JUVENILE INSTARS OF *GALUMNA CURVIFAMULUS* (ACARI, ORIBATIDA, GALUMNIDAE)

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ABSTRACT: The morphology of juvenile instars of the oribatid mite *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017 (Oribatida, Galumnidae) is described and illustrated, based on the material collected from the soil and litter near Potchefstroom (South Africa). The morphological differences of ontogenetic instars of this species from *G. alata* (Hermann, 1804), *G. obvia* (Berlese, 1914) and *G. zachvatkini* Grishina, 1982 are given.

KEY WORDS: Mite, *Galumna curvifamulus*, juvenile instars, ontogeny, morphology, South Africa.

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INTRODUCTION

In the course of taxonomic studies of the oribatid mite fauna of South Africa, we found all developmental instars of *Galumna curvifamulus* in soil and litter from Potchefstroom. Adults of this species were described in detail earlier by Ermilov, Hugo-Coetzee, Khaustov et Theron (2017). The main goal of our paper is to describe and illustrate the juvenile instars.

At present, the morphology of juvenile instars in *Galumna* Heyden, 1826 is poorly investigated: partial or complete ontogeny of only nine species (including Galumna sp.) is known (Norton and Ermilov 2014). The morphological comparison of juveniles for the majority of these species was presented by Bayartogtokh and Ermilov (2017).

MATERIAL AND METHODS

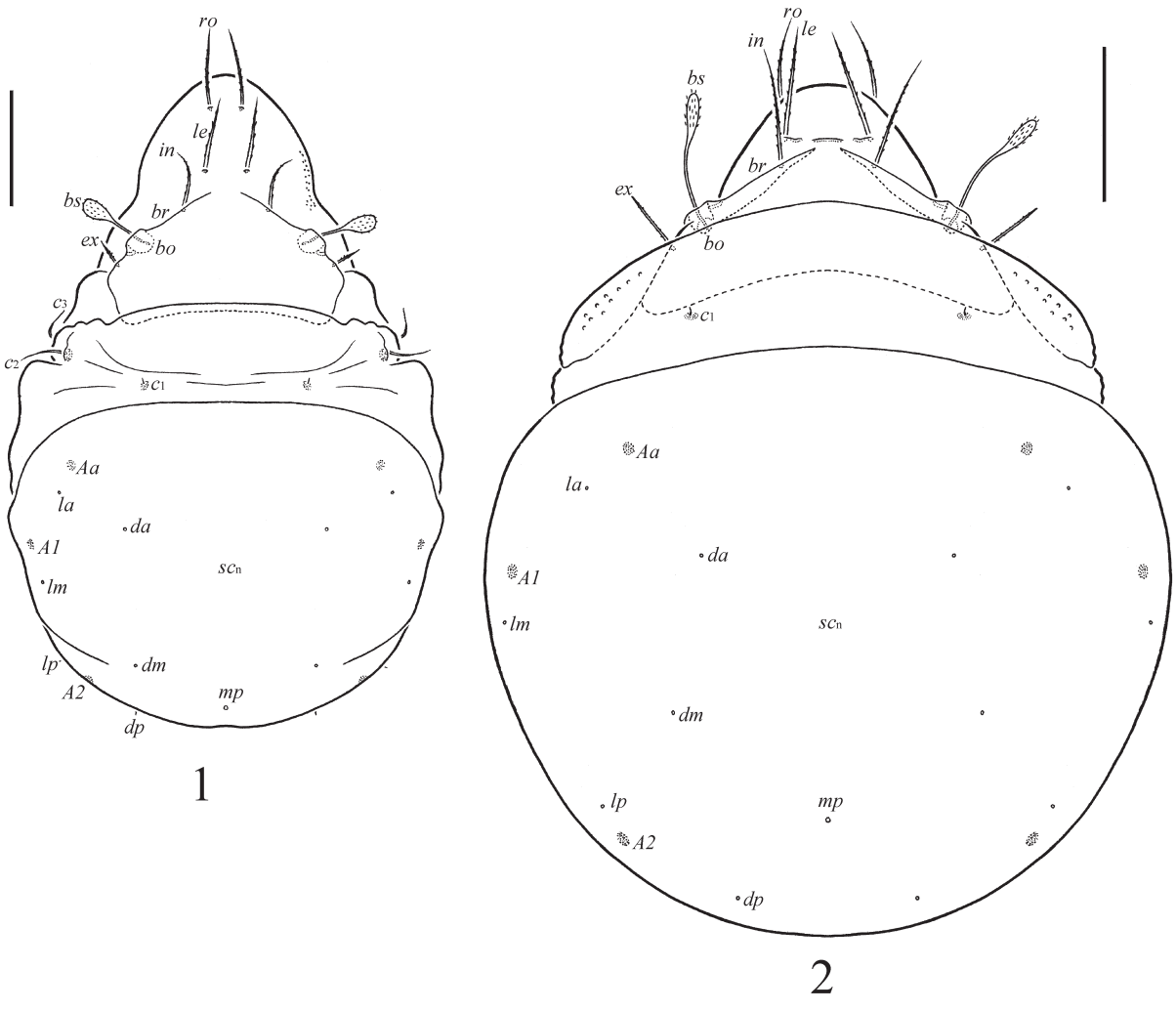
Material. One larva, five proto-, five deuto- and three tritonymphs: South Africa, west of the suburb of Grimbeekpark which is located in the eastern part of Potchefstroom, municipal owned land, forming part of the open space system of the city, 26°43′04.7″ S, 27°06′37.5″ E, 1,314 m a.s.l., soil and litter, 10.XI.2016 (collected by A.A. Khaustov, S.G. Ermilov and P.D. Theron). The juveniles belonging to *G. curvifamulus* are based on the following reason: adults were of the appropriate size to have juvenile instars with such dimensions. The other two species sampled, *G. baloghi* Wallwork, 1965 and *G. nuda* Engelbrecht, 1972 (see species list of taxa in Ermilov *et al.* 2017) are much smaller than *G. curvifamulus*.

Methods. Specimens were mounted in lactic acid on temporary cavity slides for measurement and illustration. Body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate. Gastronotic width refers to the maximum width of the gastronotum in dorsal view. Lengths of body setae were measured in lateral aspect. All body measurements are presented in micrometers. Formulas for leg setation are given in parentheses according to the sequence trochanter–femur–genu–tibia–tarsus (famulus included). Formulas for leg solenidia are given in square brackets according to the sequence genu–tibia–tarsus.

Drawings were made with a camera lucida using a Leica transmission light microscope “Leica DM 2500”. Images were obtained with an AxioCam ICc3 camera using a Carl Zeiss transmission light microscope “Axio Lab.A1”.

Morphological terminology used in this paper follows that of Ermilov and Klimov (2017), for review and application of Galumnoidea.

The following abbreviations are used: *rp*—rostrophragma; *ro*, *le*, *in*, *bs*, *ex*—rostral, lamellar, interlamellar, bothridial and exobothridial setae, respectively; *bo*—bothridium; *br*—bothridial ridge; sc_s—setal sclerite; sc_n—gastronotic macrosclerite; sc_{lat}—lateral sclerite; *oh*—humeral organ; *c*, *la*, *lm*, *lp*, *h*, *p*—gastronotic setae/alveoli; *Aa*, *A1*, *A2*, *A3*—gastronotic porose areas; *mp*—median pore; *ia*, *im*, *ip*, *ih*, *ips*, *iad*—cupules; *gla*—opisthonotal gland opening; *h*, *m*, *a*—subcapitular setae; *or*—adoral seta; *v*, *l*, *d*, *cm*, *acm*, *ul*, *sul*, *vt*, *lt*—palp setae; *sac*—axillary saccule; *cha*, *chb*—cheliceral setae; *cht*—dorsoparaxial cheliceral tooth; *Tg*—Trägårdh’s organ; *1a*, *1b*, *1c*, *2a*, *3a*, *3b*, *4a*, *4b*,



Figs. 1–2. *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017, juvenile instars: 1—larva, dorsal view (legs not shown); 2—tritonymph, dorsal view (legs not shown). Scale bars 50 μm (1), 100 μm (2).

4c—epimeral setae; *Cl*—Claparède's organ; sc_g—circumgenital macrosclerite; *sb*—striate band; *g*, *ag*, *an*, *ad*—genital, aggenital, anal and adanal setae, respectively; Tr, Fe, Ge, Ti, Ta—leg trochanter, femur, genu, tibia, tarsus, respectively; *p.a.*—leg porose area; ω, σ, φ—solenidia; ε—leg famulus; *v*, *ev*, *bv*, *l*, *d*, *ft*, *tc*, *it*, *p*, *u*, *a*, *s*, *pv*, *pl*—leg setae; La—larva, Pn—protonymph, Dn—deutonymph, Tn—tritonymph.

All studied juvenile specimens are stored (ethanol with drop of glycerol) in the collection of the Zoological Museum at the Tyumen State University, Tyumen, Russia.

DESCRIPTION

Figs. 1–32

Measurements. Total length of larva 282 (n=1), protonymph 332–348 (n=5), deutonymph 398–464 (n=5), tritonymph 547–581 (n=3). Total width of larva 182 (n=1), protonymph 265–282 (n=5), deutonymph 298–332 (n=5), tritonymph 398–431 (n=3).

Integument (Figs. 25, 26, 29). Body cuticle colorless to light brownish. Surface densely microporose. Podosomal regions, leg femora and trochanters, palp femora and trochanters, lateral parts of subcapitulum and genae, and lateral parts of epimeres granulate (diameter of granules up to 1). Anterior part of gastronotic region sparsely tuberculate. Anoadanal region and dorsolateral parts of body with folds.

Prodorsum (Figs. 1–4, 20–22). Relatively short, about 1/2 length of gastronotic region (measured in lateral view). Rostrum pointed (clearly visible in frontal view). Rostral, lamellar and interlamellar setae long, setiform, barbed, *le* slightly thicker than *ro* and *in*. Exobothridial setae setiform, erect, barbed. Bothridial setae clavate, barbed, with longer stalks than heads. Bothridial ridges diagonal, convergent, separated medially, visible in dorsal

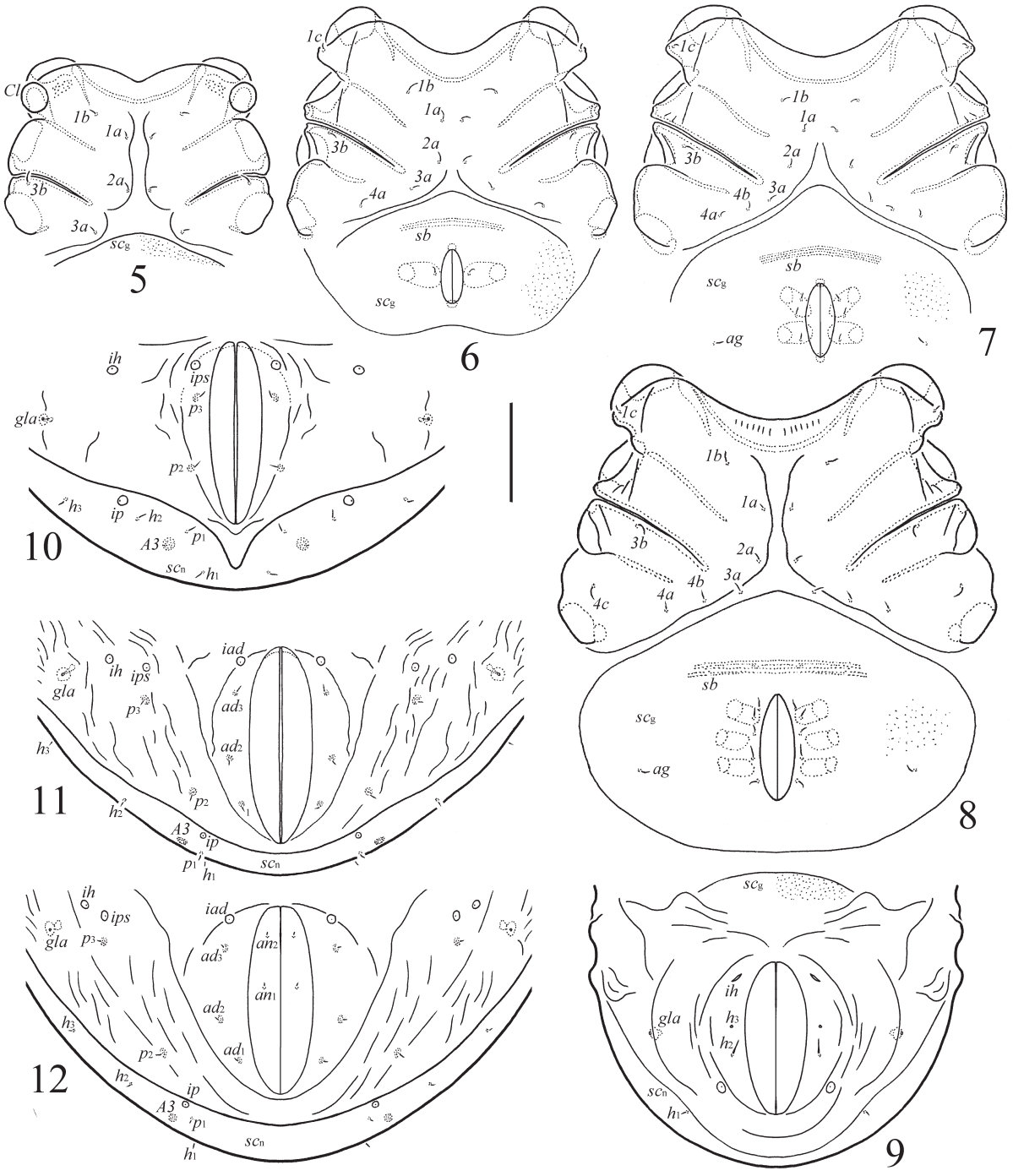
Figs. 3–4. *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017, juvenile instars: 3—larva, lateral view (gnathosoma and legs not shown); 4—tritonymph, lateral view (gnathosoma and legs not shown). Scale bars 50 μm (3), 100 μm (4).

view. Setae lengths during ontogeny are presented in Table 1.

Gastronotic region (Figs. 1–4, 23–25). Dorsal gastronotic region with large, well-bordered shield (macrosclerite) in all instars. Transversal gastronotic furrow not visible. Lateral sides with several elongate oval sclerites, their number varies. Larva with 12, nymphs with 15 pairs of gastronotic setae/alveoli, of these, seven (in larval instar) or 10 (in nymphal instars) pairs located on the macrosclerite; c_2 and c_3 (in all instars) and h_2 (in larval instar) setiform, barbed, other setae minute, smooth, or vestigial, or represented by alveoli. Setae c_1–c_3 and p_1–p_3 inserted on small sclerites. Three (in larval instar; *A3* absent) or four (in nymphal instars) pairs of rounded, porose areas present. Median pore distinct. Cupules *ia*, *im* and *ip* and opisthonotal gland openings clearly visible. Humeral organs well-developed. Setae lengths during ontogeny as presented in Table 1.

Gnathosoma (Figs. 13–15). Subcapitulum shorter than wide. Subcapitular and adoral setae setiform, barbed, *a* thicker than others. Postpalpal setae spiniform, smooth. Palps with setation 0–2–1–3–9(+ω); solenidion of palptarsi slightly curved, rounded distally, attached to *acm*, located on one tubercle. Postpalpal saccules well visible. Chelicerae with two setiform, barbed setae. Trägårdh's organ elongate triangular. Gnathosoma and setae lengths during ontogeny as presented in Table 2.

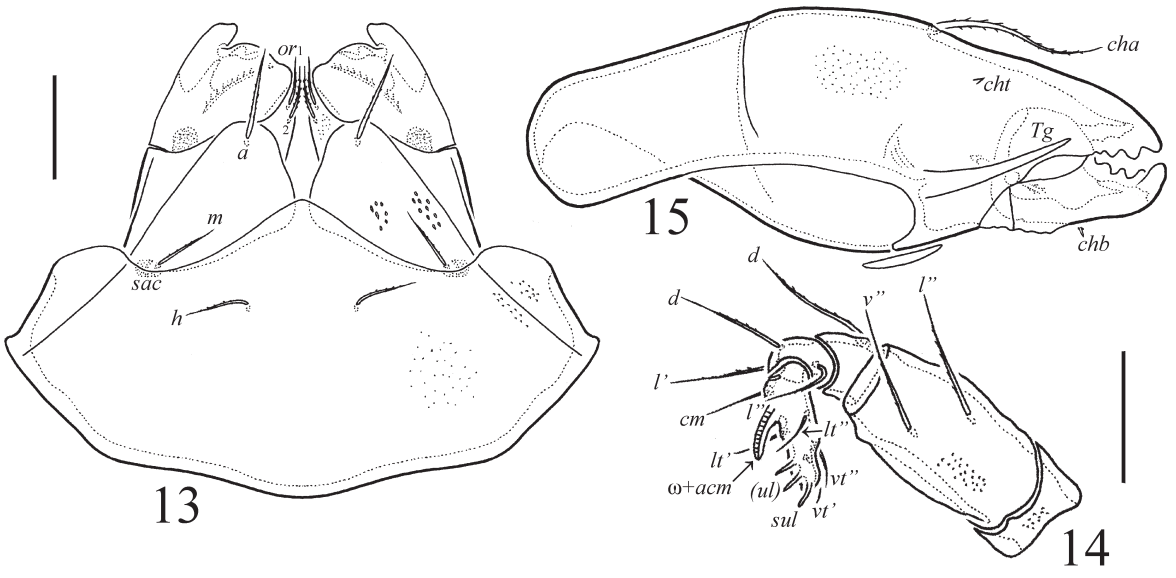
Epimeral region (Figs. 3–8, 26). Setal formulas for epimeres: larva 3–1–2 (third seta of first epimere forms protective scale over respective Claparède's organ); protonymph 3–1–2–1; deutonymph 3–1–



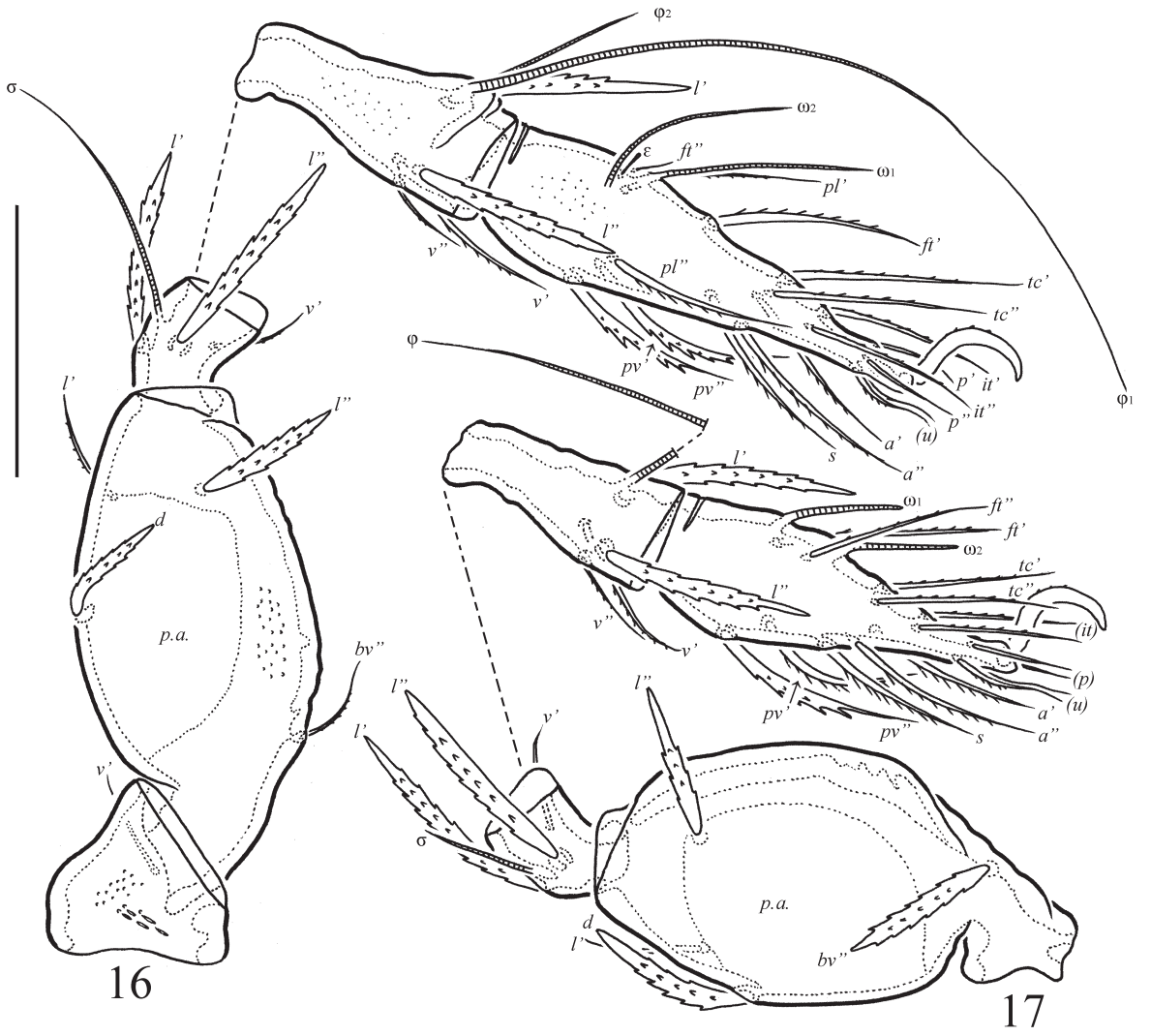
Figs. 5–12. *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017, juvenile instars: 5—epimeral region of larva; 6—epimeral and genito-aggenital regions of protonymph; 7—epimeral and genito-aggenital regions of deutonymph; 8—epimeral and genito-aggenital regions of tritonymph; 9—ano-adanal region of larva; 10—ano-adanal region of protonymph; 11—ano-adanal region of deutonymph; 12—ano-adanal region of tritonymph. Scale bar 50 μm.

2–2, tritonymph 3–1–2–3. Epimeral setae setiform, thin, smooth. Setae lengths during ontogeny as presented in Table 1.

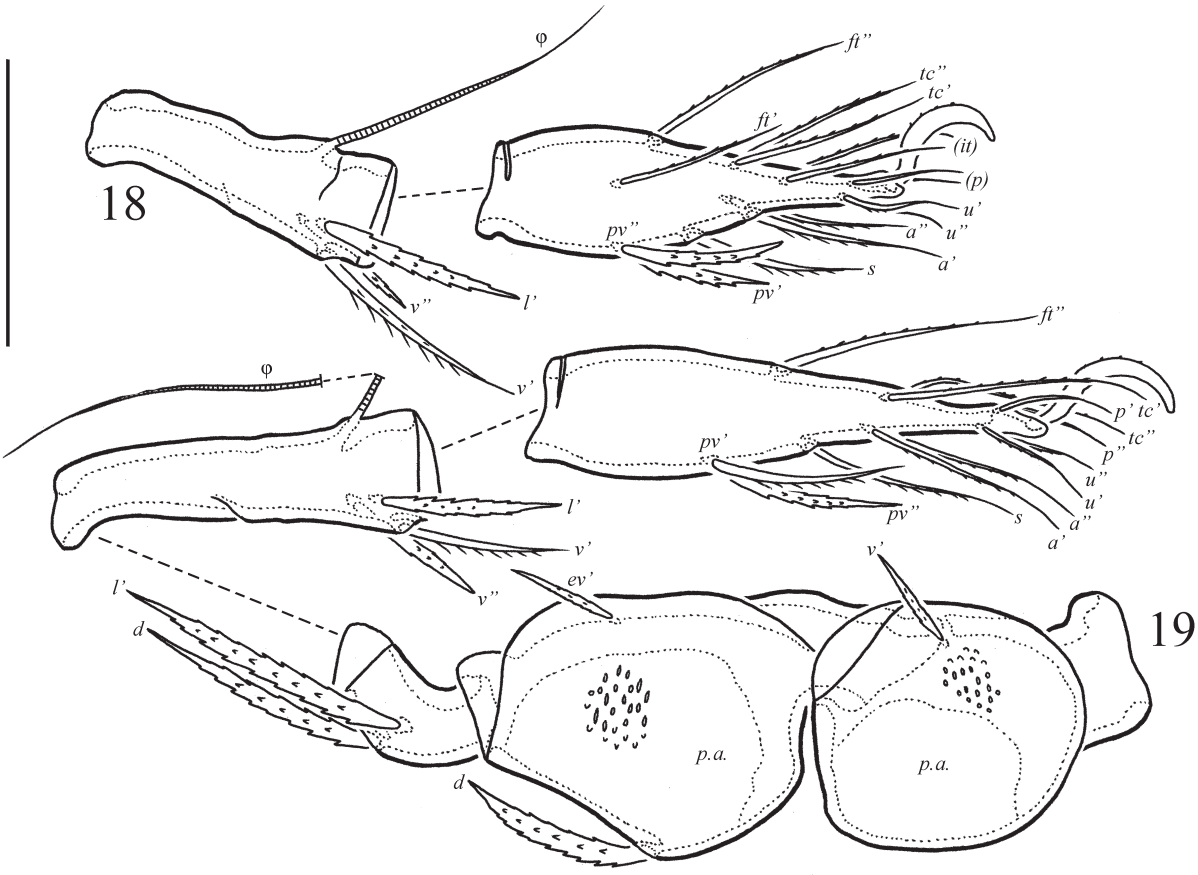
Anogenital region (Figs. 3, 4, 9–12, 27, 28). Circumgenital macrosclerite clearly bordered. A transversal striate band located anterior to genital valves. Adanal sclerite and ventral furrow between genital and anal valves not visible. Ontogeny of genital, aggenital, adanal, anal setal formulas, from larva to tritonymph: 0–1–3–5, 0–0–1–1, 0–0–3–3, 0–0–0–2, respectively. All setae setiform, thin, smooth. Adanal setae inserted on small sclerites. Cupules *ih*, *ips* and *iad* appearing in normal ontogenetic pattern. Setae lengths during ontogeny as presented in Table 1.



Figs. 13–15. *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017, gnathosoma of tritonymph: 13—subcapitulum, ventral view; 14—palp, left, antiaxial view; 15—chelicera, left, paraxial view. Scale bars 25 μm (13, 14, 15).



Figs. 16–17. *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017, legs of tritonymph: 16—leg I, right, antiaxial view; 17—leg II, without trochanter, right, antiaxial view. Scale bar 50 μm.



Figs. 18–19. *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017, legs of tritonymph: 18—tarsus and tibia of leg III, left, antiaxial view; 19—leg IV, left, antiaxial view. Scale bar 50 μm.

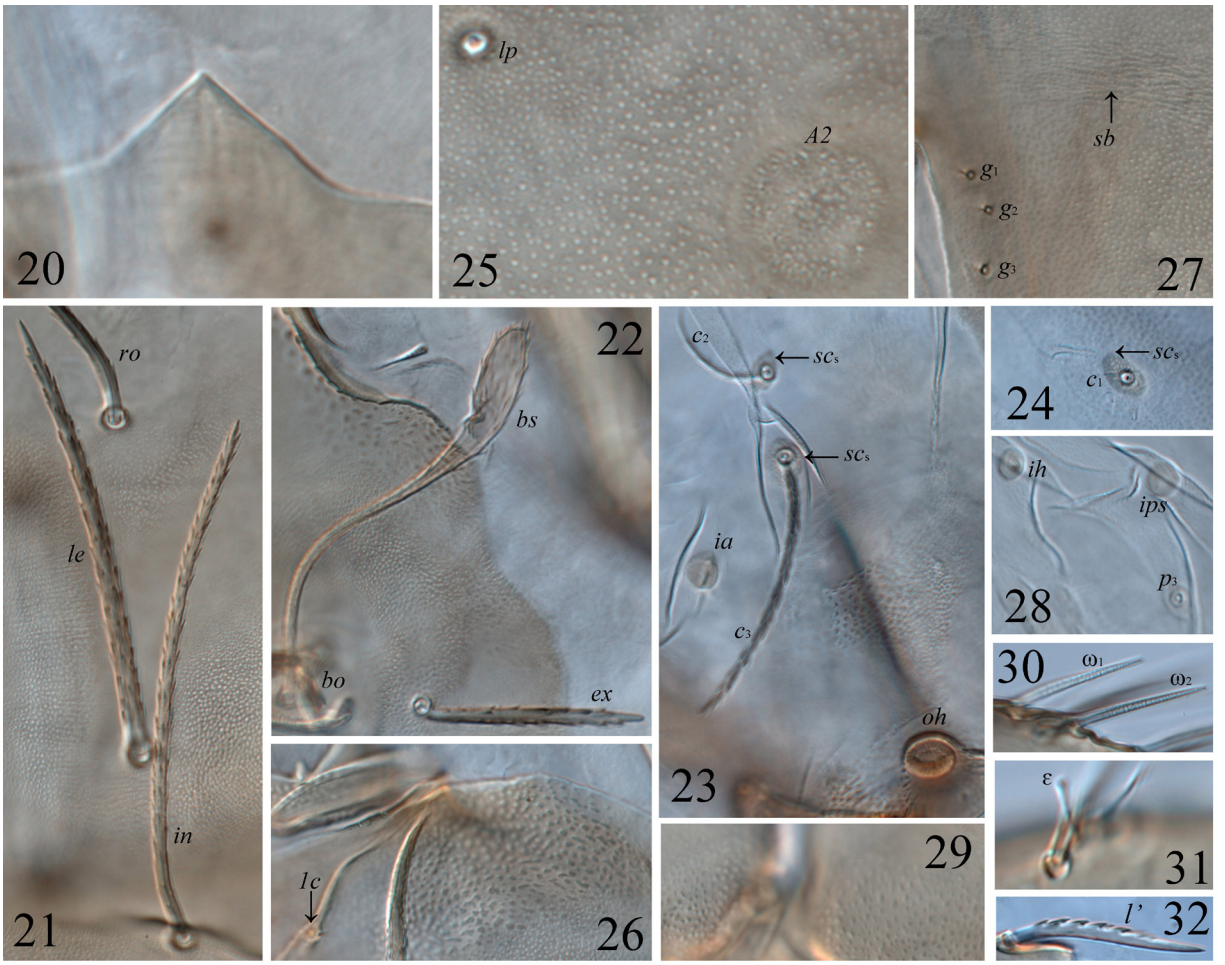
Legs (Figs. 16–19, 30–32). Claw of each leg slightly barbed dorsally. Porose areas on all femora and trochanters III and IV well visible. Leg formulas: larva: I (0–2–2–3–16) [1–1–1], II (0–2–2–2–13) [1–1–1], III (0–2–1–1–13) [1–1–0]; protonymph: I (0–2–2–3–16) [1–1–2], II (0–2–2–2–13) [1–1–1], III (0–2–1–1–13) [1–1–0], IV (0–0–0–0–7) [0–0–0]; deutonymph: I (0–4–2–3–16) [1–2–2], II (0–4–2–3–13) [1–1–2], III (1–2–1–3–13) [1–1–0], IV (0–2–2–1–12) [0–1–0]; tritonymph: I (1–4–3–4–18) [1–2–2], II (1–4–3–4–15) [1–1–2], III (1–2–1–3–15) [1–1–0], IV (1–2–2–3–12) [0–1–0]. Homology of leg setae and solenidia during ontogeny as indicated in Table 3. Famulus of leg tarsi erect, inserted posterolateral to solenidia ω_1.

Ontogenetic summary. Body surface microporose, anoadanal region and dorsolateral parts of gastronotic region with folds. Rostrum pointed. Rostral, lamellar, interlamellar and exobothridial setae long, setiform, barbed, *le* slightly thicker than others, bothridial setae clavate, barbed, with longer stalks than heads. Formula of gastronotic setae: 12–15–15–15, setae h_3 present in larva, setae c_2 and c_3 (in all instars) and h_2 (in larval instar) setiform, barbed, other setae minute or vestigial, or represented by alveoli, c_1–c_3 and p_1–p_3 inserted on sclerites. Three (*A3* absent in larval instar) or four (in nymphal instars) pairs of rounded, porose areas present. Median pore visible. Setal formulas for epimeres: 3–1–2 (larva), 3–1–2–1 (protonymph), 3–1–2–2 (deutonymph), 3–1–2–3 (tritonymph). Ontogeny of genital, aggenital, adanal and anal setal formulas: 0–1–2–3, 0–0–1–1, 0–0–3–3, 0–0–0–2, respectively. Epimeral and anogenital setae setiform, smooth. Circumgenital macrosclerite bordered, adanal sclerite not visible. Ontogeny of leg setae and solenidia is given in Table 3.

REMARKS

1. Adults of *G. curvifamulus* have an unusual morphological trait for *Galumna*: the famulus on leg tarsi I curved mediodistally at an angle of 90 degrees (Ermilov *et al*. 2017). However, all juvenile instars of this species (contrary to adults) have a straight ("normal") famulus.

2. Generally, juvenile instars of *Galumna* are morphologically very similar (Bayartogtokh and Ermilov 2017), but *G. curvifamulus* can be well



Figs. 20–32. *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017, dissected tritonymph, microscope images: 20—rostrum; 21—lamellar and interlamellar setae and basal part of rostral seta; 22—bothridial and exobothridial setae; 23—gastronotic setae c_2, c_3, cupule *ia* and humeral organ; 24—gastronotic seta c_1; 25—porose area *A2*, setal alveolus *lp* and porose gastronotic integument; 26—sculpture of lateral part of epimere I; 27—striate band partially and anterior three genital setae; 28—gastronotic seta p_3 and cupule *ips*, *ih*; 29—sculpture on leg trochanter and femora IV; 30—solenidia on tarsus II; 31—famulus on leg tarsus I; 32—lateral seta on leg genu III.

distinguishable from those of some other species by the length of some prodorsal and gastronotic setae, number of gastronotic setae in larva and the presence or absence of the median pore.

— From *Galumna alata* (Hermann, 1804) by Seniczak *et al*. (2012): the length of gastronotic setae c_2 and c_3 (c_3 longer than c_2 in *G. curvifamulus* versus c_3 shorter than c_2 in *G. alata*); the number of gastronotic setae in the larval instar (12 pairs, alveoli of h_3 present in *G. curvifamulus* versus 11 pairs, h_3 absent in *G. alata*), and the presence of median pore (versus absent in *G. alata*).

— From *G. obvia* (Berlese, 1914) (tritonymphal instar not known) by Ermilov *et al*. (2013): the length of gastronotic setae c_2 (well-developed, slightly shorter than c_3 in *G. curvifamulus* versus very short in *G. obvia*); the form of bothridial setae (clavate in *G. curvifamulus* versus narrowly lanceolate in *G. obvia*), the length of interlamellar setae (similar approximately to rostral and lamellar setae in *G. curvifamulus* versus distinctly shorter than rostral and lamellar setae in *G. obvia*), the number of gastronotic setae in the larval instar (12 pairs, alveoli of h_3 present in *G. curvifamulus* versus 11 pairs, h_3 absent in *G. obvia*), and the presence of median pore (versus absent in *G. obvia*).

— From *G. zachvatkini* Grishina, 1982 by Grishina (1982): the length of gastronotic setae on the macrosclerite (very short, vestigial or represented by alveoli in *G. curvifamulus* versus well-developed, setiform in *G. zachvatkini*); the length of interlamellar setae (similar approximately to rostral and lamellar setae in *G. curvifamulus* versus distinctly shorter than rostral and lamellar setae in *G. zachvatkini*), and the presence of median pore (versus absent in *G. zachvatkini*).

A comparison of juvenile instars of *G. curvifamulus* to *G. elimata* (C. L. Koch, 1841), *G.*

ithaensis (Jacot, 1929), *G. louisianae* (Jacot, 1929), *G. parva* Woodring, 1965 and *G. tarsipennata* Oudemans, 1914 is impractical at present, because they are weakly and incompletely described (Norton and Ermilov 2014; Bayartogtokh and Ermilov 2017).

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REFERENCES

Bayartogtokh, B. and Ermilov, S.G. 2017. Nymphal instars of two *Pergalumna* species, with remarks on morphological ontogeny of Galumnidae (Acari, Oribatida). *Systematic and Applied Acarology*, 22 (4): 518–540.

Ermilov, S.G. and Klimov, P.B. 2017. Generic revision of the large-winged mite superfamily Galumnoidea (Acari, Oribatida) of the world. *Zootaxa*, 4357 (1): 1–72.

Ermilov, S.G., Weigmann, G. and Tolstikov, A.V. 2013. Morphology of adult and juvenile instars of *Galumna obvia* (Acari, Oribatida, Galumnidae), with discussion of its taxonomic status. *ZooKeys*, 357: 11–28.

Ermilov, S.G., Hugo-Coetzee, A.A., Khaustov, A.A. and Theron, P.D. 2017. New and interesting oribatid mites (Acari, Oribatida) near Potchefstroom (South Africa), with description of two new species. *Systematic and Applied Acarology*, 22 (11): 1849–1871.

Grishina, L.G. 1982. A new species of the genus *Galumna* (Acariformes, Oribatei). *Zoologichesky Zhurnal*, 61 (1): 146–149.

Norton, R.A. and Ermilov, S.G. 2014. Catalogue and historical overview of juvenile instars of oribatid mites (Acari: Oribatida). *Zootaxa*, 3833: 1–132.

Seniczak, S., Iturrondobeitia, J.C. and Seniczak, A. 2012. The ontogeny of morphological traits in three species of Galumnidae (Acari: Oribatida). *International Journal of Acarology*, 38 (7): 612–638.

Table 1

Body setae lengths of *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017 in juvenile instars (alveolar setae also indicated)

Body setae	La (n=1)	Pn (n=2)	Dn (n=2)	Tn (n=2)
Rostral	41	53–57	73–77	77–82
Lamellar	36	53–57	65–69	73–77
Interlamellar	36	57–61	69–73	86–90
Bothridial	41	57–61	65–69	69–77
Exobothridial	16	24	32	36–41
Epimeral	*1a*, *2a*, *3a*: 2; *1b*, *3b*: 4	*1a*, *2a*, *3a*, *4a*: 4; *1b*, *3b*: 6; *1c*: 2	*1a*, *2a*, *3a*, *4a*, *4b*: 6; *1b*, *3b*: 8; *1c*: 2	*1a*, *2a*, *3a*, *4a*, *4b*: 8; *1b*, *3b*, *4c*: 12; *1c*: 4
Gastronotic	c_1: 2; c_2: 8; c_3: 16; h_2: 10; others: 1 or alveolar	c_1: 4; c_2: 10; c_3: 20; h_1–h_3,p_1–p_3: 2; others: 1 or alveolar	c_1: 4; c_2: 12; c_3: 28; h_1–h_3,p_1–p_3: 4; others: 2 or alveolar	c_1: 6; c_2: 16; c_3: 32; h_1–h_3,p_1–p_3: 4; others: 2 or alveolar
Genital	–	4	6	8
Aggenital	–	–	6	8
Anal	–	–	–	4
Adanal	–	–	6	8

Note: n—number of measured specimens.

Table 2

Size changes in the gnathosoma of *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017 in juvenile instars

Characters	La	Pn	Dn	Tn
Length of subcapitulum	53	77	102	114
Width of subcapitulum	69	90	114	143
Length of setae *a*	12	16	20	24
Length of setae *m*	8	12	16	20
Length of setae *h*	8	12	16	20
Length of adoral setae	6	8	12	16
Length of palp	53	61	73	94
Length of seta *ep*	2	2	4	6
Length of chelicera	82	98	123	151
Length of seta *cha*	24	32	41	49
Length of seta *chb*	16	20	28	32

Note: one specimen of each instar is measured.

Table 3

Development of leg setation of *Galumna curvifamulus* Ermilov, Hugo-Coetzee, Khaustov et Theron, 2017

	Tr	Fe	Ge	Ti	Ta
Leg I					
Larva	–	*d*, *bv”*	*(l)*, σ	*(l)*, *v’*, φ_1	*(ft)*, *(tc)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, *(pl)*, ε, ω_1
Protonymph	–	–	–	–	ω_2
Deutonymph	–	*(l)*	–	φ_2	–
Tritonymph	*v’*	–	*v’*	*v”*	*(it)*
Leg II					
Larva	–	*d*, *bv”*	*(l)*, σ	*l’*, *v’*, φ	*(ft)*, *(tc)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, ω_1
Protonymph	–	–	–	–	–
Deutonymph	–	(*l*)	–	*l”*	ω_2
Tritonymph	*v’*	–	*v’*	*v”*	*(it)*
Leg III					
Larva	–	*d*, *ev’*	*l’*, σ	*v’*, φ	*(ft)*, *(tc)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*
Protonymph	–	–	–	–	–
Deutonymph	*v’*	–	–	*l’*	–
Tritonymph	–	–	–	*v”*	*(it)*
Leg IV					
Protonymph	–	–	–	–	*ft”*, *(p)*, *(u)*, *(pv)*
Deutonymph	–	*d*, *ev’*	*d*, *l’*	*v’*, φ	*(tc)*, *(a)*, *s*
Tritonymph	*v’*	–	–	*l’*, *v”*	–

Note: Roman letters refer to normal setae, Greek letters refer to solenidia (except ε—famulus). One apostrophe (*’*) marks setae on anterior and double apostrophe (*”*) setae on posterior side of the given leg segment. Parentheses refer to a pair of setae. Setae are listed only for the stage in which they first appear.