

Article

Morphotaxonomic Assessment of the *pratensis* Species Complex with Ontogenetic Development and Redescription of *Oligonychus pratensis* (Banks) (Acari: Prostigmata: Tetranychidae)

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Abstract: The Banks grass mite/New World date mite, *Oligonychus pratensis* (Banks) (Acari: Prostigmata: Tetranychidae), is a globally distributed and economically significant agricultural pest. The present study comprehensively addresses the morphotaxonomic identification of globally reported populations of *O. pratensis*, to resolve ambiguities within the *pratensis* complex. Detailed morphological characterizations of all mobile stages (larva, protonymph, deutonymph, male, and female) of the Californian population of *O. pratensis* were provided, with key diagnostic traits utilized in this taxonomic assessment. The taxonomic notes are provided for worldwide populations of *O. pratensis* reported from six biogeographic realms. The taxonomic identity of the claimed populations of *O. pratensis* from South Africa (Afrotropical realm), El Salvador (Neotropical realm), China, Pakistan (Oriental realm), and Saudi Arabia (Palearctic realm) were found to either be “doubtful” or exhibit notable differences compared to the Californian population. Notably, the purported Chinese population of *O. pratensis* was identified as a cryptic species, likely a novel taxon within the *gossypii* species subgroup. Furthermore, the study confirmed the absence of *O. pratensis* in Saudi Arabia. Additionally, ontogenetic changes across developmental stages are documented. The findings of this study may contribute to a clearer understanding of the true distribution and global occurrence of *O. pratensis*, providing robust diagnostic characteristics to support future research.

Keywords: banks grass mite; intraspecific variations; morphology; new world date mite; species complex; species identification; spider mites; taxonomy



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1. Introduction

The Banks grass mite/New World date mite, *Oligonychus pratensis* (Banks) (Acari: Prostigmata: Tetranychidae), belongs to the subgenus *Reckiella* Tuttle & Baker and the species group/subgroup *exsicicator* sensu Mushtaq et al. [1]. It is a serious pest of date fruit, grasses, maize, wheat, sorghum, and sugar cane in the New World [2,3]. It was first described in Pullman, Washington, United States (type locality) on Timothy grass (*Phleum pratense* L., Poaceae; type host) [4]. To date, it has been reported on approximately 83 host plants from 13 families (Arecaceae, Cucurbitaceae, Cyperaceae, Euphorbiaceae, Juglandaceae, Malvaceae, Moraceae, Poaceae, Rosaceae, Rubiaceae, Sapindaceae, Solanaceae, Zygophyllaceae) and is distributed across 17 localities in six biogeographic realms: Afrotropical, Australasian, Nearctic, Neotropical, Oriental, and Palearctic [5].

The distribution of *O. pratensis* in some localities (e.g., China, Egypt, Pakistan, Saudi Arabia, South Africa, and Syria) remains uncertain due to the involvement of the *pratensis* species complex (cryptic/sibling species) and possible taxonomic misidentification arising

from observed morphological variations in male and female characteristics. Additionally, many descriptions are based on brief accounts of females and, in some cases, without male specimens [1,6–13]. The taxonomic identification of *O. pratensis* depends on the morphology of the male aedeagus, a feature potentially used to differentiate it from other closely related species [6,7,13–17]. However, the improper mounting of male specimens could jeopardize the significance of the aedeagal morphology for species differentiation [1]. This could explain the intraspecific variations in aedeagus shape detected in this and previous studies among different populations of *O. pratensis* described from various geographical regions [2,6,7,9,14–21].

In the original description by Banks [4], *O. pratensis* was briefly described solely based on female specimens, as males were unknown at the time, a fact later confirmed by McGregor [22]. In subsequent descriptions from various localities, males of *O. pratensis* either remained unknown (e.g., [8]), or the male slide was lost [7], or traits of the male aedeagus varied across populations [6]. In other instances, males were described briefly, sometimes without illustrating the aedeagus [10,16,19,20,23,24]. Despite exhibiting intraspecific variations, *O. pratensis* has been reported in some localities (e.g., [10,11,24]), without providing critical character information or making comparisons with the original or subsequent descriptions from the United States, the species' type locality [2,4,6,17,18,22,25,26]. Moreover, it has been revealed that some purported populations of *O. pratensis* from China [9] and Saudi Arabia [1,10] were taxonomically misidentified [1,12,27].

Given the challenges associated with the taxonomic identification of *O. pratensis*, an economically significant and widely distributed spider mite pest, the objectives of this study were to (i) assess the current taxonomic status of globally reported populations of *O. pratensis* and (ii) provide a comprehensive morphological redescription, including its ontogenetic development, based on fresh samples from California, United States, the species' type locality.

2. Materials and Methods

The complete taxonomic literature on *O. pratensis* published globally from 1912 to 2023 was compiled using various search engines, websites, acarological and entomological research journals, and personal communications with acarologists worldwide. This literature, including descriptions, illustrations, and diagnostic keys of all globally reported populations of *O. pratensis* e.g., [1,2,4,6–10,12–21,24], was critically reviewed to confirm its actual geographical distribution and discuss issues related to cryptic species within the *pratensis* species complex. Additionally, we contacted authors who reported *O. pratensis* from different countries to resolve the taxonomic identity of the *pratensis* complex. However, only one population of laboratory-reared *O. pratensis* (including all developmental stages) was kindly sent by our colleagues from California (United States) [3].

For the full morphological redescription of *O. pratensis*, slide-mounted larval, protonymphal, deutonymphal, and adult (male and female) specimens were examined under a BX51 phase-contrast microscope (Olympus, Tokyo, Japan) at the Acarology Research Laboratory, King Saud University (KSU), Saudi Arabia. Different body parts (including gnathosoma, idiosoma, and legs) were imaged using an auto-montage software system (Syncroscopy, Cambridge, UK) attached to a phase contrast microscope (DM2500, Leica®, Wetzlar, Germany). The captured images were used as templates and illustrated with Adobe Illustrator (Adobe System Inc., San Jose, CA, USA). The generic identification (based on females) was carried out using the diagnostic key by Bolland et al. [28]. The subgenus (based on males) and species groups/subgroups (based on females) were determined following the key of Mushtaq et al. [1], while species-level identification was conducted using the key of Mushtaq et al. [12,13]. Furthermore, the specimens of *O. pratensis*, reported from Riyadh, Saudi Arabia [10], were re-examined to confirm the species' identity through female and male morphological characters. The nomenclature for leg chaetotaxy and other terminologies follows Lindquist [29], and the nomenclature for body setae follows Grandjean [30,31]. Furthermore, various traits of the male aedeagus were measured from the published illus-

trations in an attempt to confirm the taxonomic identity of the globally reported populations of *O. pratensis* [13–18]. All body measurements are provided in micrometers. The slide-mounted specimens of the received Californian population of *O. pratensis* were deposited in the Acarology Section of the King Saud Museum of Arthropods (KSMA), Department of Plant Protection, College of Food and Agriculture Sciences, Riyadh, Saudi Arabia.

3. Results and Discussion

Family Tetranychidae Donnadieu.

Subfamily Tetranychinae Berlese.

Tribe Tetranychini Reck.

Genus *Oligonychus* Berlese.

Type species *Heteronychus brevipodus* Targioni-Tozzetti [32]: 255.

Diagnosis (based on female and male). As defined by Mushtaq et al. [1].

Subgenus *Reckiella* Tuttle and Baker.

Type species *Tetranychus pratensis* Banks [4]: 97.

Diagnosis (based on male). As defined by Mushtaq et al. [1].

Oligonychus (Reckiella) pratensis (Banks [4])

(Figures 1–22)

Tetranychus pratensis Banks, 1912. Banks [4]: 97

Paratetranychus pratensis (Banks, 1912). Banks [33]: 37

Oligonychus pratensis (Banks, 1912). Pritchard & Baker [33]: 349; Baker & Tuttle [17]: 274;

Oligonychus (Reckiella) pratensis (Banks, 1912). Tuttle & Baker [26]: 349; Mushtaq et al. [1]: 106.

Known host plants. 83 host plants belonging to 13 families [5].

Distribution. 17 localities/countries belonging to six biogeographic realms [5].

Diagnosis (based on male and female)—Male: Aedeagus turns dorsad with distinct terminal knob having rounded anterior projection and acute posterior projection, knob with posterior projection about 1.5–1.7 times longer than anterior projection. Knob length distinctly greater than width and height of knob stem. Shaft dorsal margin about 2–2.2 times longer than shaft width and 3 times longer than knob length. Knob axis forming strong acute angle with shaft axis. Empodium I with proximoventral claws, shorter than dorsal empodial claws. **Female:** Tibia I with nine and tibia II with seven tactile setae; peritreme straight with a bulbous end. Opisthosoma medially with transverse striae, except longitudinal to oblique striae pattern in-between setae *f1–f1*, forming irregular or V-shaped pattern posterior to *f1*, dorsal setae slender, serrate, not set on tubercles and longer than longitudinal distances to the bases of setae next-in-line.

3.1. Complete Description of the Californian Population of *O. pratensis*

Female: (Figures 1–4; n = 5)—Length of body (*v2–h2*) 298–390; width (*c3–c3*) 240–315.

Dorsum (Figure 1a–c): Propodosomal shield medially with longitudinal striae; opisthosoma medially with transverse striae except area in-between setae *f1–f1* with distinct patch of longitudinal to oblique striae, forming irregular or V-shaped pattern posterior to *f1* (Figure 1c); lateral idiosoma with longitudinal to oblique striae; dorsal striae with small, semicircular lobes, wider than long (Figure 1b); dorsal setae slender, serrate (including setae *h2* and *h3*, finely serrated), not set on tubercles and longer than longitudinal distances to the bases of setae next-in-line (Figure 1a); setae *h3* located ventrally. Lengths of dorsal setae *v2* 65–72, *sc1* 113–120, *sc2* 82–85, *c1* 97–98, *c2* 97–103, *c3* 90–102, *d1* 92–98, *d2* 98–107, *e1* 95–97, *e2* 96–97, *f1* 80–90, *f2* 82–84, *h2* 41–46. Distances between setal bases: *v2–v2* 59–67,

sc1–sc1 82–89, *sc2–sc2* 175–213, *c1–c1* 69–82, *d1–d1* 68–87, *e1–e1* 81–93, *f1–f1* 30–39, *h2–h2* 31–46, *c1–d1* 67–74, *d1–e1* 46–66, *e1–f1* 56–61, *f1–h2* 65–82.

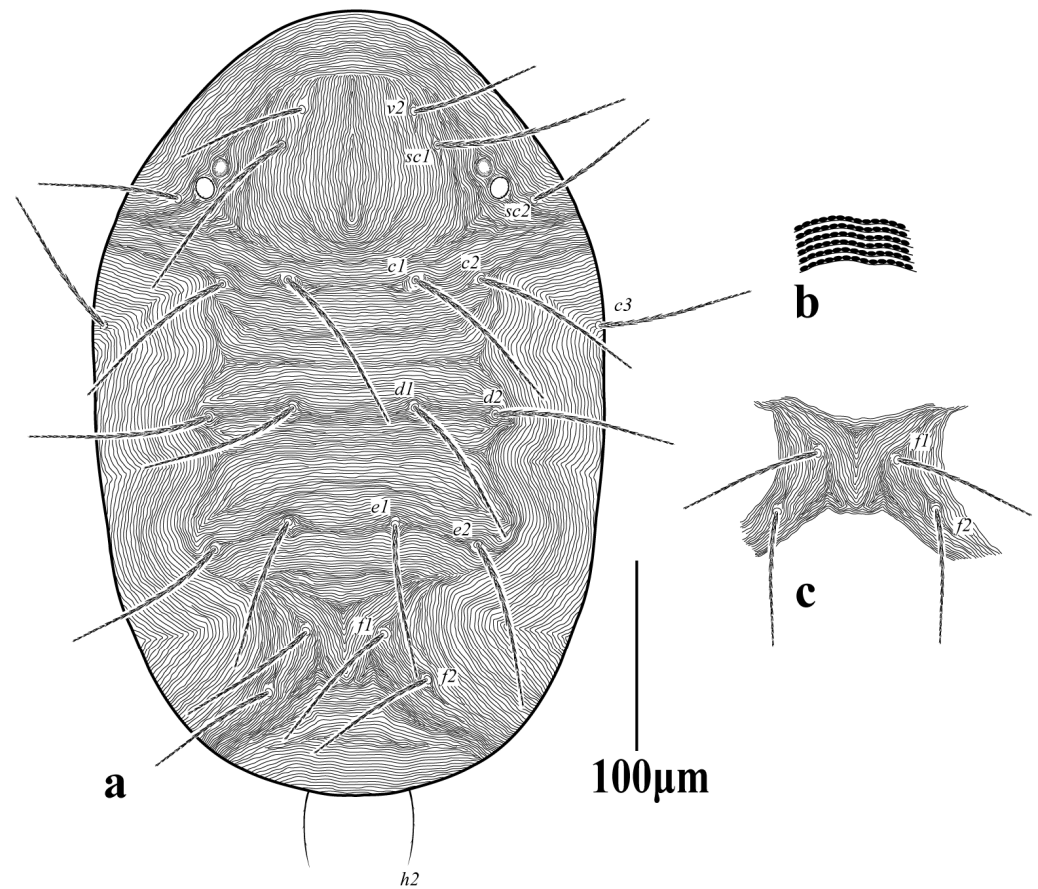


Figure 1. *Oligonychus pratensis*, female, dorsum. (a–c): (a), dorsum; (b), lobes; (c), stria pattern between seta *f1–f1*. Scale bar 100 μ m.

Venter (Figure 2): Coxisternal area between coxae I–II and area between setae *1a–ag* with transverse striae medially, small sized lobes present anterior and posterior to setae *1a*, comparatively large lobes present between setae *3a–ag*; lateral opisthosoma with transverse, longitudinal to oblique lobed striae, pregenital area with longitudinal striae, striae on genital flap transverse between *g1–g1*, oblique posteriorly; Lengths of setae *1a* 40–49, *1b* 57–59, *1c* 59–66, *2b* 57–66, *2c* 73–80, *3a* 41–44, *3b* 51–57, *4a* 53–59, *4b* 56–59, *ag* 49–52, *g1* 34–38, *g2* 34–39, *ps1* 14–19, *ps2* 16–20, *h3* 41–43. Distances between setal bases: *1a–1a* 28–32, *3a–3a* 52–57, *4a–4a* 51–52, *ag–ag* 77–82, *g1–g1* 20–25, *g2–g2* 82–98, *ps1–ps1* 20–24, *ps2–ps2* 16–25.

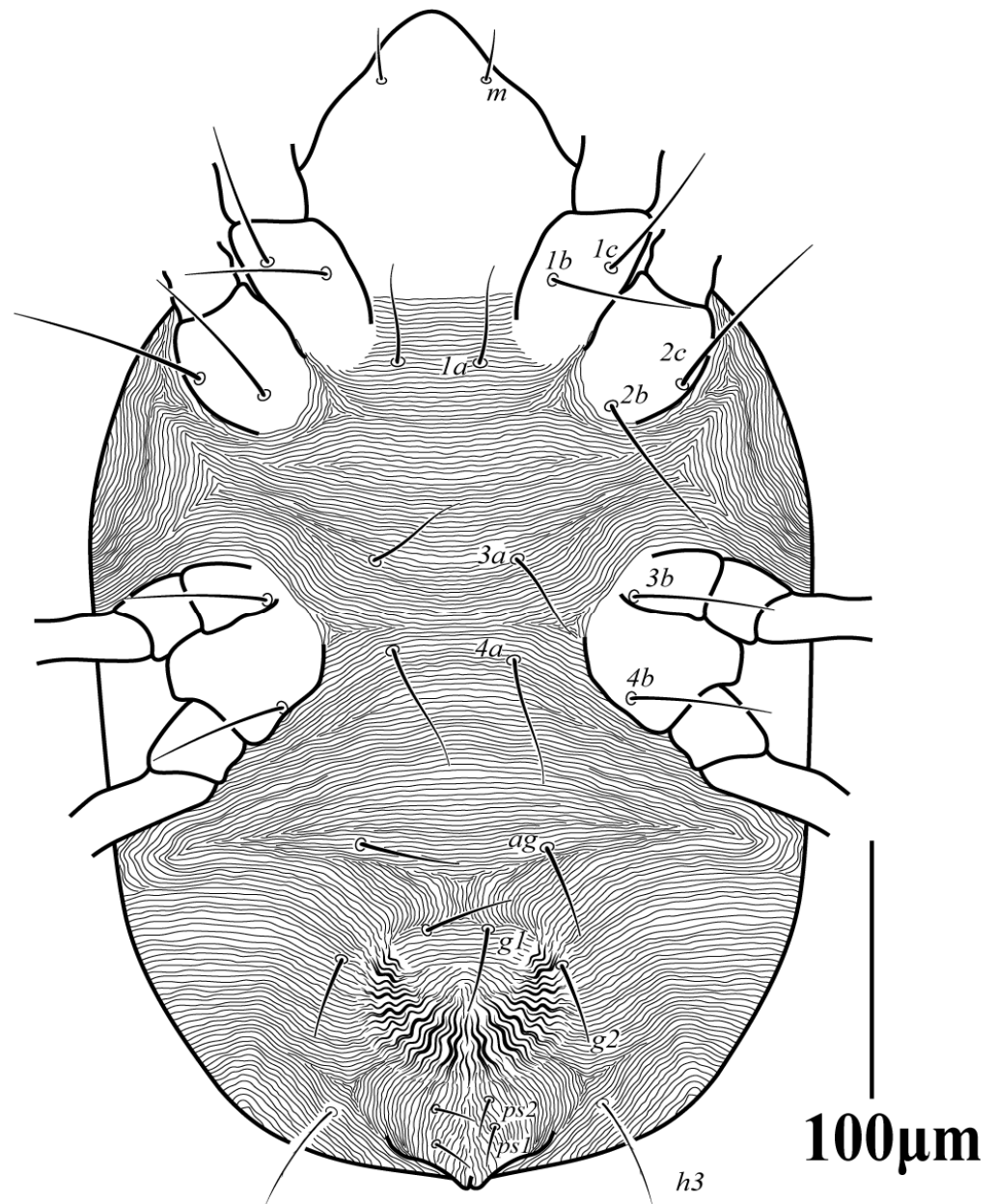


Figure 2. *Oligonychus pratensis*, female, venter. Scale bar 100 μ m.

Gnathosoma (Figure 3a,b): Ventral infracapitulum with setae *m* smooth, long 43–51, subequal to *m–m* 45–52. Palp spinneret *su* ζ 4–4.9 long, width 3–3.3, solenidion 4–6.4 long (Figure 3a). Stylophore rounded anteriorly. Peritreme simple, straight, and oval-shaped or bulbous distally (Figure 3b).

Legs (Figure 4a–d): Length of legs (excluding coxae, from trochanter to tip of claw) leg I 231–246, leg II 172–215, leg III 205–220, leg IV 242–260. Leg segment setal formula as follows: coxae 2-2-1-1; trochanters 1-1-1-1; femora 10-6-4-4; genua 5-5-4-4; tibiae 9(1 ϕ)-7-6-7; tarsi 13(1 ω +2dup)-13(1 ω +1dup)-9(1 ω)-9(1 ω). Tarsus I with four tactile setae behind proximal duplex setae (Figure 4a), and tarsus II with three tactile setae in line with and three tactile and one solenidion behind proximal to duplex setae (Figure 4b). Empodia with three pairs of proximoventral hairs.

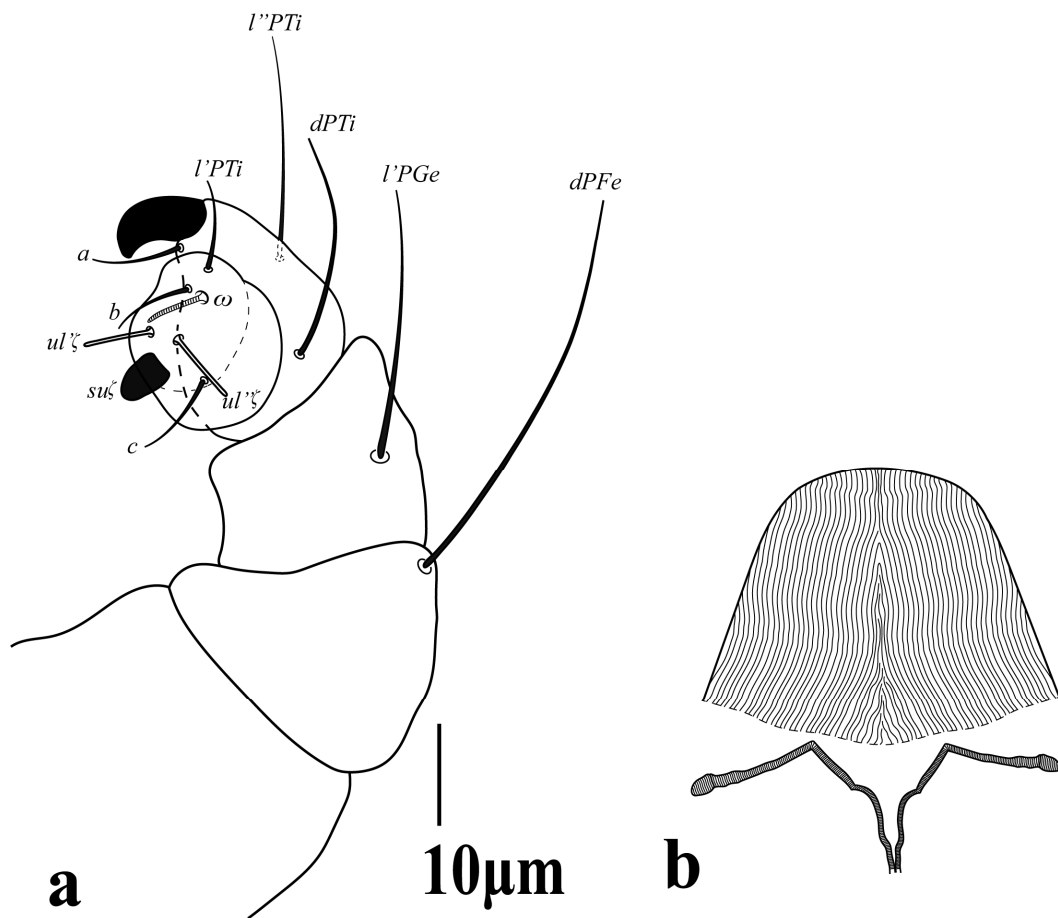


Figure 3. *Oligonychus pratensis*, female gnathosoma. (a,b); (a), palp; (b), stylophore, scale bar 10 μ m.

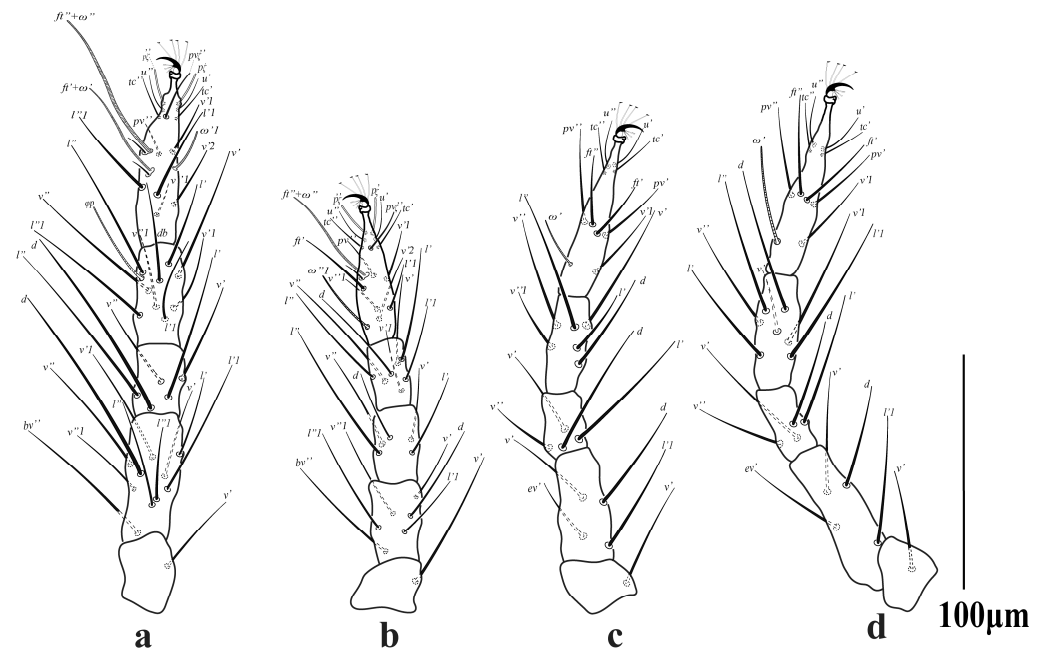


Figure 4. *Oligonychus pratensis*, female legs I–IV, (a–d); right side legs. Scale bar 100 μ m.

Male: (Figures 5–9; $n = 5$)—Length of body ($v2$ – $h2$) 245–340; width ($c3$ – $c3$) 220–240.

Dorsum (Figure 5): Propodosoma medially with longitudinal striae; opisthosoma medially and posteriorly with typical transverse striae or irregular transverse striae in-between

setae *f1* and *f2*; lateral idiosoma with longitudinal to oblique striae; all striae without lobes (Figure 5); dorsal setae slender, serrate (including setae *h2* and *h3*, finely serrated), not set on tubercles and longer than longitudinal distances to the bases of setae next-in-line (Figure 5). Lengths of dorsal setae *v2* 48–56, *sc1* 82–90, *sc2* 53–68, *c1* 65–78, *c2* 59–79, *c3* 66–79, *d1* 59–69, *d2* 71–80, *e1* 52–72, *e2* 55–67, *f1* 48–53, *f2* 41–42, *h2* 26–29, *h3* 16–23. Distances between dorsal setae: *v2*–*v2* 48–54, *sc1*–*sc1* 66–70, *sc2*–*sc2* 152–195, *c1*–*c1* 69–72, *d1*–*d1* 64–67, *e1*–*e1* 33–39, *f1*–*f1* 25–30, *h2*–*h2* 16–18, *c1*–*d1* 51–53, *d1*–*e1* 41–46, *e1*–*f1* 28–47, *f1*–*h2* 31–32.

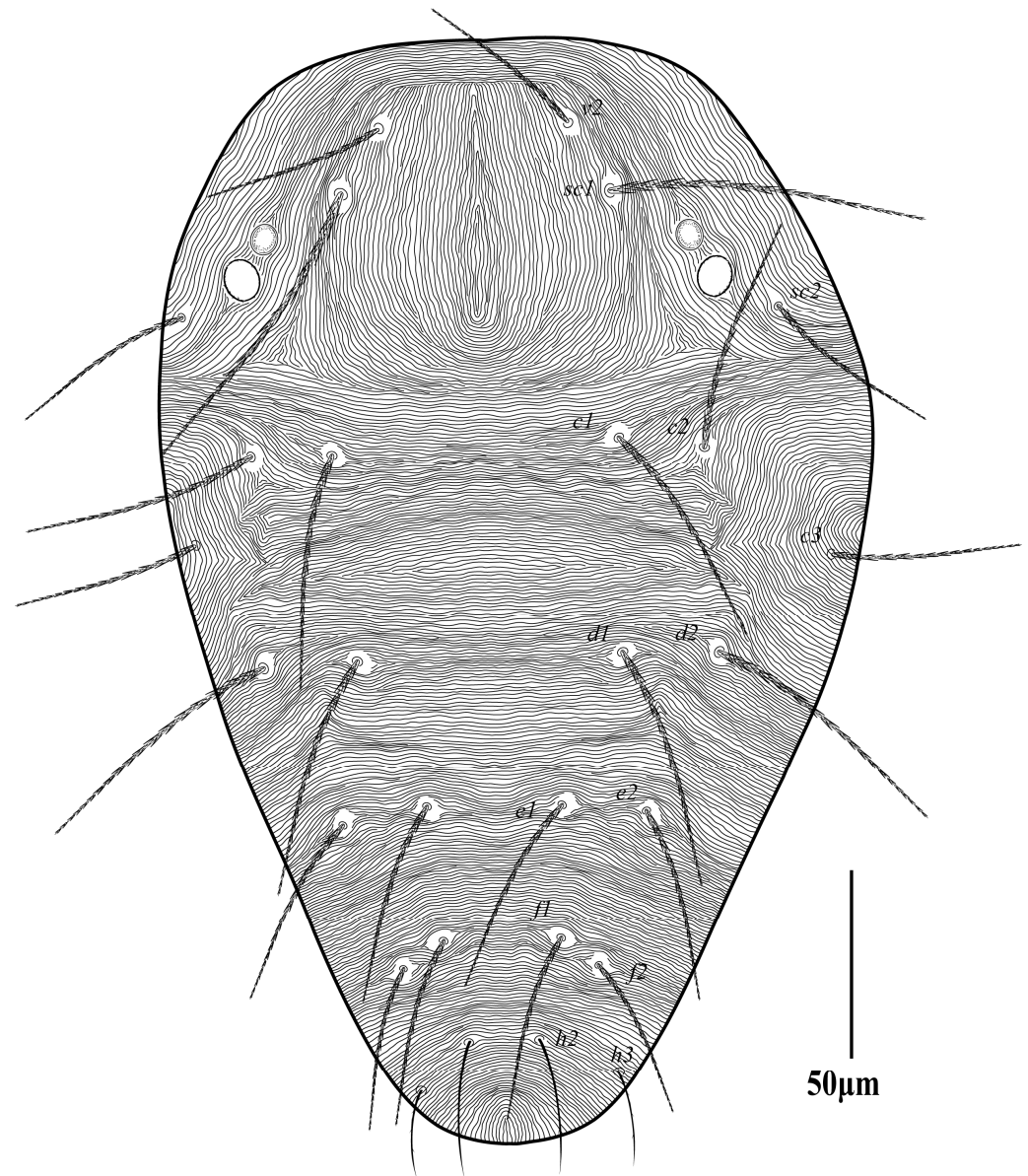


Figure 5. *Oligonychus pratensis*, male, dorsum. Scale bar 50 μ m.

Venter (Figure 6): Ventral integument medially with transverse striae, without lobes. Ventral setae smooth and thin; lengths of setae *1a* 33–39, *1b* 38–43, *1c* 46–48, *2b* 48–56, *2c* 51–57, *3a* 31–36, *3b* 41–50, *4a* 40–44, *4b* 37–48, *ag* 39–45, *g1* 15–21, *g2* 13–20, *ps1* 10–13, *ps2* 13–15. Distances between setal bases: *1a*–*1a* 25–27, *3a*–*3a* 47–48, *4a*–*4a* 41–44, *ag*–*ag* 39–40, *g1*–*g1* 12–16, *g2*–*g2* 23–31, *ps1*–*ps1* 15–20, *ps2*–*ps2* 18–24.

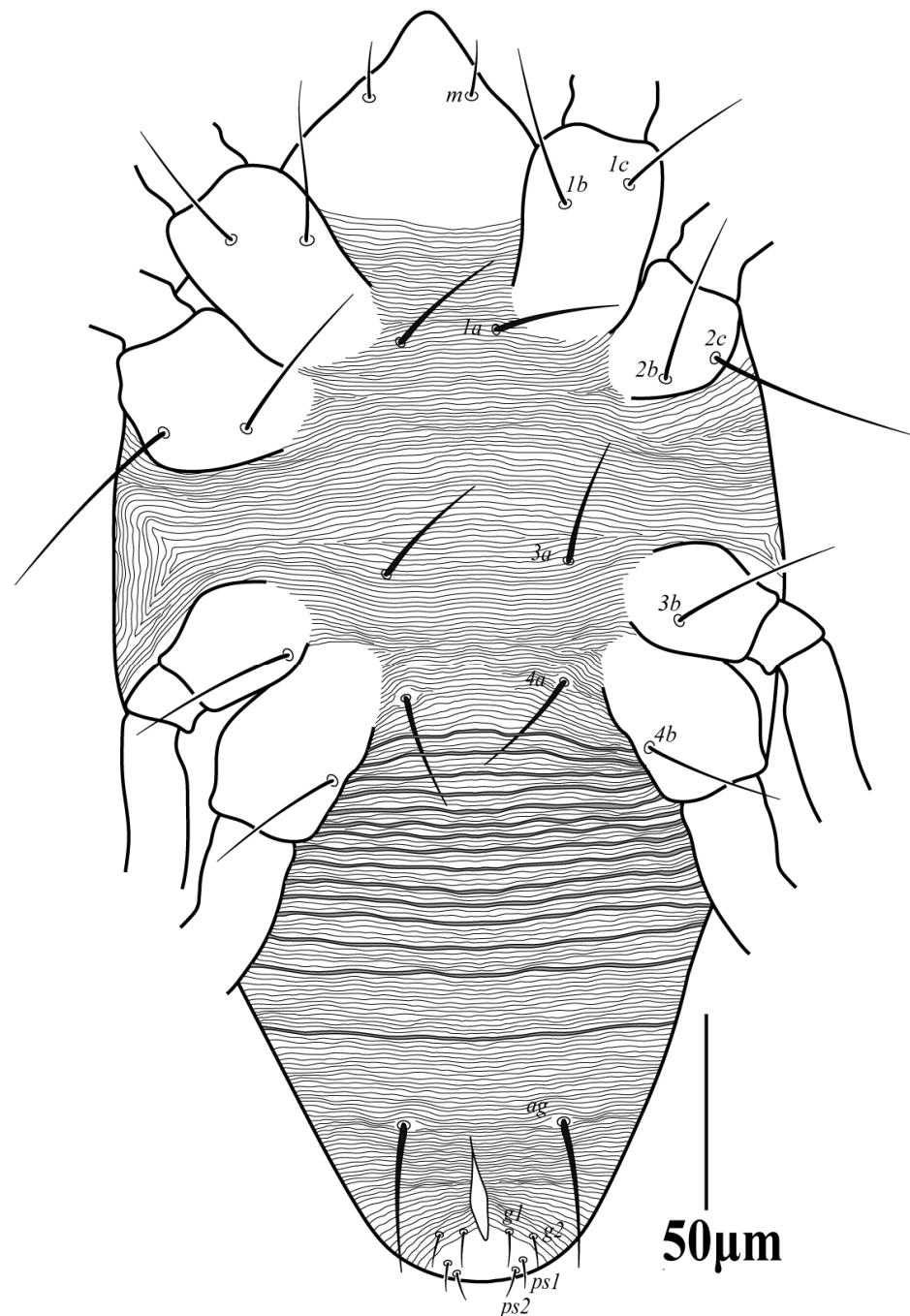


Figure 6. *Oligonychus pratensis*, male, venter. Scale bar 50 µm.

Aedeagus (Figure 7; Table 1): Dorsally directed aedeagus portion with distinct terminal knob having rounded anterior and acute posterior projections. Knob with a posterior projection about 1.5–1.7 times longer than anterior projection. Knob length distinctly greater than width and height of knob stem. Shaft dorsal margin about 2–2.2 times longer than the shaft width and 3 times longer than knob length. Knob axis forming strong acute angle with shaft axis.

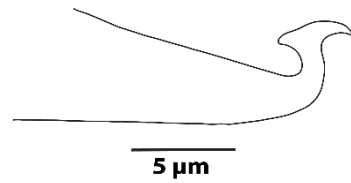


Figure 7. *Oligonychus pratensis*, male, aedeagus. Scale bar 5 μ m.

Gnathosoma (Figure 8a,b): Ventral infracapitulum with seta *m* 34–36, slightly shorter than distance between *m*–*m* 38–41. Palp spinneret *su* ζ 4–4.8 long, width 2.4–3.8, solenidion ω 4.3–5.6 long. Stylophore and peritreme similar to females.

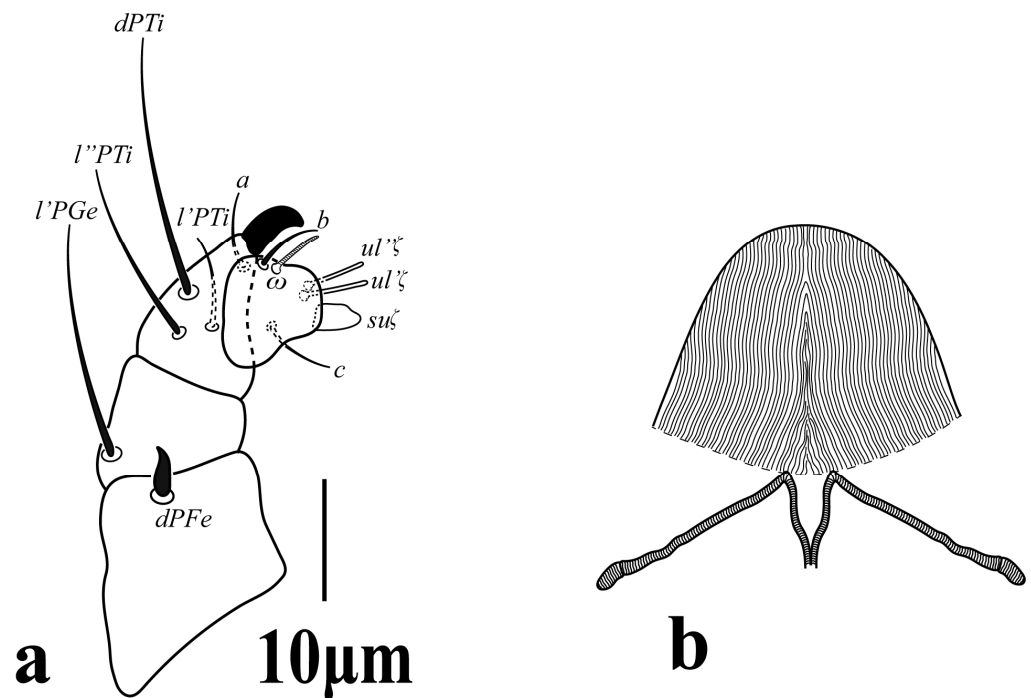


Figure 8. *Oligonychus pratensis*, male gnathosoma: (a,b); (a), palp; (b), stylophore, scale bar 10 μ m.

Legs (Figure 9a–d): Length of legs (excluding coxae, from trochanter to tip of claw) leg I 193–225, leg II 160–171, leg III 145–178, leg IV 195–201. Leg segment setal formula as follows: coxae 2-2-1-1; trochanters 1-1-1-1; femora 10-6-4-4; genua 5-6-4-4; tibiae 9(4 ϕ)-7-6-7; tarsi 13(3 ω +2dup)-13(1 ω +1dup)-9(1 ω)-9(1 ω). Tarsus I with four tactile setae well-behind and two tactile in-line with proximal duplex setae (Figure 9a) and tarsus II with five tactile setae well-behind and one tactile just behind duplex setae (Figure 9b). Empodium I with two claws, a dorsal claw and a proximoventral claw (proximoventral hairs fused to form proximoventral claw, bifid distally); empodia II–IV with three pairs proximoventral hairs.

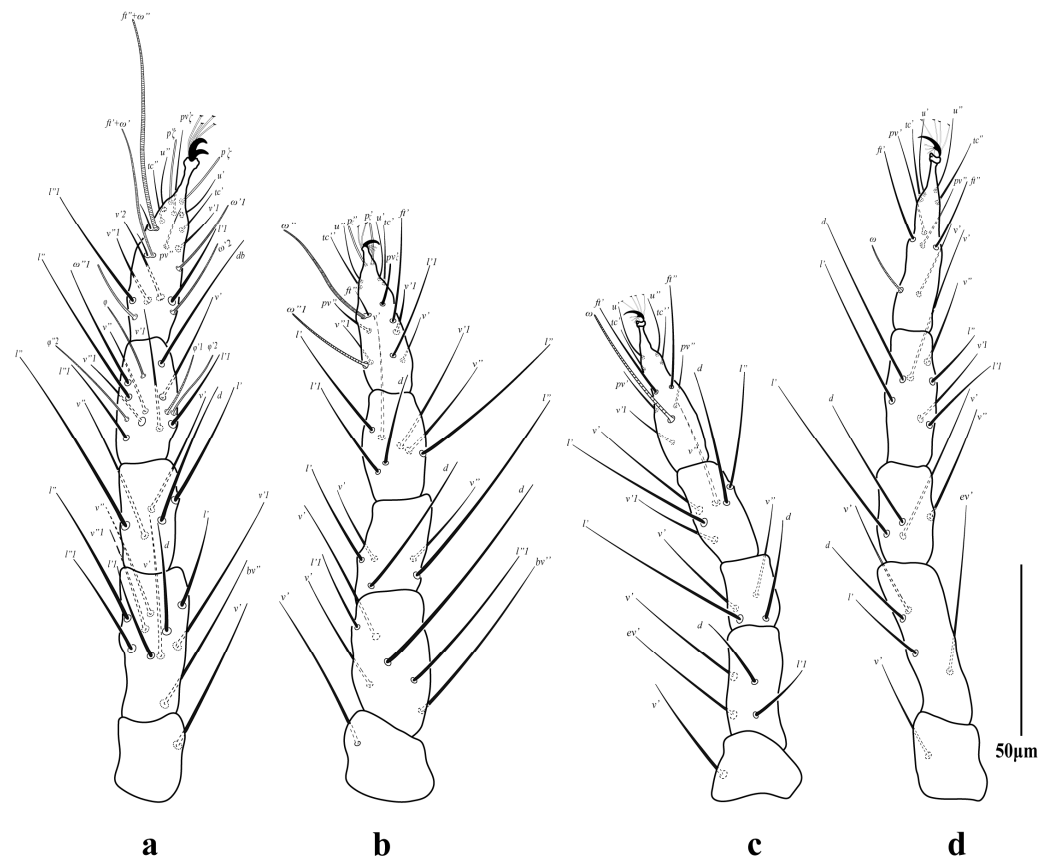


Figure 9. *Oligonychus pratensis*, male, (a–d), leg I and III, right side legs; leg II and IV, left side legs. Scale bar 50 μ m.

Deutonymph: (Figures 10–13; n = 5)—Length of body (*v2-f2*) 240–275; width (*c3-c3*) 200–220.

Dorsum (Figure 10a,b): Propodosomal shield medially with longitudinal striae; opisthosoma medially with transverse striae except area in-between setae *f1-f1* and *f1-f2* with distinct patch of typical longitudinal, irregular longitudinal, or oblique striae (Figure 10b); lateral idiosoma with longitudinal to oblique striae; stria without lobes; dorsal setae similar to females, not set on tubercles and longer than longitudinal distances to the bases of setae next-in-line (Figure 10a); setae *h2* and *h3* located ventrally, finely serrated. Lengths of dorsal setae *v2* 54–59, *sc1* 97–98, *sc2* 52–62, *c1* 51–67, *c2* 54–72, *c3* 59–71, *d1* 71–74, *d2* 58–67, *e1* 66–74, *e2* 80–85, *f1* 61–67, *f2* 52–59. Distances between setal bases: *v2-v2* 54–57, *sc1-sc1* 71–74, *sc2-sc2* 166–175, *c1-c1* 67–69, *d1-d1* 68–75, *e1-e1* 51–56, *f1-f1* 20–28, *c1-d1* 43–52, *d1-e1* 41–44, *e1-f1* 43–48.

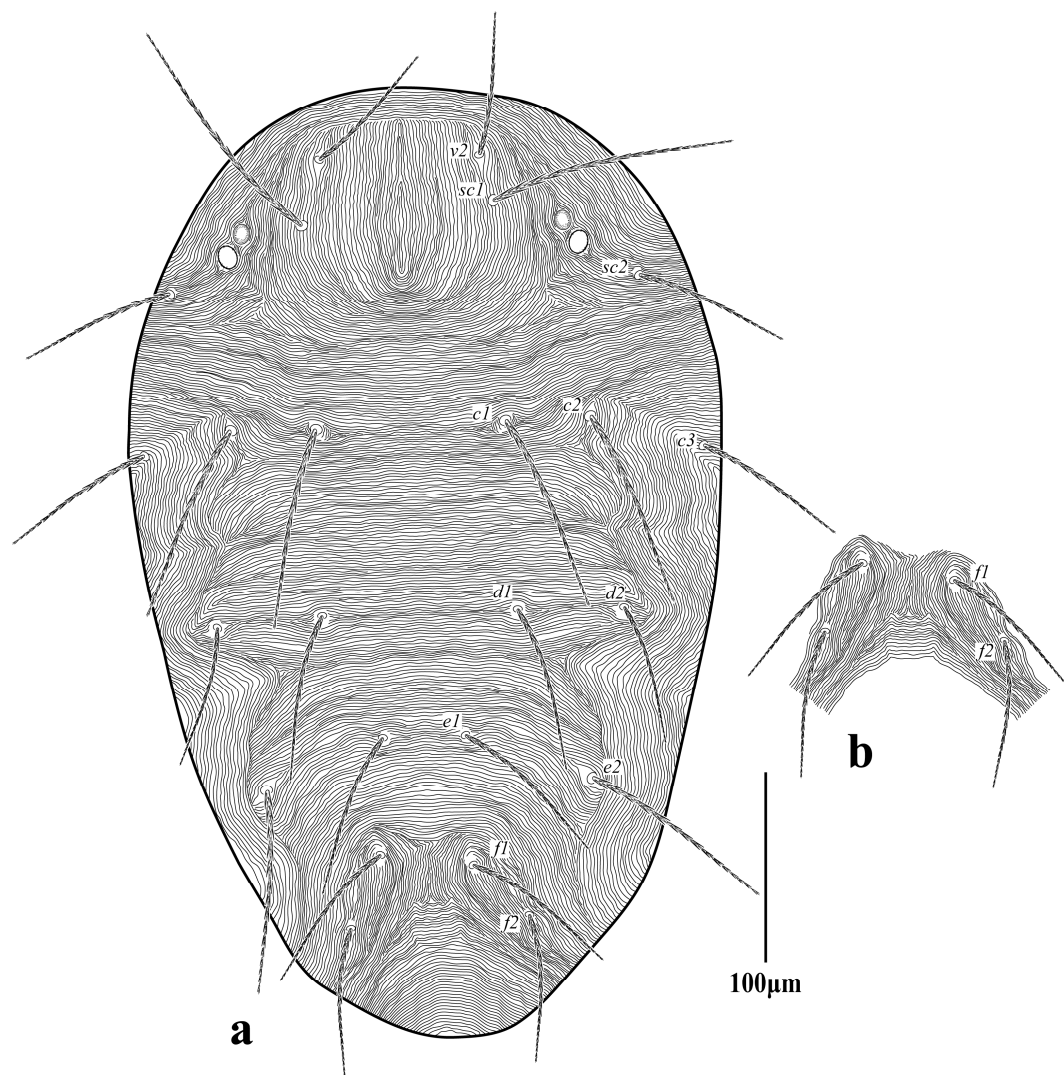


Figure 10. *Oligonychus pratensis*, deutonymph, dorsum. (a,b), (a), dorsum; (b), stria between seta *f1–f1*; Scale bar 100 µm.

Venter (Figure 11): Coxisternal area between coxae I–IV and area between setae *ag–g1* with transverse striae medially, striae without lobes; lateral opisthosoma with transverse, longitudinal to oblique striae. Lengths of setae *1a* 34–36, *1b* 31–48, *1c* 34–54, *2b* 43–49, *2c* 59–64, *3a* 29–34, *3b* 34–41, *4a* 43–45, *4b* 39–41, *ag* 38–51, *g1* 23–26, *ps1* 16–18, *ps2* 11–15, *h2* 28–33, *h3* 31–34. Setae *g2* absent. Distances between setal bases: *1a–1a* 23–25, *3a–3a* 41–43, *4a–4a* 43–50, *ag–ag* 41–44, *g1–g1* 28–28, *ps1–ps1* 11–16, *ps2–ps2* 12–15, *h2–h2* 12–18, *h3–h3* 48–66.

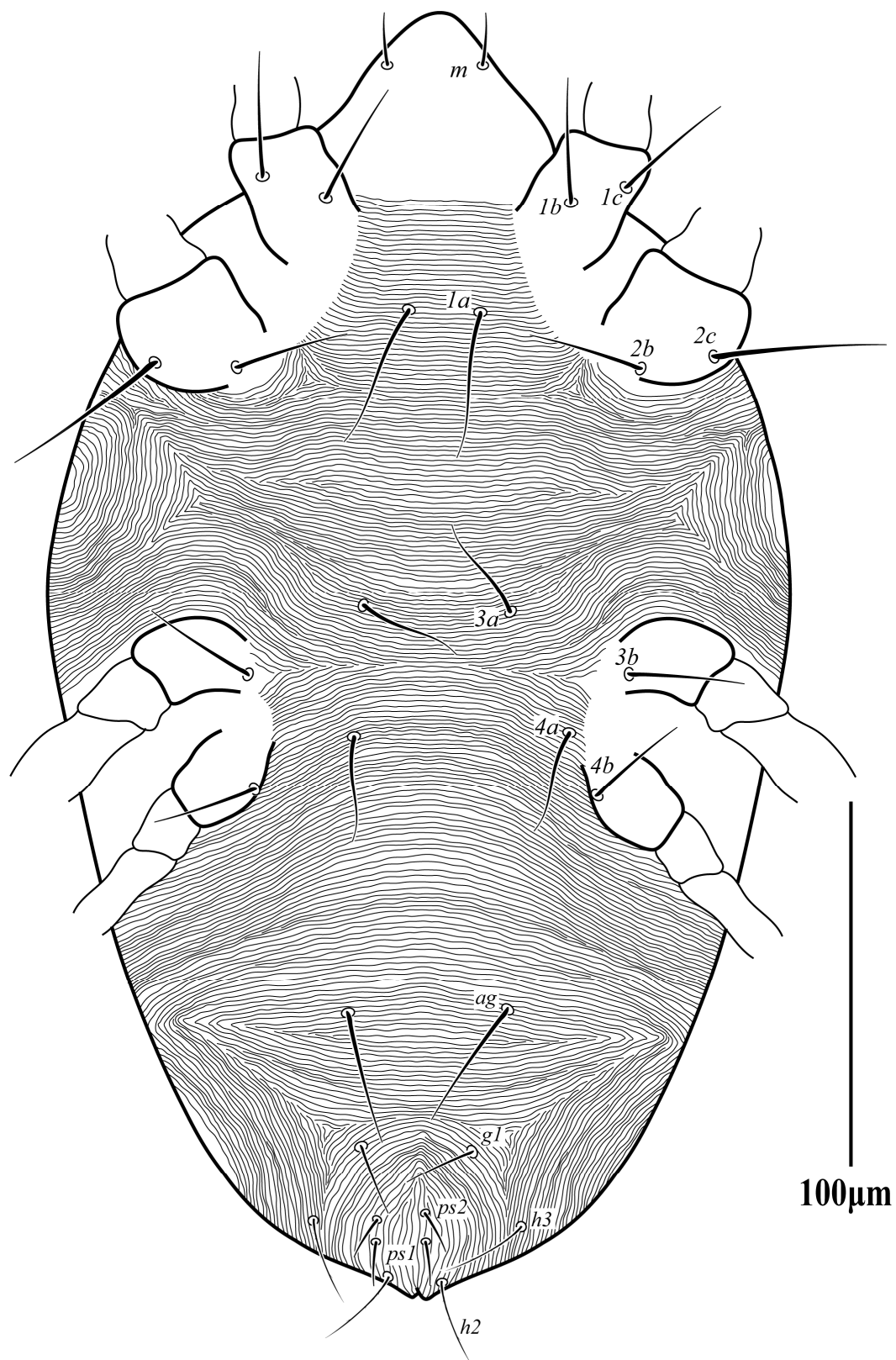


Figure 11. *Oligonychus pratensis*, deutonymph, venter. Scale bar 100 µm.

Gnathosoma (Figure 12a,b): Ventral infracapitulum with setae *m* smooth, long 26–38, shorter than distance *m*–*m* 30–34. Palp spinneret *su*ζ 4–4.7 long, width 2.4–3, solenidion *ω* 4.8–5 long (Figure 12a). Stylophore and peritreme similar to females (Figure 12b).

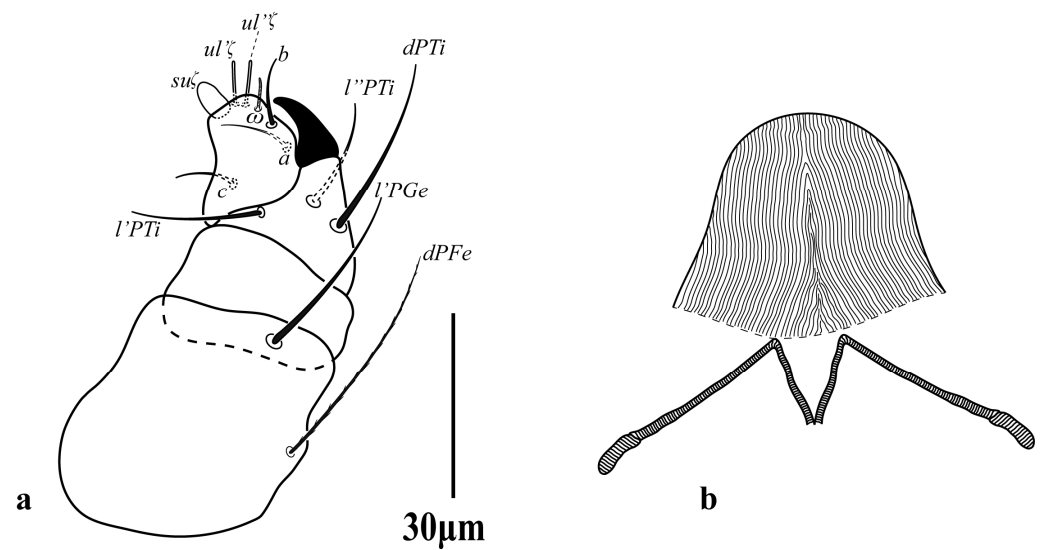


Figure 12. *Oligonychus pratensis*, deutonymph gnathosoma: (a,b); (a), palp; (b), stylophore, scale bar 30 μ m.

Legs (Figure 13a–d): Length of legs (excluding coxae, from trochanter to tip of claw) leg I 157–171, leg II 118–132, leg III 121–126, leg IV 123–144. Leg segment setal formula as follows: coxae 2-2-1-1; trochanters 1-1-1-0; femora 6-3-2-2; genua 5-5-3-3; tibiae 7(1 ϕ)-5-5-5; tarsi 12(1 ω +2dup)-10(0+1dup)-8(1 ω)-8.

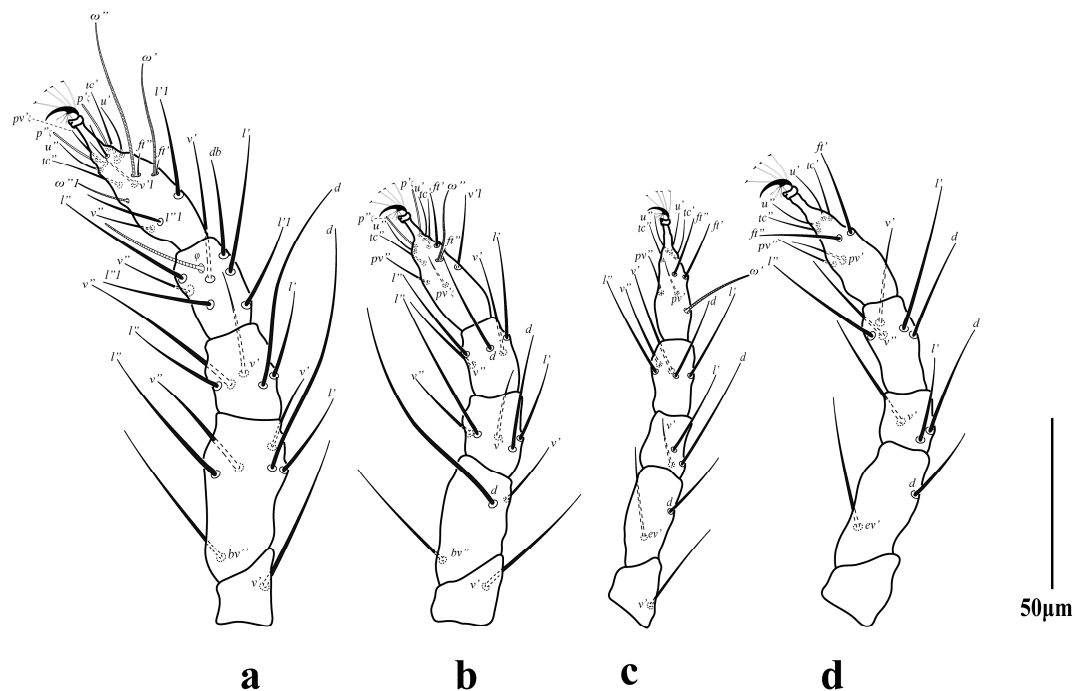


Figure 13. *Oligonychus pratensis*, deutonymph legs, (a–d), leg I–IV, right side legs. Scale bars: 50 μ m.

Protonymph: (Figures 14–17; $n = 5$)—Length of body (v_2 – f_2) 190–220; width (c_3 – c_3) 170–183.

Dorsum (Figure 14a,b): Propodosomal shield medially with longitudinal striae; opisthosoma medially with transverse striae except area in-between setae f_1 – f_1 and f_1 – f_2 with distinct patch of typical longitudinal, irregular longitudinal, or oblique striae (Figure 14b); lateral idiosoma with longitudinal to oblique striae; striae without lobes; dorsal setae similar to deutonymph, not set on tubercles, and longer than longitudinal distances to the bases of setae next-in-line; setae h_2 and h_3 located ventrally. Lengths of dorsal setae v_2 35–43, sc_1

49–66, *sc2* 34–46, *c1* 38–48, *c2* 41–54, *c3* 36–46, *d1* 34–46, *d2* 49–51, *e1* 33–49, *e2* 38–49, *f1* 33–48, *f2* 20–38. Distances between setal bases: *v2*–*v2* 45–49, *sc1*–*sc1* 60–62, *sc2*–*sc2* 131–134, *c1*–*c1* 51–56, *d1*–*d1* 52–56, *e1*–*e1* 31–33, *f1*–*f1* 21–49, *c1*–*d1* 46–51, *d1*–*e1* 33–39, *e1*–*f1* 34–44.

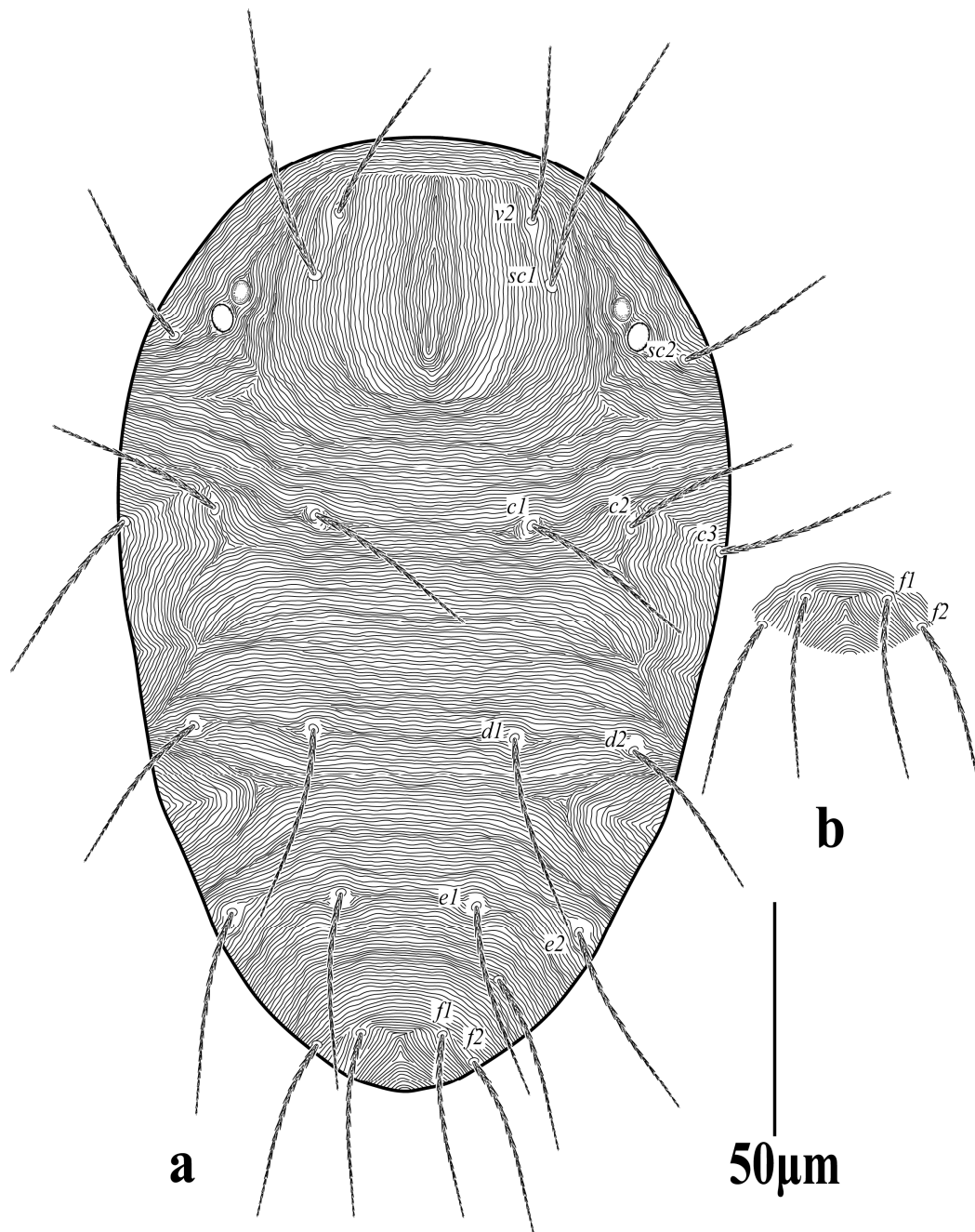


Figure 14. *Oligonychus pratensis*, protonymph dorsum. (a,b), (a), dorsum; (b), stria between seta *f1*–*f1*. Scale bar 50 μm.

Venter (Figure 15): Coxisternal area between coxae I–IV and area anterior and posterior to setae *ag* with transverse striae medially, striae without lobes; lateral opisthosoma with transverse, longitudinal to oblique striae. Lengths of setae *1a* 21–25, *1b* 28–33, *1c* 31–37, *2b* 43–45, *3a* 26–38, *3b* 25–31, *ag* 25–33, *ps1* 11–19, *ps2* 10–18, *h2* 20–23, *h3* 18–24. Setae *g1* and *g2* absent. Distances between setal bases: *1a*–*1a* 18–19, *3a*–*3a* 37–39, *ag*–*ag* 31–34, *ps1*–*ps1* 10–13, *ps2*–*ps2* 9–11, *h2*–*h2* 13–14, *h3*–*h3* 48–51.

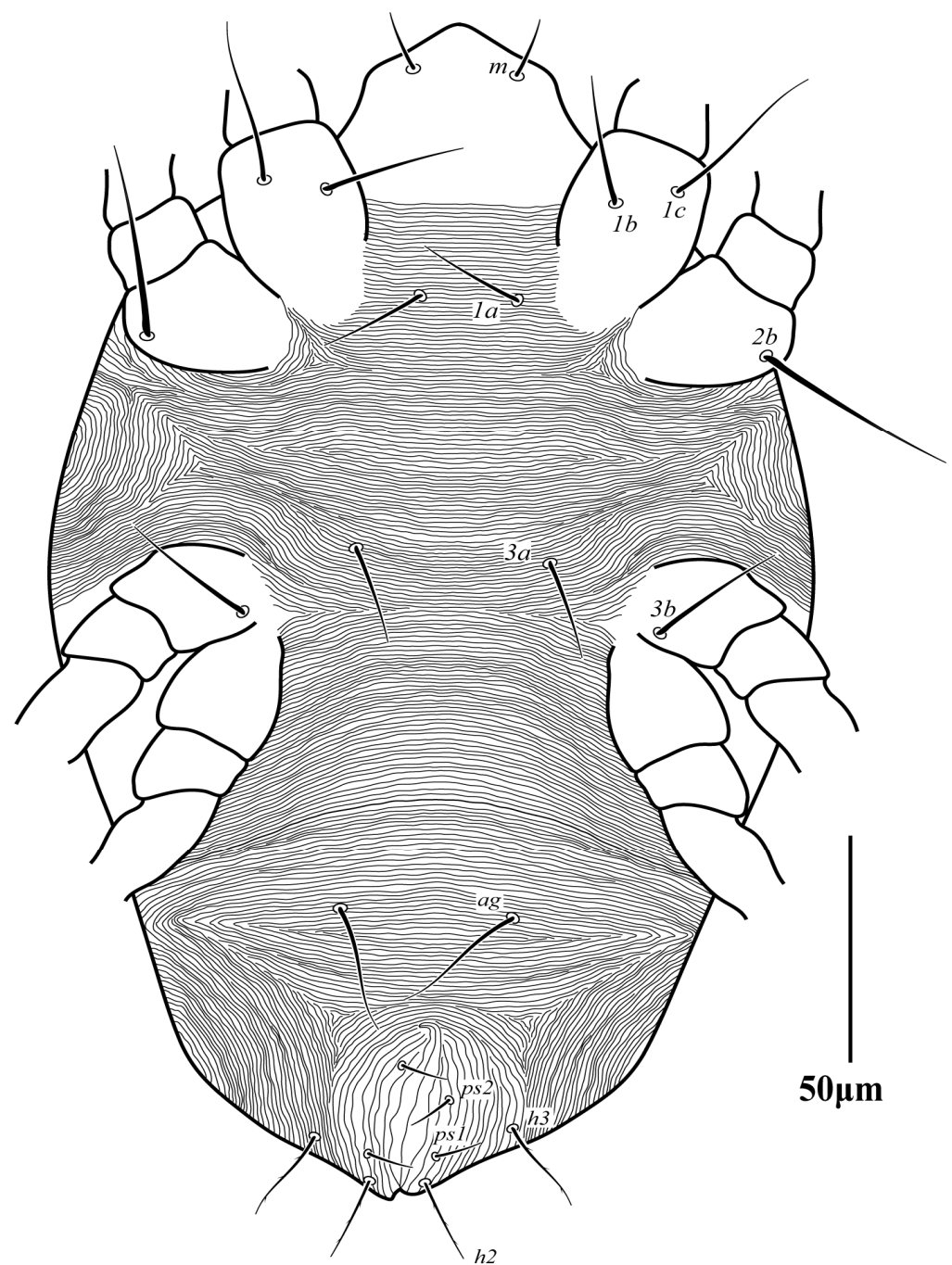


Figure 15. *Oligonychus pratensis*, protonymph venter. Scale bar 50 µm.

Gnathosoma (Figure 16a,b): Ventral infracapitulum with setae *m* smooth, long 28–34, shorter than distance *m–m* 30–32. Palp spinneret *su*ζ 4–4 long, width 2, solenidion ω 3.2–4 long (Figure 16a). Stylophore and peritreme similar to females (Figure 16b).

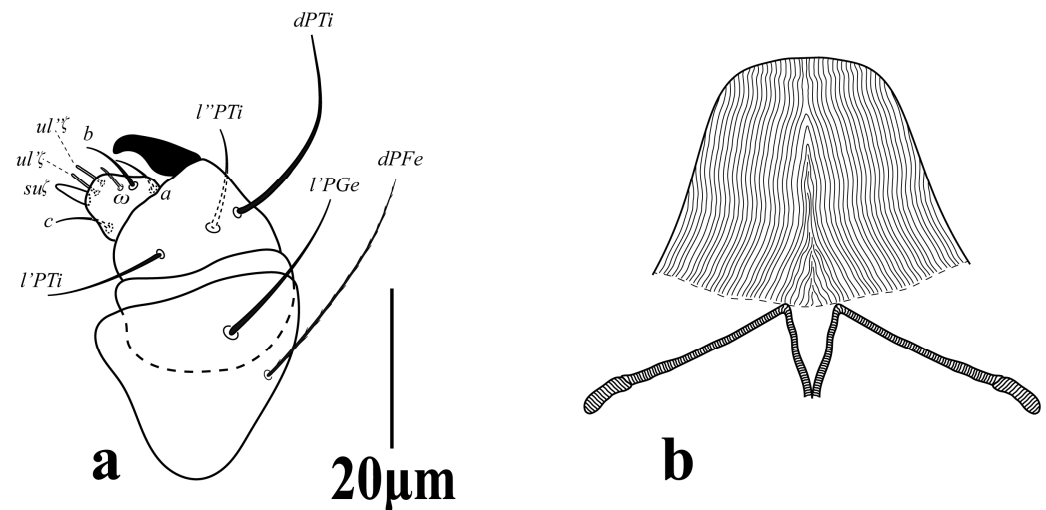


Figure 16. *Oligonychus pratensis*, protonymph gnathosoma: (a,b); (a), palp; (b), Stylophore, scale bar 20 μ m.

Legs (Figure 17a–d): Length of legs (excluding coxae, from trochanter to tip of claw) leg I 121–128, leg II 98–110, leg III 97–103, leg IV 84–100. Leg segment setal formula as follows: coxae 2-1-1-0; trochanters 0-0-0-0; femora 3-3-2-2; genua 4-4-2-2; tibiae 5(1 ϕ)-5-5-5; tarsi 9(0 ω +2dup)-9(0 ω +1dup)-8-6.

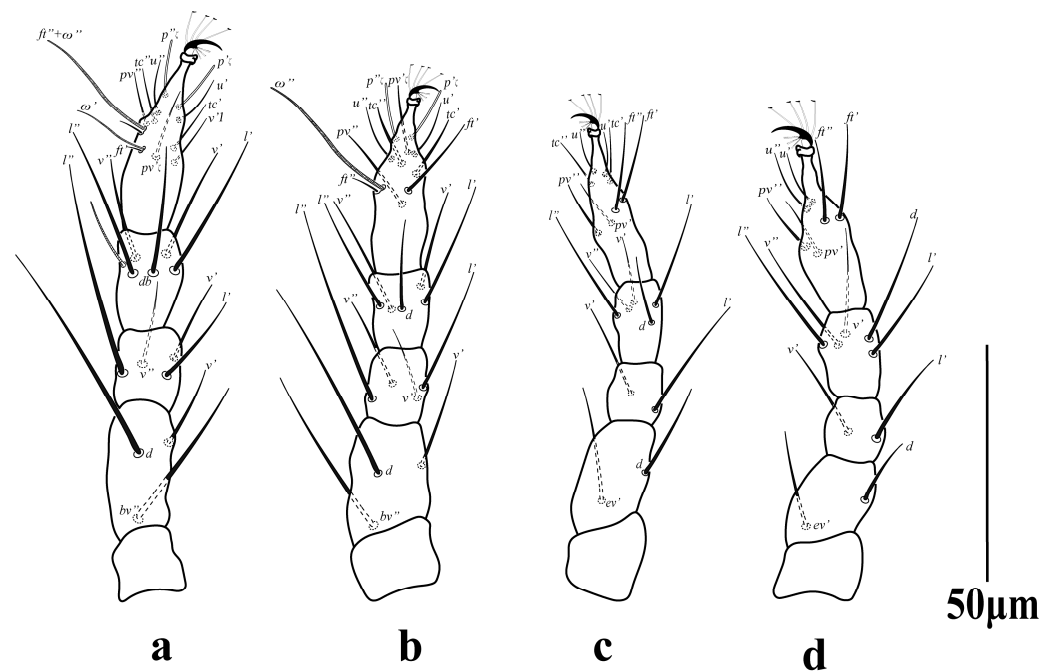


Figure 17. *Oligonychus pratensis*, protonymph legs: leg I–IV; (a–d), right side legs. Scale bars: 50 μ m.

Larva: (Figures 18–21; n = 5)—Length of body ($v2$ – $f2$) 165–190; width ($c3$ – $c3$) 125–140.

Dorsum (Figure 18): Propodosomal shield medially with longitudinal to oblique striae; opisthosoma medially with transverse striae; lateral idiosoma with longitudinal to oblique striae; striae without lobes; dorsal setae similar to deutonymph, not set on tubercles, and longer than longitudinal distances to the bases of setae next-in-line; setae $h2$ and $h3$ located ventrally. Lengths of dorsal setae $v2$ 37–48, $sc1$ 56–59, $sc2$ 44–49, $c1$ 41–49, $c2$ 38–44, $c3$ 38–47, $d1$ 37–41, $d2$ 36–43, $e1$ 34–44, $e2$ 35–44, $f1$ 34–41, $f2$ 35–36. Distances between setal bases: $v2$ – $v2$ 37–46, $sc1$ – $sc1$ 56–59, $sc2$ – $sc2$ 88–94, $c1$ – $c1$ 39–49, $d1$ – $d1$ 41–48, $e1$ – $e1$ 26–27, $f1$ – $f1$ 11–15, $c1$ – $d1$ 44–47, $d1$ – $e1$ 29–38, $e1$ – $f1$ 36–43.

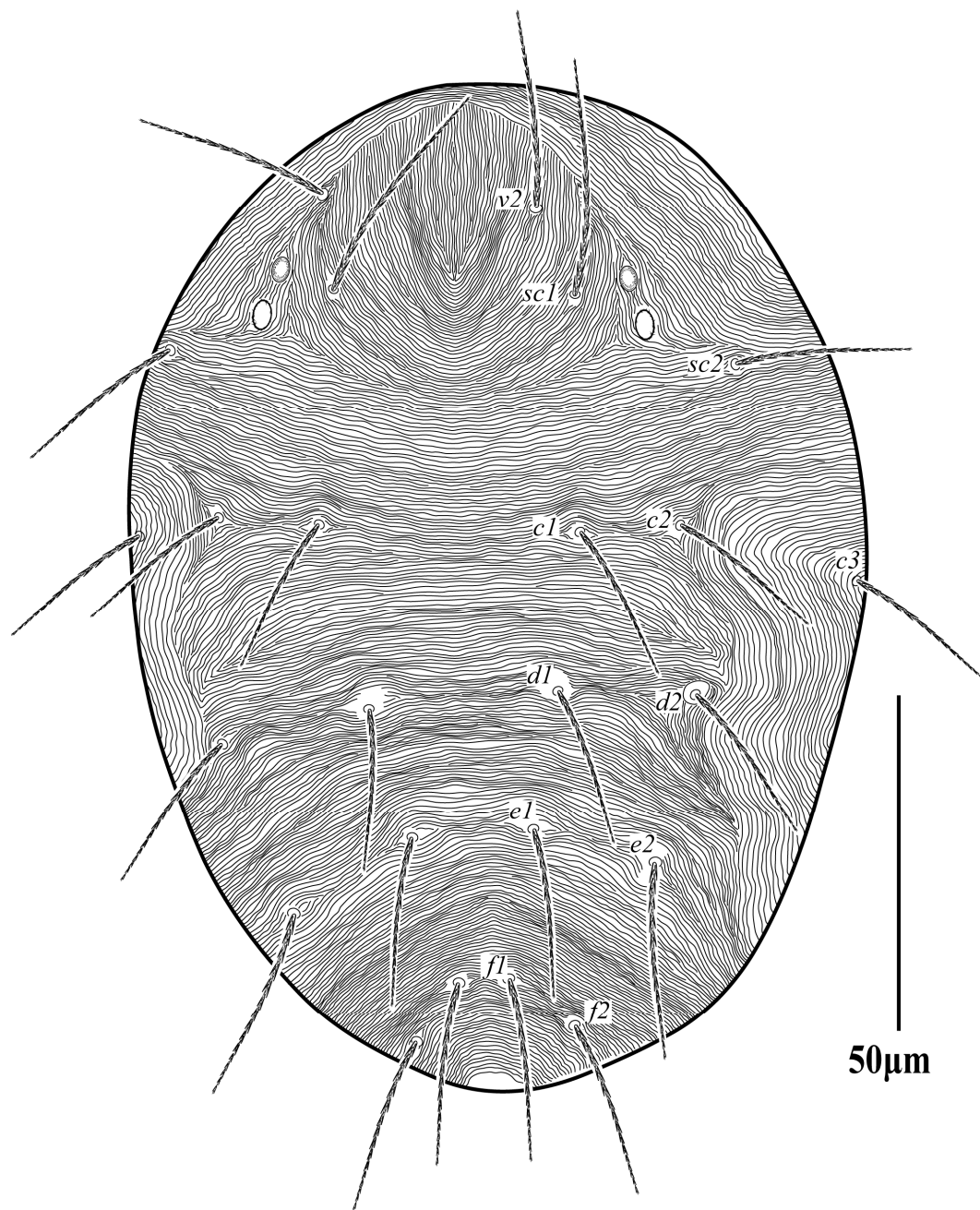


Figure 18. *Oligonychus pratensis*, larva dorsum. Scale bar 50 μ m.

Venter (Figure 19): Coxisternal area between coxae I–III and area posterior to setae 3a with transverse striae medially, striae without lobes; lateral opisthosoma with longitudinal to oblique striae. Lengths of setae 1a 23–25, 1b 29–32, 3a 23–25, ps1 9–11, ps2 11–13, h2 19–25, h3 18–22. Setae ag, g1, and g2 absent. Distances between setal bases: 1a–1a 21–22, 3a–3a 40–48, ps1–ps1 8–11, ps2–ps2 8–11, h2–h2 8–12, h3–h3 24–37.

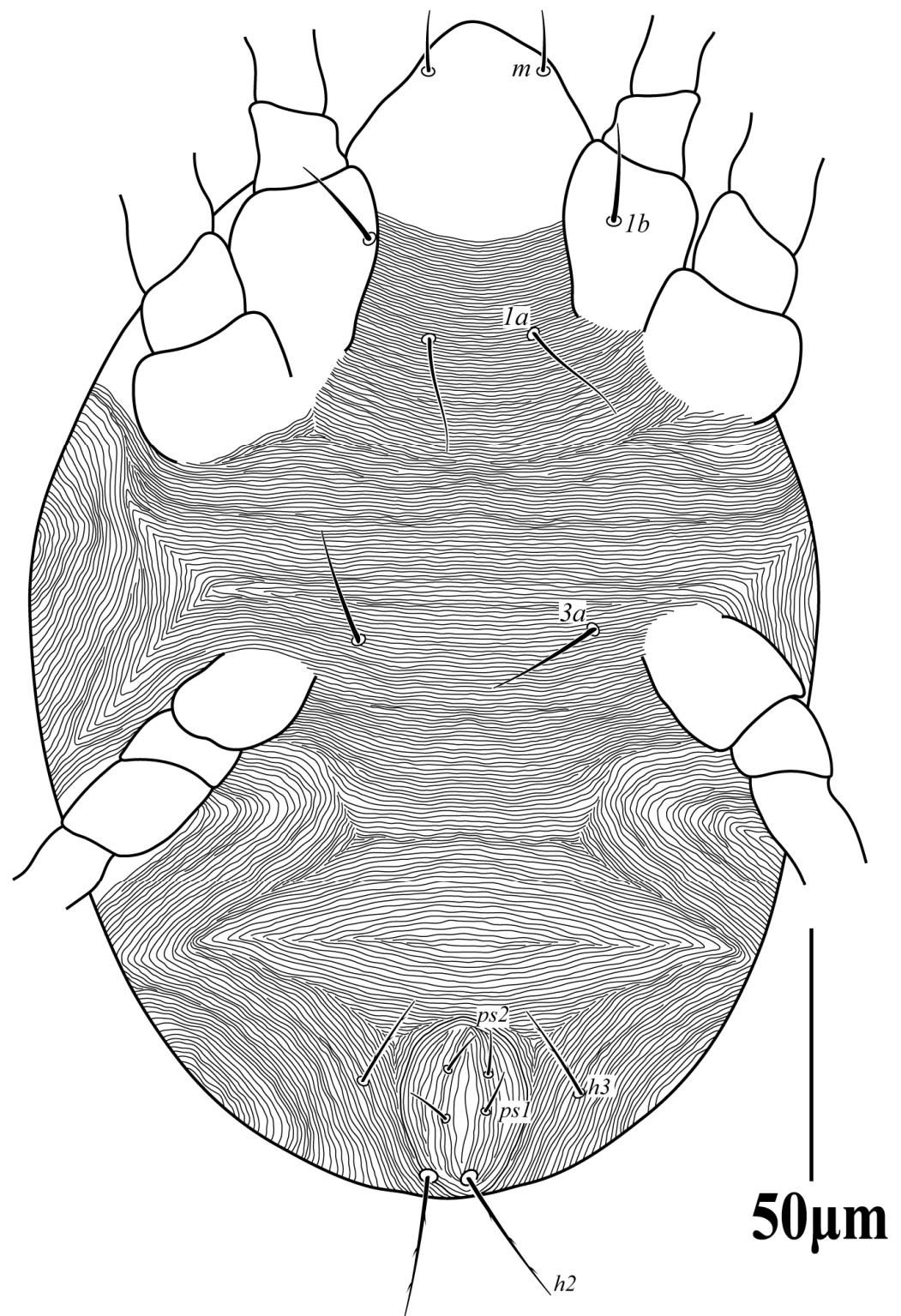


Figure 19. *Oligonychus pratensis*, larva venter. Scale bar 50 μ m.

Gnathosoma (Figure 20a,b): Palp spinneret $su\zeta$ 3.2–4.1 long, width 1.3, solenidion ω 3–3.8 long (Figure 20a). Stylophore and peritreme similar to females (Figure 20b).

Legs (Figure 21a–c): Length of legs (excluding coxae, from trochanter to tip of claw) leg I 109–118, leg II 91–103, leg III 97–107. Leg segment setal formula as follows: coxae 1-0-0; trochanters 0-0-0; femora 3-3-2; genua 4-4-2; tibiae 5(1 ϕ)-5-5; tarsi 7(0 ω +1dup)-7(0 ω +1dup)-

6. Tarsus I and tarsus II with two tactile seta proximal to duplex setae. Empodia with three pairs of proximoventral hairs.

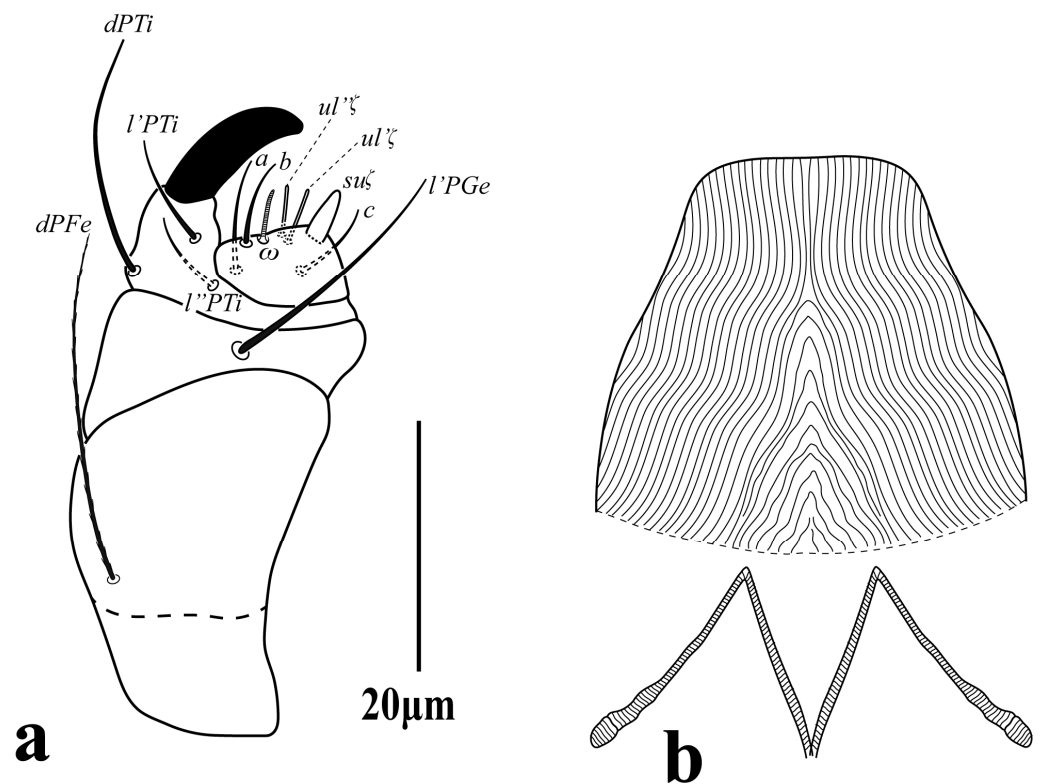


Figure 20. *Oligonychus pratensis*, larva gnathosoma; (a,b), (a) palp; (b) stylophore. Scale bar 20 μ m.

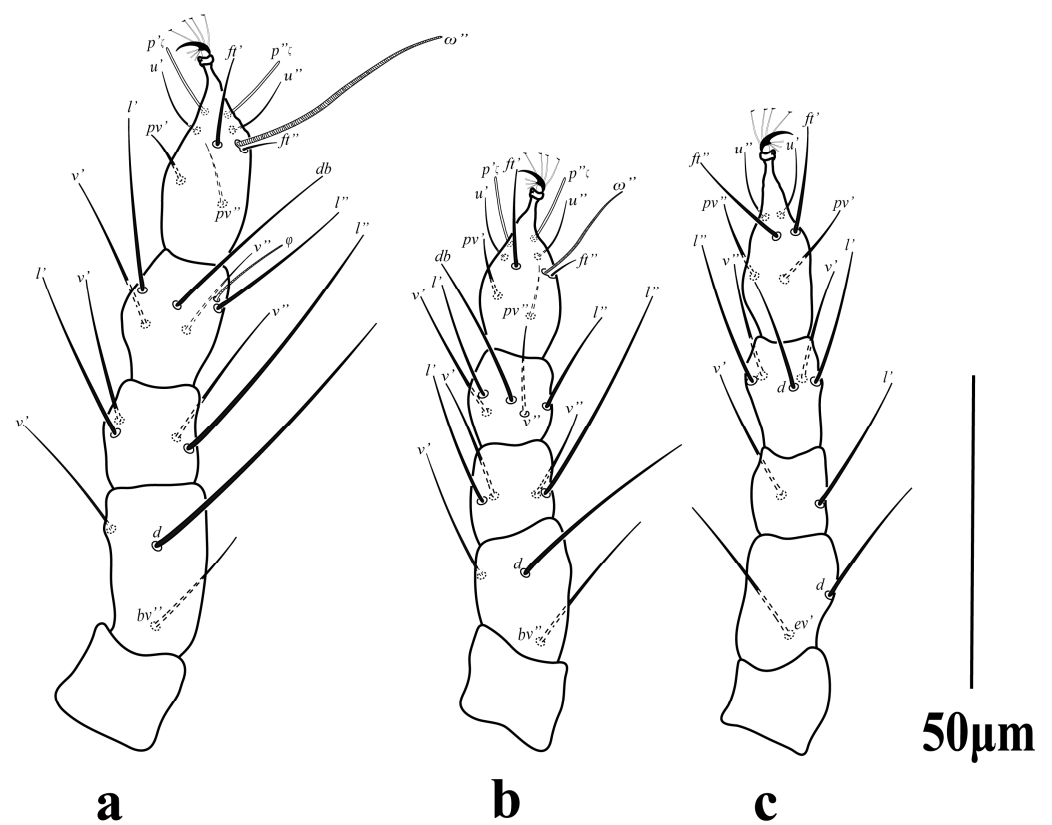


Figure 21. *Oligonychus pratensis*, larva legs: leg I–III, (a–c); right side legs. Scale bar 50 μ m.

3.2. Remarks

The complete morphological description of all developmental stages of *O. pratensis* (Californian population) is hereby provided for the first time (Table 2). The ontogenetic studies of the tetranychid mites are very rare, and it becomes difficult to provide useful information related to setal pattern differences. Li et al. [9] incorrectly provided the ontogeny of *O. pratensis* due to wrong species identification. It will be discussed in detail in later sections and will be referred to as “*pratensis* sensu Li et al.” for comparison in this section.

The basic chaetotaxy pattern in tetranychid mites was studied by Grandjean [34] and updated by Lindquist [29]. It was reported that the full extent of coxal setae appears at the deutonymphal and adult stages and that the absence or presence of setae on coxae IV could potentially differentiate between protonymph and deutonymph stages [29]. A similar pattern was observed in the Californian population of *O. pratensis*, where the coxae IV setae (4b) appear in the deutonymphal stage while they were absent in the protonymph (Table 2).

The setae on the leg trochanters of Californian *O. pratensis* followed the typical pattern of the family Tetranychidae [29], where trochanters I–III had one setae (*v'*) first appearing at deutonymphal stages and on trochanter IV only at the adult stage. Typically for the family Tetranychidae [29], femurs I–III of *O. pratensis* larvae in the present study have a 3-3-2 setal formula. This continued to appear in protonymph with formula 3-3-2-2. At the deutonymphal stage, three more setae were added to femur I, while none were added to femur II–IV. The complete set of femoral setae appeared in adult stages (Table 2). The chaetotaxy of leg genu, tibiae, and tarsi I–IV also followed the typical pattern of the subfamily Tetranychinae [29]. However, setae *v1'* were added in female tarsus II, differentiating Californian *O. pratensis* from *pratensis* sensu Li et al. [9].

3.3. Taxonomic Notes on the Globally Reported Population of *O. pratensis*

3.3.1. Notes on the Afrotropical Populations of *O. pratensis*

Oligonychus pratensis has been reported in the Afrotropical realm in four countries: Mauritius, Madagascar, Senegal, and South Africa [5,14,23,35,36]. The populations from Mauritius [35], Madagascar [36], and Senegal [23] were not described morphotaxonomically. However, brief morphological data were provided for the South African population [14], but its taxonomic identity was later questioned and deemed ‘doubtful’ as slide-mounted male specimens were lost [7]. Based on the limited morphological data from Meyer and Ryke [14] and through the available/published diagnostic keys [1,13], the South African *O. pratensis* [14] belongs to the species group/subgroup *exsiccator* [1]. However, it differs from the Californian population of *O. pratensis* in several features: females possess three tactile setae behind the proximal duplex setae (vs. four in the Californian population), and there are notable variations (or differences) in aedeagal traits (Table 1; Figure 22). For example, the shaft’s dorsal margin is approximately 2.3 times longer than the knob length (vs. 3 times); the knob is about 2.3 times longer than its stem width (vs. more than 3 times); the knob’s posterior projection is shorter than the stem height (vs. longer); and the angle between the shaft and the bent terminal part is obtuse (vs. acute in the Californian population). We recommend a comprehensive revision using integrative taxonomic approaches to confirm the distribution of *O. pratensis* in the Afrotropical realm, including recollection from previously reported localities and host plants.

Table 1. Morphometric data of different aedeagal parameters—viz. height of bent aedeagal part (H1), height of knob stem (H2), length of shaft dorsal margin (L1), length of knob (L2), width of shaft (W1), width of knob stem (W2), length of knob anterior projection (AL), length of knob posterior projection (PL), angle formed between shaft axis and knob axis (α_1), and angle formed between shaft axis and axis of bent part (α_2), relatively measured for different populations of *O. pratensis*, either collected/described in the present study or re-described from the published literature.

<i>O. pratensis</i> Populations (References)	H1/L1	H1/W1	L1/L2	L1/W1	L2/W2	L2/H2	PL/AL	PL/H2	PL/W2	α_1	α_2
<i>O. pratensis</i> (California, present study)	0.3	0.6	3.0	2.0	3.3	2.7	1.5	1.2	1.5	22.0	69.0
A-a [18]	0.3	0.6	3.5	1.9	3.0	3.0	0.7	1.0	1.0	29.0	73.0
A-b [18]	0.4	0.8	3.4	2.0	3.5	2.0	2.8	1.0	1.8	30.0	74.0
B [6]	0.6	1.0	2.0	1.7	2.5	2.5	2.8	0.9	0.9	25.0	86.0
C [14]	0.3	0.6	2.3	1.6	2.3	3.5	1.3	0.6	0.4	9.0	113.0
D [19]	0.6	1.0	2.1	1.6	2.9	1.8	1.2	0.6	1.0	24.0	75.0
E [20]	0.7	0.9	1.8	1.3	2.8	1.7	2.8	0.8	1.3	17.0	80.0
F [37]	0.4	0.6	3.2	1.7	2.6	1.8	2.1	0.8	1.1	21.0	68.0
G [7]	0.4	0.5	3.5	1.4	1.9	2.6	0.8	0.6	0.4	27.0	73.0
H [15]	0.3	0.5	3.6	1.4	1.7	1.7	2.5	0.9	0.9	18.0	70.0
I [6]	0.5	0.6	2.6	1.3	2.6	1.7	1.0	0.5	0.8	30.0	72.0
J [16]	0.7	0.7	1.8	1.0	2.5	1.5	1.6	0.5	0.8	parallel	83.0
K [17]	0.5	0.8	2.8	1.7	3.4	1.7	1.2	0.6	1.2	36.0	72.0
L-a [21]	0.5	0.8	2.8	1.6	2.0	1.9	1.2	0.6	0.7	45.0	70.0
L-b [21]	0.4	0.6	2.7	1.4	2.3	2.6	1.4	0.9	0.8	40.0	73.0
L-c [21]	0.4	0.5	2.9	1.3	3.0	2.5	0.7	0.7	0.8	25.0	78.0
M-a [9]	0.5	1.0	3.1	2.3	2.8	1.7	1.5	0.6	1.0	31.0	66.0
M-b [9]	0.4	1.0	2.9	2.3	2.8	1.9	1.2	0.7	1.0	33.0	74.0

H1/L1, The height of the bent aedeagal part (H1) divided by the length of the shaft dorsal margin (L1). **H1/W1**, The height of the bent aedeagal part (H1) divided by the shaft width (W1). **L1/L2**, The length of the shaft dorsal margin (L1) divided by the knob length (L2). **L1/W1**, The length of the shaft dorsal margin (L1) divided by the shaft width (W1). **L2/W2**, The length of the knob (L2) divided by the width of the knob stem (W2). **L2/H2**, The length of the knob (L2) divided by the height of the knob stem (H2). **PL/AL**, The length of the knob posterior projection (PL) divided by the length of the knob anterior projection (AL). **PL/H2**, The length of the knob posterior projection (PL) divided by the height of the knob stem (H2). **PL/W2**, The length of the knob posterior projection (PL) divided by the width of the knob stem (W2).

Table 2. Ontogenetic development of the chaetotaxy of legs in *Oligonychus pratensis* (Banks) (Acari: Prostigmata: Tetranychidae).

Leg	Stage	Coxa	Trochanter	Femur	Genu	Tibia	Tarsus
I	Larvae	1b	-	<i>d, v', bv''</i>	<i>l', v', l'' v''</i>	<i>db, l', v', l'', v'', ϕ</i>	<i>p\zeta', u', ft', p\zeta'', u'', ft'', pv' pv'' \omega''</i>
	Protonymph	1c	-	-	-	-	-
	Deutonymph	-	<i>v'</i>	<i>l', l'', v''</i>	<i>d</i>	<i>l'1, l''1</i>	<i>tc', tc'', \omega', v'1</i>
	Female	-	-	<i>l'1, l''1, v'1, v''1</i>	-	<i>v'1, v''1</i>	<i>\omega''1, v'', l'1, l''1</i>
	Male	-	-	<i>l'1, l''1, v'1, v''1</i>	-	<i>\phi'1, \phi''1, \phi''2</i>	<i>\omega'1, \omega'2</i>
II	Larvae	-	-	<i>d, v', bv''</i>	<i>l', v', l'', v''</i>	<i>db, l', v', l'', v'', \phi</i>	<i>p\zeta', u', ft', p\zeta'', u'', ft'', pv' pv'' \omega''</i>
	Protonymph	2b	-	-	-	-	<i>tc', tc''</i>
	Deutonymph	2c	<i>v'</i>	-	<i>d</i>	-	-
	Female	-	-	<i>l'1, l''1, v'1</i>	-	<i>l'1, v'1-</i>	-
	Male	-	-	-	-	-	-
III	Larvae	-	-	<i>ev', d</i>	<i>l', v'</i>	<i>d, l', v', l'', v''</i>	<i>u', u'', ft', ft'', pv' pv''</i>
	Protonymph	3b	-	-	-	-	<i>tc', tc''</i>
	Deutonymph	-	<i>v'</i>	-	<i>d</i>	-	<i>\omega'</i>
	Female	-	-	<i>v', l'1</i>	<i>v''</i>	<i>v''1</i>	<i>v'1</i>
	Male	-	-	-	<i>v''</i>	-	-
IV	Protonymph	-	-	<i>d, ev'</i>	<i>l', v'</i>	<i>d, l', v', l'', v''</i>	<i>u', u'', ft', ft'', pv' pv''</i>
	Deutonymph	4b	-	-	<i>d</i>	-	<i>tc', tc''</i>
	Female	-	<i>v'</i>	<i>v', l'1</i>	<i>v''</i>	<i>l'1, v'1</i>	<i>\omega', v'1</i>
	Male	-	-	-	-	-	-

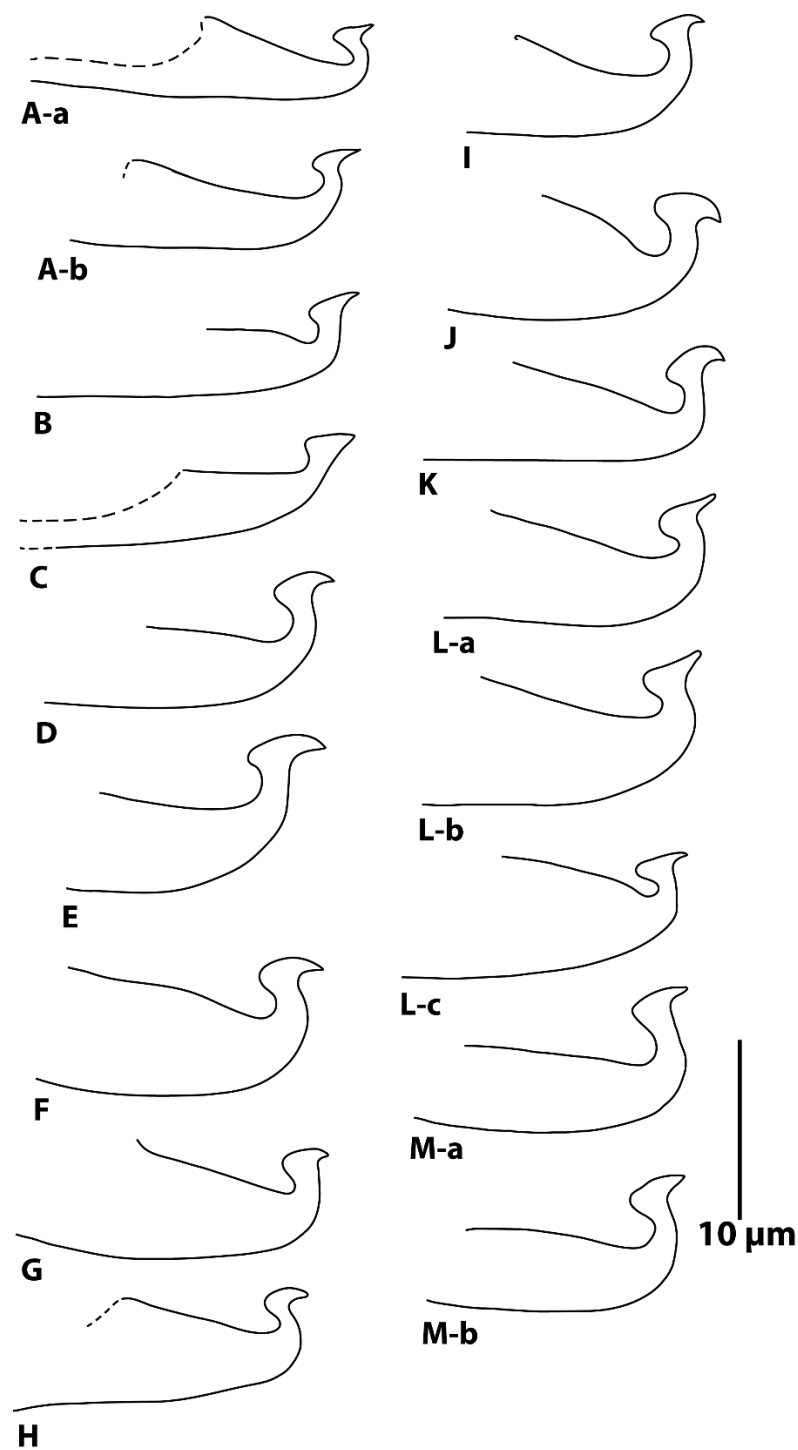


Figure 22. Different aedeagus shapes of *O. pratensis* showing variations, redrawn from previous descriptions, (A-a,A-b) [18], (B) [6] (C) [14], (D) [19], (E) [20], (F) [37], (G) [7], (H) [15], (I) [6], (J) [16], (K) [17], (L-a–L-c) [21], and, (M-a,M-b) [9]. Scale bar 10μm.

3.3.2. Notes on the Australasian Populations of *O. pratensis*

In the Australasian realm, *O. pratensis* has been reported only from the Hawaiian Islands [5,6,35]. The specimens of the Hawaiian population were initially misidentified/mislabeled as *O. exsiccator* (Zehnter) at the Acarology Laboratory, University of Hawaii at Manoa, as noted by Jeppson et al. [6]. Later, Goff [38] reexamined these specimens and confirmed them as *O. pratensis* but did not describe them morphotaxonomically. We recom-

mend a thorough investigation of the Hawaiian population of *O. pratensis* by revisiting and recollecting the fresh specimens from the reported localities and host plants.

3.3.3. Notes on the Nearctic Populations of *O. pratensis*

In the Nearctic realm, *O. pratensis* has been reported by various authors from Mexico and the United States (the country of its type locality) [5]. However, only a few authors have provided taxonomic descriptions (e.g., [2,4,6,16–18,20,22,26]), offering morphological details of only the key traits of the male aedeagus. Pritchard and Baker [6] briefly described the male of *O. pratensis*, collected from the type locality (Pullman, WA, USA), and designated it as a topotype. Further, the intraspecific variations in aedeagal morphology among different Nearctic populations of *O. pratensis* were highlighted. Additionally, the aedeagal parameters of some previously described Nearctic populations [2,16,17,20] differed from those of the Californian population examined in this study (Table 1; Figure 22).

3.3.4. Notes on the Neotropical Populations of *O. pratensis*

In the Neotropical realm, *O. pratensis* has been reported from five countries: Brazil, Colombia, Costa Rica, El Salvador, and Honduras [5]. However, most of these reports (e.g., [39–42]) lack detailed morphotaxonomic information, and only brief morphological data for the population in El Salvador were provided [19]. We observed morphological variations/differences in key traits of the male aedeagus between the populations from El Salvador and California (Table 1; Figure 22). Additionally, Feres et al. [42] reported *O. pratensis* inhabiting the desert fan palm, *Washingtonia filifera* (Lindl.) H.Wendl. (Arecaceae), in Brazil, without morphological description or illustration. Globally, *W. filifera* has not been reported as a host for *O. pratensis* [5], except for a misidentification of *O. washingtoniae* as *O. pratensis* in Saudi Arabia [1,27]. Recently, *O. washingtoniae* has also been reported in Iran, inhabiting the same host plant [43], which raises doubts about identifying *O. pratensis* reported by Feres et al. [42].

3.3.5. Notes on the Oriental Populations of *O. pratensis*

In the Oriental (Indomalayan) realm, *O. pratensis* has been reported from two countries: China and Pakistan [5]. In China, *O. pratensis* was reported on grasses (Poaceae) in Jiangxi Province by Ma and Yuan [44] and in Hunan Province by Li et al. [9]. However, Ma and Yuan [44] did not provide morphological details for the Jiangxi population, whereas Li et al. [9] provided a full morphological description and ontogenetic development for the Hunan population. The taxonomic identity of the claimed Hunan population of *O. pratensis* [9] was later revealed as a cryptic species belonging to the species subgroup *gossypii* of the species group *exsicicator* [1]. Within the *gossypii* subgroup (10 species), the Hunan population closely resembles *O. uruma* [45], as both share key morphological traits of the male aedeagus, female and male palp spinneret, female medial dorsal hysterosomal striae, and number of setae on tibia I. However, the claimed Chinese population of *O. pratensis* differs from *O. uruma* by having a female peritreme straight distally (vs. hooked), female tarsus III and IV with eight and nine tactile setae, respectively (vs. 9 and 10), and a male aedeagus with a shaft dorsal margin almost three times longer than the knob (vs. less than 2.5 times longer in *O. uruma*). The present study reveals that the purported Chinese population of *O. pratensis* [9] is probably a ‘new species’ in the genus *Oligonychus*.

From Pakistan, *O. pratensis* has been reported, first and only time on *Abelmoschus esculentus* (L.) Moench (Malvaceae), *Morus alba* L. (Moraceae), and *Solanum melongena* L. (Solanaceae) [8,46]. The Pakistani populations were either briefly described based on a single female specimen [46], or without any morphological details [46]. We found that the females of Pakistani *O. pratensis* [8] exhibited notable differences, such as having eight setae on femur I and seven setae on tibia III vs. 10 and six, respectively, in the Californian population of *O. pratensis*.

3.3.6. Notes on the Palearctic Populations of *O. pratensis*

In the Palearctic realm, *O. pratensis* has been reported in five countries: Algeria, Egypt, Iraq, Saudi Arabia, and Syria [5]. Unfortunately, no morphological details were provided for any of these reported populations. Despite our efforts to obtain specimens from some Palearctic populations for morphological comparisons, including attempts with colleagues (e.g., [11]), we were unsuccessful. In Saudi Arabia (SA), *O. pratensis* has been reported on *Zea mays* L., *Cynodon dactylon* L. (Poaceae), and *W. filifera* [1,10,47], but without morphological details. Subsequent studies have since corrected this misidentification of two Saudi populations of *O. pratensis*. The identity of the *O. pratensis* population reported from Riyadh (SA) was confirmed as *O. washingtoniae* [1,27], while another from Baha was reidentified as *O. afrasiaticus* (McGregor) [10,13]. In this study, the third reported *O. pratensis* population, collected from Riyadh in 2010/2014 [10], was re-examined and confirmed as *O. afrasiaticus*. Furthermore, an integrated taxonomic investigation of *Oligonychus* species diversity in SA did not report *O. pratensis* [48], suggesting its absence in the region. These findings encourage revisiting, re-collecting, and re-examining the *O. pratensis* populations reported in Algeria, Iraq, Egypt, and Syria to confirm the species' identity.

4. Conclusions

In conclusion, the present study comprehensively discussed the taxonomic challenges associated with the *Oligonychus pratensis* species complex, based on the globally published literature and the detailed morphological characterization of the Californian population of *O. pratensis*. Several populations previously identified as *O. pratensis* from South Africa (Afrotropical realm), El Salvador (Neotropical realm), China, Pakistan (Oriental realm), and Saudi Arabia (Palearctic realm) were determined to be either 'doubtful' or 'misidentified.' Furthermore, populations briefly described in localities such as Algeria, Brazil, Egypt, Iraq, and Syria warrant comprehensive re-examination. This should involve re-collecting specimens from the reported localities and employing modern integrated taxonomic approaches. Additionally, the morphological analysis conducted in this study suggests that the *O. pratensis* population reported in China may represent a novel species within the genus *Oligonychus* (*Reckia*), specifically belonging to the *gossypii* subgroup of the *exsicicator* species group sensu Mushtaq et al. Moreover, it was revealed that *O. pratensis* does not occur in Saudi Arabia and that prior records of this species from the region likely resulted from morphological misidentification. The current morphological and previously conducted molecular characterization (GenBank accession number: OQ185450) [13] of the Californian population of *O. pratensis* can serve as a guideline for confirming the taxonomic identity of any closely related populations/species within the *pratensis* complex.

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