Acta Zoologica Academiae Scientiarum Hungaricae 55 (4), pp. 365–379, 2009

MORPHOLOGICAL ANALYSIS OF THE JUVENILE STAGES OF *PROVERTEX KUEHNELTI* MIHELČIČ (ACARI: ORIBATIDA, SCUTOVERTICIDAE)

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The knowledge of the juvenile stages of the genus *Provertex* MIHELČIČ, 1959 is very fragmentary; only one author gave a vague characterization of the developmental instars of two species – *Provertex delamarei* TRAVÉ, 1963 and *P. mailloli* TRAVÉ, 1964. This work provides a detailed description of the juveniles of *Provertex kuehnelti* MIHELČIČ, 1959 and shows that spinose and thickened notogastral setae are the only morphological features specific for the juveniles of this genus. Additionally a comparison with the larva and nymphs of two *Scutovertex* species confirms the systematic position of the genus *Provertex* within the family of Scutoverticidae.

Key words: taxonomy, morphology, development, *Scutovertex*

INTRODUCTION

MIHELČIČ (1959) described *Provertex kuehnelti* for the first time and established the genus *Provertex*. TRAVÉ (1963) classified this genus as a member of the family Scutoverticidae. But up to the present the systematic position within this family and some morphological features of *Provertex* are controversial issues (e.g. WOAS 2002). MIHELČIČ's description of *P. kuehnelti* (1959) was incomplete and was redescribed by KRISPER and SCHUSTER (2009), recently. TRAVÉ (1963, 1964) reported on variable characters in the species *P. delamarei* and *P. mailloli*, moreover KRISPER and SCHUSTER (2009) stated that the intraspecific morphological variability in *P. kuehnelti* seems to be higher than in the other species of the genus. To clarify the taxonomic status of the genus *Provertex* it is necessary to redescribe arguable species and to find more, new, and constant morphological properties of each species. The actual study provides detailed data about the morphology of the juvenile stages of *P. kuehnelti* and compares the characters with those of two congeneric species and of *Scutovertex minutus* (KOCH, 1836) and *S. sculptus* MICHAEL, 1879.

MATERIALS AND METHODS

Mite collection: Samples were collected from alpine rocky habitats of Styria (Austria) in June 2007. Specimens were extracted from moss samples using Berlese-Tullgren funnels.

Collection sites. (1) Graz, Buchkogel, coordinates: N 47°05'; E 15°23', altitude: 540 m, 31/05/2007 (G. KRISPER leg.). (2) Hochschwab (Northern Limestone Alps), Fölzalm, coordinates: N 47°36,352'; E 15°11,150', altitude: 1568 m, 27/06/2007 (G. KRISPER leg.).

Breeding: With the sampled adults of *P. kuehnelti* breeding experiments were performed to obtain all juvenile stages for morphological investigation. Cylindrical polystyrol-containers supplied with plaster of Paris were used as breeding boxes and the animals were fed with small pieces of lichens and mosses or thin layers of coccal green algae.

Preparation and microscopic investigation: Juvenile specimens from the offspring were preserved in ethanol (70%). For investigation in transmitted light they were embedded in SWAN-medium (gum-arabic, distilled water, chloral hydrate, glucose, pure acetic acid) or in Berlese mountant. Observations and drawings were made with a differential interference contrast microscope (Olympus BH-2) equipped with a drawing attachment. For SEM-investigations the samples were dehydrated in ascending ethanol concentrations, dried on air and mounted on aluminium-stubs with double sided sticky tape and then sputter-coated with gold. The SEM-micrographs were made at the Research Institute for Electron Microscopy and Fine Structure Research, Graz, University of Technology, with a Zeiss Leo Gemini DSM 982.

RESULTS

Juvenile stages of Provertex kuehnelti – *common features*

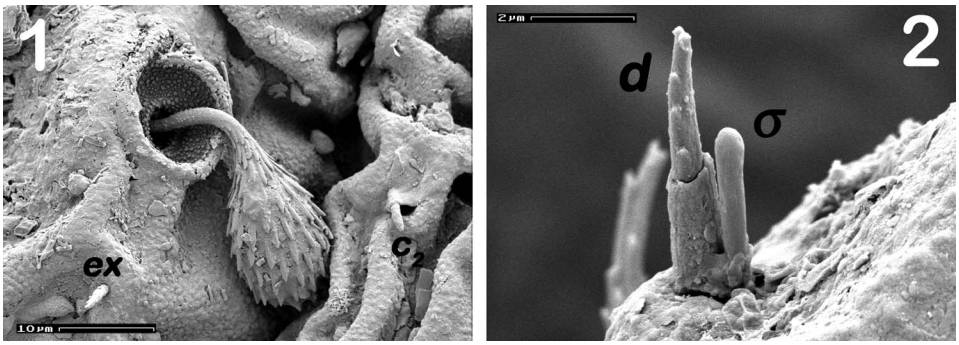
Habitus. Gastronotic cuticle plicate, color ranges from yellowish white to brown. Prodorsum and legs more strongly sclerotised than hysterosomatic region and consequently a bit darker colored. Most setae with a cerotegumental collar.

Prodorsum. Rostral setae simple and long. Interlamellar setae (*in*) short, acute, located between bothridia. Interlamellar setae in every stage longer than lamellar setae. Lamellar setae (*le*) inserted on anterior third of prodorsum, short and acuminate. Exobothridial setae (*ex*) very short. Sensillus (*ss*) spinose and clavate, not flattened. Border of bothridium spiral-like, laterally opened (Fig. 1).

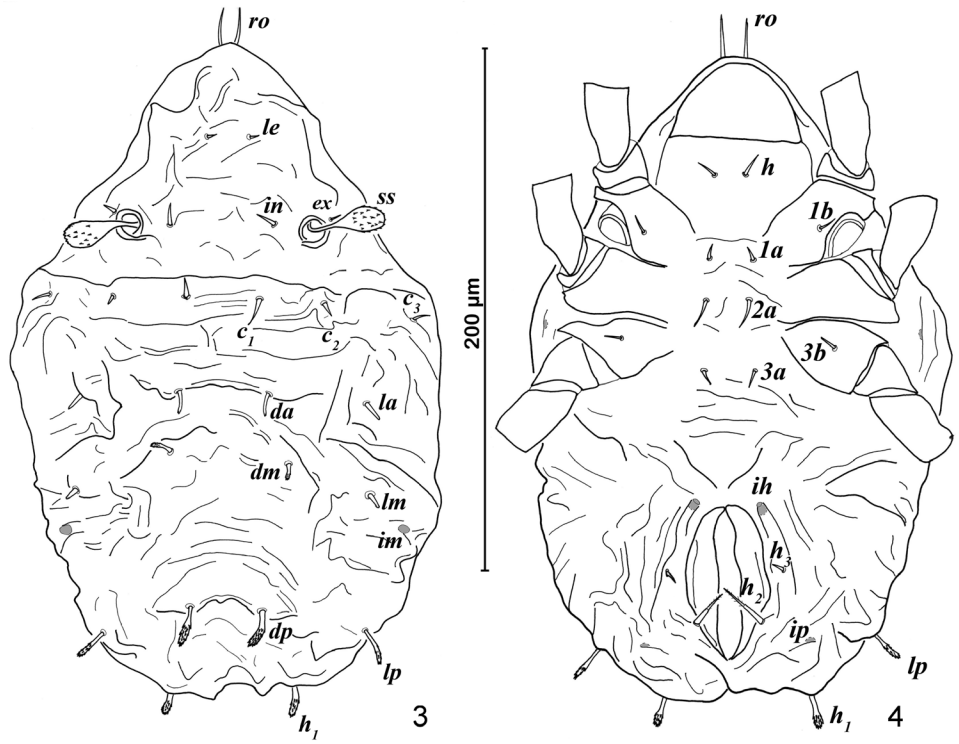
Gastronotic region. Orifice of opisthonotal gland small, reservoir exiguous, to detect difficultly.

Subcapitulum. Diarthric, atelebasic dentate rutella with three teeth; first one spattle-like and twice as large as second one, second tooth triangular and acute, third short and blunt. Pedipalp pentamerous, chaetome 0–2–1–3–9 (solenidion excluded). Top of solenidion ω tangent to eupathidium *acm.*

Legs. Dorsal setae *d* on genu and tibia always associated to solenidia (Fig. 2). Solenidia on tibia I located on a small apophysis. Slightly invaginated porose areas on the ventral paraxial side of each femur.



Figs 1–2. *Provertex kuehnelti*, tritonymph, SEM-Micrographs: 1 = left bothridium, 2 = solenidion σ coupled with seta *d* (genu left leg I)



Figs 3–4. *P. kuehnelti*, larva: 3 = dorsal view, 4 = ventral view

Morphology of larva

Idiosoma. Length (N = 7): 194–255 µm (mean 223 µm)

Gastronotic region (Fig. 3). Twelve pairs of notogastral setae. Setae c_1, c_2 and c_3 short. Setae *da*, *la, lm* slightly thickened and blunt. Setae *dm, dp, lp*, h_1 broadened distally and spinose, whereas seta *dp* is the strongest and seta *dm* the least. Cupula *im* situated posterior to seta *lm*. Cupula *ia* lateral on a level with sejugal furrow.

Ventral region of the idiosoma (Fig. 4). Formula of epimeral setae (I–III): 2–1–2. Setae *1a*, *2a*, *3a* arranged in two median rows. Seta *1b* laterally on epimeron I next to Claparède's organ. Seta *3b* laterally on epimeron III. Porose areas on apodemes 2, sejugal and 3. Seta h_3 short and acuminate, seta h_2 solid, spinose, remarkable long, seta h_1 thickened distally and spinose. Cupula *ih* anterior to anal aperture, cupula *ip* laterally between setae h_2 and h_1.

Legs (Figs 5–7); setation see Table 1.

Morphology of protonymph

Idiosoma. Length (N = 19): 274–322 µm (mean 295 µm)

Gastronotic region (Fig. 8). Fifteen pairs of notogastral setae; ps_1, ps_2 and ps_3 added in this stage. All three setae simple, seta ps_1 short.

Ventral region of idiosoma (Fig. 9). Cupula *ips* located anterior to anal aperture (same place as *ih* in larval stage). Setae ps_3 and ps_2 flanking anal opening. Seta ps_1 short and situated posterior near setae h_2 and h_1. Seta h_2 shaped like seta h_1 in this and the following stages (Fig. 10). Cupula *ih* now located slightly laterally on a level with *ips*. One pair of genital setae present in the middle of genital valves. Epimeral setation (I-IV): 3–1–2–1. Seta *1c* on epimeral plate I close to trochanter. Seta *4b* situated close to posterior margin of epimeron IV.

Legs (Figs 11–14); solenidia and chaetome see Table 1. Porose area on femur IV divided into two deepened parts. From this stage small porose areas on the ventral side of trochanter III and IV.

Morphology of deutonymph

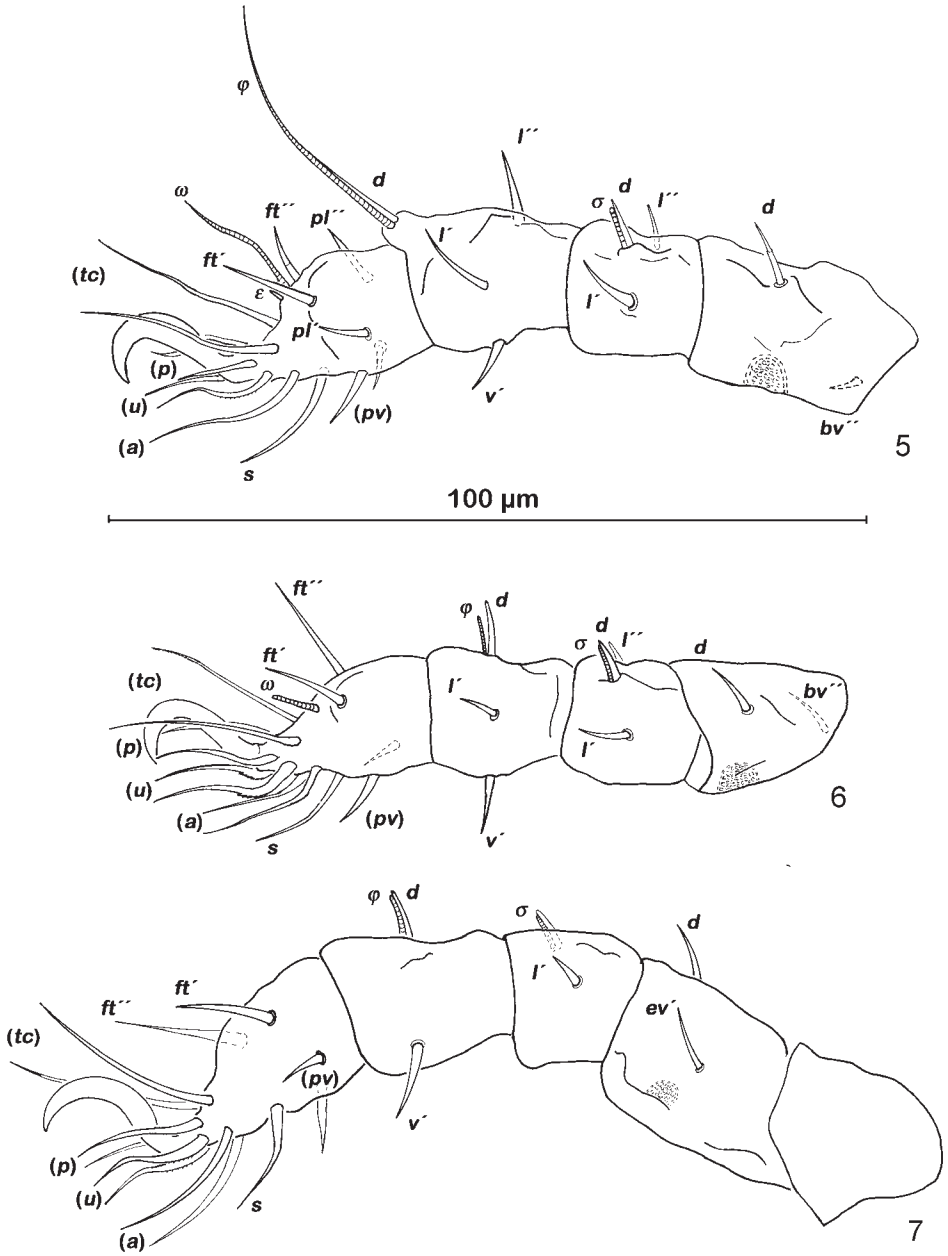
Idiosoma. Length (N = 9): 322–403 µm (mean 367 µm)

Gastronotic region (Fig. 15). Fifteen pairs of notogastral setae. Seta ps_1 thickened and spinose from this stage.

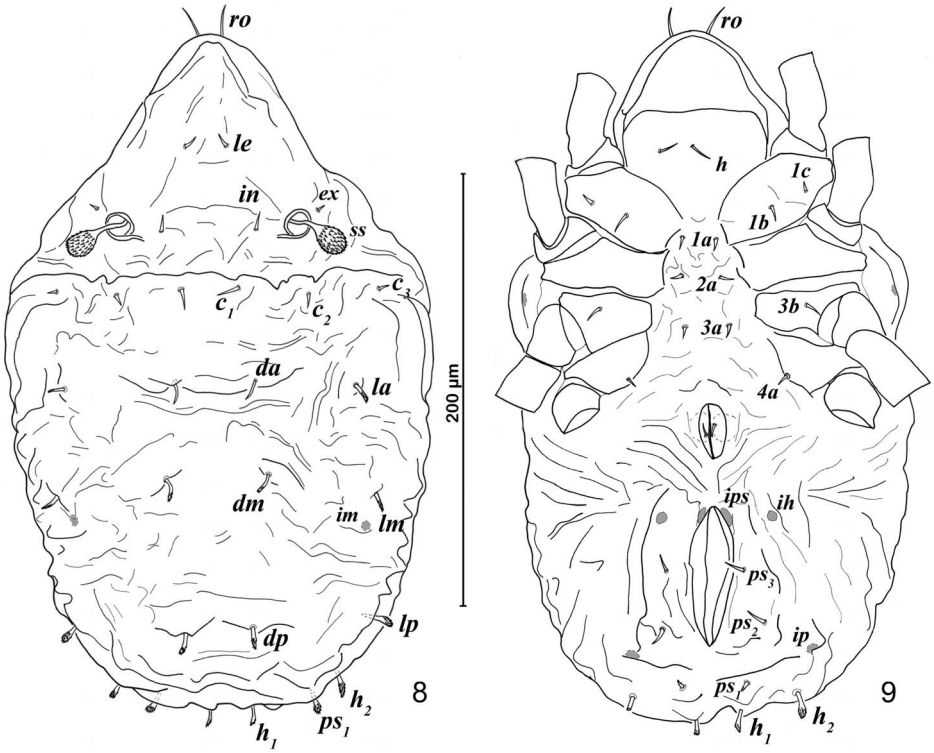
Ventral region of idiosoma (Fig. 16). Adanal setae appearing on paraproctal valves; seta ad_3 in the anterior third, ad_1 and ad_2 located on posterior half of paraproctal valves. Cupula *iad* flanking anal aperture anteriorly (same place as *ips* in

Table 1. Development of setiform organs in *Provertex kuehnelti*. Setae and solenidia are listed opposite the instar in which they appear first; parentheses indicate pairs of setae.

	Instars	Trochanter	Femur	Genu	Tibia	Tarsus	Chaetome	Solenidia
Leg I	Larva		*d, bv''*	*(l), d,* σ	*(l), v', d,* φ_2	*(ft), (tc), (p), (u), s, (a), (pv), (pl),* ε, ω_1	0–2–3–4–16	1–1–1
	Protonymph		–	–	–	ω_2	0–2–3–4–16	1–1–2
	Deutonymph		*(l)*	–	φ_2	–	0–4–3–4–16	1–2–2
	Tritonymph	*v''*	–	*v'*	*v''*	*(it)*	1–4–4–5–18	1–2–2
	Adult	–	–	*d* lost	*d* lost	–	1–4–3–4–18	1–2–2
Leg II	Larva		*d, bv''*	*(l), d,* σ	*l', v', d,* φ	*(ft), (tc), (p), (u), s, (a), (pv),* ω_1	0–2–3–3–13	1–1–1
	Protonymph		–	–	–	–	0–2–3–3–13	1–1–1
	Deutonymph		*(l)*	–	*l''*	ω_2	0–4–3–4–13	1–1–2
	Tritonymph	*v''*	–	*v''*	*v''*	*(it)*	1–4–4–5–15	1–1–2
	Adult	–	–	*d* lost	*d* lost	–	1–4–3–4–15	1–1–2
Leg III	Larva		*d, ev'*	*l', d,* σ	*v', d,* φ	*(ft), (tc), (p), (u), s, (a), (pv)*	0–2–2–2–13	1–1–0
	Protonymph		–	–	–	–	0–2–2–2–13	1–1–0
	Deutonymph	*v''*	–	–	*l'*	–	1–2–2–3–13	1–1–0
	Tritonymph	*l'*	–	–	*l''*	*(it)*	2–2–2–4–15	1–1–0
	Adult	–	–	*d* lost	*d* lost	–	2–2–1–3–15	1–1–0
Leg IV	Protonymph					*ft´´, (p), (u), (pv)*	0–0–0–0–7	0–0–0
	Deutonymph		*d, ev'*	*l', d*	*v, d,* φ	*(tc), s, (a)*	0–2–2–2–12	0–1–0
	Tritonymph	*v'*	–	–	*(l)*	–	1–2–2–4–12	0–1–0
	Adult	–	–	–	*d* lost	–	1–2–2–3–12	0–1–0



Figs 5–7. *P. kuehnelti*, larva, right legs: 5 = leg I paraxial view, 6 = leg II paraxial view, 7 = leg III antiaxial view



Figs 8–9. *P. kuehnelti*, protonymph: 8 = dorsal view, 9 = ventral view

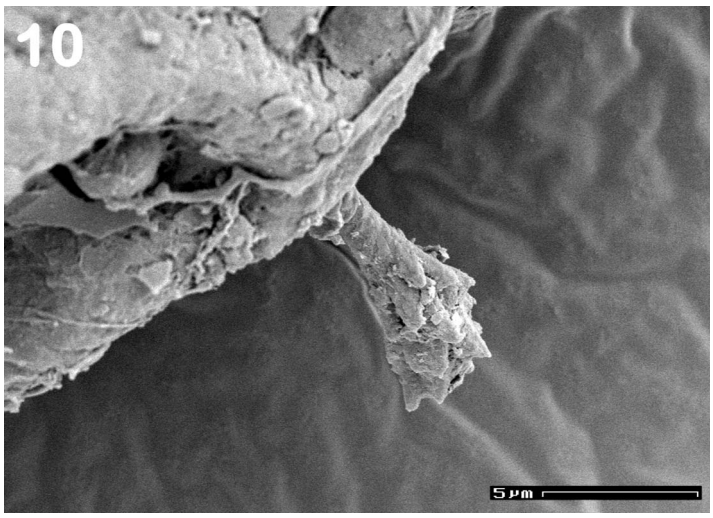
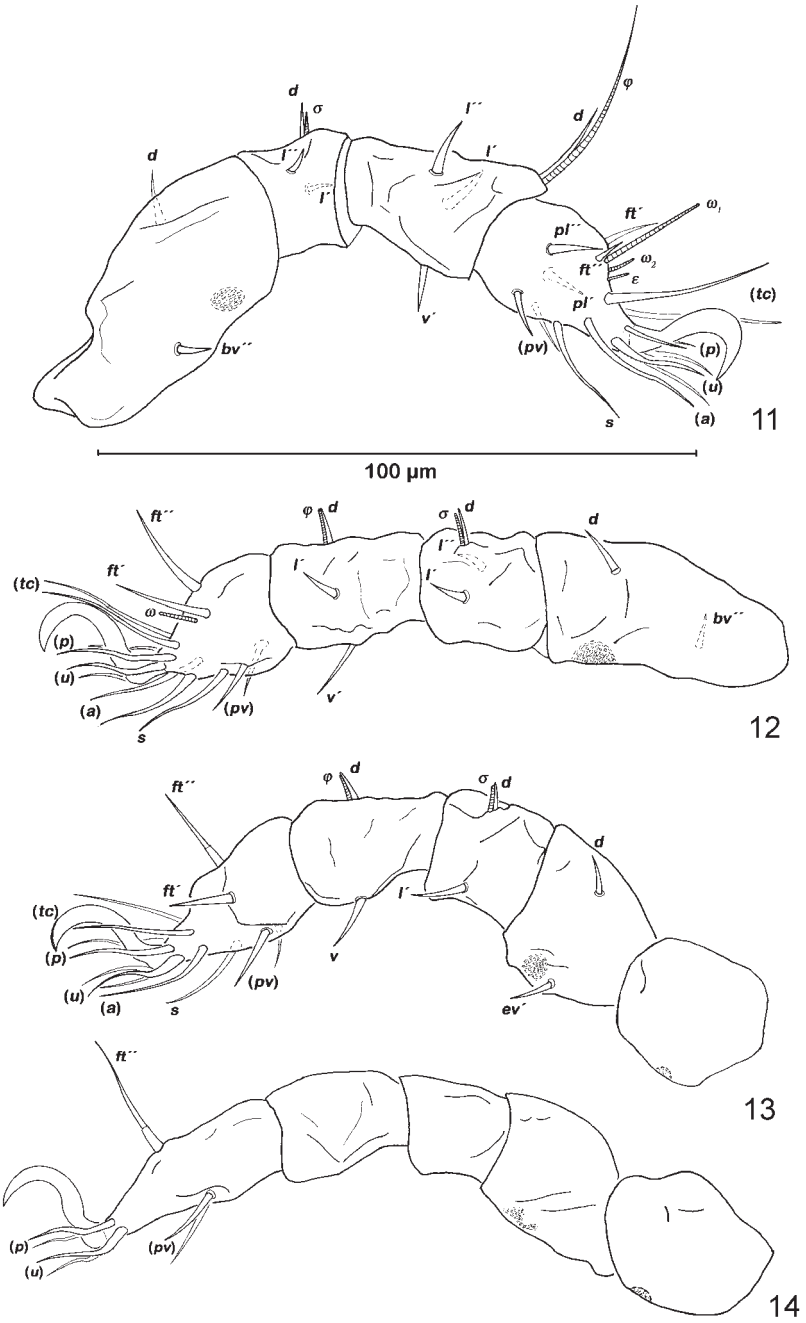


Fig. 10. *P. kuehnelti*, protonymph, SEM-micrograph of notogastral seta h_2



Figs 11–14. *P. kuehnelti*, protonymph, right legs: 11 = leg I antiaxial view, 12 = leg II paraxial view, 13 = leg III antiaxial view, 14 = leg IV antiaxial view

protonymph). Cupulae *ih* and *ips* dislocated laterally. Three pairs of genital setae on genital valves (no variation). One pair of aggenital setae lateral to posterior half of genital opening. Formula of epimeral setation (I–IV): 3–1–2–2.

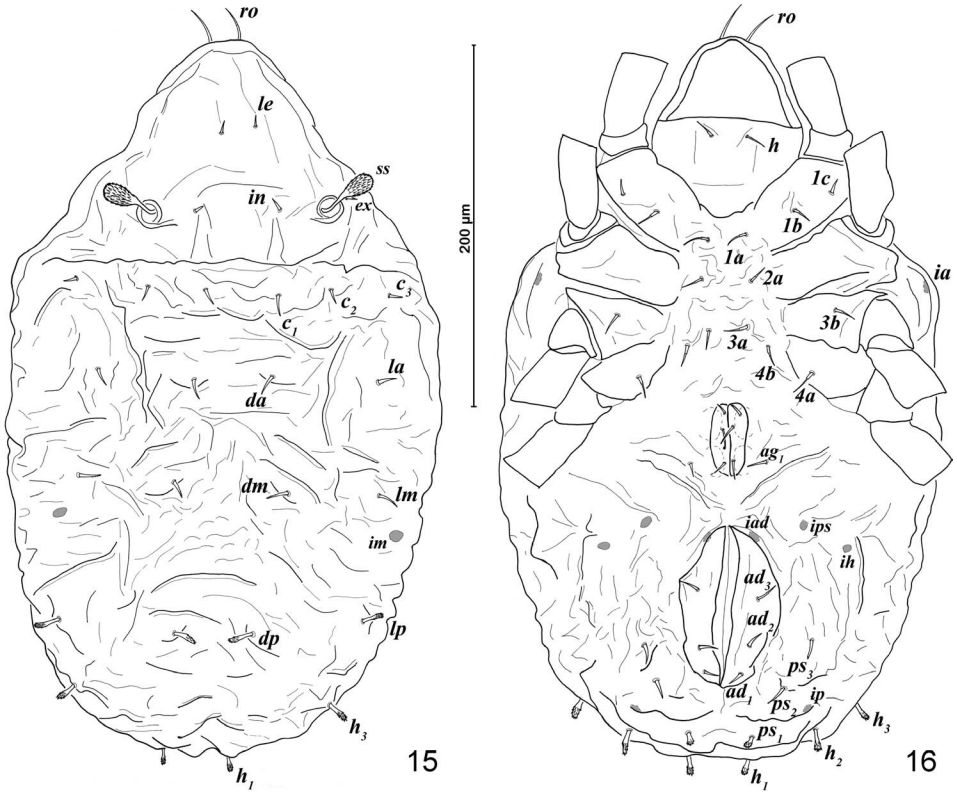
Legs (Figs 17–20); setation see Table 1. Porose areas on femur I–IV more invaginated, building cavities.

Morphology of tritonymph

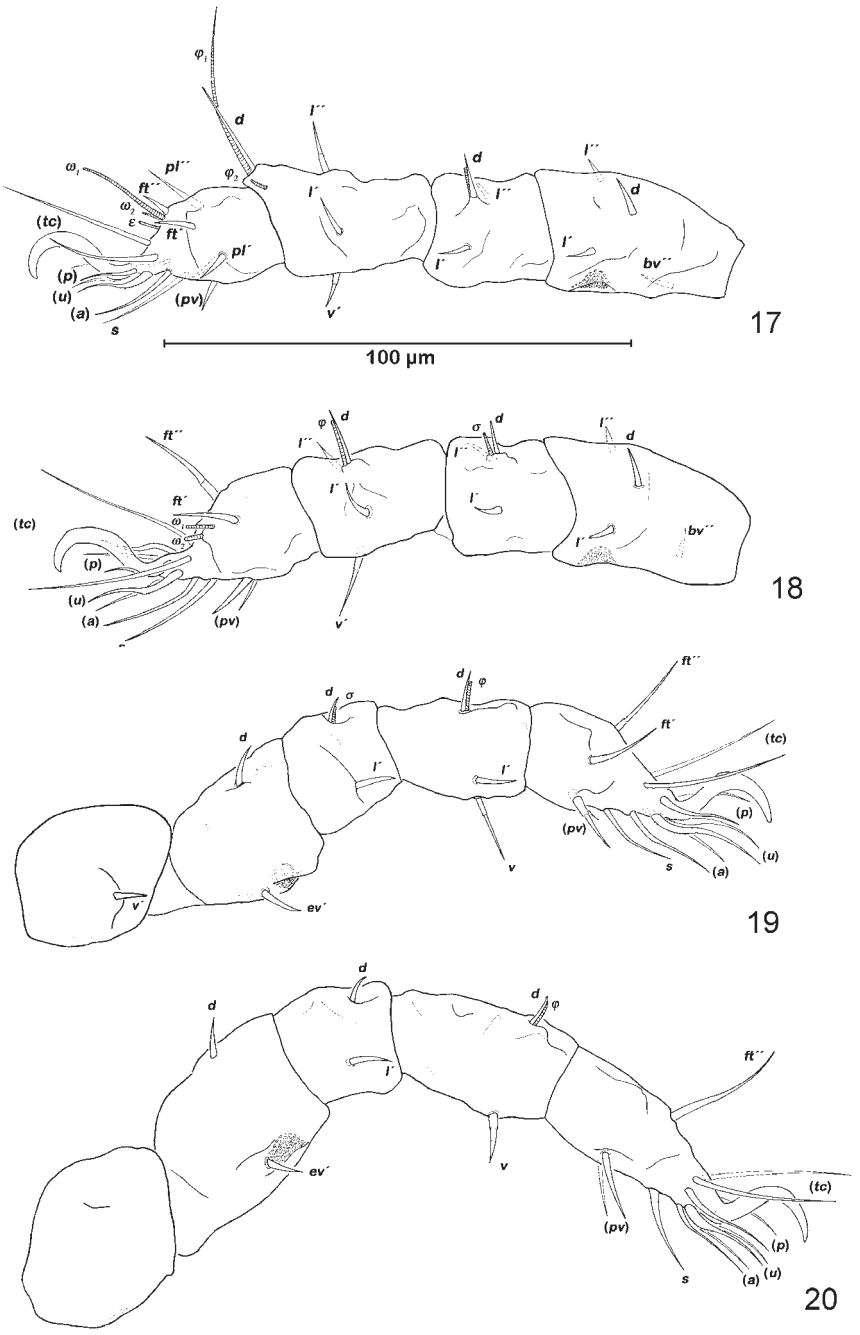
Idiosoma. Length (N = 14): 403–471 μm (mean 443 μm)

Gastronotic region. (Fig. 21) – Fifteen pairs of notogastral setae.

Ventral region of idiosoma (Fig. 22). Two pairs of anal setae appear on anal valves. Seta an_2 next to ad_3 and seta an_1 next to ad_2. Seta ad_1 blunt on top in this stage. Setae ps_3 and ps_2 slightly spinose. Five pairs of genital setae on genital valves (constant). Epimeral setation (I–IV): 3–1–2–2.



Figs 15–16. *P. kuehnelti*, deutonymph: 15 = dorsal view, 16 = ventral view

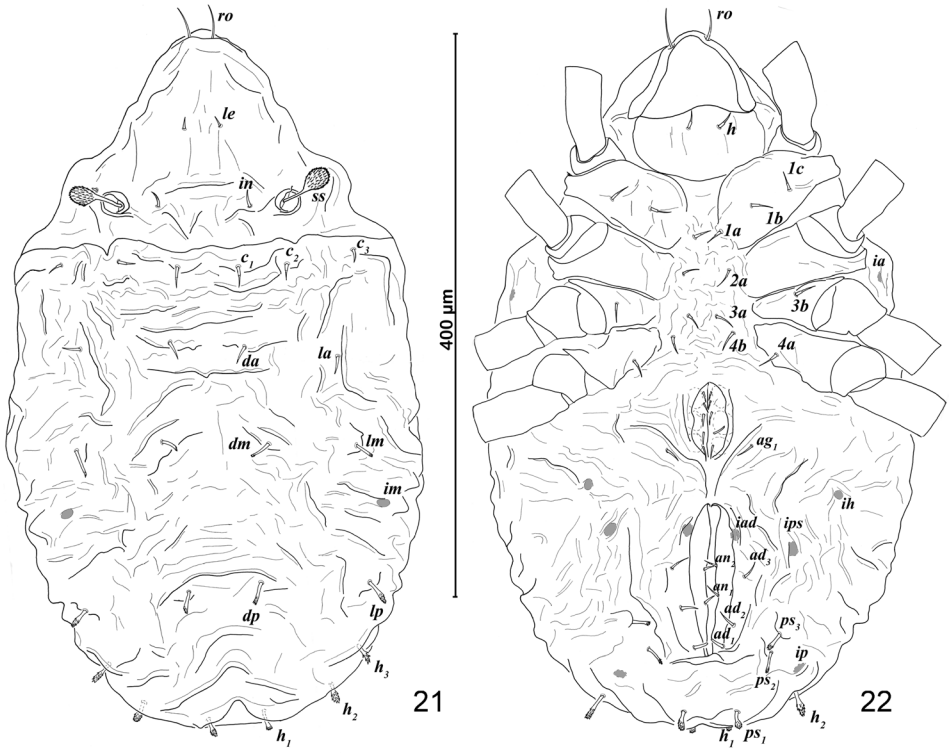


Figs 17–20. *P. kuehnelti*, deutonymph, right legs, paraxial view: 17 = leg I, 18 = leg II, 19 = leg III, 20 = leg IV

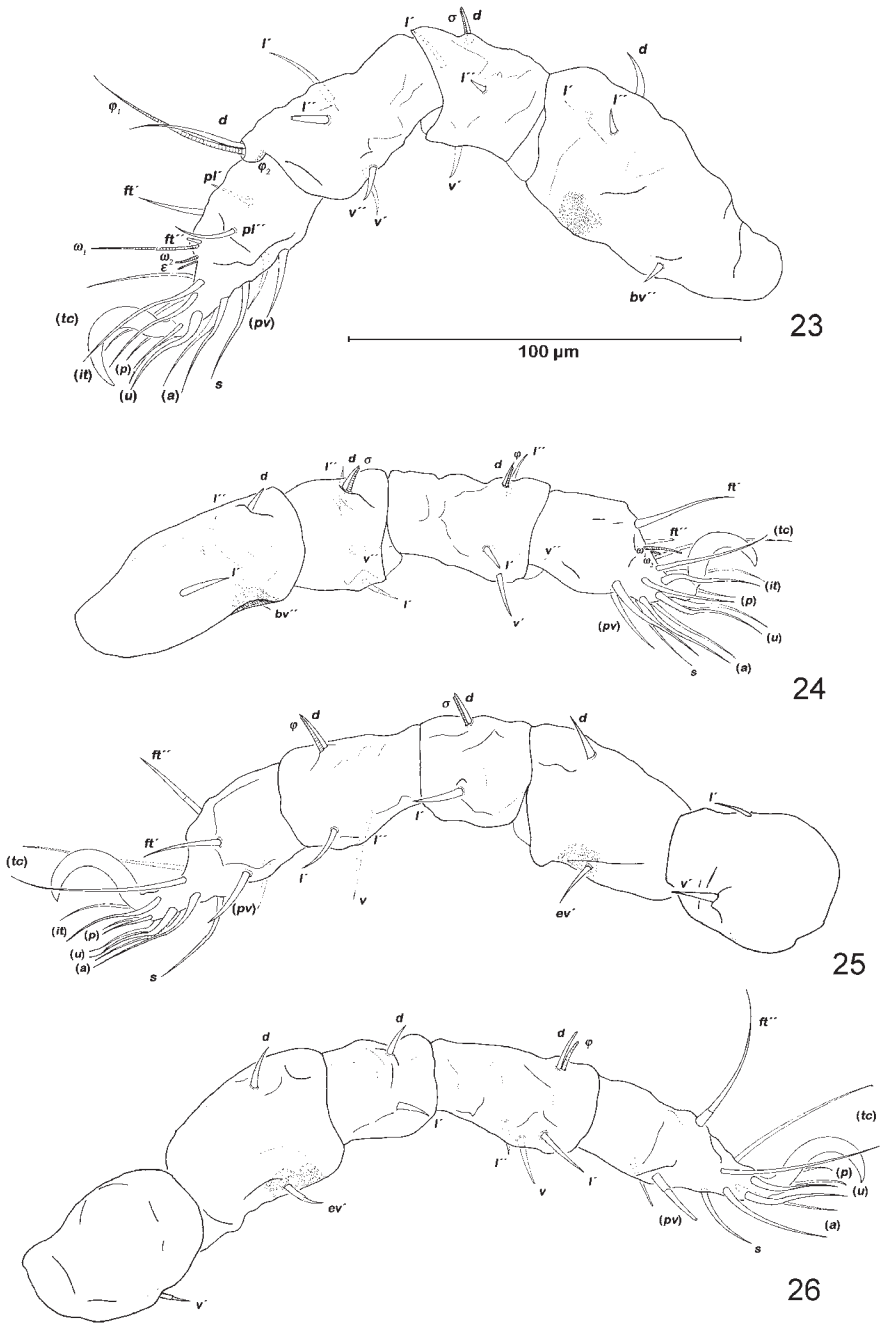
Legs (Figs 23–26); chaetome and solenidia see Table 1. Porose areas on femur I–IV building deep cavities (Fig. 27).

Transformation of characters during development

The larva of *P. kuehnelti* shows spinose, very long and solid seta h_2. The degree of spinosity of this seta is variable from individual to individual. From the protonymphal stage this seta is still spinose and solid but the other setae *h* have now the same appearance. The notogastral setae *dm*, *dp*, *lm*, *lp* maintain the thickened and spinose shape in all juvenile stages, whereas setae c_1, *da* and *la* show a variability in their aspect. The degree of thickness and spinosity of these setae varies from individual to individual. The majority of specimens show simple shaped seta c_1 and slightly broadened setae *da* and *la* with a barely visible spinosity. In a few cases these setae can be shaped like the posterior notogastral setae. Generally there is a tendency to reduce these setae to a simple setal form from larva to tritonymph.



Figs 21–22. *P. kuehnelti*, tritonymph: 21 = dorsal view, 22 = ventral view



Figs 23–26. *P. kuehnelti*, tritonymph, legs: 23 = left leg I antiaxial view, 24 = right leg II antiaxial view, 25 = left leg III paraxial view, 26 = right leg IV paraxial view

In all stages there are invaginated porose areas located distally on the ventral paraxial side of all femora. Already in the larva porose areas appear on the apodemes 2, 3 and on the sejugal apodeme. The solenidia on genu and tibia are always coupled with the dorsal setae *d*, which are reduced in the adult stage.

DISCUSSION

Comparative aspects: A comparison of the juveniles of *P. kuehnelti* is only partially possible with two other *Provertex* species. TRAVÉ (1963) described the immature stages of *P. delamarei* but only sketched a tritonymph in dorsal view. In another paper (1964) he gives a very short report about the morphology of the juveniles of *P. mailloli*. Using this data, the larva and nymphs of *P. delamarei* show in large part conformity with the juveniles of *P. kuehnelti*. The leg chaetome is identical as well as the epimeral, genital, anal and notogastral setation. Looking at the drawing of the tritonymph of *P. delamarei* made by TRAVÉ (1963) the only difference seems to be the shape of the notogastral setae, which are depicted as simple lines. Indeed he mentions in his text that all notogastral setae, especially the posterior ones, are broadened and spinose, but to which extend is unclear. With this information it is not possible to decide if this character is different from *P. kuehnelti*. In his later work TRAVÉ (1964) explains that the only difference between the juveniles of *P. delamarei* and *P. mailloli* are the scarcely spinose posterior notogastral

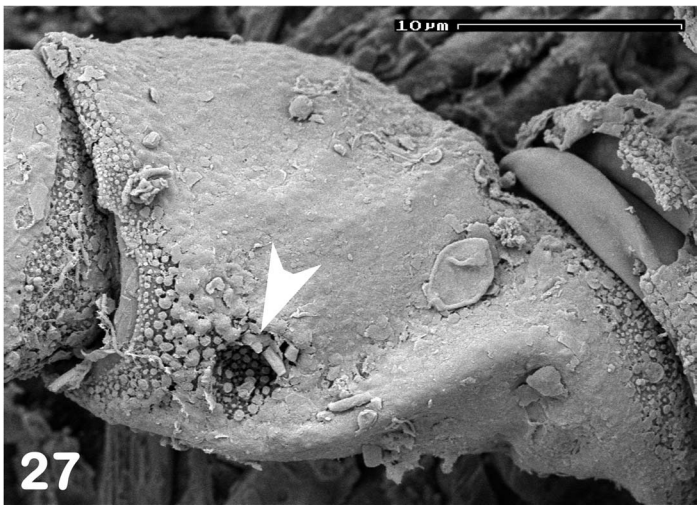


Fig. 27. *P. kuehnelti*, tritonymph, SEM-micrograph: femur IV ventrolateral view, arrow points to porose area covered by cerotegument

setae of *P. mailloli*. So we can assume that *P. mailloli* exhibits also lesser spinose notogastral setae than *P. kuehnelti*. Another difference between the juveniles of *P. mailloli* and *P. kuehnelti* is the body size of each stage. The body lengths of *P. mailloli* given by TRAVÉ (1964) are at an average of 30–50 µm larger than that of *P. kuehnelti*. But this is not a surprising fact, as *P. mailloli* presents the largest of this three mentioned species.

Comparing the juvenile stages of *P. kuehnelti* to the juveniles of *Scutovertex minutus* (SCHÄFFER & KRISPER 2007) and *S. sculptus* (PFINGSTL *et al*. 2008) following differences can be found: *P. kuehnelti* is lacking specifically shaped lateral setae *l* on tibia I, the tibial apophysis is smaller than in *Scutovertex*, the notogastral setae are thickened and spinose whereas the juveniles of both *Scutovertex* species show a simple setal form in this aspect and no opisthonotal glands can be observed in any stage of all *Provertex* species. The chaetome and solenidia on the legs are the same, only *S. sculptus* differs in the number of setae of tibia III in the deutonymph (one seta less). The epimeral, genital and anal formulas are also identical. Both genera exhibit deepened porose areas on the femura of all legs and dorsal setae *d* coupled with solenidia in all juvenile stages. The larval seta h_2 is shaped conspicuously long in *S. minutus* and *S. sculptus*. This is also the case in *P. kuehnelti* but in this species the seta is also spinose. Whether *P. delamarei* and *P. mailloli* possess such extraordinary shaped larval setae h_2 could not be ascertained because TRAVÉ gave no information about this character in his descriptions.

Conclusions – Due to the fragmentary data of the juveniles of *P. delamarei* and *P. mailloli* it is very difficult to define characters representative for the juveniles of the genus of *Provertex*. At the moment we only can state that thickened and more ore less spinose notogastral setae are characteristic for all of these three mentioned *Provertex* species.

The comparison of larva and nymphs of *Provertex* with juveniles of members of the genus *Scutovertex* revealed some characters common to both genera. For example the respiratory organs on the legs, identical numbers of solenidia, with solenidia associated dorsal setae DDC n3 (GRANDJEAN 1953) etc. These facts support the assumption of different authors (GRANDJEAN 1953, TRAVÉ 1963) that *Provertex* is a discrete genus with a close relation to the genus *Scutovertex*. The additional usage of juvenile morphology and developmental characteristics should help to clarify the relationships within the Scutoverticidae in the future.

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Acknowledgements – The authors thank Prof. Dr. F. HOFER, head of the Research Institute for Electron Microscopy (FELMI) and his team for making the SEM-micrographs. This work was supported by the Austrian Science Foundation (FWF, project number P19544-B-16).

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Received July 22, 2009, accepted September 14, 2009, published November 16, 2009