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Article

Ontogeny of *Tyrophagus perniciosus* Zakhvatkin (Acari: Acaridae) from Western Iran

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ABSTRACT

This paper provides a re-description and description of all ontogenetic stages of the acarid mite, *Tyrophagus perniciosus* Zakhvatkin, 1941, collected from the soil and under forest trees litter in Hamedan province, Western Iran.

KEY WORDS: Acarid mite; description; forest; mobile stages; re-description.

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INTRODUCTION

The family Acaridae (Acari: Sarcoptiformes) is an ecologically diverse and cosmopolitan group including more than 90 genera and about 400 described species (Fan and Zhang 2007; O'Connor 2009). They are known to have alarm pheromones (Sonenshine 1985). The idiosomal chaetotaxy of astigmatic mites in the frame of ontogenetic hypothesis was mentioned completely and detailed by Griffiths *et al.* (1990) that the genus *Tyrophagus* was categorized in hypothesis VI. The cosmopolitan genus *Tyrophagus* (with 35 valid species) was erected by Oudemans, 1924 with *Acarus putrescentiae* Schrank, 1781 as its type species (Fan and Zhang 2007). Eight species of this genus have been recorded from Iran until now, namely: *T. brevicrinatus* Robertson, 1959, *T. longior* (Gervais 1844), *T. neiswanderi* Johnston & Bruce, 1965, *T. vanheurni* Oudemans, 1924 [syn.: *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 (Khanjani *et al.* 2000; Kamali *et al.* 2001, Haddad Irani-Nejad *et al.* 2007, Lotfollahi *et al.* 2010). *Tyrophagus perniciosus* Zakhvatkin, 1941 was collected and described from dust granaries, warehouses and also associated with oats and barley from Russia (Zakhvatkin 1941). *Tyrophagus perniciosus* Zakhvatkin was recorded from different continents including Asia, Australia, Europe and North America (Fan and Zhang 2007). In Iran, the species has been recorded from alfalfa farms of Northwest of East Azerbaijan province (Haddad Irani-Nejad *et al.* 2007; Lotfollahi *et al.* 2010). Alarm pheromones have been reported in this species (Leal *et al.* 1989; Kuwahara 2010). A comparison of characters of ontogenetic stages of *T. perniciosus* Zakhvatkin, 1941 is presented in Table 1.

MATERIAL AND METHODS

The mites were collected from the soil and litter under common hawthorn trees, *Crataegus monogyna* Jacq. (Rosaceae), Nahavand region (34° 08' 46.7" N, 48° 13' 26.2" E), Hamedan province, Iran, 14 July 2015. Specimens were mounted directly in Hoyer's medium on microscope slides. Slides were dried in an oven (50°C), sealed with industrial painting material and examined under an Olympus BX51 Differential Interference Contrast (DIC) microscope. Drawings were made with a camera lucida and all measurements are presented in micrometers (µm). The terminology and abbreviations of idiosomal chaetotaxy follows that of Griffiths *et al.* (1990), Grandjean (1939) for leg chaetotaxy; organotaxy complies with Klimov and OConnor (2003).

RESULTS

Acaridae Latreille, 1802 *Tyrophagus* Oudemans, 1924: 250.

Type species: *Acarus putrescentiae* Schrank, 1781

Tyrophagus perniciosus Zakhvatkin, 1941: 104.

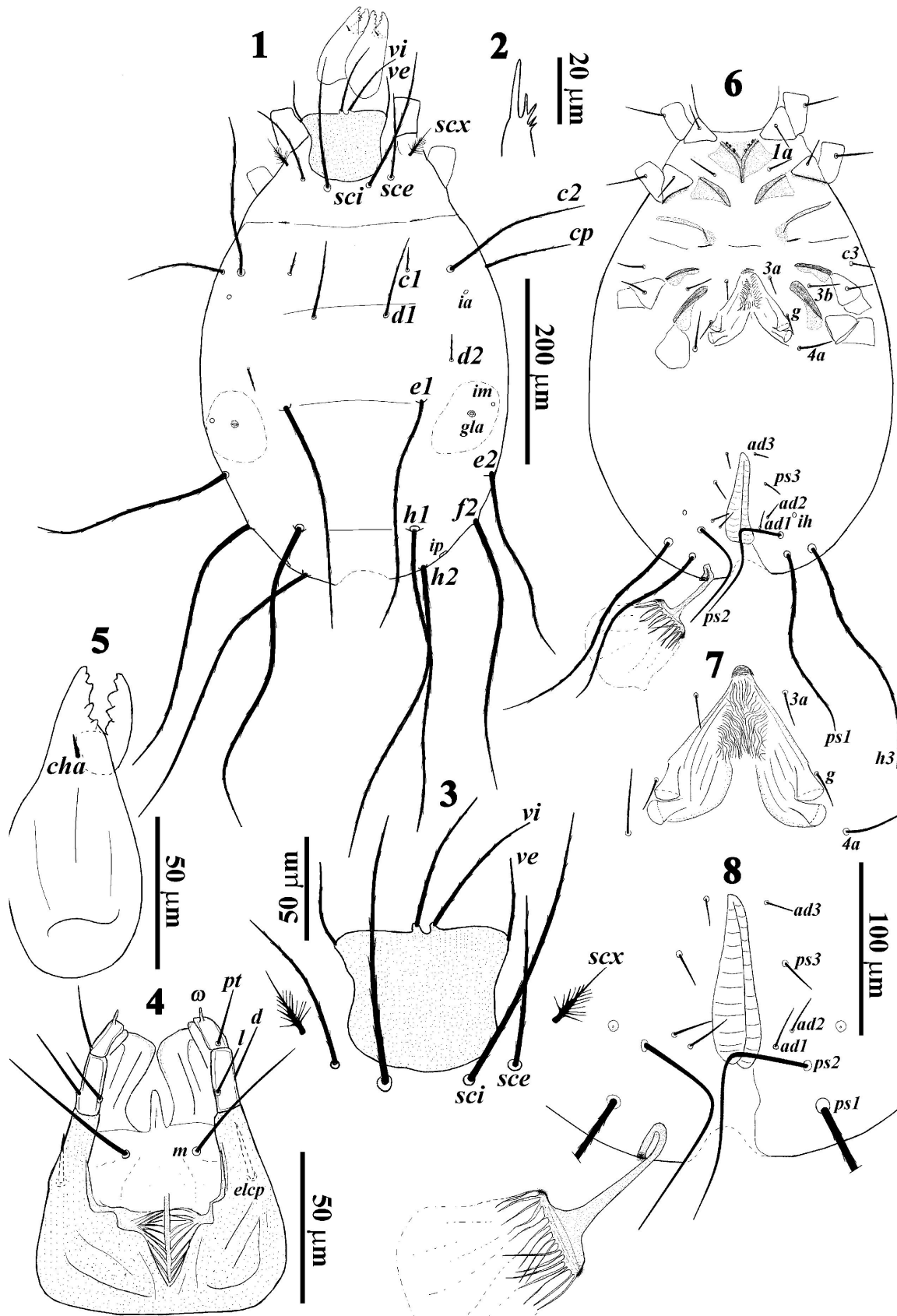
Diagnosis

Dorsal seta *dl* considerably longer than seta *cl*, 2.4–3.2 times; eyespots absent; supracoxal seta *scx* tapering from base to tip or slightly widened in basal 2/3; spermathecal duct very wide along its entire length; solenidion $\omega 1$ of tarsi I-II cylindrical and obviously widened apically. Coxal plates II broadly triangular and with a well-developed apodeme near base of trochanter seta; aedeagus obviously curves, sickle-shaped.

Female (Figs. 1–12, 53–54, 63; n = 6) – Idiosoma oval. Length of body including gnathosoma 549–687, excluding gnathosoma 465–575; width 263–375.

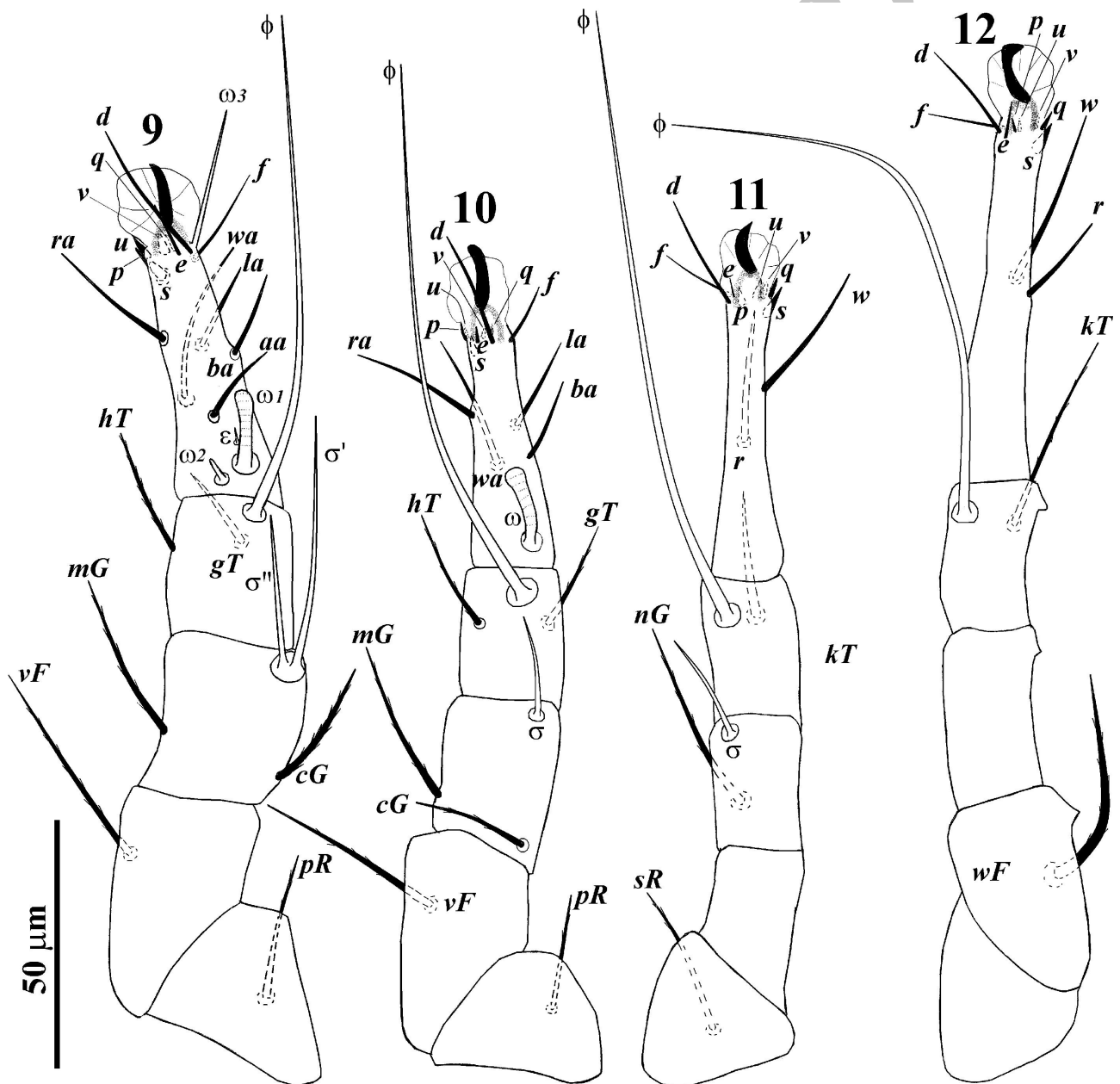
Dorsum (Figs. 1–3). Prodorsal shield punctate, with 2 pairs of setae (*vi* and *ve*) almost pentagonal in shape with lateral margins a slightly concave; 78–102 long, 90–125 wide between setae *ve-ve*. Eyespots absent (Figs. 1, 3); Basal lobe of Grandjean's organ with one large tooth and four small teeth, 17–20, 5–7, 4–5, 2–3 and 2 long, respectively (Fig. 2). Supracoxal seta *scx* pectinate with 8 rays on each side and broadly expanding from the base but gradually tapers to a fine point distally (Figs. 1, 3). All dorsal setae finely serrated. All opisthosomal setae whip-like except *cl*, *dl* and *d2*. Opisthosoma with 3 pairs of lyrifissures (*ia*, *im* and *ip*) and 1 pair of opisthosomal gland (*gla*) at level of seta *e1*; Seta *cl* is the shortest whereas seta *hl* is the longest dorsal setae. Length of dorsal setae: *vi* 80–112; *ve* 41–57; *sci* 178–237; *sce* 122–150; *scx* 37–50; *cl* 27–45; *c2* 180–225; *cp* 125–153; *dl* 95–133; *d2* 28–45; *e1* 250–330; *e2* 195–270; *f2* 310–350; *hl* 365–400; *h2* 325–375. Distances: *vi-vi* 8–12; *vi-ve* 45–60; *ve-ve* 96–110; *sce-sce* 95–110; *sci-sce* 25–27; *sci-sci* 35–45; *sce-ve* 67–82; *cl-cl* 110–155; *cl-c2* 38–50; *c2-c2* 185–255; *c2-cp* 28–40; *cp-cp* 252–330; *cl-dl* 48–57; *dl-dl* 65–90; *dl-d2* 78–112; *d2-d2* 195–265; *d2-gla* 50–60; *gla-gla* 210–305; *gla-e1* 47–65; *e1-e1* 115–170; *e1-e2* 87–135; *e2-e2* 210–310; *e2-f2* 45–55; *f2-f2* 200–255; *e1-h1* 118–155; *h1-h1* 88–112; *h1-h2* 40–65; *h2-h2* 85–100. Ratio: *dl/cl* 2.95–3.51; *dl/d2* 2.95–3.40; *d2/cl* 1.00–1.04.

Gnathosoma (Figs. 4–5) – Punctate; palp two-segmented, palp tarsus with a simple seta (*pt*) and one solenidion (ω) 15–20 and 4–7 long, respectively; palp tibia with two simple setae (*d* 18–25 and *l* 17–20 long); infracapitulum with one simple seta (*m*) 44–50 long, distance: *m-m* 18–25. Rutellum distinct and developed (Fig. 4); chelicerae 95–110 long, cheliceral seta *cha* spine-like 5–7 long, movable and fixed digits with 4–5 teeth (Fig. 5). Palp coxa with one *elcp* setae 17–23 (Fig. 4).



Figures 1-8. *Tyrophagus perniciosus* Zakhvatkin, 1941 (female) – 1. Dorsal view of idiosoma; 2. Grandjean's organ; 3. Pro-dorsal shield; 4. Gnathosoma; 5. Chelicera; 6. Ventral view of idiosoma; 7. Genital region; 8. Anal region, copulatory opening and spermatheca.

Venter (Figs. 6–8, 63) – Coxal plates I divided with apodemes I anteriorly on each side with 3 nodules; coxal plates II broadly triangular and with an well-developed apodeme near base of trochanter seta (Fig. 63); between coxae II and III with a pair of thin sclerotized sejugal apodemes, 45–65 long; coxal plates III-IV each with apodemes (Fig. 6); genital region (posterior to sejugal apodemes to coxae IV) with two pairs of genital papillae 18-25 long and 13-15 wide, a pair of setae (*g*) and genital folds (Figs. 6–7). 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*) at level of seta *ad2* base. Copulatory opening (8–11 in diameter) located posterior to anal opening, spermathecal duct (38–50 long) very wide along its entire length and join base of spermathecal sac and with a long neck, 80 long (Figs. 6, 8); Length of ventral setae: *1a* 37–50, *c3* 37–50, *3a* 20–25, *3b* 31–50, *4a* 38–47, *g* 15-20, *ad3* 14–23, *ad2* 22–37, *ad1* 23–37, *ps3* 25–35, *ps2* 125–170, *ps1* 200–260, *h3* 270–300.



Figures 9–12. *Tyrophagus perniciosus* Zakhvatkin, 1941 (female) – 9. Leg I; 10. Leg II; 11. Leg III; 12. Leg IV.

Legs (Figs. 9–12, 53–54) – 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 and ω of legs I–II cylindrical with obviously widened apex (Figs. 9–10, 53–54). Tarsi I–II with solenidion ω 1 cylindrical and distinctly widened apically (Figs. 9–10, 53–54). Measurements of leg segments and setae as follows: **Leg I:** Tr 45–55, *pR* 23–37, Fe 52–70, *vF* 37–50, Ge 35–44, *cG* 30–41, *mG* 44–60, σ 1 55–65, σ 2 27–34, Ti 30–45, *gT* 25–35, *hT* 30–37, ϕ 110–137, Ta (L.) 60–72, Ta (W.) 21–27, ω 1 17–21, ω 2 5–8, ω 3 29–35, ϵ 3, *aa* 16–24, *ba* 15–23, *wa* 37–42, *ra* 30–37, *la* 19–22, *d* 29–40, *e* 6–10, *f* 16–20, *p* 4–6, *q* 4–6, *s* 6–7, *u* 5–6, *v* 5–6, empodial claws 11–14; **Leg II:** Tr 37–45, *pR* 28–35, Fe 50–60, *vF* 50–63, Ge 30–44, *cG* 26–35, *mG* 40–50, σ 22–26, Ti 30–40, *gT* 25–33, *hT* 27–40, ϕ 125–135, Ta (L.) 55–65, Ta (W.) 18–22, ω 16–21, *ba* 17–21, *wa* 35–42, *ra* 30–33, *la* 19–24, *d* 23–27, *e* 5–7, *f* 14–19, *p* 4–5, *q* 4–5, *s* 6–8, *u* 5–6, *v* 5–6, empodial claws 10–12; **Leg III:** Tr 35–40, *sR* 33–40, Fe 35–50, Ge 30–40, *nG* 42–50, σ 20–25, Ti 32–40, *kT* 27–41, ϕ 125–141, Ta (L.) 60–75, Ta (W.) 16–20, *w* 27–35, *r* 23–30, *d* 18–25, *e* 6–9, *f* 15–21, *p* 3, *q* 3, *s* 5–7, *u* 4–6, *v* 4–6, empodial claws 9–12; **Leg IV:** Tr 35–50, Fe 50–60, Ge 40–50, Ti 35–45, *kT* 28–35, ϕ 121–150, Ta (L.) 75–90, Ta (W.) 15–18, *w* 27–36, *r* 17–23, *d* 24–35, *e* 7–8, *f* 17–20, *p* 3–4, *q* 3–4, *s* 5–7, *u* 5–6, *v* 5–6, empodial claws 9–12; Fe, Ge and Ti IV with minute preapical process (Fig. 12).

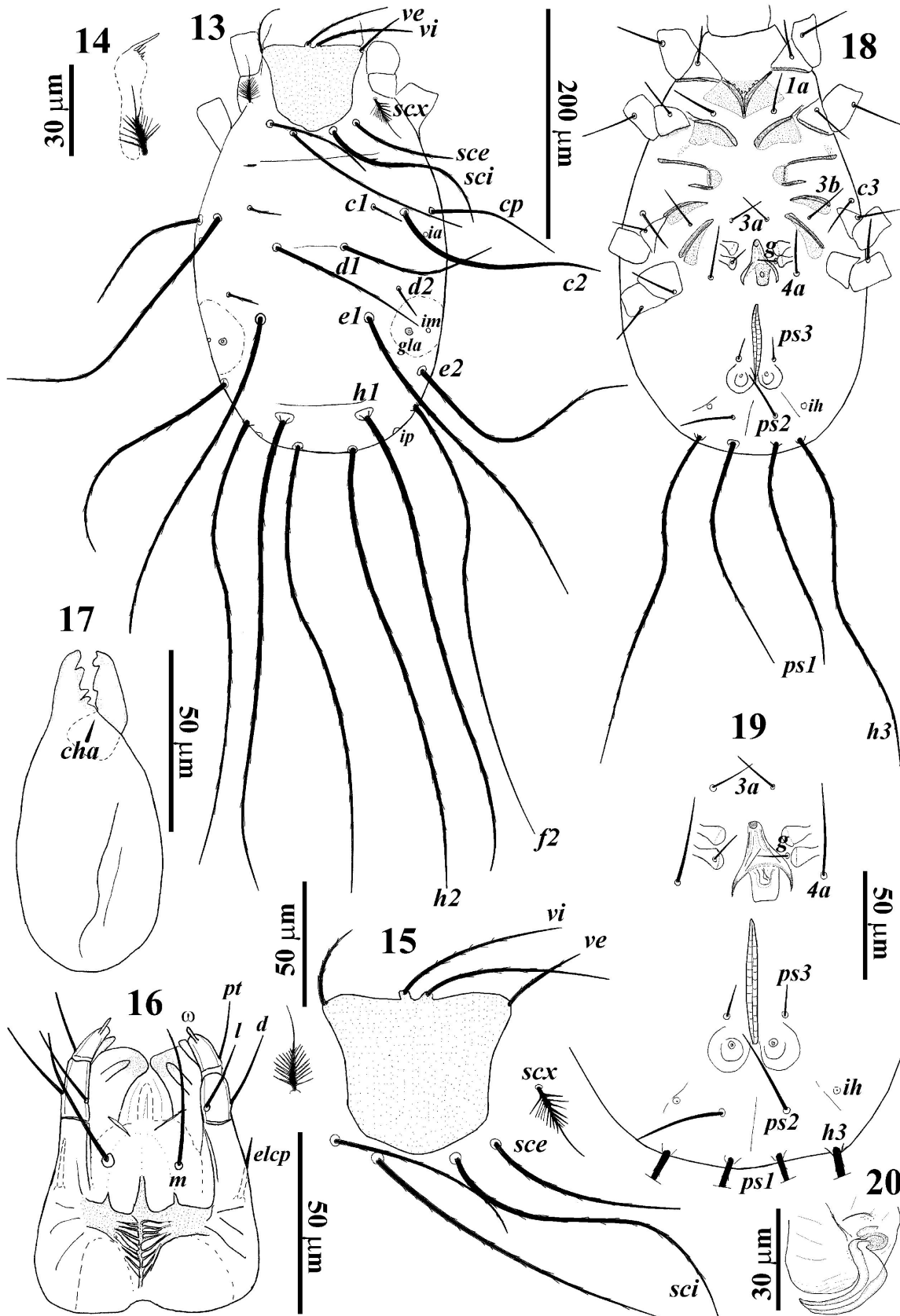
Male (Figs. 13–24, 55–56, 64–66; n = 5) – Idiosoma oval, length of body including gnathosoma 433–502, excluding gnathosoma 360–437; width 210–225.

Dorsum (Figs. 13–15). Prodorsal shield punctate, with two pairs of seta (*vi* and *ve*) nearly pentagonal in shape with lateral margins slightly concave; 57–70 long, 73–90 wide between setae *ve*–*ve*. Eyespots absent; Basal lobe of Grandjean's organ with one large tooth and four small teeth, 13–16, 6–7, 6–7, 3 and 3 long, respectively (Fig. 14). Supracoxal seta *scx* pectinated with 9–10 branches on each side (Figs. 14–15). All dorsal setae finely serrated. All opisthosomal setae whip like except *c1* and *d2*. Opisthosoma with three pairs of lyrifissures (*ia*, *im* and *ip*) and one pair of opisthosomal glands (*gla*) at level of seta *e1*; setae *c1* the shortest and seta *h1*-2 the longest dorsal setae. Length of dorsal setae: *vi* 70–80; *ve* 38–43; *sci* 150–170; *sce* 82–100; *scx* 25–35; *c1* 25–26; *c2* 180–228; *cp* 100–120; *d1* 95–120; *d2* 24–25; *e1* 270–302; *e2* 212–218; *f2* 312–330; *h1* 363–385; *h2* 337–370. Distances: *vi*-*vi* 8–10; *vi*-*ve* 30–38; *ve*-*ve* 68–85; *sce*-*sce* 70–72; *sci*-*sce* 15–18; *sci*-*sci* 28–30; *c1*-*c1* 87–105; *c1*-*c2* 24–32; *c2*-*c2* 150–165; *c2*-*cp* 18–30; *cp*-*cp* 170–215; *c1*-*d1* 37–45; *d1*-*d1* 47–65; *d1*-*d2* 58–80; *d2*-*d2* 147–165; *d2*-*e2* 75–90; *d2*-*gla* 35–50; *gla*-*gla* 150–162; *d2*-*e1* 33–38; *e1*-*e1* 85–102; *e1*-*e2* 57–62; *e2*-*e2* 150–175; *e2*-*f2* 31–40; *f2*-*f2* 140–155; *e1*-*h1* 83–112; *h1*-*h1* 65–75; *h1*-*h2* 30–42; *h2*-*h2* 40–45.

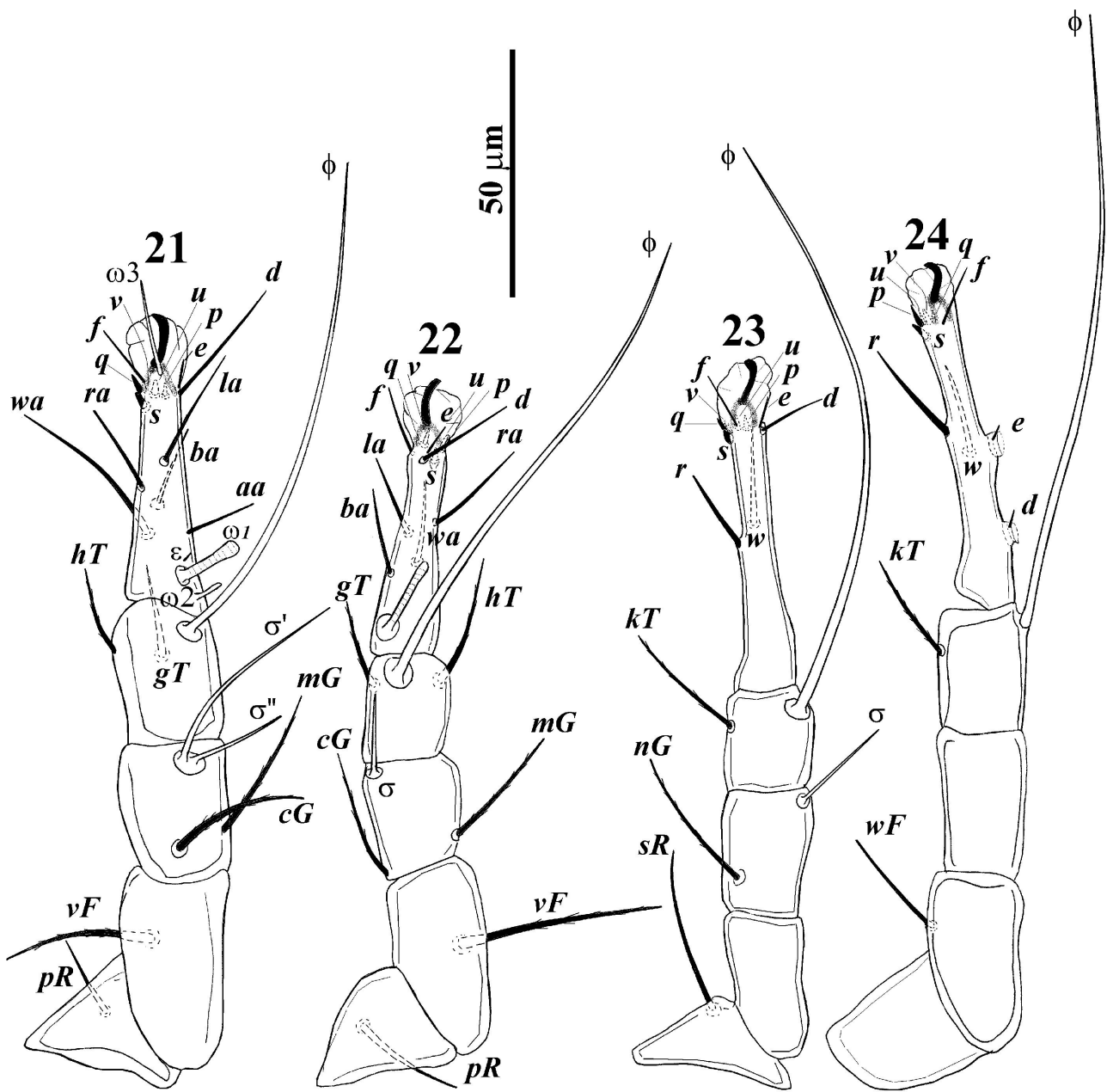
Gnathosoma (Figs. 16–17) – Punctate; palp two-segmented, palp tarsus with a simple seta (*pt*) and one solenidion (ω) 15–16 and 4–5 long, respectively; palp tibia with 2 simple setae (*d* 18–23 and *l* 15–18 long); infracapitulum with 1 simple seta (*m*) 32–42 long, distance: *m*-*m* 16–20. Rutellum distinct and developed (Fig. 16); chelicerae 75–83 long, cheliceral seta *cha* spine like 5 long, movable and fixed digits with 3–4 teeth (Fig. 17). Palp coxa with one *elcp* setae 14–15 (Fig. 18).

Venter (Figs. 18–20, 64–66) – Coxal plates I divided with apodemes I anteriorly with 4 nodes on each side; coxal plates II with an well-developed apodeme near base of trochanter seta (Fig. 64); between coxae II and III with a pair of thin sclerotized sejugal apodemes, 50–55 long; coxal plates III–IV each one with apodemes (Fig. 18); genital region (between coxae IV) with two pairs of genital papillae 15 long and 10 wide, and a pair of setae (*g*); aedeagus obviously curves, sickle-shaped, aedeagus shaft 24–30 long, lateral arms supporting aedeagus turning inwards (Figs. 19–20, 65–66). 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 and a pair of anal discs 4 in diameter (Figs. 18–19).

Length of ventral setae: *1a* 27–35, *c3* 22–30, *3a* 18–23, *3b* 30–36, *4a* 35–40, *g* 13–15, *ps3* 13–15, *ps2* 35–43, *ps1* 172–180, *h3* 250–280.



Figures 13–20. *Tyrophagus perniciosus* Zakhvatkin, 1941 (male) – 13. Dorsal view of idiosoma; 14. Grandjean's organ; 15. Prodorsal shield; 16. Gnathosoma; 17. Chelicera; 18. Ventral view of idiosoma; 19. Genital and anal regions; 20. Lateral view of aedeagus.



Figures 21–24. *Tyrophagus perniciosus* Zakhvatkin, 1941 (male) – 21. Leg I; 22. Leg II; 23. Leg III; 24. Leg IV.

Legs (Figs. 21–24, 55–56) – 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 $\omega 1$ and ω of legs I–II cylindrical with obviously widened apex (Figs. 21–22, 55–56). Measurements of leg segments and setae as follows: **Leg I:** Tr 35–41, *pR* 25–33, Fe 49–50, *vF* 38–41, Ge 35–37, *cG* 27–30, *mG* 36–41, $\sigma 1$ 38–50, $\sigma 2$ 17–20, Ti 28–30, *gT* 20–23, *hT* 23–27, ϕ 105–117, Ta (L.) 70–82, Ta (W.) 18–19; $\omega 1$ 15–17, $\omega 2$ 5–7, $\omega 3$ 25–28, ε 3–4, *aa* 16–17, *ba* 20–24, *wa* 29–31, *ra* 24–30, *la* 16–17, *d* 28–30, *e* 4–6, *f* 13–16, *p* 3–4, *q* 3–4, *s* 5–7, *u* 4–5, *v* 4–5 empodial claws 9–11; **Leg II:** Tr 29–40, *pR* 25–28, Fe 40–45, *vF* 43–50, Ge 30–35, *cG* 23–27, *mG* 30–37, σ 18–19, Ti 25, *gT* 17–19, *hT* 24–25, ϕ 117–125, Ta (L.) 49–50, Ta (W.) 15–17, ω 16–18, *ba* 21–22, *wa* 27–33, *ra* 26–30, *la* 15–18, *d* 26–28, *e* 4–6, *f*

13–16, *p* 3–4, *q* 3–4, *s* 5–7, *u* 4–5, *v* 4–5, empodial claws 8–12; **Leg III:** Tr 28–35, *sR* 30–37, Fe 33–38, Ge 28–30, *nG* 37–42, σ 15–20, Ti 25, *kT* 27–33, ϕ 135–140, Ta (L.) 56–60, Ta (W.) 13, *w* 26–30, *r* 24–28, *d* 23–24, *e* 5–6, *f* 13–14, *p* 3–4, *q* 3, *s* 5, *u* 4–5, *v* 4–5, empodial claws 8–10; **Leg IV:** Tr 30–35, Fe 40–45, *wF* 25–35, Ge 35–37, Ti 25–30, *kT* 23–29, ϕ 118–130, Ta (L.) 67–70, Ta (W.) 10–12, *w* 21–30, *r* 16–20, *d* 2–3, *e* 2–3, *f* 17–20, *s* 5, *p* 3–5, *q* 3, *u* 4–5, *v* 4–5, empodial claws 7–9. 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 15–21, *e-d* 15–18, *e-f* 25–30 (Fig. 24).

Tritonymph (Figs. 25–35, 57–58; n= 6) – Idiosoma oval. Length of body including gnathosoma 330–385, excluding gnathosoma 265–320; width 154–190.

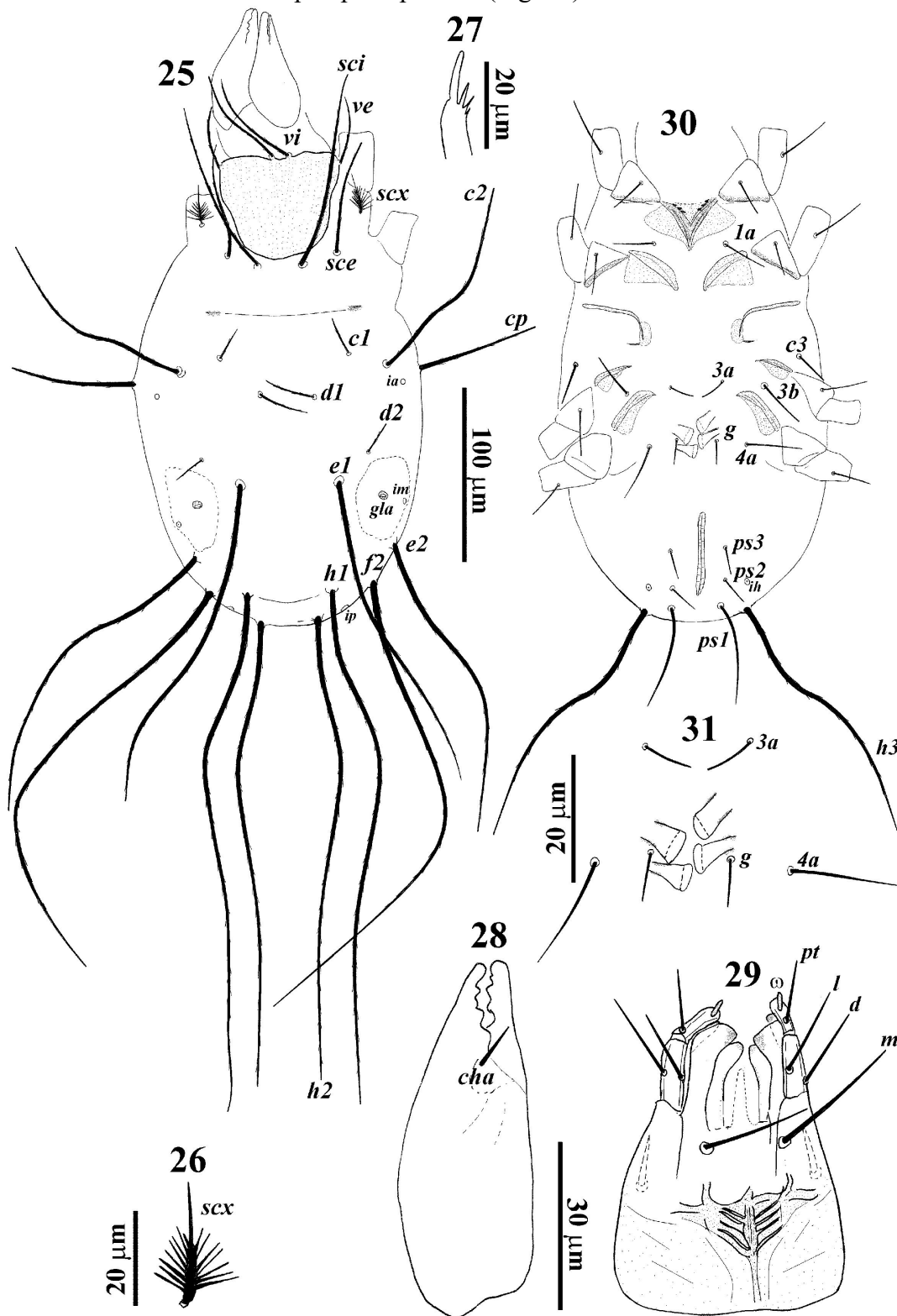
Dorsum (Figs. 25–27) – Prodorsal shield punctate, 55–60 long, 60–80 wide between setae *ve-ve*, nearly pentagonal in shape with lateral margins slightly concave and with two pairs of seta (*vi* and *ve*); eyespots absent; basal lobe of Grandjean's organ with one large tooth and three small teeth, 12–15, 4–5 long, 3 and 1–2 respectively (Fig. 27). Supracoxal seta *scx* pectinated with 7–8 rays on each side (Figs. 25, 27). 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 seta *e1*; setae *c1* the shortest and setae *f2*, *h1* and *h2* the longest dorsal setae. Length of dorsal setae: *vi* 50–61; *ve* 28–39; *sci* 100–124; *sce* 58–73; *scx* 24–27; *c1* 16–17; *c2* 115–135; *cp* 70–85; *d1* 36–44; *d2* 16–20; *e1* 175–215; *e2* 135–165; *f2* 237–275; *h1* 260–295; *h2* 250–295. Distances: *vi-vi* 6–8; *vi-ve* 28–30; *ve-ve* 60–75; *sce-sce* 56–67; *sci-sce* 15; *sci-sci* 23–30; *sci-c1* 55–68; *c1-c1* 70–90; *c1-c2* 16–25; *c2-c2* 110–140; *c2-cp* 15–20; *cp-cp* 145–180; *c1-d1* 33–41; *d1-d1* 33–45; *d1-d2* 44–55; *d2-d2* 100–131; *d2-e2* 58–67; *d2-gla* 18–30; *gla-gla* 97–138; *d2-e1* 22–28; *e1-e1* 53–80; *e1-e2* 44–60; *e2-e2* 120–150; *e1-f2* 60–80, *e2-f2* 24–35; *f2-f2* 91–130; *e1-h1* 56–70; *h1-h1* 44–60; *h1-h2* 17–30; *h2-h2* 24–40.

Gnathosoma (Figs. 28–29) – Palp two-segmented, palp tarsus with a simple seta (*pt*) and one solenidion (ω) 8–11 and 4–5 long, respectively; palp tibia with two simple setae (*d* 14–18 and *l* 11–14 long); infracapitulum with one simple seta (*m*) 28–30 long, distance: *m-m* 15–18. Rutellum distinct and developed (Fig. 28); chelicerae 65–70 long, cheliceral seta *cha* spine like 5–6 long, movable and fixed digits with 3–4 teeth (Fig. 28). Palp coxa with one *elcp* setae 9–12 (Fig. 29).

Venter (Figs. 30–31). Coxal plates I divided with apodemes I anteriorly with 3 nodes on each side; coxal plates II with a well-developed apodeme; a pair of thin sclerotized and narrow sejugal apodemes between coxae II and III 36–40 long; genital region with two pairs of genital papillae 10–13 long and 6–9 wide and a pair of setae (*g*) (Figs. 30–31). Anal region with three pairs of pseudoanal setae (*ps1-3*), setae *ps1* and *ps3* the longest and shortest anal setae, respectively (Fig. 30); a pair of lyrifissures (*ih*) at level of setae *ps2*. Length of ventral setae: *la* 20–26, *c3* 25–30, *3a* 12–17, *3b* 23–25, *4a* 25–27, *g* 11–13, *ps3* 14–17, *ps2* 18–24, *ps1* 68–100, *h3* 160–205.

Legs (Figs. 32–35, 57–58) – 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. 32–35). Leg I–II with cylindrical and apex obviously widened solenidion ($\omega1$ and ω , respectively) (Figs. 32–33, 57–58). Measurements of leg segments and setae as follows: **Leg I:** Tr 25–30, *pR* 16–19, Fe 30–37, *vF* 27–30, Ge 24–27, *cG* 17–21, *mG* 25–28, $\sigma1$ 30–38, $\sigma2$ 15–17, Ti 20–23, *gT* 14–19, *hT* 15–20, ϕ 80–95, Ta (L.) 35–45, Ta (W.) 13–15, $\omega1$ 12–14, $\omega2$ 3–4, $\omega3$ 15–20, $\varepsilon3$, *aa* 9–11, *ba* 11–15, *wa* 22–30, *ra* 17–22, *la* 13–17, *d* 18–23, *f* 10–13, *e* 4, *p* 3, *q* 3, *s* 4–5, *u* 4–5, *v* 4–5, empodial claws 8–10; **Leg II:** Tr 20–25, *pR* 16–18, Fe 30–35, *vF* 30–40, Ge 20–25, *cG* 10–15, *mG* 16–22, σ 12–15, Ti 20–23, *gT* 13–14, *hT* 13–18, ϕ 76–90, Ta (L.) 33–40, Ta (W.) 11–13, ω 13–14, *ba* 11–14, *wa* 19–26, *ra* 18–21, *la* 12–16, *d* 15–19, *e* 3–4, *f* 9–10, *p* 2–3, *q* 2–3, *s* 4, *u* 3–4, *v* 3–4 empodial claws 7–9; **Leg III:** Tr 20–27, *sR* 17–25, Fe 24–25, Ge 20–24, *nG* 20–25, σ 10–12, Ti 19–24, *kT* 18–21, ϕ 95–105, Ta (L.) 38–43, Ta (W.) 9–10, *w* 17–21, *r* 13–18, *d* 14–16, *e* 3–4, *f* 8–10, *p* 2, *q* 2, *s* 3–4, *u* 3, *v* 3, empodial

claws 7; **Leg IV:** Tr 25–30, Fe 27–33, wF 17–21, Ge 20–25, Ti 21–24, kT 17–20, ϕ 74–90, Ta (L.) 50–55, Ta (W.) 9–10, w 17–23, r 10–14, d 15–17, e 3, f 8–11, p 2, q 2, s 3–4, u 3, v 3, empodial claws 7–9; Fe, Ge and Ti IV with minute preapical process (Fig. 35).

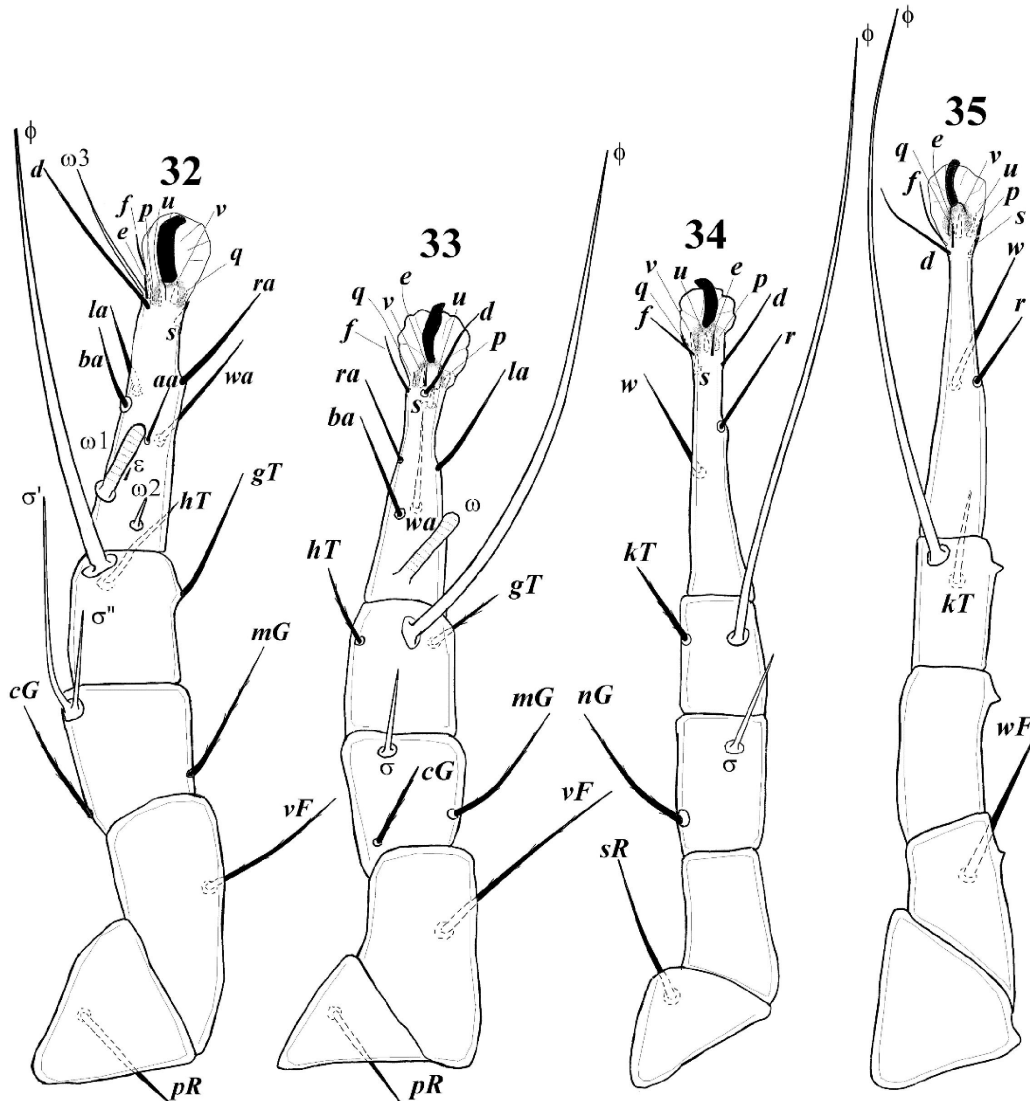


Figures 25-31. *Tyrophagus perniciosus* Zakhvatkin, 1941 (tritonymph) – 25. Dorsal view of idiosoma; 26. Supracoxal seta (*scx*); 27. Grandjean's organ; 28. Chelicera; 29. Gnathosoma; 30. Ventral view of idiosoma; 31. Genital region.

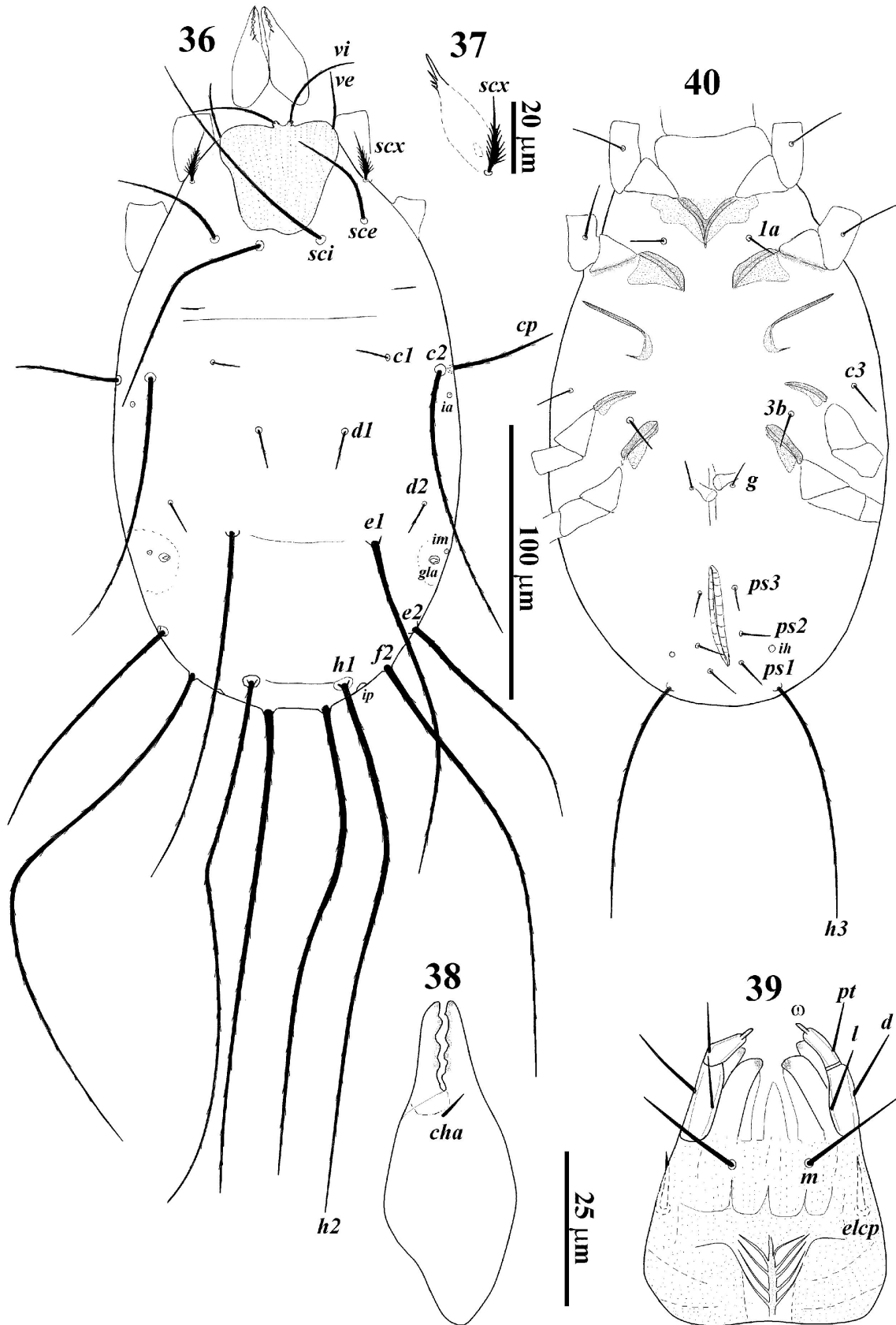
Deutonymph (Hypopus) – Absent.

Protonymph (Figs. 36–44, 59–60; n = 4) – Idiosoma oval. Length of body including gnathosoma 270–295, excluding gnathosoma 210–250; width 110–156.

Dorsum (Figs. 36–37) – Prodorsal shield present and eyespots absent. Basal lobe of Grandjean's organ with one large and three small teeth, 9–10, 4–5, 3 and 3 long, respectively (Fig. 37). Supracoxal seta *scx* pectinate with 6–7 rays seven branches on each side (Figs. 36, 37). 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*; setae *c1* and *d2* the shortest and setae *h1* the longest dorsal setae. Length of dorsal setae: *vi* 39–42; *ve* 26–29; *sci* 80–91; *sce* 39–43; *scx* 22–24; *c1* 12–13; *c2* 80–100; *Cp* 48–60; *d1* 16–20; *d2* 10–13; *e1* 145–170; *e2* 80–100; *f2* 180–190; *h1* 210–232; *h2* 180–195. Distances: *vi-vi* 5–6; *vi-ve* 19–20; *ve-ve* 42–45; *sce-sce* 50–63; *sci-sce* 14–16; *sci-sci* 20–22; *sci-c1* 48–55; *c1-c1* 60–75; *c1-c2* 15–21; *c2-c2* 90–115; *c2-Cp* 12–17; *Cp-Cp* 115–150; *c1-d1* 25–35; *d1-d1* 25–35; *d1-d2* 33–46; *d2-d2* 75–100; *d2-e2* 55–60; *d2-gla* 20–24; *gla-gla* 90–105; *d2-e1* 23–28; *e1-e1* 48–60; *e1-e2* 30–48; *e2-e2* 75–100; *e2-f2* 17–23; *f2-f2* 65–80; *e1-h1* 55–62; *h1-h1* 37–40; *h1-h2* 12–15; *h2-h2* 20–30.



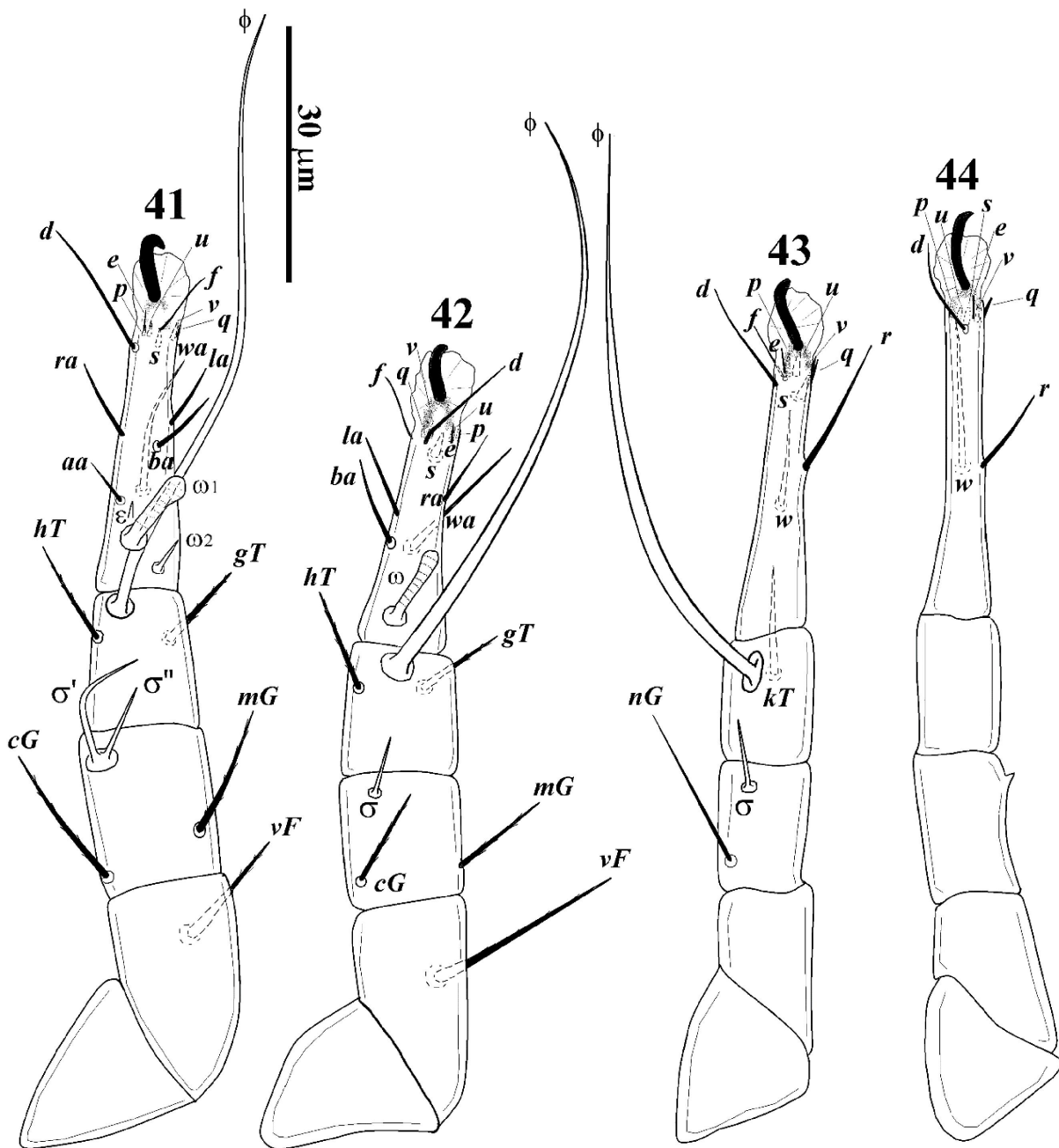
Figures 32-35. *Tyrophagus perniciosus* Zakhvatkin, 1941 (tritonymph) – 32. Leg I; 33. Leg II; 34. Leg III; 35. Leg IV.



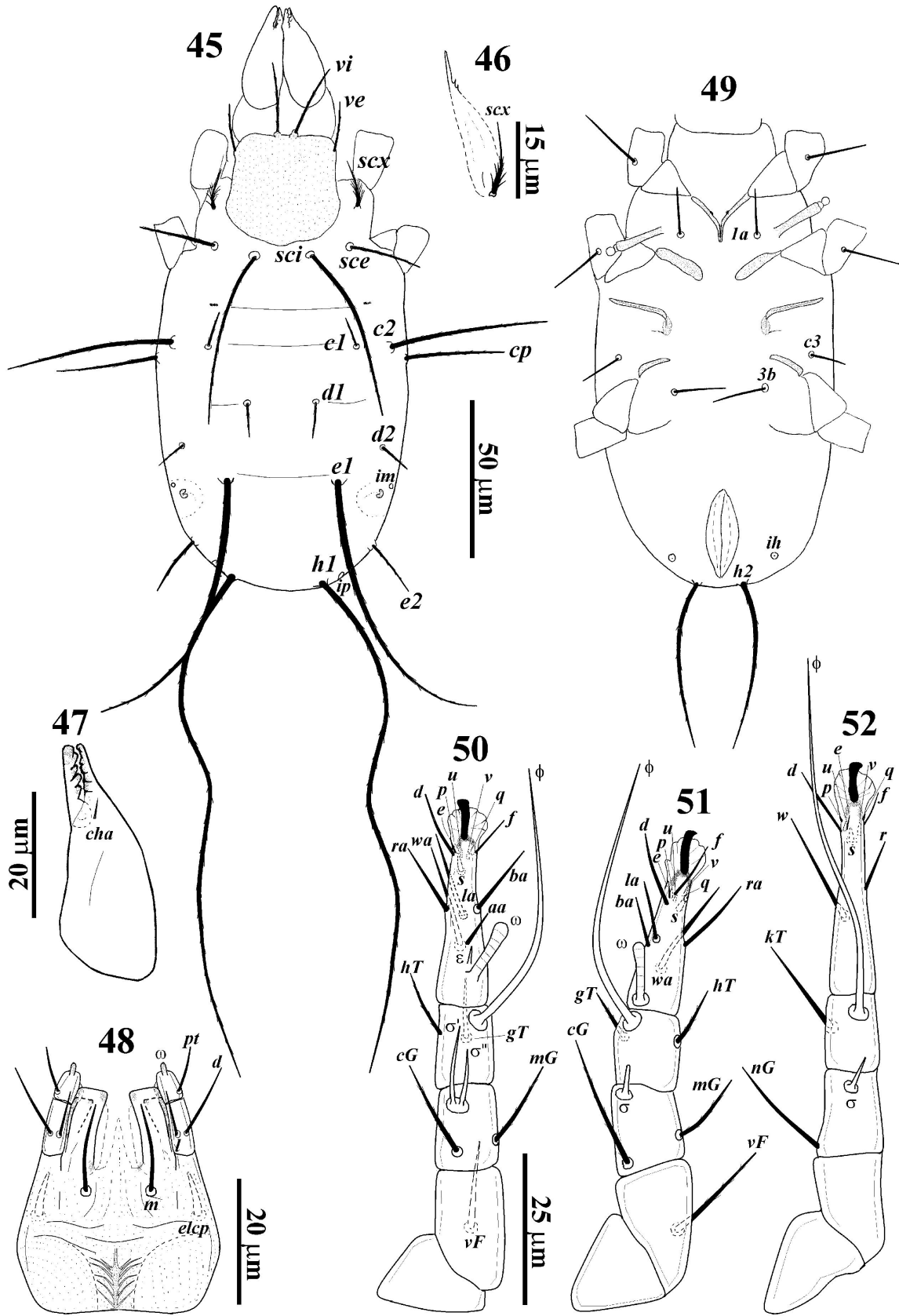
Figures 36-40. *Tyrophagus perniciosus* Zakhvatkin, 1941 (protonymph) – 36. Dorsal view of idiosoma; 37. Supracoxal seta (scx) and Grandjean's organ; 38. Chelicera; 39. Gnathosoma; 40. Ventral view of idiosoma.

Gnathosoma (Figs. 38–39) – Palp two-segmented, palp tarsus with a simple seta (*pt*) and one solenidion (ω) 6–7 and 3–4 long, respectively; palp tibia with two simple setae (*d* 11–12 and *l* 8–9 long); infracapitulum with one simple seta (*m*) 18–22 long, *m-m* 13–16. Rutellum visible (Fig. 39); chelicerae 50–53 long, cheliceral seta *cha* spine like 4 long (Fig. 38). Palp coxa with one *elcp* setae 8–9.

Venter (Fig. 40) – Coxal plates I divided with apodemes I anteriorly without nodes; coxal plates II with a well-developed apodeme; a pair of thin sclerotized and narrow sejugal apodemes between coxae II and III 28–34 long; genital region with one pair of genital papillae 10–11 long and 7 wide and a pair of setae (*g*) (Fig. 40). Anal region with three pairs of pseudoanal setae (*ps1-3*) sub equal in length (Fig. 40); a pair of lyrifissures (*ih*) between setae *ps1-2*. Length of ventral setae: *1a* 17, *3b* 18–19, *c3* 13–16, *g* 10–12, *ps3* 8–11, *ps2* 10–12, *ps1* 12–15, *h3* 100–103.



Figures 41–44. *Tyrophagus perniciosus* Zakhvatkin, 1941 (protonymph) – 41. Leg I; 42. Leg II; 43. Leg III; 44. Leg IV.



Figures 45-52. *Tyrophagus perniciosus* Zakhvatkin, 1941 (larva) – 45. Dorsal view of idiosoma; 46. Supracoxal seta (scx) and Grandjean's organ; 47. Chelicera; 48. Gnathosoma; 49. Ventral view of idiosoma; 50. Leg I; 51. Leg II; 52. Leg III.

Legs (Figs. 41–44, 59–60) – 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; solenidium $\omega 1$ and ω of legs I–II cylindrical with obviously widened apex (Figs. 41–44, 59–60). Measurements of leg segments and setae as follows: **Leg I:** Tr 21–23, Fe 28–30, vF 16–22, Ge 17–22, cG 14–15, mG 15–16, $\sigma 1$ 20, $\sigma 2$ 8, Ti 16–18, gT 12–15, hT 11, ϕ 65–69, Ta (L.) 30–33, Ta (W.) 11–12, $\omega 1$ 10–12, $\omega 2$ 4, ε 3, aa 6–8, ba 8–11, wa 18–19, ra 13–17, la 9–10, d 17, e 3–5, f 9, p and q 3, s 4, v and u 3–4, empodial claws 7–10; **Leg II:** Tr 20, Fe 25–29, vF 23–24, Ge 17–18, cG 10–11, mG 14, σ 8–9, Ti 15–17, gT 11–13, hT 9, ϕ 59–70, Ta (L.) 25–30, Ta (W.) 9–10, ω 10, ba 8–10, wa 13, ra 12–13, la 8–9, d 14–15, e 2–3, f 9, p and q 2–3, s 3–4, v and u 3–4, empodial claws 7–10; **Leg III:** Tr 15–18, Fe 17–20, Ge 15–17, nG 16–18, σ 7, Ti 15, kT 12–16, ϕ 70–73, Ta (L.) 29–31, Ta (W.) 8–9, w 15–18, r 10, d 11–13, e 3, f 8, p and q 2, s 3, v and u 2–3, empodial claws 6–10; **Leg IV:** Tr 23–24, Fe 20–21, Ge 16–17, Ti 15–17, Ta (L.) 34–35, Ta (W.) 8, w 12–15, r 8–11, d 11–13, e 2–3, p and q 2, s 2–3, v and u 2–3, empodial claws 6–10; Ge IV with minute preapical process (Fig. 44).

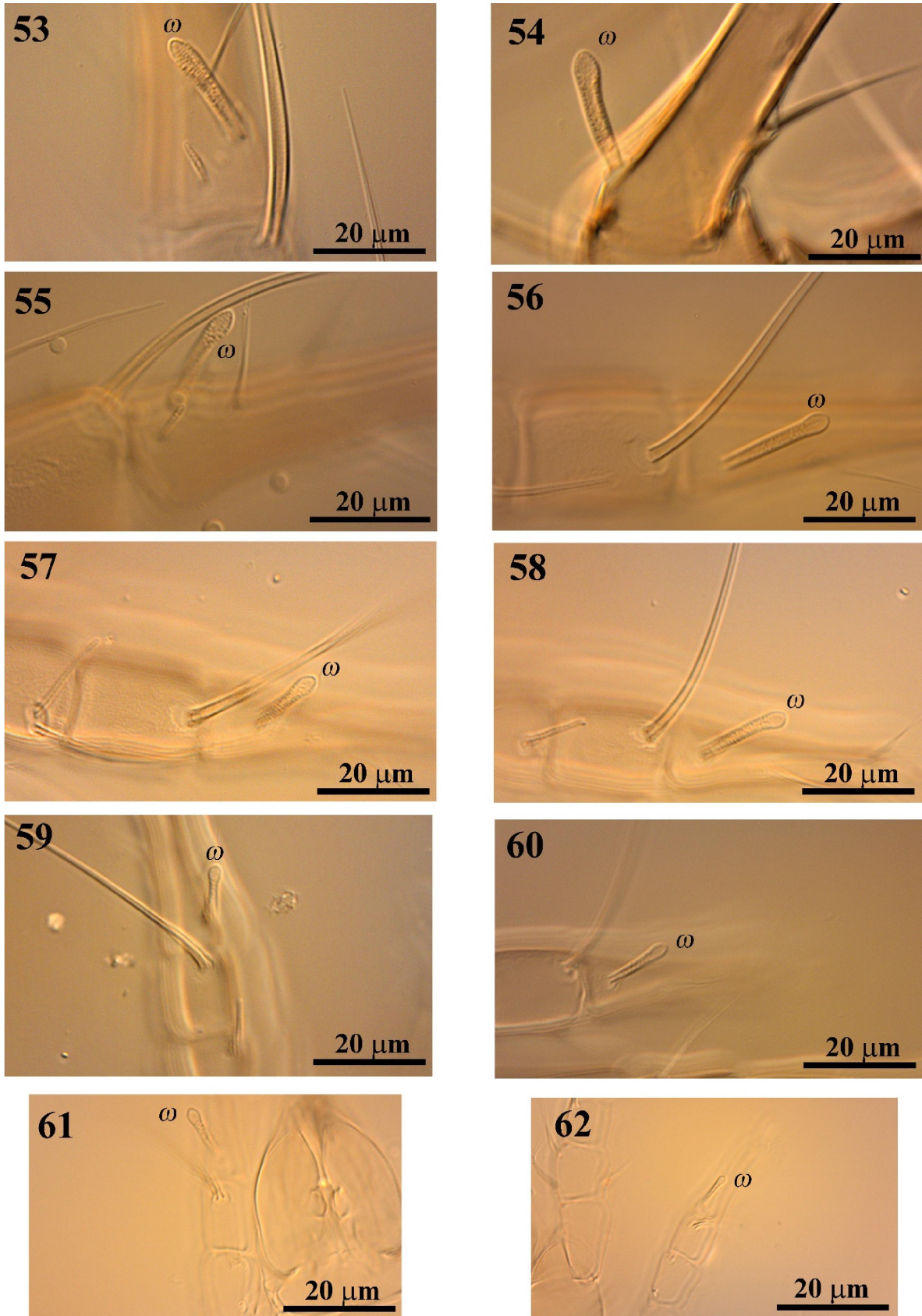
Larva (Figs. 45–52, 61–62; n = 5) – Idiosoma oval. Length of body including gnathosoma 180–198, excluding gnathosoma 145–160; width 79–85.

Dorsum (Figs. 45–46) – Prodorsal shield present and eyespots absent. Basal lobe of Grandjean's organ finger like and with one large and two small teeth, 5, 1 and 1 long, respectively (Fig. 45). Supracoxal seta scx pectinate with 4–5 rays branches on each side (Fig. 45–46). 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 $c1$, $d1$ and $d2$ the shortest and setae $h1$ the longest dorsal setae. Length of dorsal setae: vi 24–25; ve 17–20; sci 50; sce 21–22; scx 12–15; $c1$ 10–12; $c2$ 47–50; Cp 30–35; $d1$ 10–11; $d2$ 7–10; $e1$ 95; $e2$ 18–20; $h1$ 185–188; $h2$ 50. Distances: $vi-vi$ 4; $vi-ve$ 15–18; $ve-ve$ 32–38; $sce-sce$ 43–45; $sci-sce$ 11–14; $sci-sci$ 18–19; $sci-c1$ 40–45; $c1-c1$ 44–46; $c1-c2$ 10–12; $c2-c2$ 68–70; $c2-Cp$ 5–12; $Cp-Cp$ 80–85; $c1-d1$ 25–27; $d1-d1$ 20; $d1-d2$ 20–25; $d2-d2$ 60–65; $d2-e2$ 35–40; $d2-gla$ 12–14; $gla-gla$ 58–62; $d2-e1$ 22–25; $e1-e1$ 31–35; $e1-e2$ 20–25; $e2-e2$ 55; $e1-h1$ 35; $h1-h1$ 30; $h2-h2$ 11–15.

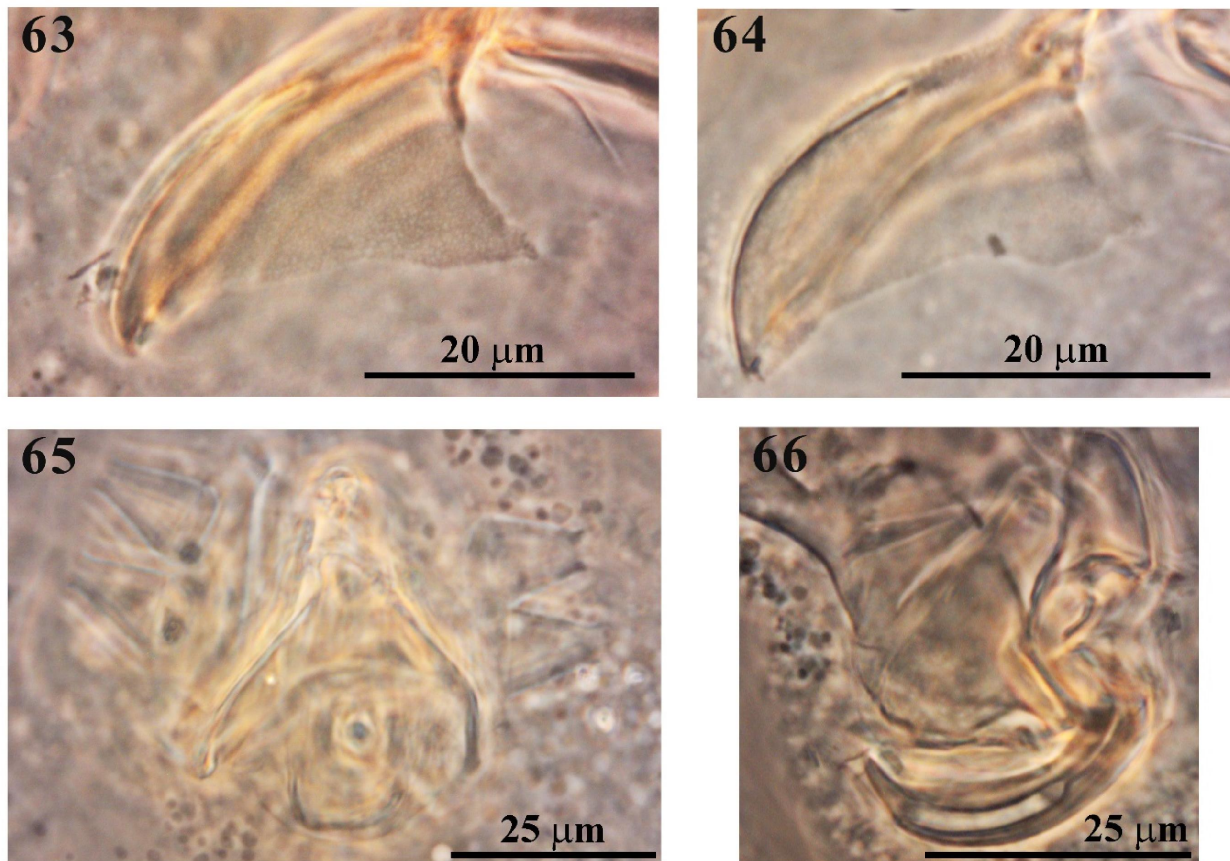
Gnathosoma (Figs. 47–48) – Palp two-segmented, palp tarsus with a simple seta (pt) and one solenidium (ω) 5–6 and 2–3 long, respectively; palp tibia with two simple setae (d 9–10 and l 6–7 long); infracapitulum with one simple seta (m) 16–17 long, $m-m$ 9–10. Rutellum visible (Fig. 48); chelicerae 35–37 long, cheliceral seta cha spine like 2–3 long, movable and fixed digits with 4 teeth (Fig. 47). Palp coxa with one $elcp$ setae 5–6.

Venter (Fig. 49) – Coxal plates I–III with narrow apodemes; Claparède organ between coxae I–II, with base tube like and 15–16 in length terminating in a spherical knob distally, 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: $1a$ 12–13, $3b$ 15–16, $c3$ 10–14, $h2$ 50.

Legs (Figs. 50–52, 61–62) – 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; solenidium $\omega 1$ and ω of legs I–II cylindrical with obviously widened apex (Figs. 50–52, 61–62). Measurements of leg segments and setae as follows: **Leg I:** Tr 16–17, Fe 20, vF 12–15, Ge 12–15, cG 12–13, mG 8–10, $\sigma 1$ 12–14, $\sigma 2$ 8, Ti 11–12, gT 5–7, hT 7–10, ϕ 52–55, Ta (L.) 25–26, Ta (W.) 8, ω 8, ε 3, aa 5–6, ba 7–8, wa 10–12, ra 8–10, la 5–7, d 10, e 3, f 7–8, q and p 2, s 3–4, v and u 2–3, empodial claws 5–6; **Leg II:** Tr 15, Fe 18–20, vF 16–17, Ge 13–15, cG 7–12, mG 8–9, σ 4–6, Ti 10–11, gT 7, hT 6–8, ϕ 48–49, Ta (L.) 20, Ta (W.) 7–8, ω 6–8, ba 7–8, wa 9–12, ra 8, la 6–7, d 10–12, e 2, f 6–9, q and p 2, s 3, v and u 2–3, empodial claws 5–6; **Leg III:** Tr 15–16, Fe 15, Ge 13–14, nG 15–17, σ 5, Ti 13–15, kT 11–14, ϕ 53–54, Ta (L.) 24–28, Ta (W.) 6, w 13, r 6–7, d 9, e 2, f 6, q and p 1, s 2–3, v and u 1–2, empodial claws 5 long.



Figures 53–62. *Tyrophagus perniciosus* Zakhvatkin, 1941 – Solenidion $\omega 1$ on tarsus I-II: 53–54. Female; 55–56. Male; 57–58. Tritonymph; 59–60. Protonymph; 61–62. Larva.



Figures 63-66. *Tyrophagus perniciosus* Zakhvatkin, 1941: 63. Coxa II (female); 64. Coxa II (male); 65. Aedeagus; 66. Lateral view of aedeagus.

DISCUSSION and CONCLUSION

This is the first re-description of all stages of this species from Iran. This re-description shows minor differences between Iranian specimens and re-description from New Zealand (Fan and Zhang 2007), however differs from the later in: 1. The ratio of hysterosomal setae $d1$ about $3.1-3.9 \times$ length of $d2$ whereas $2.7-3.8$; 2. Leg I-IV with empodial claws $10-12$ and $9-12$ long respectively in Iranian specimens vs. $15-23$ and empodial claws $17-24$ long in New Zealand specimens. Male: The ratio of hysterosomal setae $d1$ about $3.7-5.0 \times$ length of $c1$ and $3.7-5.4 \times$ length of $d2$; $d2$ about $0.92-1.0 \times$ length of $c1$ in Iranian species whereas $3.2-4.0$, $2.9-3.4$ and $1.1-1.2$ in New Zealand specimens, respectively. This study has been clearly shown the differential chaetotaxy especially hysterosomal region, organotaxy develops during ontogenetic (larva, protonymph, tritonymph and adults [♀ & ♂]) and also agree with the hypothesis of Griffiths *et al.* (1990). The ontogenetic characters of this species are presented in Table 1.

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Table 1. Ontogenetic characters of *T. perniciosus* Zakhvatkin, 1941.

Character / Stage	Larva	Protonymph	Tritonymph	Adult (♂)	Adult (♀)
<i>vi</i>	+	+	+	+	+
<i>ve</i>	+	+	+	+	+
<i>sci</i>	+	+	+	+	+
<i>sce</i>	+	+	+	+	+
<i>scx</i>	+	+	+	+	+
<i>c1</i>	+	+	+	+	+
<i>c2</i>	+	+	+	+	+
<i>c3</i>	+	+	+	+	+
<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)
<i>gla</i>	+	+	+	+	+
Copulatory opening	-	-	-	-	+
Spermatheca	-	-	-	-	+
Aedeagus	-	-	-	+	-
Anal suckers	-	-	-	+	-
Claparède organ	+	-	-	-	-
Cx. I-IV*	1-0-1	1-0-1-0	1-0-2-1	1-0-2-1	1-0-2-1
Tr. I-IV*	0-0-0	0-0-0-0	1-1-1-0	1-1-1-0	1-1-1-0
Fe. I-IV*	1-1-0	1-1-0-0	1-1-0-1	1-1-0-1	1-1-0-1
Ge. I-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- 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- 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	-	-	-	+	-


*: Numbers of setae.

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انتوژنی *Tyrophagus perniciosus* Zakhvatkin (Acari: Acaridae) از غرب ایران

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چکیده

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واژگان کلیدی: کنه‌های آکارید؛ توصیف؛ جنگل؛ غالبیت؛ مراحل متحرک؛ بازتوصیف.

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