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MORPHOLOGY OF JUVENILE INSTARS OF *METABELBA PAPILLIPES* (ACARI, ORIBATIDA, DAMAEIDAE)

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ABSTRACT: The morphology of juvenile instars of the oribatid mite *Metabelba papillipes* is described and illustrated. Juveniles of *Metabelba papillipes* are very similar in structure to those of *Porobelba spinosa*, showing differences in structure and lengths of setae of body and legs, and also in the structure of gastronotic cornicles. Juvenile instars of these species are identical in genital, aggenital, anal, adanal, gastronotal and epimeral setation, in structure of cerotegument and in some other aspects of body morphology.

KEY WORDS: *Metabelba papillipes* (Nicolet, 1855), *Metabelba* Grandjean, 1936, Damaeidae, morphology, juvenile instars, ontogeny, oribatid mite.

INTRODUCTION

The oribatid mite family Damaeidae (Acari, Oribatida) includes 12 genera and more than 250 known species, of which 30 are in the genus *Metabelba* Grandjean 1936. Collectively, this genus is distributed in the Holarctic region (Subías 2004; online version 2010), although North American species all may be either wrongly placed or introductions from Europe (R. Norton, pers. comm.). Juvenile instars in *Metabelba* have not been studied in detail so far. Grandjean (1953) listed several characters of juvenile instars of *Metabelba*, Norton (1977) considered some features of the leg setation of juvenile *Metabelba pulverulenta* (Koch 1839) (= *M. pulverosa* Strenzke 1953), and Bulanova-Zachvatkina (1965) illustrated larval, proto- and deutonymphal exuviae of *Metabelba pulverulenta*.

The purpose of the present work is to describe and illustrate the morphology of all juvenile instars of *Metabelba papillipes* (Nicolet, 1855). It is the first such complete treatment for any member of *Metabelba*. Adults of this species were redescribed or otherwise documented by several other authors (in particular, Hammen and Strenzke 1953; Bulanova-Zachvatkina 1965; Weigmann 2006).

MATERIALS AND METHODS

Most of the studied mites of *Metabelba papillipes* were collected by the author in the Nizhniy Novgorod region (European part of Russia) during the spring and summer of 2008–2009. Specimens were found in moss on a toppled deciduous tree (*Betula pendula*) in a mixed forest (Volodarskiy district: 56º15′N, 43º40′E). The collected material included 35 adults and 49 juveniles (16 larvae, 12 protonymphs, 9 deutonymphs, 12 tritonymphs). Additional specimens of juvenile instars were obtained from laboratory cultures (2 larvae, 1 protonymph, 1 deutonymph). Culturing methods were presented earlier (Ermilov 2008), but the specific diet was not determined.

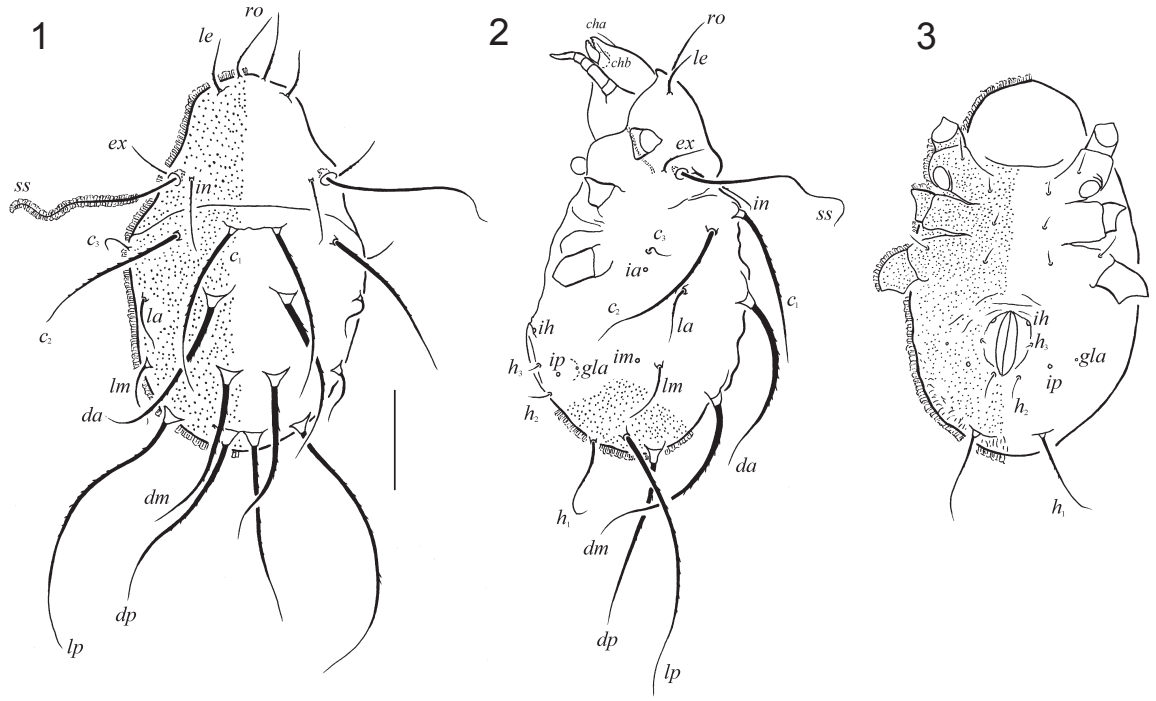
The illustrated specimens were permanently mounted and studied on flat microscope slides, however measurements were obtained with undistorted specimens, temporarily mounted in deep-cavity microscope slides. All body measurements are presented in micrometers.

RESULTS

Dimensions. Total length of: larva 184–205 (mean 191; n=11), protonymph 200–233 (mean 218; n=10), deutonymph 274–323 (mean 296; n=5), tritonymph 348–398 (mean 376; n=7), adult 464–498 (mean 478; n=17). Total width of: larva 102–110 (mean 107; n=4), protonymph 110–131 (mean 124; n=5), deutonymph 172–184 (mean 177; n=4), tritonymph 182–215 (mean 203; n=7), adult 265–298 (mean 279; n=13). Body of all instars approximately 1.7–1.8 times longer than wide.

Integument. Body cuticle colourless to pale yellow. Legs, gnathosoma, basal apophyses of some setae, gastronotic cornicles more sclerotized, weakly brownish (also often applies to upaired median sclerite bearing setae c_1, small bow-shaped crest bearing setae h_1 and p_1 in nymphs, and epimeres). Cuticle smooth or with rare small folds. Granular cerotegument covers body and legs in all juveniles. Dorsally granules very small (up to 4 μm), spherical; laterally granules larger (up to 10 μm), conical or sometimes very elongated. Body setae with or without cerotegument.

Prodorsum (Figs. 1, 2, 4, 5). Relatively short, about half-length of gastronotic region in lateral view. Rostrum broadly rounded. Pair of weak but distinct longitudinal ridges present laterally in nymphs. All prodorsal setae (except for nymphal



Figs 1–3. *Metabelba papillipes*, larva: 1 — dorsal view, legs removed; 2 — lateral view, legs partly removed; 3 — ventral view, legs partly removed, subcapitulum removed. Scale bar 50 μm.

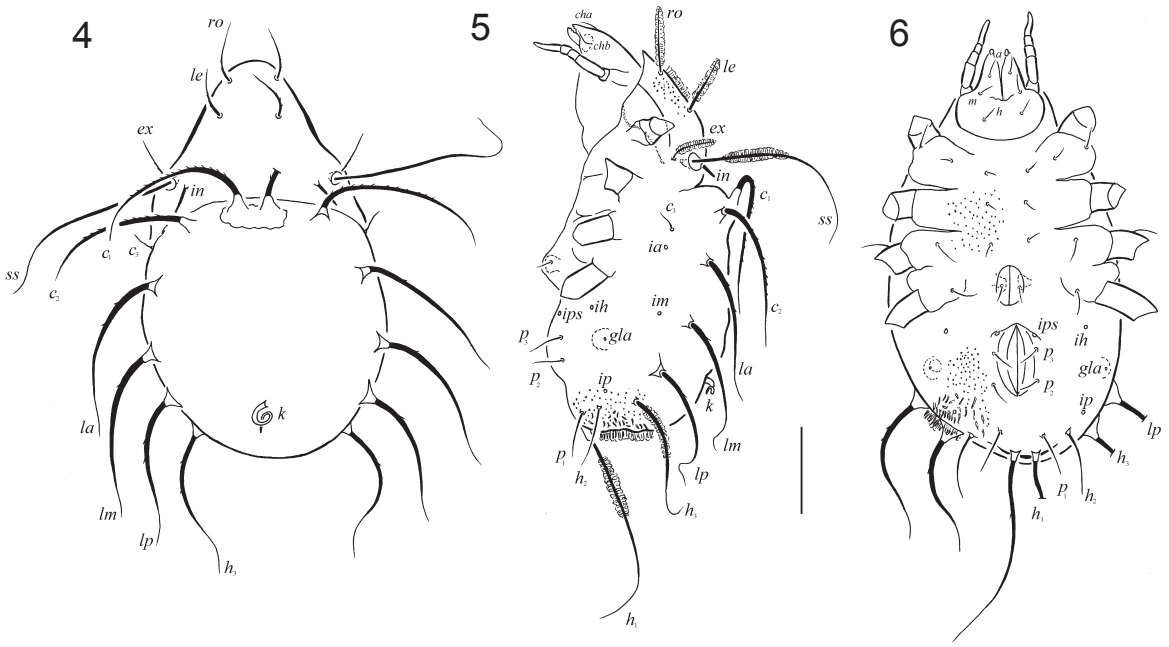
Table 1.
Prodorsal setae measurements in *Metabelba papillipes* during ontogeny

Character	Larva mean (min-max)	Protonymph mean (min-max)	Deutonymph mean (min-max)	Tritonymph mean (min-max)	Adult mean (min-max)
	n=4	n=4	n=4	n=4	n=4
Length of rostral setae	39 (36–45)	41 (36–45)	50 (45–53)	59 (53–65)	72 (69–77)
Length of lamellar setae	30 (24–36)	33 (28–36)	55 (53–57)	75 (69–82)	83 (77–90)
Length of interlamellar setae	39 (36–45)	16	20	23 (20–24)	108 (102–114)
Length of sensilli	105 (98–110)	135 (127–143)	156 (147–164)	165 (155–172)	156 (147–164)
Length of exobothridial setae	28 (24–32)	30 (28–32)	38 (36–41)	51 (49–53)	58 (57–61)

in) strongly to weakly darkened, setiform, with flagellate tips, barbed (except *ss*), set on small tubercles. Setae *ro* and *le* located on edge of rostrum in larva; *le* becomes more posteriorly placed in nymphs. Setae *ro* longer than *le* in larva and protonymph, but shorter than *le* in deuto- and tritonymphs. Larval setae *in* comparatively long, barbed, directed posteriad; nymphal *in* short, strong, smooth with blunt and slightly swollen tip, directed posteriorly. Sensilli (*ss*) longest setae of prodorsum. Bothridia (*bo*) well developed, funnel-shaped, with large opening. Comparison of prodorsal setae measurements of juvenile instars given in Table 1.

Gastronotic region (Figs. 1, 2, 4, 5). Broadly oval. Rounded posteriorly. Larva with typical 12 pairs of gastronotic setae. Setae dark-coloured, with flagellate tips (except h_2, h_3), well barbed (except h_3), set on small tubercles (c_3, h_2, h_3) or apophyses (others), as illustrated. Setae *lp* longest; setae c_1, c_2, *da*, *dm, dp* slightly shorter than *lp*; others yet smaller, relative sizes (decreasing): $h_1 > la$, $lm > c_3, h_2$; setae h_3 minute, shortest. Setae *da*, *dm* slightly thicker than c_1, c_2, *dp*, *lp*; other setae thinner than latter group.

Cornicle *k* of nymphs helical, tip (distal 1/7th or 1/8th) longitudinally split, but inconspicuously so, as halves remain in contact. Nymphs with typical 12 pairs of gastronotic setae. Setal pair c_1 set on single medial sclerite. Setae h_1 longest; others in decreasing order: c_1, c_2, *la*, *lm, lp*, $h_3 > h_2 > p_1 > c_3, p_2, p_3$. Setae c_1, c_2 most strongly barbed, many



Figs 4–6. *Metabelba papillipes*, protonymph: 4 — dorsal view, larval scalp and legs removed; 5 — lateral view, larval scalp removed, legs partly removed; 6 — ventral view, legs partly removed. Scale bar 50 μm.

Table 2.
Size changes in the gnathosoma of *Metabelba papillipes* during ontogeny

Character	Larva mean (min-max)	Protonymph mean (min-max)	Deutonymph mean (min-max)	Tritonymph mean (min-max)	Adult mean (min-max)
	n=3	n=3	n=3	n=3	n=3
Length of subcapitulum	49	57	66 (65–69)	75 (73–77)	100 (90–106)
Width of subcapitulum	47 (45–49)	55 (53–57)	63 (61–65)	75 (73–77)	74 (69–77)
Length of palps	n=5	n=4	n=3	n=4	n=5
	48 (45–53)	53 (49–57)	66 (65–69)	75 (73–77)	90 (86–94)
Length of chelicerae	n=5	n=5	n=4	n=4	n=7
	47 (45–49)	48 (45–49)	55 (53–57)	71 (69–73)	98 (86–102)

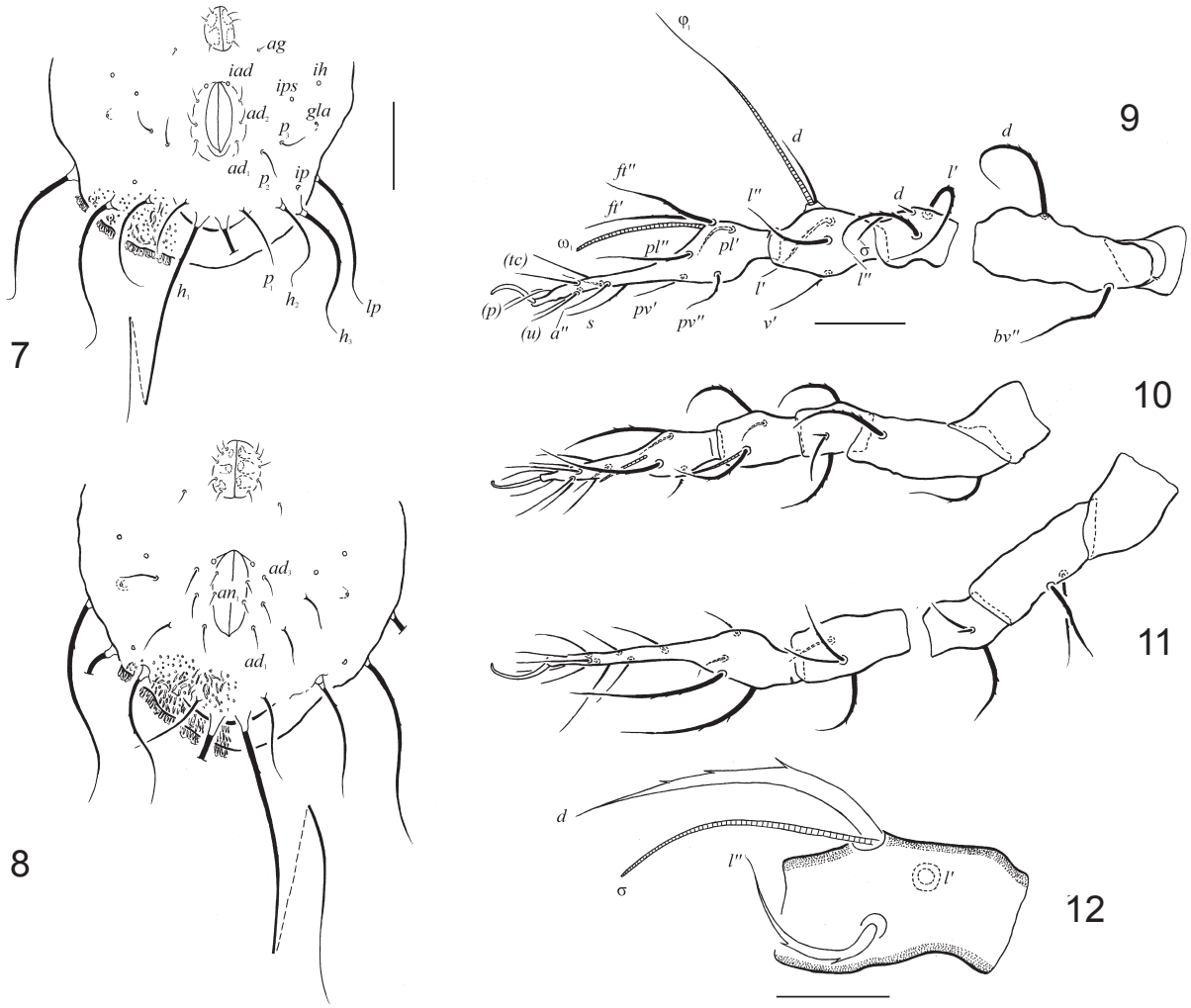
other setae with 1–3 barbs. Setae c_1, c_2, *la*, *lm*; *lp*, h_1, h_3 thicker than other gastronotic setae. Hysterosoma with small, weakly bowed sclerotized crest bearing setal pairs h_1 and p_1, best seen in ventral aspect. Cupules *ia*, *im*, *ip*, *ih*, *ips* well visible, in normal position for Damaeidae.

Anogenital region (Figs. 3, 6–8). Ontogenetic genital, aggenital, adanal, anal formulas, larva to tritonymphs, 0–1–3–5, 0–0–1–1, 0–0–3–3, 0–0–0–2 respectively. All setae setiform, thin, smooth. Cupules *iad* and small opisthonotal gland opening (*gla*) well visible, appearing in normal ontogenetic pattern.

Epimeral region (Figs. 3, 6). Epimeral setal formula of: larva 3–1–2 (third setae of the first epimere forms protective scale over Claparède's organ), protonymph 3–1–2–1, deutonymph 3–1–2–2, tritonymph 3–1–3–3. Setae setiform, smooth. Lateral setae (*1c*, *3b*, *3c*, *4a*, *4c*) longer than other setae.

Gnathosoma. Typical of Damaeidae (Norton 1978). Subcapitular setae (*h*, *m*, *a*) setiform, smooth, equal length setae (Fig. 6). Two pairs of lateral lip setae setiform, smooth. Palp setal formulas: larva 0–1–1–3–9+1ω; nymphs 0–2–1–3–9+1ω. Chelicerae with few blunt teeth on fixed and movable digits; two setae (*cha*, *chb*; Figs. 2, 5) both long, barbed; barbs of *chb* long in middle-distal part. Comparison of subcapitulum, palps and chelicerae given in Table 2.

Legs (Figs. 9–12). All legs shorter than body; length of individual segments given in Table 5. Most setae long, barbed; usually with 1–3 barbs, visible unilaterally. Tibia I–III (and IV in deuto-, tritonymphs) and genua I–III with coupled seta *d* and solenidion on dorsal side. Tibia I with short,



Figs. 7–12. *Metabelba papillipes*, anogenital region of juveniles (7–9): 7 — deutonymph; 8 — tritonymph; legs of juveniles (9–12): 9–11 — legs I–III of larva, respectively; 12 — genu I of protonymph. Scale bar 50 μm (7, 8); 20 μm (9–11), 10 μm (12).

setiform, smooth seta *d* and very long solenidion; tibia II–IV with seta *d* and solenidion approximately equal in length. Larval genua with short seta *d* and longer solenidion; nymphal genua with seta *d* and solenidion with approximately equal length. Solenidion ω_1 on tarsus I very long, reaching bases of setae *tc*. Famulus very small, hardly visible (famulus base is not sunken in a sclerotized cup). Ontogeny of leg setae and solenidia given in Tables 3 and 4.

DISCUSSION

Juvenile instars have been studied for relatively few genera of Damaeidae. These include: *Damaeus* Koch 1835 (Grandjean 1960; Norton 1978), *Epidamaeus* Koch 1835 (Bulanova-Zachvatkina 1957; Norton 1979; Moraza et al. 1990), *Spatiodamaeus* Bulanova-Zachvatkina 1957 (Sitnikova 1959), *Kunstidamaeus* Miko 2006 (Miko and Mourek 2008), *Belba* Heyden 1826 (Norton 1979; Norton and Palacios-Vargas 1982), *Caenobelba* Norton 1980 (Norton 1980), *Dyobelba* Norton 1979 (Norton 1979; Norton and Ryabinin 1994; Bayartogtokh and Norton 2007), *Lanibelba* Norton 1980 (Norton 1980), *Quatrobelba* Norton 1980 (Norton 1980), and *Porobelba* Grandjean 1936 (Ermilov and Łochyńska, 2009).

Juvenile instars of *Metabelba papillipes* are most similar in structure to those of *Porobelba*, which are known only for *Porobelba spinosa* (Sellnick 1920). Juvenile instars of *Metabelba papillipes* and *Porobelba spinosa* are identical in general body form, including: form and structure of cerotegument, some aspects of cuticular morphology (for example, nymphs posteriorly with sclerotized bow-shaped crest bearing setae h_1 and p_1; nymphal cornicles helical), and formulas of setae. We can distinguish juvenile instars of these species by the following characters.

Larvae:

1) some prodorsal setae of *Metabelba papillipes* (*ro* 39, *in* 39, *ss* 105, *ex* 28) slightly to much lon-

Table 3.
Setal and solenidial counts on legs of *Metabelba papillipes* during ontogeny*

	Formula of setae	Formula of solenidia
Leg I		
Larva	0–2–3–4–16	1–1–1
Protonymph	0–2–3–4–16	1–1–2
Deutonymph	1–4–4–5–16	1–2–2
Tritonymph	1–6–4–5–18	1–2–2
Adult	1–10–4–4–20	1–2–2
Leg II		
Larva	0–2–3–3–13	1–1–1
Protonymph	0–2–3–3–13	1–1–1
Deutonymph	1–4–4–4–13	1–1–2
Tritonymph	1–6–4–5–15	1–1–2
Adult	1–10–4–5–17	1–1–2
Leg III		
Larva	0–2–2–3–13	1–1–0
Protonymph	1–2–2–3–13	1–1–0
Deutonymph	2–3–3–4–13	1–1–0
Tritonymph	4–5–3–4–15	1–1–0
Adult	4–9–4–5–17	1–1–0
Leg IV		
Protonymph	0–0–0–0–7	0–0–0
Deutonymph	1–2–2–3–12	0–1–0
Tritonymph	2–5–3–4–12	0–1–0
Adult	3–9–4–4–14	0–1–0

*Number of setae on trochanter-femur-genu-tibia-tarsus (including famulus); number of solenidia on genua-tibia-tarsus.

ger long than in *Porobelba spinosa* (*ro* 24–32, *in* 24–32, *ss* 69–82, *ex* 12–16).
2) prodorsal setae *in* > *le* in *M. papillipes*; *le* > *in* in *P. spinosa*;
3) gastronotic region without rudimentary cornicle in *M. papillipes*; gastronotic region with rudimentary cornicle in *P. spinosa*;
4) length of gastronotic setae: $c_2 \approx da$ in *M. papillipes*; $c_2 < da$ in *P. spinosa*;
5) length of ω_1 on tarsi I: very long, reaching bases of setae *tc* in *M. papillipes*; rather short, not reaching setae *tc* in *P. spinosa*.

Nymphs:
1) prodorsal setae of *M. papillipes* longer than in *P. spinosa* (*ro*: 41 > 28–32 Pn, 50 > 32–45 Dn, 59 > 41–49 Tn; *le* 55 > 45–49 Dn, 75 > 49–57 Tn; *ss* 135 > 86–98 Pn, 156 > 98–127 Dn, 165 > 106–135 Tn; *ex* 30 > 15–20 Pn, 38 > 20–28 Dn, 51 > 24–32 Tn).
2) gastronotic cornicles with distal longitudinal split in *M. papillipes*; cornicles without distal split in *P. spinosa*;
3) length of gastronotic setae: *la*, *lm*, *lp* $\approx c_1, c_2$ (in *M. papillipes*); *la*, *lm*, *lp* > c_1, c_2 in *P. spinosa*;
4) barbs of gastronotic and leg setae: well developed in *M. papillipes*; only weakly developed in *P. spinosa*;
5) seta *d* and solenidion of genua: approximately equally long in *M. papillipes*; with seta *d* longer than solenidion in *P. spinosa*;
6) leg setation (data for *M. papillipes* before parentheses, data for *P. spinosa* within parentheses; Dn, Tn = deutonymph, tritonymph): Fe II Tn with 6 setae (4 setae); Fe III, Fe IV Tn 5 (3); Tr Dn IV 2 (1); Tr III Tn 4 (2); Tr IV 2 (1).

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Table 4.
Development of leg setation of *Metabelba papillipes**

	Trochanter	Femur	Genu	Tibia	Tarsus
Leg I					
Larva	–	*d, bv″*	*d*σ, (*l*)	*d*ϕ$_1$, (*l*), *v′*	(*ft*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*), (*pl*), *e* (minute), ω$_1$
Protonymph	–	–	–	–	ω$_2$
Deutonymph	*v′*	(*l*$_1$)	*v′*	*v″*, ϕ$_2$	–
Tritonymph	–	(*v*$_1$)	–	–	(*it*)
Adult	–	(*l*$_2$), (*v*$_2$)	–	*d* lost	(*v*)
Leg II					
Larva	–	*d*, *bv″*	*d*σ, (*l*)	*d*ϕ, *l′*, *v′*	(*ft*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*), ω$_1$
Protonymph	–	–	–	–	–
Deutonymph	*v′*	(*l*$_1$)	*v′*	*l″*	ω$_2$
Tritonymph	–	(*v*$_1$)	–	*v″*	(*it*)
Adult	–	(*l*$_2$), (*v*$_2$)	–	–	(*v*)
Leg III					
Larva	–	*d*, *ev′*	*d*σ, *l′*	*d*ϕ, *l′*, *v′*	(*ft*), (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)
Protonymph	*v′*	–	–	–	–
Deutonymph	*l′*	*l*$_1$'	*v′*	*v″*	–
Tritonymph	*d*, *v″*	(*v*$_1$)	–	–	(*it*)
Adult	–	*l*$_1$″, *l*$_2$′, (*v*$_2$)	*v″*	*l″*	(*v*)
Leg IV					
Protonymph	–	–	–	–	*ft″*, (*p*), (*u*), (*pv*)
Deutonymph	*v′*	*d*, *ev′*	*d*, *l′*	*d*ϕ, *l′*, *v′*	(*tc*), (*a*), *s*
Tritonymph	*l′*	*l*$_1$′, (*v*$_1$)	*v′*	*v″*	–
Adult	*d*	*l*$_1$″, *l*$_2$′, (*v*$_2$)	*v″*	*l″*, *d* lost	(*v*)

*Roman letters refer to normal setae (e — famulus), Greek letters refer to solenidia, *d*σ and *d*ϕ — solenidia and seta coupled. 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 juvenile instar in which they first appear.

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Table 5.
Body and leg measurements of *Metabelba papillipes* during ontogeny

	Larva, mean (min-max)	Protonymph, mean (min-max)	Deutonymph, mean (min-max)	Tritonymph, mean (min-max)	Adult, mean (min-max)
	n=3	n=3	n=3	n=3	n=3
Leg I	179.3 (178–182)	206.0 (194–218)	254.7 (252–260)	282.7 (276–292)	349.7 (347–351)
leg I:body length	0.94	0.94	0.86	0.75	0.73
trochanter I	18.7 (16–20)	22.7 (20–24)	29.3 (28–32)	36.0	–
femur I	45.0 (41–49)	57.0 (53–61)	70.3 (69–73)	75.7 (73–77)	122.7 (118–127)
genu I	20.0	22.7 (20–24)	26.7 (24–28)	32.0 (28–36)	49.0
tibia I	29.3 (28–32)	32.0 (28–36)	46.3 (45–49)	50.3 (49–53)	59.7 (57–61)
tarsus I	66.3 (65–69)	71.7 (69–73)	82.0	88.7 (86–90)	118.3 (114–123)
Leg II	153.3 (149–158)	183.3 (178–194)	223.7 (218–227)	256.7 (255–259)	300.7 (298–302)
leg II:body length	0.80	0.84	0.75	0.68	0.63
trochanter II	18.7 (16–20)	22.7 (20–24)	29.3 (28–32)	36.0	–
femur II	37.7 (36–41)	50.3 (49–53)	59.7 (57–61)	67.7 (65–69)	106.0 (102–110)
genu II	21.3 (20–24)	21.3 (20–24)	26.7 (24–28)	26.7 (24–28)	43.7 (41–45)
tibia II	22.7 (20–24)	28.0	37.7 (36–41)	47.7 (45–49)	54.3 (53–57)
tarsus II	53.0	61.0 (57–65)	70.3 (69–73)	78.7 (77–82)	96.7 (90–106)
Leg III	166.3 (161–173)	180.3 (173–190)	231.3 (222–240)	262.3 (253–269)	357.7 (355–362)
leg III:body length	0.87	0.82	0.78	0.69	0.75
trochanter III	26.7 (24–28)	29.3 (28–32)	39.3 (36–41)	43.7 (41–45)	77.3 (73–82)
femur III	36.0	39.3 (36–41)	51.7 (49–53)	62.3 (57–65)	88.7 (86–90)
genu III	20.0	21.3 (20–24)	26.7 (24–28)	26.7 (24–28)	40.7 (36–45)
tibia III	26.7 (24–28)	29.3 (28–32)	39.3 (36–41)	47.7 (45–49)	54.3 (53–57)
tarsus III	57.0 (53–61)	61.0 (57–65)	74.3 (73–77)	82.0	96.7 (90–106)
Leg IV	–	196.3 (193–198)	252.7 (249–257)	318.3 (317–321)	461.0 (445–473)
leg IV:body length		0.90	0.85	0.84	0.96
trochanter IV		33.3 (32–36)	43.7 (41–45)	57.0 (53–61)	114.0 (110–118)
femur IV		36.3 (32–41)	51.7 (49–53)	69.0	96.7 (94–98)
genu IV		21.3 (20–24)	26.7 (24–28)	28.0	45.0 (41–49)
tibia IV		26.7 (24–28)	39.3 (36–41)	59.7 (57–61)	71.7 (69–73)
tarsus IV		78.7 (77–62)	91.3 (90–94)	104.7 (102–106)	133.7 (131–139)