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MORPHOLOGY OF JUVENILE INSTARS OF *EUEREMAEUS TRAVEI* (ACARI: ORIBATIDA)

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ABSTRACT: Juvenile instars of *Eueremaeus travei* are described and illustrated in detail. Juveniles of *Eueremaeus travei* and *Eueremaeus oblongus* are compared. New diagnoses to Eremaeidae, *Eremaeus*, *Eueremaeus* and *Tricheremaeus* are given. An identification key to nymphs of the genera is presented.

KEY WORDS: Oribatida, morphology, juvenile instars, ontogeny, Eremaeidae, *Eueremaeus*, *Eremaeus*, *Tricheremaeus*, *Asperemaeus*, diagnosis, key

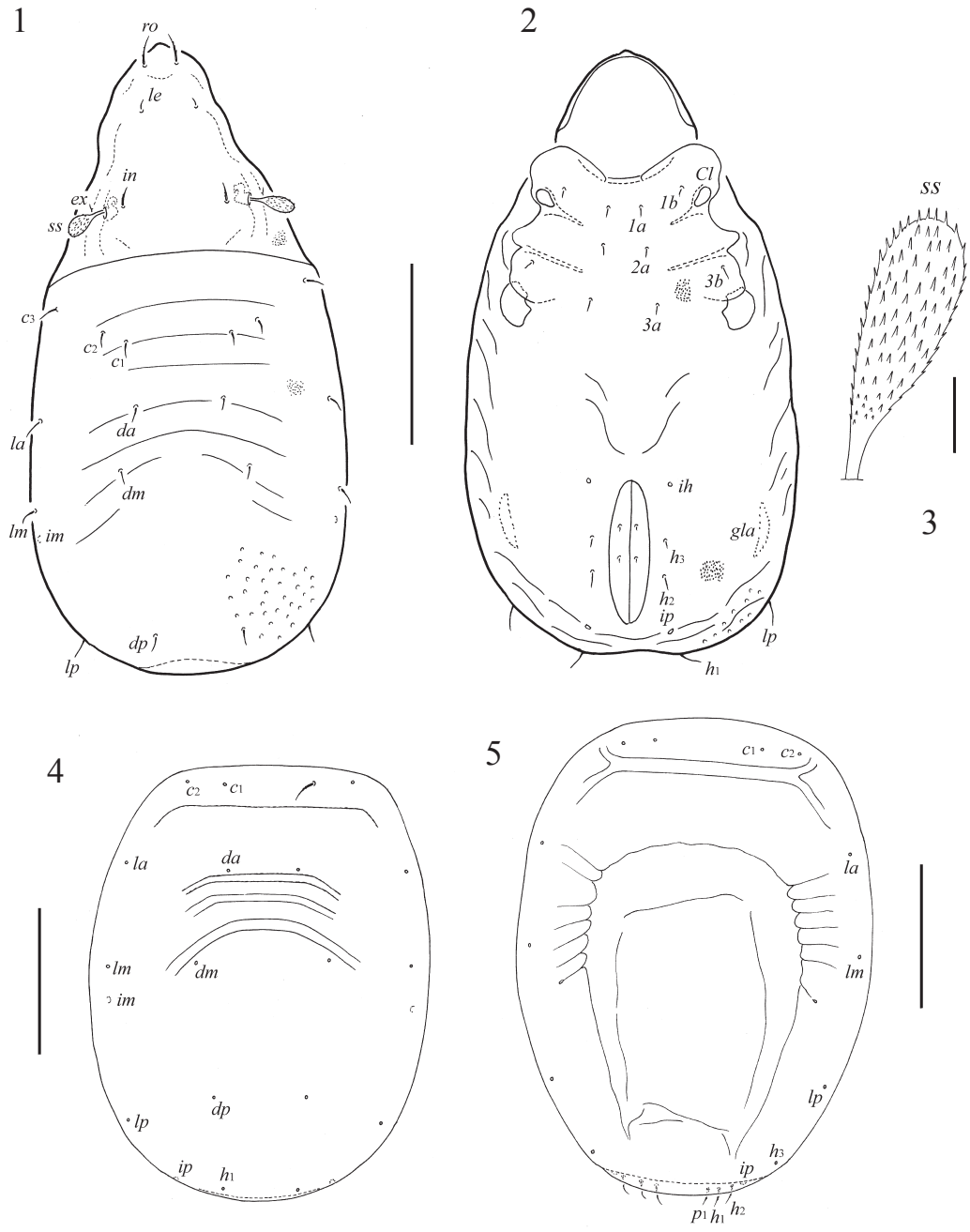
INTRODUCTION

The oribatid mite family Eremaeidae (Acari: Oribatida) comprises seven genera and 81 species that are collectively distributed in the Holarctic and Oriental regions. The genera include: *Asperemaeus* Behan-Pelletier, 1982 (two species), *Carinabella* Hammer, 1977 (two species), *Caucaseremaeus* Subías et Shtanchaeva, 2006 (one species), *Eremaeus* Koch, 1835 (26 species), *Eueremaeus* Mihelčič, 1963 (35 species), *Proteremaeus* Piffl, 1965 (nine species), and *Tricheremaeus* Berlese, 1908 (six species). At present, the juvenile instars of only a few species of eremaeid mites have been studied, and these works relate to only four of the seven genera (none for *Carinabella, Caucaseremaeus* and *Proteremaeus*), and in some cases only to selected instars. Therefore, diagnoses of Eremaeidae (e.g. Grandjean 1953; Behan-Pelletier 1993) and its superfamily, Zetorchestoidea (= Eremaeoidea auct.; Norton, Behan-Pelletier 2009; Sidorchuk, Norton 2011), are all based on incomplete knowledge.

The four genera for which information on juveniles is available have received different levels of study. For *Asperemaeus* only the tritonymph of *A. longipilus* Behan-Pelletier, 1982 is known. *Tricheremaeus* is better known, with four of the six named species having been studied. Michael (1885, 1888) briefly described a nymph of *T. serratus* (Michael, 1885). Grandjean (1963) described the juvenile instars of *T. nemossensis* Grandjean, 1934. Miko (1993) described the juveniles of *T. travei* Miko, 1993 and Miko and Weigmann (2007) briefly described those of *T. abnobensis* Miko et Weigmann, 2006.

Juvenile instars of several species each of *Eremaeus* and *Eueremaeus* have been studied. Lions (1971) described them for *Er. hepaticus cordiformis* Grandjean, 1934. Behan-Pelletier (1993) described the tritonymph of four species, and in most cases gave information about other instars: *Er. kananaskis* Behan-Pelletier, 1993, *Er. occidentalis* Behan-Pelletier, 1993, *Er. oresbios* Behan-Pelletier, 1993, *Er. translamellatus* Behan-Pelletier, 1993. Ermilov (2009) described the juvenile instars of *Er. hepaticus hepaticus* Koch, 1835. For *Euermaeus*, Michael (1880) briefly described a nymph of *E. oblongus* (Koch, 1835) and Fujikawa (1991) briefly described the deutonymph of *E. hokkaiensis* Fujikawa, 1991. Behan-Pelletier (1993) described the deutonymph of *E. nahani* Behan-Pelletier, 1993; she also described the tritonymph of nine other species, and in most cases gave information about other instars: *E. carinatus* Behan-Pelletier, 1993, *E. columbianus* (Berlese, 1916), *E. higginsi* Behan-Pelletier, 1993, *E. masinasin* Behan-Pelletier, 1993, *E. proximus* (Berlese, 1916), *E. stiktos* (Higgins, 1962), *E. tetrosus* (Higgins, 1979), and *E. woolleyi* (Higgins, 1979). Most recently, Ermilov (2009) described the juvenile instars of *E. oblongus*.

The primary purpose of the present work is to describe and illustrate the morphology of juvenile instars of *Eueremaeus travei* Micelčič, 1963. This species known from Western Europe (Subías 2004, online version 2012), but only the adult has been described. Its juveniles are compared with those of *Eu. oblongus*, the only other *Eueremaeus* species for which equally complete data are available.



Figs. 1–5. *Eueremaeus travei*, juvenile instars: 1 — larva, dorsal view; 2 — larva, ventral view, legs (except trochanters III) and gnathosoma not shown; 3 — sensillus of protonymph; 4 — larval scalp; 5 — protonymphal scalp. Scale bar 100 μm (1, 2, 4, 5); 20 μm (3).

Also, we present a comparative analysis of juveniles in genera of Eremaeidae, and use this to augment their diagnoses and that of the family. A diagnostic key based on nymphs is presented, for the four genera that are known sufficiently.

MATERIALS AND METHODS

Material. Specimens of *Eueremaeus travei* were from: Spain, Zaragoza, Monasterio de Piedra, petroglyphic moss, collected by M.E. Minguez, 4 April 1974. This field-collected material included: 9 larvae, 9 protonymphs, 16 deutonymphs and 12 tritonymphs. All specimens are in the personal collection of the first author.

Specimens were studied and illustrated in lactic acid, 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. Gastronotic width refers to the maximum width in dorsal aspect. Setal formulae for appendages relate to successive segments, basal to distal.

General terminology used in this paper follows that of F. Grandjean (see Travé and Vachon

Table 1.
Comparison of prodorsal setae measurements (in μm) of *Eueremaeus travei* during ontogeny

Character	Larva	Protonymph	Deutonymph	Tritonymph
	n*=4	n=4	n=4	n=4
Length of rostral seta	24	32–36	36–41	53–57
Length of lamellar seta	8–10	20	36–41	53–57
Length of interlamellar seta	12	24	32–41	53–57
Length of sensillus	32	36–41	41–53	57–65
Length of exobothridial seta	4–6	4–8	8	12

*Number of studied specimens

1975 for many references), Behan-Pelletier (1993) and Norton and Behan-Pelletier (2009).

RESULTS

Description of juvenile instars of *Eueremaeus travei* Micelčič, 1963

Figs 1–21

Dimensions. Length: larva 332–348 (mean 340; n=6), protonymph 431–464 (mean 444; n=5), deutonymph 531–630 (mean 583; n=6), tritonymph 680–780 (mean 742; n=7). Width: 166–182 (mean 174; n=6), protonymph 215–249 (mean 228; n=5), deutonymph 315–348 (mean 334; n=6), tritonymph 398–464 (mean 426; n=7).

Integument. General body cuticle weakly sclerotized, colourless to yellow. Body cuticle (except central part of prodorsum and lateral parts of epimeres) with typical micropolygonal ornament. Latero-posterior parts of gastronotic region foveolate (diameter of foveolae up to 4 μm). Cuticle of gastronotic region in larva with several transverse folds.

Prodorsum (Figs. 1, 3, 6). Relatively short, about half length of gastronotic region in lateral view. Rostrum rounded in dorsal view. Nymph with rudimentary costular lines. Rostral (*ro*), lamellar (*le*) and interlamellar (*in*) setae setiform, slightly barbed. Exobothridial (*ex*) seta short, thin, smooth. Sensillus (*ss*) clavate, with short stalk and longer, oblong, barbed head. Prodorsal setae measurements given in Table 1.

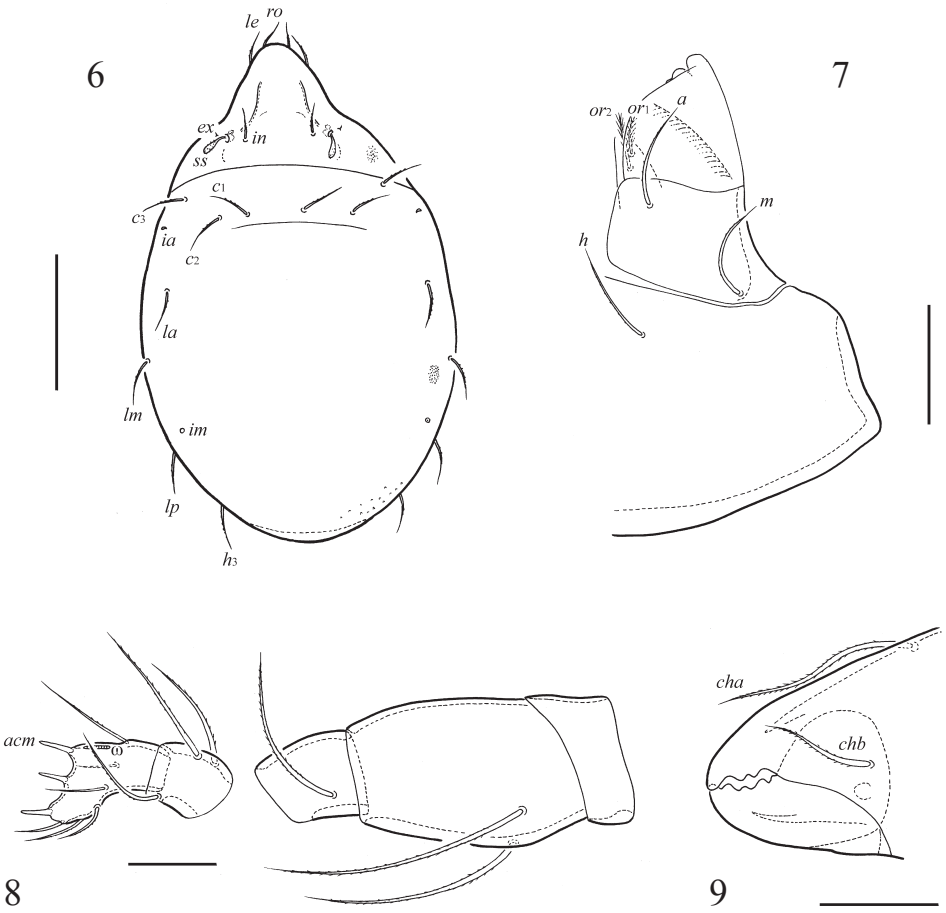
Gastronotic region (Figs. 1, 4–6). Rounded posteriorly, except larva with weakly developed concavity, seen only in ventral view. Nymphs with caudal region more strongly pigmented, but lack caudal ledge. All instars with 12 pairs of setiform, slightly barbed gastronotic setae. Three pairs of setae (p_1, h_1, h_2) usually inserted close together. Larval scalp with nine pairs of alveoli; that of nymphs usually with six pairs of alveoli and three caudal setae (other setae rarely presenty). Cupules *ia* and *im* present, but often poorly visible.

Gnathosoma (Figs. 7–9). All hypostomal setae (*h*, *m*, *a*) setiform, slightly barbed, differ little in length. Lateral lip with two pairs of ciliate adoral setae; or_1 shorter than or_2. Palp setal formula of larva 0–1–1–3–9+ω, of nymphs 0–2–1–3–9+ω. Palpal solenidion ω slightly thickened, blunt-ended, pressed to tarsus, located posterior to eupathidium *acm*. Palp setae (except dorso-distally on tarsus) barbed. Cheliceral setae long, barbed; *cha* longer than *chb*.

Epimeral region (Figs. 2, 10–12). Setal formulae for successive epimeres: larva 3–1–2 (third seta of first epimere forms protective scale over respective Claparède's organ (*Cl*)); protonymph 3–1–2–1; deutonymph 3–1–2–2, tritonymph 3–1–3–3. Setae setiform, slightly barbed. Median setae shorter than others. Brachytracheae developed and typical for Eremaeidae (Grandjean 1963; Behan-Pelletier 1993), but often poorly visible.

Anogenital region (Figs. 2, 13–15). Ontogenetic formulae (larva to tritonymph, respectively): genital 0–1–3–5, aggenital 0–0–1–1, adanal 0–0–5–5, anal 0–0–0–5. Larva with two pairs of paraproctal setae, protonymph with five pairs of adanal alveoli, deutonymph with five pairs of anal alveoli. Setae setiform, thin, smooth or with indistinct barbs. Cupules *ih*, *ips*, *iad* and *ip* appearing in normal ontogenetic pattern. Opisthonotal gland opening (*gla*) small, often poorly visible.

Legs (Figs. 16–21). Ontogeny of leg setae and solenidia given in Tables 2 and 3. Femora and trochanters III, IV of nymphs with well developed dorsal and ventral keel. Each dorsal keel with scalloped or bluntly-toothed margin. Setae setiform, barbed or ciliate (except smooth *p* on leg I). Famulus short, thin, straight. Solenidia ω_1 on tarsus I, ω_1 and ω_2 on tarsus II thickened, blunt-ended; other solenidia setiform.



Figs. 6–9. *Eueremaeus travei*, juvenile instars: 6 — tritonymph, dorsal view; 7 — subcapitulum of protonymph, left part; 8 — palp of protonymph; 9 — chelicera of protonymph, distal part. Scale bar 200 μm (6); 20 μm (7, 9), 10 μm (8).

Juvenile instars of only two species of *Eueremaeus*, *E. travei* and *E. oblongus*, have now been studied in detail. Both species can occur in the same habitats of Western Europe, and their larva and nymphs are very similar in body form, cuticle surface, morphology of body setae, and body setal formula. Therefore a close comparison of juveniles is necessary to distinguish them in mixed samples, the important characters being as follows below.

Larva

— Body size: 332–348 × 166–182 in *E. travei*; 265–282 × 132–149 in *E. oblongus*.

— Length of lamellar seta: shorter than rostral seta (8–10 vs. 20) in *E. travei*; little longer than rostral seta (24–28 vs. 20–24) in *E. oblongus*.

— Morphology of sensillus: with short stalk (considerably shorter than head) in *E. travei*; with long stalk (little shorter than head) in *E. oblongus*.

Nymphs

— Body size: protonymph 431–464 × 215–249, deutonymph 531–630 × 315–348, tritonymph 680–780 × 398–464 in *E. travei*; protonymph 315–348 × 166–182, deutonymph 415–431 × 232–249, tritonymph 498–531 × 249–282 in *E. oblongus*.

— Caudal ledge, having gastronotic setae p_1, h_1, h_2: not developed in *E. travei*; well developed in *E. oblongus*.

— Caudal ledge of exuvial scalps: not developed in *E. travei*; well developed in *E. oblongus*.

— Morphology of sensillus: with short stalk (considerable shorter than head) in *E. travei*; with long stalk (little shorter than head) in *E. oblongus*.

By combining the knowledge on juvenile instars given in the references indicated above, augmented by the current study, the following revised diagnoses can be offered for juveniles of Eremaeidae and those of its genera for which larva and nymphs were described. As only its tritonymphal instar has been studied, we do not propose a revised diagnosis for *Asperemaeus*. Adult characters are included in the diagnoses by Behan-Pelletier (1993) for Eremaeidae, *Eremaeus* and *Eueremaeus*, and by Grandjean (1963) for *Trichereremaeus*.

Table 2.
Setal and solenidial counts on legs of *Eueremaeus travei* during ontogeny

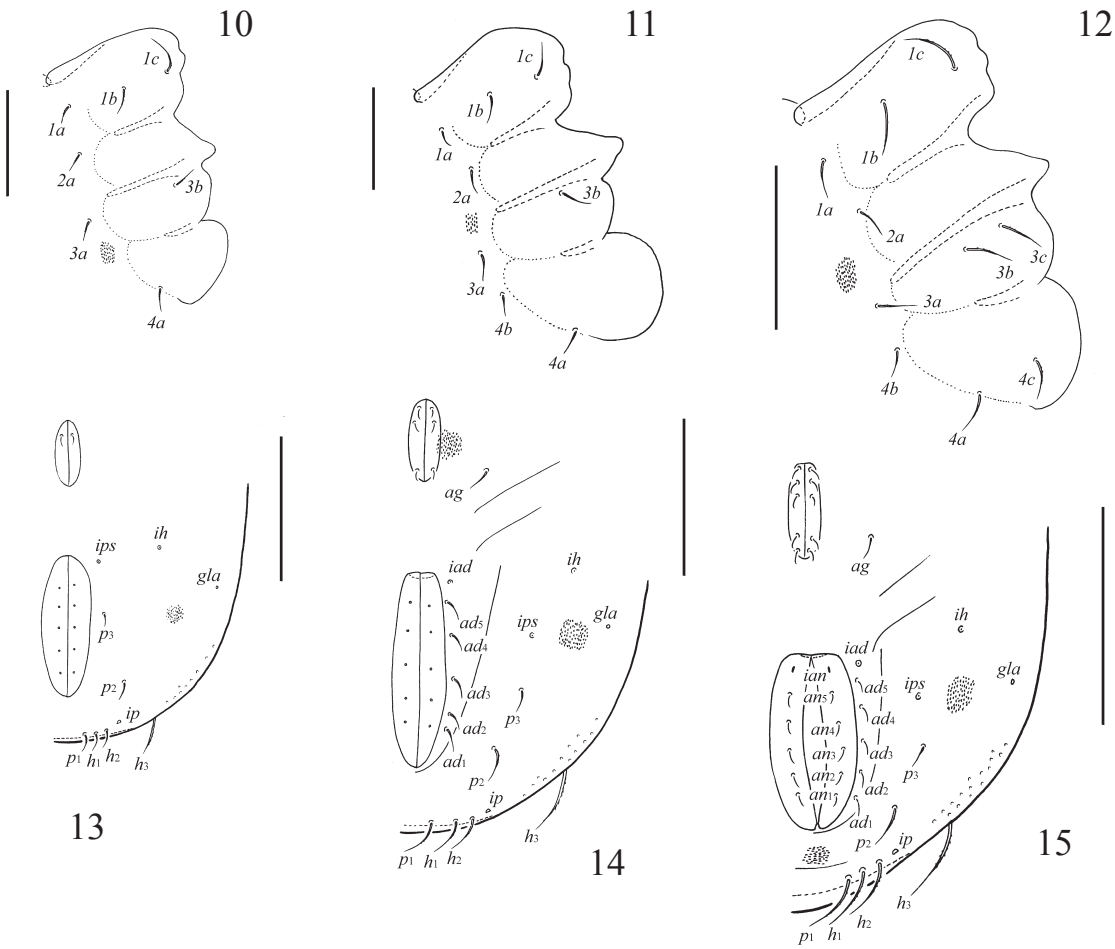
	Formula of setae	Formula of solenidia
Leg I		
Larva	0–2–2–3–16	1–1–1
Protonymph	0–3–2–3–16	1–1–2
Deutonymph	1–4–3–3–16	1–2–2
Tritonymph	1–4–3–4–18	1–2–2
Leg II		
Larva	0–2–2–2–13	1–1–1
Protonymph	0–3–2–2–13	1–1–1
Deutonymph	1–4–3–3–13	1–1–2
Tritonymph	1–4–3–4–15	1–1–2
Leg III		
Larva	0–2–1–1–13	1–1–0
Protonymph	0–2–1–1–13	1–1–0
Deutonymph	1–3–1–2–13	1–1–0
Tritonymph	2–3–2–3–15	1–1–0
Leg IV		
Protonymph	0–0–0–0–7	0–0–0
Deutonymph	0–2–1–1–12	0–1–0
Tritonymph	1–2–2–3–12	0–1–0

Formula for leg setae in sequence trochanter–femur–genu–tibia–tarsus (famulus included); formula for solenidia in sequence genu–tibia–tarsus.

Table 3.
Development of leg setation of *Eueremaeus travei*

	Trochanter	Femur	Genu	Tibia	Tarsus
Leg I					
Larva	–	*d, bv″*	*(l)*, σ	*(l), v′*, φ_1	*(ft), (tc), (p), (u), (a), s, (pv), (pl), e*, ω_1
Protonymph	–	*l′*	–	–	ω_2
Deutonymph	*v′*	*l″*	*v′*	φ_2	–
Tritonymph	–	–	–	*v″*	*(it)*
Leg II					
Larva	–	*d, bv″*	*(l)*, σ	*l′, v′*, φ	*(ft), (tc), (p), (u), (a), s, (pv)*, ω_1
Protonymph	–	*l′*	–	–	–
Deutonymph	*v′*	*l″*	*v′*	*l″*	ω_2
Tritonymph	–	–	–	*v″*	*(it)*
Leg III					
Larva	–	*d, ev′*	*l′*, σ	*v′*, φ	*(ft), (tc), (p), (u), (a), s, (pv)*
Protonymph	–	–	–	–	–
Deutonymph	*v′*	*l′*	–	*l′*	–
Tritonymph	*l′*	–	*v′*	*v″*	*(it)*
Leg IV					
Protonymph	–	–	–	–	*ft″, (p), (u), (pv)*
Deutonymph	–	*d, ev′*	*d*	*v′*, φ	*(tc), (a), s,*
Tritonymph	*v′*	–	*v′*	*l′, v″*	–

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



Figs. 10–15. *Eueremaeus travei*, left half of epimeral (10–12) and anogenital (13–15) regions of nymphs: 10, 13 — protonymph; 11, 14 — deutonymph; 12, 15 — tritonymph. Scale bars (10, 11) 50 μm; (12–14) 100 μm; (15) 200 μm.

Diagnosis of juvenile instars of the family Eremaeidae

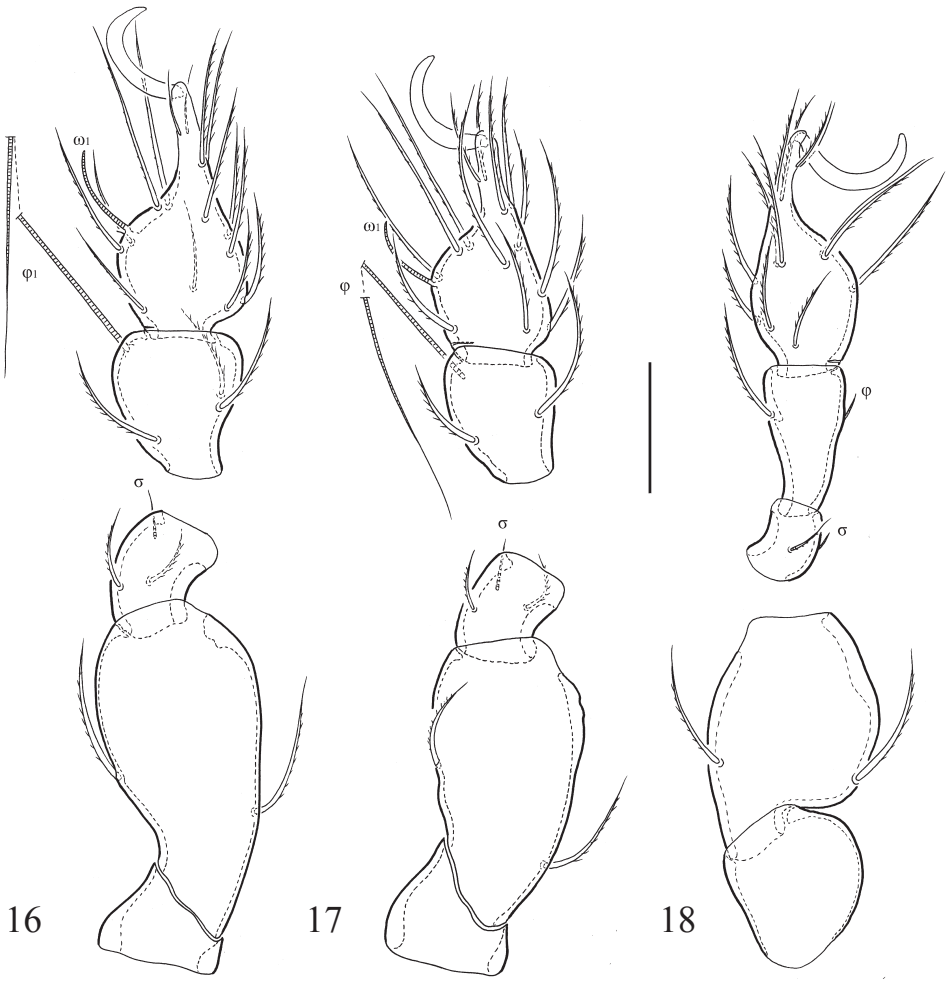
Gastronotic region of nymphs covered by exuvial scalps. Larva and nymphs with 12 pairs of gastronotic setae or setal neotrichy present. Exuvial scalps with nine pairs of setae (or alveoli) or setal neotrichy present. Epimeral region with brachytracheae. Prodorsal setae developed. Epimeral setal formulae (larva-protonymph-deutonymph-tritonymph): larva 3–1–2, protonymph 3–1–2–1, deutonymph 3–1(or 2)–2(or 3)–2, tritonymph 3–1(or 2)–2(or 3)–2(or 3). Genital setal formulae (larva to tritonymph) 0–1–3–5; aggenital 0–0–1–1. Larva with two pairs of paraproctal setae. Rudimentary adanal setae in protonymph and rudimentary anal setae in deutonymph present or absent. Tritonymph with three or more pairs of anal and adanal setae. Cupules *ian* present in tritonymph. Second seta on palpfemur developed in protonymph. Palptarsal solenidion not fused with eupathidial seta *acm*. Leg seta *d* on tibia I–III and genua I–III absent or present. Leg IV of protonymph with typical formula 0–0–0–0–7.

Diagnosis of juvenile instars of the genus *Eremaeus*

Anterior tecta on epimere I not overlapping medially in nymphs. Larva and nymphs with 12 pairs of gastronotic setae; p_1, h_1, h_2 inserted close together in nymphs. Exuvial scalps with nine pairs of setae or alveoli. Rudimentary adanal setae in protonymph and rudimentary anal setae in deutonymph present. Tritonymph with five pairs (rarely more) of anal and adanal setae. Leg seta *d* absent from tibiae I–III and genua I–III.

Diagnosis of juvenile instars of the genus *Eueremaeus*

Anterior tecta on epimere I overlapping medially in nymphs. Larva and nymphs with 12 pairs of gastronotic setae; setae p_1, h_1, h_2 inserted close together in nymphs. Exuvial scalps with nine pairs of setae or alveoli. Rudimentary adanal setae in protonymph and rudimentary anal setae in deutonymph present. Tritonymph with five pairs (rarely more) of anal and adanal setae. Leg seta *d* absent from tibiae I–III and genua I–III.



Figs. 16–18. *Eueremaeus travei*, legs of larva: 16 — leg I, left, paraxial view; 17 — leg II, left, paraxial view; 18 — leg III, right, antiaxial view. Scale bars 20 μm.

Diagnosis of juvenile instars of the genus *Tricheremaeus*

Gastronotic setal and exuvial setal neotrichy present (more than 16 pairs of long gastronotic setae). Rudimentary adanal setae in protonymph and rudimentary anal setae in deutonymph absent. Tritonymph with five pairs (rarely more) of anal and adanal setae. Leg seta *d* present on tibiae I–III and genua I–III.

Key to genera of Eremaeidae based on nymphs

1. Gastronotic region with more than 16 pairs of gastronotic setae ..... *Tricheremaeus*
— Gastronotic region with 12 pairs of gastronotic setae 2
2. Leg seta *d* absent from tibiae I–III and genua I–III; tritonymph with five pairs (rarely more) of anal and adanal setae 3
— Leg seta *d* present on tibiae I–III and genua I-III; tritonymph with three pairs of anal and adanal setae ..... *Asperemaeus*[1]
3. Anterior tecta on epimere I not overlapping medially ..... *Eremaeus*
— Anterior tecta on epimere I overlapping medially ..... *Eueremaeus*

The larvae of *Tricheremaeus* clearly differ from those of *Eremaeus* and *Eueremaeus* by the presence of gastronotic setal and exuvial setal neotrichy. However, we could not distinguish between larvae of *Eremaeus* and *Eueremaeus*, therefore no key to larvae is presented.

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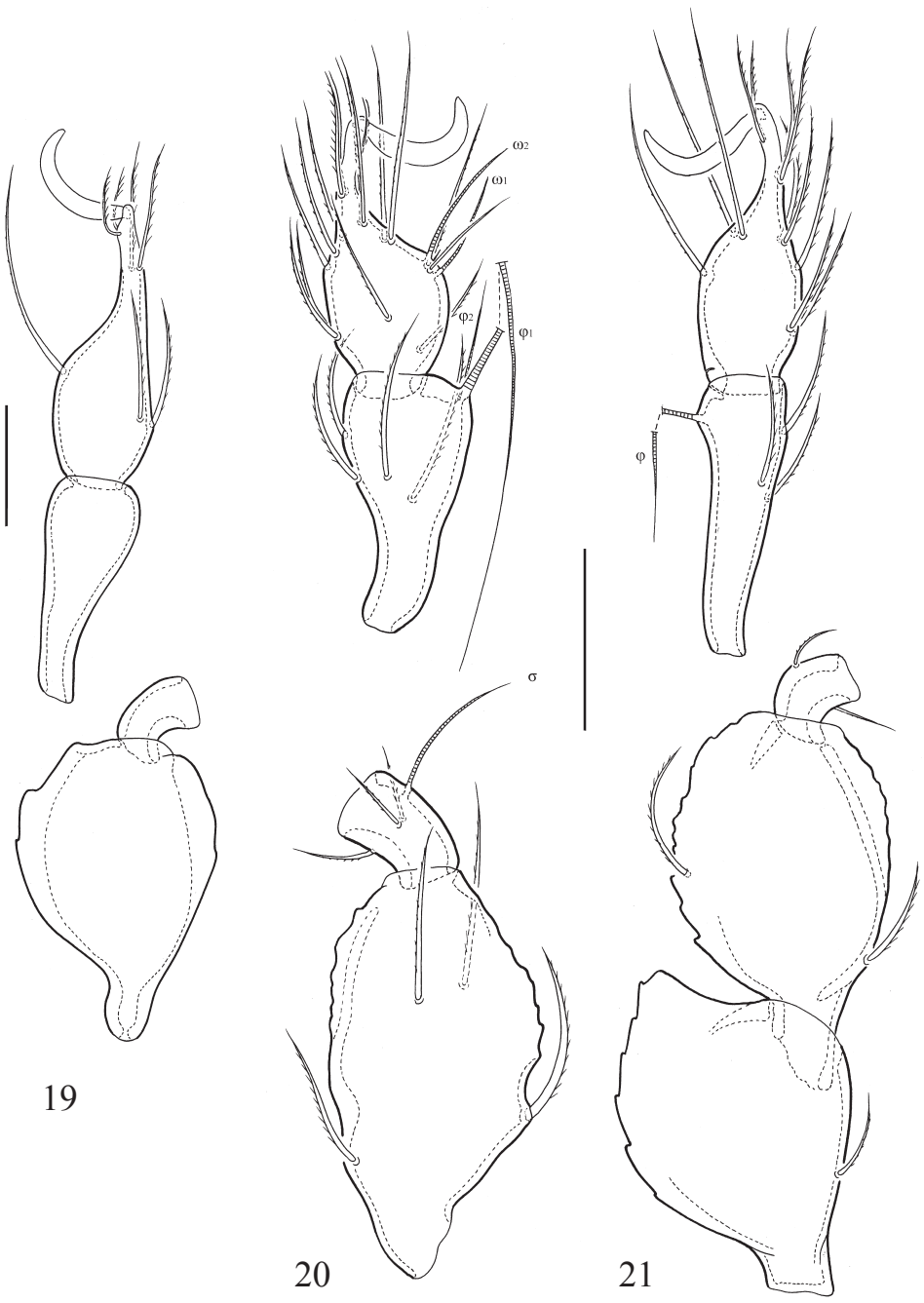
[1] Only the morphology of the tritonymph is known (Behan-Pelletier 1982), but in other eremaeid genera the these characters are consistent among the three nymphal instars, so we assume the same is true of *Asperemaeus*.



Figs. 19–21. *Eueremaeus travei*, legs of nymphs: 19 — leg IV of protonymph, without trochanter, left, antiaxial view; 20 — leg I of tritonymph, without trochanter, left, antiaxial view, 21 — leg IV of tritonymph, left, antiaxial view. Scale bar (19) 20 μm; (20, 21) 50 μm.

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