

Three new species of the genus *Proctotydaeus* (Acari: Iolinidae) associated with Brazilian stingless bees

TAIRIS DA-COSTA^{1,2*}, LUANA FABRINA RODIGHERO², GUILHERME LIBERATO DA SILVA², JOSE IRVING MONJARÁS-BARRERA³, BETINA BLOCHTEIN¹ & NOELI JUAREZ FERLA²

¹Laboratório de Entomologia, Escola de Ciências da Saúde e da Vida, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, RS, Brasil.

²Laboratório de Acarologia, Tecnovates, Universidade do Vale do Taquari – Univates, Lajeado, RS, Brasil.

³Universidad Autónoma de Tamaulipas, Instituto de Ecología Aplicada, División del Golfo 356, Colonia Libertad, Ciudad Victoria, Tamaulipas, México.

*Corresponding author: tairiscosta@gmail.com

Abstract

Proctotydaeus (Acari: Iolinidae) species live in bird nests, insect colonies, plants and barn straw, and comprise 17 species belonging to four subgenera. Here, we report three new species of *Proctotydaeus* mites living inside stingless bee colonies in Brazil. *Proctotydaeus* (*Neotydeolus*) *lasaroi* Da-Costa, Rodighero & Ferla **sp. nov.**, *Proctotydaeus* (*Oriolella*) *dorsoreticulatus* Da-Costa, Rodighero & Ferla **sp. nov.** and *Proctotydaeus* (*Oriolella*) *quadrifasciatae* Da-Costa, Rodighero & Ferla **sp. nov.** are described and illustrated based on specimens collected from three species of stingless bees in the state of Rio Grande do Sul, Brazil.

Key words: Meliponini, *Neotydeolus*, nests, *Oriolella*, Pronematinae

Introduction

Mites of the superfamily Tydeoidea are cosmopolitan organisms, which can be fungivorous, phytophagous, predators and scavengers (Gerson *et al.* 2003; Sadeghi *et al.* 2012). Tydeoidea was organized by André & Fain (2000) into four families: Ereynetidae Oudemans, 1931, Iolinidae Pritchard, 1956, Triophytidae André, 1980 and Tydeidae Kramer, 1877. Iolinid mites can be found in soil, on plants and in association with insects, comprising 37 genera and 132 species (Zhang *et al.* 2011; Theron *et al.* 2012; Ahmad-Hosseini *et al.* 2017). Through cladistic analysis, Iolinidae include three subfamilies: Iolininae Pritchard, 1956, Pronematinae André, 1980 and Tydaecolinae Pritchard, 1956 (André & Fain 2000).

Iolinidae includes *Proctotydaeus* Berlese, 1911, which was originally described in Tydeidae, later transferred to Iolinidae (Baker 1965) and then returned to Tydeidae (André 1979; André 1980). Pritchard (1956) erected the new superfamily Iolinoidea but Krantz (1978) reconsidered *Proctotydaeus* as a member of Tydeoidea. Species of this genus live in bird nests, with insects, on plants and on barn straw but the associations are not clear (Kaźmierski 1998; Gerson *et al.* 2003). This genus contains 17 species belonging to four subgenera: *Neotydeolus* Flechtmann & Camargo, 1974, *Oriolella* Baker, 1968, *Proctotydaeus* Berlese, 1911 and *Proctotydulus* Kaźmierski, 1998.

Three species of the subgenus *Neotydeolus* are known to be associated with bees: *Proctotydaeus* (*N.*) *alveari* Rosa, André & Flechtmann, 1985 has been reported in the nests of *Melipona pernigra* Moure & Kerr; *Proctotydaeus* (*N.*) *partamonae* Rosa & Flechtmann, 1983 has been found in the

nests of *Partamona* (*Partamona*) sp. and *Melipona lateralis* Erichson, and *Proctotydaeus* (*N.*) *therapeutikos* Flechtmann & Camargo, 1974 has been reported in the nests of *Scaptotrigona postica* Latreille.

Four species of the subgenus *Proctotydaeus* are known associated with the thoracic region and wings of Acrididae: *Proctotydaeus* (*P.*) *galapagosensis* Fain & Evans, 1966 on *Schistocerca melanocera* Stål; *Proctotydaeus* (*P.*) *lineata* Price, 1972 on *Schistocerca* sp.; *Proctotydaeus* (*P.*) *viator* Berlese, 1911 on *Acridias parvulus* and *Proctotydaeus* (*P.*) *schistocerae* Fain & Evans, 1966 on *Schistocerca melanocera* Stål.

The subgenus *Proctotydulus* includes six species: *Proctotydaeus* (*P.*) *oblongus* Kuznetzov, 1973 found on the Greek nut tree; *Proctotydaeus* (*P.*) *pteroni* Ueckermann & Meyer, 1988 on *Pteronia paniculata* Thunb; *Proctotydaeus* (*P.*) *pyrrhippeus* Treat, 1961 on *Acronycta* sp., *Amphipyra* sp., *Apamea* sp.; *Proctotydaeus* (*P.*) *rusticus* Meyer & Rodrigues, 1966 on *Gossypium* sp.; *Proctotydaeus* (*P.*) *hypobori* Khaustov, 1997 on bark beetles and *Proctotydaeus* (*P.*) *longitrichus* Khaustov, 1997 in straw.

Four species of the subgenus *Oriolella* are known: *Proctotydaeus* (*O.*) *polonicus* Kaźmierski, 1998, reported on sweepings of barn straw; *Proctotydaeus* (*O.*) *lindquisti* Kaźmierski, 1998 in nests of *Otus asio* Linnaeus; *Proctotydaeus* (*O.*) *sinhai* Momen, 1990 on *Cryptolestes ferrugineus* (Stephens) and *Proctotydaeus* (*O.*) *farbae* Baker, 1968 has been found in bark-beetle tunnels (Polyphaga: Ipidae). In this study, three new species of *Proctotydaeus* belonging to the subgenera *Neotydeolus* and *Oriolella* are described and illustrated based on specimens collected from nests of stingless bees in the state of Rio Grande do Sul, Brazil.

Material and methods

Mite specimens were taken from the hives of the native stingless bees *Melipona quadrifasciata quadrifasciata* Lepeletier (Fig. 1A), *Scaptotrigona bipunctata* (Lepeletier) (Fig. 1B) and *Tetragonisca fiebrigi* (Schwarz) (Fig. 1C). The hives were in the municipalities of Bom Princípio, Ijuí, Porto Alegre, Rolante and Santa Maria from the state of Rio Grande do Sul, Southern Brazil (Fig. 1D). The specimens were collected under a binocular microscope (Leica S6E) and mounted on glass slides in Hoyer's medium. The prepared specimens were examined with a phase-contrast microscope (Axio Scope. A1-Zeiss) and the drawings were made using camera lucida and edited in CorelDraw X8®.

The nomenclature of the idiosomal chaetotaxy follows Kaźmierski (1998) and Panou *et al.* (2000). The specimens were checked using the key of Kaźmierski (1998) and all descriptions of the genus. All measurements are shown in micrometers (µm) and the measurements of the holotypes are followed by the ranges of the paratypes in the parentheses.

Systematics

Family **Iolinidae** Pritchard, 1956

Subfamily **Pronematinae** André, 1980

Genus ***Proctotydaeus*** Berlese, 1911

Diagnosis of genus

Prodorsum procurved; setae *ro* situated behind the *la-la*; palp chaetotaxy: 6(+1 ω)-1-2); chaetotaxy of legs I–IV: I: 8-3+1-3-3-1; II: 7-2-3-3-1; III: 7-2-2-2-1 and IV: 7-2-1-(1-1)-0 or 7-2-1-2-0 (Kaźmierski 1998).

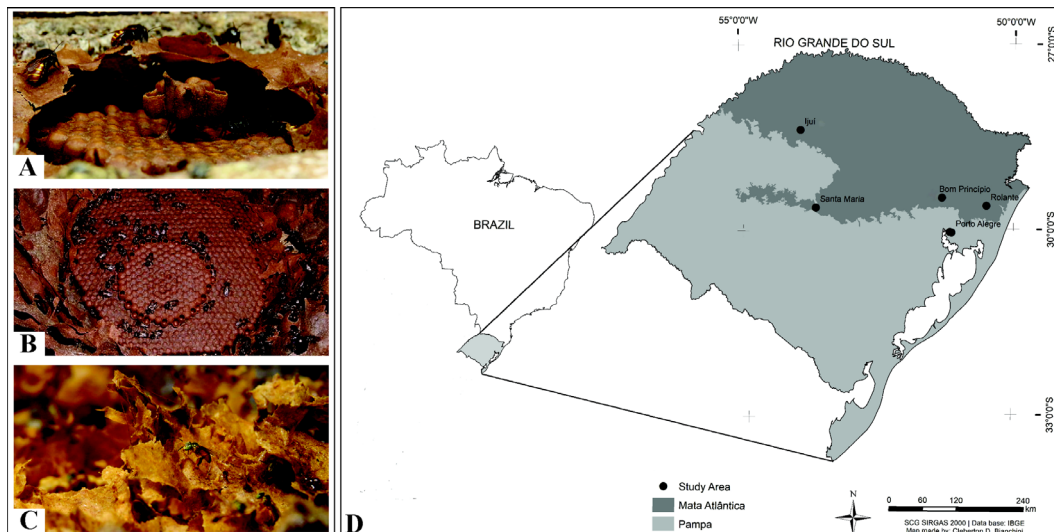


FIGURE 1. (A) Nest of *M. quadrifasciata*; (B) Nest of *S. bipunctata*; (C) Adult individual of *T. fiebrigi*; (D) Map showing the location of sampling sites in Rio Grande do Sul State, Brazil.

Subgenus *Neotydeolus* Flechtmann & Camargo, 1974

Diagnosis of the subgenus

Bothridial setae club-like; setae *ps2* absent or present; Paraproctal suckers poorly developed and papilla absent; *tc*ζ on tarsus I of medium size (about double the length of the segment); spurs absent (Flechtmann & Camargo 1974; Kaźmierski 1998).

Proctotydaeus (Neotydeolus) lasaroi Da-Costa, Rodighero & Ferla sp. nov.

(Figs 2–6)

Diagnosis

Prodorsum procurved, dorsum and venter with serrated setae. Dorsal and ventral ornamentation entirely striated. Bothridial setae clublike, setae *la* small, setae *ps1*, *ps2* and *ps3* present. Palptarsus with eupathidium *p*ζ distally semilunar and setae κ bifurcate.

Description

Adult female (n = 5)—Body of medium size, oval. Length of idiosoma 212 (195–213), width 115 (110–125).

Dorsum (Fig. 2)—Dorsum with 13 pairs of setae (*ro*, *la*, *bo*, *ex*, *c1*, *c2*, *d1*, *e1*, *f1*, *f2*, *h1*, *h2* and *ps1*) (Fig. 6A). Eyes absent. Dorsum completely covered with dotted striations; prodorsum procurved with irregular longitudinal striae between *ro* and *la*; striation between *c1* transverse; striation between *d1* longitudinal; striation between *f1* and *f2* transverse; striation between *h1*, *h2* and *ps1* longitudinal. All dorsal setae serrate; bothridial setae (*bo*) club-like (Fig. 6B). Lyrifissures *ia* located between setae *c1* and *d1*, *im* situated close to *e1* and *ip* situated close to *f2*. Lengths of dorsal setae: *ro* 13 (11–13); *la* 5; *bo* 21 (21–22); *ex* 16 (14–16); *c1* 12 (11–12); *c2* 12 (11–12); *d1* 14 (13–15); *e1* 16 (14–16); *f1* 16 (15–16); *f2* 19 (18–19); *h1* 16 (14–16); *h2* 21 (19–21); *ps1* 12 (9–12). Distances between dorsal setae: *ro*–*ro* 14 (13–15); *la*–*la* 35 (35–36); *bo*–*bo* 36 (31–36); *c1*–*c1* 34

(33–37); *c2–c2* 86 (79–87); *d1–d1* 26 (25–27); *e1–e1* 24 (22–24); *f1–f1* 20 (19–23); *f2–f2* 45 (40–45); *h1–h1* 23 (22–25); *h2–h2* 49 (43–49); *ro–la* 18 (15–20); *c1–d1* 47 (47–52); *d1–e1* 29 (27–29); *e1–f1* 21 (21–24); *f1–f2* 15 (12–15); *h1–h2* 14 (12–14).

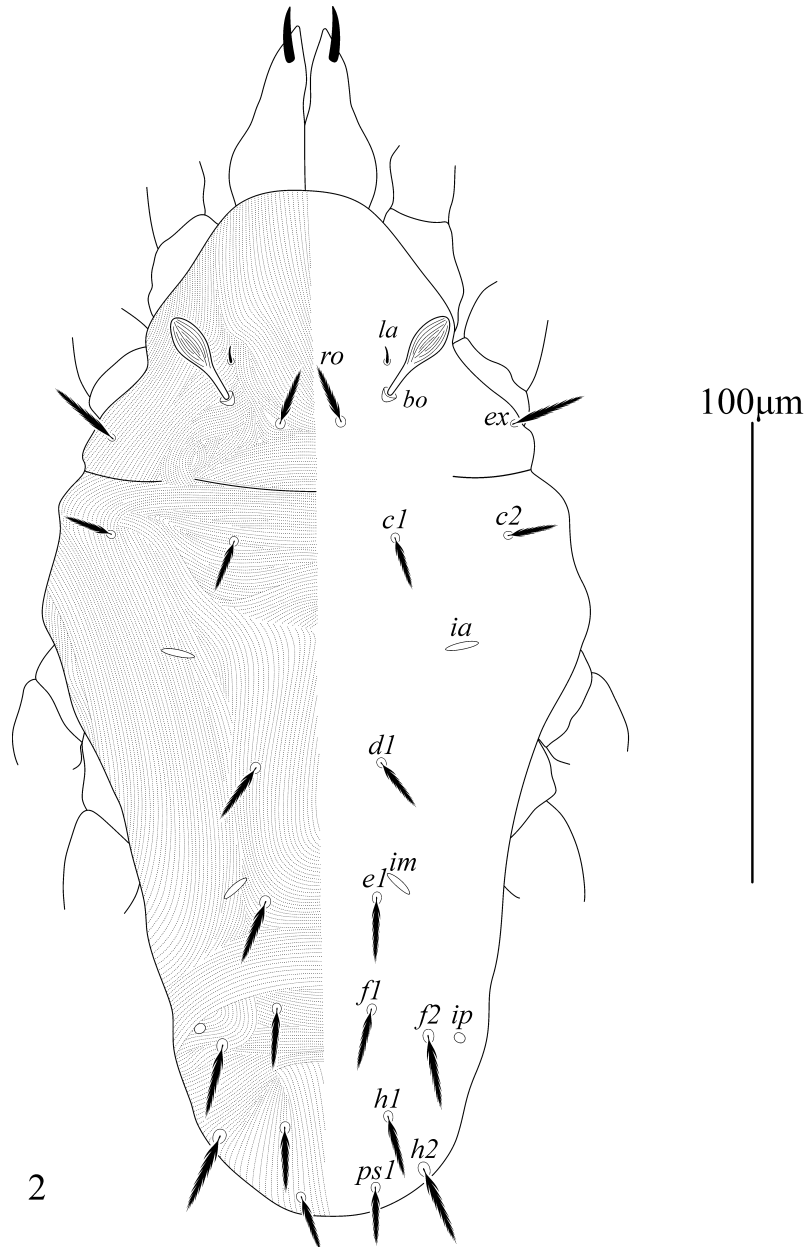


FIGURE 2. *Proctotydaeus (Neotydeolus) lasaroi* sp. nov., female (holotype) in dorsal view.

Venter (Fig. 3)—All ventral setae serrated (excluding *ps3*) and venter completely striated. Ventral setae similar in shape to dorsal setae. Longitudinal striae between *pt*, *mta* and *mtβ*. Lyrifissures *ih* located posteroventrally. Epimeral formula: 3-1-4-2. Measurements of setae: *pt* 10 (9–10); *mta* 10 (8–10) and *mtβ* 10 (9–10). Four pairs of aggenital setae (*ag1*, *ag2*, *ag3* and *ag4*) and two pairs of pseudanal setae (*ps2* and *ps3*). Setal lengths: *ag1* 8 (7–9); *ag2* 8; *ag3* 9 (7–9); *ag4* 10 (8–10); *ps2* 12 (10–16) (Fig. 6C) and *ps3* 8 (6–9).

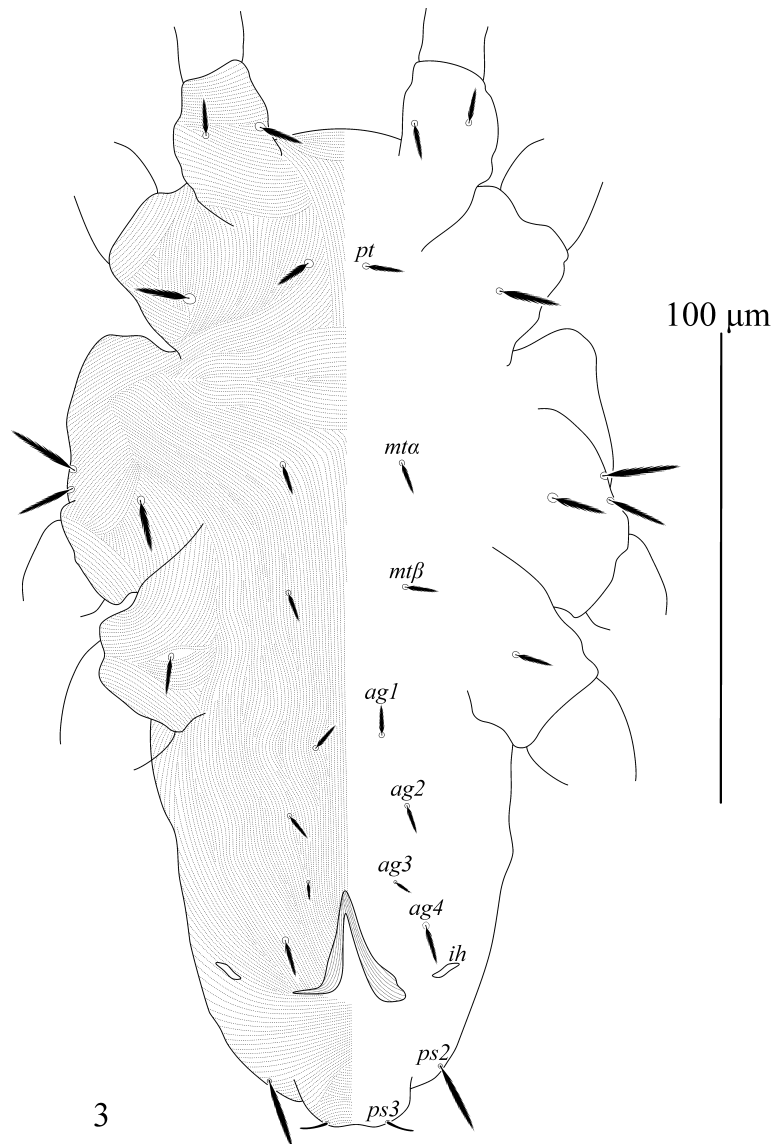


FIGURE 3. *Proctotydaeus (Neotydeolus) lasaroi* sp. nov., female (holotype) in ventral view.

Gnathosoma (Fig. 4A–B)—Length 51 (49–51), width 36 (35–38). Gnathosoma visible from above. Subcapitulum with longitudinal striae behind *sc1* and *sc2*. Infracapitular setae simple. Setal lengths: *sc1* 14 (12–14); *sc2* 14 (12–14) (Fig. 4A). Palp 33 (32–34) long, setation 6(+1 ω)-1-2. Palptarsus with eupathidium $p\zeta$ distally semilunar (Fig. 4B), *ba* and ω very small. Cheliceral stiletos 13 (11–13) long.

Legs (Fig. 5A–D)—All leg I setae serrated (except *u'* and *u''*). Tarsi I without apotele and claws, tarsi II–IV with two claws and hairy empodium. Setae *u'* and *u''* on tarsus I bifurcate and minute, setae κ bifurcate (Fig. 6D). Chaetotaxy of legs I–IV (tarsus to trochanter): I: 8(+1 ω)-3(+1 ϕ +1 κ)-3-3-1 (Fig. 5A); II: 7(+1 ω)-2-3-3-1 (Fig. 5B); III: 7-2-2-2-1 (Fig. 5C) and IV: 7-2-1-2-0 (Fig. 5D). Lengths of legs: leg I 131 (110–131); leg II 136 (115–136); leg III 133 (112–133) and leg IV 141 (106–141). Length of tarsus I 17 (16–18) and 10 wide; length of solenidion ωI 4; length *tc*' ζ 29 (27–30); *tc*'' ζ 30 (24–30); length of seta *k* 3 (2–3).

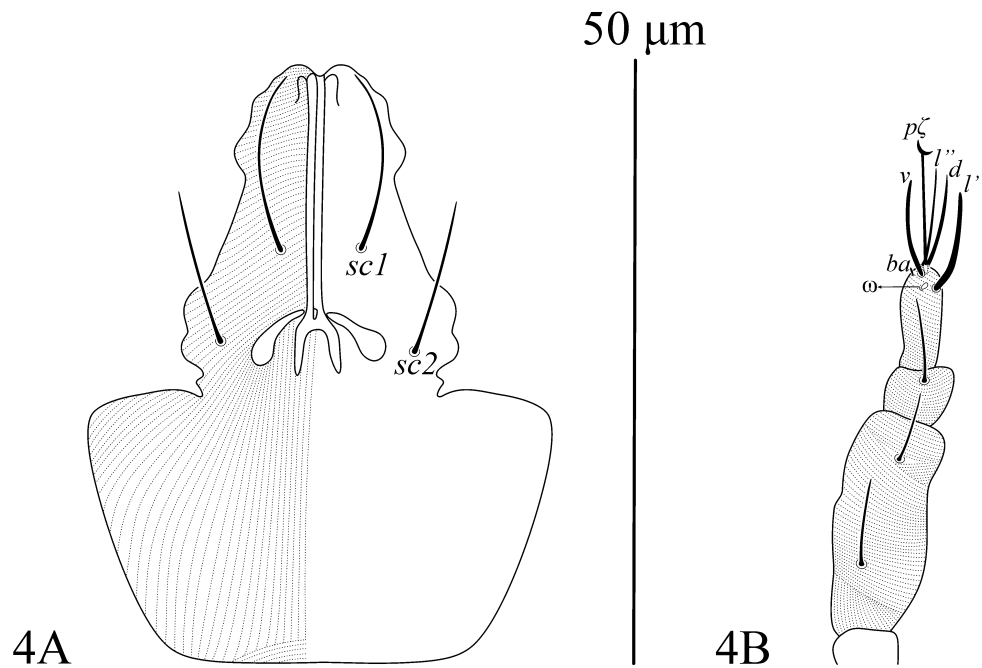


FIGURE 4. *Proctotydaeus* (*Neotydeolus*) *lasaroi* sp. nov., female (holotype). (A) Gnathosoma in ventral view. (B) Palptarsus.

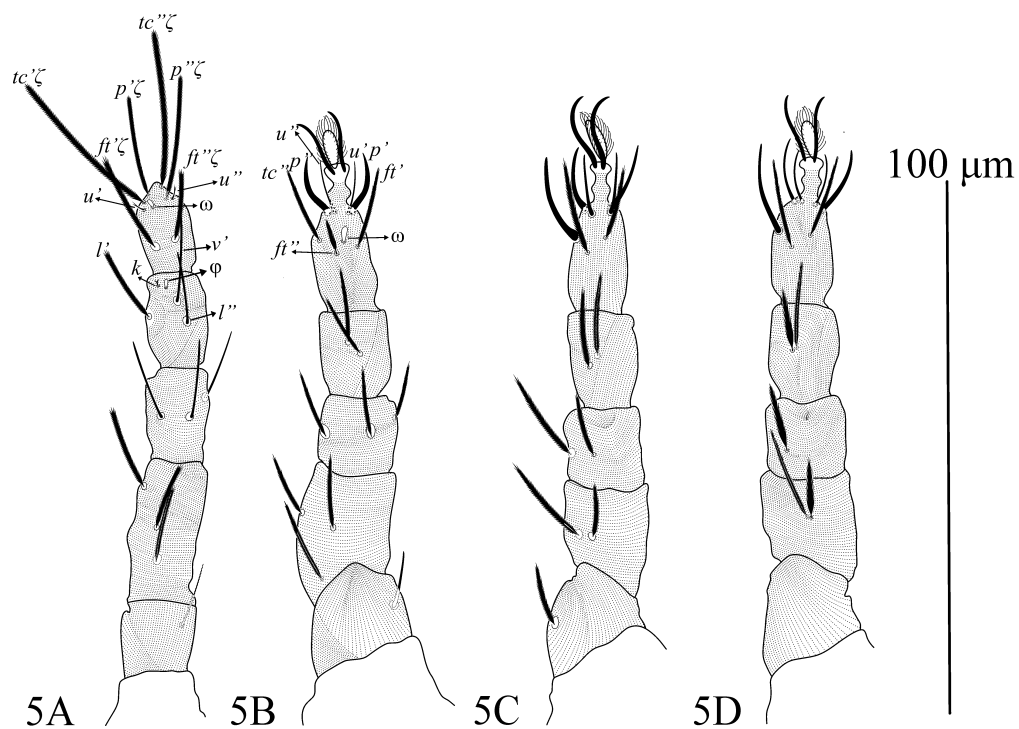


FIGURE 5. *Proctotydaeus* (*Neotydeolus*) *lasaroi* sp. nov., female (holotype). (A) leg I. (B) leg II. (C) leg III. (D) leg IV.

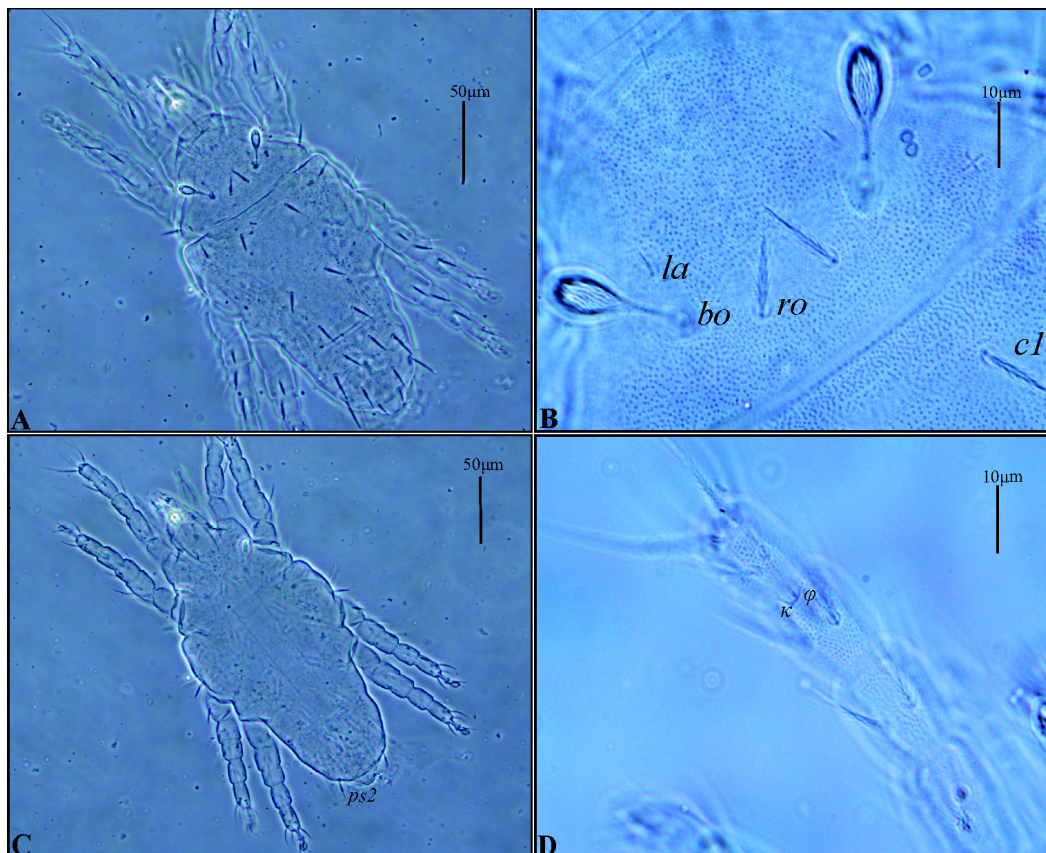


FIGURE 6. *Proctotydaeus (Neotydeolus) lasaroi* sp. nov. (A) Dorsum. (B) Ornamentation between *la*, *bo* and *ro*. (C) Setae *ps2* in ventral view. (D) Setae κ bifurcate.

Type material

Female holotype and four female paratypes collected in brood cells of *S. bipunctata*, as follows: Holotype, Bom Princípio, Rio Grande do Sul, Brazil, October 10, 2018, T. Da-Costa. Four paratype females, Santa Maria, Rio Grande do Sul, Brazil, January 22, 2019, T. Da-Costa. Female holotype deposited at the Departamento de Entomologia e Acarologia, Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo (ESALQ/USP), Piracicaba, São Paulo, Brazil. One paratype female deposited at the Technological Science Museum of the Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Rio Grande do Sul, Brazil. Other paratypes deposited at the Natural Science Museum (ZAUMCN) of the University of Vale do Taquari–Univates, Lajeado, Rio Grande do Sul, Brazil.

Male. not found.

Etymology

The name *lasaroi* is given in honor of the biologist Lásaro Vanderlei Fernandes da Silva (*in memoriam*), Laboratory Technician of the Escola Superior de Agricultura Luiz de Queiroz (ESALQ/USP), Department of Entomology and Acarology. The honor is given due to his help in the preparation of many dissertations of the graduate students of ESALQ/USP between 1998 and 2019. The last author of this paper received his help in the preparation of his own thesis and is grateful to this selfless technician's professional assistance. Furthermore, many other Brazilian and foreign

acarologists were helped by him when visiting the Laboratory of Agricultural Acarology of the ESALQ/USP.

Remarks

This new species resembles *Proctotydaeus* (*Neotydeolus*) *therapeutikos* Flechtmann & Camargo, 1974, with trichobothria clublike, setae *la* small and dorsal setae serrated. Nevertheless, it can be differentiated by the presence of *ps2* instead of absence, dorsum covered with dotted striations instead of continuous striations and chaetotaxy of trochanters: 1-1-1-0 instead of 1-0-1-0.

Subgenus ***Oriolella*** Baker, 1968

Diagnosis of the subgenus

Bothridial setae whip-like; setae *ps2* present; Paraproctal suckers poorly developed and papilla absent; *tc* on tarsus I long (longer than twice the length of segment); setae *u* very small and bifurcate and femur IV not divided (Każmierski 1998).

***Proctotydaeus* (*Oriolella*) *dorsoreticulatus* Da-Costa, Rodighero & Ferla sp. nov.**

(Figs 7–11)

Diagnosis

Prodorsum procurved, dorsal shields reticulated and striated. Striations around dorsal shield and between *ro* and *c1*, *e1* and *fl*, *f2* and *ps1*. Dorsum and venter with serrated setae. Ventral ornamentation entirely striated. Bothridial setae (*bo*) strongly serrated with a slight expansion distally. Apophysis in shape of spur on femur IV and palptarsus with eupathidium $\rho\zeta$ distally semilunar.

Description

Adult female (n = 5)—Body of medium size, oval. Length of idiosoma 169 (169–187), width 86 (86–102).

Dorsum (Fig. 7)—Dorsum with 13 pairs of setae (*ro*, *la*, *bo*, *ex*, *c1*, *c2*, *d1*, *e1*, *fl*, *f2*, *h1*, *h2* and *ps1*) (Fig. 11A). Eyes absent. Dorsum with striae and reticulated; longitudinal striations around dorsal shields; striation between *ro* and *c1*, *e1* and *fl* and *ps1* transverse; reticulations between *la*, *bo* and *ro*, *c1*, *c2*, *d1*, *e1* and *fl*; reticulations formed by pores (Fig. 11B). All dorsal setae strongly serrate, *fl*, *f2*, *h1* and *h2* reach setae in next rows. Bothridial setae (*bo*) strongly serrated with a slight expansion posteriorly. Lyrifissures *ia* located between setae *c1* and *d1*, *im* situated close to *d1* and *e1*, *ip* between setae *e1* and *fl*. Lengths of dorsal setae: *ro* 8 (6–8); *la* 6 (4–6); *bo* 24 (23–26); *ex* 19 (12–19); *c1* 10 (8–10); *c2* 9 (7–10); *d1* 10 (8–10); *e1* 10 (9–10); *fl* 13 (11–13); *f2* 22 (14–22); *h1* 10 (10–12); *h2* 15; *ps1* 8 (6–9). Distances between dorsal setae: *ro*–*ro* 17 (17–20); *la*–*la* 31 (31–35); *bo*–*bo* 33 (33–36); *c1*–*c1* 27 (27–35); *c2*–*c2* 79 (79–92); *d1*–*d1* 26 (26–33); *e1*–*e1* 26 (26–33); *fl*–*fl* 15 (15–18); *f2*–*f2* 30 (30–38); *h1*–*h1* 14 (14–18); *h2*–*h2* 26 (26–40); *ro*–*la* 18 (18–21); *c1*–*d1* 41 (41–49); *d1*–*e1* 19 (19–25); *e1*–*fl* 20 (16–22); *fl*–*f2* 8 (8–11); *h1*–*h2* 5 (5–13).

Venter (Fig. 8)—All ventral setae serrated (excluding *ps3* and *ps2*, which are terminally smooth) and venter completely striated. Ventral setae similar in shape to dorsal setae. Longitudinal striae between *pt*, *mta* and *mtb*. Lyrifissures *ih* located posteroventrally. Epimeral formula: 3-1-4-2. Measurements of setae: *pt* 7 (7–9); *mta* 6 (6–7) and *mtb* 8 (7–10). Four pairs of aggenital setae (*ag1*, *ag2*, *ag3* and *ag4*) and two pairs of pseudanal setae (*ps2* and *ps3*). Setal lengths: *ag1* 6 (4–6); *ag2* 7 (4–7); *ag3* 8 (7–8); *ag4* 9 (7–10); *ps2* 16 (15–18) and *ps3* 5 (5–6).

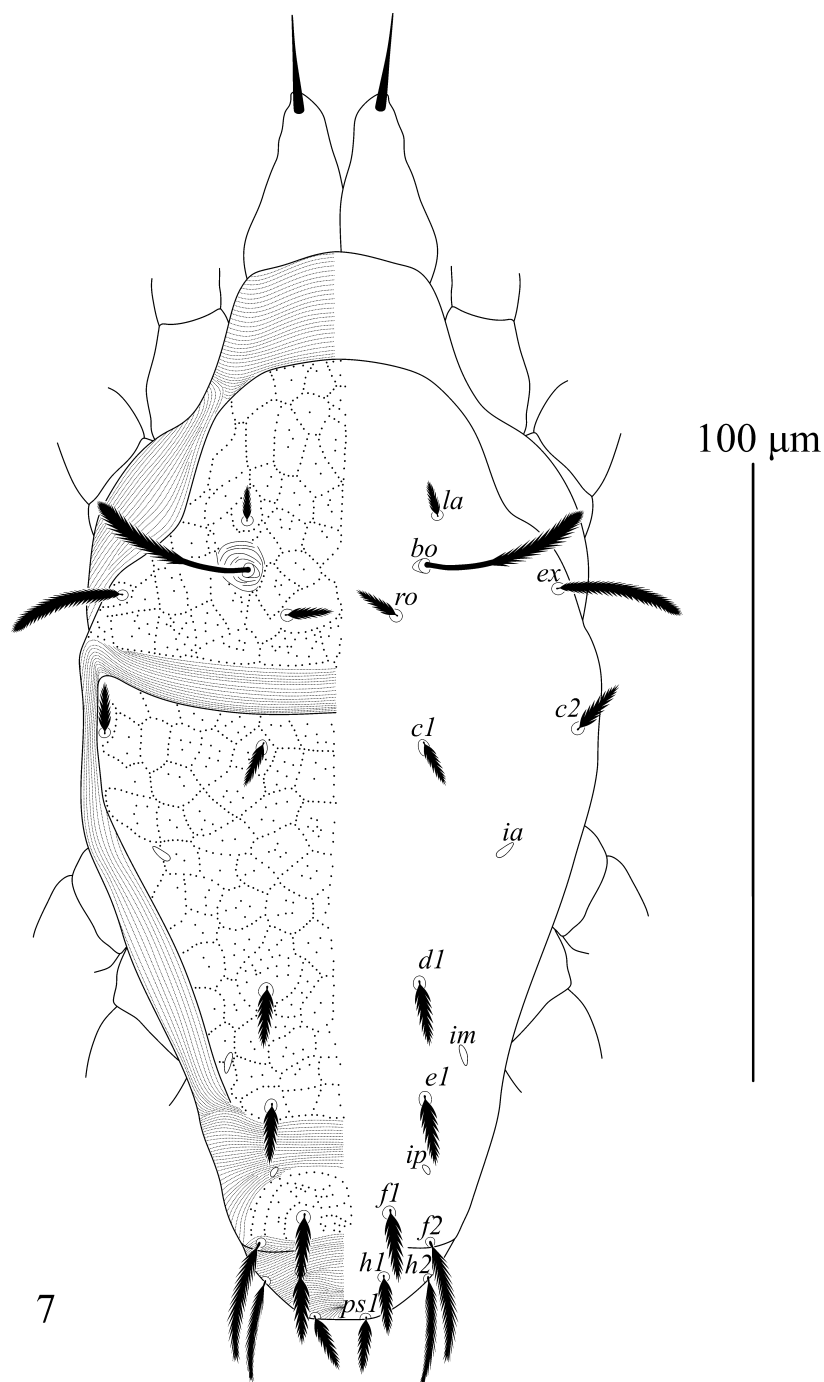


FIGURE 7. *Proctotydaeus (Oriolella) dorsoreticulatus* sp. nov., female (holotype) in dorsal view.

Gnathosoma (Fig. 9A–B)—Length 46 (46–47), width 42 (36–42). Gnathosoma visible from above. Subcapitulum with longitudinal striae behind *sc1* and *sc2*. Infracapitular setae simple. Setal lengths: *sc1* 6 (5–10); *sc2* 11 (11–15) (Fig. 9A). Palp 38 (30–40) long, setation 6(+1 ω)-1-2. Palptarsus with eupathidium $\rho\zeta$ distally semilunar (Fig. 9B), *ba* and ω very small. Cheliceral stiletos 16 (10–16) long.

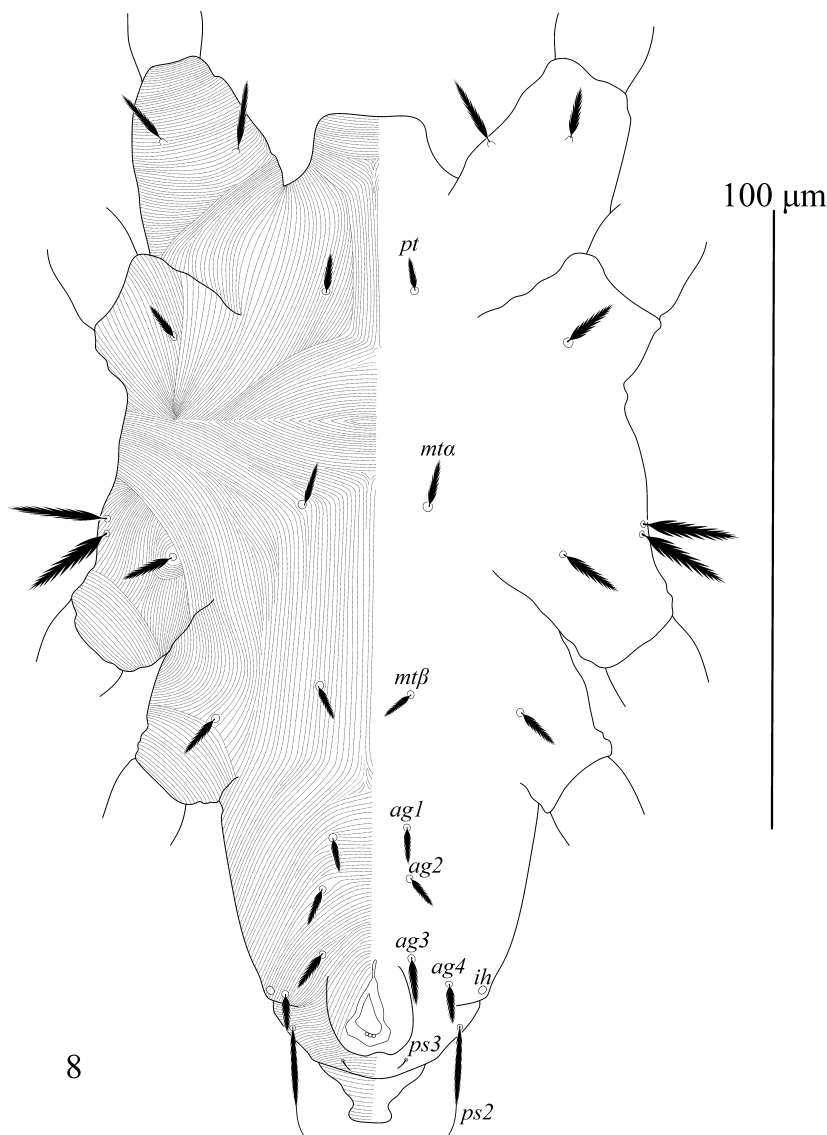


FIGURE 8. *Proctotydaeus (Oriolella) dorsoreticulatus* sp. nov., female (holotype) in ventral view.

Legs (Fig. 10A–D)—All leg I setae serrated, setae of tarsus II–IV smooth. Tarsi I without apotele and claws, tarsi II–IV with two claws and hairy empodium. Setae *u'*, *u''* on tarsus I bifurcate and minute, apophysis in shape of spur in femur IV. Chaetotaxy of legs I–IV (tarsus to trochanter): I: 8(+1 ω)-3(+1 ϕ +1 κ)-3-3-1 (Fig. 10A); II: 7(+1 ω)-2-3-3-1 (Fig. 10B); III: 7-2-2-2-1 (Fig. 10C) and IV: 7-2-1-2-0 (Fig. 10D). Length of leg I 145 (105–145); leg II 119 (90–119); leg III 117 (104–123) and leg IV 105 (96–120). Length of tarsus I 19 (12–19) and 9 (8–9) width; length of solenidion ωI 7 (6–8); length *tc'* ζ 51 (33–51); *tc''* ζ 50 (32–50); length of seta *k* 1 (1–3).

Type material

Female holotype and four female paratypes collected in nests of *T. fiebrigi*, as follows: Holotype, Bom Princípio, Rio Grande do Sul, Brazil, October 09, 2018, L. Rodighero. One paratype female, Porto Alegre, Rio Grande do Sul, Brazil, September 19, 2018, T. Da-Costa. One paratype

female, Porto Alegre, Rio Grande do Sul, Brazil, September 21, 2018, T. Da-Costa. One paratype female, Rolante, Rio Grande do Sul, Brazil, October 17, 2018, L. Rodighero. One paratype female, Santa Maria, Rio Grande do Sul, Brazil, January 22, 2019, L. Rodighero. Female holotype deposited at the Departamento de Entomologia e Acarologia, Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo (ESALQ/USP), Piracicaba, São Paulo, Brazil. One paratype female deposited at the Technological Science Museum of the Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Rio Grande do Sul, Brazil. Others paratypes were deposited at the Natural Science Museum (ZAUMCN) of the University of Vale do Taquari – Univates, Lajeado, Rio Grande do Sul, Brazil.

Male. not found.

Etymology

The name *dorsoreticulatus* derives from the characteristic dorsal ornamentation that distinguishes it from the other species.

Remarks

This new species resembles *Proctotydaeus* (*Oriolella*) *lindquisti* Kaźmierski, 1998, with dorsal setae serrated, apophysis on femur IV and setae *u* minute. However, it differs by having a dorsal shield reticulated instead of totally striated. Seta *c1* and *d1* short (10 and 10, respectively) instead of long (30 and 31). In addition, bothridial setae (*bo*) are strongly serrated with a slight distal expansion instead of whip-like and eupathidium $p\zeta$ is distally semilunar instead of cleft.

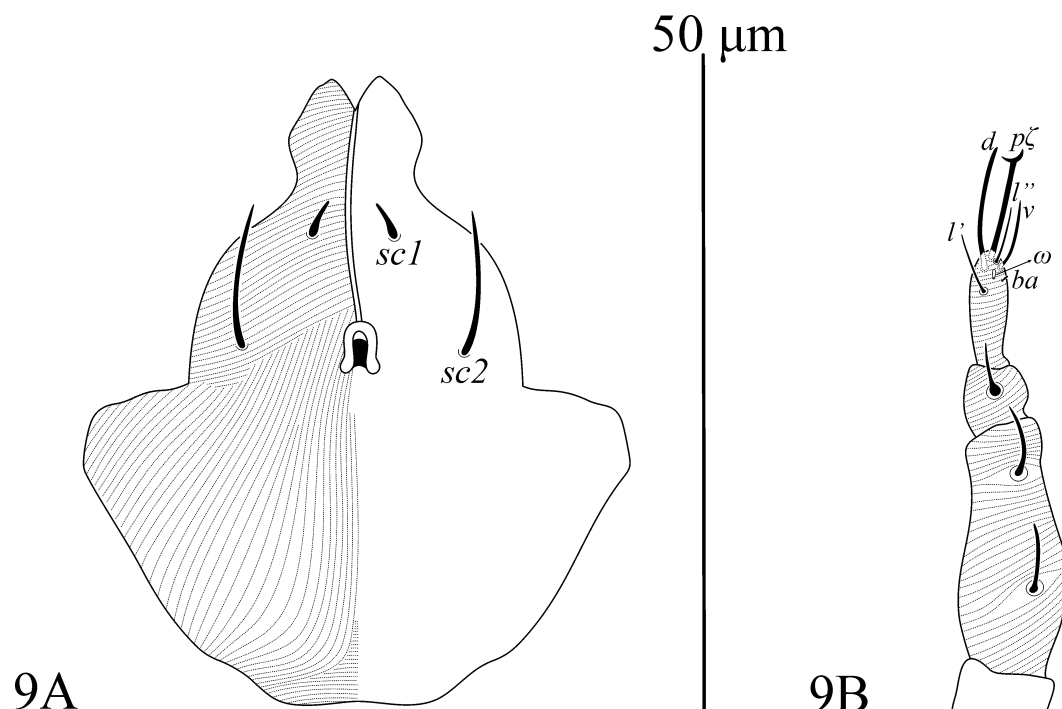


FIGURE 9. *Proctotydaeus* (*Oriolella*) *dorsoreticulatus* sp. nov., female (holotype). (A) Gnathosoma in ventral view. (B) Palptarsus.

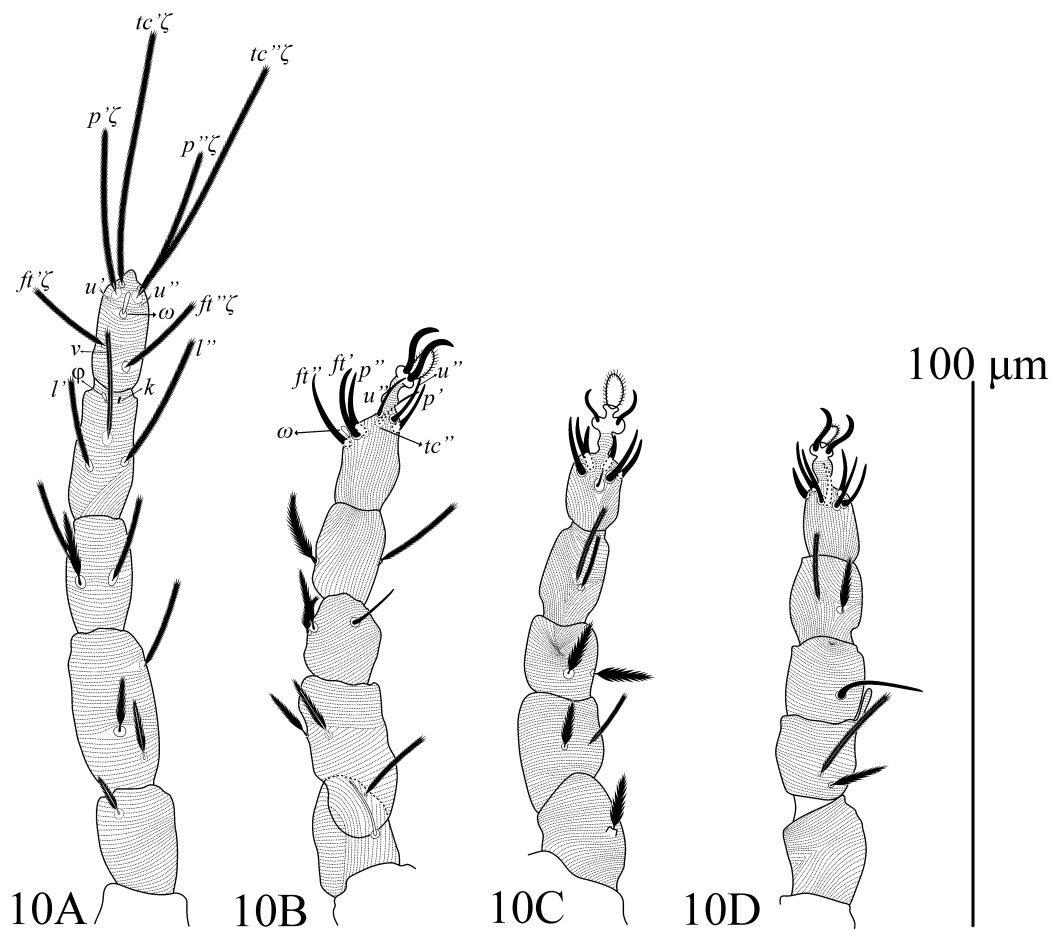


FIGURE 10. *Proctotydaeus (Oriolella) dorsoreticulatus* sp. nov., female (holotype). (A) leg I. (B) leg II. (C) leg III. (D) leg IV.

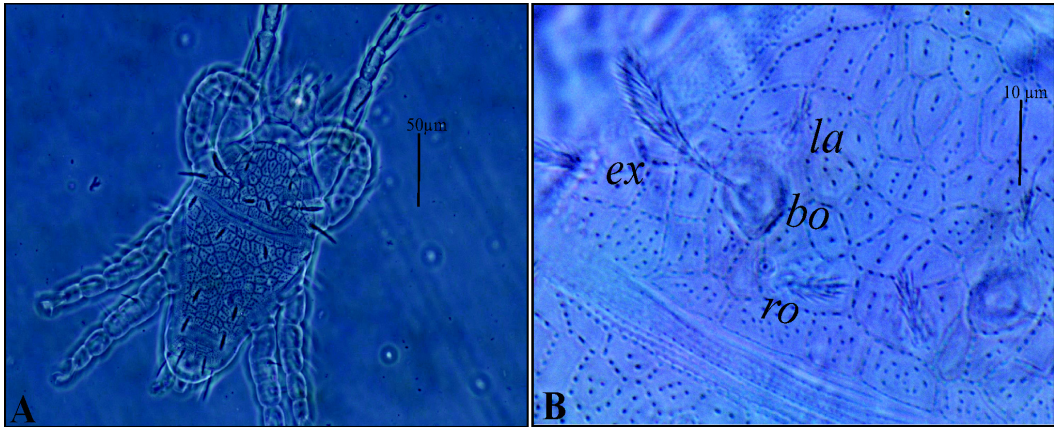


FIGURE 11. *Proctotydaeus (Oriolella) dorsoreticulatus* sp. nov. (A) Dorsum. (B) Reticulation between *la*, *bo*, *ro* and *ex*.

***Proctotydaeus (Oriolella) quadrifasciatae* Da-Costa, Rodighero & Ferla sp. nov.**

(Figs 12–15)

Diagnosis

Prodorsum procurved, dorsum and venter with serrated setae. Dorsal and ventral ornamentation entirely striated. Trichobothria serrated and setae *la* small. Palptarsus with eupathidium $\rho\zeta$ distally semilunar.

Description

Adult female (n = 4)—Body of medium size, oval. Length of idiosoma 245 (210–252), width 125 (113–125).

Dorsum (Fig. 12)—Dorsum with 13 pairs of setae (*ro*, *la*, *bo*, *ex*, *c1*, *c2*, *d1*, *e1*, *f1*, *f2*, *h1*, *h2* and *ps1*). Eyes absent. Dorsum completely covered with striae; prodorsum procurved with irregular longitudinal striae between *la*, *bo* and *ro*; striation between *ro*, *c1*, *d1*, *e1*, *f1* and *f2* transverse; striation between *c2*, *h1*, *h2* and *ps1* longitudinal. All dorsal setae serrate. Bothridial setae (*bo*) distally serrated. Lyrifissures *ia* located between setae *c1* and *d1*, *im* situated between setae *e1* and *f1*, *ip* situated close to *f1*. Lengths of dorsal setae: *ro* 9 (9–11); *la* 5; *bo* 33 (31–46); *ex* 14 (14–18); *c1* 10 (10–16); *c2* 19 (15–19); *d1* 11 (11–16); *e1* 16 (13–17); *f1* 13 (11–16); *f2* 18 (18–21); *h1* 13 (13–15); *h2* 17 (17–18); *ps1* 12. Distances between dorsal setae: *ro-ro* 20 (17–20); *la-la* 34 (31–37); *bo-bo* 36 (34–39); *c1-c1* 44 (34–44); *c2-c2* 125 (102–125); *d1-d1* 33 (30–34); *e1-e1* 46 (35–46); *f1-f1* 38 (28–38); *f2-f2* 60 (48–60); *h1-h1* 34 (23–34); *h2-h2* 49 (37–49); *ro-la* 22 (21–22); *c1-d1* 55 (51–55); *d1-e1* 38 (31–38); *e1-f1* 25 (25–32); *f1-f2* 16 (16–21); *h1-h2* 11 (8–11).

Venter (Fig. 13)—All ventral setae serrated (excluding *ps3*) and venter completely striated. Ventral setae similar in shape to dorsal setae. Longitudinal striae between *pt*, *mta* and *mt β* . Lyrifissures *ih* located posteroventrally. Epimeral formula: 3-1-4-2. Measurements of setae: *pt* 10 (8–10); *mta* 11 (10–11) and *mt β* 12 (10–12). Four pairs of aggenital setae (*ag1*, *ag2*, *ag3* and *ag4*) and two pairs of pseudanal setae (*ps2* and *ps3*). Setal lengths: *ag1* 8 (8–9); *ag2* 9 (8–10); *ag3* 8 (8–10); *ag4* 9 (9–10); *ps2* 17 (16–20) and *ps3* 7 (7–8).

Gnathosoma (Fig. 14A–B)—Length 54 (49–54), width 41 (37–41). Gnathosoma visible from above. Subcapitulum with transverse striae between *sc1* and longitudinal striae behind *sc2*. Infracapitular setae simple. Setal lengths: *sc1* 9; *sc2* 12 (11–12) (Fig. 14A). Palp 37 (29–37) long, setation 6(+1 ω)-1-2. Palptarsus with eupathidium $\rho\zeta$ distally semilunar (Fig. 14B), *ba* and ω very small. Cheliceral stilettos 14 long.

Legs (Fig. 15A–D)—Tarsi I without apotele and claws, tarsi II–IV with two claws and hairy empodium. Setae *u'*, *u''* on tarsus I bifurcate and setae κ bifurcate. Chaetotaxy of legs I–IV (tarsus to trochanter): I: 8(+1 ω)-3(+1 ϕ +1 κ)-3-3-1 (Fig. 15A); II: 7(+1 ω)-2-3-3-1 (Fig. 15B); III: 7-2-2-2-1 (Fig. 15C) and IV: 7-2-1-2-0 (Fig. 15D). Length of leg 133 (114–136); leg II 155 (121–158); leg III 137 (133–147) and leg IV 149 (127–152). Length of tarsus I 17 (14–17) and 11 (10–11) width; length of solenidium ωI 5 (4–6); length *tc'* ζ 27 (27–31); *tc''* ζ 29 (27–30); length of seta *k* 1 (1–2).

Type material

Female holotype and three female paratypes collected in brood cells of *M. quadrifasciata*, as follows: Holotype, Porto Alegre, Rio Grande do Sul, Brazil, September 28, 2018, L. Rodighero. Three paratype females, Ijuí, Rio Grande do Sul, Brazil, March 01, 2019, T. Da-Costa. Female holotype deposited at the Departamento de Entomologia e Acarologia, Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo (ESALQ/USP), Piracicaba, São Paulo, Brazil. One paratype female deposited at the Technological Science Museum of the Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Rio Grande do Sul, Brazil. Other

paratypes were deposited at the Natural Science Museum (ZAUMCN) of the University of Vale do Taquari – Univates, Lajeado, Rio Grande do Sul, Brazil.

Male. not found.

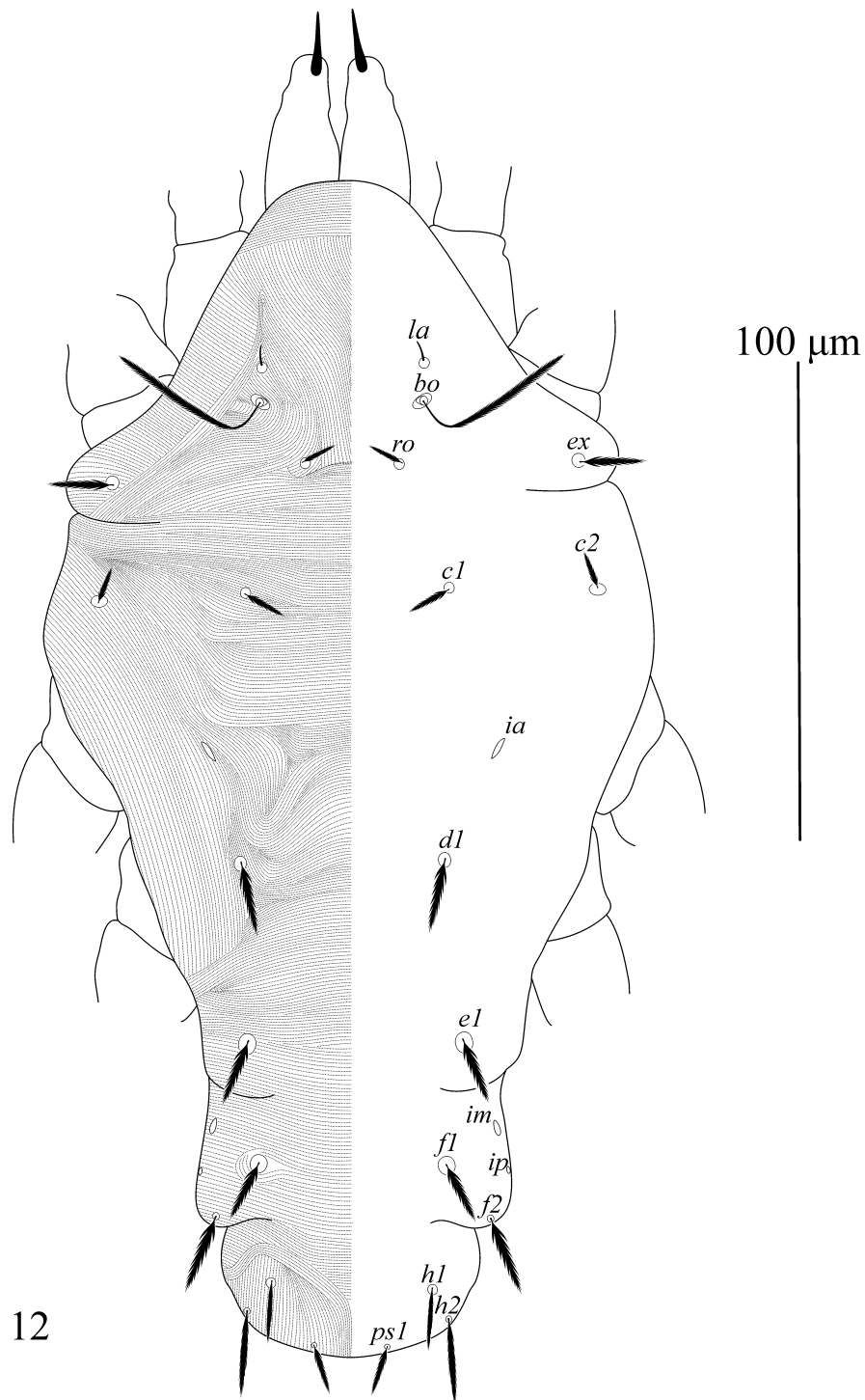


FIGURE 12. *Proctotydaeus (Oriolella) quadrifasciatae* sp. nov., female (holotype) in dorsal view.

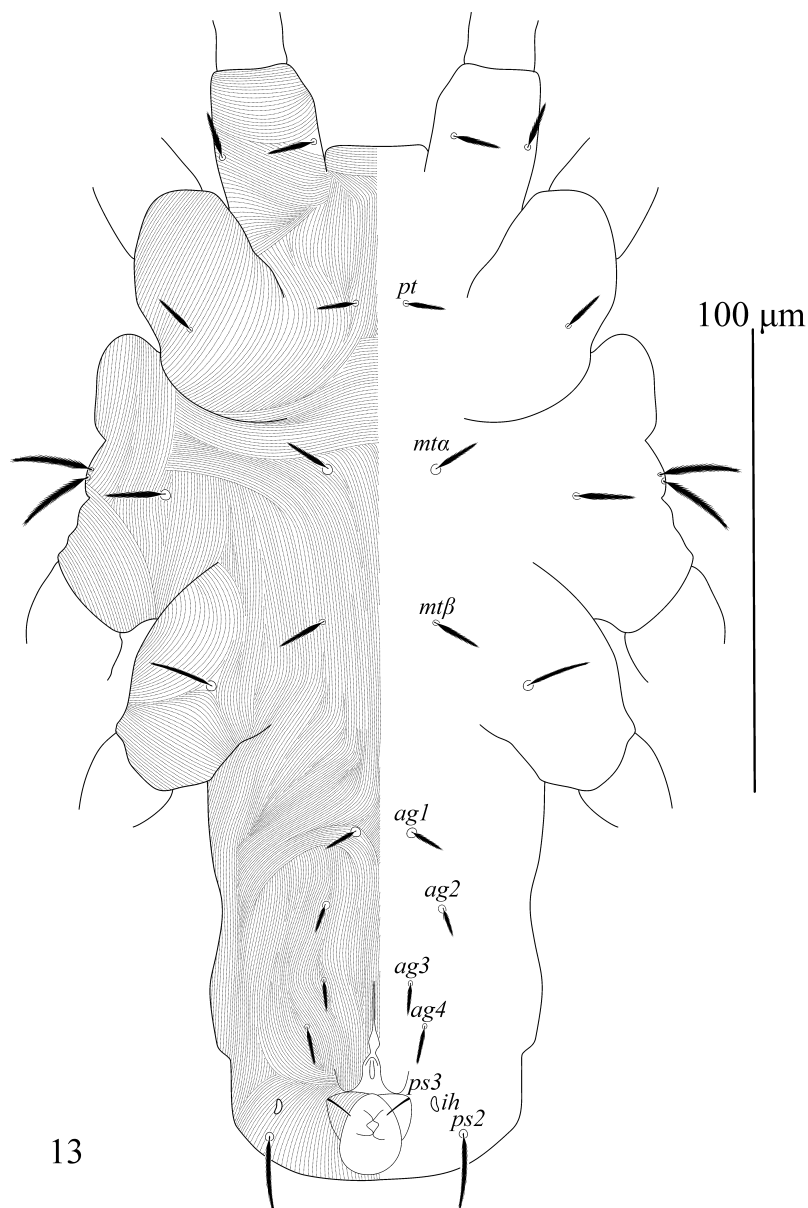


FIGURE 13. *Proctotydaeus (Oriolella) quadrifasciatae* **sp. nov.**, female (holotype) in ventral view.

Etymology

The name *quadrifasciatae* originated from the name of its stingless bee host species *M. quadrifasciata*.

Remarks

This new species resembles *Proctotydaeus (Oriolella) polonicus* Kaźmierski, 1998, with dorsal setae serrated and dorsal shield striated. Nevertheless, it differs because bothridial setae (*bo*) are distally serrated and short (33) instead of whip-like and long (76). Setae *ro*, *c1* and *h2* short (9, 10 and 17, respectively) instead of long (26, 31 and 64, respectively). In addition, eupathidium $\rho\zeta$ is distally semilunar instead of cleft.

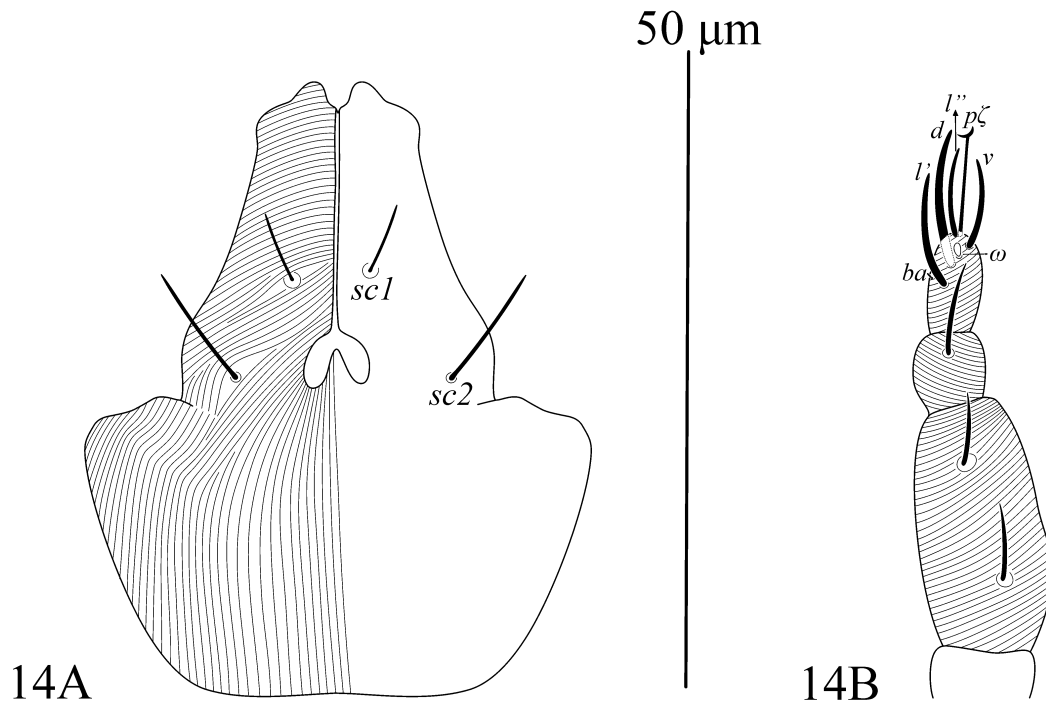


FIGURE 14. *Proctotydaeus (Oriolella) quadrifasciatae* sp. nov., female (holotype). (A) Gnathosoma in ventral view. (B) Palptarsus.

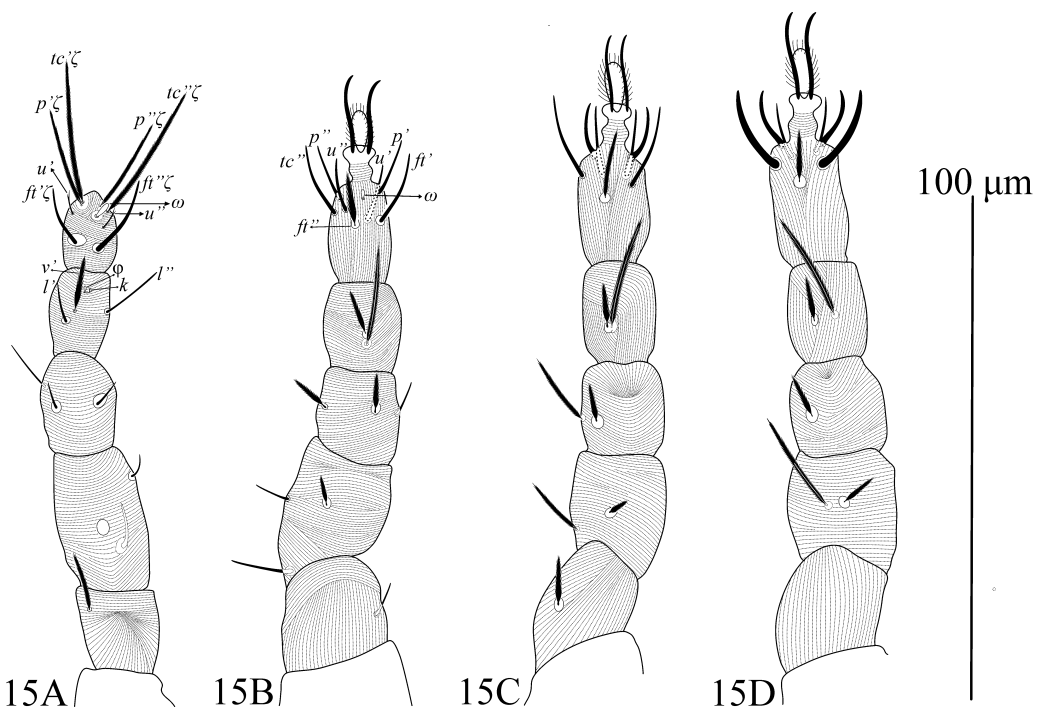


FIGURE 15. *Proctotydaeus (Oriolella) quadrifasciatae* sp. nov., female (holotype). (A) leg I. (B) leg II. (C) leg III. (D) leg IV.

Discussion

Iolinidae presents a high diversity of characters based on dorsal chaetotaxy, palp, legs and epimeral formula (Ripka *et al.* 2013; Darbemamieh *et al.* 2015; Ahmad-Hosseini *et al.* 2017). Other morphological characteristics, such as dorsal ornamentation, shape and size of dorsal setae, are also important characters for species differentiation.

Kaźmierski (1998) revised *Proctotydaeus*, distinguishing it as the largest genus within Pronematinæ and differentiated it by the presence of bothridial setae club-like and whip-like, femur IV divided or not, presence or absence of *ps2*. The same author highlighted important morphological characteristics for the classification of each subgenus. However, in this study, we observed some limitations for the subgenus *Proctotydaeus*. Our species showed distinct characteristics, never described for the genus, such as the presence of *ps2* in the subgenus *Neotydeolus*, reticulation in the dorsal shield and different shapes of bothridial setae in subgenus *Oriolleta*.

From these observed characteristics, we classified these species according to subgenus due to the larger number of characters that resembled them. André (1980) comments that *Proctotydaeus* presents evolutionary variations in the chaetotaxy, and the absence of *ps2* in the subgenus *Neotydeolus* makes it identical to the genus *Naudea*. The other characteristics (reticulation of prodorsal shield and shape of bothridial setae) observed in these species may be a result of their life history and habit, as Iolinidae is characterized by a high evolutionary rate and low diversification (André & Fain 2000). Therefore, the description of three new species of *Proctotydaeus* aims to better understand the distribution, taxonomy and ecological niches of these mites.

Acknowledgments

The authors are grateful to University of Vale do Taquari – Univates for providing all the necessary material during the study and for the scholarship awarded to LFR. The authors are grateful to the Conselho Nacional do Desenvolvimento Científico e Tecnológico (CNPq) for the research productivity scholarship given to BB and NJF. This study was partly financed by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

References

- Ahmad-Hosseini, M., Khanjani, M. & Karamian, R. (2017) A new species of *Neopronematus* and a re-description of *Pronematus rykei* Meyer & Rodrigues (Acari: Iolinidae) from Iran. *Zootaxa*, 4337, 493–508.
<https://doi.org/10.11646/zootaxa.4337.4.2>
- André, H.M. (1979) A generic revision of the family Tydeidae (Acari: Actiniedida). I. Introduction, paradigms and general classification. *Annales de la Societe royale Zoologique de Belgie*, 108, 189–208.
- André, H.M. (1980) A generic revision of the family Tydeidae (Acari: Actiniedida). IV. Generic descriptions, keys and conclusions. *Annales de la Societe royale Zoologique de Belgie*, 116, 103–168.
- André, H.M. & Fain, A. (2000) Phylogeny, ontogeny and adaptive radiation in the superfamily Tydeoidea (Acari: Actiniedida), with a reappraisal of morphological characters. *Zoological Journal of the Linnean Society*, 130, 405–448.
<https://doi.org/10.1111/j.1096-3642.2000.tb01636.x>
- Baker, E.W. (1965) A review of the genera of the family Tydeidae (Acarina). *Advances in Acarology*, 2, 95–133.
- Baker, E.W. (1968) Two new genera of Tydeidae (Acarina). *Annals of the Entomological Society of America*, 61, 968–970.
<https://doi.org/10.1093/aesa/61.4.968>
- Berlese, A. (1911) Acarorum species novae quindecim. *Gen. Proctotydaeus n. gen. Redia*, 7, 430–431.

- Darbemamieh, M., Hajiqanbar, H., Khanjani, M. & Kaźmierski, A. (2015) New species and records of *Neopronematus* (Acari: Iolinidae) from Iran with a key to world species. *Zootaxa*, 3990, 235–246. <https://doi.org/10.11646/zootaxa.3990.2.4>
- Fain, A. & Evans, G.O. (1966) The genus *Proctotydaeus* Berl. (Acari: Iolinidae) with descriptions of two new species. *Annals and Magazine of Natural History*, 9, 149–157. <https://doi.org/10.1080/00222936608651647>
- Flechtmann, C.H. & Camargo, C.A. (1974) Acari associated with stingless bees (Meliponidae, Hymenoptera) from Brazil. *Proceedings of the 4th International Congress of Acarology*, 315–319.
- Gerson, U., Smiley, R.L. & Ochoa, R. (2003) *Mites (Acari) for pest control*. Oxford, UK, Blackwell Science, 540 pp.
- Kaźmierski, A. (1998) A review of the genus *Proctotydaeus* Berlese (Actiniedida: Tydeidae: Pronematinae). *Acarologia* 39, 33–47.
- Khaustov, A.A. (1997). Two new species of mites of the genus *Proctotydaeus* (Acariformes, Tydeidae) from Crimea and North Eastern Ukraine. *Vestnik Zoologii*, 90–93. (In Russian)
- Kramer, P. (1877) Grundzuge zur Systematik der Milben. *Arch. Naturgesch*, 2, 215–247.
- Krantz, G.W. (1978) *A Manual of Acarology*, 2nd ed. Corvallis, OR, USA. Oregon State University Book Stores, 509 pp.
- Kuznetsov, N.N. & Livshitz, L.Z. (1973) Some new Tydeid species (Acariformes, Tydeidae) of Crimean fauna. *Nauchnye Doklady Vysshei Shkoly Biologicheskii Nauki*, 8, 13–18.
- Meyer, M.K.P. & Rodrigues, M.C. (1966) Acari associated with cotton in Southern Africa (reference to other plants). *Garcia de Orta*, 13, 1–33.
- Momen, F. (1990) A new species of tydeid mite (Acari: Tydeidae) associated with rusty grain beetle on dried wheat. *Entomologische Mitteilungen aus dem Zoologischen Staatsinstitut und Zoologischen Museum Hamburg*, 10, 19–24.
- Oudemans, A.C. (1931) Acarologische aantekeningen CVIII. *Entomologisches Berichten*, 8, 251–263.
- Panou, H., Emmanouel, N.G. & Kazmierski, A. (2000) *Neopronematus*, a new genus of the subfamily Pronematinae (Acari: Prostigmata: Tydeidae) and a new species from Greece. *Acarologia*, 41, 321–325.
- Price, D.W. (1972) A new iolinid mite from the Galapagos Islands (Acarina: Iolinidae). *Annals of the Entomological Society of America*, 65, 793–796. <https://doi.org/10.1093/aesa/65.4.793>
- Pritchard, A.E. (1956) A new superfamily of trombidiform mites with the description of a new family, genus and species (Acarina: Iolinoidea: Iolinidae: Iolina nana). *Annals of the Entomological Society of America*, 49, 204–206. <https://doi.org/10.1093/aesa/49.3.204>
- Ripka, G., Laniecka, I. & Kazmierski, A. (2013) On the arboreal acarofauna of Hungary: Some new and rare species of prostigmatic mites (Acari: Prostigmata: Tydeidae, Iolinidae and Stigmaeidae). *Zootaxa*, 3702, 1–50. <https://doi.org/10.11646/zootaxa.3702.1.1>
- Rosa, A.E. & Flechtmann, C.H.W. (1983) Acari domum meliponinarum brasiliensium habitantes. III. *Proctotydaeus partamonae*, sp. n. (Acari: Acariformes, Tydeidae). *Revista Brasileira de Biologia*, 43, 273–276.
- Rosa, A.E., André, H. & Flechtmann, C.H.W. (1985) Acari domum meliponinarum brasiliensium habitantes. 8. *Proctotydaeus alvearii* sp. n. (Acari: Acariformes: Tydeidae). *Revista Brasileira de Biologia*, 45, 79–83.
- Sadeghi, H., Laniecka, I. & Kaźmierski, A. (2012) Tydeoid mites (Acari: Triophtydeidae, Iolinidae, Tydeidae) of Razavi Khorasan province, Iran, with description of three new species. *Annales Zoologici*, 62, 99–114. <https://doi.org/10.3161/000345412X633685>
- Theron, N., Roets, F., Dreyer, L.L., Esler, K.J. & Ueckermann, E.A. (2012) A new genus and eight new species of Tydeoidea (Acari: Trombidiformes) from *Protea* species in South Africa. *International Journal of Acarology*, 38, 257–273. <https://doi.org/10.1080/01647954.2011.619576>
- Treat, A.E. (1961) A tydeid mite from noctuid moths. *Acarologia*, 3(2), 147–152.
- Ueckermann, E.A. & Meyer, M.K.P.S. (1988) South African Acari. IV. Some mites of the Addo Elephant National Park. *Koedoe*, 31, 31–51. <https://doi.org/10.4102/koedoe.v31i1.483>
- Zhang, Z.Q., Fan, Q.H., Pesic, V., Smit, H., Bochkov, A.V., Khaustov, A.A., Baker, A., Wohltmann, A., Wen, T., Amrine, J.W., Beron, P., Lin, J., Gabryś, 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. <https://doi.org/10.11646/zootaxa.3148.1.24>

Submitted: 23 Jan. 2020; accepted by Eddie Ueckermann: 6 Apr. 2020; published: 15 Jun. 2020