Zootaxa 3619 (3): 201–245
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

http://dx.doi.org/10.11646/zootaxa.3619.3.1
http://zoobank.org/urn:lsid:zoobank.org:pub:B5FD216D-77C7-4354-9DE7-176C75752EED

Morphological analysis of the oribatid mite species *Scutovertex pannonicus* Schuster and description of its juvenile stages (Acari: Oribatida: Scutoverticidae)

ELKE MCCULLOUGH & GÜNTHER KRISPER
Institute of Zoology, Karl-Franzens University, Universitätsplatz 2, A- 8010 Graz, Austria. E-mail: elke99100@yahoo.de

Abstract

This paper provides a detailed redescription of the adult as well as the first morphological description of all juvenile instars (inclusive egg, prelarva and earlier larval stages) of *Scutovertex pannonicus*. The adults are characterized by their relatively large size (692–892 µm), their well developed sharply bordered foveae which are regularly distributed on the whole notogaster, except in the central field and the posterior notogastral brush-like setae ps_1, h_1-h_3. The exochorion of the eggs shows the typical structures for the genus *Scutovertex* like 'mushrooms' and granules with the species-specific expression of the 'mushrooms' and its substructures. The exochorion is covered with an extra thin layer which is typical for this species. The larva and the nymphs can be distinguished from those of *S. sculptus* and *S. minutus* mainly by their lateral setae *l'* and *l"* on tibia I which are strongly serrated and slightly broadened.

Key words: egg, prelarva, biology, development, distribution, taxonomy

Introduction

The oribatid mite species *Scutovertex pannonicus* Schuster, 1958 belongs to the family Scutoverticidae. This species was found for the first time in 1958 in the area of the National Park Neusiedlersee–Seewinkel, the eastern, Pannonian part of Burgenland which is the only place in Austria where this strongly salt tolerant (halophilous) species occurs together with the strong halophyte *Lepidium cartilagineum*. Some individuals of *S. pannonicus* were sometimes even found on the salt influenced raw areas (Schuster 1959). In the family Scutoverticidae only few species show a distribution in saline habitats, like for example *S. arenocolus* Pfingstl and Schäffer, 2009 from the German Baltic coast or *S. pilosetosus* Poldermann, 1977 from the North Sea coast. The scope of this work is to complete the description of morphological characters of the adults of *S. pannonicus* (e.g. details of legs and subcapitulum) as well as to describe the egg and all juvenile stages of this species.

Material and methods

Mite collection. Samples were taken from the soil surface and up to a depth of two to five centimetres, and were left for extraction in Berlese–Tullgren funnels for five to seven days. The samples were collected in the zone around the soda pools with more or less salty soil. Collection sites: a) Lake Illmitzer Zicklacke: south / west shore with the soda pool only a few meters away; salt steppe area; with *Artemisia sántonicum*, *Aster tripolium ssp. pannonicum*, moss between bulked grass, sand; N 47 45,914', E 16 46,885'; 18/09/2006, 13/10/2006, 27/03/2007, 30/09/2008. b) Lake Oberer Stinker (next to the locus typicus): to the west of the trail; small elevation with vegetation in the middle of a soda pool; with *Artemisia sántonicum*, *Lepidium cartilagineum* and moss very close together, sand; N 47 49,127', E 16 47,495'; 18/09/2006, 13/10/2006, 27/03/2007, 03/11/2007, 30/09/2008. c) Lake Lange Lacke: to the west of the cattle watering place with the soda pool 20 to 30 meters further away; salt steppe area; with *Artemisia sántonicum*, moss, grass; N 47 45,468', E 16 52,149'; 18/09/2006, 13/10/2006, 27/03/2007.

Accepted by H. Schatz: 17 Dec. 2012; published: 28 Feb. 2013

Types and reference material. The holotype is deposited in the Senckenberg Museum Frankfurt (SMF no. 17141) (see Schuster 1997). Paratypes (two microscopic slides at that time made by R. Schuster) from the collection of R. Schuster are deposited now in the Senckenberg Museum für Naturkunde Görlitz (SMNG): Microscopic slide one (Coll.-no. 55/47322) contains three adults and one separate notogaster, specimens from locus typicus = locality 'A' in fig. 1 Schuster 1959. Microscopic slide two (Coll.-no. 55/47323) with dissected parts under two coverslips; specimens from locality 'K' in fig. 1 Schuster 1959).

Specimens collected by the authors, are stored in ethanol (adults; SMNG Coll.-no. 06/47325) or prepared as microscopic slides (juveniles; SMNG Coll.-no. 07/47324).

Breeding. Breeding was necessary to exclude the possibility having not *S. pannonicus* juveniles because sundry *Scutovertex* species have similar looking juvenile instars. For obtaining all juvenile stages of *S. pannonicus*, adults were kept in cylindrical polystyrene containers supplied with plaster of Paris used as breeding boxes. The animals were fed on collected substrate such as pieces from moss but mainly on some coccal green algae.

Preparation, observation and drawing. All specimens were preserved in small tubes filled with ethanol (70%). For investigations in transmitted light the material was mainly embedded in HOYER's medium (gum-arabic, distilled water, glycerine, chloral hydrate). On a heater and in the desiccator permanent slides were dried for several weeks. Ringing with 'Glyptal 1201 Red Enamel' followed. Lactic acid was used as clearing agent as well as for the study of specimens in cavity slides. Observations and measurements were made with a differential interference contrast microscope (Reichert Diavar) as well as with a stereo microscope (Leica Wild M8). For drawings a differential interference contrast microscope was used equipped with a drawing tube. For detailed drawings (e.g. pedipalps, chelicerae, and genital organs) some of the individuals had to be totally broken apart with two dissection pins. The attention at the investigations lay mainly on the external morphology. Inner anatomy was left out only the ovipositor and spermatopositor were studied. As far as possible the sexes were determined. Abbreviations used see table 1.

LM-micrographs from specimens in slides or lactic acid in the microscope were taken with a digital camera Olympus 700. For SEM-investigations the specimens were dehydrated in ascending ethanol concentrations, dried on air, mounted on aluminium-stubs with double sided sticky tape, and then sputter-coated with gold. The SEM-micrographs were taken at the Research Institute for Electron Microscopy and Fine Structure Research, Graz, University of Technology using a Zeiss Leo Gemini DSM 982.

TABLE 1. *Scutovertex pannonicus*; List of abbreviations (in alphabetical order within section); Note: Abbreviations which concern larger body regions written in capital letters, like notogaster = NG. Other parts not being setae, solenidia, lyrifissures and cupules are written in capital and small letters, like sensillus = Ss. Setae, solenidia, lyrifissures and cupules only in small letters.

Stages					
LA	larva	DN	deutonymph		
PN	protonymph	TN	tritonymph		
General dorsal, ventral, and internal structures					
ad $_{1-3}$	adanal setae	g_{1-6}	genital setae	*Pd I*	pedotectum I
Ad	adanal segment	*Gla*	opisthonotal gland	*Pd II*	pedotectum II
ag_1	agenital seta	Gp_{1-3}	genital papillae	*PD*	prodorsum
Apo	apodeme	*Gpl*	genital plate	*Po*	porose area
Apo.sj.	sejugal apodeme	*in*	interlamellar seta	*Ps*	pseudanal segment
an_{1-2}	anal setae	*ia, im,ip, ih, ips*	notogastral lyrifissures	*Ri*	ribbed ring structure
An	anal segment	*iad*	adanal lyrifissure	*ro*	rostral seta
Bo	bothridium	*kd, kv, kl*	eugenital setae of ovipositor - tube	*Sac*	sac-like structure
c $_{2-3}$*, la, dm, lm dp, lp,* $h_{1-3,}ps_{1-3}$	notogastral setae	*Lam*	lamella	S_{1-3}	sacculi

.....continued on the next page

TABLE 1. (Continued)

Cl	claparede's organ	*le*	lamellar seta	*Ss*	sensillus
Csp	cuspis	*Len*	lenticulus	*Trl*	translamella
Ep_{I-IV}	epimera	*Lf*	preanal apodeme	*1a, 1b, 1c, 2a, 3a, 3b, 4a, 4b*	epimeral setae
euL_{I-III}	eugenital lobes	*Ms*	muscle sigilla	psi_1, $psi_{2,}$ $tau_{1,}$ tau_{a-c}	eugenital setae of ovipositor - lobes
ex	exobothridial setae	*NG*	notogaster	psi_1, $psi_{2,}$ tau_{1-4}	eugenital setae of spermatopositor
Egg, prelarva, and early larval stage					
Clp	claparede's organ	*Gr*	granulae	*Pi*	pigmented cell
Enc	endochorion	*K*	'egg tooth'		
Exc	exochorion	*Lg*	laterofrontal groove		
Legs					
a	anterolateral seta	*ita*	lyriffisure tarsus I	*Tro*	trochanter
AcI-IV	acetabula	*Mcl*	main claw	*u*	unguinal seta
Acl	adjacent claw	*p*	proral seta	*v*	ventral seta
d	dorsal seta	*pl*	posterolateral seta	ε	famulus tarsus I
ft	fastigial seta	*pv*	primiventral seta	σ	solenidion genu
it	iteral seta	*s*	subunguinal seta	φ	solenidion tibia
l	lateral seta	*tc*	tectal seta	ω	solenidion tarsus
LI-IV	leg I-IV	*Tr*	trachea	***⊿co***	condylus
Pedipalpus					
acm	anteroculminal seta	*e*	epine – supracoxal seta	*sul*	subultimal seta
As	axillary saccule	*lt*	lateral setae tarsus I	*ul*	ultimal seta
cm	culminal seta	*ita*	lyrifissure - tarsus	ω	solenidion - tarsus
cmp	posteroculminal seta	*Pdp*	pedipalpus	***⊿co***	condylus
Subcapitulum					
a	anterior genal seta	*H*	mentum (hypostome)	*Oe*	oesophagus
Ac	capitular apodeme	*L*	lateral lip	*Og*	opening subcapitular gland
Br	rutellar brush	*LS*	labrum – upper lip	*or*	adoral seta
Cpc	podocephalic canal	*m*	median genal seta	*Phx*	pharynx
G	gena	*Mn*	mental tectum	*Po.ma.*	manubrial porose area
h	setae of mentum	*Mnt*	mentotectum	*Ru*	rutellum
Chelicera					
Ch	chelicera	*En*	cheliceral sheath attachment	*Trg*	Trägårdh's organ
cha	posterior seta	*D.f.*	fixed digit	***⊿co***	condylus
chb	anterior seta	*D.m.*	mobile digit		

Results

Due to breeding a description of eggs was obvious and one prelarval stage as well as three different developmental levels of the larva could be detected.

Egg and first description of the juvenile instars

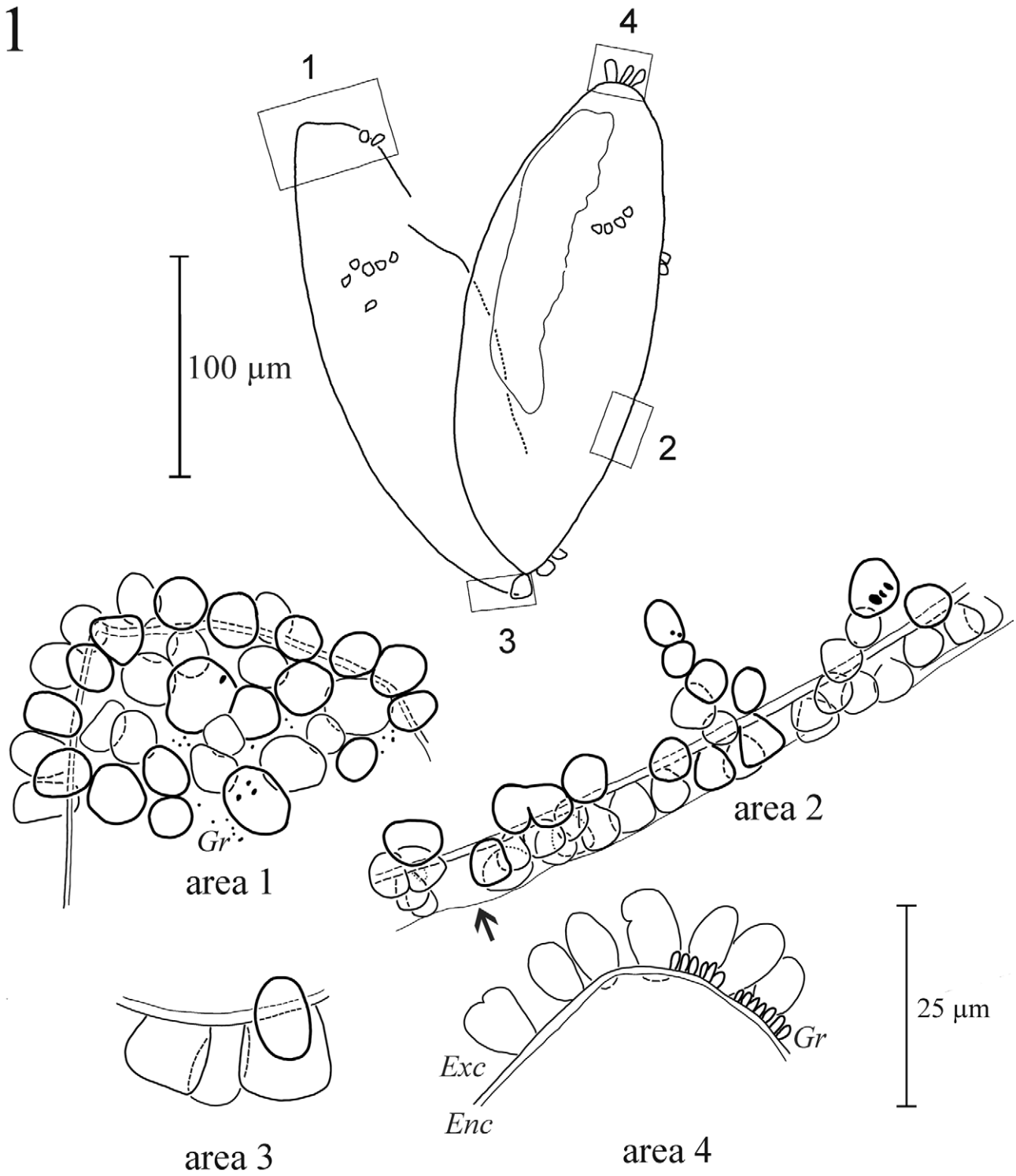
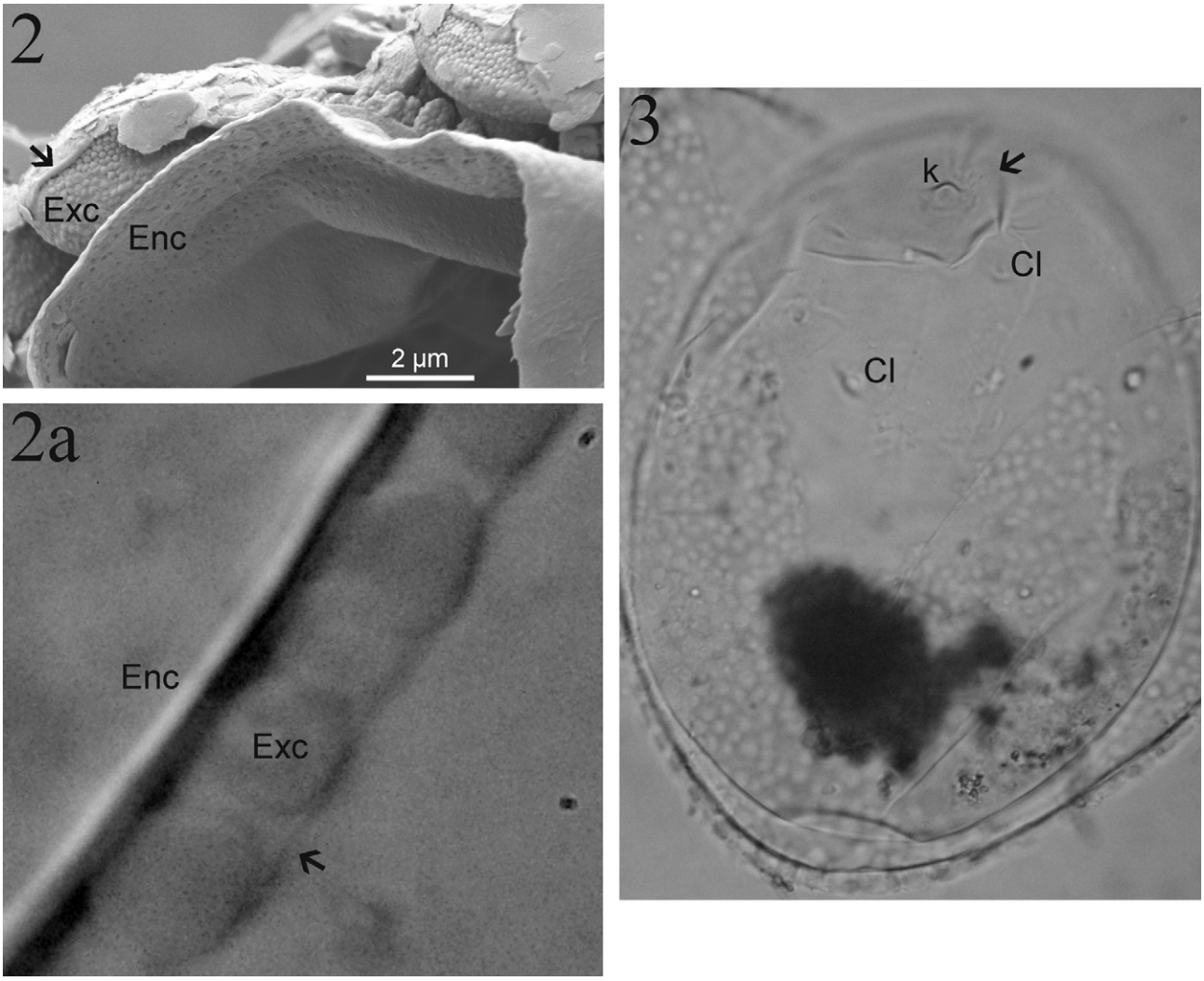


FIGURE 1. *Scutovertex pannonicu*s egg. Upper drawing overview of egg-shell. Area 1–4 details of different parts from the overview. Arrow indicates to external thin layer on exochorion.

Egg. Total length. With exochorion layer (n=7): 236–295 µm (mean 272 µm). Without exochorion layer: 220–273 µm (mean 256 µm). Measured from egg-pole to egg-pole. **Habitus.** Eggs oval (fig. 1) and white coloured, turning from light orange / yellowish into dark brown before the hatch of larva. Egg-shell consists of three layers: endochorion (inner layer), exochorion (outer mushroom-like layer), and an external thin layer covering the exochorion (figs. 2, 2a). Exochorion with two different types of formations: raspberry-like or globular granules

(*Gr*) and ‘mushrooms’ (figs. 1-area 4, 2). Granules seem to be composed of several small pellets. Shaft of ‘mushrooms’ short and broadened; broadened cap with slightly conical, rounded, sometimes triangular or quadrangular outline. Additionally ‘mushrooms’ show a substructure: an even layer of densely packed granules.

Prelarva. Habitus. Prelarval stage (covered by egg shell) only documented with photomicrographs (fig. 3). Clearly visible one of the two typical ‘egg-teeth’, a pair of claparède organs, and laterofrontal groove. At posterior part of hysterosoma a dark coloured enclosure occurs.



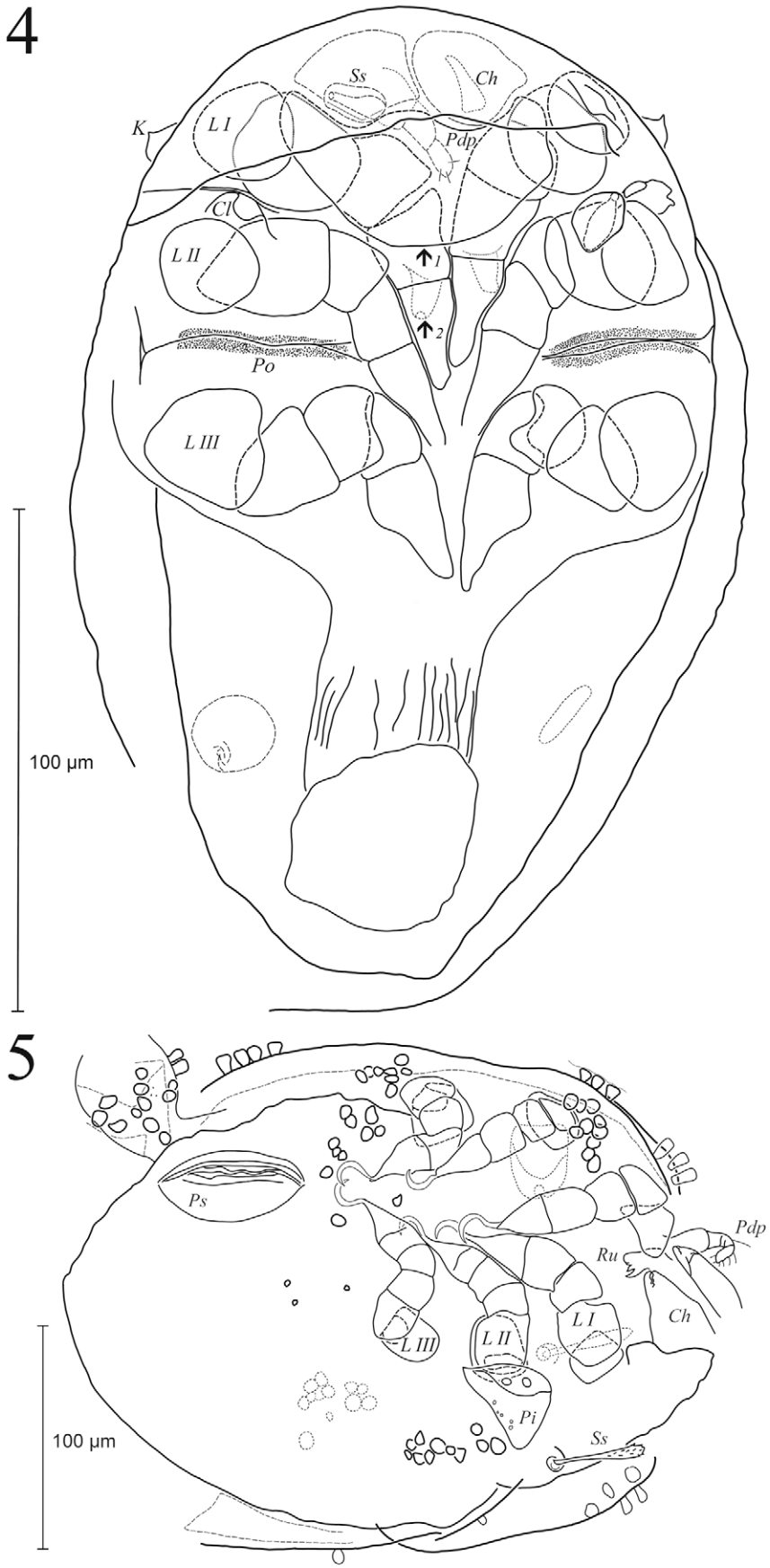
FIGURES 2, 2a, 3. *S. pannonicu*s egg-shell and prelarva. **2**, **2a**, detail of egg shell with endochorion Enc), exochorion (Exc), and thin layer on exochorion (arrow); 2 = SEM, 2a = transmitted light. **3**, prelarva with one ‘egg-tooth’ (k), claparèd’s organ (Cl) and laterofrontal groove (arrow); transmitted light.

Larval development (Stages covered by egg shell)

Earlier stage:

Length. Body length (n=1): 186 µm.

Habitus (fig. 4). Already similar to larva. Three well developed legs, a pair of opisthonotal glands, cuticle porose in the area of apodemes, a pair of claparède organs between basis of leg I and II, and ‘egg-teeth’. Mentum, pedipalps and chelicerae already well developed. Sensilli very small, clavate, and enclosed by a thin membrane. Dark coloured enclosure in same position as in prelarva.



FIGURES 4–5. *S. pannonicu*s larva. Ventral view. **4**, early stage within egg shell; enclosed sensillus (*Ss*) (arrow), mentum (arrow 1), tibial cone (arrow 2), no setae and claws drawn. **5**, later stage within egg shell; with 'pigmented cell' (*Pi*); oil glands and claparèd's organ in this slide not detectable, no setae drawn.

Later stage:

Length. Body length (n=1): 202 µm.

Habitus (fig. 5)**.** Sensillus as in hatching larva and pseudanal segment well visible. One pair of big 'pigmented cells' (fig. 5a), near the basis of leg II.

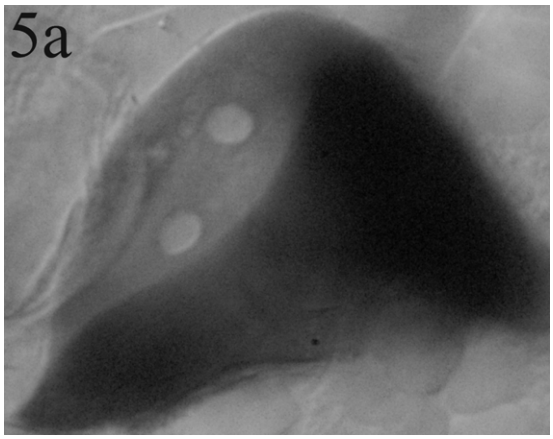


FIGURE 5a. *S. pannonicus* larva. **5a**, 'pigmented cell' of later stage within egg shell; transmitted light.

Common features in all juvenile instars

Fully developed larva, proto, deuto- and tritonymphs generally similar in their appearance and vary just in measurements and setation numbers due to their postembryonic stages.

Habitus. Cuticle of gastronotic- and anogenital region strongly, remaining regions much weaker plicate and slightly granulated. Colour changes from larva to tritonymph from light yellowish brown to grey-brown with silvery glimmer. Legs, epimeral region, and prodorsum more sclerotized regions and a little darker coloured. Most of setae with cerotegumental collar around their base. Some setae serrate.

Prodorsum. Rostral setae spiniform-serrate and straight forwarded with tendency being slightly curved inwards in later stages. Lamellar setae (*le*) short and acute situated at anterior half of prodorsum. Interlamellar setae (*in*) shorter than *le*, acute, inserting between bothridia. Exobothridial setae acute, short approximately as *in*, antiaxial of bothridia. Sensilli (fig. 6) clavate, distally slightly thickened, covered with more or less longish, distally rounded platelets; in permanent slides these looking spinose in lateral view. Proximal part of setal shaft, before entering the bothridium without platelets. Bothridium spiral-like, border laterally open. Thin arc-shaped lamellae divide the bothridium into several chambers. Outer chambers provided with granulated cerotegument. Setal base is S-shaped leading into a sac-like structure. One of inner chambers is a ribbed ring-structure surrounding the seta. Lamellae and translamella weakly developed as small ridges, becoming more distinct with proceeding stages.

Gastronotic region. Setae acute and short. Cupules disk-like.

Subcapitulum. Diarthric. Setae of mentum short and acute. A pair of rutella, lateral lips, upper lip, and pedipalps with two condyles between femur and trochanter. On basis of palps one axillary saccule on axial and one epine (not so well developed as in adult) on antiaxial side (fig. 7).

Ventral region of idiosoma. Porose areas in the area of apodeme I–IV and of the sejugal apodeme. Epimeral setae short and acute. Postero-laterally one pair of opisthonotal glands, filled with red secretion well visible in living individuals; orifice mostly well discernable. Cupules disk-like. Setae short and acute.

Legs. Monodactylous. General appearance snaggy, with lots of ridges, and granulated cerotegument mostly detached. In the middle of tarsus I transverse ridge and approximately on dorsal-axial side one lyrifissure. Tibia I distally with tibial cone. All legs with two condyles each between femur and trochanter as well as between trochanter and epimeron. No tracheae but on the ventral axial side in distal half of the femur a porose area in all nymphal instars. Most of setae with cerotegumental collar around their base and most of them serrate, in any case the setae of tibia and tarsus. Lateral setae of tibia I remarkable different; setae *l'* and *l"* strongly serrate and thicker and stronger developed than the other setae but still longish in shape.

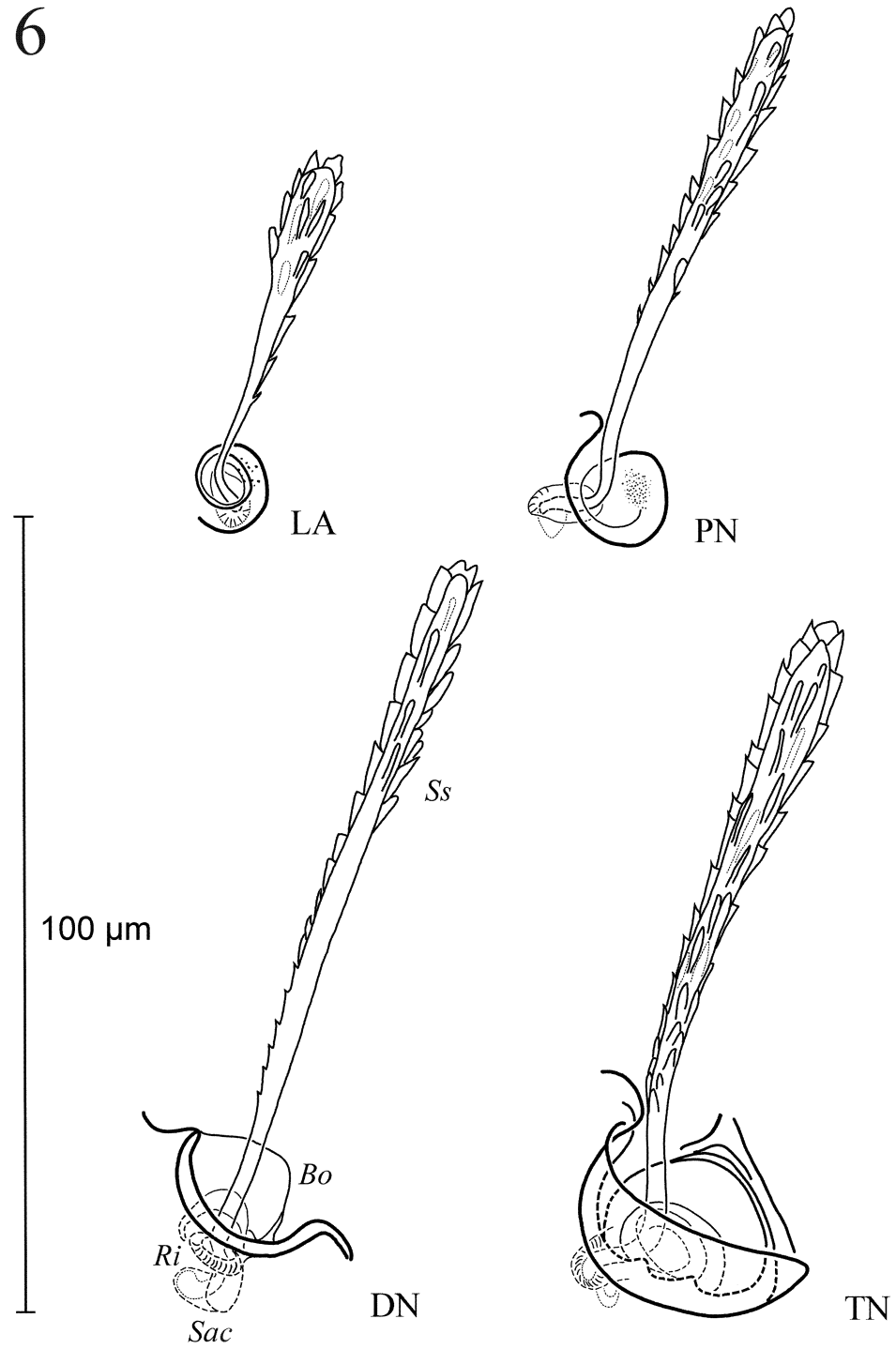


FIGURE 6. *S. pannonicus* juveniles. Sensillus and bothridium in detail from larval to tritonymphal stage.

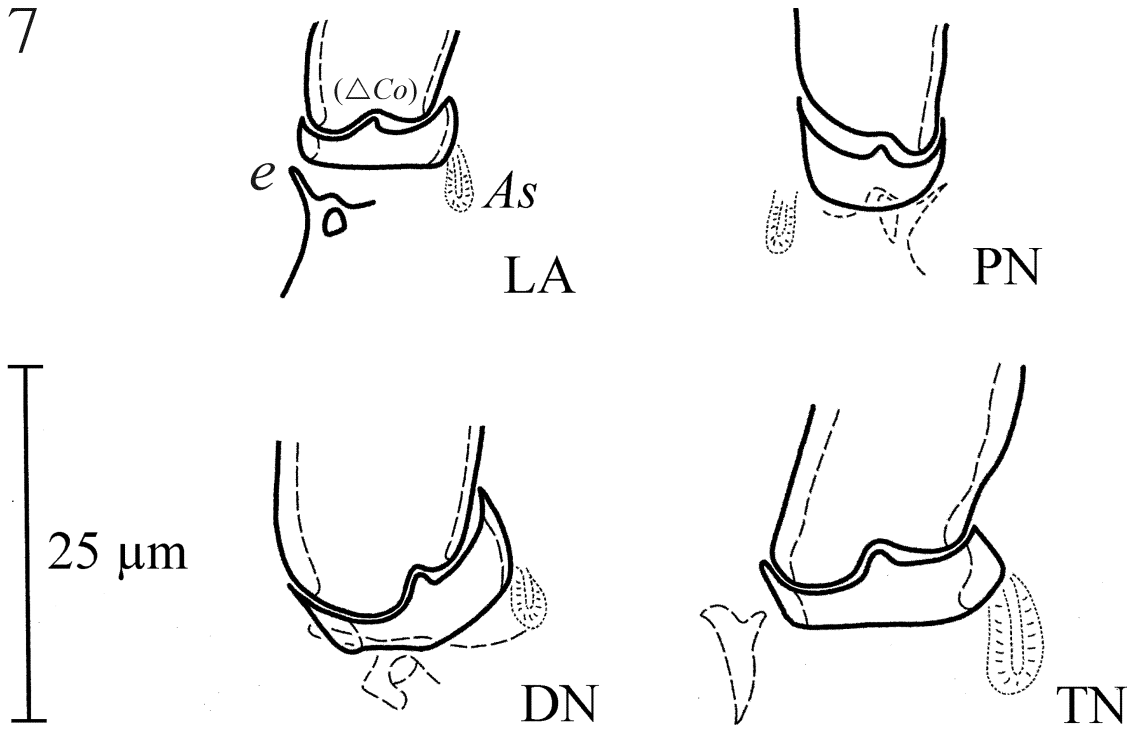


FIGURE 7. *S. pannonicu*s juveniles. Basis of pedipalp in detail with trochanteral-femoral joint from larval to tritonymphal stage.

Larva

Idiosoma. Body length (n=4): 248–267 µm (mean 254 µm).

Gastronotic region (fig. 8)**.** 12 pairs of notogastral setae, $c_{1\text{-}3}$, *da, dm, dp, la, lm, lp,* $h_{1\text{-}3}$. Setae h_2 and h_3 only visible on ventral side. Setae generally situated on bumps, setae c_1, *da, dm, dp*, and h_1 on very well developed ones. Cupule *ia* laterally from seta c_3 positioned on level of sejugal furrow, *im* between seta *lm* and *lp* but more close to *lm*. Cupules *ih* and *ip* only visible on ventral side. Setae drawn in detail in fig. 8a.

Anogenital region (fig. 9)**.** Paraproctal segment formed as pseudanal segment. Gastronotic setae h_2 and h_3 situated laterally on the posterior half of pseudanal segment. Setae h_2 remarkable long and thick. Cupule *ih* located on the anterior edge of pseudanal segment. Cupule *ip* is placed laterally between setae h_2 and h_1. Setae drawn in detail in fig. 9a.

Epimeral region (fig. 9)**.** 6 pairs of setae *1a, 1b, 1c* (= scaliform seta of clapared's organ, see Norton et al. 1996), *2a, 3a, 3b* – formula 3-1-2; *1a, 2a,* and *3a* located median. *1b* situated in the middle of epimeron I near claparede's organ and *3b* in the middle of epimeron III. Setae drawn in detail in fig. 9a.

Legs (figs. 10–12)**.** Setation see table 2. Setae drawn in detail in figs. 10a, 10b, 11a.

Protonymph

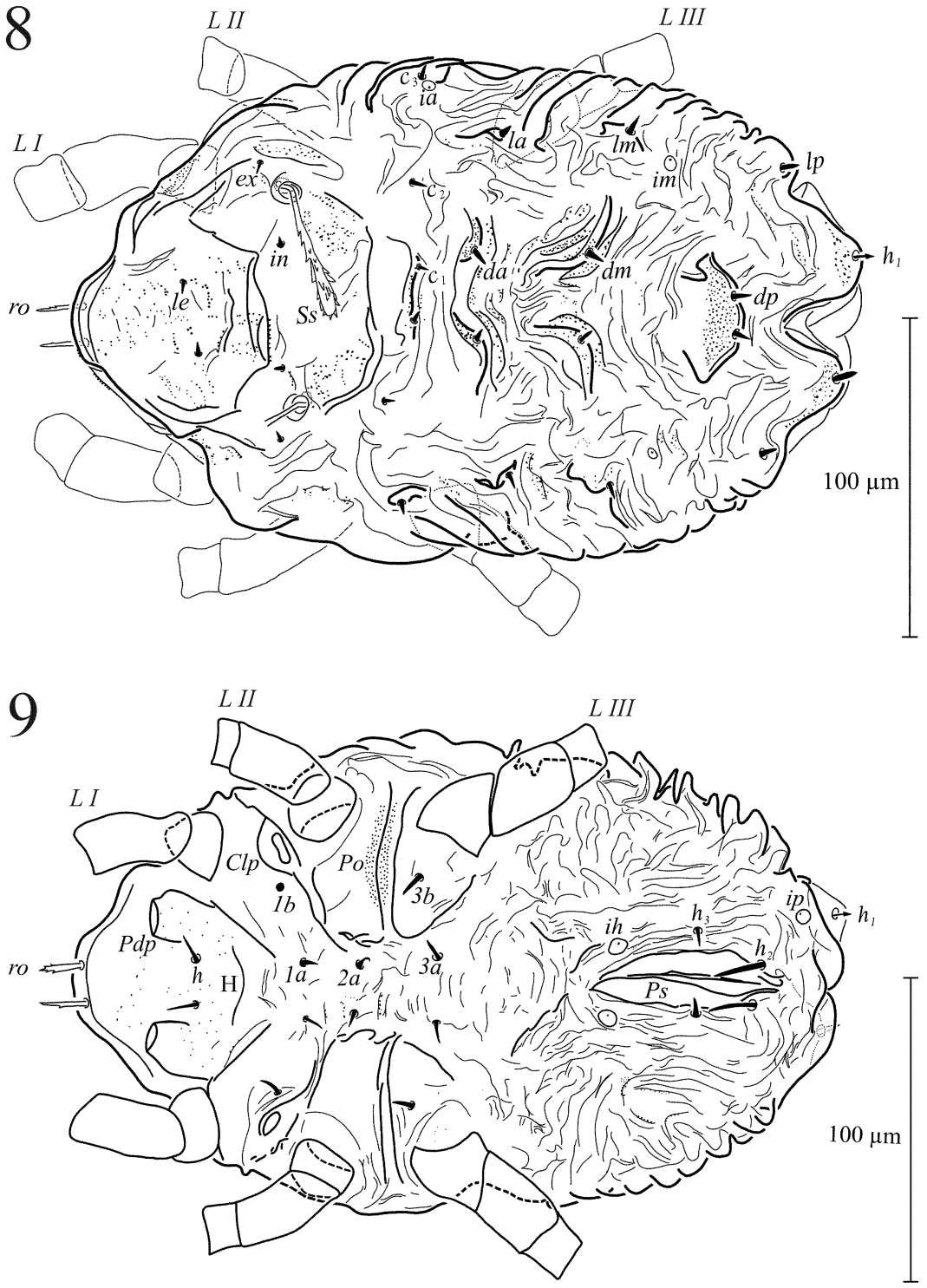
Idiosoma. Body length (n=5): 346–440 µm (mean 390 µm).

Gastronotic region (fig. 13)**.** 15 pairs of notogastral setae, $c_{1\text{-}3}$, *da, dm, dp, la, lm, lp,* $h_{1\text{-}3}$ and $ps_{1\text{-}3}$. Setae $ps_{1\text{-}3}$ only visible on the ventral side. Setae on bumps like in larva. Cupule *ia* and *im* in same position as in larva. Cupules *ih, ip* and *ips* located ventrally. Setae drawn in detail in fig. 13a.

Anogenital region (fig. 14)**.** Genital valves with one pair of genital setae, one pair of genital papillae. Also adanal - paraproctal segment added in this stage. Gastronotic setae ps_2 and ps_3 situated laterally on more or less posterior half of adanal segment. Setae ps_1 located between cupules *ip* behind adanal segment. Cupule *ips* laterally on anterior edge of adanal aperture. Cupules *ip* and *ih* displaced laterally. Setae drawn in detail in fig. 14a.

Epimeral region (fig. 14)**.** 7 pairs of setae *1a, 1b, 1c, 2a, 3a, 3b, 4a* – formula 3-1-2-1. *1c* located more or less on antiaxial edge of epimeron I and *4a* midway of the posterior border of epimeron IV. Setae drawn in detail in fig. 14a.

Legs (figs. 15–18)**.** Setation see table 2. Setae drawn in detail in fig. 15a.



FIGURES 8–9. *S. pannonicus* larva. **8**, dorsal view. **9**, ventral view, *Clp* with 'scaliform' seta (*1c*); genae and rutella not drawn.

Deutonymph

Idiosoma. Body length (n=2): 478 µm and 484 µm.

Gastronotic region (fig. 19)**.** 15 pairs of notogastral setae, c_{1-3}, *da*, *dm*, *dp*, *la*, *lm*, *lp*, h_{1-3} and ps_{1-3}. Setae ps_{1-3} only visible on ventral side. Setae on bumps like in larva. Cupule *ia* and *im* in same position as in larva. Cupules *ih*, *ip* and *ips* located ventrally. Setae drawn in detail in fig. 19a.

Anogenital region (fig. 20)**.** Genital valves with three pairs of genital setae; two pairs of genital papillae. Laterally of genital aperture one pair of aggenital setae. The last paraproctal segment, the anal segment is

developed. Adanal setae adjacent along the posterior part of anal valves. Setae $ps_{1\text{-}3}$ displaced laterally. Cupule *iad* flanking anal opening anteriorly, *ih* now positioned near opening of opisthonotal gland *gla* and cupules *ih* and *ips* on anterior side of gland with *ih* almost on the same level as *iad*. Setae drawn in detail in fig. 20a.

Epimeral region (fig. 20)**.** 8 pairs of setae *1a*, *1b*, *1c*, *2a*, *3a*, *3b*, *4a*, *4b* – formula 3-1-2-2. Seta *4b* located median. Setae drawn in detail in fig. 20a.

Legs (figs. 21–24)**.** Setation see table 2. Setae drawn in detail in figs. 21a, 22a, 24a.

TABLE 2. *Scutovertex pannonicus*; leg setation of all stages. First development of setae characterized by letters; **( )** = pair of setae; – = no change with regard to the preceding stage; **[ ]** = individual variation. **LA** = Larva, **PN** = Protonymph, **DN** = Deutonymph, **TN** = Tritonymph, **AD** = Adult. **Tro** = trochanter, **Fem** = femur, **Gen** = genu, **Ti** = tibia, **Ta** = tarsus, **Sol** = solenidia.

	Instars	Tro	Fem	Gen	Ti	Ta	Chaetome	Sol
Leg I	LA		*d*, *bv*´´	(*l*), *d*, σ	(*l*), *v*”, *d*, φ_1	(*ft*), (*tc*), (*p*), (*u*), *s*, (*a*), (*pv*), (*pl*), ε, ω_1	0-2-3-4-16	1-1-1
	PN		–	–	–	ω_2	0-2-3-4-16	1-1-2
	DN		(*l*)	–	φ_2	–	0-4-3-4-16	1-2-2
	TN	*v*´´	–	*v*´	*v*´	(*it*)	1-4-4-5-18	1-2-2
	AD	–	–	*d* lost	*d* lost	–	1-4-3-4-18	1-2-2
Leg II	LA		*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
	PN		–	–	–	–	0-2-3-3-13	1-1-1
	DN		(*l*)	–	–	ω_2	0-4-3-3-13	1-1-2
	TN	*v*´´	–	*v*´	*l*´´, *v*´	(*it*)	1-4-4-5-15	1-1-2
	AD	–	–	*d* lost	*d* lost	–	1-4-3-4-15	1-1-2
Leg III	LA		*d*, *ev*´	*l*´, *d*, σ	*v*, *d*, φ	(*ft*), (*tc*), (*p*), (*u*), *s*, (*a*), (*pv*)	0-2-2-2-13	1-1-0
	PN		–	–	–	–	0-2-2-2-13	1-1-0
	DN	*v*´	–	–	–	–	1-2-2-2-13	1-1-0
	TN	*l*´	–	–	(*l*)	(*it*)	2-2-2-4-15	1-1-0
	AD	–	–	*d* lost	*d* lost	–	2-2-1-3-15	1-1-0
Leg IV	PN					*ft*´´, (*p*), (*u*), (*pv*)	0-0-0-0-7	0-0-0
	DN		*d*, *ev*´	*l*´, *d*	*v*, *d*, φ	(*tc*), *s*, (*a*)	0-2-2-2-12	0-1-0
	TN	*v*´	–	–	(*l*)	–	1-2-2-4[3]-12	0-1-0
	AD	–	–	–	*d* lost	–	1-2-2-3-12	0-1-0

Tritonymph

Idiosoma. Body length (n=6): 566–685 µm (mean 634 µm).

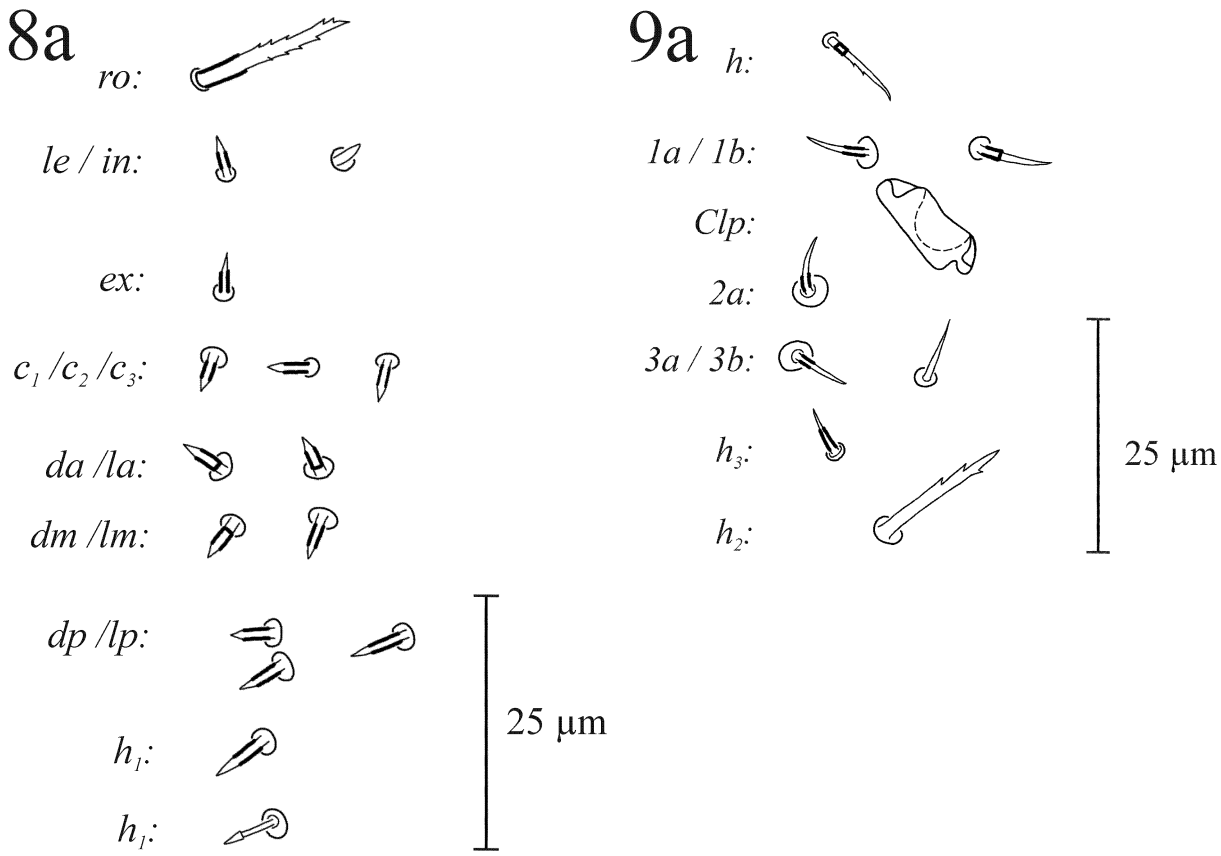
Prodorsum. Rostral setae already similar to the form of adults.

Gastronotic region (figs. 25, 26)**.** 15 pairs of notogastral setae, $c_{1\text{-}3}$, *da*, *dm*, *dp*, *la*, *lm*, *lp*, $h_{1\text{-}3}$ *and* $ps_{1\text{-}3}$; some of them becoming broader. Setae $ps_{1\text{-}3}$ only visible on ventral side. Setae on bumps like in larva. Cupule *ia* and *im* in same position as in deutonymph. Cupules *ih*, *ip* and *ips* located ventrally. Setae drawn in detail in figs. 25a, 26a.

Anogenital region (fig. 27)**.** Genital valves with five pairs of genital setae, three pairs of genital papillae. Variation in one individual shows only 4 pairs of genital setae. Setae ag_1 on level of setae g_5. There is no paraproctal segment added in this stage anymore only two pairs of anal setae. Anal setae on the posterior half of anal valves. Adanal setae displaced laterally. Setae $ps_{1\text{-}3}$ in same position as in deutonymph as well as the cupules *iad*, *ih* and *ips*. Setae and cupule *ia* drawn in detail in fig. 27a.

Epimeral region (fig. 27)**.** 8 pairs of setae *1a*, *1b*, *1c*, *2a*, *3a*, *3b*, *4a*, *4b* – formula 3-1-2-2. Setae *4a* moved more to the posterior edge of epimeron 4. Setae drawn in detail in fig. 27a.

Legs (figs. 28–31)**.** Setation see table 2. Setae drawn in detail in figs. 29a, 30a.



FIGURES 8a, 9a. *S. pannonicu*s larva. **8a**, setae drawn in detail of dorsal side; black lines on setae = cerotegumental collar. **9a**, setae drawn in detail of ventral side.

Redescription of the adult

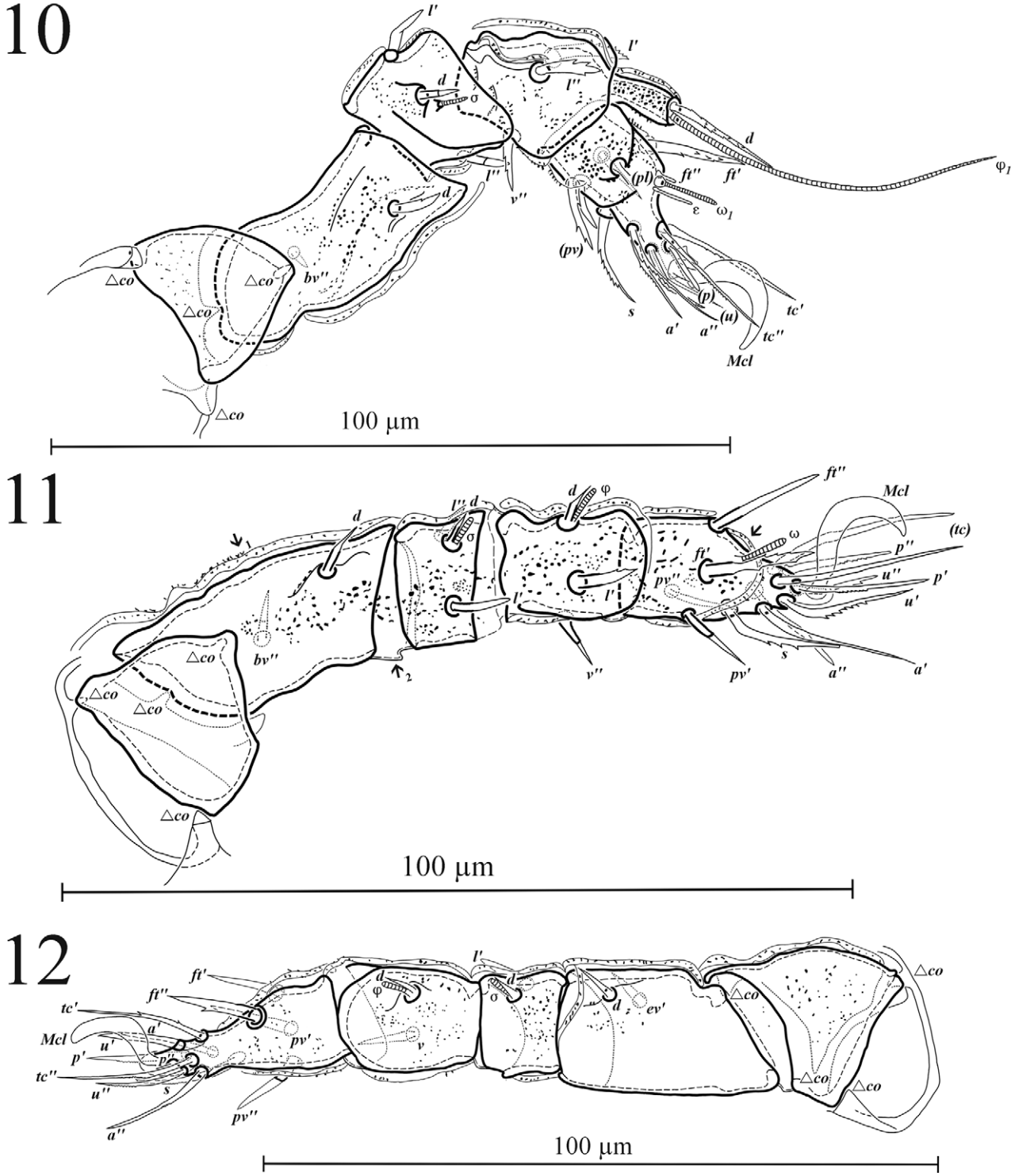
Diagnosis. Well developed cusps, interlamellar median rigdes (forming Y-shaped structure; keel-like) almost reaching translamella. Anterior of translamella rostrum with more or less well developed circular ridge. Sensillus clavate, with platelets. Notogaster with regularly distributed cuticular foveae. Setae *lp*, h_{1-3} and ps_1 longest and distally strongest brush-like broadened notogastral setae, whereas setae $c_{2-(3)}$, ps_2 and ps_3 are short and acute.

Measurements. (n=201): body length: 692–892 µm (mean 792 µm). Body width: 415–569 µm (mean 492 µm). Weak sexual dimorphism represented in body size; smallest individuals are males and biggest are females but with broad range of overlap in body length.

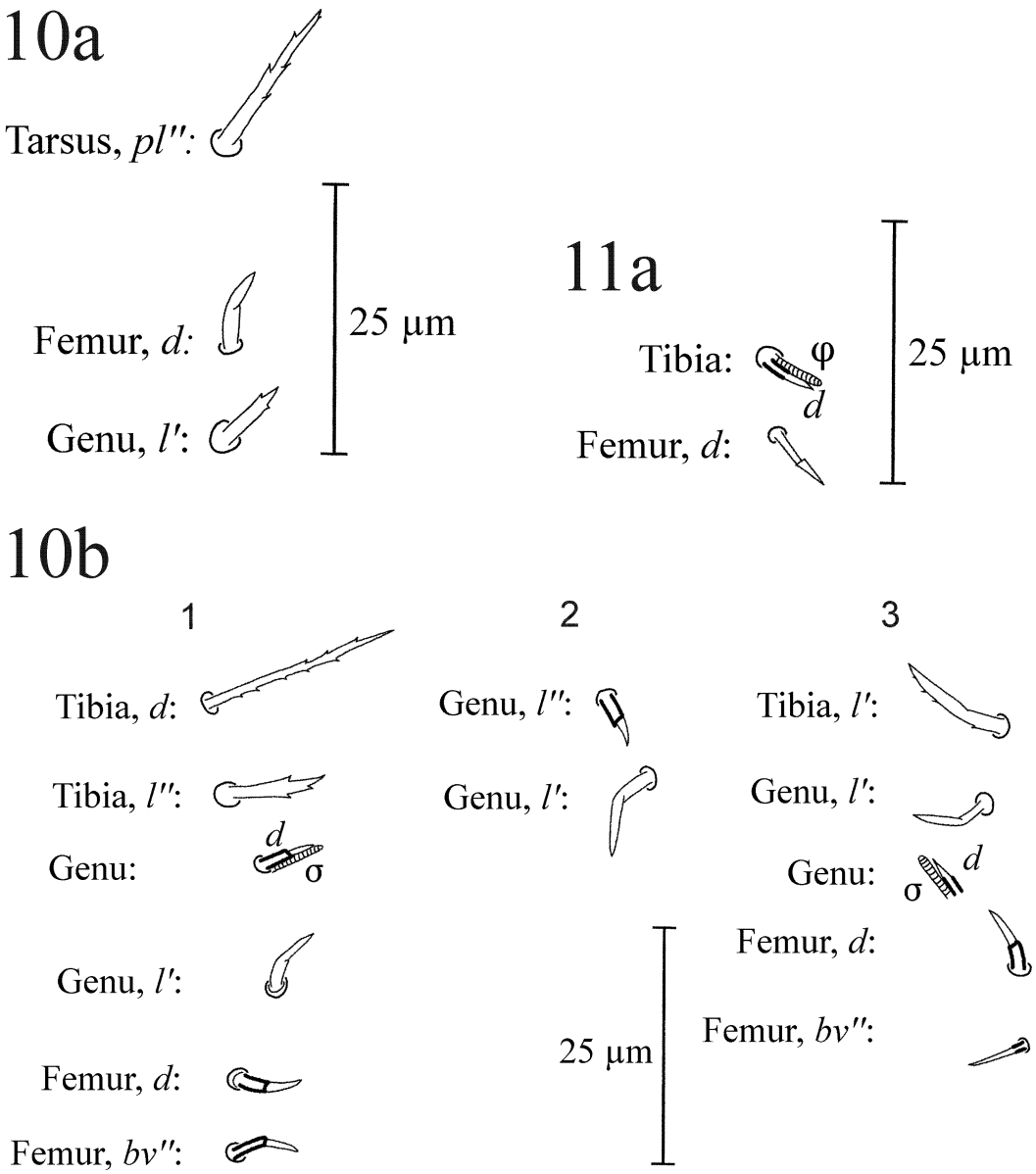
Habitus (fig. 32). In dorsal view body contour oval. Colour of body black; after hatching light brown with well visible longish oil gland reservoirs containing a reddish secretion. Colour of legs and lenticulus light brown. Body characterised by cuticular wrinkles producing lots of elevations and cavities. Entire body surface inclusive legs and cavities (also foveae) covered with granulated cerotegument; granules of different shape often interconnected and interconnections forming reticulate patterns (figs. 33–36). Amorphous secretion layer additionally covers cerotegument in great parts of the body (figs. 32, 38).

Prodorsum (figs. 37–38). Medially with approximately Y-shaped elevation, leading from proximal end of lamellae towards translamella not reaching it; length of elevation slightly different. Ridge-like lamellae well developed, slightly converging and connected by translamella. Cusps (fig. 39) longish, well developed but varying in length to a minor extend. Lamellar and rostral setae long, spiniform-serrate, almost same length and strongly curved inwards to median axis. Rostrum with more or less well developed circular ridge (fig. 40). Cuplike

trichobothrium (figs. 39, 41, 42). Sensilli (figs. 41, 41a) clavate (broadened in distal quarter of its length), more or less flattened, covered with distally rounded platelets, and secretion layer. Proximal part of setal shaft, before entering the bothridium, without platelets. Inner wall of bothridium also covered with granulated cerotegument like other grooves and protected areas (figs. 35, 42). Proximal end of sensillus S-curved and before leading into a sac-like structure (*Sac*) surrounded by a ribbed-ring structure (*Ri*). Tutorium V-shaped ridge (fig. 39). No exobothridial and interlamellar setae.

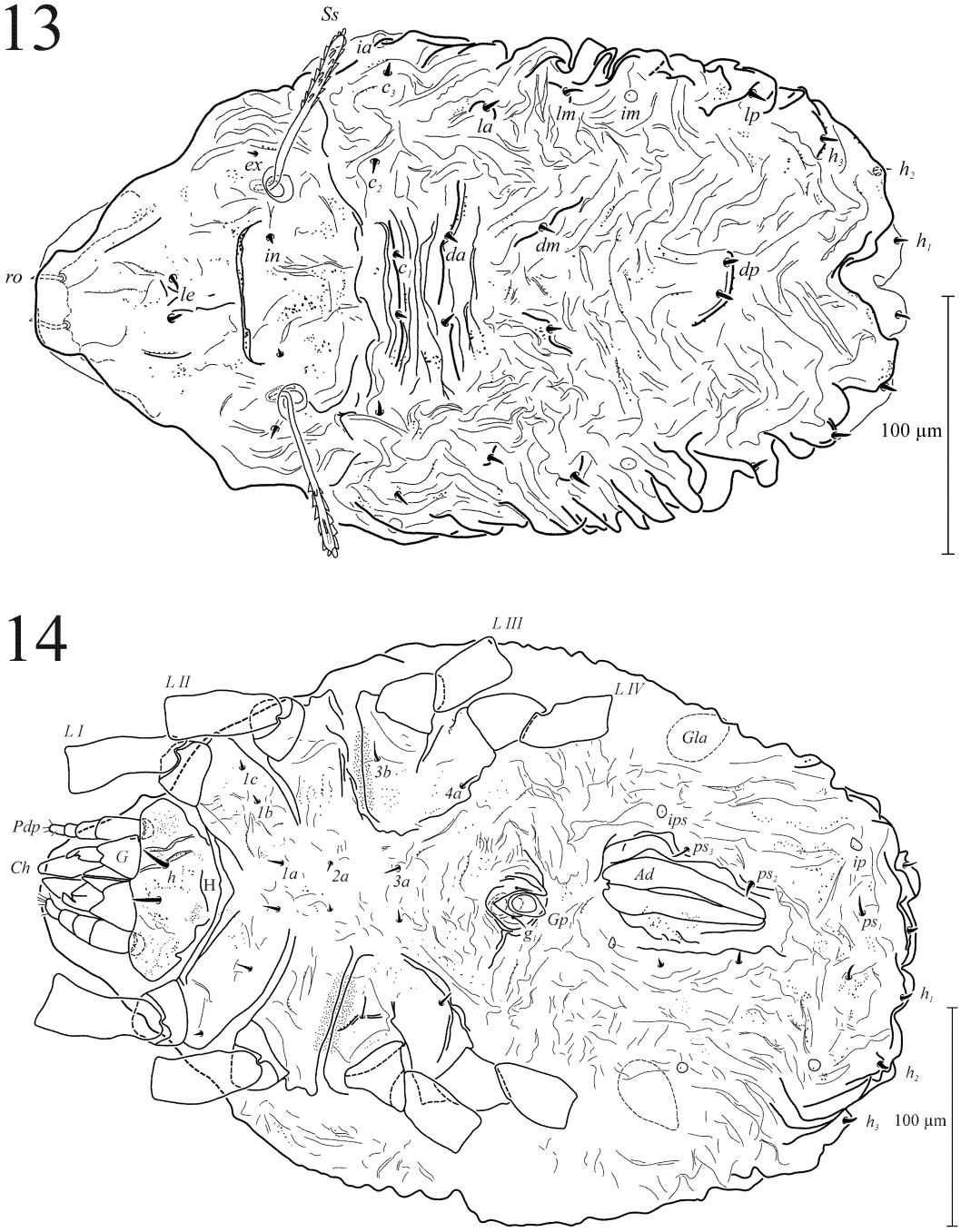


FIGURES 10–12. *S. pannonicu*s larva. **10**, right leg I (broken during preparation); tarsus and tibia antiaxial view; genu dorsal view; femur and trochanter paraxial view. **11**, left leg II, paraxial view; transverse ridge (arrow), cerotegumental layer (arrow 1), articulation membrane (arrow 2). **12**, left leg III; dorso-paraxial view.



FIGURES 10a, 10b, 11a. *S. pannonicu*s larva, leg setae drawn in detail. **10a**, right leg I. **10b**, setae and solenidia of leg I of different individuals (no. 1–3). **11a**, setae drawn in detail of left leg II.

Notogaster (figs. 32, 43). Oval; small boss on posterior border of notogaster in area of setae ps_1 and h_1. Notogastral foveae well discernable, distributed more or less regularly – area in the middle of notogaster without foveae. Lenticulus at anterior border, its shape almost rectangular (fig. 45). Surface smooth although seeming densely spotted in transmitted light (fig. 37). Area anteriorly of lenticulus with transverse wrinkles and with a pair of slit-like structures laterally (figs. 37, 38, 45). Area posterior of lenticulus with small ribs. Ten to eleven pairs of notogastral setae, $c_{2-(3)}$, *dm*, *la*, *lp*, h_{1-3}, and ps_{1-3}. Setae c_2, ps_2 and ps_3 not broadened, short and acute. Setae *la* longer than last mentioned ones, distally slightly broadened and spinose. Seta *dm* long, spinose and not broadened. Setae *lp*, h_{1-3} and ps_1 longest and distally strongest brush-like broadened ones. All setae inserting on little bumps. Three pairs of saccules S_{1-3}. S_1 between *la* and *lp*. S_2 between h_3 and h_2. S_3 posterior of h_2. Five pairs of lyrifissures *ia*, *im*, *ip*, *ih* and *ips*. Lyrifissure *ia* located laterally, hidden underneath humeral projection, on a small bump at level of sejugal furrow, near trichobothrium (figs. 39, 42, 46); *im* between *la* and *lp*, anteriorly of S_1; *ip* between h_2 and h_1. Lyrifissures *ips* and *ih* laterally and anteriorly of ps_3 (fig. 39). Orifice of opisthonotal gland antiaxial of seta *lp*. Setae of notogaster drawn in detail in figs. 43a, 43b.

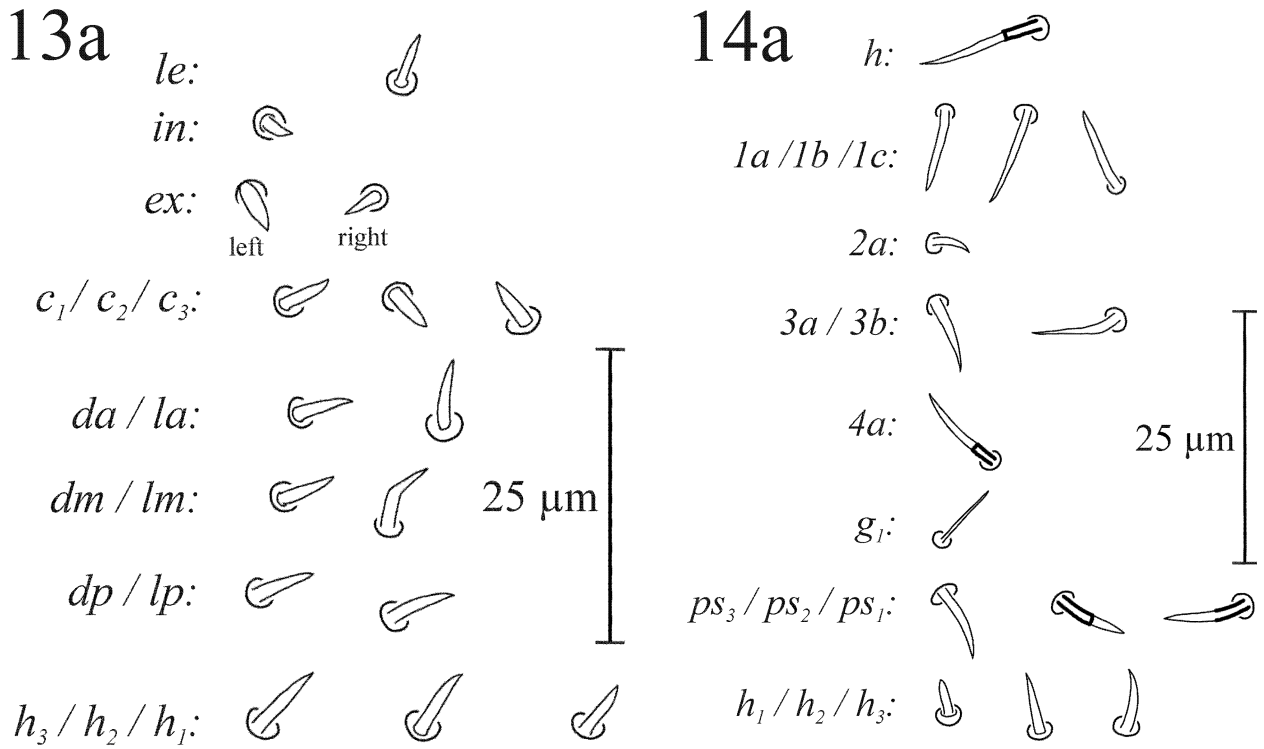


FIGURES 13–14. *S. pannonicus* protonymph. **13**, dorsal view. **14**, ventral view.

Subcapitulum (figs. 47, 47a-c, 48). Subcapitulum diarthric, embedded in camerostome. Inner margin of camerostome formed by rostrophragma. From posterolateral corner of camerostome a triangular longish lamella leading rostrad; distal end of latter structure overlapped by rostral lobe. No genal incision.

Mentum with granulated cerotegument often interconnected to reticulate pattern, on anterior border with irregular interrupted ribs. Setae of mentum inserting on small bumps on ribs; spiniform. Transition mentum to mental tectum characterised by a deeper groove also covered with cerotegument (fig. 48a). Podocephalic canal laterally of mentum. Genae (fig. 48b) with sharp lateral edges, one pair of anterior genal setae and one pair of median genal setae; spiniform, serrate and with a sharp bend in the first half of setae. Rutella pantelebasic, distally with four teeth and rutellar brush. Manubrial porose area behind rutellar brush. Mental tectum, genae and rutella without cerotegument; smooth appearance. Upper lip and lateral lips underneath genae and rutella (fig. 48c). Lateral lips with two pairs of adoral setae; hook-shaped, robust, serrate and shorter than setae *a*, *m* and *h*. At

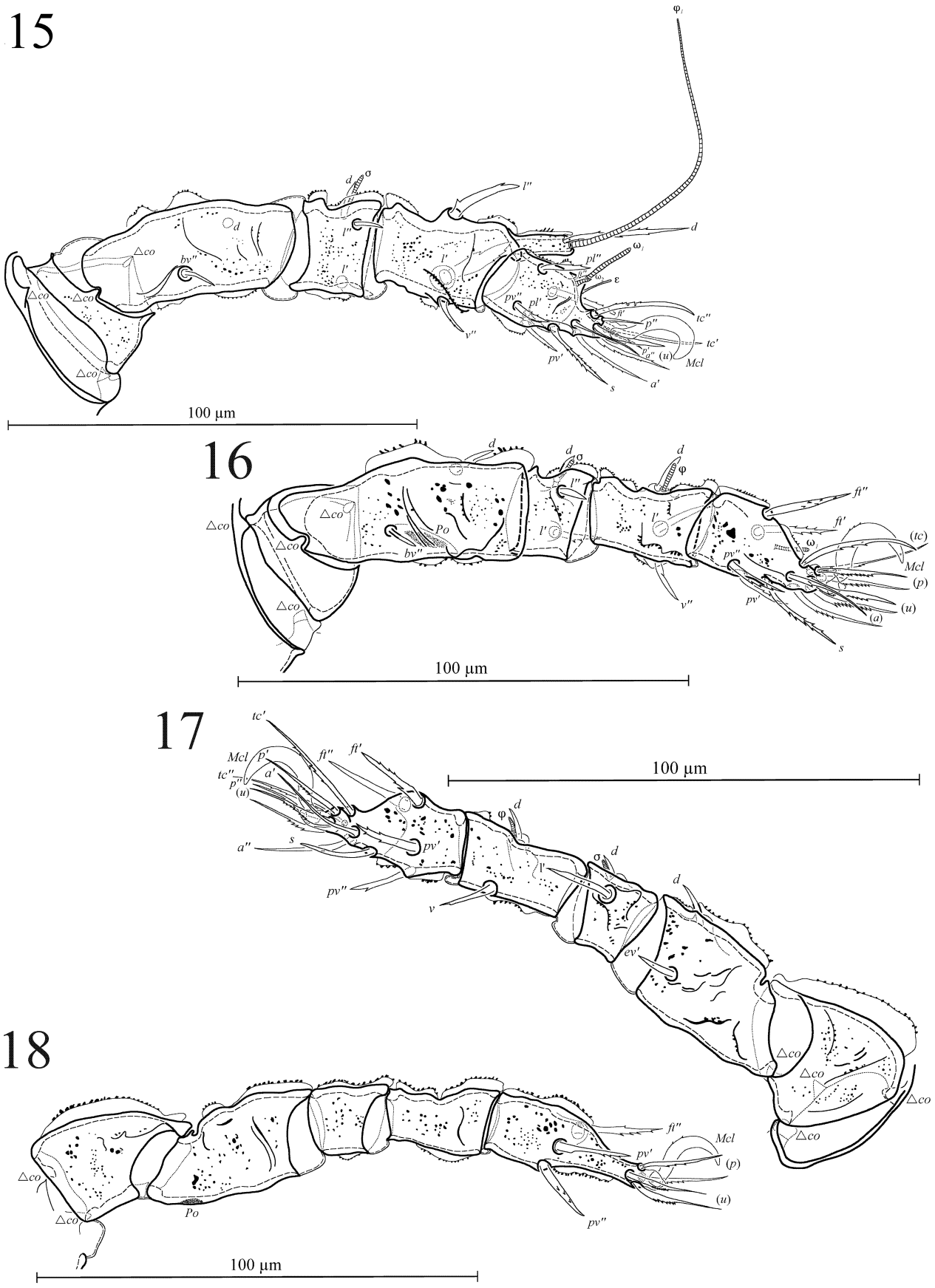
anterior lateral edge of mentum basis of pedipalps (fig. 50). Pedipalp pentamerous; setation formulae: chaetome 0-2-1-3-9, solenidia 0-0-1. Setae in general spiniform and of different length. Setae *v'* on femur, *l"* and *d* on tibia serrate; others more or less smooth. Tarsal solenidion ω recumbent, distal end touching insertion of eupathidium *acm*. Four eupathidial setae *sul*, *ul* (paired) and *acm* bacilliform with slightly broadened basis and terminal pore (fig. 49). Setae of pedipalp drawn in detail in fig. 50a. One lyrifissure (*ita*) on palptarsus. Two condyles between femur and trochanter. Axillary saccule at axial side of basis of pedipalp, epine (*e*) on the antiaxial side of basis. Chelicerae (fig. 51): fixed digit and mobile digit with strong teeth. Trägårdh's organ slender, on axial side of chelicerae; cheliceral sheath and porose area observable. Anterior and posterior seta spiniform and serrate; almost same length. Underneath mentum a capitular apodeme, one pair of openings of subcapitular gland near insertion of setae of mentum and pharynx leading into oesophagus.



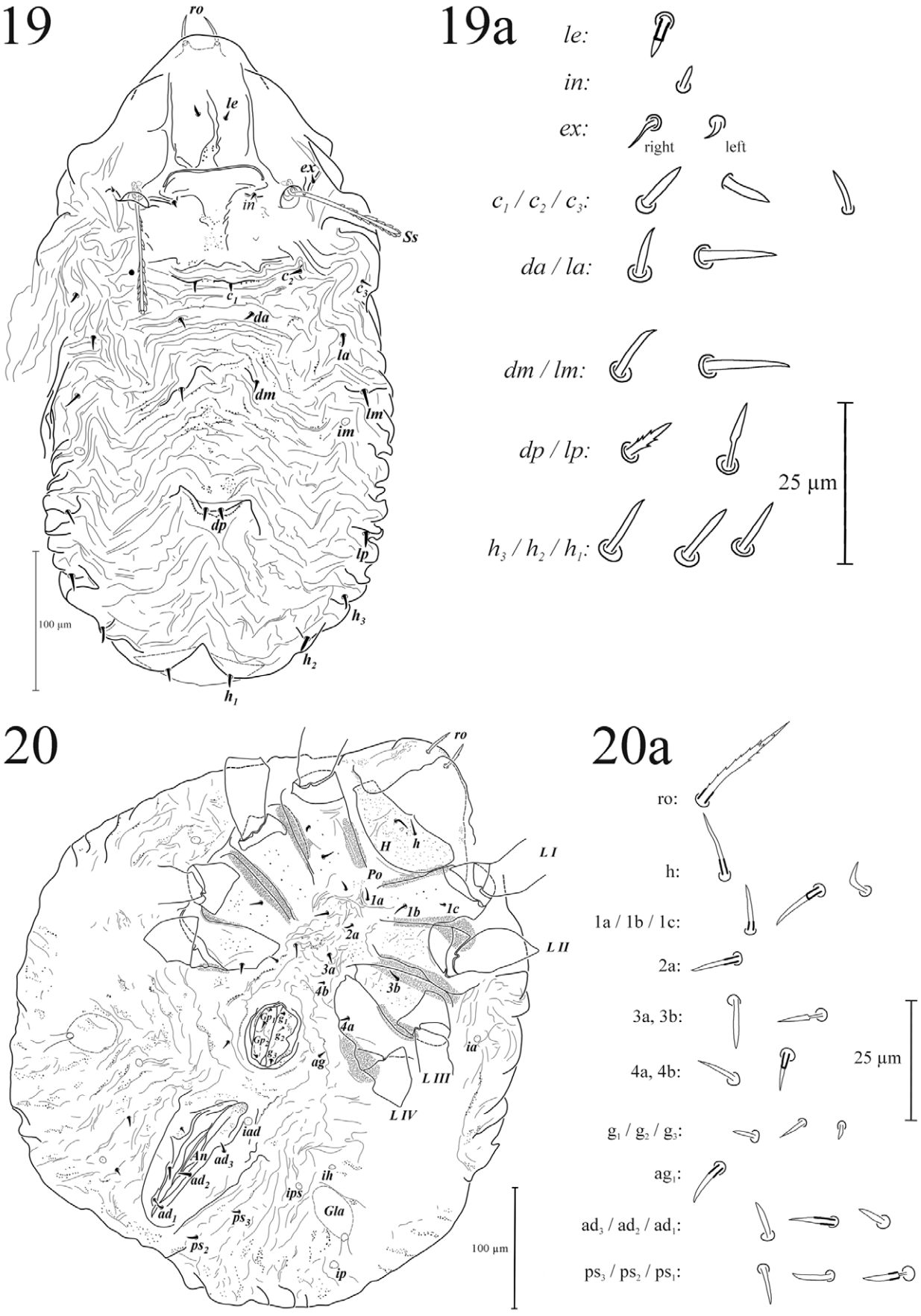
FIGURES 13a, 14a. *S. pannonicu*s protonymph. **13a**, setae drawn in detail of dorsal side. **14a**, setae drawn in detail of ventral side.

Epimeral region (figs. 52, 53). Eight pairs of setae *1a, 1b, 1c, 2a, 3a, 3b, 4a, 4b* – formula 3-1-2-2. All setae spiniform, acute, and smooth. Setae *1c* located at basis of pedotectum I and *4b* displaced caudad between genital plate and basis of trochanter IV. Apodeme I, II, sejugal and III, epimera I-IV as well as pedotectum I and II clearly visible. Apodeme IV always absent. Only anterior borders of epimeron I and II reach median axis. Tutorium v-like ridge rostrad of acetabulum I (fig. 39). Ventral part of pedotectum I large with well developed projection showing towards leg I. Contour of pedotectum II reminds a little of the end of an 'elephant's trunk' (figs. 52, 53). Setae of epimeral region drawn in detail in fig. 52a.

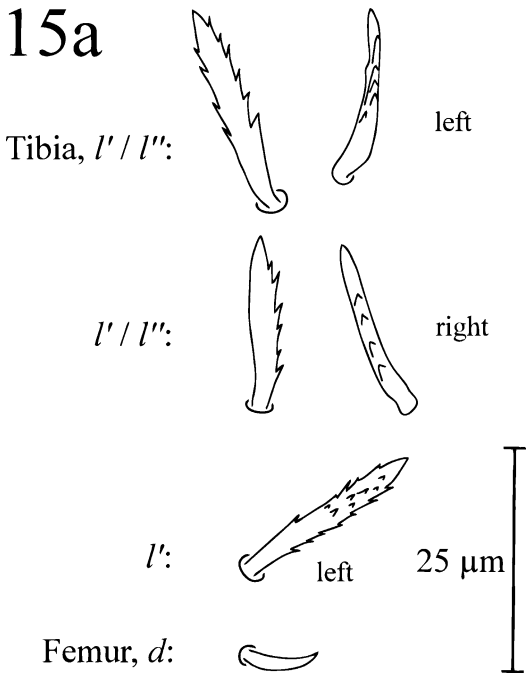
Anogenital region (figs. 52, 53). Genital plate slightly broadened anteriorly. Genital setation 6+6, also variation 5+5 and 5+6, position of setae often irregular (fig. 54). First two pairs, often also the last two pairs, located next to each other near median axis. Setae g_1 longest, followed by g_6; others shorter. All setae spiniform, acute, and smooth. Three pairs of genital papillae well visible. Proximal and distal part of ovipositor divided by a circular fold (fig. 55). Three pairs of small and acute eugenital setae (*kd*, *kv*, *kl*) positioned around circular fold; visible only if ovipositor is fully extended. Distally three eugenital lobes, each with four eugenital setae. Median lobe with one pair of long (ψ_1) and one pair of shorter setae (ψ_2). Outer lobes with each one long (τ_1) and three shorter (τa-c) eugenital setae. All setae smooth. Tube totally wrinkled and soft, therefore well expandable. Spermatopositor (fig. 55a) very small, delicate and difficult to detect. Six pairs of eugenital setae; five shorter and one longer (τ_1) pair. Genital plate surrounded by grooves. A deeper and rounded one anteriorly of genital plate; first



FIGURES 15–18. *S. pannonicu*s protonymph. **15**, right leg I, ventro-antiaxial. **16**, right leg II, ventro-antiaxial. **17**, right leg III, antiaxial. **18**, left leg IV, ventro-antiaxial.



FIGURES 19, 19a, 20, 20a. *S. pannonicu*s deutonymph. **19**, dorsal view. **19a**, setae drawn in detail. **20**, exuvia, ventral view. **20a**, setae drawn in detail.



FIGURES 15a. *S. pannonicu*s protonymph, some leg setae drawn in detail of right leg I.

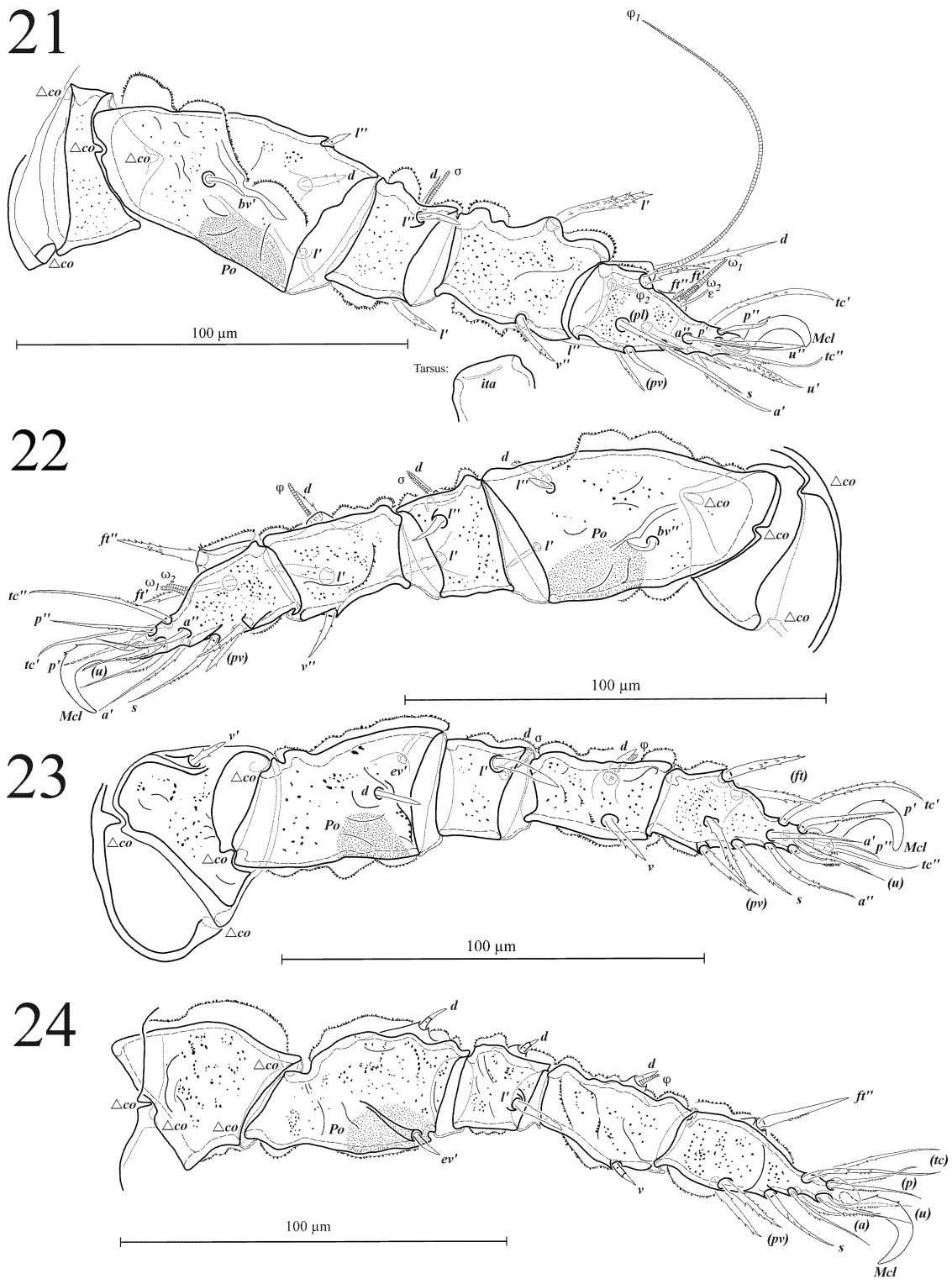
two pairs of genital setae seem reaching into it (fig. 53). A pair of longish grooves laterally and posteriorly of genital plate . Posterior grooves much longer and deeper than lateral ones, leading towards acetabulum IV. A round depression posteriorly of acetabulum IV (figs. 53, arrow 2; 56). One pair of aggenital setae situated laterally between genital- and anal plate. Anal plate broadened posteriorly. Anal setation 2+2; variation in one individual 3+2 (fig. 53a, white arrow). Three pairs of adanal setae; ad_1 posteriorly of anal opening (fig. 57) – seems reaching into the boss (fig. 53), ad_2 and ad_3 laterally of anal plate. Lyrifissure (*iad)* laterally of anterior border of anal plate. Preanal organ cup-like. Surface of anogenital region with grooves, ribs and granulated cerotegument. Setae of anogenital region drawn in detail in fig. 52a.

Legs (figs. 58–61). Setation see table 2. Tridactylous, heterodactylous. Empodial claw prominent almost smooth, the two lateral adjacent claws thinner, strongly bent, and dorsally slightly serrate. Legs snaggy, covered with granulated cerotegument, and ribs especially on femur and trochanter. Genu smallest segment with one rounded, longish rib; seta *l'* situated on it. Tarsus and tibia longish in shape, femur and trochanter broadened. Only area of apotele shiny, thin and smooth. One lyrifissure (*ita*) antiaxial on tarsus I (fig. 62). Setae on tarsus, tibia and genu generally serrate. Other setae more or less smooth. Tarsus I with transverse ridge (fig. 59). Dorsally on tarsus a small bump bearing two solenidia (ω_1, ω_2), one famulus (ε) and one seta (*ft"*); all four of them located close to each other (figs. 58a, 63). Tibia with tibial cone bearing solenidion φ_1 and φ_2 (figs. 58b, 63, 64). All legs with tracheae (figs. 65, 67–70). In leg I and II trachea divided into two branches, originating dorsolaterally in femur near seta *l"* (fig. 66). The long branch leading into tibia or tarsus, the short branch goes around proximal area of femur sometimes reaching almost genu. In leg III and IV only one long branch, originating in proximal part of femur, leading into tibia and tarsus; variations in length occur. Trochanter III and IV with own trachea which curves along the inner wall. Setae drawn in detail in figs. 58c, 61a.

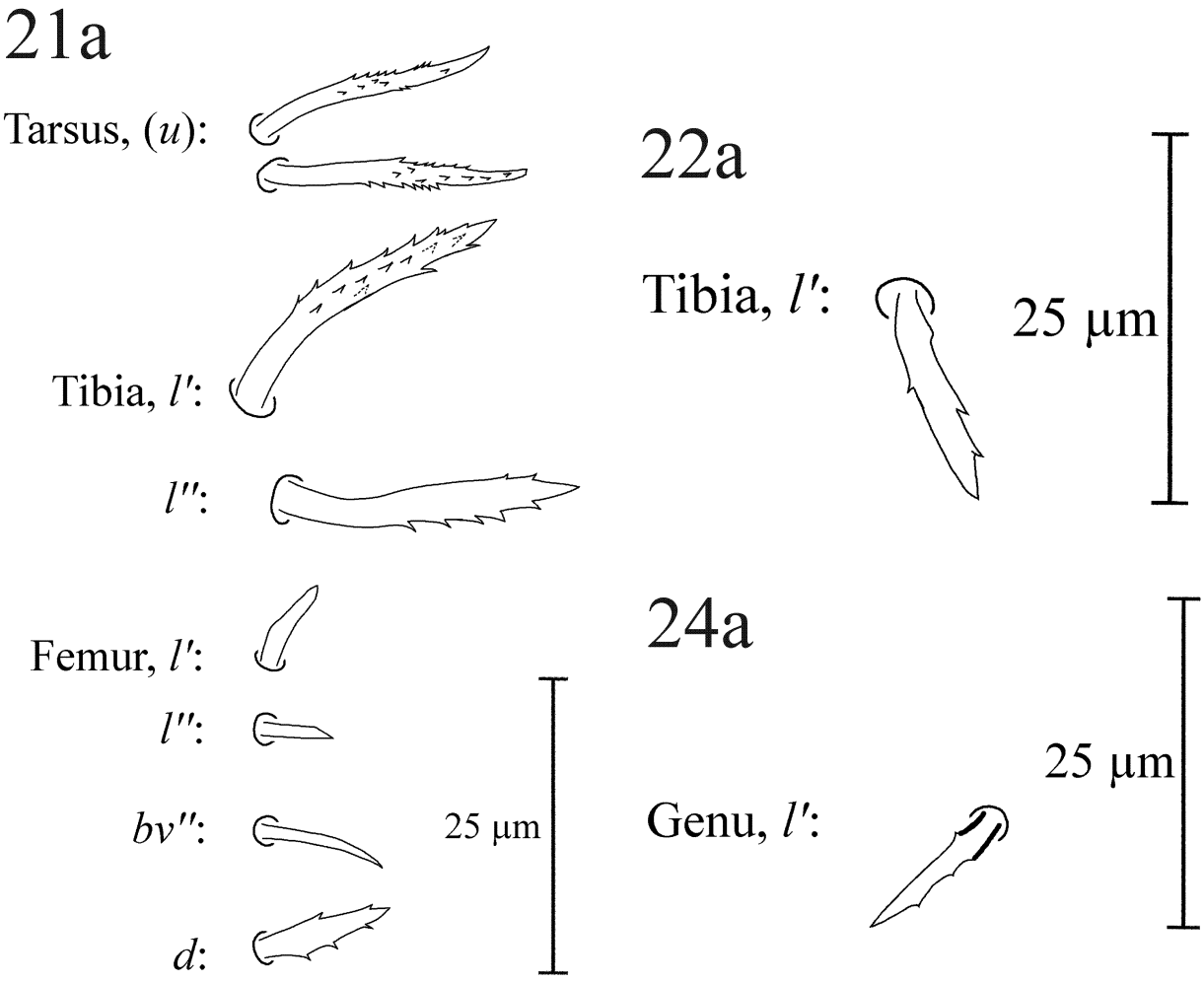
Biology, ecology and distribution

Biology. Rearing and breeding lasted for several weeks. A kind of mating could not be detected, but males deposited spermatophores on plaster of Paris, on the wall of the box, and also on the notogaster of other mites. A total amount of 25 eggs were laid somewhere in the box. Freshly laid eggs could be seen easily due to their light orange / yellowish colour. With proceeding age and development of the larva the colour turned into dark brown; the reddish coloured secretion of the two oil glands could be seen laterally. Out of these 25 eggs, 12 individuals hatched in total. Out of those six larvae, five protonymphs and one deutonymph were obtained. Generally it was to

notice that it took about 2–12 days from one moult to the other, sometimes longer. Most of the time the juveniles were inactive, especially before moulting – in between they normally were active and also fed on some coccal green algae.



FIGURES 21–24. *S. pannonicus* deutonymph. **21**, right leg I, ventro-antiaxial. **22**, left leg II, ventro-antiaxial. **23**, left leg III, ventro-antiaxial. **24**, left leg IV; antiaxial view.



FIGURES 21a, 22a, 24a. *S. pannonicus* leg setae of deutonymph. **21a**, some setae drawn in detail of right leg I. **22a**, seta drawn in detail of left leg II. **24a**, seta drawn in detail of left leg IV.

Tritonymphs could be collected already from the extracted sample due to their largeness compared to adults of *Scutovertex sculptus*. Some of them hatched to an adult and the circumgastric way of leaving the exuvia was well observable.

The body of hatched adults was very soft. It could be easily smashed with a needle, the longish reservoirs of the opisthonotal glands (fig. 71) were shining through the notogaster and also the notogastral foveae were well detectable. After the hatch the individuals had a light-brown coloured body, legs were little darker but never turned into their typical dark brown to black colouration which they have in open land and never became sclerotized. After one week in the cylindrical polystyrol-box they died.

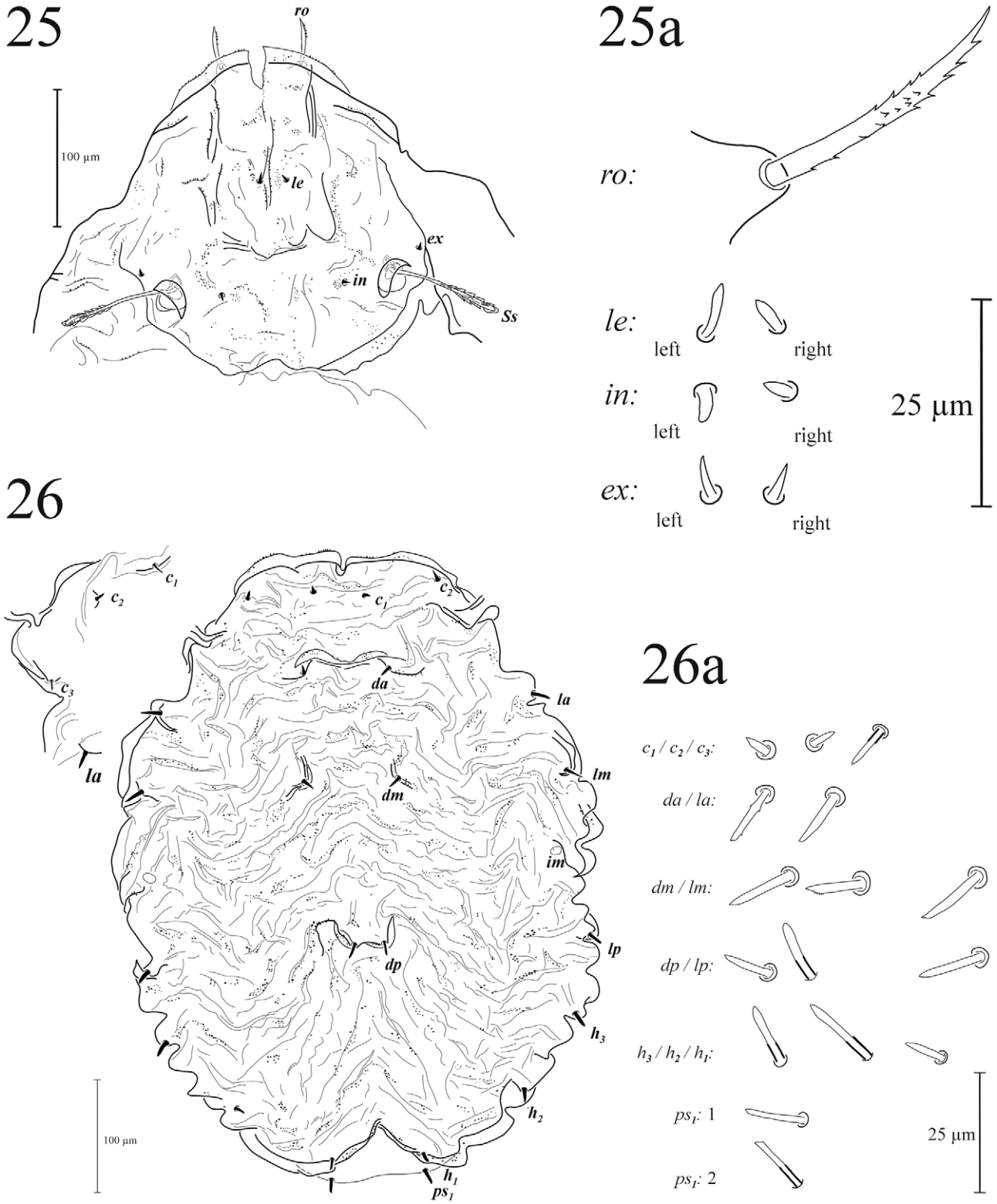
During the time of rearing the phenomenon of aggregation could be observed. It was to notice that, with an amount of 20 adults, groupings consisted of a maximum of seven to nine individuals. With increasing amount the groupings became bigger, too. Females and males were sitting together.

The subject of aggregation is already known in many other species like *Phauloppia lucorum* (Oliveira *et al.* 2007), *Fortuynia atlantica* (Krisper & Schuster 2008), *Collohmannia gigantea* (Raspotnig 2006) or in some Ameronothridae (Søvik 2004).

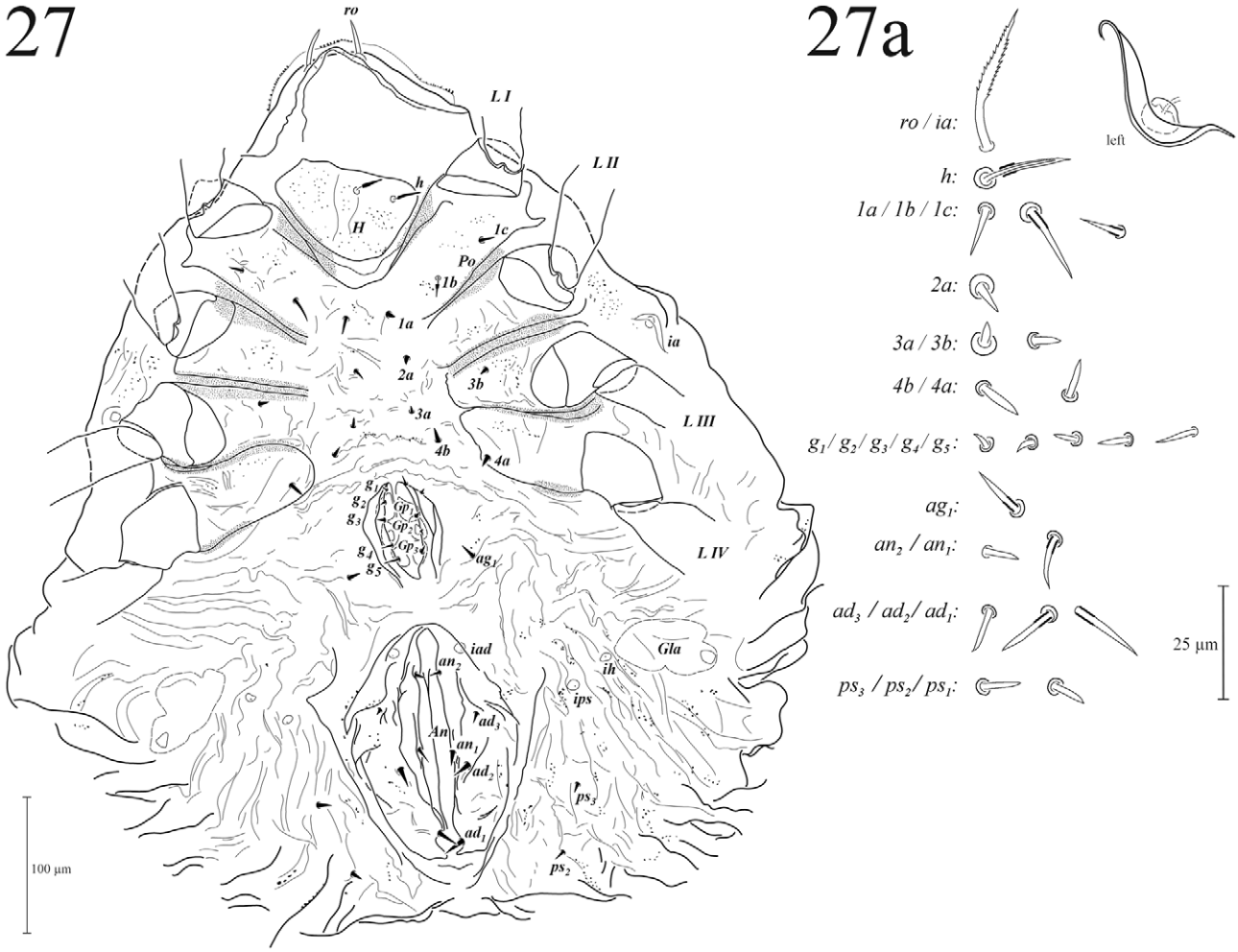
Ecology and distribution. It is to adhere that the best time to obtain the biggest amount of juveniles and especially of adults of *S. pannonicus* is the end of March / begin of April and the mid / end of October. In the mid of February (20th Feb.) only nymphs and larvae could be extracted from the samples. In all other months only a few, mostly no individuals could be found.

Referring to the collection sites (fig. 72) it is to mention that the area near lake Oberer Stinker (fig. 73) shows the highest abundance of *S. pannonicus* where it is to find in small sand-hills in moss and in connection with

Artemisia sántonicum and *Lepidium cartilagineum*. The abundance at the Illmitzer Zicklacke was far less and at the area of Lange Lacke only a few individuals could be found. East of the Austrian boarder the Palaearctic species *S. pannonicus* occurs in the steppe areas from Eastern Europe to Central Asia. From west to east we can follow the subsequent collecting sites (fig. 74): Austria—Bashkiria—Tajikistan—Kyrgysztan—Novosibirsk—region of Altai—Mongolia (Shtanchaeva & Netuzhilin 2003).



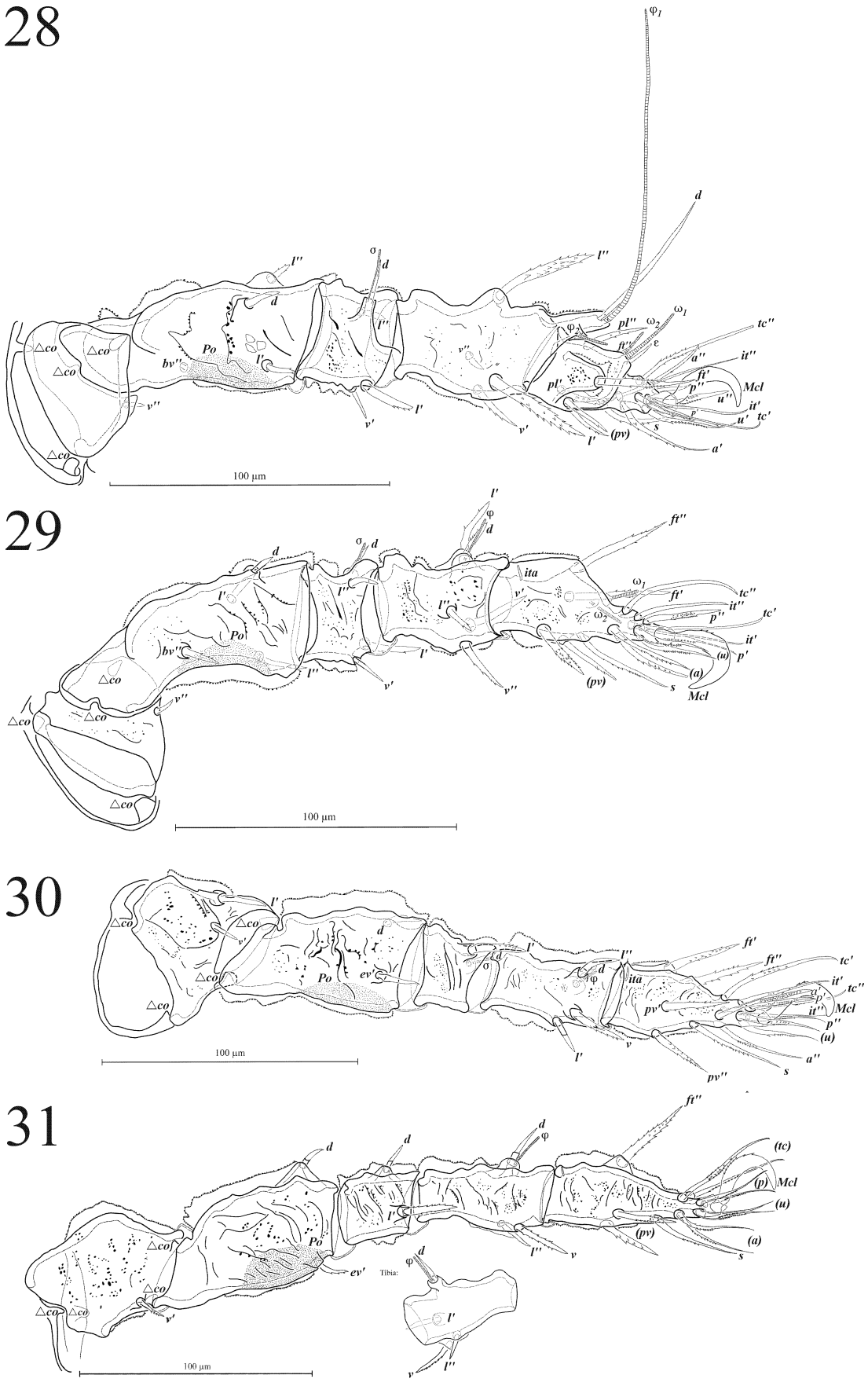
FIGURES 25, 25a, 26, 26a. *S. pannonicus* tritonymphal exuvia. **25**, dorsal view of prodorsum. **25a**, setae drawn in detail of prodorsum. **26**, dorsal view of gastronotic region. **26a**, setae drawn in detail of gastronotic region.



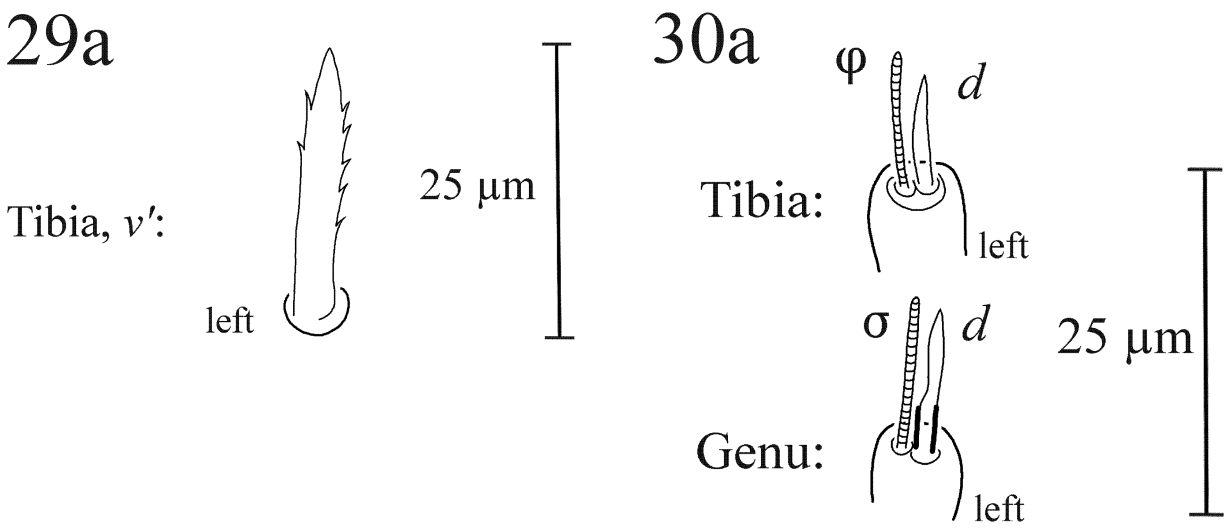
FIGURES 27, 27a. *S. pannonicu*s tritonymphal exuvia. **27**, ventral view. **27a**, setae drawn in detail.

Discussion

Egg morphology. During rearing an investigation of eggs was obvious. The fundamental structures of the exochorion are typical for the genus *Scutovertex* like the 'mushrooms' and granules (Krisper *et al.* 2008). These structures are more similar to those of *S. sculptus* (Pfingstl *et al.* 2008) than to *S. minutus* (Schäffer & Krisper 2007). The differences to *S. sculptus* are: (1) Form of the granules (*Gr*) not conical but looking like raspberries. (2) The 'mushrooms' are more regular in the form of the caps. (3) The substructure on the 'mushrooms' creates an uneven surface in *S. sculptus* whereas in *S. pannonicus* the densely packed granules form an even layer (figs. 75, 76). (4) For *S. pannonicus* a thin external layer on the exochorion is typical. Such an extra layer is also described for *Scutovertex arenoculus* (Pfingstl *et al.* 2009) from the Baltic Coast. Both species live in soils influenced by salt. In Krisper *et al.* (2008) it is speculated that this layer should protect the embryo from osmotic effects due to salt. Although specimens of *S. sculptus* (Pfingstl *et al.* 2008) derive from the same sampling sites as *S. pannonicus* (Illmitz, Burgenland, Austria) only the latter species exhibits this extra layer. This is probably to explain with the fact that the area around the lakes are characterised by their mosaic-like inter-locking and gradual succession of vegetation from the saline soil to the salt-free areas. *Scutovertex pannonicus* is preferably to find in combination with *Lepidium cartilagineum* a strong halophyte from this area (Schuster 1959).



FIGURES 28–31. *S. pannonicus* tritonymph. **28**, left leg I, dorso-paraxial view. **29**, right leg II, antiaxial view. **30**, left leg III, ventro antiaxial view. **31**, left leg IV, antiaxial view; and left tibia IV, paraxial view, notice seta *l'*.



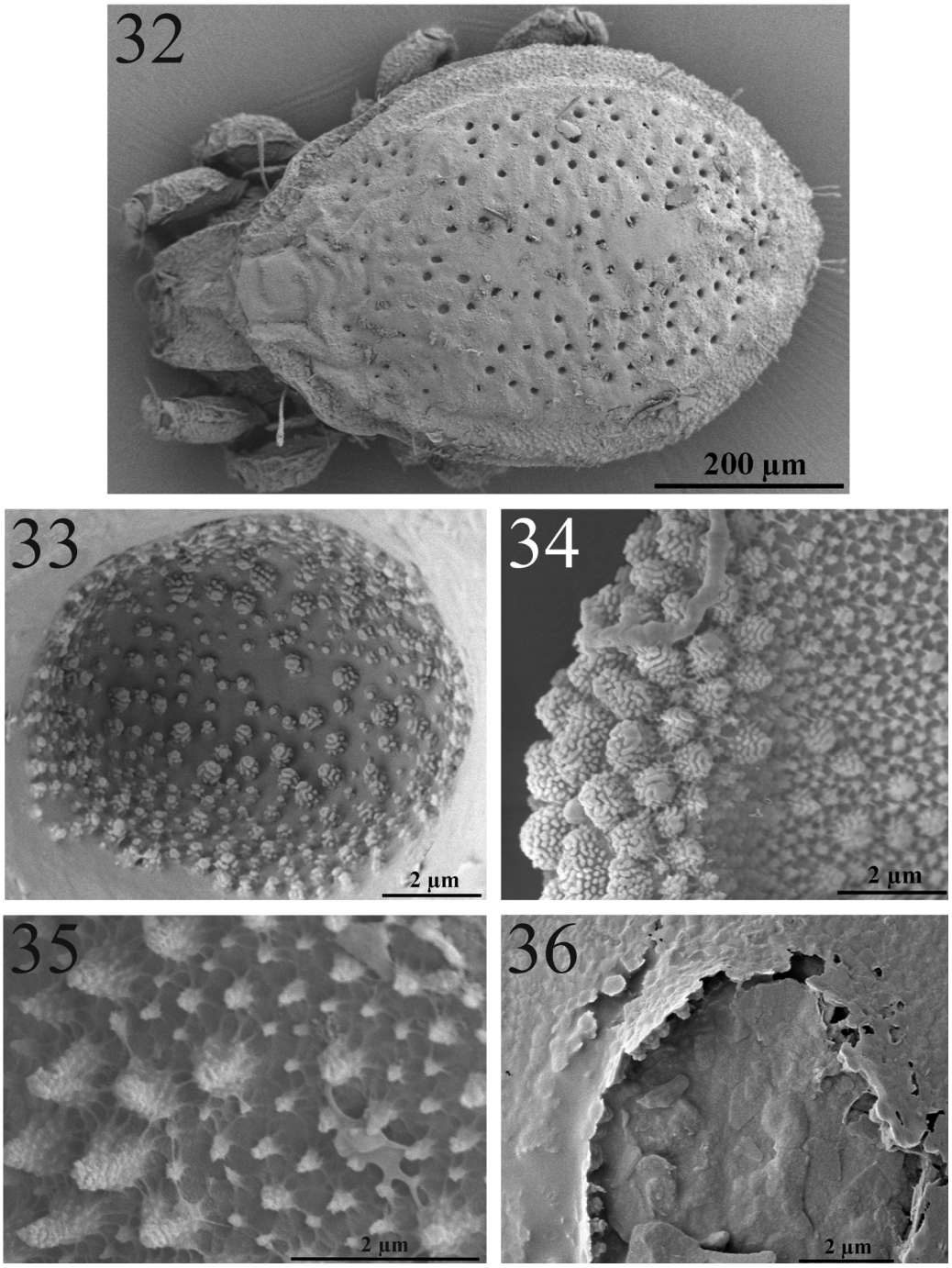
FIGURES 29a, 30a. *S. pannonicus* leg setae of tritonymph. **29a**, tibial seta *v'* of right leg II. **30a**, solenidia with coupled seta *d* on tibia and genu of left leg III.

Morphology of different larval stages. During investigations of the juveniles three different stages before the fully developed larva appears could be detected. First the prelarva, second an earlier larval stage, and third a later larval stage. The prelarva shows the typical structures, similar to those of *Damaeus onustus* (Grandjean 1954) and *Podacarus auberti* (Grandjean 1955). In the earlier larval stage the 'egg-teeth' are still developed–which presumes that in this stage the prelarval integument still exists. Both the prelarva and the earlier larval stage bear two relatively dark spots in the area of the later anal opening which could be for aggregation of the excretory products (apparently guanine), intended to be removed probably in the larva (correspondence with Dr. A. Shatrov, Saint Petersburg).

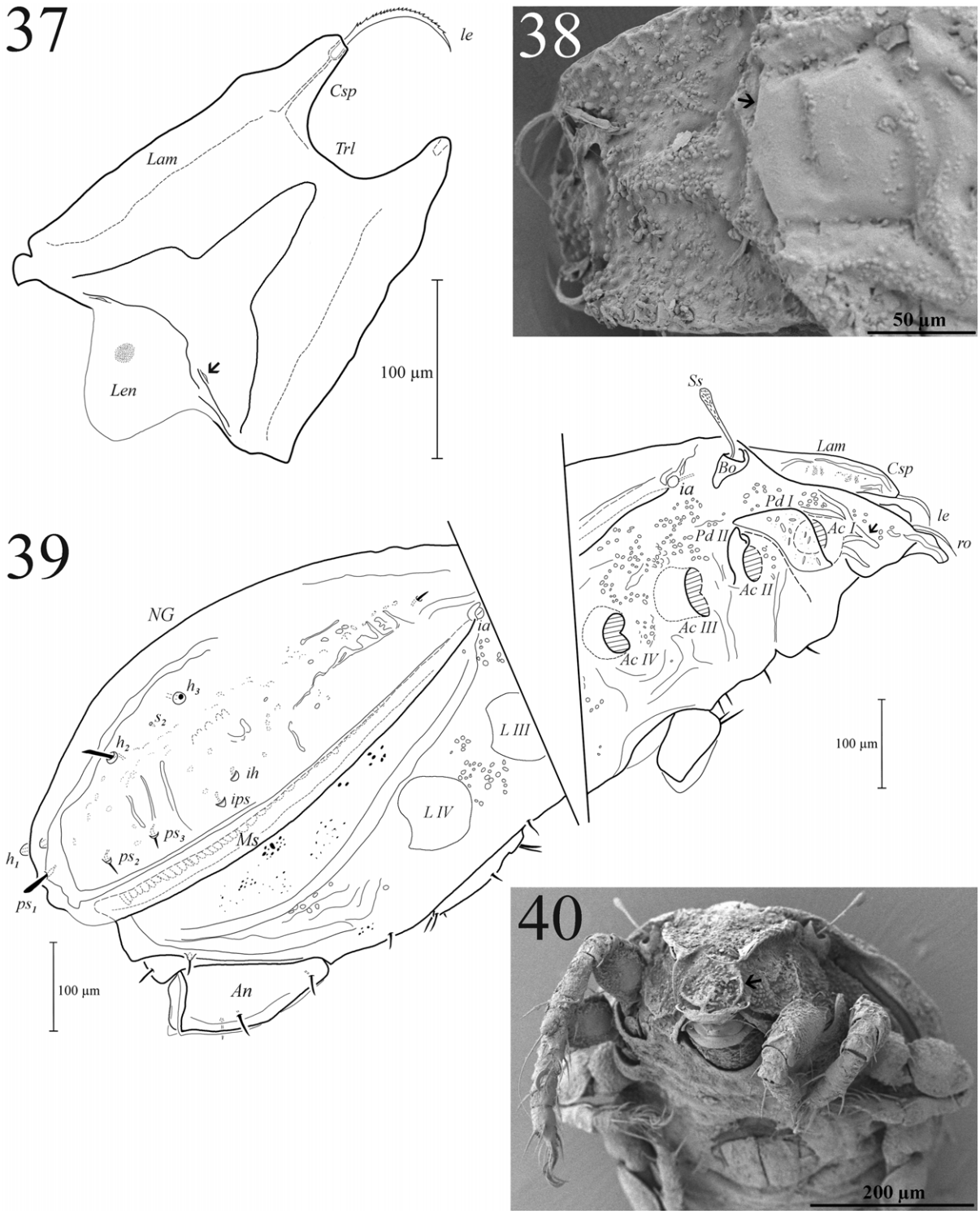
Juveniles' morphology. Typical for juveniles is the presence of cerotegumental collars on the basis of setae. These structures are not always well visible so it is not quite sure if really all setae do have a collar – but it is to presume that this is the case for almost all setae inclusive for those on the legs. Due to mechanical wear some of the setae lost their cerotegumental collar and remained in the form of an arrow (see also figs. 8a seta h_1, 19a seta *lp* or 20a seta *3b*). According to Norton (1977), normal setae have a central axis covered by an isotropic external layer which is a continuation of the epiostracum (= epicuticle in Alberti *et al*. 1981). Furthermore, only in rare cases the setal axis itself is branched. Normally the epicuticle provides structures like barbs and e.g. scales. The axis inserts in a cup-like alveolus (see also fig. 67 femur II seta *l"*) formed in the ectostracum (= procuticle in Alberti *et al*. 1981). The collar itself than should be made of cerotegument (= transparent and cement layer in Alberti *et al*. 1981). However, the 'arrow'-phenomenon may occur due to the loss of the collar which takes along the underlying external layer; in such a case the remaining looks like an 'arrow'.

In tritonymphs individual variations within the number of setae are observable: only four genital setae instead of five and tibia IV sometimes bearing three setae instead of four (see fig. 31). A variation in the leg chaetome is reported also for *S. minutus* (Schäffer & Krisper 2007); affected are tibia I (four or five setae) and tibia III (two or three setae) in the deutonymphal stage.

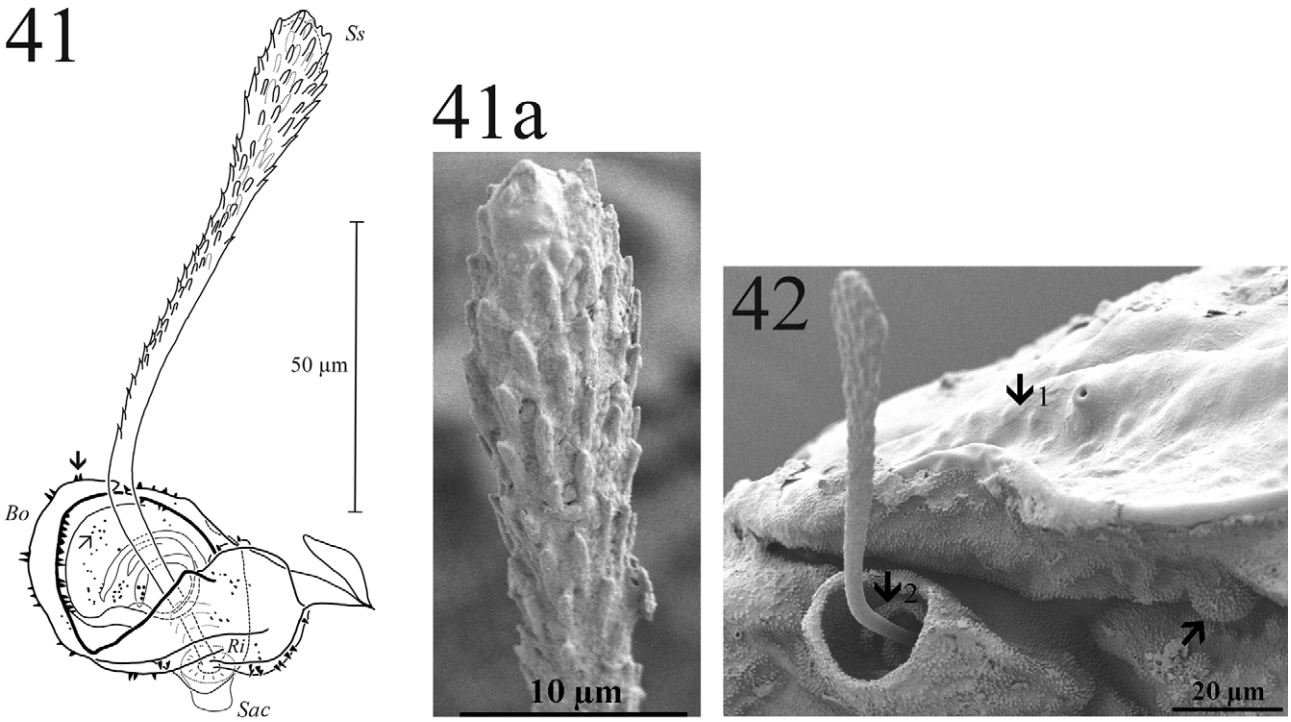
Another observation concerns the already proven sexual dimorphism in the genus *Scutovertex*. Two protonymphal individuals from the same sampling time showed a significant difference in their body size. It can be speculated that possibly already in juvenile stages sexual size dimorphism is determined.



FIGURES 32–36. *S. pannonicus* adult. **32**, habitus; dorsal view. **33**, cerotegument in notogastral fovea. **34**, cerotegument on boarder of acetabulum. **35**, cerotegument of inner side of trichobothrium. **36**, detached cerotegumental layer from an upside down view.



FIGURES 37–40. *S. pannonicus* adult. **37**, prodorsum; dorsal view; keel-like structure in the middle; slit like structure near lenticulus (arrow). **38**, Prodorsum; slit-like structure (arrow). **39**, habitus; lateral view; on right side part with prodorsum, trichobothrium, lyrifissure (*ia*), v-shaped tutorium (arrow), pedotecta, acetabula I-IV; on left side hysterosoma. **40**, frontal view with circular ridge on rostrum (arrow).



FIGURES 41, 41a, 42. *S. pannonicu*s adult. **41**, trichobothrium; cerotegument (arrows). **41a**, distal end of sensillus. **42**, lyrifissure (*ia*) (arrow); amorphous secretion layer (arrow 1); rigdes on inner wall of bothridium (arrow 2).

Ontogenetic character transformation. During the development from larva to adult some morphological changes and regressions become noticeable.

(1) Regression of setae happens within interlamellar and exobothridial setae which disappear in adult completely. Also notogastral setae *da*, *lm*, c_1, and in most cases c_3 disappear in adult. Concerning seta c_3 it is to note, that also Schuster (1958) mentioned that the occurrence of this seta is very rare in general. The leg setae *d* coupled with solenidia on tibia and genu I-IV in the juveniles are reduced in the adult stage, too.

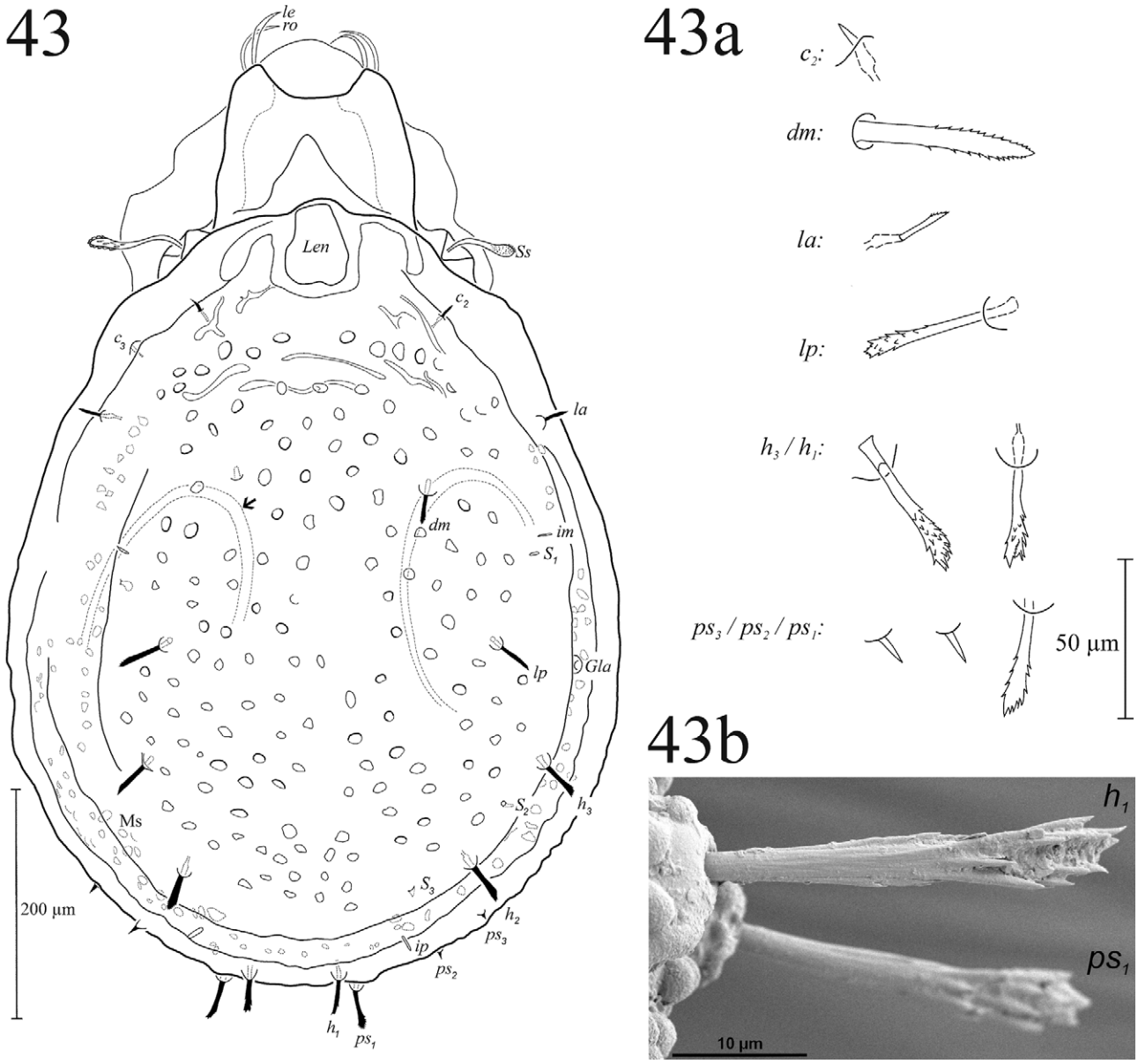
(2) The lamellar setae change from short and acute to long, spiniform-serrated setae.

Another change can be noticed on tibia I where setae *l'* and *l"* transform from shorter slightly broadened and strongly serrated to longish, still strongly serrated setae. These setae are very useful for the differentiation between species of juvenile *Scutovertex*. The rostral setae change from straight forwarded spiniform-serrated setae to long and spiniform-serrated setae strongly curved inwards. These setae could also be another character for the differentiation between *Scutovertex*-species. For example in *S. sculptus* (Pfingstl *et al.* 2008) these setae are mentioned to be lanceolate-serrate at least in the deuto- and tritonymph, in *S. minutus* (Schäffer & Krisper 2007) the same setae are described being longish in shape. But not only the last two mentioned characters are useful in determination, also the shape of the tibial cone (see also Schäffer *et al.* 2008, Pfingstl *et al.* 2008, Schäffer & Krisper 2007) could probably be a structure which is different in various species and is worth being investigated.

Other setal modifications occur within some gastronotic and ventral setae. Setae h_2 in the larva are much longer and thicker than the others; from protonymphal- to tritonymphal stage they are short and acute like the other gastronotic setae. Most of the notogastral setae in adults are than long and broadened distally. All genital setae in juveniles are short and acute, in adults the genital setae are generally much longer but of different length.

Porose areas on the femora of the legs occur normally already in the larva (Grandjean 1940). But often they become visible in the protonymphal stage for the first time, and still they are often difficult to detect there. From the deutonymphal stage onwards these areas can be observed much easier. The formation of the respiratory organs of the legs in adults is different to those of the juveniles. They become true tracheae, as it is typical for the genus *Scutovertex* (Grandjean 1940).

Constant morphological characters in juveniles and adults. The discussion of the following morphological characters is necessary due to the fact that these structures are mainly left out in descriptions and remained undiscussed.



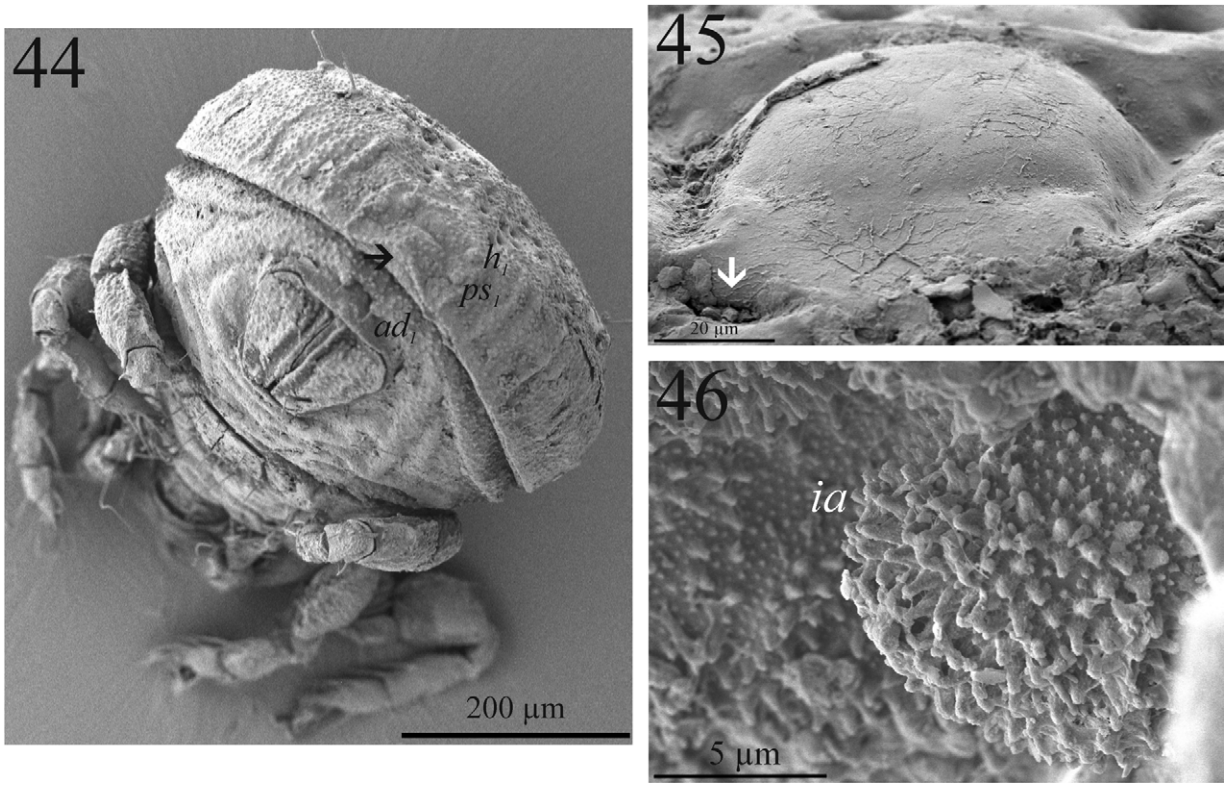
FIGURES 43, 43a–b. *S. pannonicu*s adult. **43,** habitus; eggs shining through notogastral cuticle (arrow). **43a**, setae drawn in detail of notogaster. **43b**, setae h_1 and ps_1.

The trichobothrium is very similar in juveniles and adults. The longish, distally rounded platelets of the sensillus are probably produced by the epicuticle. These platelets might be the distal ends of single strands similar to those of the brush like setae of adults e.g. h_1 (see fig. 43b).

The axillary saccule, a porose cuticular invagination, on the basis of the pedipalps was first detected in *Eupelops* by Grandjean (1936). In *S. pannonicus* it can be found in the juveniles as well as in the adults. This structure is not only present in the licneremaeoid families Scutoverticidae and Adhaesozetidae (Woas 2002), but also in representatives of Ceratozetoidea, Galumnoidea, Oribatellidae, Phenopelopidae and Unduloribatidae (Norton *et al*. 1997).

On the antiaxial side of the basis of the pedipalps a pair of supracoxal setae (epine *e*) (Grandjean 1957) also appear already in the juveniles. In comparison with the adult ones, which are clearly detectable as a kind of setae, the epines from all juvenile instars are not so distinct (see also fig. 7 compared with fig. 50)**.**

Adult morphology. The round depression posterior of acetabulum IV occurs in adults only. This structure is not so well developed in *S. minutus*. Nothing is known so far about the function of this invagination and would require a detailed histological investigation.



FIGURES 44–46. *S. pannonicu*s adult. **44**, caudal view with boss (arrow). **45**, frontal view of lenticulus with slit-like structure (arrow). **46**, bump, covered by cerotegument, bearing lyrifissure *ia* under humeral projection.

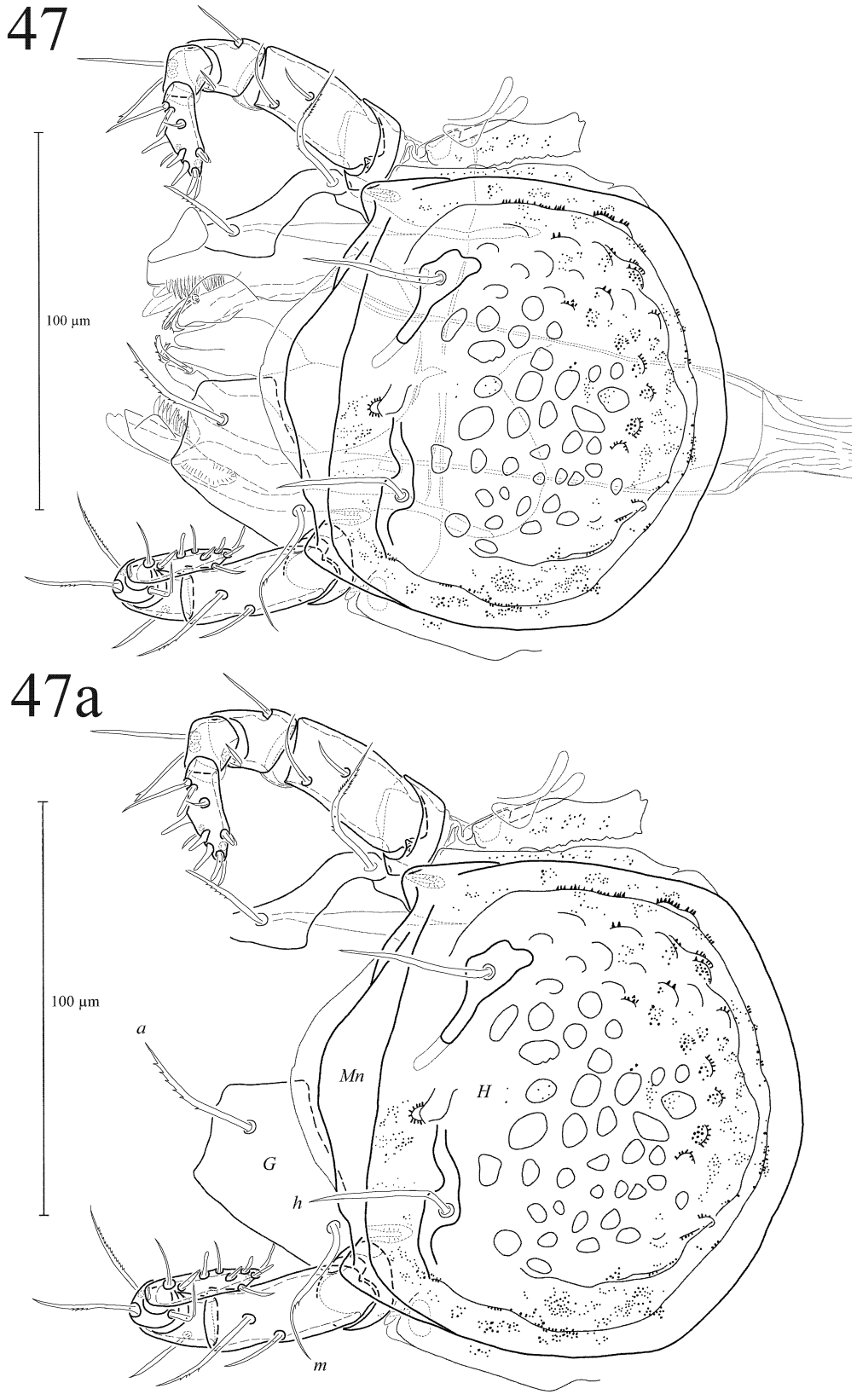
On the prodorsum the median Y-shaped elevation varies a bit concerning its length. Schuster (1958) described this structure reaching the translamella but the reinvestigation of the slides of the collection Schuster revealed that the end of the elevation comes relatively close to the translamella but do never reach it. *S. arenoculus* shows as well such a Y-shaped prodorsal elevation (Pfingstl *et al.* 2009).

The lenticulus is mentioned to be a part of the notogaster (Krantz & Walter 2009, Alberti & Coons 1999). After preparations for a detailed drawing of the prodorsum it was detected that a part of the lenticulus was separated and seemed to be attached firmly at the prodorsum. This part could perhaps be the cornea, according to the composition of the lenticulus of *Hydrozetes lemnae* (Alberti & Coons 1999). The tight connection between the cornea and the prodorsum could point to a prosomal origin of the cornea in *Scutovertex*.

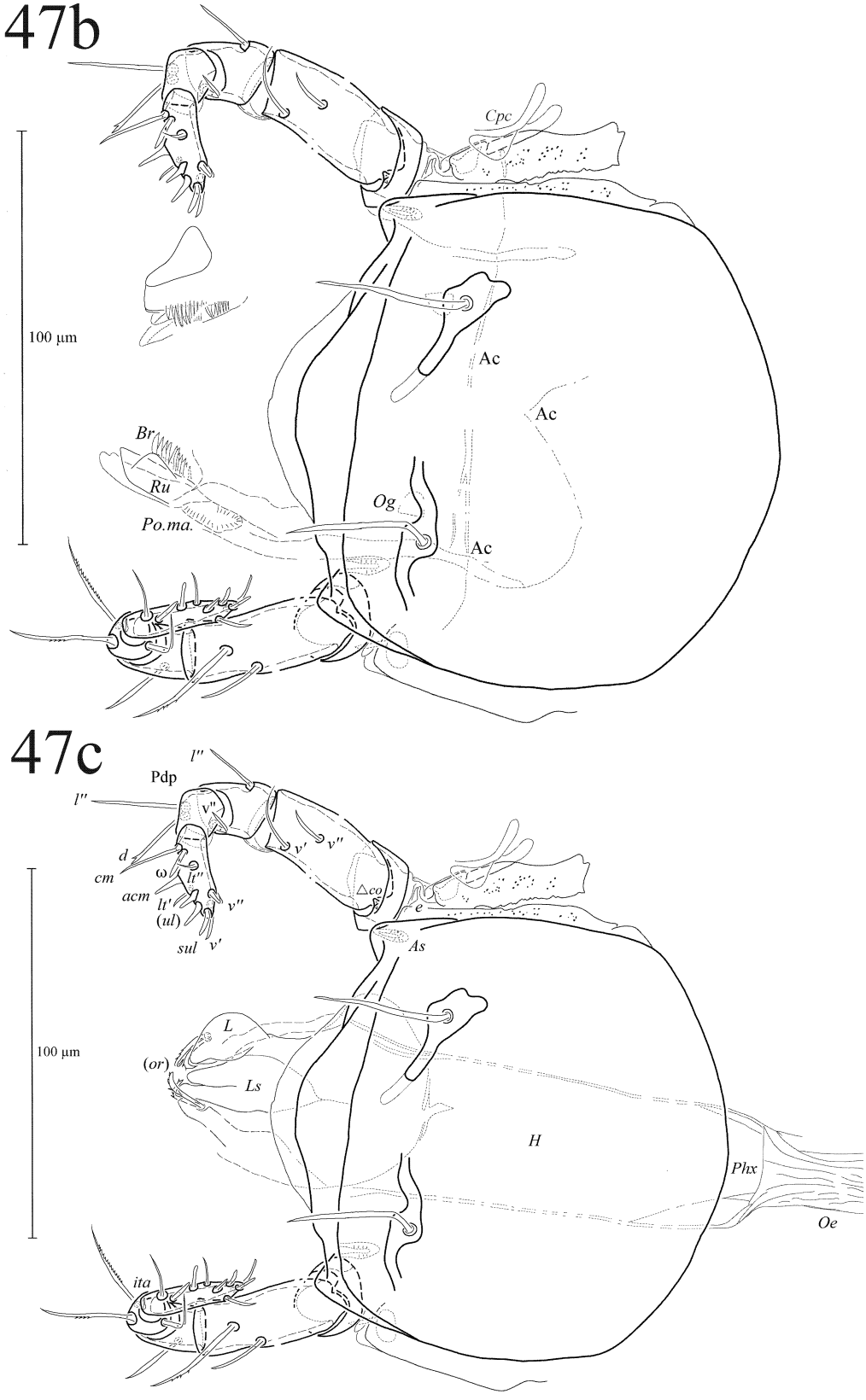
The respiratory organs on the legs are termed as a trochantero-femoral system. In the genus *Scutovertex* these respiratory organs in adults are developed as true tracheae.

Grandjean (1940) published a detailed description of the position and form of the tracheae in femur I-IV and trochanter III-IV for *S. minutus*. These leg tracheae are quite similar in *S. pannonicus*. In *S. minutus* (Grandjean 1940) as well as in *Aquanothrus* (Norton *et al*. 1997) the long branch of the femoral trachea in femur III and IV normally reaches the tibia but sometimes also the tarsus. In *S. pannonicus* the individual variation in the lengths of the long as well as the short branches is very high. The long branch reaches the tarsus not only in leg III and IV but also in leg I and II. Sometimes it reaches even almost the anterior half of the tarsus. There is not only a variation between single individuals, there is also a difference within one individual between the left and right leg. This case seems to be the only one known until now because in no other species within *Scutovertex* it was noticed that the trachea would also reach the tarsus in leg I and II.

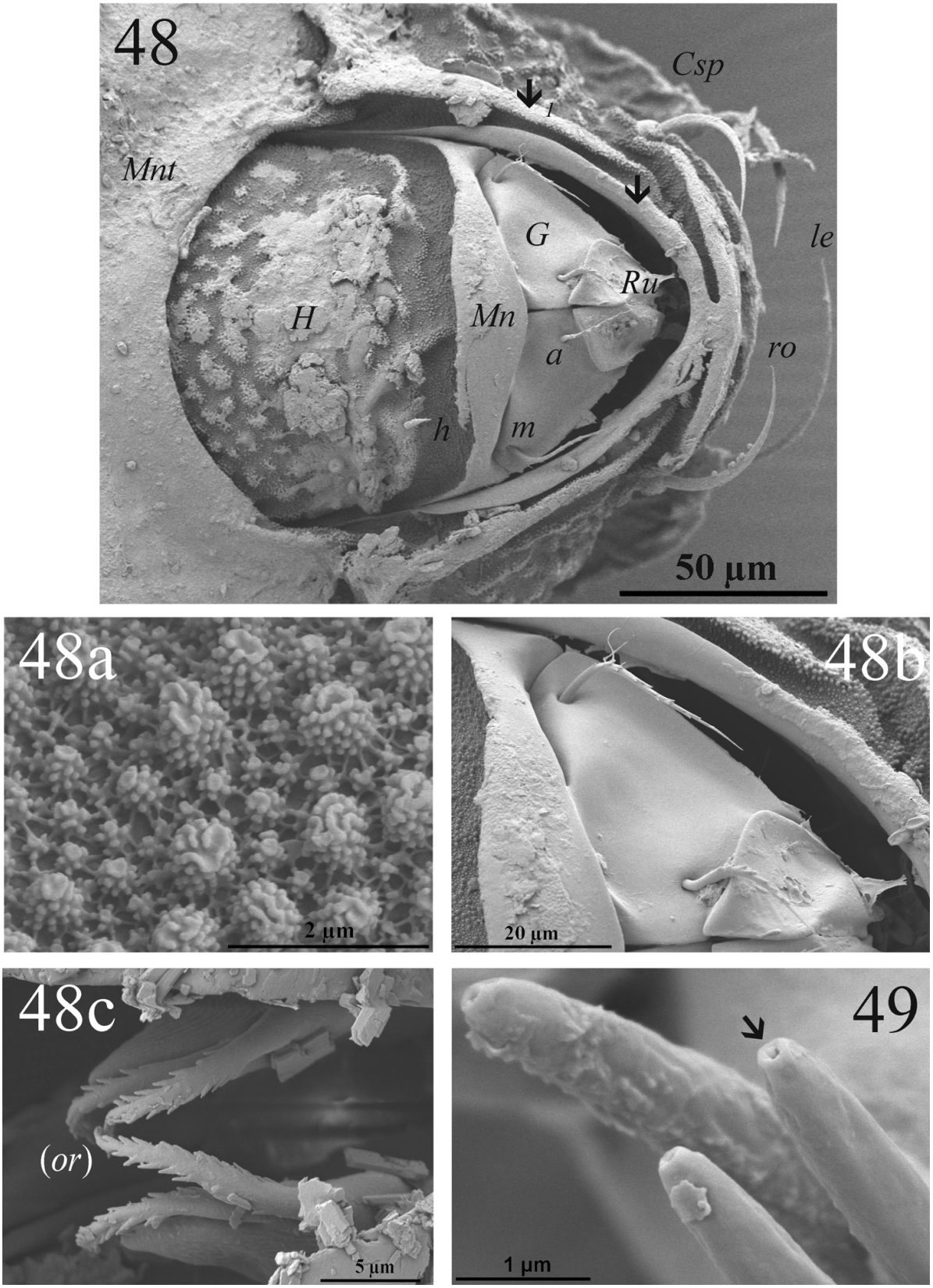
The ovipositor of *S. pannonicus* has the same general structural design as described for instance for *Heminothrus targionii* or *Eremaeus hepaticus* (Grandjean 1956a); such characters are the three pairs of setae (*k*) around the circular fold of the contractile, plicate tube, the three eugenital lobes with four pairs of eugenital setae on each lobe and with the distal setae on the lobes longer than the others (also mentioned in Wallwork 1977). Grandjean (1956a) reports that the setae *k* are not as constant as the setae on the lobes. For example *Nothrus silvestris* (Grandjean 1956a) with two pairs of *k*-setae, *Machadobelba symmetrica* (Wallwork 1977) with no *k*-setae, and *Fortuynia atlantica* (Krisper & Schuster 2008) with 16-18 *k*-setae. Also the form and length of the lobes or the tube itself are variable between species.



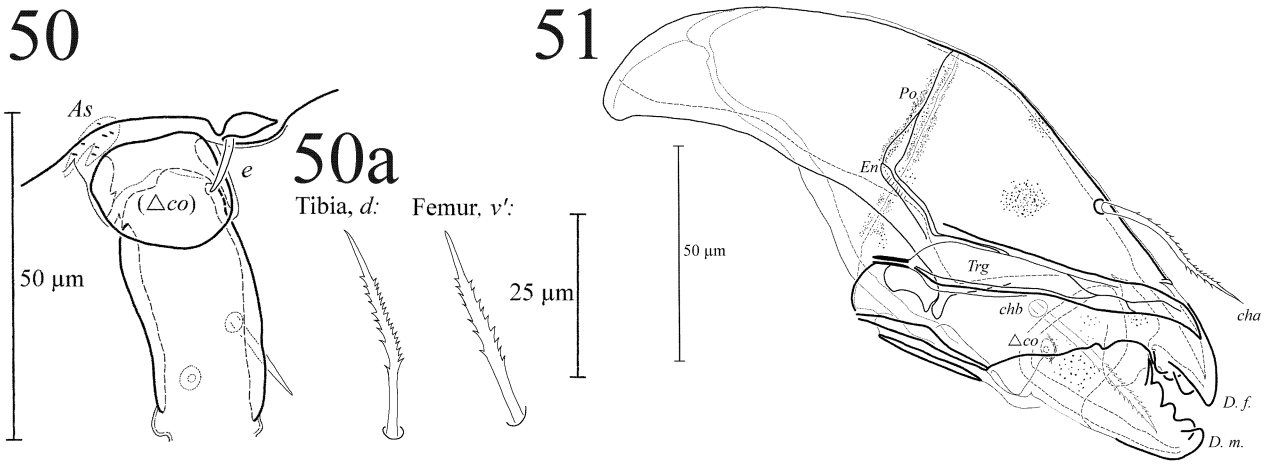
FIGURES 47, 47a. *S. pannonicu*s adult. **47**, complete overview of subcapitulum with pedipalps. **47a**, mentum with cerotegument and setae; mental tectum; gena with setae.



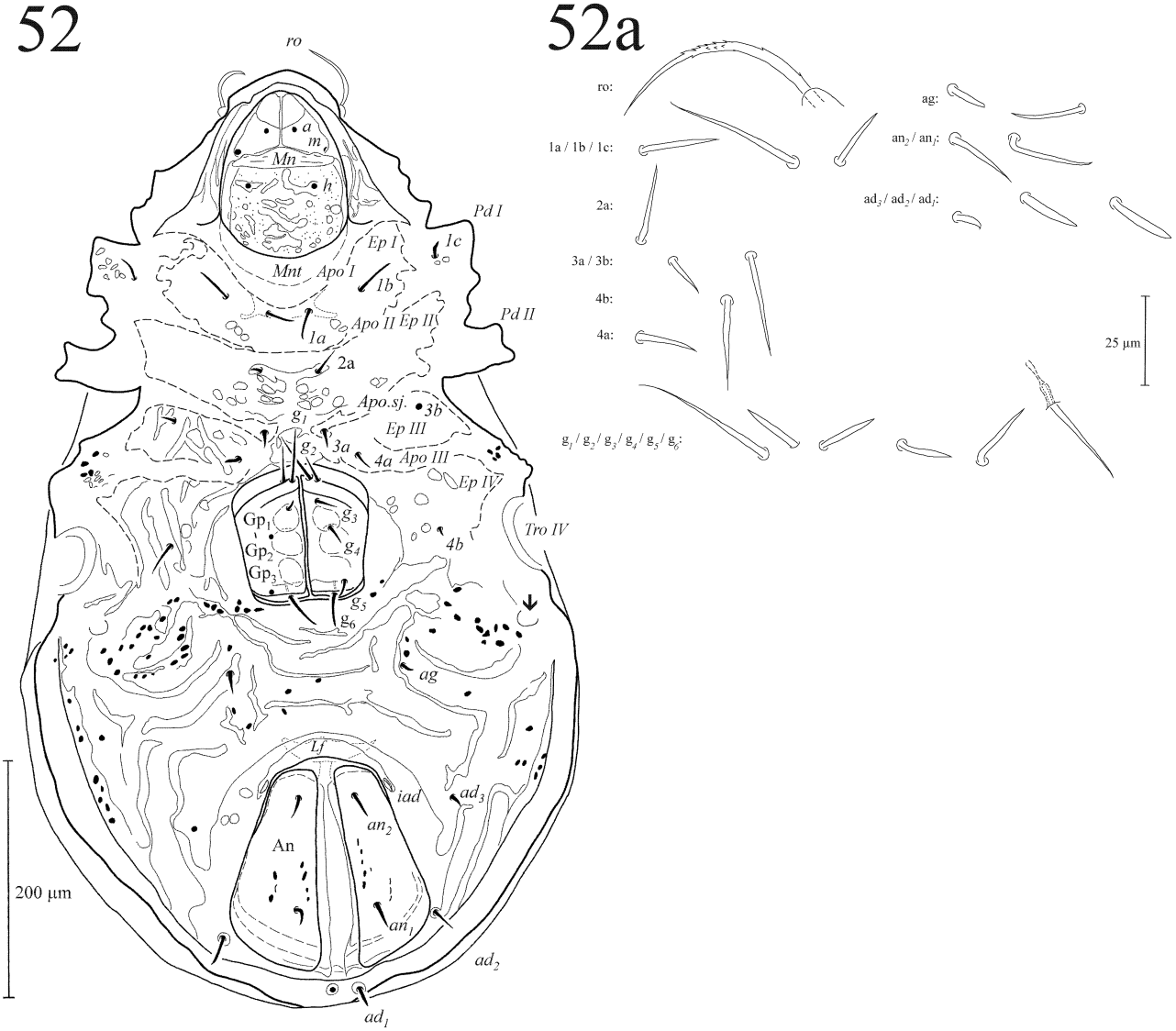
FIGURES 47b, 47c. *S. pannonicu*s adult. Mentum without cerotegument. **47b**, capitular apodeme; openings subcapitular gland; rutella with brush and manubrial porose area; podocephalic canal. **47c**, pharynx; oesophagus; lateral- and upper lip with two pairs of adoral setae; pedipalp.



FIGURES 48, 48a–c, 49. *S. pannonicu*s adult. **48**, subcapitulum overview; boarder of camerostome (arrow); triangular longish lamella (arrow 1). **48a**, cerotegument in groove between mentum and mental tectum. **48b**, right gena. **48c**, two pairs of adoral setae. **49**, eupathidial setae of pedipalp with terminal porus (arrow).



FIGURES 50, 50a, 51. *S. pannonicu*s adult. **50**, basis of pedipalp with axillary saccule, epine and a pair of condyli. **50a**, setae drawn in detail of tibia and femur of pedipalp. **51**, left chelicera; paraxial view.



FIGURES 52, 52a. *S. pannonicu*s adult. **52**, habitus; ventral view; round depression near trochanter IV (arrow). **52a**, setae drawn in detail of epimeral- and anogenital region.

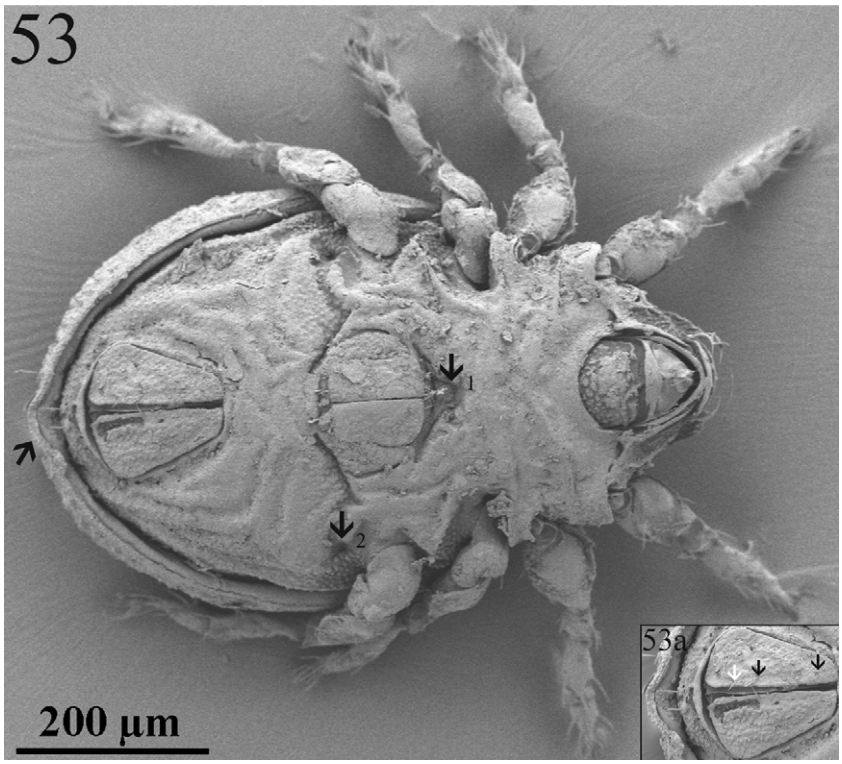
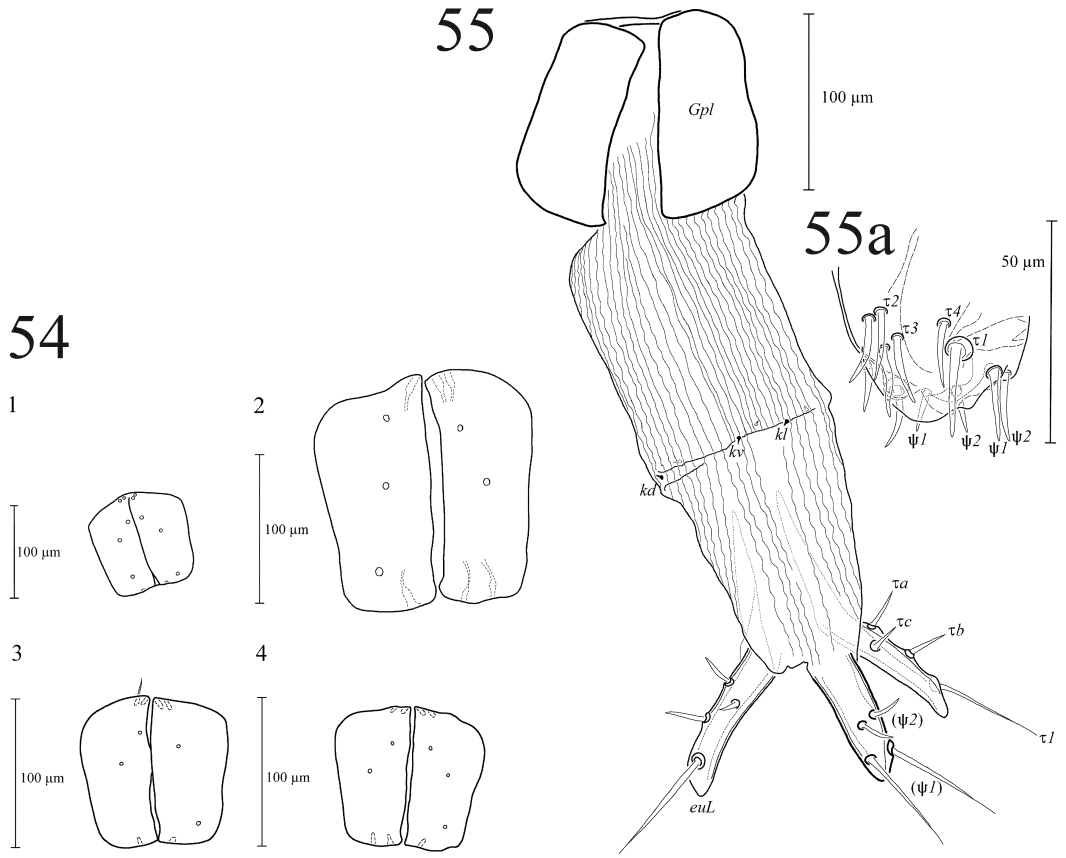
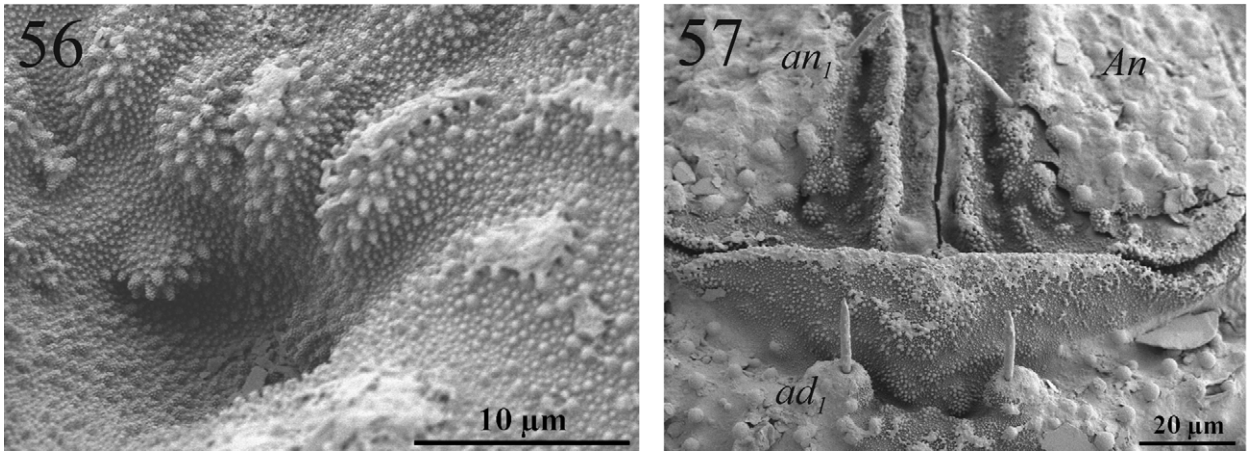


FIGURE 53. *S. pannonicus* adult. **53,** habitus; ventral view; boss caudal (arrow); deep and rounded groove anteriorly of genital plate (arrow 1); round depression near trochanter IV (arrow 2). **53a**, white arrow: individual variation of anal setae with an additional third one; black arrows: normal setae an_1 and an_2



FIGURES 54–55. *S. pannonicus* adult. **54**, variation of number and position of setae of genital plates of different individuals. **1**, left and right side six setae. **2**, left: five setae; right: six setae. **3**, left and right side five setae. **4**, left and right six setae. **55**, ovipositor. **55a**, distal part of spermatopositor.



FIGURES 56–57. *S. pannonicu*s adult. **56**, round depression near trochanter IV. **57**, anal plate; caudal view; with setae ad_1.

The spermatopositor is a very delicate structure and not always well detectable. The general habitus of the spermatopositor of *S. pannonicus* could not be described but the arrangement of the setae was visible. It is similar to *Ameronothrus lineatus* (Schubart 1975) because there are only six pairs of eugenital setae too: four pairs of setae $\tau_{1\text{-}4}$ and two pairs of setae $\psi_{1\text{-}2}$. In *Damaeus onustu*s (Grandjean 1956b) for example a seventh pair (*kx*) is developed.

Acknowledgments

We want to thank the administration of the National park 'Neusiedler See – Seewinkel' for the permission of collecting soil, moss, and grass samples directly in the protected areas. Special thanks also to Ferdinand Hofer, head of the research institute of Electron Microscopy at the Technical University of Graz, and to Christof Elis for realizing the SEM – micrographs. Some material for this study was kindly provided by Reinhart Schuster, Tobias Pfingstl, and Sylvia Schäffer. This work was supported by the Austrian Science Foundation (FWF, project number P19544-B16).

References

Alberti, G. & Coons, L.B. (1999) Acari: Mites. *In*: Harrison, F.W. & Foelix, R.F. (Eds), *Microscopic Anatomy of Invertebrates, Volume 8C, Chelicerate Arthropoda*. Wiley-Liss Inc. New York, pp. 515–1215.

Alberti, G., Storch, V. & Renner, H. (1981) Über den feinstrukturellen Aufbau der Milbencuticula (Acari, Arachnida). *Zoologische Jahrbücher. Abteilung für Anatomie und Ontogenie der Tiere*, 105, 183–236.

Grandjean, F. (1936) Les Oribates de Jean Frédéric Hermann et de son père (Arachn. Acar.). *Annales de la Société Entomologique de France*, 105, 27–110.

Grandjean, F. (1940) Observations sur les Oribates (14e série). *Bulletin du Muséum nationale d'Histoire Naturelle Paris* (2), 12, 161–169, figs. 1–3.

Grandjean, F. (1954) Observations sur les Oribates (31e série). *Bulletin du Muséum nationale d'Histoire Naturelle Paris* (2), 26, 582–589.

Grandjean, F. (1955) Sur un Acarien des îles Kerguélen. *Podacarus auberti* (Oribate). *Memoires du Museum National d'Histoire naturelle. (n.s.), série A, Zoologie*, 8, 109–150.

Grandjean, F. (1956a) Caractères chitineux de l'ovipositeur, en structure normale, chez les oribates (Acariens). *Archives de Zoologie experimentale et generale*, 93, *Notes et Revues*, 2, 96–106.

Grandjean, F. (1956b) Observations sur les Oribates (34e série). *Bulletin du Muséum nationale d'Histoire Naturelle Paris* (2), 28, 205–212.

Grandjean, F. (1957) Observations sur les Oribates (37e série). *Bulletin du Muséum nationale d'Histoire Naturelle Paris* (2), 29, 88–95.

Krantz, G.W. & Walter, D.E. (2009) *A manual of Acarology.* 3rd edition. Texas Tech University Press, Lubbock, Texas, 807 pp.

Krisper, G. & Schuster, R. (2008) *Fortuynia atlantica* sp. nov., a thalassobiontic oribatid mite from the rocky coast of the Bermuda Islands (Acari: Oribatida: Fortuynidae). *Annales Zoologici (Warszawa)*, 58, 419–432. http://dx.doi.org/10.3161/000345408X326753

Krisper, G., Pfingstl, T. & Ebermann, E. (2008) SEM-Investigations on the exochorion of scutoverticid eggs. *Soil Organisms*, 80, 217–221.

Norton, R.A. (1977) A review of F. Grandjean's system of leg chaetotaxy in the Oribatei and its application to the Damaeidae. *In*: Dindal, D. L. (Ed), *Biology of Oribatid Mites*. State University of New York, Syracuse, New York, pp. 33–62.

Norton, R.A., Alberti, G., Weigmann, G. & Woas, S. (1997) Porose integumental organs of oribatid mites (Acari, Oribatida): 1. Overview of types and distribution. *Zoologica (Stuttgart)*, 146, 1–31.

Norton, R.A., Behan-Pelletier, V. & Wang, H.-F. (1996) The aquatic oribatid mite genus *Mucronothrus* in Canada and the Western U.S.A (Acari: Trhypochthoniidae). *Canadian Journal of Zoology*, 74, 926–949. http://dx.doi.org/10.1139/z96-106

Oliveira, A.R., Norton, R.A., de Moraes, G.J. & Faccini, J.L.H. (2007) Preliminary observations on courtship behavior in *Mochloribatula* (Oribatida: Mochlozetidae). *In*: Morales-Malacara, J.B., Behan-Pelletier, V., Ueckermann, F., Pérez, T.M., Estrada-Venegas, E.G. & Badii, M. (Eds) *Acarology XI: Proceedings of the International Congress*. Instituto de Biologia and Facultad de Ciencias, UNAM, Sociedad Latinoamericana de Acarologia, Mexico, pp. 715–718.

Pfingstl, T., Schäffer, S., Ebermann, E. & Krisper, G. (2008) Intraspecific morphological variation of *Scutovertex sculptus* Michael (Acari: Oribatida: Scutoverticidae) and description of its juvenile stages. *Zootaxa*, 1829, 31–51.

Pfingstl, T., Schäffer, S., Ebermann, E. & Krisper, G. (2009) Differentiation between two epilittoral species, *Scutovertex arenocolus* spec. nov. and *Scutovertex pilosetosus* Poldermann (Acari: Oribatida) from different European coasts. *Zootaxa*, 2153, 35–54.

Polderman, P.J.G. (1977) *Scutovertex pilosetosus* nov. spec. from the Netherlands (Acari, Oribatida). *Entomologische Berichten, Amsterdam*, 37, 129–132.

Raspotnig, G. (2006) Chemical alarm and defence in the oribatid mite *Collohmannia gigantea* (Acari: Oribatida). *Experimental and Applied Acarology*, 39, 177–194. http://dx.doi.org/10.1007/s10493-006-9015-4

Schäffer, S. & Krisper, G. (2007) Morphological analysis of the adult and juvenile instars of *Scutovertex minutus* (Acari, Oribatida, Scutoverticidae). *Revue Suisse de Zoologie*, 114, 663–683.

Schäffer, S., Krisper, G., Pfingstl, T. & Sturmbauer, C. (2008) Description of *Scutovertex pileatus* sp. nov. (Acari, Oribatida, Scutoverticidae) and molecular phylogenetic investigation of congeneric species in Austria. *Zoologischer Anzeiger*, 247, 249–258. http://dx.doi.org/10.1016/j.jcz.2008.02.001

Schubart, H. (1975) Morphologische Grundlagen für die Klärung der Verwandtschaftsbeziehungen innerhalb der Milbenfamilie Ameronothridae (Acari, Oribatei). *Zoologica*, 123, 23–91.

Schuster, R. (1958) Beitrag zur Kenntnis der Milbenfauna (Oribatei) in pannonischen Trockenböden. *Sitzungsberichte der Österreichischen Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse*, Abteilung 1, 167, 221–235.

Schuster, R. (1959) Ökologisch-faunistische Untersuchungen an bodenbewohnenden Kleinarthropoden (speziell Oribatiden) des Salzlachengebietes im Seewinkel. *Sitzungsberichte der Österreichischen Akademie der Wissenschaften, mathematisch-naturwissenschaftliche Klasse*, Abteilung 1, 168, 27–78.

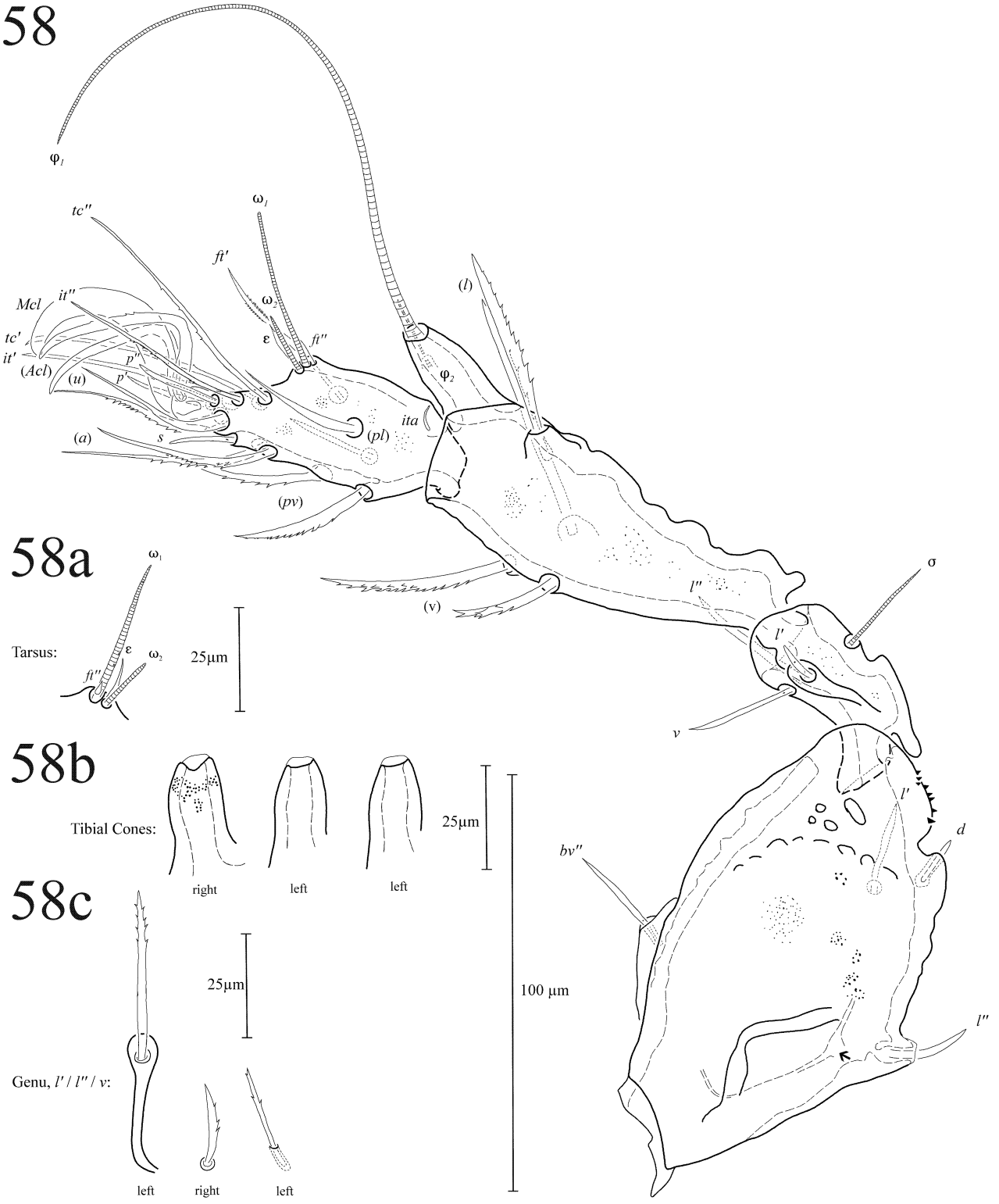
Schuster, R. (1997) Type material of soil mite species described in the period 1957–1965. *EURAAC Newsletter*, 9 (2/3), 4–8.

Shtanchaeva, U.Ya. & Netuzhilin, I.A. (2003) A Review of the world fauna of Scutoverticidae Oribatid Mites (Acari, Oribatida) with description of new species. *Zoologicheskii-Zhurnal*, 82, 781–803.

Søvik, G. (2004) The biology and life history of arctic populations of the littoral mite *Ameronothrus lineatus* (Acari, Oribatida). *Experimental and Applied Acarology*, 34, 3–20. http://dx.doi.org/10.1023/B:APPA.0000044436.80588.96

Wallwork, J.A. (1977) The structure of the ovipositor and the mechanics of oviposition in the oribatid mite *Machadobelba symmetrica* Bal. (Acari: Cryptostigmata). *Acarologia*, 19, 149–154.

Woas, S. (2002) Acari: Oribatida. *In*: Adis, J. (Ed), *Amazonian Arachnida and Myriapoda. Identification keys to all classes, orders, families, some genera, and lists of known terrestrial species*. Pensoft Series Faunistica No 24, Sofia, pp. 21–291.



FIGURES 58, 58a–c. *S. pannonicus* adult. **58**, left leg I; antiaxial view; without trochanter; arrow indicates stigma of trachea in proximal part of femur. **58a**, in detail drawn solenidia-group on tarsus I. **58b**, tibial cones from different individuals. **58c**, setae drawn in detail of genu I.

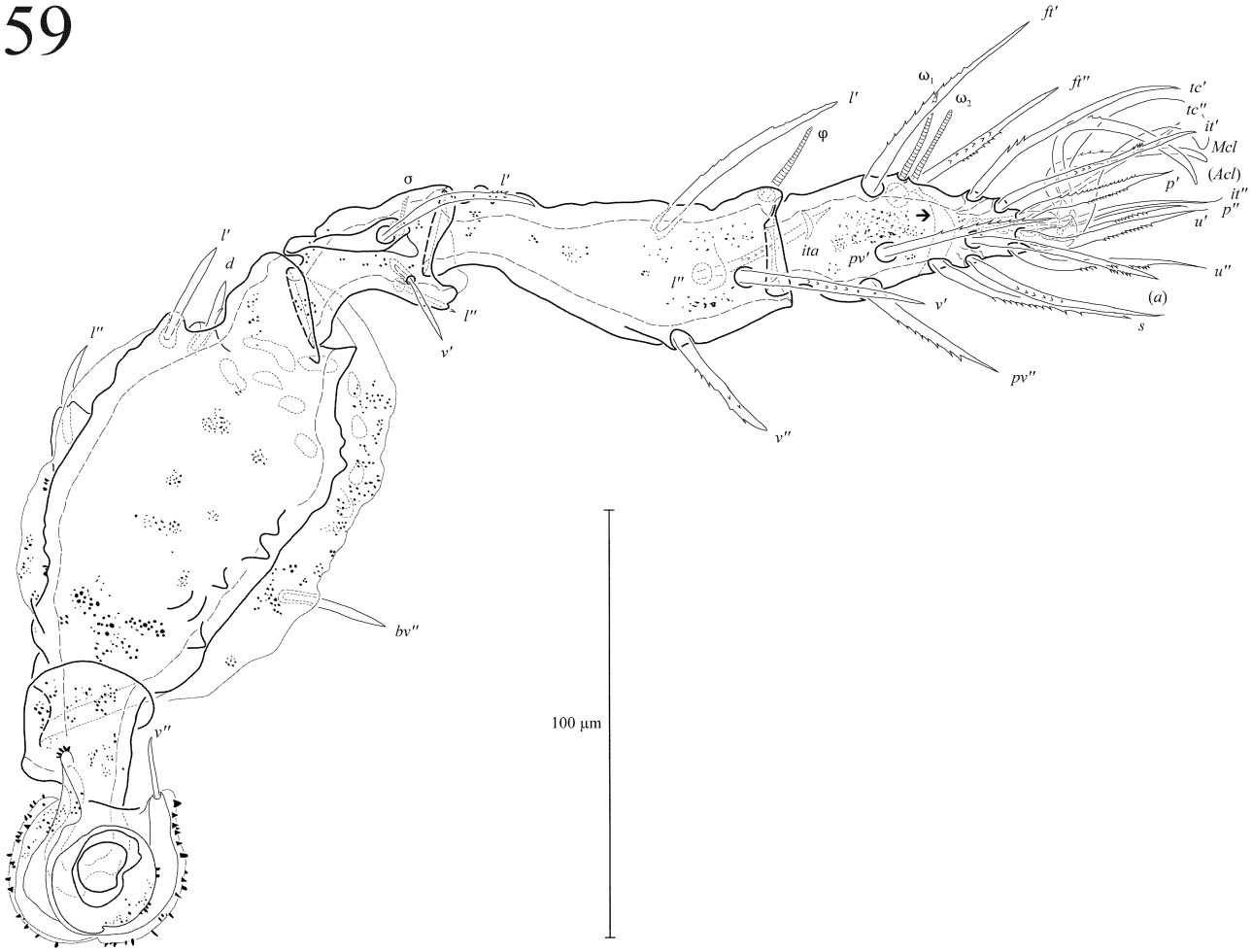


FIGURE 59. *S. pannonicus* adult, left leg II; ventro-paraxial view; with trochanter; tarsus with transverse ridge (arrow).

60

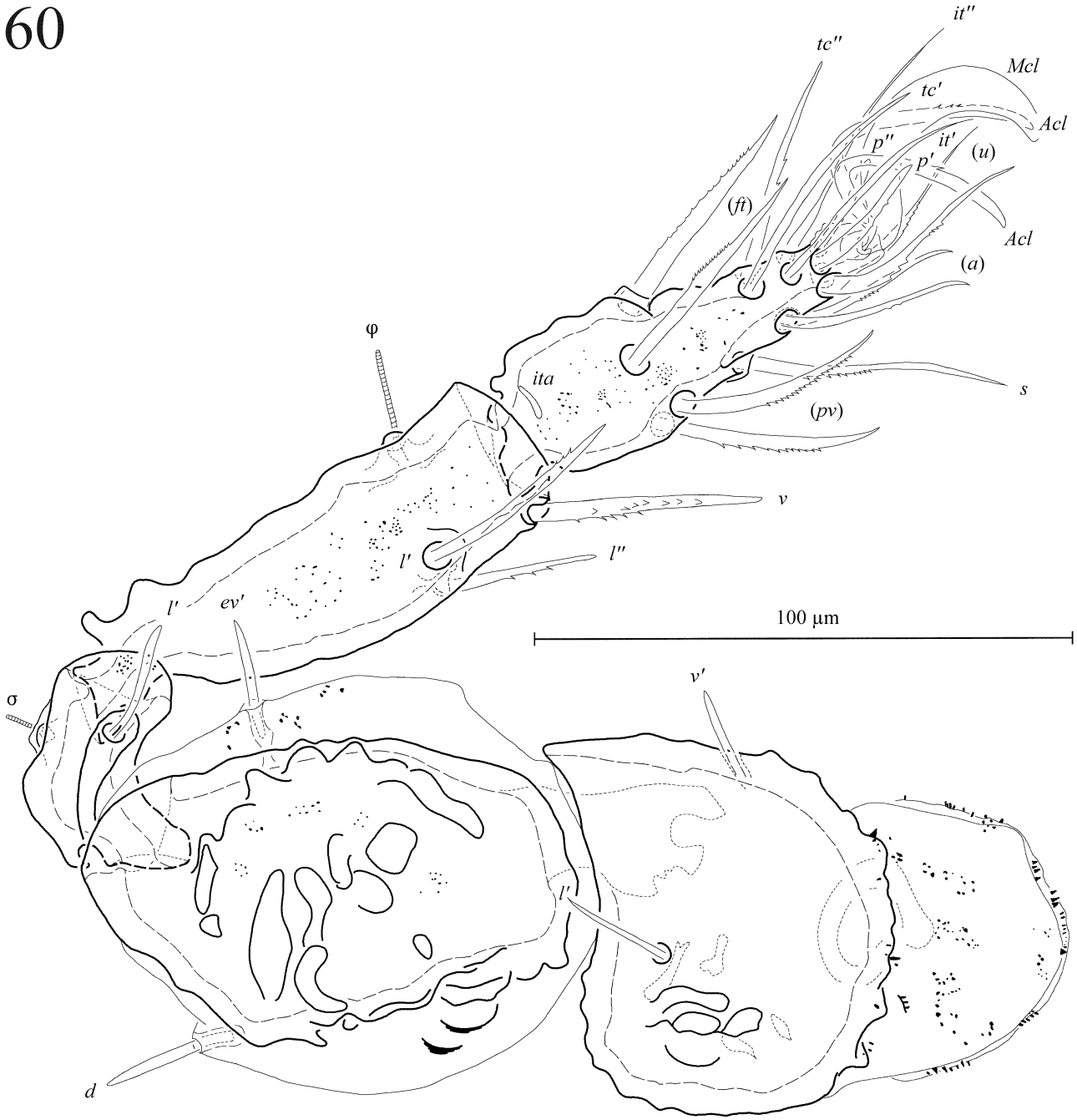
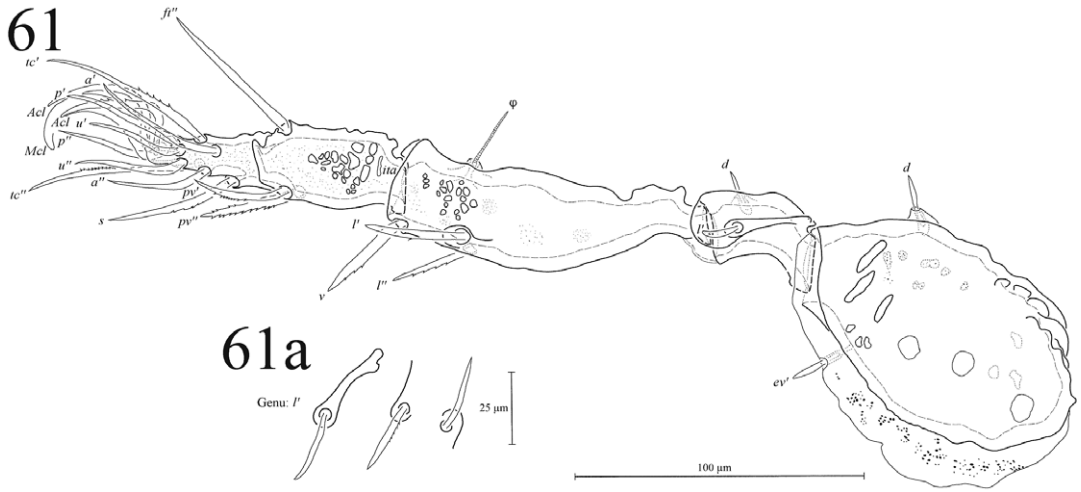
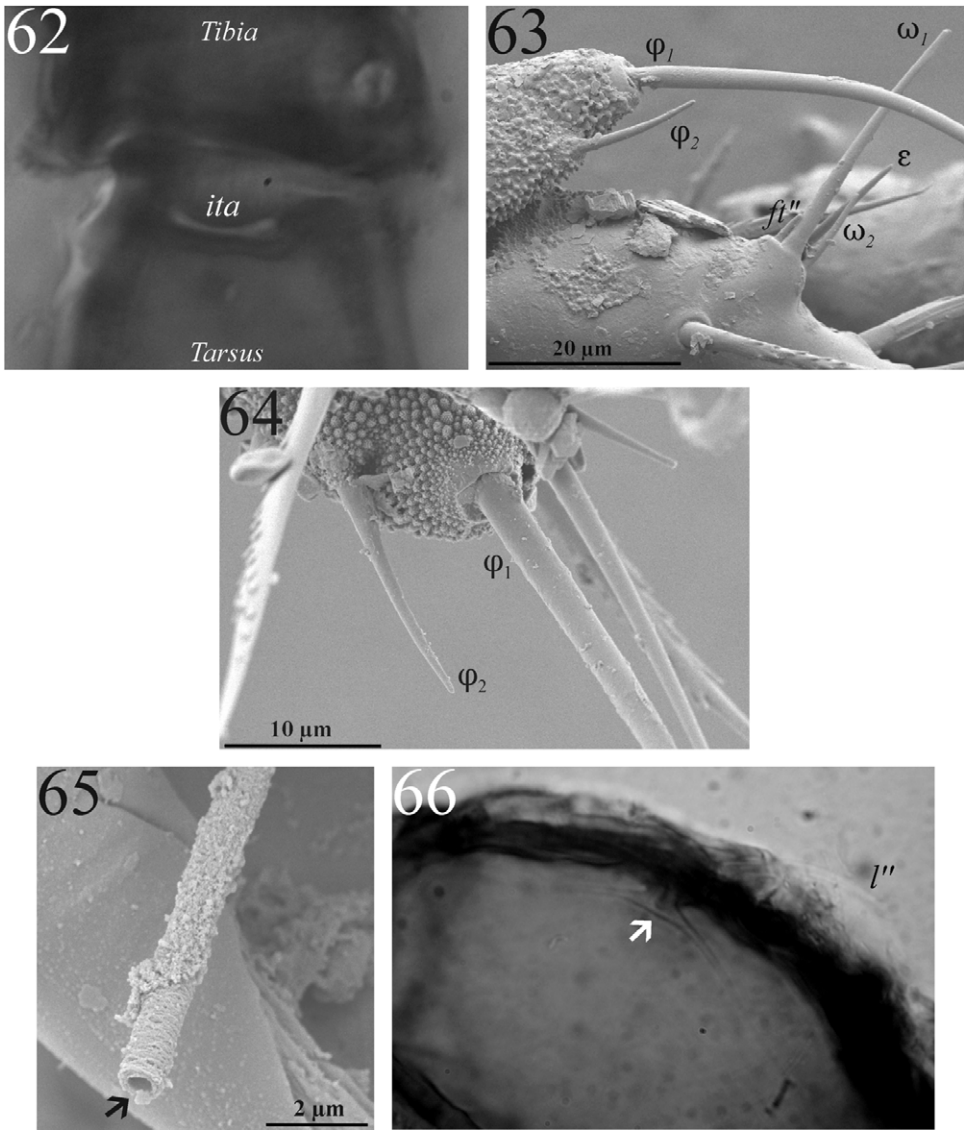


FIGURE 60. *S. pannonicu*s adult, left leg III; antiaxial view.



FIGURES 61, 61a. *S. pannonicu*s adult. **61**, right leg IV; ventro-antiaxial view; trochanter omitted. **61a**, seta *l'* drawn in detail of genu IV of different individuals.



FIGURES 62–66. *S. pannonicu*s adult. **62**, lyrifissure *ita* on tarsus I (microphotograph). **63**, lateral view of tibial cone with φ_1 and φ_2 and tarsal solenidia-group with ω_1, ω_2, ε and *ft''*. **64**, dorsal view of tibial cone with φ_1 and φ_2. **65**, cut trachea of leg. **66**, trachea of leg I in femur originating near seta *l''*.

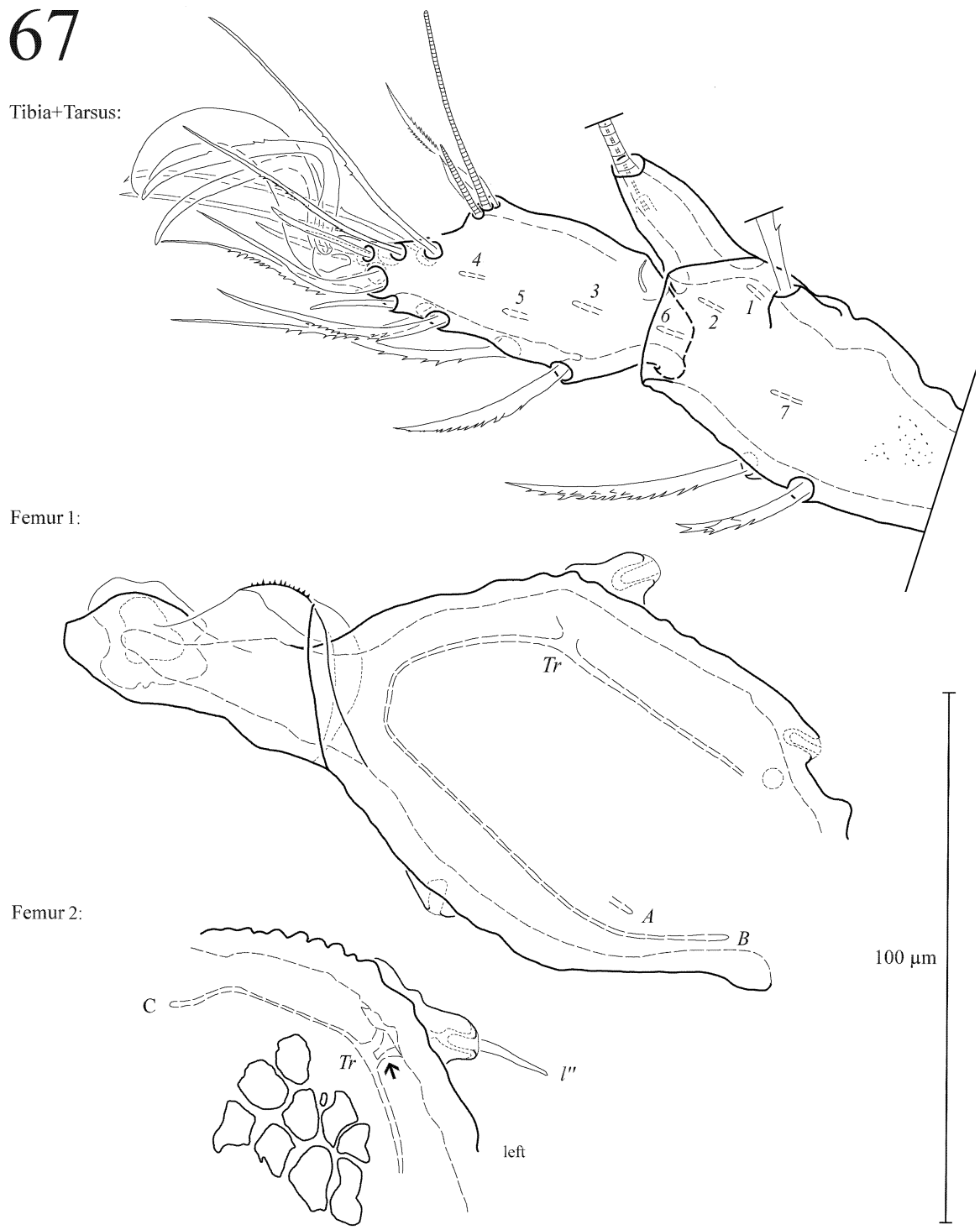


FIGURE 67. *S. pannonicus* adult, trachea leg I. Tarsus and distal half of tibia: variations of length of long branch of femoral trachea leading into tibia or tarsus (1–7); femur I: variations of length of short branch of femoral trachea (A+B); femur II: trachea originating near seta *l''* and another possible length of short branch (C). Several setae and structures omitted.

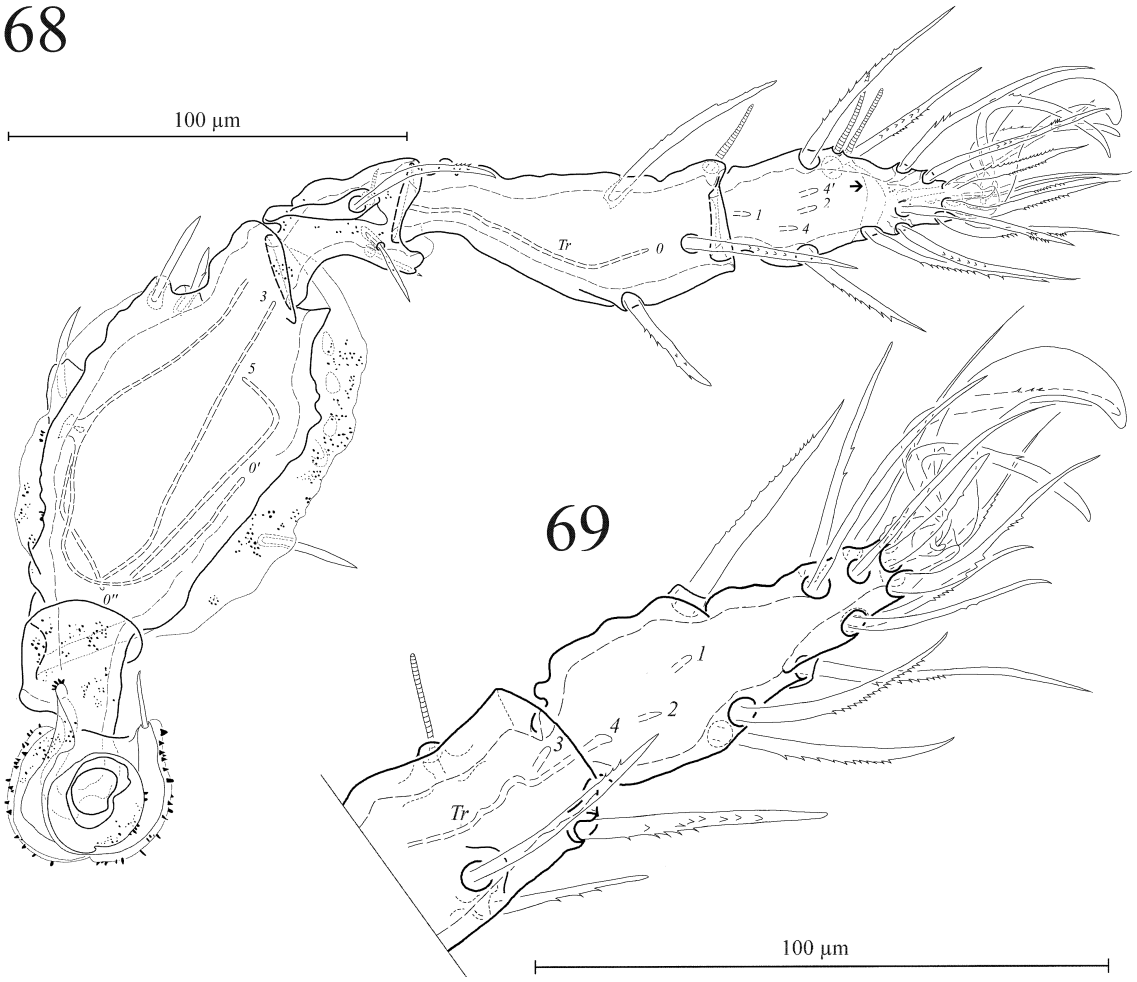
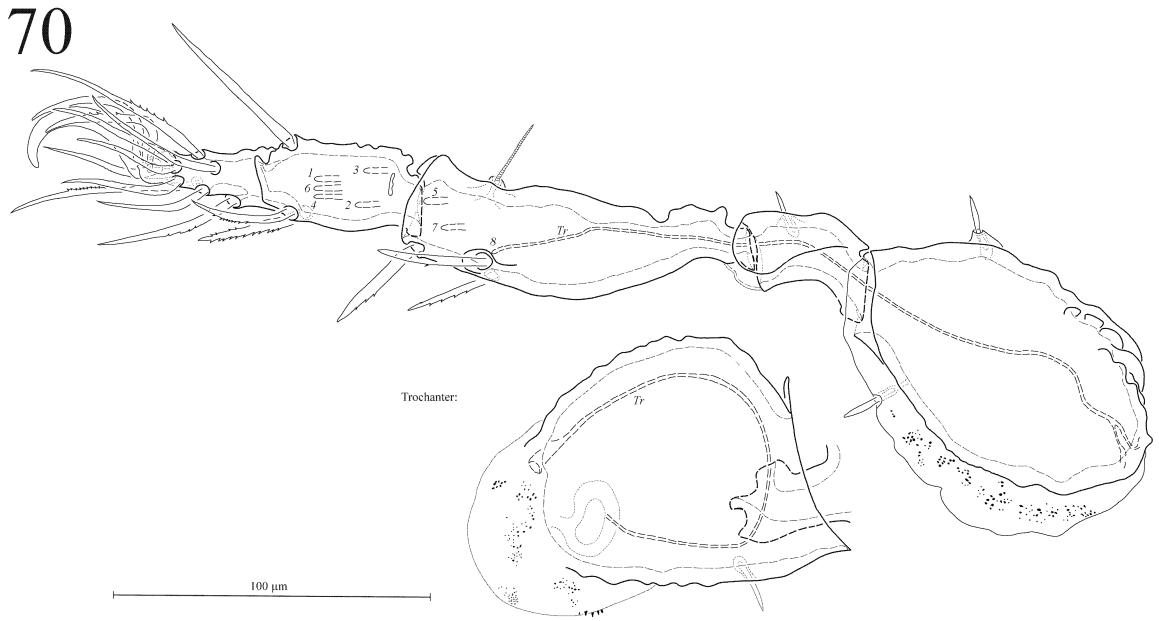


FIGURE 68. *S. pannonicus* adult. Several setae and structures omitted. **68**, trachea leg II. Same number = same individual; ‘ and “ = left and right side. Variations in length of long branch of femoral trachea leading into tibia or tarsus (0, 1, 2, 4, 4’); variations in length of short branch of femoral trachea leading around femur (0’, 0’’, 3, 5). **69**, trachea leg III. Tarsus and distal half of tibia: variations of length of long branch of femoral trachea (1–4) leading into tibia or tarsus.



FIGURES 70. *S. pannonicus* adult, trachea leg IV. Variations in length of branch of femoral trachea leading into tibia or tarsus (1–8); trochanter: trachea ending not visible. Several setae and structures omitted.

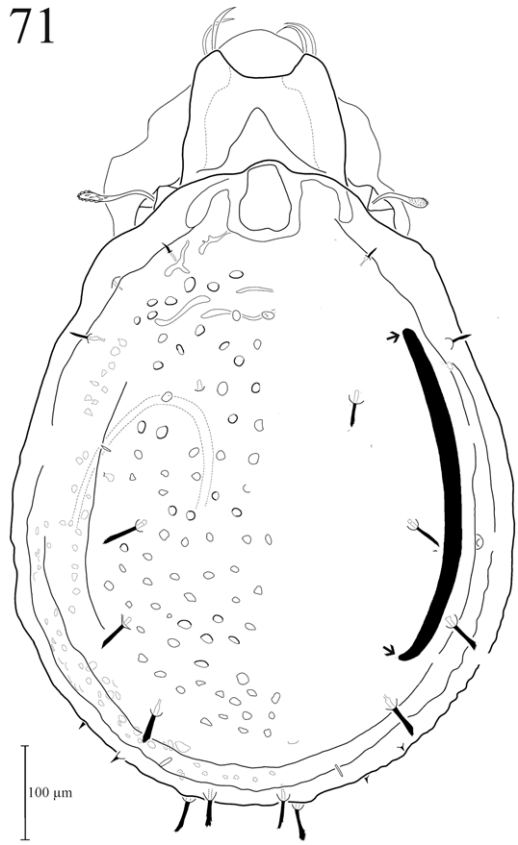


FIGURE 71. *S. pannonicus*. Dimension of the longish red oil gland as seen in freshly hatched adults; arrows point the beginning and end, drawn schematically.

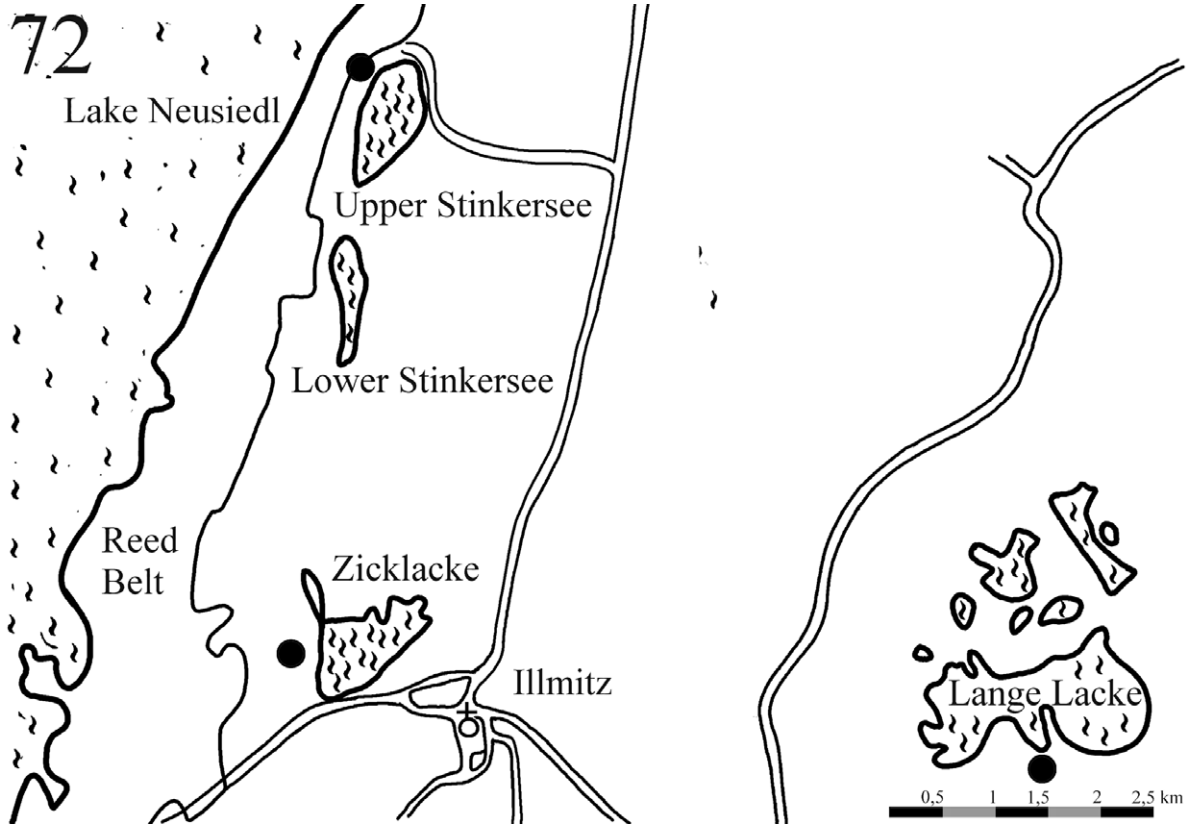


FIGURE 72. *S. pannonicus*. Overview of collecting sites (round dots) near Illmitz (Burgenland, Austria).

FIGURE 73. *S. pannonicus*. Small sand hills near lake Oberer Stinker (Burgenland, Austria). Photograph by Julia Jagersbacher-Baumann.

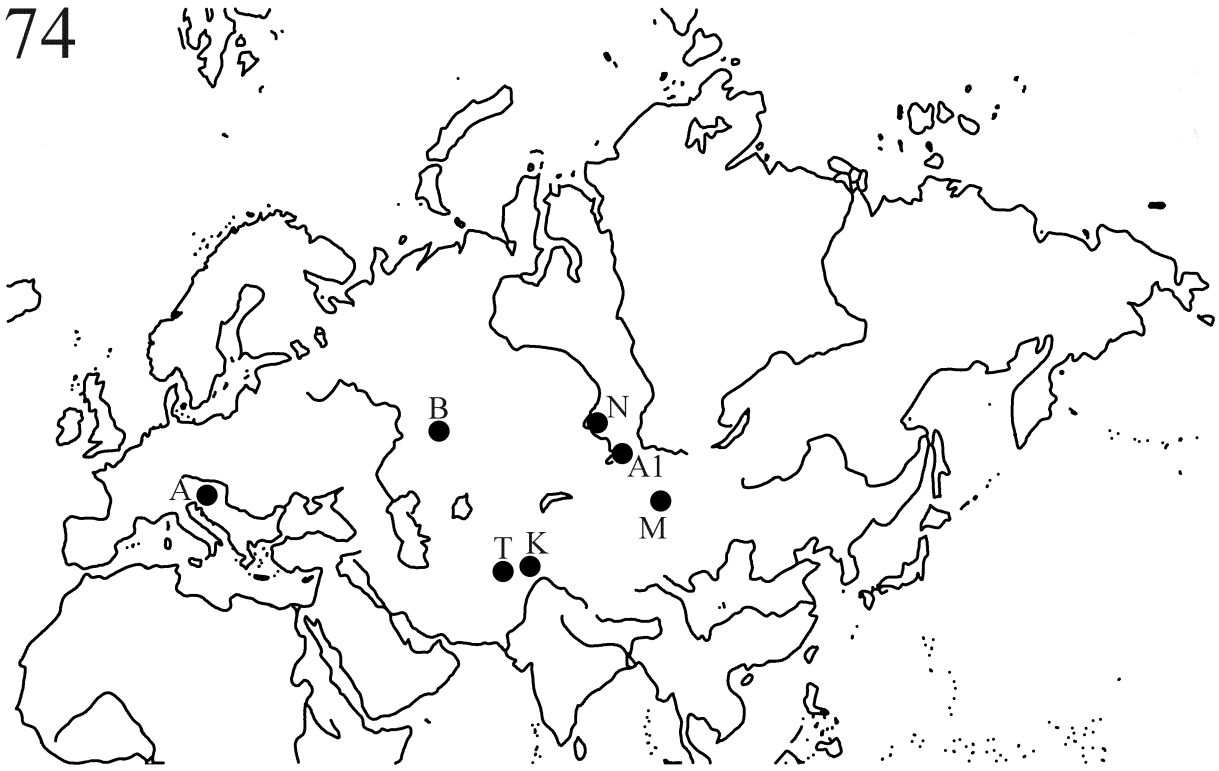


FIGURE 74. Overview of palaearctic distribution of *S. pannonicus*. **(A)** saline soil—Seewinkel Austria, **(B)** Bashkiria, **(T)** Tajikistan, **(K)** Kyrgysztan, **(N)** Novosibirsk, **(Al)** region of Altai, **(M)** Mongolia.