

TYROPHAGUS PUTRESCENTIAE (SCHRANK) (ACARI: ACARIDAE) FROM WESTERN IRAN WITH A KEY TO IRANIAN SPECIES OF THE GENUS

Bahman Asali Fayaz¹, Mohammad Khanjani^{1*} and Hassan Rahmani²

¹Department of Plant Protection, College of Agriculture, Bu-Ali Sina University, Hamedan, Iran

²Department of Plant Protection, College of Agriculture, Zanjan University, Zanjan, Iran

*Corresponding author: mkanjani@gmail.com

ABSTRACT: This paper reports the redescription of all stages (egg, immatures and adult) of the mold mite, *Tyrophagus putrescentiae* (Schrank 1781), collected from bean leaves infested with opportunity fungus in the Department of Plant Protection laboratory, Hamedan, Iran.

KEY WORDS: Acari, Sarcoptiformes, *Tyrophagus*, redescription, key.

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INTRODUCTION

The family Acaridae (Acari: Sarcoptiformes) is a large cosmopolitan group including more than 90 genera and about 400 described species (Fan and Zhang 2007). The genus *Tyrophagus* was erected by Oudemans, 1924a with type species *Acarus putrescentiae* Schrank, 1781. Up to now about 35 species of the genus *Tyrophagus* Oudemans were recorded from around the world (Fan and Zhang 2007), eight species of the genus have been recorded from Iran (Khanjani *et al.* 2000; Kamali *et al.* 2001; Hadad Iraninezhad *et al.* 2007; Lotfollahi *et al.* 2010), namely: *T. brevicrinatus* Robertson, 1959; *T. longior* (Gervais 1844); *T. neiswanderi* Johnston and Bruce, 1965; *T. vanheurni* Oudemans, 1924b [= *T. palmarum* Oudemans; sensu Robertson, 1959 (Fan and Zhang, 2007); *T. perniciosus* Zakhvatkin, 1941; *T. putrescentiae* (Schrank, 1781); *T. similis* Volgin, 1949; *T. zachvatkini* Volgin, 1948. Mold mites, *T. putrescentiae*, are well-known and treated as one of the most common, economical, cosmopolitan and polyphagous mites of agricultural (Chmielewski 1999) and medical importance (Klimov and OConnor 2009). Currently there is a disagreement on the concept of *T. putrescentiae* (Schrank, 1781) and *T. communis* Fan and Zhang, 2007 between Klimov and OConnor (2009, 2010) and Fan and Zhang (2014). In this study the concept of *T. putrescentiae* was followed but with circumspection. Furthermore, a key to Iranian species of the genus *Tyrophagus* is presented, based on the literature. In addition, the comparison of characters of adult and immatures (larva, protonymph and tritonymph) stages of *T. putrescentiae* is provided in Table 1.

MATERIAL AND METHODS

All specimens were collected from bean leaves infested with opportunity fungus. The mites were mounted directly in Hoyer's medium on microscope slides. The slides were dried in an oven (50°C), sealed with industrial painting material, and examined with an Olympus BX51 Differential Interference Contrast (DIC) microscope. Drawings were made with a camera lucida. All measurements are presented in micrometers (µm). The terminology and abbreviations of idiosomal chaetotaxy used follows that of Griffiths *et al.* (1990); Grandjean (1939) for leg chaetotaxy; organotaxy complies with Klimov and OConnor (2003).

Acaridae Latreille, 1802

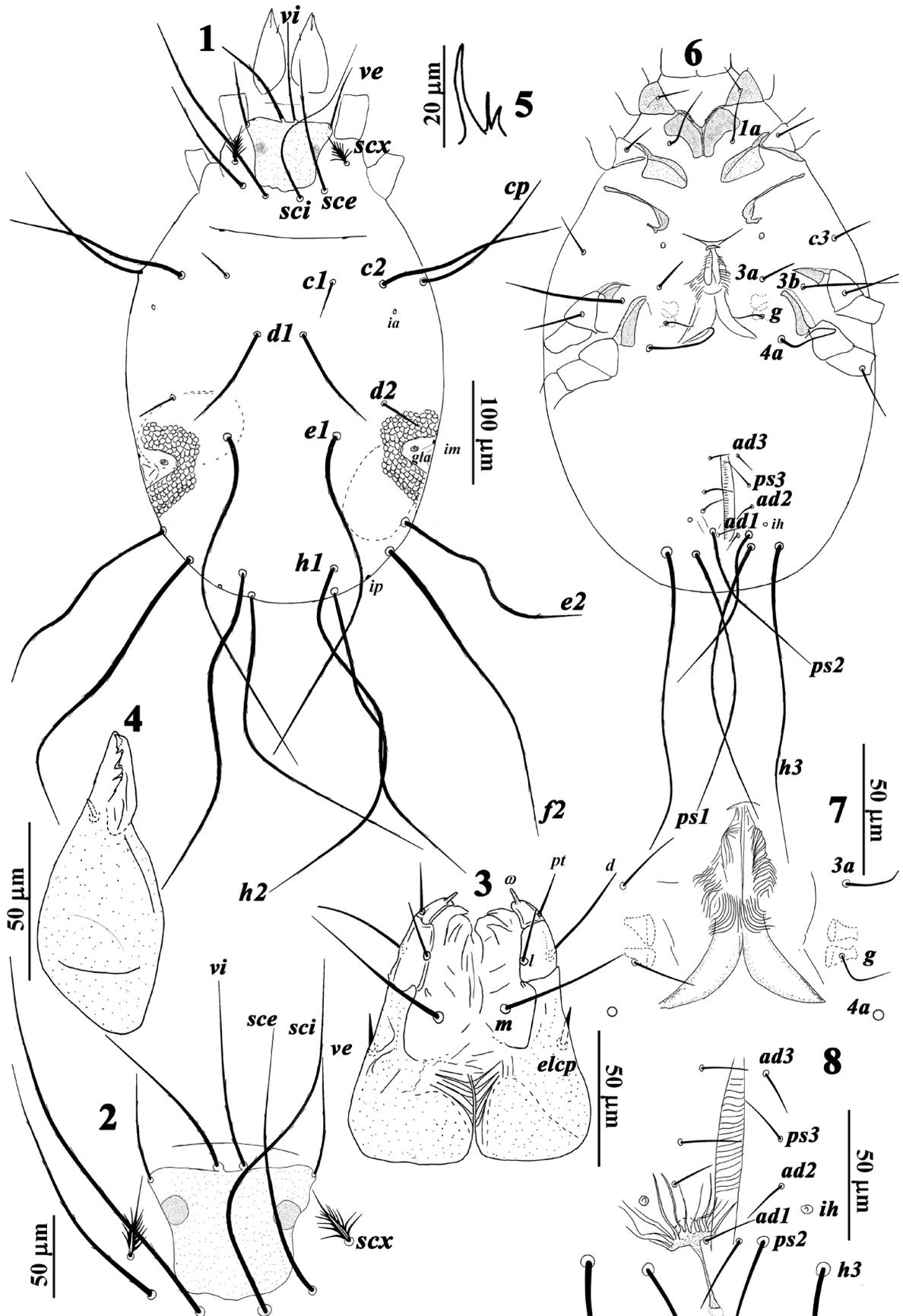
***Tyrophagus* Oudemans, 1924 (Oudemans 1924a: 250).**

Type species: *Acarus putrescentiae* Schrank, 1781.

***Tyrophagus putrescentiae* (Schrank, 1781)**

Female (Figs. 1–12; n = 7). Idiosoma oval. Length of body including gnathosoma 578–700, excluding gnathosoma 485–580; width 300–350.

Dorsum (Figs. 1, 2, 5). Prodorsal shield punctate, with two pairs of setae (*vi* and *ve*) almost pentagonal in shape with lateral margins a slightly concave; 76–85 long, 90–95 wide between setae *ve-ve*. Eyespots present in lateral position of prodorsal shield (~ 17–20 in diameter) (Figs. 1–2); Basal lobe of Grandjean's organ with one large tooth and two small teeth, 15–20, 5–8, and 3–5 long, respectively (Fig. 5). Supracoxal seta *scx* pectinated with six branches on each side and broadly expanding from the base but gradually tapers to a



Figures 1–8. *Tyrophagus putrescentiae* (Schrank, 1781) (female): 1. Dorsal view; 2. Prodorsal shield; 3. Gnathosoma; 4. Chelicera; 5. Grandjean's organ; 6. Ventral view; 7. Genital region; 8. Anal region, copulatory opening and spermatheca.

fine point distally (Fig. 2). All dorsal setae finely serrated. All opisthosomal setae whip-like except *c1*, *d1*, and *d2*. Opisthosoma with three pairs of lyrifissures (*ia*, *im* and *ip*) and one pair of opisthosomal gland (*gla*) at level of seta *e1*; seta *c1* is the shortest and setae *e1*, *f2*, *h1*, and *h2* are the longest dorsal setae; length of dorsal setae: *vi* 94–100; *ve* 55–65; *sci* 180–225; *sce* 101–130; *scx* 35–45; *c1* 30–42; *c2* 210–230; *cp* 168–200; *d1* 91–130; *d2* 42–50; *e1* 325–340; *e2* 220–250; *f2* 320–350; *h1* 320–360; *h2* 335–370. Distances: *vi-vi* 10–15; *vi-ve* 35–42; *ve-ve* 82–100; *ve-scx* 42–50; *scx-scx* 125–140; *scx-sce* 32–40; *sce-sce* 90–102; *sci-sce* 25–40; *sci-sci* 30–35; *sci-c1* 90–110; *c1-c1* 110–150; *c1-c2* 58–70; *c2-c2* 230–270; *c2-cp* 35–50; *cp-cp* 300–340; *c1-d1* 70–80; *d1-d1* 35–50; *d1-d2* 120–130; *d2-d2* 240–270; *d2-e2* 140–160; *d2-gla* 65–82; *gla-gla* 260–300; *d2-e1* 60–80; *e1-e1* 120–150; *e1-e2* 120–145; *e2-e2* 250–290; *e2-f2* 35–45; *f2-f2* 190–230; *e1-h1* 150–165; *h1-h1* 95–100; *h1-h2* 25–50; *h2-h2* 80–90. Ratio: *d1/c1* 3.03–3.1; *d1/d2* 2.17–2.60; *d2/c1* 1.2–1.4.

Gnathosoma (Figs. 3–4). Punctate; palpi two-segmented, palp tarsus with a simple seta (*pt*) and one solenidion (ω) 12–15 and 4–6 long, respectively; palp tibia with two simple setae (*d* 25–30 and *l* 15–20 long); infracapitulum with one simple seta (*m*) 28–40 long (Fig. 3); Chelicerae 85–95 long, cheliceral seta *cha* spine-like 5–7 long, movable and fixed digits with 2–4 teeth (Fig. 4). Palp coxa with one *elcp* setae 10–13 (Fig. 3). Distance: *m-m* 12–20.

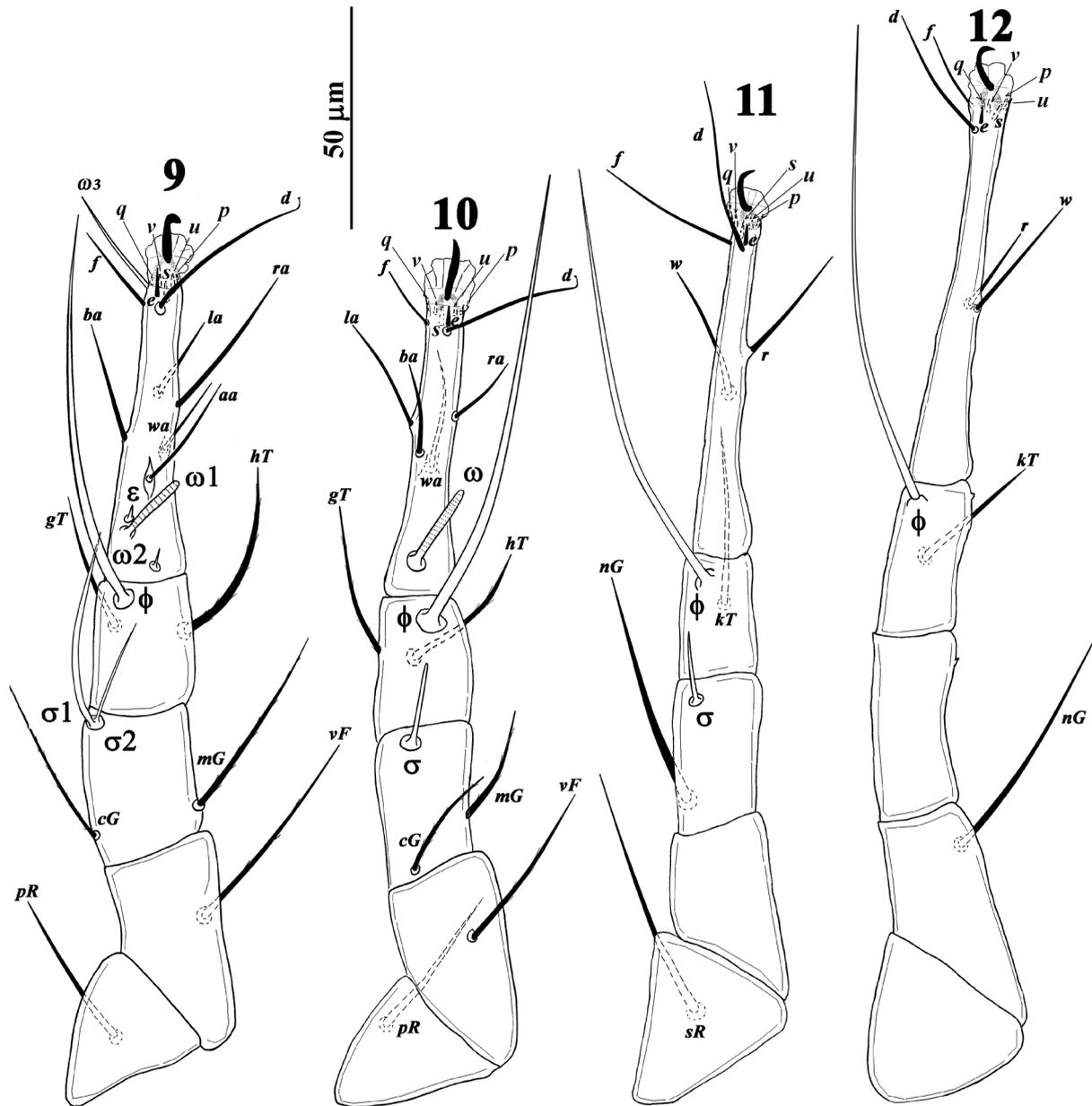
Venter (Figs. 6–8). Coxal plates I divided with apodemes I anteriorly on each side with five nodules; coxal plates II broadly triangular and with a well-developed apodeme near base of trochanter seta; between coxae II and III a pair of thin sclerotized sejugal apodemes; coxal plates III–IV each with apodemes (Fig. 6); genital region (posterior to sejugal apodemes to coxae IV) with two pairs of genital papillae, a pair of setae (*g*), and genital folds (Fig. 7). Anal region with three pairs of adanal setae (*ad1*–3) and three pairs of pseudoanal setae (*ps1*–3), seta *ps1* the longest anal setae (Fig. 6); a pair of lyrifissures (*ih*) posterior to seta *ad2*. Copulatory opening (7–10 in diameter) located posterior to anal opening, spermathecal duct (25–40 long) joins base of spermathecal sac (Fig. 8); length of ventral setae: *1a* 55–60, *c3* 30–35, *3a* 27–38, *3b* 95–110, *4a* 90–100, *g* 25–30, *ad3* 15–22, *ad2* 17–22, *ad1* 15–22, *ps3* 25–31, *ps2* 130–150, *ps1* 230–270, *h3* 280–300. Distances: *1a-1a* 60–70, *1a-3a* 120–140, *3a-3a* 95–135, *3a-3b* 35–60, *g-g*

90–125, *g-4a* 28–35, *4a-4a* 130–160, *ad3-ad3* 22–44, *ad3-ps3* 25–32, *ps3-ps3* 45–60, *ps3-ad2* 20–30, *ad2-ad2* 40–65, *ad2-ad1* 31–51, *ad1-ps2* 12–20, *ps2-ps2* 30–55, *ps2-ps1* 20–35, *ps1-ps1* 60–85, *ps1-h3* 25–45, *h3-h3* 120–150.

Legs (Figs. 9–12). Setal formulae of leg segments I–IV as follows (solenidia and special setae in parentheses): coxae 1–0–2–1; trochanters 1–1–1–0; femora 1–1–0–1, genua 2(2 σ)–2(1 σ)–1(1 σ)–0; tibiae 2(1 ϕ)–2(1 ϕ)–1(1 ϕ)–1(1 ϕ); tarsi 13(3 ω , 1 ϵ)–12(1 ω)–10–10. Solenidion ω 1 cylindrical, with apex slightly widened (figs. 9–12). Measurements of leg segments and setae as follows: Leg I 220–250: Tr 35–40, *pR* 38–45, Fe 50–60, *vF* 45–55, Ge 35–40, *cG* 40–47, *mG* 45–50, σ 1 46–50, σ 2 25–28, Ti 30–35, *gT* 38–45, *hT* 43–50, ϕ 115–130, Ta 70–75, ω 1 17–20, ω 2 5–7, ω 3 22–26, ϵ 3–5, *aa* 25–30, *ba* 25–33, *wa* 40–50, *ra* 30–40, *la* 25–30, *d* 40–50, *e* 5–8, *f* 15–20, *p* 4, *q* 5, *s* 5–6, *u* 4–5, *v* 5, empodium 15–20, claw 10–14; Leg II 200–237: Tr 30–35, *pR* 40–45, Fe 40–55, *vF* 60–73, Ge 35–44, *cG* 33–40, *mG* 42–50, σ 20–24, Ti 30, *gT* 40–48, *hT* 40–50, ϕ 120–130, Ta 65–70, ω 20–22, *ba* 24–30, *wa* 33–40, *ra* 30–35, *la* 20–28, *d* 40–45, *e* 4–5, *f* 14–20, *p* 4, *q* 4, *s* 6, *u* 4–5, *v* 4–5, empodium 14–20, claw 10–12; Leg III 212–245: Tr 35–40, *pR* 45–60, Fe 40–50, Ge 32–40, *nG* 50–65, σ 16–20, Ti 30–35, *kT* 45–50, ϕ 120–125, Ta 75–80, *w* 30–40, *r* 28–33, *d* 35–44, *e* 5, *f* 30–35, *p* 3–4, *q* 3–4, *s* 5, *u* 4, *v* 4, empodium 14–18, claw 10–15; Leg IV 239–270: Tr 35–42, Fe 45–50, Ge 44–50, Ti 35–43, *kT* 40–53, ϕ 110–120, Ta 80–85, *w* 35–40, *r* 25–32, *d* 36–40, *e* 5, *f* 28–32, *p* 3–4, *q* 3–4, *s* 5, *u* 4, *v* 4, empodium 12–17, claw 10–12; Ge and Ti IV with minute preapical process (Fig. 10).

Male (Figs. 13–24; n = 5). Idiosoma oval, length of body including gnathosoma 520–630, excluding gnathosoma 420–540; width 240–310.

Dorsum (Figs. 13–16). Prodorsal shield punctate, with two pairs of setae (*vi* and *ve*) nearly pentagonal in shape with lateral margins slightly concave; 78–87 long, 90–100 wide between setae *ve-ve*. Eyespots present on lateral margin of prodorsal shield (~ 15–17 in diameter) (Figs. 13, 16); Basal lobe of Grandjean's organ with one large tooth and three small teeth, 13–18, 6–7 and 4–5 long, respectively (Fig. 15). Supracoxal seta *scx* pectinated with six branches on each side (Fig. 14). All dorsal setae finely serrated. All opisthosomal setae whip-like except *c1*, *d1* and *d2*. Opisthosoma with three pairs of lyrifissures (*ia*, *im* and *ip*) and one pair of opisthosomal glands (*gla*) at level of



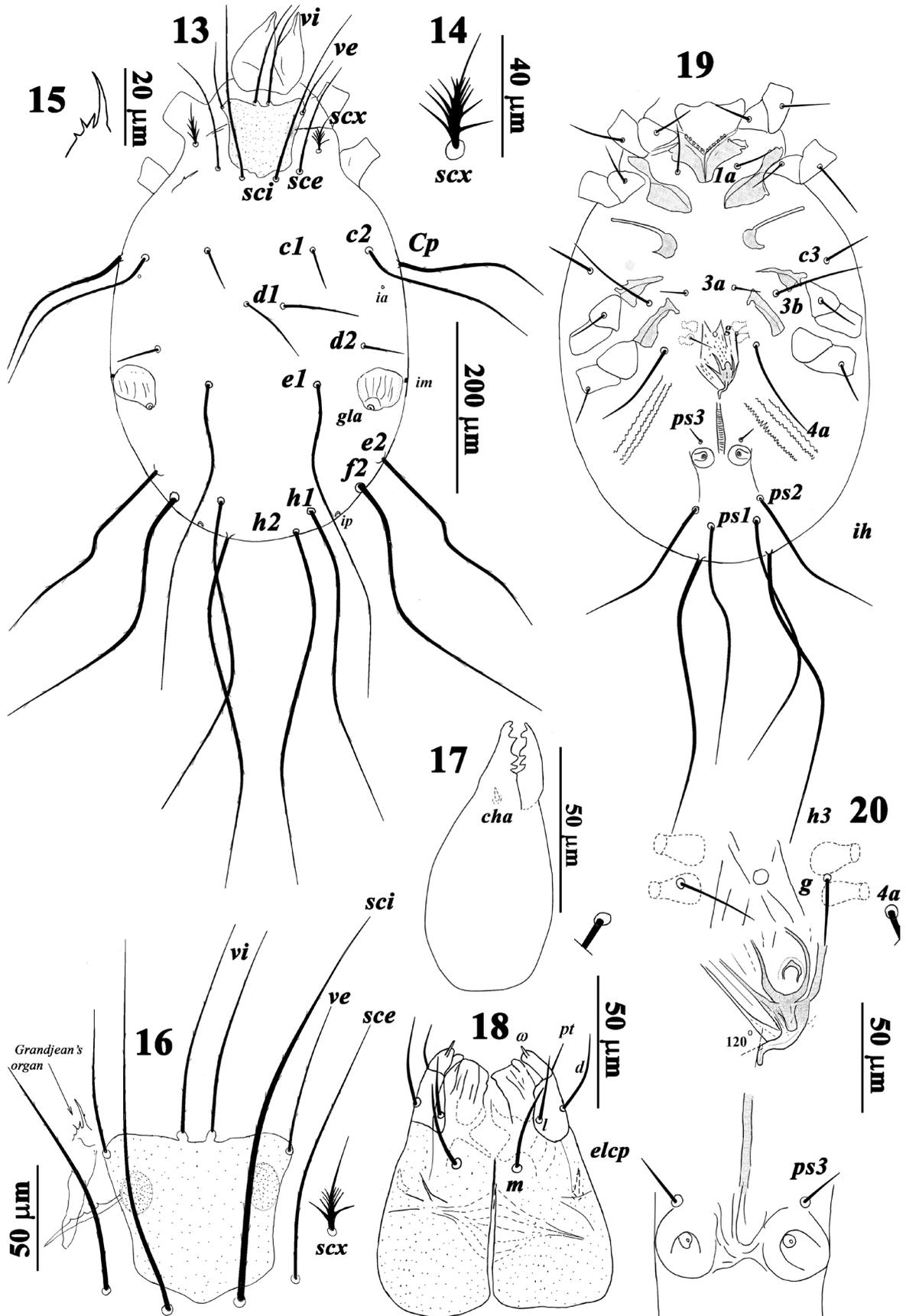
Figures 9–12. *Tyrophagus putrescentiae* (Schrank, 1781) (female): 9. Leg I; 10. Leg II; 11. Leg III; 12. Leg IV.

seta *el*; setae *cl* the shortest and setae *el*, *f2*, *h2* the longest dorsal setae; length of dorsal setae: *vi* 87–100; *ve* 60–65; *sci* 180–195; *sce* 105–115; *scx* 33–43; *c1* 32–40; *c2* 200–220; *cp* 180–190; *d1* 95–105; *d2* 45–50; *e1* 310–330; *e2* 225–230; *f2* 305–320; *h1* 300–305; *h2* 315–320. Distances: *vi-vi* 10–12; *vi-ve* 37–40; *ve-ve* 95–98; *ve-scx* 44–50; *scx-scx* 135–140; *scx-sce* 28–32; *sce-sce* 98–108; *sci-sce* 30–32; *sci-sci* 30–40; *sci-cl* 95–100; *c1-c1* 123–130; *c1-c2* 60–68; *c2-c2* 265–270; *c2-cp* 40–45; *cp-cp* 320–330; *c1-d1* 70–75; *d1-d1* 40–50; *d1-d2* 118–124; *d2-d2* 235–250; *d2-e1* 135–150; *d2-gla* 70–78; *gla-gla* 260–280; *d2-el* 60–65; *e1-el* 120–130; *e1-e2* 125–133; *e2-e2* 260–270; *e2-f2* 35–48; *f2-f2*

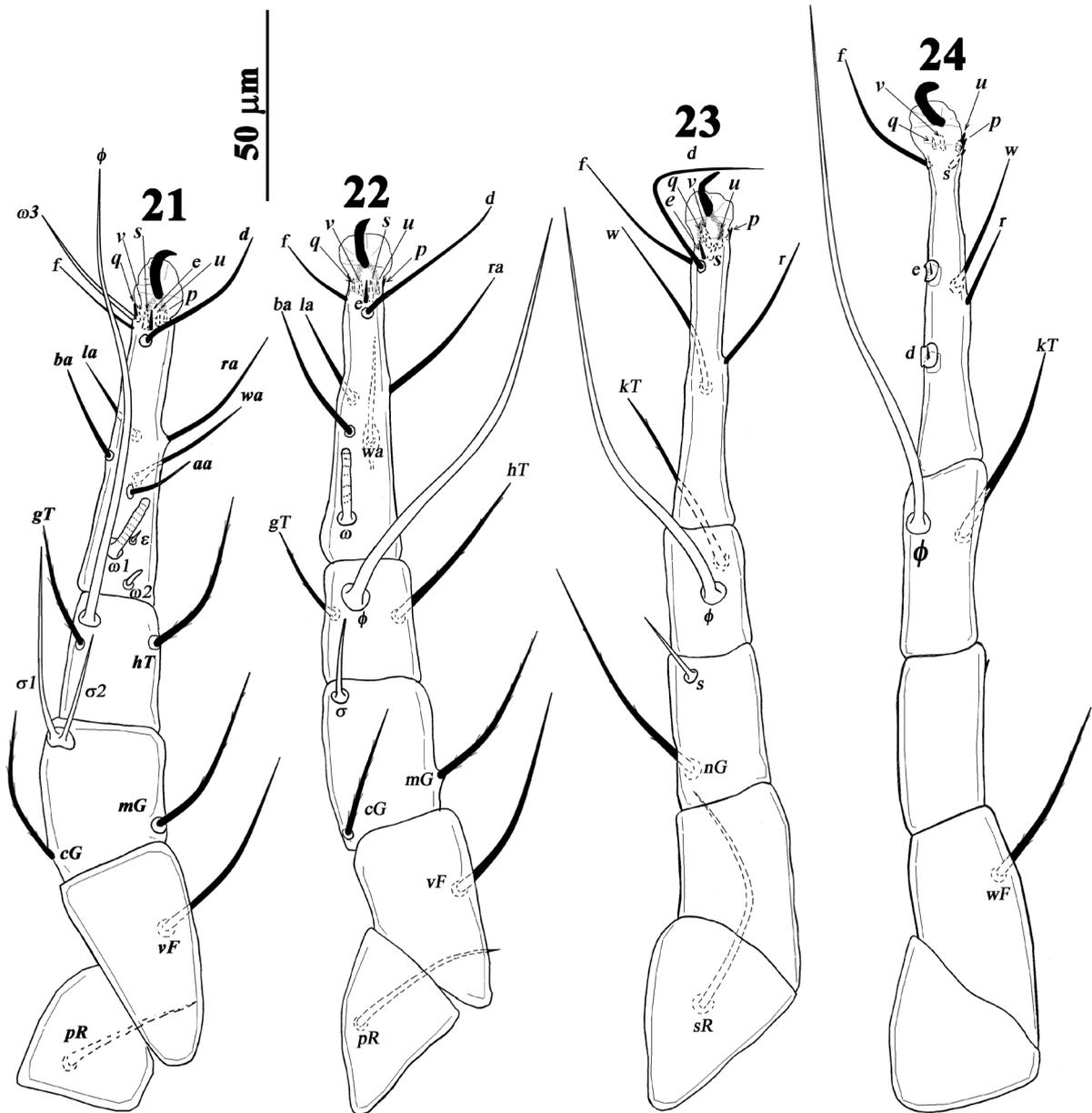
200–220; *e1-h1* 140–155; *h1-h1* 100–110; *h1-h2* 25–35; *h2-h2* 60–75.

Gnathosoma (Figs. 17–18). Punctate; palpi two-segmented, palp tarsus with a simple seta (*pt*) and one solenidion (ω) 10–13 and 4–5 long, respectively; palp tibia with two simple setae (*d* 20–25 and *l* 15–20 long); infracapitulum with one simple seta (*m*) 30–35 long (Fig. 18); chelicerae 80–90 long, cheliceral seta *cha* spine like 4–5 long, movable and fixed digits with 3–4 teeth (Fig. 17). Palp coxa with one *elcp* setae 10 (Fig. 18). Distance: *m-m* 17–19.

Venter (Figs. 19–20). Coxal plates I divided with apodemes I anteriorly with 5–6 nodes on each side; coxal plates II with a well-developed apodeme



Figures 13–20. *Tyrophagus putrescentiae* (Schrank, 1781) (male): 13. Dorsal view; 14. Supracoxal seta (*scx*); 15. Grandjean's organ; 16. Prodorsal shield; 17. Chelicera; 18. Gnathosoma; 19. Ventral view; 20. Genital and anal regions.

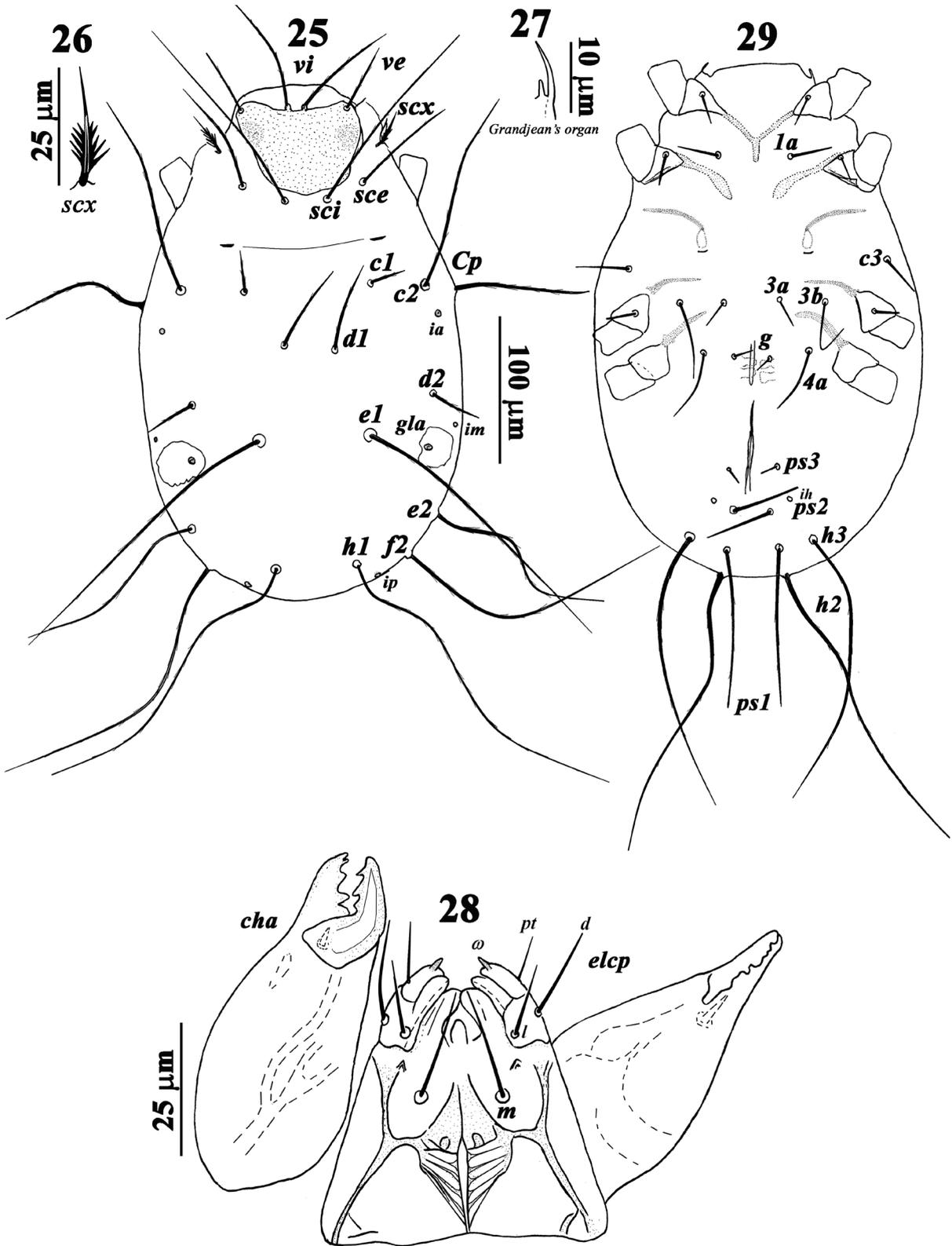


Figures 21–24. *Tyrophagus putrescentiae* (Schrank, 1781) (male): 21. Leg I; 22. Leg II; 23. Leg III; 24. Leg IV.

near base of trochanter seta; between coxae II and III with a pair of thin sclerotized sejugal apodemes; Coxal plates III–IV each one with apodemes (Fig. 19); genital region (between coxae IV) with two pairs of genital papillae and a pair of setae (g); aedeagus with two obvious curves, S-shaped and distally bent at an angle of 120°–125°, aedeagus shaft 23–27 long, lateral arms supporting aedeagus turning out wards (Figs. 19–20). Anal region with three pairs of pseudoanal setae (*ps1*–3), seta *ps1* and *ps3* the longest and the shortest anal setae respectively, a pair of anal suckers 20–25 and a pair of anal discs 4–5 in diameter (Figs. 19–20); length of ventral setae: *1a* 50–58, *c3* 45–50, *3a* 29–33, *3b* 110–115, *4a* 100–105, *g* 30–35, *ps3* 17–20, *ps2* 150–165, *ps1* 245–255, *h3* 295–300. Distances:

1a–*1a* 65–71, *1a*–*3a* 130–135, *3a*–*3a* 55–65, *3a*–*3b* 40–45, *g*–*g* 50–65, *g*–*4a* 30–34, *4a*–*4a* 100–120, *ps1*–*ps2* 20–25, *ps2*–*ps3* 70–75, *ps2*–*ps2* 60–75, *ps1*–*ps1* 48–53, *ps1*–*h3* 35–40, *h3*–*h3* 120–125.

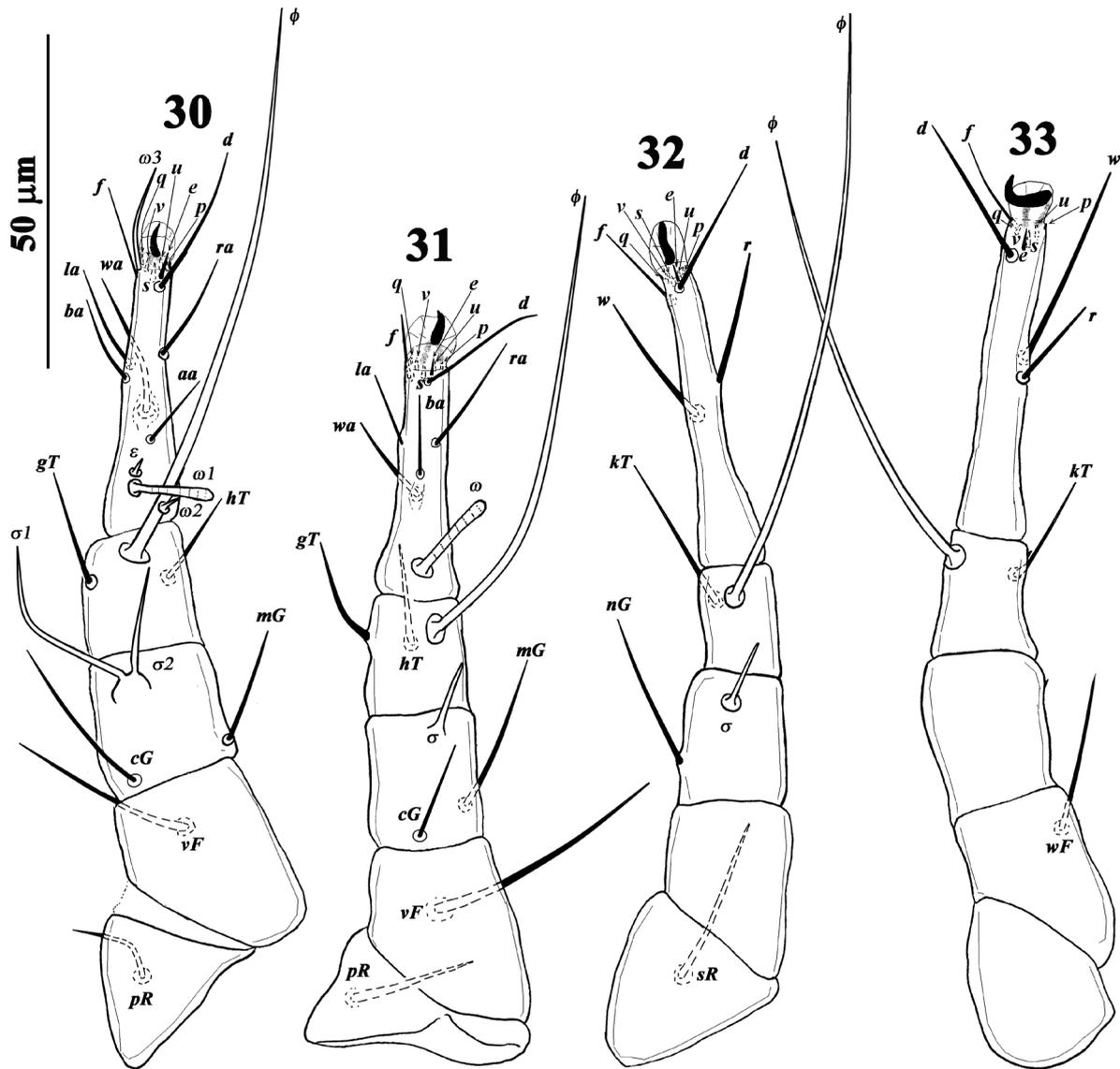
Legs (Figs. 21–24). Setal formulae of leg segments I–IV as follows (solenidia and special setae in parentheses): coxae 1–0–2–1; trochanters 1–1–1–0; femora 1–1–0–1, genua 2(2σ)–2(1σ)–1(1σ)–0; tibiae 2(1φ)–2 (1φ)–1 (1φ)–1 (1φ); tarsi 13 (3ω, 1ε)–12 (1ω)–10–10, solenidium ω1 cylindrical, with apex slightly widened (figs. 21–24). Measurements of leg segments and setae as follows: Leg I: Tr 35–45, *pR* 40–44, Fe 50–55, *vF* 50, Ge 35–40, *cG* 44–47, *mG* 48–50, σ1 50–60, σ2 25–28, Ti 30–35, *gT* 32–35, *hT* 40–45, φ 120–130, Ta 70–82, ω1 16–18, ω2 5–6, ω3 22–25, ε 4, *aa* 20–25, *ba* 25–28,



Figures 25–29. *Tyrophagus putrescentiae* (Schrank, 1781) (tritonymph): 25. Dorsal view; 26. Supracoxal seta (*scx*); 27. Grandjean's organ; 28. Gnathosoma; 29. Ventral view.

wa 48–52, *ra* 30–38, *la* 18–25, *d* 40–44, *e* 5–6, *f* 16–20, *p* 4, *q* 4, *s* 5–6, *u* 4–5, *v* 5, empodium 15–18, claw 10; Leg II: Tr 30–40, *pR* 35–40, Fe 48–54, *vF* 65–70, Ge 35–45, *cG* 38–40, *mG* 40–50, σ 20–21,

Ti 30, *gT* 35–40, *hT* 38–45, ϕ 125–130, Ta 70–78, ω 19–20, *ba* 25–28, *wa* 42–50, *ra* 35–40, *la* 22–23, *d* 40–44, *e* 5–6, *f* 15–18, *p* 3, *q* 3, *s* 5–6, *u* 4, *v* 4, empodium 15–18, claw 8–10; Leg III: Tr 35–45,



Figures 30–33. *Tyrophagus putrescentiae* (Schrank, 1781) (tritonymph): 30. Leg I; 31. Leg II; 32. Leg III; 33. Leg IV

pR 40–54, *Fe* 44–50, *Ge* 35–40, *nG* 55–68, σ 15–20, *Ti* 38–40, *kT* 45–52, ϕ 125–130, *Ta* 70–75, *w* 35–40, *r* 25–30, *d* 35–38, *e* 5, *f* 30–35, *p* 3, *q* 3, *s* 5, *u* 4, *v* 4–5, empodium 15–20, claw 10; Leg IV: *Tr* 35–40, *Fe* 45–50, *Ge* 40–45, *Ti* 40, *kT* 28–32, ϕ 110–115, *Ta* 78–83, *w* 42–50, *r* 18–22, *d* 3, *e* 2–3, *f* 30–38, *s* 5–7, *p* 3, *q* 3, *u* 4, *v* 4, empodium 15, claw 9–10. Tarsus IV with two suckers (seta *d* on proximal and seta *e* on distal sucker), distance between base of seta *d* and proximal segment of tarsus 25, *e*–*d* 18–23, *e*–*f* 25–28 (Fig. 24) and *Ge* and *Ti* IV with minute preapical process (Fig. 24).

Tritonymph (Figs. 25–33; n = 5). Idiosoma oval. Length of body including gnathosoma 410–475, excluding gnathosoma 340–410; width 210–240.

Dorsum (Figs. 25–27). Prodorsal shield punctate, 50–60 long, 65–80 wide between setae *ve*–*ve*, nearly pentagonal in shape with lateral margins slightly concave and with two pairs of seta (*vi* and *ve*); eyespots present on lateral margins of prodorsal shield (~ 10–13 in diameter) (Fig. 25); basal lobe of Grandjean's organ with one large tooth and a small teeth, 11–13 and 4 long, respectively (Fig. 27). Supracoxal seta *scx* pectinated with five branches on each side (Fig. 26). All dorsal setae finely serrated. All opisthosomal setae whip-like except *cl*, *d1* and *d2*. Opisthosoma with three pairs of lyrifissures (*ia*, *im* and *ip*) and one pair of opisthosomal glands (*gla*) at level of seta *e1*; seta *cl* the shortest and setae *e1*, *f2*, *h1* and *h2* the longest dorsal setae; length of dorsal setae: *vi* 52–60; *ve* 35–38; *sci* 120–135; *sce* 60–63; *scx* 24–30; *cl*

20–25; *c2* 110–130; *cp* 85–100; *d1* 52–60; *d2* 25; *e1* 180–200; *e2* 120–130; *f2* 200–220; *h1* 180–200; *h2* 185–230. Distances: *vi-vi* 8–10; *vi-ve* 25–30; *ve-ve* 60–68; *ve-scx* 30–35; *scx-scx* 100–120; *scx-sce* 25–35; *sce-sce* 80–90; *sci-sce* 28–30; *sci-sci* 40–30; *sci-cl* 66–80; *cl-cl* 80–95; *cl-c2* 38–48; *c2-c2* 150–210; *c2-cp* 20–35; *cp-cp* 210–240; *cl-d1* 50–70; *d1-d1* 30–40; *d1-d2* 75–95; *d2-d2* 155–180; *d2-e2* 85–100; *d2-gla* 38–50; *gla-gla* 175–230; *d2-e1* 40–60; *e1-e1* 80–110; *e1-e2* 65–80; *e2-e2* 150–180; *e2-f2* 25–30; *f2-f2* 120–150; *e1-h1* 85–110; *h1-h1* 55–70; *h1-h2* 15–30; *h2-h2* 40–50.

Gnathosoma (Fig. 28). Palpi two-segmented, palp tarsus with a simple seta (*pt*) and one solenidion (ω) 10 and 3–4 long, respectively; palp tibia with two simple setae (*d* 15–20 and *l* 10–11 long); infracapitulum with one simple seta (*m*) 23–25 long (Fig. 28); chelicerae 60–75 long, cheliceral seta *cha* spine like 5 long, movable and fixed digits with 4 teeth (Fig. 28). Palp coxa with one *elcp* setae 7–9 (Fig. 28). Distance: *m-m* 14–20.

Venter (Fig. 29). Coxal plates I divided with apodemes I narrow and without nodes; coxal plates II with narrow apodemes; a pair of thin sclerotized and narrow sejugal apodemes between coxae II and III; genital region with two pairs of genital papillae and a pair of setae (*g*) (Fig. 29). Anal region with three pairs of pseudoanal setae (*ps1-3*), setae *ps1* and *ps3* the longest and shortest anal setae, respectively (Fig. 29); a pair of lyrifissures (*ih*) between setae *ps2-3*. Length of ventral setae: *1a* 28–38, *c3* 25–30 *3a* 15–18, *3b* 45–52, *4a* 44–50, *g* 15–18, *ps3* 15–18, *ps2* 35–40, *ps1* 115–130, *h3* 170–185. Distances: *1a-1a* 50–55, *1a-3a* 95–115, *3a-3a* 35–40, *3a-3b* 28–40, *g-g* 18–25, *g-4a* 28–33, *4a-4a* 70–90, *ps3-ps3* 25–31, *ps2-ps2* 23–30, *ps2-ps1* 25–40, *ps1-ps1* 30–40, *ps1-h3* 20–30, *h3-h3* 75–85.

Legs (Figs. 30–33). Setal formulae of leg segments I–IV as follows (solenidia and special setae in parentheses): coxae 1–0–2–1; trochanters 1–1–1–0; femora 1–1–0–1, genua 2(2 σ)–2(1 σ)–1(1 σ)–0; tibiae 2(1 ϕ)–2(1 ϕ)–1(1 ϕ)–1(1 ϕ); tarsi 13(3 ω , 1 ϵ)–12(1 ω)–10–10 (Figs. 30–33). Measurements of leg segments and setae as follows: Leg I: Tr 25–30, *pR* 17–22, Fe 30–35, *vF* 30–35, Ge 23–25, *cG* 18–23, *mG* 28–30, σ 1 25–32, σ 2 12–16, Ti 19–23, *gT* 15–20, *hT* 18–22, ϕ 80–95, Ta 44–50, ω 1 15–16, ω 2 4, ω 3 17–20, ϵ 3–4, *aa* 12–15, *ba* 16–20, *wa* 20–25, *ra* 18–20, *la* 15–18, *d* 24–30, *f* 16–20, *e* 5, *p* 2–3, *q* 2–3, *s* 5–6, *u* 4, *v* 4, empodium 10–13, claw 7–10; Leg II: Tr 20–25,

pR 18–25, Fe 27–33, *vF* 35–42, Ge 20–22, *cG* 12–15, *mG* 20–24, σ 10–12, Ti 18–23, *gT* 15–20, *hT* 16–20, ϕ 80–95, Ta 38–40, ω 14–16, *ba* 13–17, *wa* 16–20, *ra* 22–25, *la* 14–15, *d* 25, *e* 5, *f* 14–17, *p* 2–3, *q* 2–3, *s* 4–5, *u* 3–4, *v* 3–4, empodium 8–10, claw 8–10; Leg III: Tr 25–30, *pR* 25–30 Fe 25–30, Ge 24–25, *nG* 27–30, σ 10–12, Ti 20–25, *kT* 28–35, ϕ 90–100, Ta 45–45, *w* 22–25, *r* 17–20, *d* 20–22, *e* 5, *f* 15–20, *p* 2, *q* 2, *s* 5, *u* 3–4, *v* 3–4, empodium 8–12, claw 5; Leg IV: Tr 25–30, Fe 28–30 Ge 23–28, Ti 25, *kT* 15–19, ϕ 70–75, Ta 44–50, *w* 21–25, *r* 17–20, *d* 22–25, *e* 4–5, *f* 18–22, *p* 2, *q* 2, *s* 5, *u* 4, *v* 4, empodium 10–12, claw 8–10; Ge and Ti IV with minute preapical process (Fig. 33).

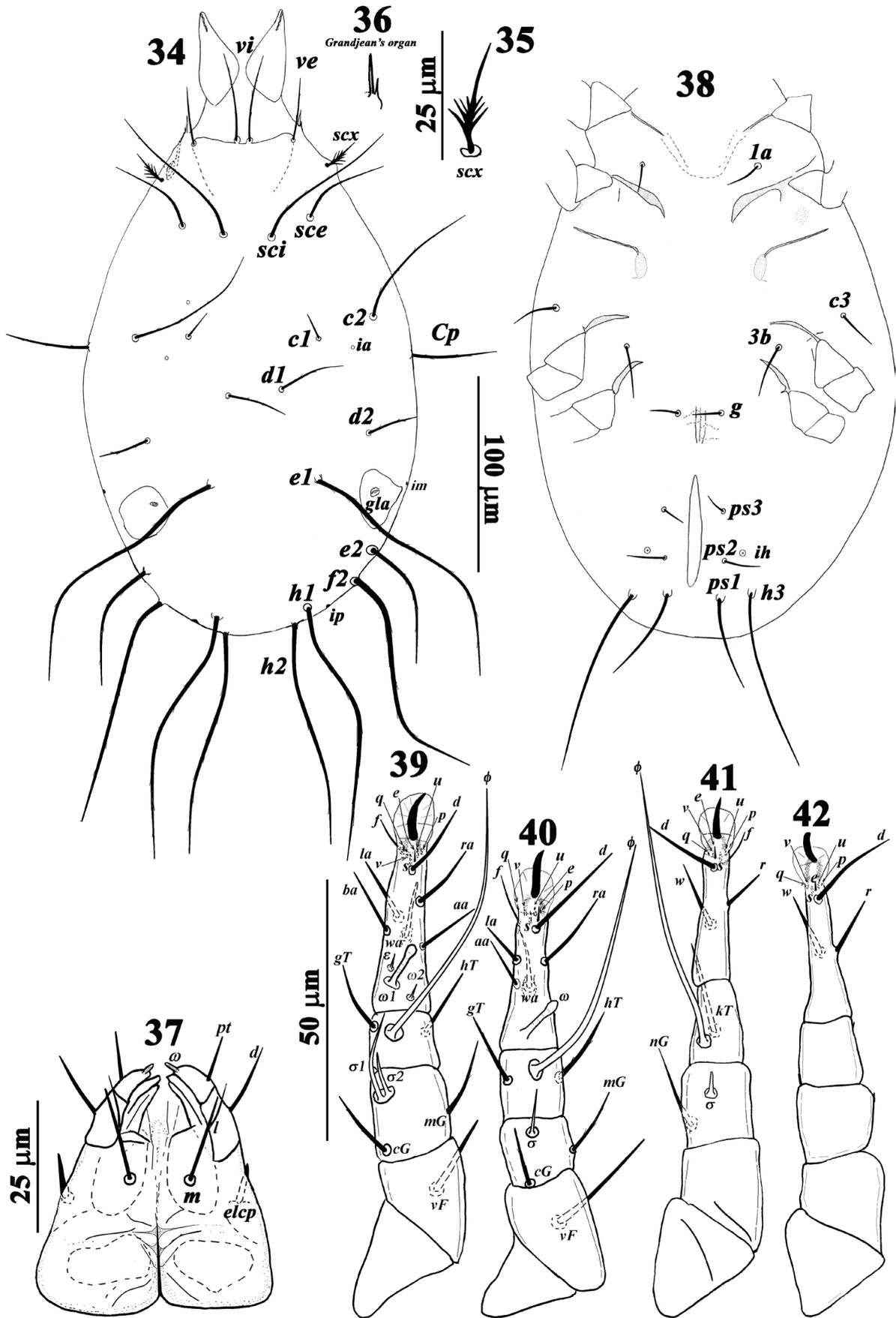
Deutonymph (Hypopus): unknown

Protonymph (Figs. 34–42; n = 3). Idiosoma oval. Length of body including gnathosoma 310–350, excluding gnathosoma 250–290; width 150–180.

Dorsum (Figs. 34–36). Prodorsal shield and eyespots indistinct and absent, respectively. Basal lobe of Grandjean's organ with one large and one small tooth, 7–8 and 4 long, respectively (Fig. 36). Supracoxal seta *scx* pectinated with four branches on each side (Fig. 35). All dorsal setae finely serrated. All opisthosomal setae whip-like except *cl*, *Cp*, *d1* and *d2*. Opisthosoma with three pairs of lyrifissures (*ia*, *im* and *ip*) and one pair of opisthosomal gland (*gla*) at level of seta *e1*; seta *cl* the shortest and setae *e1*, *f2*, *h1* and *h2* the longest dorsal setae; length of dorsal setae: *vi* 40–45; *ve* 25–31; *sci* 85–92; *sce* 40–44; *scx* 21–26; *cl* 15–18; *c2* 65–80; *Cp* 60–70; *d1* 30–40; *d2* 17–20; *e1* 125–135; *e2* 50–68; *f2* 125–130; *h1* 135–140; *h2* 125–135. Distances: *vi-vi* 6; *vi-ve* 18–22; *ve-ve* 40–55; *ve-scx* 25–30; *scx-scx* 80–91; *scx-sce* 20–26; *sce-sce* 66–75; *sci-sce* 25; *sci-sci* 26–28; *sci-cl* 50–58; *cl-cl* 65–75; *cl-c2* 25–31; *c2-c2* 125–135; *c2-Cp* 18–25; *Cp-Cp* 150–180; *cl-d1* 35–40; *d1-d1* 25–30; *d1-d2* 46–55; *d2-d2* 110–125; *d2-e2* 60–68; *d2-gla* 25–33; *gla-gla* 118–125; *d2-e1* 31–37; *e1-e1* 58–65; *e1-e2* 48–55; *e2-e2* 110–127; *e2-f2* 18–20; *f2-f2* 95–110; *e1-h1* 60–70; *h1-h1* 40–50; *h1-h2* 10; *h2-h2* 25–38.

Gnathosoma (Fig. 37). Palpi two-segmented, palp tarsus with a simple seta (*pt*) and one solenidion (ω) 7–8 and 3 long, respectively; palp tibia with two simple setae (*d* 14–16 and *l* 7–8 long); infracapitulum with one simple seta (*m*) 12–15 long (Fig. 37); chelicerae 50 long, cheliceral seta *cha* spine like 3 long. Palp coxa with one *elcp* setae 5–7. Distance: *m-m* 15–22.

Venter (Fig. 38). Coxal plates and apodemes I strongly reduced; coxal plates II with narrow



Figures 34–42. *Tyrophagus putrescentiae* (Schrank, 1781) (protonymph): 34. Dorsal view; 35. Supracoxal seta (scx); 36. Grandjean's organ; 37. Gnathosoma; 38. Ventral view; 39. Leg I; 40. Leg II; 41. Leg III; 42. Leg IV.

apodemes; a pair of thin sclerotized and narrow sejugal apodemes between coxae II and III; genital region with one pair of genital papillae, a pair of setae (*g*) (Fig. 38). Anal region with three pairs of pseudoanal setae (*ps1*–*3*), seta *ps1* the longest anal seta (Fig. 38); a pair of lyrifissures (*ih*) between setae *ps2*–*3*. Length of ventral setae: *la* 20–25, *3b* 28–35, *c3* 20–25, *g* 10–14, *ps3* 10–13, *ps2* 16–18, *ps1* 50–52, *h3* 105–125. Distances: *la*–*la* 45–60, *la*–*3b* 82–90, *3b*–*3b* 60–75, *3b*–*c3* 30–38, *g*–*g* 18–20, *ps3*–*ps3* 20–30, *ps2*–*ps2* 20–28, *ps2*–*ps1* 18–20, *ps1*–*ps1* 22–27, *ps1*–*h3* 16–20, *h3*–*h3* 61–70.

Legs (Figs. 39–42). Setal formulae of leg segments I–IV as follows (solenidia and special setae in parentheses): coxae 1–0–1–0; trochanters 0–0–0–0; femora 1–1–0–0, genua 2(2 σ)–2(1 σ)–1(1 σ)–0; tibiae 2(1 ϕ)–2(1 ϕ)–1(1 ϕ)–0; tarsi 13 (2 ω , 1 ϵ)–12 (1 ω)–10–9 (figs. 39–42). Measurements of leg segments and setae as follows: Leg I: Tr 15–20, Fe 25–29, *vF* 18–25, Ge 15–18, *cG* 13–14, *mG* 14–16, σ 1 17–20, σ 2 7–10, Ti 15–17, *gT* 12–15, *hT* 12–14, ϕ 50–58, Ta 25–33, ω 1 9–10, ω 2 3–4, ϵ 2–3, *aa* 10–12, *ba* 14, *wa* 20, *ra* 17–18, *la* 12–15, *d* 20–24, *e* 4, *f* 11–13, *p* and *q* 2–3, *s* 4, *v* and *u* 3–4, empodium 10–11, claw 6–7; Leg II: Tr 18–25, Fe 25–33, *vF* 25–30, Ge 14–16, *cG* 12–14, *mG* 15–20, σ 7–9, Ti 13–15, *gT* 13–14, *hT* 12, ϕ 52–60, Ta 27–30, ω 8–10, *ba* 10, *wa* 15, *ra* 15–20, *la* 10–12, *d* 17–20, *e* 4, *f* 8–10, *p* and *q* 2–3, *s* 4, *v* and *u* 3–4, empodium 10, claw 7–8; Leg III: Tr 20–24, Fe 18–20, Ge 15–20, *nG* 18–20, σ 4–6, Ti 15, *kT* 14–18, ϕ 55–70, Ta 28–36, *w* 15, *r* 10–12, *d* 15–18, *e* 4, *f* 8–10, *p* and *q* 2, *s* 3–4, *v* and *u* 3, empodium 10, claw 8; Leg IV: Tr 25, Fe 15–20, Ge 15–18, Ti 15–17, Ta 30–35, *w* 14–17, *r* 8–11, *d* 13, *e* 3, *p* and *q* 1–2, *s* 3, *v* and *u* 2, empodium 8, claw 6; Ge and Ti IV with minute preapical process (fig. 42).

Larva (Figs. 43–51; n = 5). Idiosoma oval. Length of body including gnathosoma 220–290, excluding gnathosoma 180–235; width 120–150.

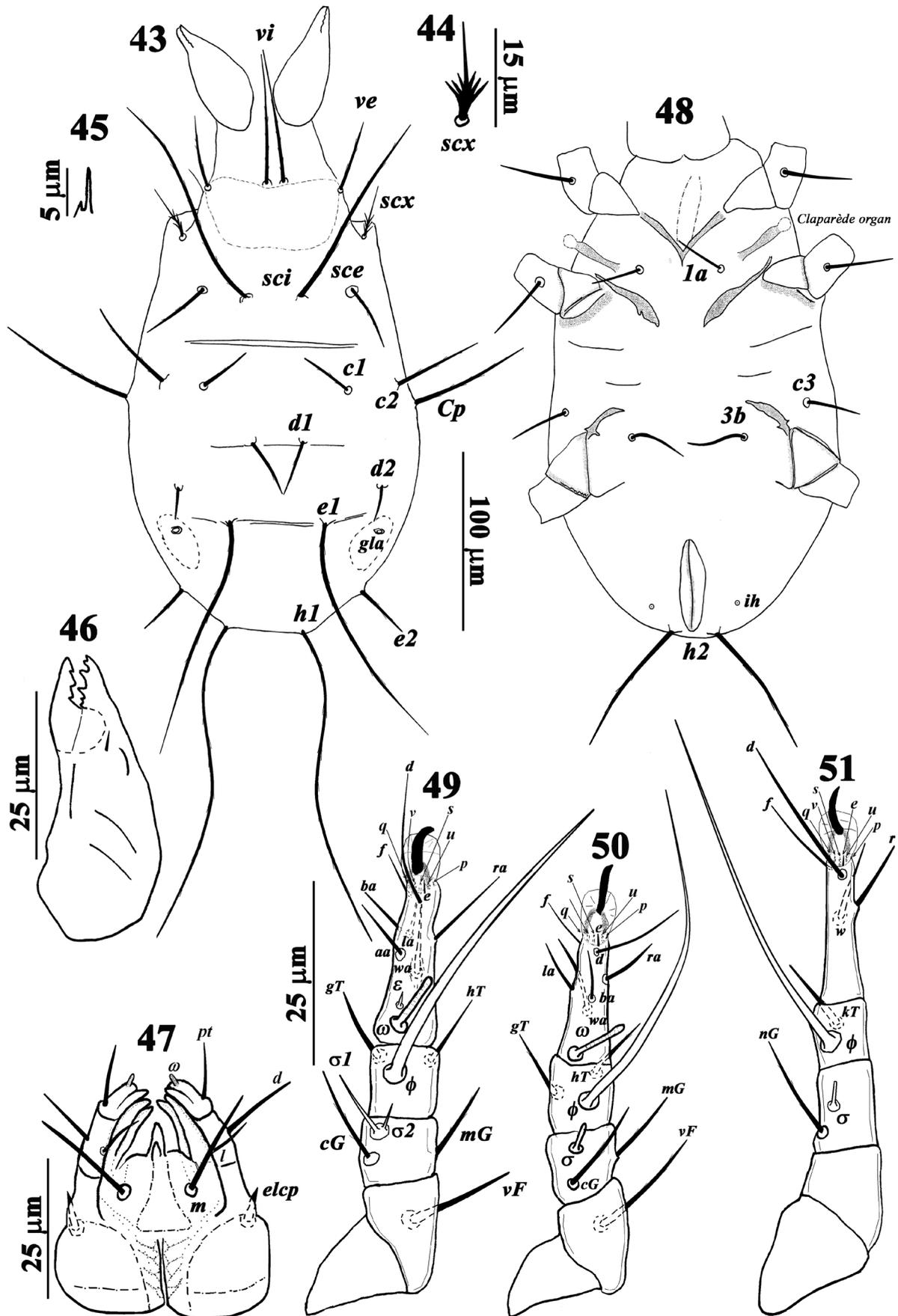
Dorsum (Figs. 43–45). Prodorsal shield and eyespots indistinct. Basal lobe of Grandjean's organ finger-like and with one large and one small tooth, 5–7 and 2 long, respectively (Fig. 45). Supracoxal seta *scx* pectinated with three branches on each side (Fig. 44). All dorsal setae finely serrated. Opisthosomal setae *e1*, *h1* whip-like. Setae *f2* and *h3* absent. Opisthosoma with one pair of opisthosomal glands (*gla*) at level of seta *e1*; setae *d2* and *c1* the shortest and seta *h1* the longest dorsal setae; length

of dorsal setae: *vi* 27–30; *ve* 15–20; *sci* 48–55; *sce* 20–25; *scx* 10–18; *c1* 12–15; *c2* 30–37; *Cp* 35–42; *d1* 20–25; *d2* 11–13; *e1* 80–85; *e2* 14–18; *h1* 105–125; *h2* 45–60. Distances: *vi*–*vi* 5; *vi*–*ve* 12–20; *ve*–*ve* 35–45; *ve*–*scx* 20–25; *scx*–*scx* 65–75; *scx*–*sce* 20–25; *sce*–*sce* 55–75; *sci*–*sce* 20–25; *sci*–*sci* 20–25; *sci*–*c1* 35–55; *c1*–*c1* 55–70; *c1*–*c2* 18–27; *c2*–*c2* 88–120; *c2*–*Cp* 15–20; *Cp*–*Cp* 100–135; *c1*–*d1* 25–30; *d1*–*d1* 20–26; *d1*–*d2* 35–45; *d2*–*d2* 80–115; *d2*–*e2* 40–55; *d2*–*gla* 20–25; *gla*–*gla* 90–112; *d2*–*e1* 25–35; *e1*–*e1* 40–50; *e1*–*e2* 35–50; *e2*–*e2* 80–100; *e1*–*h1* 44–53; *h1*–*h1* 44–50; *h1*–*h2* 17–25; *h2*–*h2* 11–17.

Gnathosoma (Figs. 46–47). Palpi two-segmented, palp tarsus with a simple seta (*pt*) and one solenidion (ω) 5–8 and 2–3 long, respectively; palp tibia with two simple setae (*d* 10–12 and *l* 7–8 long); infracapitulum with one simple seta (*m*) 15–18 long (fig. 47); chelicerae 35–40 long, cheliceral seta *cha* spine like 2 long, movable and fixed digits with 3–5 teeth (fig. 46). Palp coxa with one *elcp* seta 5. Distance: *m*–*m* 10–11.

Venter (Fig. 48). Coxal plates I–III with narrow apodemes; Claparède organ, between coxae I–II, with base tube-like and 16–20 in length terminating in a spherical knob distally, 3–4 in diameter), setae *3a*, *4a*, genital papillae and seta, adanal and pseudoanal setae absent; a pair of lyrifissures (*ih*) anterolateral of setae *h2*. Length of ventral setae: *la* 14–15, *3b* 20, *c3* 17–20. Distances: *la*–*la* 25–35, *la*–*3b* 65–80, *3b*–*3b* 35–55, *3b*–*c3* 31–45.

Legs (Figs. 49–51). Setal formulae of leg segments I–IV as follows (solenidia and special setae in parentheses): coxae 1–0–1; trochanters 0–0–0; femora 1–1–0, genua 2(2 σ)–2(1 σ)–1(1 σ); tibiae 2(1 ϕ)–2(1 ϕ)–1(1 ϕ); tarsi 13 (1 ω , 1 ϵ)–12 (1 ω)–10 (Figs. 49–51). Measurements of leg segments and setae as follows: Leg I: Tr 14–16, Fe 20–17, *vF* 17–20, Ge 13–15, *cG* 9–11, *mG* 12–15, σ 1 12–15, σ 2 5–6, Ti 11–13, *gT* 11–13, *hT* 8–10, ϕ 50–55, Ta 25–29, ω 1 8–10, ϵ 3–4, *aa* 7–11, *ba* 7–11, *wa* 10–13, *ra* 11–13, *la* 8–11, *d* 17–20, *e* 3, *f* 8–11, *q* and *p* 2, *s* 2–3, *v* and *u* 2–3, empodium 5–7, claw 3–4; Leg II: Tr 13–15, Fe 18–21, *vF* 17–20, Ge 13–15, *cG* 11–15, *mG* 8–10, σ 4–5, Ti 10–11, *gT* 10–11, *hT* 9–11, ϕ 44–52, Ta 18–24, ω 5–7, *ba* 7–11, *wa* 11–13, *ra* 8–10, *la* 8–10, *d* 14–17, *e* 3, *f* 6–8, *q* and *p* 1–2, *s* 2, *v* and *u* 2, empodium 8–10, claw 5–7; Leg III: Tr 15–17, Fe 15–18, Ge 11–12, *nG* 18–20, σ 4–6, Ti 13–15, *kT* 13–15, ϕ 48–60, Ta 26–30, *w* 10–13, *r* 10–12, *d* 16–18, *e* 3, *f* 11–13, *q*



Figures 43–51. *Tyrophagus putrescentiae* (Schrank, 1781) (larva): 43. Dorsal view; 44. Supracoxal seta (scx); 45. Grandjean's organ; 46. Chelicera; 47. Gnathosoma; 48. Ventral view; 49. Leg I; 50. Leg II; 51. Leg III.

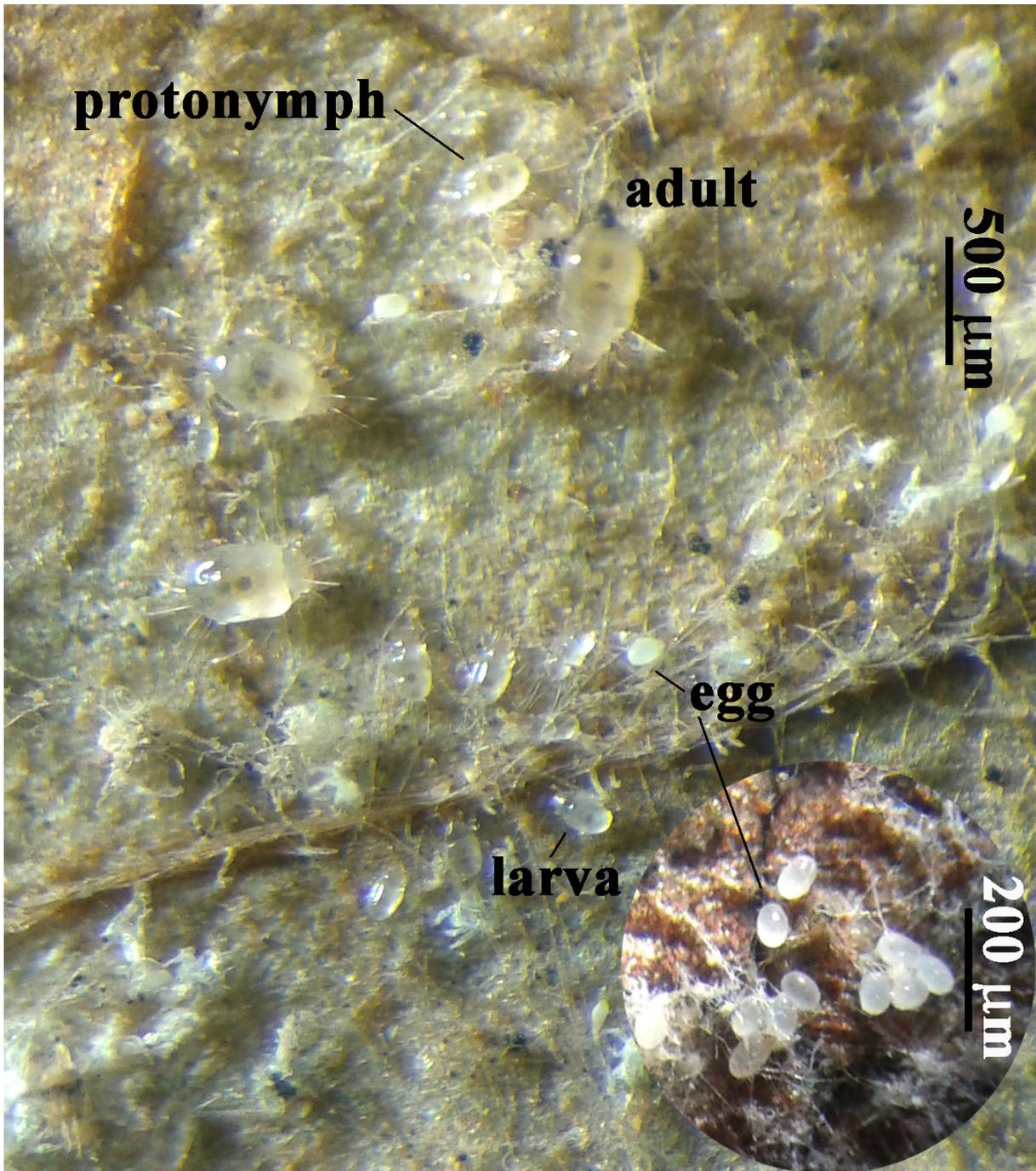


Figure 52. *Tyrophagus putrescentiae* (Schrank, 1781): egg, larva, protonymph and adult

and *p* 1, *s* 2, *v* and *u* 1–2, empodium 10, claw 6 long.

Egg (Fig. 52). White and oval in shape, 125–140 long \times 80–90 wide (Fig. 52).

DISCUSSION & CONCLUSION

We redescribed developmental stages of *T. putrescentiae* based on specimens from Iran. *T. putrescentiae* mites are important as pests contaminating food with fungi, causes of allergens, and an alternative prey or food source for mass

rearing of predatory mites used in biological control (Huang *et al.* 2013). This redescription demonstrates minor differences between Iranian specimens and a recent redescription from New Zealand (Fan and Zhang 2007) but differs as follows: (Female): 1. Measurements and distances of dorsal seta *c*1 30–42; *c*2 210–230; *c*3 30–35; *h*1 320–360; *h*3 280–300; *d*2–*gla* 65–82 in Iranian specimens opposed to *c*1 50–51; *c*2 247–261; *c*3 47–49; *h*1 384–392; *h*3 314–319; *d*2–*gla* 48–51 in New Zealand specimens; (Male): 1. Prodorsal shield 90–100

wide between setae *ve-ve* versus 68–77; 2. *vi/ve* =1.45–1.54 vs. 1.8–2.3; 3. Measurements of setae *ve* 60–65; *cp* 180–190; *ps1* 245–255; *ps2* 150–165; I ϕ 120–130; II ϕ 125–130 vs. *ve* 44–46, *cp* 141–151; *ps1* 178–181; *ps2* 81–106; I ϕ 81–108, II ϕ 102–115. Furthermore this redescription closely resembles a redescription by Klimov and OConnor (2009) in having distal one-third of aedeagus (bent at an angle more than 110°); pattern of coxal sclerotization II; shape of solenidion I ω 1; also genu and tibia IV with small preapical processes in all mobile stages (except larvae) according to other redescriptions from Spain (Jorrín-Novo *et al.* 2003). The discriminative characters of immature and adult stages of this species are listed in Table 1.

Key to Iranian *Tyrophagus* species (modified from Samšínák 1962 and Fan and Zhang 2007)

- 1. Dorsal seta *dl* sub equal to seta *cl* in length 2
 — Dorsal seta *dl* 1.5–3 times longer than seta *cl* in length 3
- 2. Supracoxal seta (*scx*) short (less than 20 μ m) and almost smooth; lateral arms supporting aedeagus turning out wards
 *T. brevicrinatus* Robertson, 1959
 — Supracoxal seta (*scx*) slender and with pectination (40–50 μ m long); lateral arms supporting aedeagus turning inwards *T. similis* Volgin, 1949
- 3. Eyespots present..... 4
 — Eyespots absent..... 5
- 4. Penis S-shaped
 *T. putrescentiae* (Schrank, 1781)
 — Penis not distinctly S-shaped
 *T. neiswanderi* Johnston and Bruce, 1965

- 5. Dorsal seta *dl* considerably longer than seta *cl*, 2.4–3.2 times..... 6
 — Dorsal seta *dl* at most twice as long as seta *cl* 7
- 6. Supracoxal seta *scx* slender; spermathecal duct cylindrical shaped..... *T. vanheurni* Oudemans, 1924b [= *T. palmarum* Oudemans; sensu Robertson, 1959 (Fan and Zhang, 2007)]
 — Supracoxal seta *scx* tapering from base to tip or slightly widened in basal 2/3; spermathecal duct very wide along its entire length.....
 *T. perniciosus* Zakhvatkin, 1941
- 7. Solenidion I ω 1 tapered distally and cylindrical shaped *T. longior* (Gervais, 1844)
 — Solenidion I ω 1 not tapered distally.....
 *T. zachvatkini* Volgin, 1948

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Table 1. Idiosomal and leg chaetotaxy, and organotaxy status of *T. putrescentiae* (Schrank) in mobile stages.

Character / Stage	Larva	Protonymph	Tritonymph	Adult (Female)	Adult (Male)
<i>vi</i>	+	+	+	+	+
<i>ve</i>	+	+	+	+	+
<i>sci</i>	+	+	+	+	+
<i>sce</i>	+	+	+	+	+
<i>scx</i>	+	+	+	+	+
<i>cl</i>	+	+	+	+	+
<i>c2</i>	+	+	+	+	+
<i>c3</i>	+	+	+	+	+

Tyrophagus putrescentiae from Western Iran

<i>Cp</i>	+	+	+	+	+
<i>d1</i>	+	+	+	+	+
<i>d2</i>	+	+	+	+	+
<i>e1</i>	+	+	+	+	+
<i>e2</i>	+	+	+	+	+
<i>f2</i>	-	+	+	+	+
<i>h1</i>	+	+	+	+	+
<i>h2</i>	+	+	+	+	+
<i>h3</i>	-	+	+	+	+
Grandjean's organ	+	+	+	+	+
<i>1a</i>	+	+	+	+	+
<i>3a</i>	-	-	+	+	+
<i>3b</i>	+	+	+	+	+
<i>4a</i>	-	-	+	+	+
<i>g</i>	-	-	+	+	+
<i>ad1</i>	-	-	-	-	+
<i>ad2</i>	-	-	-	-	+
<i>ad3</i>	-	-	-	-	+
<i>ps1</i>	-	+	+	+	+
<i>ps2</i>	-	+	+	+	+
<i>ps3</i>	-	+	+	+	+
Genital papillae	-	+ (1 pair)	+ (2 pairs)	+ (2 pairs)	+ (2 pairs)
Opisthosomal gland (<i>gla</i>)	+	+	+	+	+
Copulatory opening	-	-	-	-	+
Spermatheca	-	-	-	-	+
Aedeagus	-	-	-	+	-
Anal suckers	-	-	-	+	-
Claparède organ	+	-	-	-	-
Leg IV	-	+	+	+	+
Cx. I-III or IV	1-0-1	1-0-1-0	1-0-2-1	1-0-2-1	1-0-2-1
Tr. I-III or IV	0-0-0	0-0-0-0	1-1-1-0	1-1-1-0	1-1-1-0
Fe. I-III or IV	1-1-0	1-1-0-0	1-1-0-1	1-1-0-1	1-1-0-1
Ge. I-III or IV	2(2σ)-2(1σ)- 1(1σ)	2(2σ)-2(1σ)- 1(1σ)-0	2(2σ)-2(1σ)- 1(1σ)-0	2(2σ)-2(1σ)- 1(1σ)-0	2(2σ)-2(1σ)- 1(1σ)-0
Ti. I-III or IV	2(1φ)-2 (1φ)-1 (1φ)	2(1φ)-2 (1φ)-1 (1φ)-0	2(1φ)-2 (1φ)-1 (1φ)-1 (1φ)	2(1φ)-2 (1φ)-1 (1φ)-1 (1φ)	2(1φ)-2 (1φ)-1 (1φ)-1 (1φ)
Ta. I-III or IV	13 (1ω, 1ε)-12 (1ω)-10	13 (2ω, 1ε)-12 (1ω)-10-9	13 (3ω, 1ε)-12 (1ω)-10-10	13 (3ω, 1ε)-12 (1ω)-10-10	13 (3ω, 1ε)-12 (1ω)-10-10
Ta. IV with suckers	-	-	-	-	+

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