 at anterior margin. Interval between prodorsal and hysteronotal shield 20–36. Setae *h1* on striated area. Without supranel concavity. Opisthosomal lobes slightly attenuate apically, terminal cleft trapezoid shaped, 33–37 in length, 35–46 in width. Epimerites I fused into a narrow U, without lateral extensions. Distance between dorsal setae: *c1-c1* 70–79, *c1-d1* 41–49, *d1-d2* 32–42, *e1-e2* 33–62, *h1-h1* 27–32, *d2-e1* 46–68, *c2-d2* 65–82, *d2-e2* 93–115, *e1-h1* 63–89, *e2-h2* 33–42. Genual solenidion σ III situated as in male. Length of genual solenidia: σ I 31–35, σ III 13–17.

Diagnosis. The new species, *Proctophyllodes brevis* **sp. nov.**, belongs to the *pinnatus* species group. In all of species of this group, the male pregenital apodeme is absent, the genital sheath supported basally by a strongly sclerotized ring, anal suckers circular; adanal accessory glands are absent, and the opisthogastric setae in trapezoidal arrangement and inserted on connected shields (Atyeo & Braasch, 1966). Within this group, the new species is related to *P. truncatus* Robin, 1877 from *Passer montanus* (Linnaeus, 1758) (Passeridae) by having the similar shape of the opisthogastric shield. In males of *P. brevis* **sp. nov.**, the base of setae *h2* are expanded, and the anal suckers are about 17–21 in length and 16–18 in width. In males of *P. truncatus*, the shape of setae *h2* is normal, and the anal suckers are 21 in length and 10 in width. And in females, all type materials of *P. brevis* **sp. nov.** have fully developed terminal appendages, whereas *P. truncatus* rarely has fully developed terminal appendages.

Etymology. The specific name is derived from Latin word, *brevis*, which refers to the anal suckers in male is short.



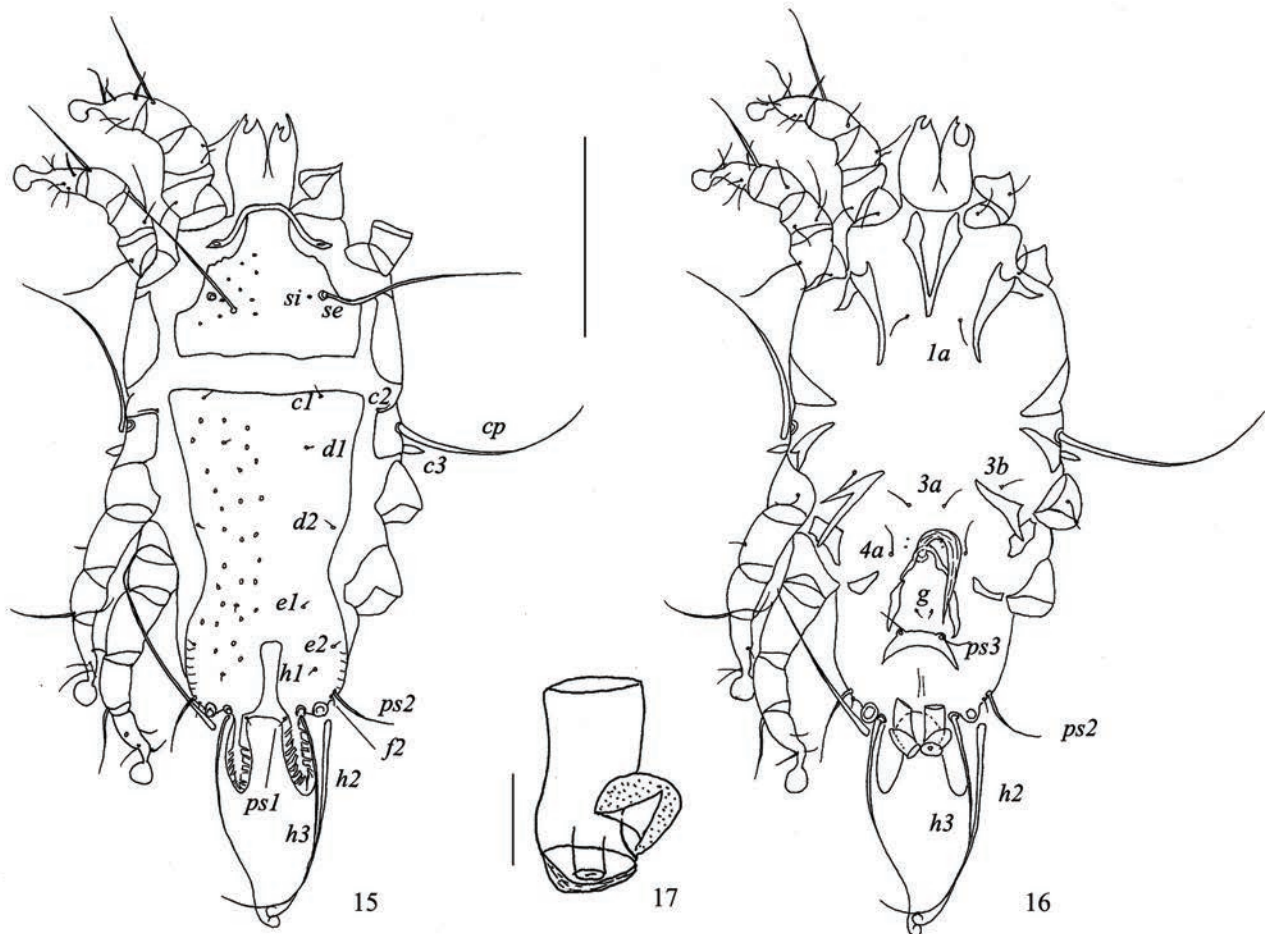
Figs 13–14. *Proctophyllodes brevis* **sp. nov.**, female. 13. Dorsal view. 14. Ventral view. Scale bar = 100 μ m.

Proctophyllodes garrula* **sp. nov.* (Figs 15–19, 26, 29)

Holotype male, from *Garrulax poecilorhynchus* Gould (Passeriformes: Timaliidae), Huangshan (30°7'N, 118°7'E), Anhui, China, 23 May 2008, coll. Jin Liu. Paratypes 3 females, same data as holotype.

Male. Idiosoma length 266, width 143. Prodorsal shield: greatest length 78, greatest width 96. Distance between scapular setae: *se-se* 56. Anterior part with small sparsely disposed pit-like lacunae, lateral margins entire. Setae *ve* absent. Setae *c2* on edge of humeral shield. Subhumeral setae *c3* lanceolate, 14 length, 4.4 width. Hysteronotal shield length 161, width 97; anterior margin straight, posterior angles rectangular, surface of shield with lacunae. Inventral between prodorsal shield and hysteronotal shield 18. Supranal concavity opened from the posterior margin, anterior end reach to level of setae

e2. Terminal lamellae elongated, with pennate venation, length of lamellae 40, width 14, not overlapping. Epimerites IV-shaped. Paragenital apodemes absent. Genital arch in moderate size. Aedeagus extending to level of setae *ps3*, 62 in length. Opisthogastric setae arranged in trapezoidal arrangement. Opisthogastric shield fragmented to three small shields and posterior shield bearing setae *ps3*, setae *g* inserted on striated area. Anal suckers cylindrical, 23 in length, 8.8 in width, with trapezoid shape accessory glands. Distances between hysteronotal setae: *c1-c1* 61, *c1-d1* 31, *d1-d2* 82, *e1-e1* 40, *h1-h1* 42, *d2-e1* 48, *c2-d2* 58, *d2-e2* 14, *e1-h1* 82, *e2-h2* 36, *g-g* 8.9, *ps3-ps3* 25, *g-ps3* 13. Tarsus IV 24 long, seta *d* near midlevel of this segment. Genual solenidion σ III situated at posterior segment. Length of genual solenidia: σ I 24, σ III 7.



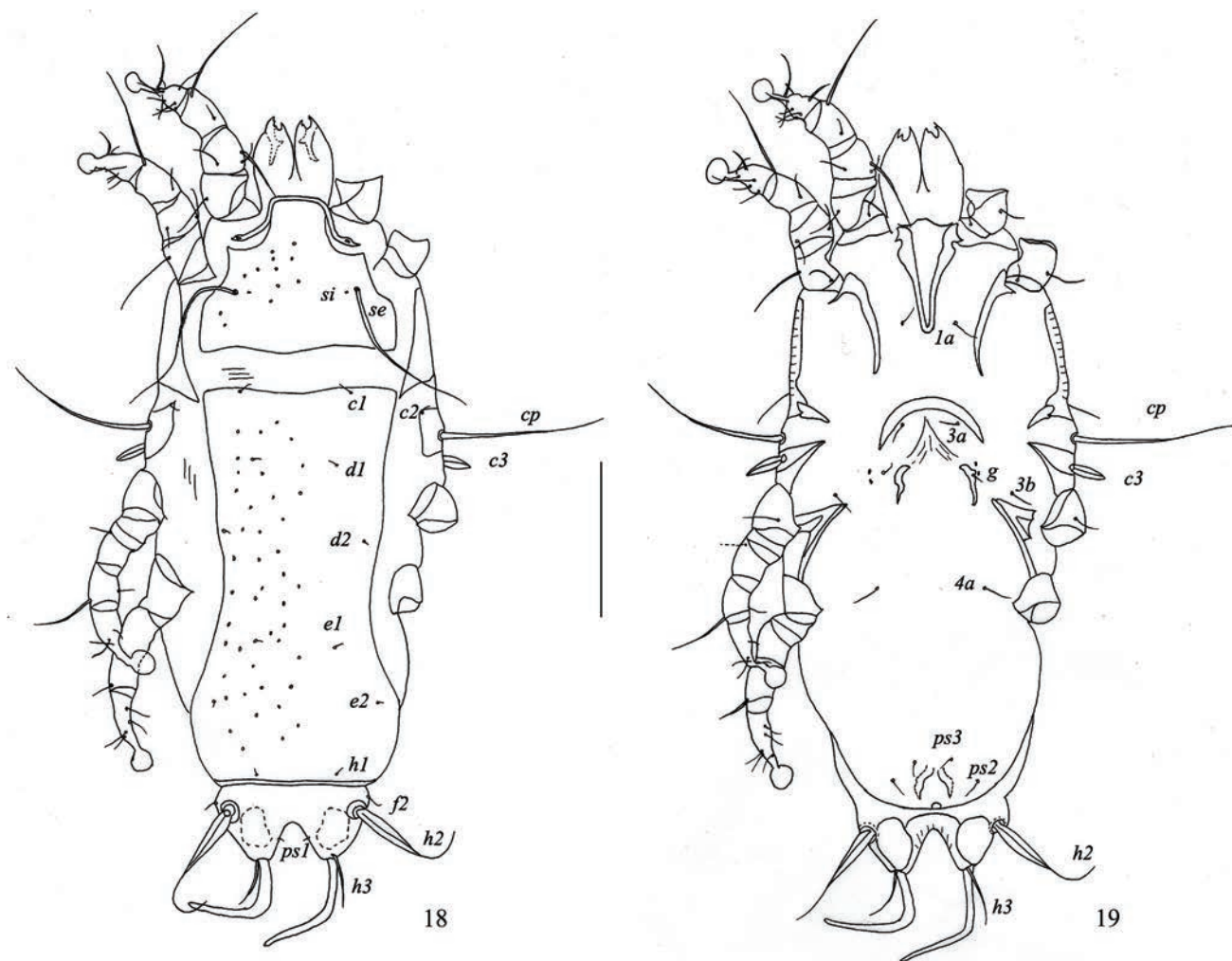
Figs 15–17. *Proctophyllodes garrula* sp. nov., male. 15. Dorsal view. 16. Ventral view. 17. Anal sucker. Scale bars: 15–16 = 100 μ m, 17 = 10 μ m.

Female. Length of idiosoma 354–389, width 151–185. Prodorsal shield with lacunae like male, posterior margin straight, 88–98 in length, 113–129 in width. Setae *ve* absent. Distances between scapular setae *se-se* 74–78. The arrangement of *c1* and *c2* as in males. Subhumeral setae *c3* lanceolate, 20–21 long, 5.8–6.7 wide. Hysterosoma with a large anterior shield and the lobar region. Anterior shield roughly rectangular, with anterior margin almost straight, greatest length 242–263, width 112–123 at anterior margin, surface of shield with lacunae like male. Interval between prodorsal and hysteronotal shield 20–22. Setae *h1* on posterior margin of anterior hysteronotal shield. Length of setae *h3* 75–98. Without supranal concavity. Opisthosomal lobes slightly attenuate apically, terminal cleft with V-shaped, greatest length 23–27, greatest width 37–39. Epimerites IV-shaped. Distance between dorsal setae: *c1-c1* 67–69, *c1-d1* 52–57, *d1-d2* 34–43, *e1-e2* 51–60, *h1-h1* 39–57, *d2-e1* 59–67, *c1-d2* 94–103, *d2-e2* 100–110, *e2-h2* 62–69. Genual solenidion σ III situated as in male. Length of genual solenidia: σ I 29–33, σ III 9–11.

Diagnosis. The new species, *Proctophyllodes garrula* **sp. nov.**, belongs to the *tricetratus* species group. The males in this group are mainly characterized by the short aedeagus (not extending to the bases of terminal lamellae) and the reduced sclerotization of the central part of the opisthogastric shield (Atyeo & Braasch, 1966). Mironov *et al.* (2012) thought that this species group might be artificial, for the opisthogastric shield varied in this group, which were represented by one or two pairs of sclerites, or one unpaired genital fragment and two adanal fragments.

Within this group, the new species differs from other species by the following features: in male, the opisthogastric shield is separated into two anterior fragments and one unpaired posterior fragment, and the anal suckers have trapezoid-shaped accessory glands.

Etymology. The specific name, *garrula* (*garrulus*), derives from the generic name, *garrulax*, of the type host.



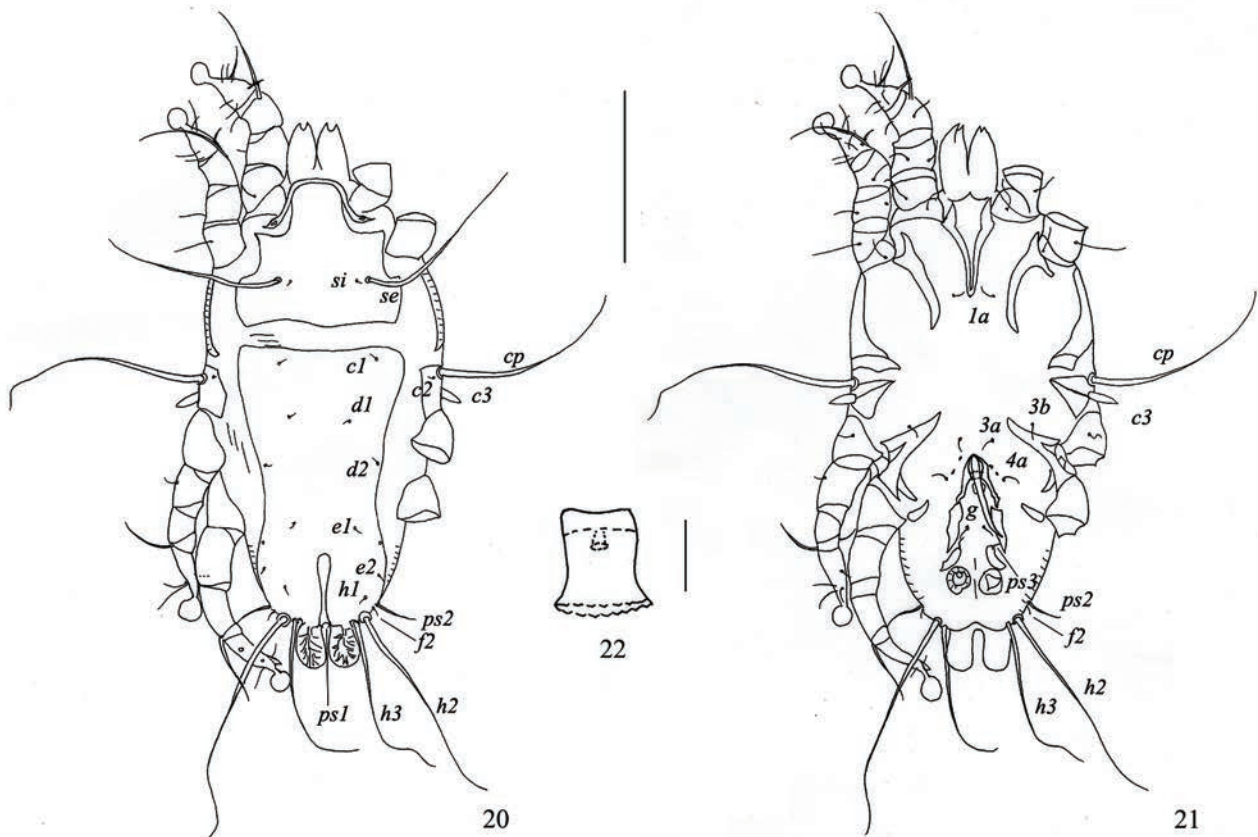
Figs 18–19. *Proctophyllodes garrula* **sp. nov.**, female. 18. Dorsal view. 19. Ventral view. Scale bar = 100 μ m.

***Proctophyllodes canora* sp. nov.** (Figs 20–24, 27, 30)

Holotype male, from *Garrulax canorus* (Linnaeus) (Passeriformes: Timaliidae), Libo (25°19'N, 107°56'E), Guizhou, China, 22 August 2007, coll. Zi-Ying Wang. Paratypes 4 males and 8 females, same data as holotype.

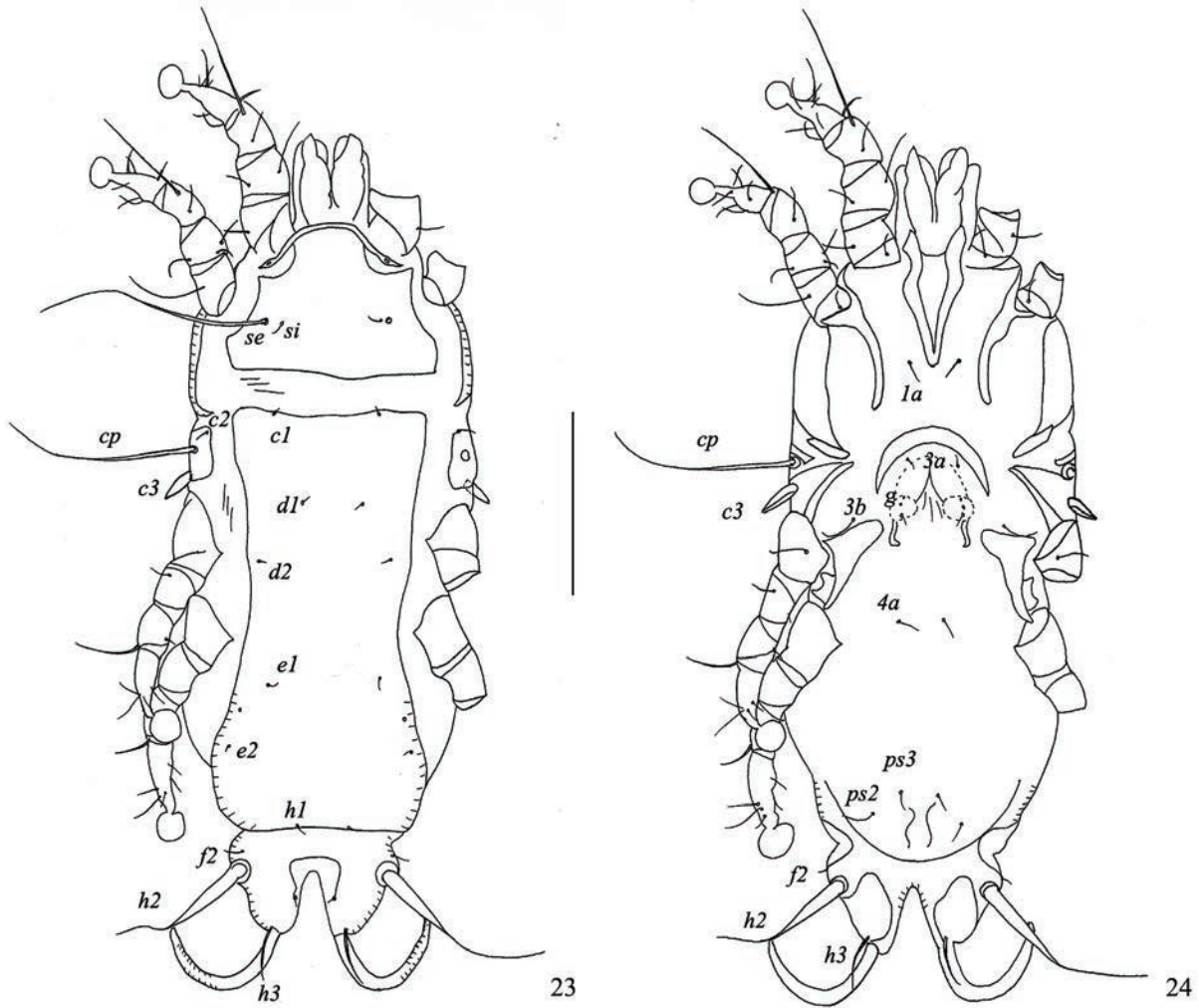
Male. Idiosoma length 257(231–257), width 138(120–138). Prodorsal shield length 80(68–80), width 101(91–101). Distances between scapular setae: *se-se* 52(50–52); lateral margins entire. Setae *ve* absent. Setae *c2* in medial margin of humeral shield. Subhumeral setae *c3* lanceolate, 16(15–17) in length, 6.7(4.8–6.8) in width. Hysteronotal shield: length 155(145–155), width 91(80–92); anterior margin straight. Interval between prodorsal shield hysteronotal shield: 17(15–17). Supranal concavity opened from the posterior margin, anterior end extending beyond level of setae *e2*, and to midlevel

between *e1* and *e2*. Terminal lamellae ovate, with pennate venation, length of lamellae 29(24–29), width 15(15–18), not overlapping. Epimerites IV-shaped. Paragenital apodemes absent. Genital arch well developed. Aedeagus extending to level of setae *g* end, not to *ps3*, 59(59–88) in length. Opisthogastric setae arranged in trapezoidal arrangement. Opisthogastric shield fragmented into four shields, two anterior plates larger and two posterior bearing seta *ps3*. Anal suckers cylindrical, 13(12–16) in length, 11(10–13) in width, corolla with approximately 20 small teeth. A spine-like projection at the apex of tarsus IV. Distances between hysteronotal setae: *c1-c1* 57(57–59), *c1-d1* 32(25–32), *d1-d2* 61(61–64), *e1-e1* 63(62–67), *h1-h1* 21(21–48), *d2-e1* 27(27–37), *c2-d2* 93(88–96), *d2-e2* 30(28–37), *e1-h1* 72(71–86), *e2-h2* 31(15–31), *g-g* 9.1(7.9–8.8), *ps3-ps3* 18(18–21), *g-ps3* 11(9.0–12.0). Tarsus IV 28(24–28) long, with a spine-like projection at the apex, seta *d* near midlevel of this segment. Genual solenidion σ III situated at posterior segment. Length of genual solenidia: σ I 25(22–25), σ III 7(6–8).

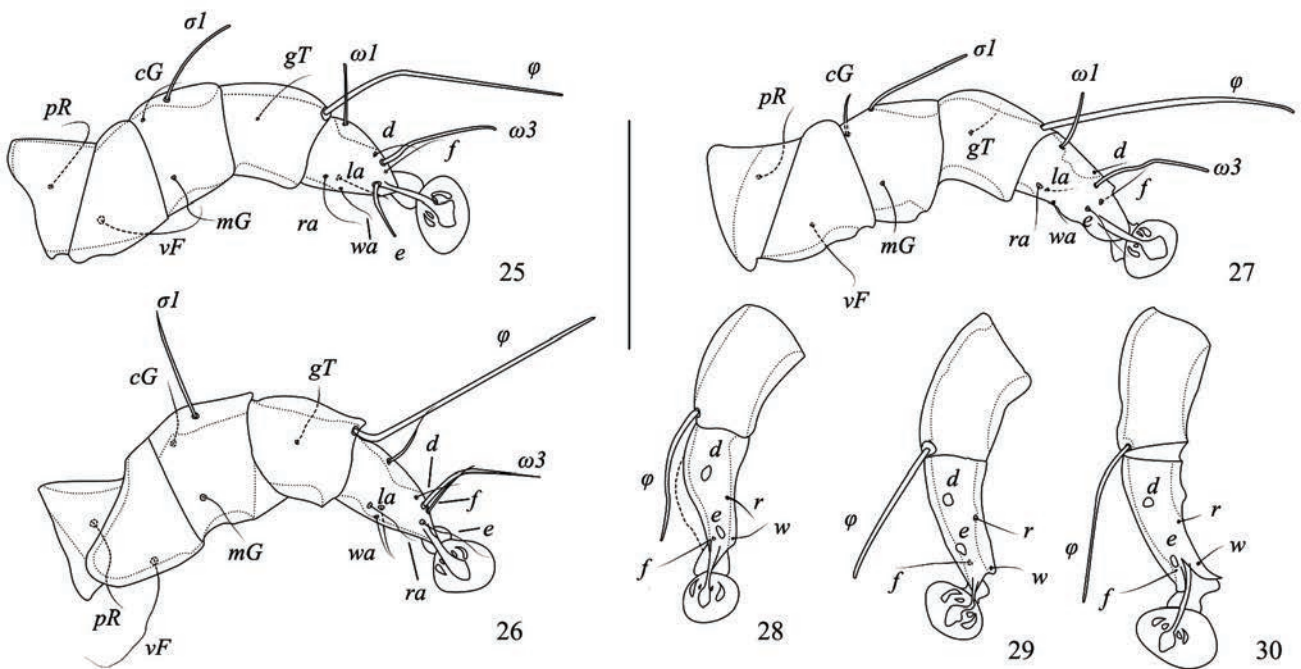


Figs 20–22. *Proctophyllodes canora* sp. nov., male. 20. Dorsal view. 21. Ventral view. 22. Anal sucker of paratype. Scale bars: 20–21 = 100 μ m, 22 = 10 μ m.

Female. Length of idiosoma 344–371, width 148–162. Prodorsal shield: posterior margin straight, 85–91 in length, 111–127 in width. Setae *ve* absent. Distances between scapular setae *se-se* 71–76. The arrangement of *c1* and *c2* as in males. Subhumeral setae *c3* lanceolate, 22–27 long, 4.7–6.9 wide. Hysterosoma with a large anterior shield and the lobar region, but the striated area barely discernible. Anterior shield roughly rectangular, with anterior margin almost straight, greatest length 240–253, width at anterior margin 105–121. Interval between prodorsal and hysteronotal shields 9.8–19.0. Setae *h1* on striated area. Length of setae *h3* 94–97. Without supranal concavity. Opisthosomal lobes in small size and lightly attenuate apically, terminal cleft in a form of triangle, 33–37 in length, 24–29 in width. Epimerites IV-shaped, without lateral extensions. Distance between dorsal setae: *c1-c1* 60(58–65), *c1-d1* 52(51–52), *d1-d2* 32(30–32), *e1-e2* 68(58–68), *h1-h1* 37(34–40), *d2-e1* 77(65–77), *c2-d2* 82(82–93), *d2-e2* 108(100–107), *e1-h1* 77(76–78), *e2-h2* 68(64–69). Genual solenidion σ III situated as in male. Length of genual solenidia: σ I 30–36, σ III 9–12.



Figs 23–24. *Proctophyllodes canora* sp. nov., female. 23. Dorsal view. 24. Ventral view. Scale bar = 100 μ m.



Figs 25–30. *Proctophyllodes* spp., male. 25–27. Leg I. 28–30. Tibia and tarsus IV. 25, 28. *P. brevis* sp. nov. 26, 29. *P. garrula* sp. nov. 27, 30. *P. canora* sp. nov. Scale bar = 50 μ m.

Diagnosis. The new species, *Proctophyllodes canora* sp. nov., belongs to the *tricetratus* species group. Within this group, the new species is similar to *P. minlae* Atyeo & Braasch, 1966 from *Minla cyanouroptera* Hodgson, 1838 (Timaliidae) by having small terminal lamellae and an opisthogastric shield which is split into two pairs of sclerites. The new species can be distinguished from the latter as follows: in male, the terminal lamellae is ovate and with pennate venation; there is a spine-like projection only at the apex of tarsus IV but not ambulacra. In males of *P. minlae*, the terminal lamellae is rectangular and with radiate venation; and apex of each ambulacra has a spine-like projection except tarsus IV.

Etymology. The specific name, *canora*, is derived from the specific name of the type host.

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