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MORPHOLOGY OF JUVENILE INSTARS OF *LOHMANNIA TURCMENICA* BULANOVA-ZACHVATKINA, 1960 AND *L. PARADOXA* (HALLER, 1884) (ACARI: ORIBATIDA: LOHMANNIIDAE)

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Abstract.— The morphology of juvenile instars of two species of lohmanniid oribatid mites, *Lohmannia turcmenica* Bulanova-Zachvatkina, 1960 and *L. paradoxa* (Haller, 1884), is described and illustrated. Known juvenile instars of this genus are compared. A new generic diagnosis of juvenile instars of *Lohmannia* is given.

Key words.— oribatid mites, Lohmanniidae, *Lohmannia turcmenica*, *L. paradoxa*, morphology, juvenile instars, ontogeny.

INTRODUCTION

The main goal of the present work is to describe and illustrate the morphology of juvenile instars of two oribatid mite species of the genus *Lohmannia* Michael, 1898 (Acari, Oribatida, Lohmanniidae) – *Lohmannia turcmenica* Bulanova-Zachvatkina, 1960 and *L. paradoxa* (Haller, 1884). Adults of these species were described by several authors, including Haller (1884), Bulanova-Zachvatkina (1960), Pérez-Íñigo (1967) and Mahunka (1974).

Lohmannia comprises 26 species, which are distributed in the pantropical and subtropical regions (Subías 2004, online version 2013). At present, the juvenile instars of five species of this genus have been studied in details: *Lohmannia banksi* Norton, Metz et Sharma, 1978 (Norton *et al.* 1978, Schatz and Schuster 2012), *L. egyptica* (Elbadry et Nasr, 1977) (Shereef 1976), *L. jornoti* Mahunka, 1985 (Schatz 1993), *L. similis* Balogh, 1962 (Schatz 1993, Schatz and Schuster 2012) and *L. vulcania* Schatz, 1993 (Schatz 1993). The main morphological characters of juvenile instars of *Lohmannia* were summarized by Ermilov *et al.* (2012). Known juvenile instars of this genus are compared, and a new diagnosis is given.

MATERIALS AND METHODS

Specimens of *Lohmannia turcmenica* were collected from Spain, 38°08'N, 06°32'E, Badajoz Province, Segura de León village, 610 m a.s.l., 24.IV.2012, by J. P. Zaballos and S. Pérez. All samples were taken from deep layers of soil. The field-collected material included four larvae, four protonymphs, 12 deutonymphs and 11 tritonymphs.

Specimens of *Lohmannia paradoxa* were collected from Spain, 37°58'N, 04°29'E, Cordoba Province, Pedro Abad village, 155 m a.s.l., 25.IV.2012, by J. P. Zaballos and S. Pérez. All samples were taken from

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deep layers of soil. The field-collected material included three larvae, six protonymphs, 11 deutonymphs and 14 tritonymphs.

Juvenile instars were studied and illustrated in lactic acid and mounted on temporary cavity slides for the duration of the study. All body measurements are presented in micrometers. Body length was measured in lateral view. Notogastral width refers to the maximum width in dorsal aspect. Formulae for leg setation are given according to the sequence trochanter–femur–genu– tibia–tarsus (famulus included). Formulae for leg solenidia are given according to the sequence genu–tibia–tarsus.

Terminology used in this paper follows that of Grandjean (1950), Norton and Behan-Pelletier (2009), Norton (2010).

Results

Morphology of juvenile instars

Lohmannia turcmenica Bulanova-Zachvatkina, 1960 (Figs 1–17)

Measurements. Body length (three specimens): larva 381–398, protonymph 464–498, deutonymph 587–597, tritonymph 630–730. Body width (three specimens): larva 182–199, protonymph 215–249, deutonymph 298–315, tritonymph 365–398.

Integument. General body cuticle colourless (larvae) to yellowish (some nymphs). Microfoveolate layer (distinctly visible under high magnification) covers body and legs in all juvenile instars. These foveolae are polygonal, situated close to each other forming a polygonal network. Anterior part of gastronotic region with wide, transverse striate band.

Prodorsum. Rostrum of larva widely rounded, with several small teeth; rostrum of nymphal instar narrower, rounded, without teeth. Rostral (*ro*), lamellar (*le*), interlamellar (*in*) and exobothridial (*exa*, *exp*) setae of larval instar thickened, narrowly phylliform, with short cilia (one or two rows of cilia present usually situated close to each other). Rostral and anterior exobothridial setae of nymphal instars widely phylliform, ciliate; lamellar and interlamellar setae thickened, narrowly phylliform, with short cilia; posterior exobothridial setae reniform, ciliate. Sensilli (*ss*) of all juvenile instars pectinate, with long branches (8–9 in larva; 10–12 in nymphs) on one side, and several barbs on other side. Relative length of prodorsal setae: $ro \approx le \approx in \approx ss > exa > exp$. Postbothridial transverse band (S_b) weakly visible.

Gastronotic region. Anterior margin straight or weakly convex. Transversal bands poorly visible: larval instar with five (S_2, S_3–S_6; posterior bands not visible), nymphal instars with seven (S_2, S_3–S_8) bands; S_2 complete, S_6 also complete, but indistinctly developed medially, S_3–S_5, S_7, S_8 incomplete. Larva with 13 (excluding three pairs on pseudoanal plates) and nymphs with 16 pairs of gastronotic setae. Larval setae h_4 absent. All setae thickened, indistinctly or narrowly phylliform, with short cilia (one or two rows of cilia present usually situated close to each other). Medial and medio-lateral setae clearly shorter than lateral and posterior setae. Setae f_1 and h_1 of larval instar more widely phylliform than other notogastral setae. Setae p_1 of protonymphal instar similar to p_2 and p_3 in length, but clearly shorter and wider than both latter setae. Cupules oblong, thin.

Gnathosoma. Subcapitulum with one pair of lateral tubercles. Larva with three (a, m_1, h) and nymphs with four pairs of subcapitular setae (m_2 added in protonymph). Setae a setiform, thickened, smooth; setae h, m_1 and m_2 widely phylliform, ciliate. Larva with two and nymphs with three pairs of adoral setae (or_3 added in protonymph): or_1 more or less triangular, wide in proximal part, blunt-ended; or_2 long, setiform, thick, smooth, weakly truncate distally; or_3 setiform, smooth, pointed. Palp setal formula: larva and protonymph 0–0–2–10(+1ω); deuto- and tritonymph 0–1–2–10(+ω). Solenidion longer than palptarsus, thick, blunt-ended. Cheliceral seta *chb* long, setiform, slightly barbed; setae *cha* short, thin, thorn-like.

Epimeral region. Setal formulae for epimeres: larva 3–1–2; protonymph 3–1–2–1; deutonymph 3–1–3–3, tritonymph 3–1–3–4. Epimeral setae phylliform, ciliate; *2a*, *3a*, *4a* and *4b* shorter than others. Claparède's organ (*Cl*) of larva short, distinct.

Anogenital region. Genital valves divided in deuto- and tritonymph (undivided in protonymph). Ontogenetic genital, anal and adanal formulae (from larva to tritonymph) 0–1–5–8, 0–0–2–2, 0–4–4–4, respectively. Pseudoadanal (in protonymph) and pseudoanal (in deutonymph) plates with paraproctal setae. All setae setiform, weakly thickened or thin (anal setae), with short cilia. Cupules oblong, thin, appearing in normal ontogenetic pattern.

Legs. Leg formulae: larva I (0–2–3–4–15) [2–1–1], II (0–2–3–4–13) [1–1–1], III (0–2–2–3–12) [1–1–0]; protonymph I (0–2–3–4–16) [2–1–2], II (0–3–3–4–13) [1–1–1], III (1–3–2–3–12) [1–1–0], IV (0–0–0–0–6) [0–0–0]; deutonymph I (0–5–3–5–16) [2–1–2], II (0–5–3–5–13) [1–1–1], III (2–3–2–3–12) [1–1–0], IV (1–2–2–2–11) [1–0–0]; tritonymph I (0–5–3–5–16) [2–1–2], II (0–6–3–5–13) [1–1–1], III (2–3–2–3–12) [1–1–0], IV (2–3–2–3–12) [1–0–0]. Ontogeny and homology of leg setae and solenidia given in Table 1. Femora with ventral ridges. Setae setiform or phylliform, ciliate or barbed (except smooth p and some d). Famulus (ε) tubercle-like. Solenidion ω_2 on tarsi II not added in ontogeny. Solenidia ω_1 on tarsi I, ω on tarsi II and φ on tibiae III thickened, blunt-ended; other solenidia thin, pointed.

Table 1. Development of leg setation of *Lohmannia turcmenica* Bulanova-Zachvatkina, 1960

	Trochanter	Femur	Genu	Tibia	Tarsus
Leg I					
Larva	–	*d*, *bv*"	*d*, (*l*), σ', σ"	*d*, (*l*), *v*', φ	(*ft*), (*tc*), (*p*), (*u*), (*a*), *s*, *m*, (*pv*), ε, ω_1
Protonymph	–	–	–	–	*n*, ω_2
Deutonymph	–	(*l*), *v*"	–	v"	–
Tritonymph	–	–	–	–	–
Leg II					
Larva	–	*d*, *bv*"	*d*, (*l*), σ	*d*, (*l*), *v*', φ	(*ft*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*), ω
Protonymph	–	l''_1	–	–	–
Deutonymph	–	l'_1, *v*"	–	v"	–
Tritonymph	–	l''_2	–	–	–
Leg III					
Larva	–	*d*, *ev*'	*d*, *l*', σ	*d*, *l*', *v*', φ	(*ft*), (*tc*), (*p*), (*u*), *a*', *s*, (*pv*)
Protonymph	*v*'	*l*'	–	–	–
Deutonymph	*l*'	–	–	–	–
Tritonymph	–	–	–	–	–
Leg IV					
Protonymph	–	–	–	–	*ft*", *p*', (*u*), (*pv*)
Deutonymph	*v*'	*d*, *ev*'	*d*, *l*', σ	*d*, *l*'	*ft*', *tc*', *p*", *a*', *s*
Tritonymph	*l*'	*l*'	–	*v*'	*tc*"

Roman letters refer to normal setae (*e* — famulus), Greek letters refer to solenidia. One apostrophe (') marks setae on anterior and double apostrophe („) marks setae on posterior side of the given leg segment. Parentheses refer to a pseudosymmetrical pair of setae. Setae are listed only for the instar in which they first appear.

Lohmannia paradoxa (Haller, 1884)
(Figs 18–29)

Measurements. Body length (three specimens): protonymph 547–581, deutonymph 680–697, tritonymph 813–846. Body width (three specimens): protonymph 249–265, deutonymph 332–348, tritonymph 398–415.

Integument. General body cuticle colourless (larvae) to yellowish (some nymphs). Microfoveolate layer (distinctly visible under high magnification) covers body and legs in all juvenile instars. These foveolae are polygonal, situated close to each other forming a polygonal network. Also, larger foveolae (up to 2) covers dorsal side of body. Anterior part of gastronotic region with wide, transverse striate band.

Prodorsum. Triangular, about $^2/_3$ length of gastronotic region in lateral view. Rostrum rounded. Prodorsal setae with short cilia (one or two rows of cilia present usually situated close to each other). Rostral and lamellar setae widely phylliform; interlamellar and anterior exobothridial setae narrowly phylliform; posterior exobothridial setae reniform. Sensilli pectinate, with 10 to 12 long branches on one side and several barbs on other side. Relative length of prodorsal setae: *ro* ≈ *le* ≈ *in* ≈ *ss* ≈ *exa* > *exp*. Postbothridial transverse band weakly visible.

Gastronotic region. Anterior margin weakly convex. Eight transversal bands (S_2, S_3–S_9) poorly visible: S_2 complete, others incomplete. Nymphs with 16 pairs of gastronotic setae. All setae clearly phylliform, with short cilia (one or two rows of cilia present usually situated close to each other). Medial and medio-lateral setae clearly shorter than lateral and posterior setae. Cupules oblong, thin.

Gnathosoma. Subcapitulum with one pair of lateral tubercles. Four pairs of subcapitular setae present. Setae *a* setiform, thickened, smooth; setae *h* and m_2 reniform, ciliate, m_1 phylliform, ciliate. Three pairs of adoral setae present: or_1 more or less triangular, wide in proximal part, blunt-ended; or_2 long, setiform, thick, smooth, weakly truncate distally; or_3 setiform, smooth, pointed. Palp setal formula: protonymph 0–0–2–10 (+1ω); deuto- and tritonymph 0–1–2–10(+ω). Solenidion longer than palptarsus, thick, blunt-ended. Cheliceral seta *chb* long, setiform, slightly barbed; setae *cha* short, thin, thorn-like.

Epimeral region. Setal formulae for epimeres: protonymph 3–1–2–1; deutonymph 3–1–3–3, tritonymph 3–1–3–4. Epimeral setae phylliform, ciliate; *2a*, *3a*, *4a*

and *4b* (also *4c* in deutonymph) shorter than others.

Anogenital region. Genital valves divided in deuto- and tritonymph (undivided in protonymph). Ontogenetic genital, anal and adanal formulae (from proto- to tritonymph) 1–5–8, 0–2–2, 0–4–4, respectively. One pair in proto-, three pairs in deuto- and four pairs in tritonymphal instars of genital setae weakly phylliform, ciliate, others setiform, thickened, also ciliate. Anal setae setiform, with short cilia. Adanal setae long, phylliform, ciliate. Cupules oblong, thin, appearing in normal ontogenetic pattern.

Legs. Leg morphology and formulae of nymphal instars similar to *Lohmannia turcmenica*. Femora with ventral ridges. Femora I with long, conical, ventral tooth; femora II with large ventral tubercle.

Discussion

The juvenile instars of *Lohmannia* species that are known (*L. banksi*, *L. egyptica*, *L. jornoti*, *L. paradoxa*, *L. similis*, *L. turcmenica*, *L. vulcania*) are similar in their main morphological characters and are difficult to distinguish. Only some differences were found in the morphology of some prodorsal, notogastral, genital and subcapitular setae, leg femora and in the epimeral formulae (see Table 2).

By combining the knowledge given in the references (Norton *et al.* 1978, Shereef 1976, Schatz 1993, Schatz and Schuster 2012, Ermilov *et al.* 2012), augmented by the present study, we propose a diagnosis of juvenile instars of *Lohmannia*.

Diagnosis of juvenile instars of the genus *Lohmannia*: Rostrum rounded, with smooth margin, sometimes dentate in larval instar. Body surface microfoveolate, microtuberculate or microgranulate. Sensilli pectinate, with long branches (7–12 in larva; 9–12 in nymphs). Posterior exobothridial setae shortest on prodorsum, reniform (in nymphal instars, rarely in larval instar) or phylliform (in larval instar); other prodorsal and also notogastral setae ciliate or serrate, usually narrowly or widely phylliform, rarely setiform, thickened. Transversal bands S_2 (sometimes also S_6) complete, others incomplete; S_1 absent. Notogaster with 13 (larval instar) and 16 (nymphal instars) pairs of setae. Subcapitulum with three (larva) to four (nymphs) pairs of subcapitular setae. Palptarsi with 10 setae. Epimeral setal formulae 3–1–3–3 in deutonymph, 3–1–3–4(3) in tritonymph. Genital plates divided in deuto- and tritonymph. Anal plates

Table 2. Comparison of juvenile instars in *Lohmannia*

Character	*L. banksi*		*L. egyptica*		*L. jornoti*		*L. paradoxa*	*L. similis*		*L. turcmenica*		*L. vulcania*	
	L	N	L	N	L	N	N	L	N	L	N	L	N
Morphology of exobothridial setae *exp*	Phylliform	Reniform	Reniform	Reniform	Phylliform	Reniform	Reniform	Phylliform	Reniform	Phylliform	Reniform	Nearly reniform	Reniform
Morphology of notogastral setae	Slightly phylliform	Clearly phylliform	Clearly phylliform	Clearly phylliform	Slightly phylliform	Slightly phylliform	Clearly phylliform	Slightly phylliform	Slightly phylliform	Slightly phylliform	Slightly phylliform	Slightly phylliform	Slightly phylliform, except p_1
Morphology of subcapitular setae h, m1, m2	Data absent	Data absent	Data absent	Data absent	*h*, phylliform, m_1 setiform	*h*, m_2 phylliform, m_1 setiform	*h*, m_2 reniform, m_1 phylliform	*h*, phylliform, m_1 setiform	*h* phylliform, m_1, m_2 setiform	*h*, m_1 phylliform	*h*, m_1, m_2 phylliform	*h*, phylliform, m_1 setiform	*h*, m_2 phylliform, m_1 setiform
Epimeral formula	3–1–2	Tn: 3–1–3–4	2–1–2	Tn: 3–1–3–3	3–1–2	Tn: 3–1–3–4	Tn: 3–1–3–4	3–1–2	Tn: 3–1–3–4	3–1–2	Tn: 3–1–3–4	3–1–2	Tn: 3–1–3–4
Phylliform setae on genital plates	–	Present	–	Present	–	Present	Present	–	Absent	–	Absent	–	Present
Morphology of leg femora	Normal for genus	Normal for genus	Normal for genus	Normal for genus	Normal for genus	Normal for genus	F I: with tooth, F II: with tubercle	Normal for genus	Normal for genus	Normal for genus	Normal for genus	Normal for genus	Normal for genus

L – larval instar, N – nymphal instars, Tn – tritonymphal instar, F – femur.

with two pairs of setae. Phylliform setae on legs present.

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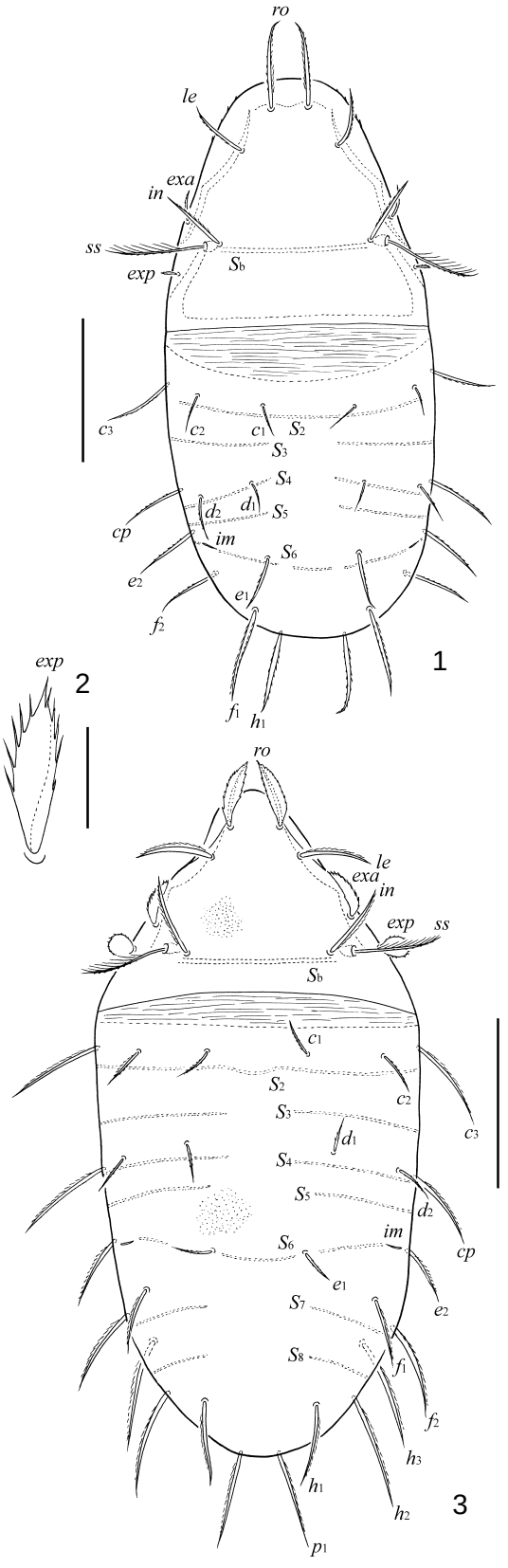
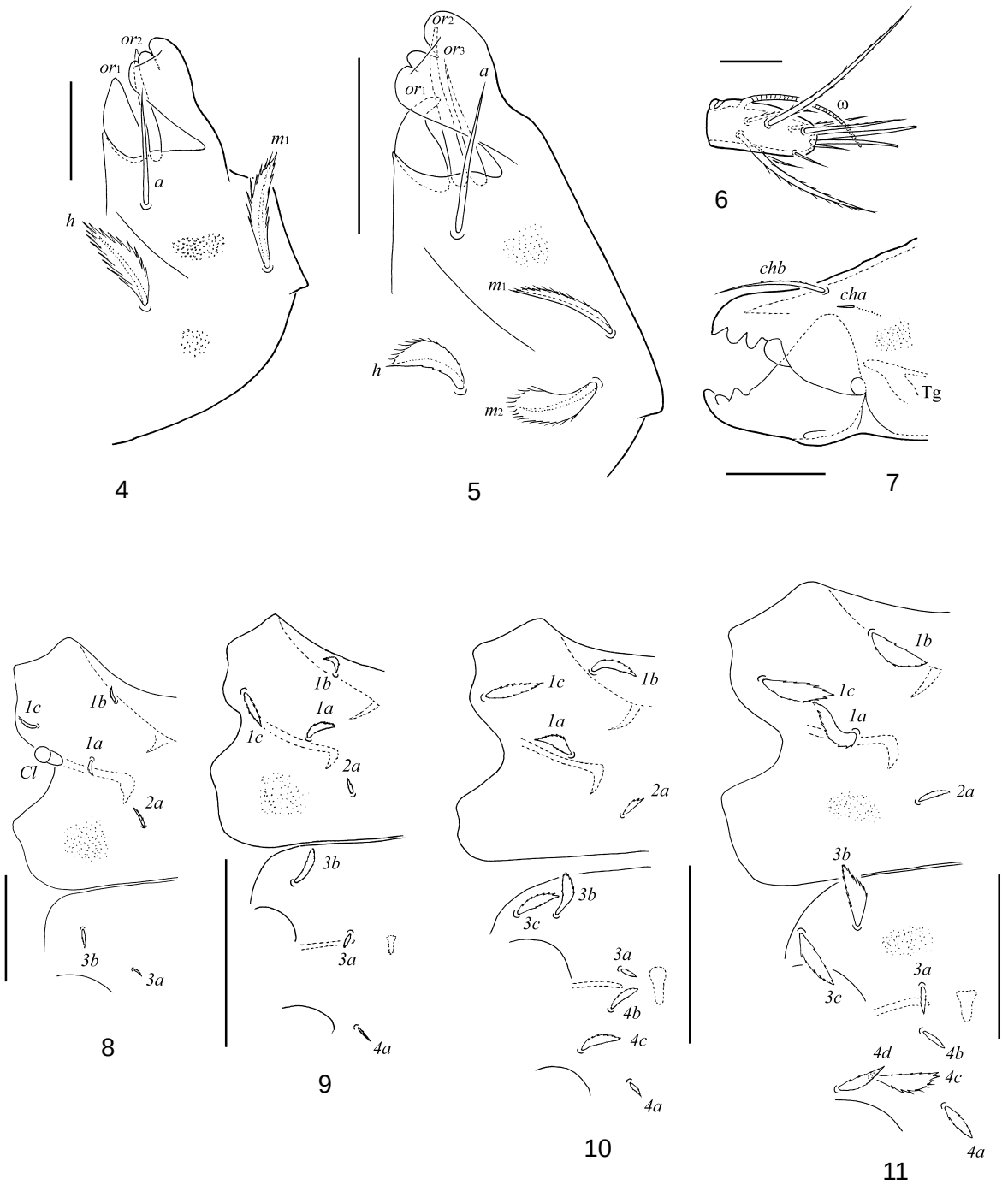
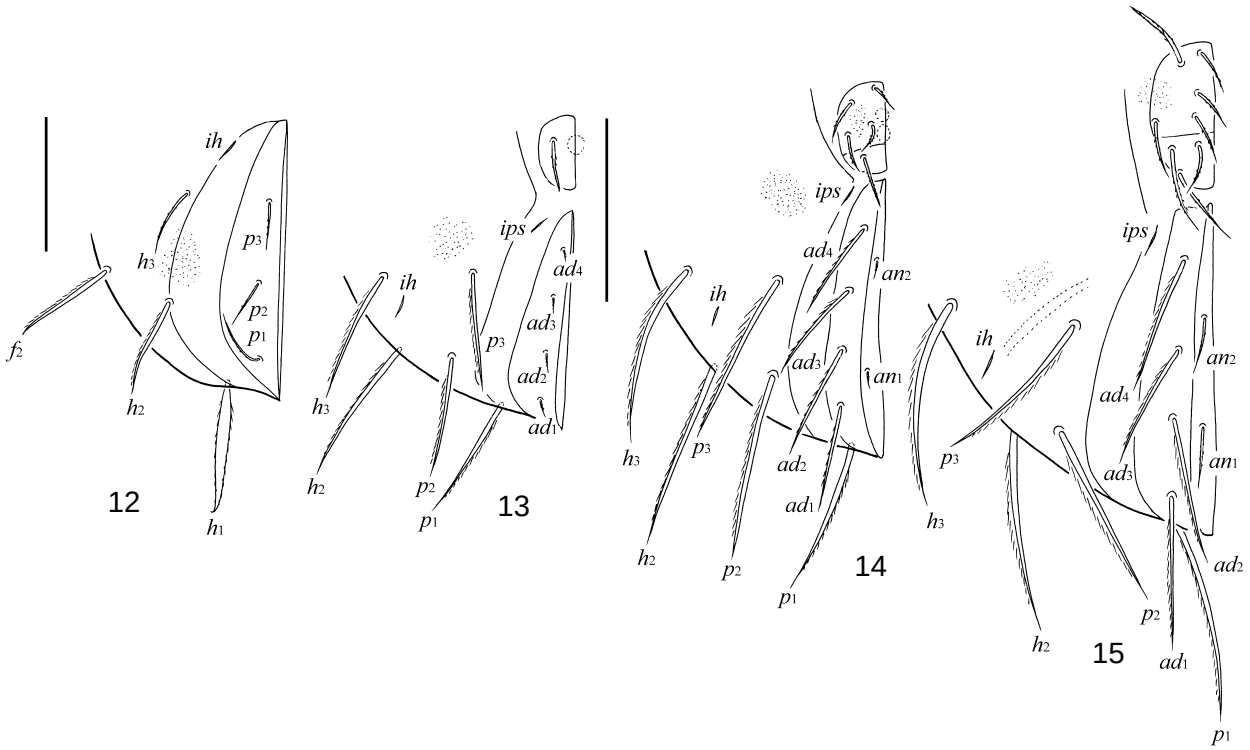


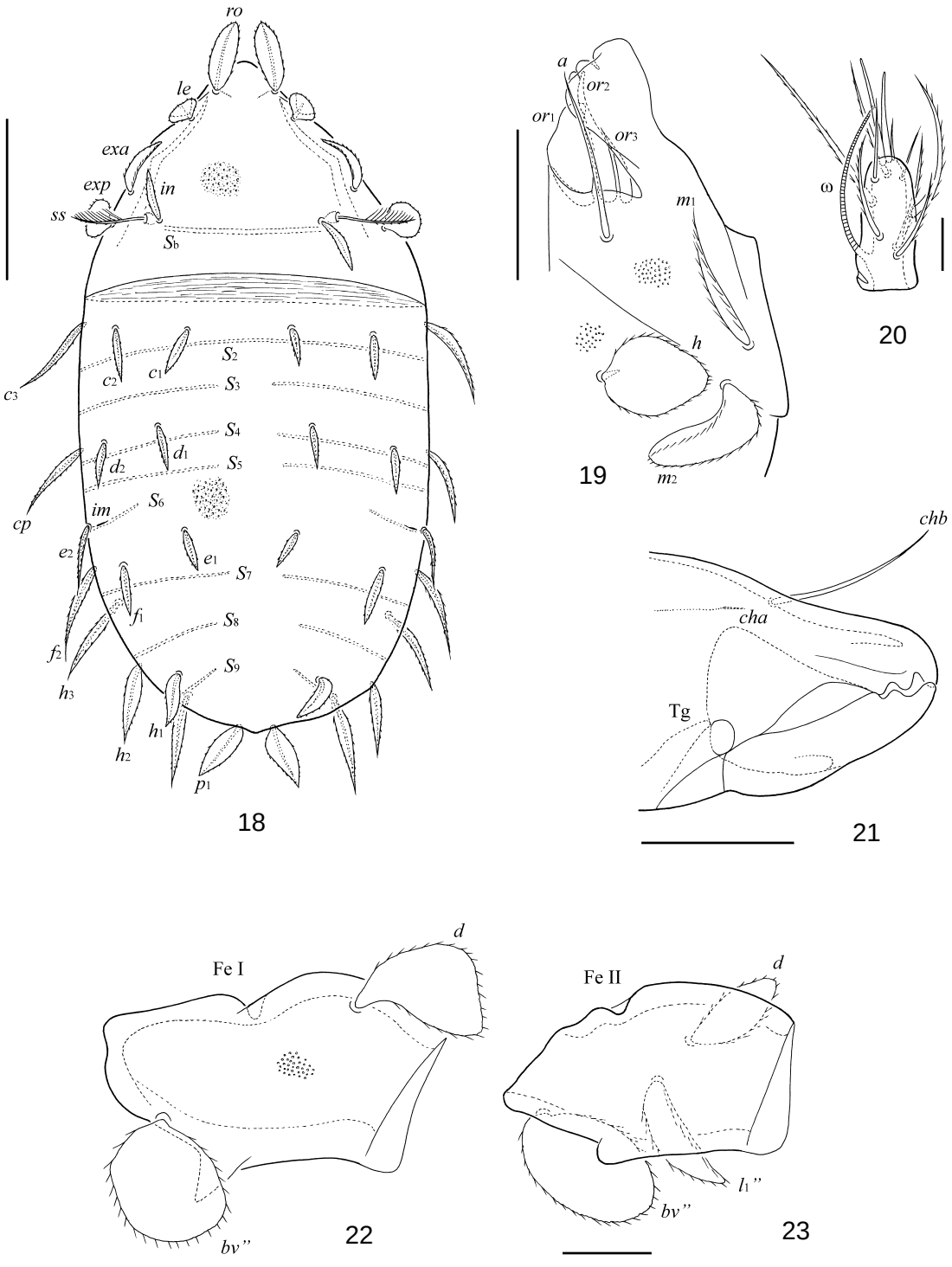
Figures 1–3. *Lohmannia turcmenica* Bulanova-Zachvatkina, 1960 (1) larva, dorsal view; (2) prodorsal seta exp of larva; (3) tritonymph, dorsal view. Scale bar: (1) 100 μm; (2) 10 μm; (3) 200 μm.



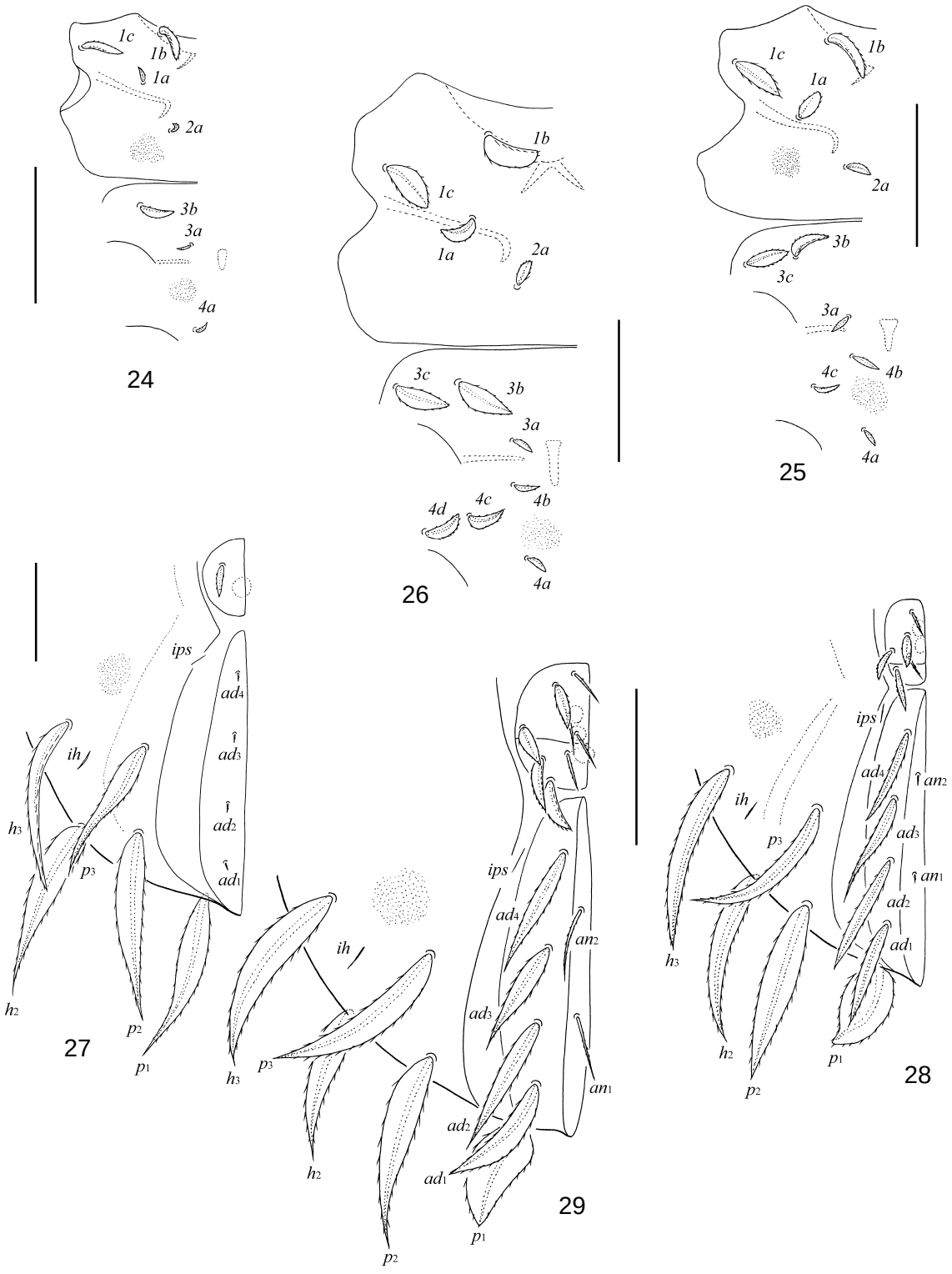
Figures 4–11. *Lohmannia turcmenica* Bulanova-Zachvatkina, 1960 (4) left half of subcapitulum of larva, ventral view; (5) left half (posterior part not illustrated) of subcapitulum of tritonymph, ventral view; (6) palptarsus of deutonymph; (7) anterior part of chelicera of larva; (8) right half of epimeral region of larva; (9) right half of epimeral region of protonymph; (10) right half of epimeral region of deutonymph; (11) right half of epimeral region of tritonymph. Scale bar: (4, 7) 20 μm; (5, 8) 50 μm; (6) 10 μm; (9–11) 100 μm.



Figures 12–17. *Lohmannia turcmenica* Bulanova-Zachvatkina, 1960 (12) right half of anogenital region of larva; (13) right half of anogenital region of protonymph; (14) right half of anogenital region of deutonymph; (15) right half of anogenital region of tritonymph; (16) leg I of larva, left, paraxial view; (17) leg III of larva, right, antiaxial view. Scale bar: (12) 50 μm; (13–15) 100 μm; (16, 17) 20 μm.



Figures 18–23. *Lohmannia paradoxa* (Haller, 1884) (18) tritonymph, dorsal view; (19) left half (posterior part not illustrated) of subcapitulum of tritonymph, ventral view; (20) palptarsus of tritonymph; (21) anterior part of chelicera of tritonymph; (22) femur of leg I of protonymph, right, antiaxial view; (23) femur of leg II of protonymph, left, paraxial view. Scale bar: (18) 200 μm; (19, 21) 50 μm; (20) 10 μm; (22, 23) 20 μm.



Figures 24–29. *Lohmannia paradoxa* (Haller, 1884) (24) right half of epimeral region of protonymph; (25) right half of epimeral region of deutonymph; (26) right half of epimeral region of tritonymph; (27) right half of anogenital region of protonymph; (28) right half of anogenital region of deutonymph; (29) right half of anogenital region of tritonymph. Scale bar: (24, 27) 50 μm; (25, 26, 28, 29) 100 μm.