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Comparative analysis of the external morphology in tritonymphs of parasitic mites of the tribes Elephantulobiini and Protomyobiini (Acariformes: Myobiidae)

Andre V. Bochkov

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Zoological Institute, Russian Academy of Sciences, Universitetskaya emb. 1, 199034 St. Petersburg, Russia. andrevbochkov@gmail.com@zin.ru

Abstract — The comparative analysis of the external morphology of tritonymphs in parasitic mites belonging to the tribes Elephantulobiini and Protomyobiini (Acariformes: Myobiidae) was carried out based on representatives of the genera *Elephantulobia* Fain, 1972 (Elephantulobiini); *Limnogalobia* Fain & Lukoschus, 1976 (Protomyobiini: Afromyobiina); *Blarinobia* Jameson, 1955, *Eutalpacarus* Jameson, 1949, *Gymnomyobia* Fain & Lukoschus, 1976, *Placomyobia* Jameson, 1970 (Protomyobiini: Amorphacarina), and *Nectogalobia* Fain & Lukoschus, 1976 (Protomyobiini: Protomyobiina). A key to genera of the tribes Elephantulobiini and Protomyobiini based on tritonymphs is given.

Keywords — Acari; external morphology; tritonymphs; Myobiidae; parasites

Introduction

The family Myobiidae (Acariformes: Myobioidea) is represented by permanent obligate ectoparasites of small mammals and presently includes about 600 species in 54 genera (Bochkov *et al.*, 2008). The family is subdivided into five subfamilies, among which the subfamily Protomyobiinae (39 genera) is most morphologically diverse. This subfamily includes three tribes: Acanthophthiriini (22 genera) from bats, Elephantulobiini (one genus) from elephant shrews, and Protomyobiini (16 genera) from shrews, moles, gymnures, and tenrecs. The tribe Protomyobiini includes three subtribes: Afromyobiina (15 species in five genera from otter shrews and Malagasy tenrecs), Amorphacarina (35 species in nine genera from shrews, moles, and gymnures), and Protomyobiina (17 species in two genera from shrews) (Bochkov, 1997b).

The detailed phylogeny of the family has never been constructed, although the preliminary phylogenetic hypotheses were proposed by Dusbabek (1969) and Bochkov (1997a) based mainly on the morphology of adult mites. The juvenile and adult stages of myobiids strongly differ from each other by their external morphology, and juveniles are poorly studied in this relation. The comparative investigation of external morphology of juvenile myobiids (mainly tritonymphs) is a base for the future step in a comprehensive phylogenetic analysis of the family, and following this goal, representatives of most genera in the tribe Protomyobiini were recently examined (Bochkov and Mirolubov, 2015). The present work is the continuation necessary to fill gaps in our knowledge about tritonymphal mor-

TABLE 1: States of some characters in tritonymphs of the tribes Elephantulobiini and Protomyobiini *ao1* – dorsal setae of gnathosoma; *n* – ventral setae of gnathosoma; S – legs I symmetrical; A – legs I asymmetrical

Mite genera	Characters			
	ao1	*n*	Legs I	Claw formula of legs I-IV
Elephantulobia	+	+	S	0-1-1-1
Limnogalobia	+	-	A	0-2-1-1
Nectogalobia	+	+	S	2-2-1-1
Blarinobia	+	+	S	2-1-1-1
Eutalpacarus	+	+	S	2-2-1-1
Gymnomyobia	+	+	S	2-1-1-1
Placomyobia	+	+	S	2-1-1-1

phology in mites of this tribe. Tritonymphs of six genera of this tribe and also two of three species known in the tribe Elephantulobiini whose external morphology was not specially investigated are examined here. A key to genera of the tribes Elephantulobiini and Protomyobiini based on tritonymphs is provided for the first time.

Materials and methods

In a total, seven species belonging to six genera of the Protomyobiini and two species of the genus *Elephantulobia* (Elephantulobiini) were examined (material housing in the Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium). The list of examined species is given in Appendix 1.

Mounted specimens were studied using a Leica compound microscope with phase contrast optics. Drawings were made with a *camera lucida*.

The idiosomal and leg setation follow Grandjean (1939, 1944) as interpreted by Bochkov *et al.* (2008). The designations proposed by Bochkov and Mirolubov (2015) for leg I setae of myobiid immature stages are used. Host taxonomy follows Wilson and Reeder (2005).

Comparison of external morphology in tritonymphs of the tribes Elephantulobiini and Protomyobiini

Gnathosoma (Table 1; Figure 2A, B) — The general structure of gnathosoma in myobiid tritonymphs of the tribe Protomyobiini was described in details by Bochkov and Mirolubov (2015). As in the most immatures of myobiids, their palps are absent, the subcapitulum bears one pair of dorsal setae *ao1* and one pair of ventral setae *n*.

Character 1. Among seven genera examined in this paper, setae *n* are absent in *Limnogalobia* vs. present in all other genera.

Idiosoma (Table 2; Figure 1) — The tritonymphal stage can be absent in some protomyobiins (Lukoschus, 1969; Bochkov and OConnor, 2006). In species of all genera investigated herein, this stage is present.

Character 2. Idiosoma is less than 1.3 times longer than wide (*Nectogalobia* and *Placomyobia*), vs. 1.5 or more times longer than wide in all other genera.

Character 3. Setae *ve* are absent in *Elephantulobia* vs. present in all other genera.

Character 4. Setae *si* are absent in *Elephantulobia* vs. present in all other genera.

Character 5. Setae *se* are absent in *Elephantulobia, Eutalpacarus,* and *Placomyobia* vs. present in all other genera.

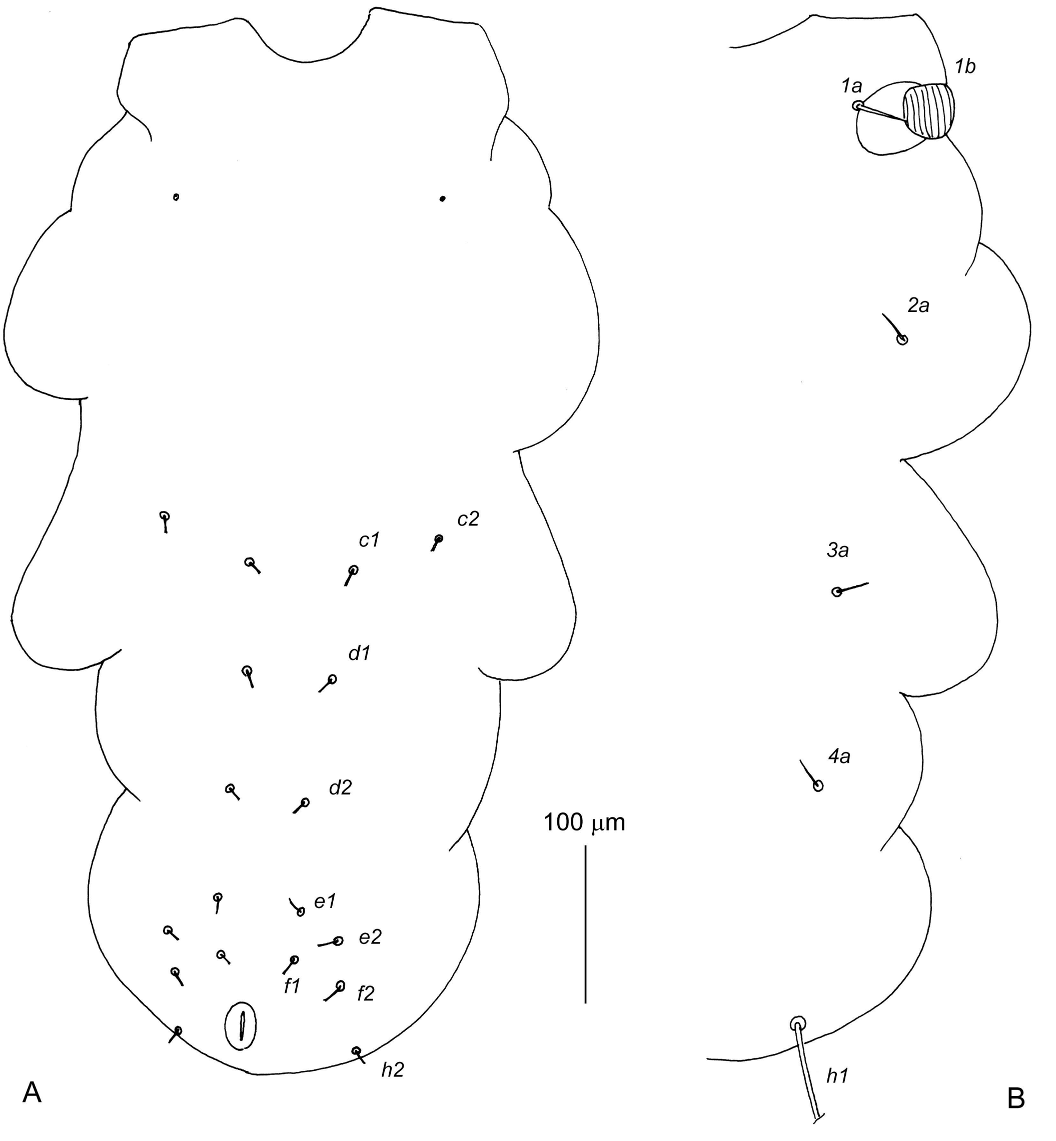

FIGURE 1: *Elephantulobia elephantuli* Fain, 1972, tritonymph: A – Idiosoma in dorsal view; B – Same in ventral view.

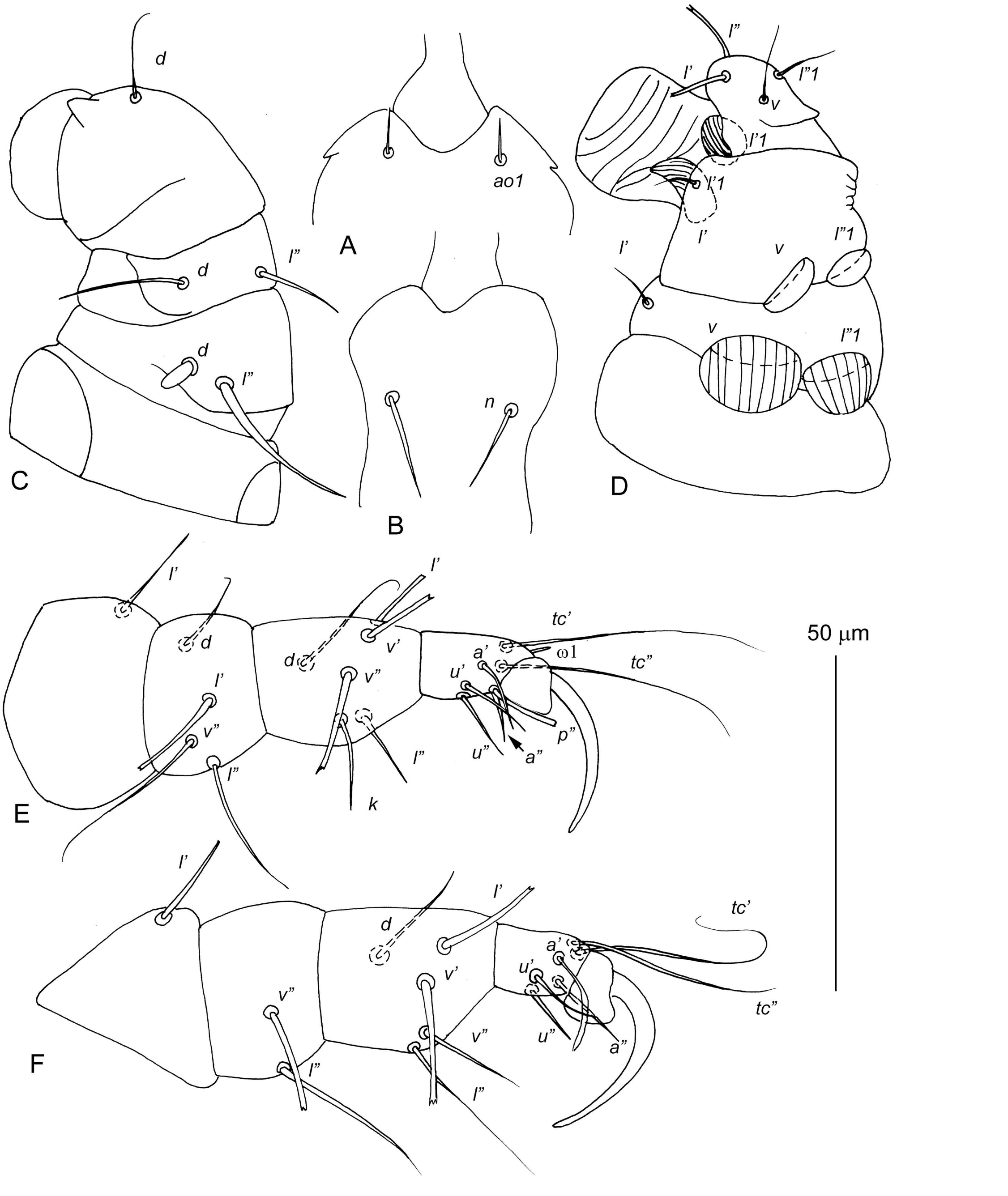

FIGURE 2: *Elephantulobia elephantuli* Fain, 1972, tritonymph: A – Subcapitular apex in dorsal view; B – Same in ventral view; C – Leg I in dorsal view; D – Same in ventral view. E. Leg II in ventral view. F. Leg III in ventral view.

TABLE 2: Idiosomal setae in tritonymphs of the tribes Elephantulobiini and Protomyobiini

Mite genera	Setae																				
	vi	*ve*	*si*	*se*	*c1*	*c2*	*d1*	*d2*	*e1*	*e2*	*f1*	*f2*	*h1*	*h2*	*1a*	*1b*	*1c*	*2a*	*2b*	*2c*	*3a*	*4a*
Elephantulobia	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	-	+	+
Limnogalobia	-	+	+	+	+	+	+	+	+	+	+	-	+	-	+	+	-	+	+	-	+	-
Nectogalobia	-	+	+	+	-	+	-	-	-	-	-	-	+	-	+	+	-	+	+	+	+	+
Blarinobia	-	+	+	+	-	+	-	-	-	+	+	-	+	-	+	+	+	+	-	-	+	+
Eutalpacarus	-	+	+	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	-	-	+	+
Gymnomyobia	-	+	+	+	+	+	-	-	-	-	-	-	+	-	+	+	+	-	-	-	-	-
Placomyobia	-	+	+	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	-	-	+	+

Character 6. Setae *c1* are absent in *Blarinobia, Eutalpacarus, Nectogalobia,* and *Placomyobia* vs. present in all other genera.

Character 7. Setae *c2* are absent in *Eutalpacarus* and *Placomyobia* vs. present in all other genera.

Character 8. Setae *d1, d2,* and *e1* are present only in *Elephantulobia* and *Limnogalobia* vs. absent in all other genera.

Character 9. Setae *e2* and *f1* are present only in *Blarinobia*, *Elephantulobia,* and *Limnogalobia* vs. absent in all other genera.

Character 10. Setae *f2* and *h2* are present only in *Elephantulobia* vs. absent in all other genera.

Character 11. Setae *1c* are absent in tritonymphs of *Elephantulobia, Limnogalobia*, and *Nectogalobia* vs. present in all other genera.

Character 12. Setae *2a* and *3a* are absent only in *Gymnomyobia* vs. present in other genera.

Character 13. Setae *2b* are present only in *Limnogalobia* and *Nectogalobia* vs. absent in all other genera.

Character 14. Setae *2c* are present only in *Nectogalobia* vs. absent in all other genera.

Character 15. Setae *4a* are absent in *Limnogalobia* and *Gymnomyobia* vs. present in all other genera.

Legs (Tables 1, 3, 4; Figures 2-6) — In immature stages of myobiids, legs normally consist of four segments (femur and genu are fused) and their tarsi bear one or two claws. Legs I are modified into a complicate attachment organ to seize the host hairs (see for details Bochkov and Mirolubov, 2015).

Character 16. Legs I are asymmetric in *Limnogalobia* vs. symmetric in all other genera.

Character 17. Claws are absent on legs I in *Elephantulobia* and *Limnogalobia* vs. present in all other genera.

Character 18. Legs I with ventral paraxial process in *Nectogalobia* vs, without this process in all other genera.

Character 19. Seta *dTa* of leg I is absent in *Nectogalobia* vs. present in all other genera.

Character 20. Seta *l′1Ti* is absent on legs I in *Limnogalobia* vs. present in all other genera.

Character 21. Setae *dFG* of leg I are mushroom-like in *Nectogalobia* vs. inflated in all other genera.

Character 22. Seta *l′FG* of leg I is absent in *Limnogalobia* vs. present in all other genera.

Character 23. Eupathidia *l′* and *l″* of leg I are split apically in *Elephantulobia* and *Limnogalobia* vs. not split in all other genera.

Character 24. Tarsi II are with 1 claw in *Blarinobia*, *Elephantulobia, Gymnomyobia,* and *Placomyobia* vs. with two claws in all other genera.

Character 25. Claws on tarsi II are asymmetric in *Nectogalobia* vs. symmetric in all other genera.

Character 26. Seta *v″* is absent on tibiae III and IV in *Limnogalobia* and *Nectogalobia* vs. present in all other genera.

Character 27. Seta *l″* of femora-genua III and IV is absent in *Gymnomyobia* vs. present in all other genera.

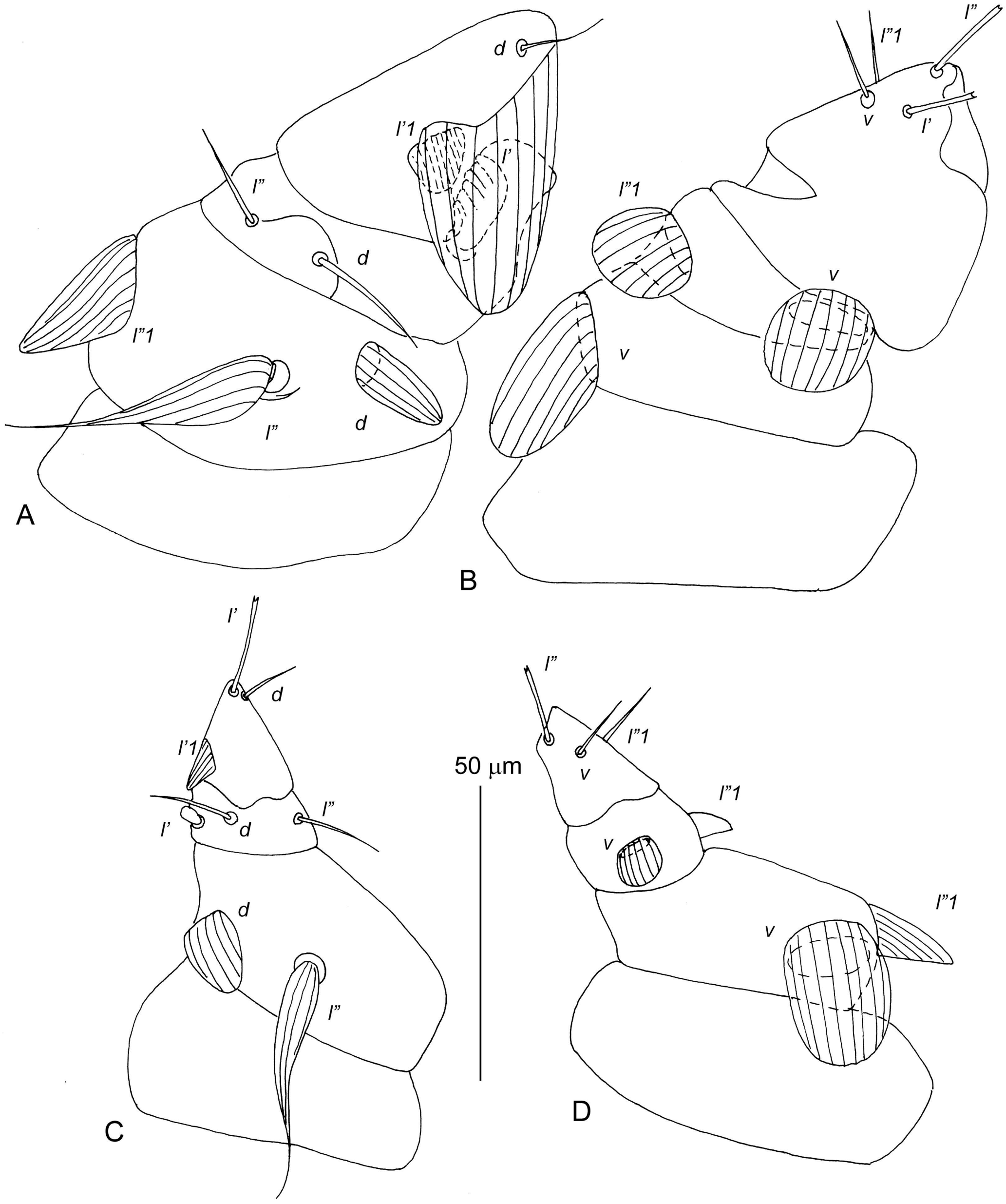

FIGURE 3: *Limnogalobia limnogale* Fain & Lukoschus, 1976, legs I of tritonymph: A – Left leg I in dorsal view; B – Same in ventral view; C – Right leg I in dorsal view; D – Same in ventral view.

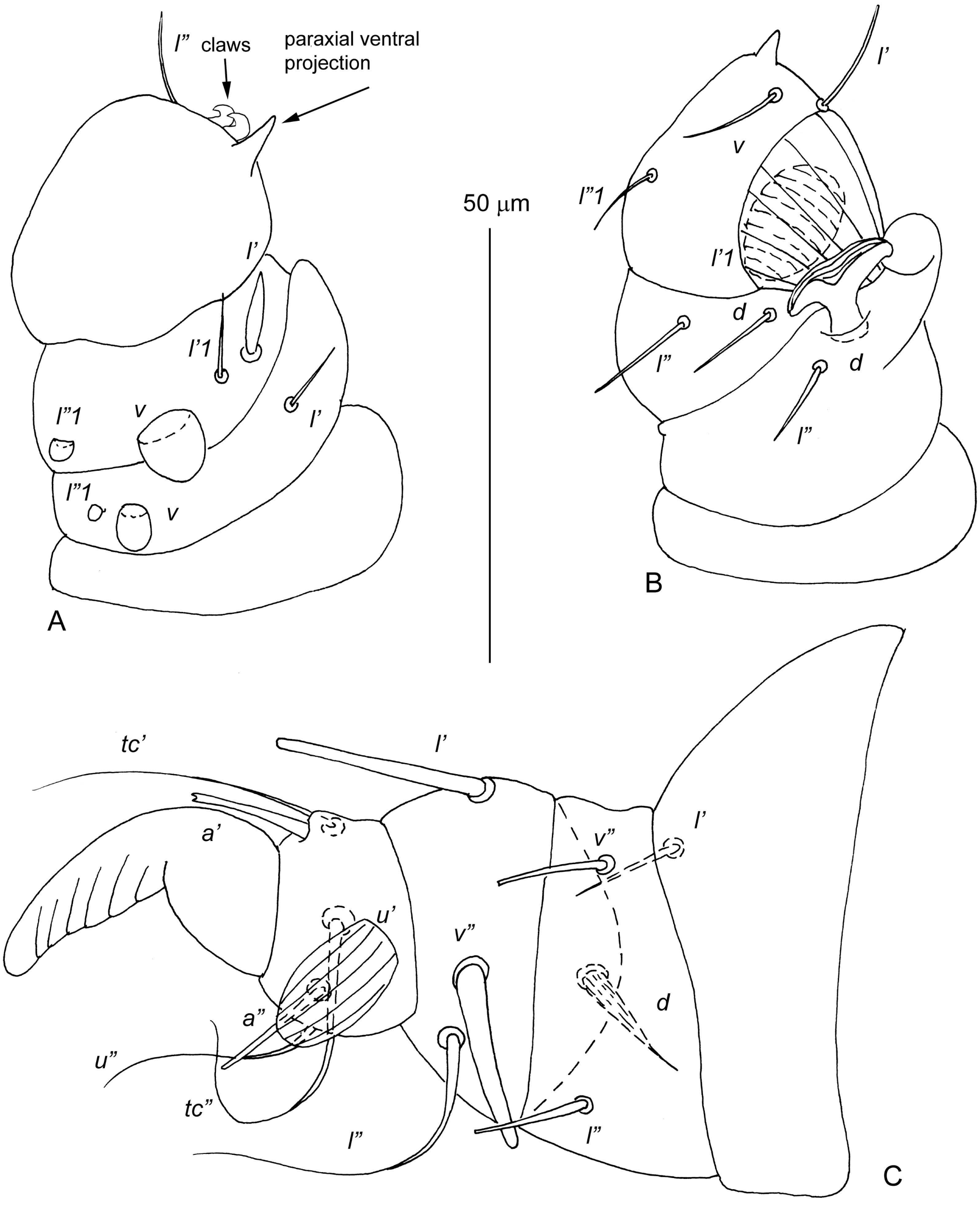

FIGURE 4: *Nectogalobia sinensis* Fain & Lukoschus, 1976, legs of tritonymph: A – Leg I in ventral view; B – Same in dorsal view; C – Leg III in ventral view.

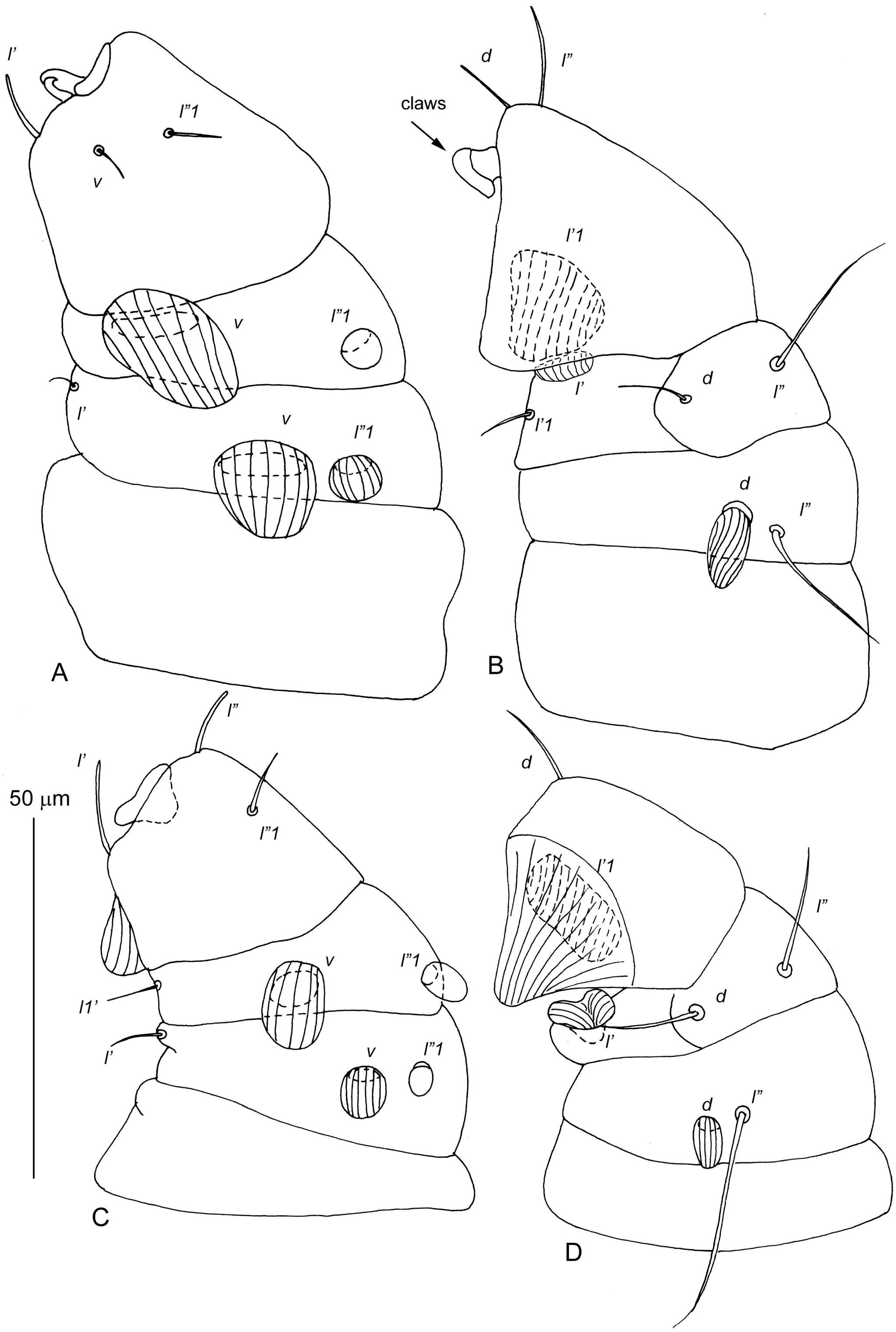

FIGURE 5: Legs I of tritonymphs. *Blarinobia simplex* (Ewing, 1938) (A, B): A – Ventral view; B – Dorsal view. *Eutalpacarus inflatus* Jameson, 1963 (C, D): C – Ventral view; D – Dorsal view.

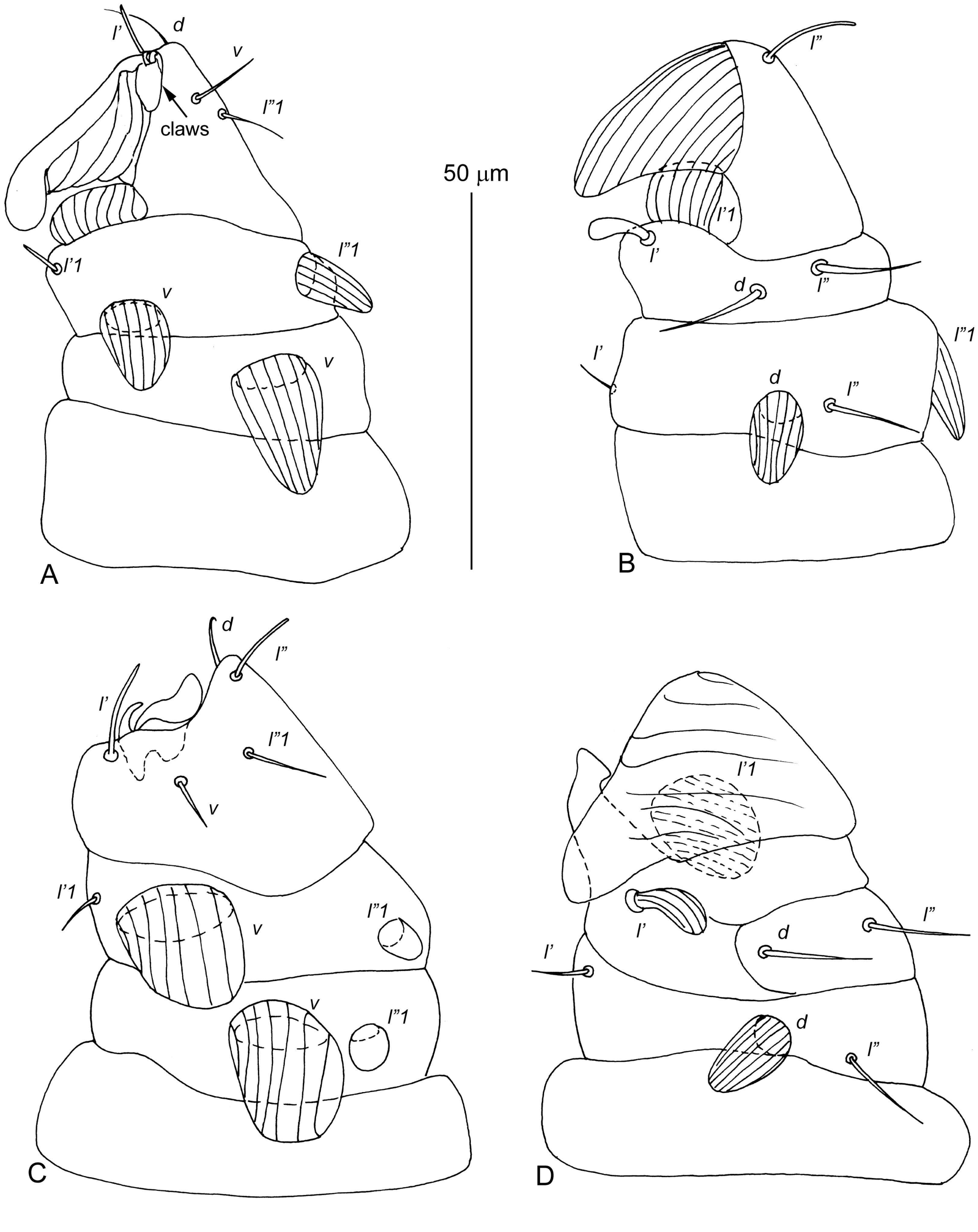

FIGURE 6: Legs I of tritonymphs. *Gymnomyobia nectogale* Fain & Lukoschus, 1976 (A, B): A – Ventral view; B – Dorsal view. *Placomyobia wilsoni* Jameson, 1970 (C, D): C – Ventral view; D – Dorsal view.

TABLE 3: Setae of legs I in tritonymphs of the tribes Elephantulobiini and Protomyobiini

Mite genera	Setae																
	dTa	*l′Ta*	*l″Ta*	*l″1Ta*	*l′1Ta*	*vTa*	*dTi*	*l′Ti*	*l″Ti*	*vTi*	*l′1Ti*	*l″1Ti*	*dFG*	*l′FG*	*l″FG*	*l″1FG*	*vFG*
Elephantulobia	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Limnogalobia	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+
Nectogalobia	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Blarinobia	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Eutalpacarus	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+
Gymnomyobia	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Placomyobia	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

TABLE 4: Number of setae on segments of legs II–III in tritonymph of the tribes Elephantulobiini and Protomyobiini ta – tarsus; ti – tibia; fe+ge – femur-genu; tr – trochanter; () – number of solenidia

Mite genera	Number of setae											
	taII	tiII	fe+geII	trII	taIII	tiIII	fe+geIII	trIII	taIV	tiIV	fe+geIV	trIV
Elephantulobia	7(1)	6	4(1)	1	6	5	2	1	6	5	2	1
Limnogalobia	7(1)	6	4(1)	1	6	4	2	1	6	4	2	1
Nectogalobia	7(1)	6	4(1)	1	6	4	2	1	6	4	2	1
Blarinobia	7(1)	6	4(1)	1	6	5	2	1	6	5	2	1
Eutalpacarus	7(1)	6	4(1)	1	6	5	2	2	6	5	2	2
Gymnomyobia	7(1)	6	4(1)	1	6	5	1	1	6	5	1	1
Placomyobia	7(1)	6	4(1)	1	6	5	2	1	6	5	2	1

Character 28. Seta *d* of trochanters III and IV is present in *Eutalpacarus* vs. absent in all other genera.

Key to genera of the tribes Elephantulobiini and Protomyobiini (Tritonymphs) (in genera *Eadiea* Jameson, 1949 and *Hylomysobia* Bochkov & OConnor, 2006, tritonymphs are absent and the last nymphal stage is a deutonymph)

1. Claws of legs I present. Setae *l′* and *l″* of tarsus I not bidentate apically 6
— Claws of legs I absent. Setae *l′* and *l″* bidentate apically 2

2. Seta *l′1* of tibia I absent 3
— Seta *l′1* of tibia I present. . . . . *Elephantulobia* Fain, 1972 (Figures 1 and 2)

3. Ventral setae *n* of subcapitulum absent. Setae *1c* absent. Tarsus I with 2 claws 4
— Ventral setae *n* of subcapitulum present. Setae *1c* present. Tarsus I with 1 claw . . *Afromyobia* Radford, 1954

4. Setae *1c* present. Trochanters III and IV with 1 seta. Tarsus IV with 1 claw 5
— Setae *1c* absent. Trochanters III and IV without setae. Tarsus IV without claws. . . . . *Madamyobia* Fain & Lukoschus, 1975

5. Setae *4a* present. 6
— Setae *4a* absent. . . . . *Limnogalobia* Fain & Lukoschus, 1976 (Figure 3)

6. Tarsus I without paraxial ventral projection. Setae *dTa* present. Seta *dFG* of legs I not mushroom-shaped 8
— Tarsus I with paraxial ventral projection. Setae *dTa* absent. Seta *dFG* of legs I mushroom-shaped. 7

7. Claw of legs III and IV not widened and without notches. Seta *u′* of tarsi III and IV filiform. Tibiae III and IV with 5 setae each. Femur-genu II with 3 setae; femora-genua III and IV with 1 seta each. . . . . *Protomyobia* Ewing, 1938
— Claw of legs III and IV distinctly widened and with notches. Seta *u′* of tarsi III and IV strongly inflated and striated. Tibiae III and IV with 4 setae each. Femur-genu II with 4 setae; femora-genua III and IV with 2 setae each. . . . . *Nectogalobia* Fain & Lukoschus, 1976 (Figure 4)

8. Legs I symmetrical 9
— Legs I asymmetrical . . *Amorphacarus* Ewing, 1938

9. Setae *4a* present 11
— Setae *4a* absent 10

10. Setae *c1* absent. Tarsus II with 2 claws. Femora-genua III and IV with 2 setae each. . . . . *Chimarrogalobia* Uchikawa, 1986
— Setae *c1* present. Tarsus II with 1 claw. Femora-genua III and IV with 1 seta each. . . . . *Gymnomyobia* Fain & Lukoschus, 1976 (Figure 6A, B)

11. Tarsus II with 2 claws. Trochanters III and IV with 2 setae each 13
— Tarsus II with 1 claw. Trochanters III and IV with 1 seta each 12

12. Subcapitular setae *ao1* filiform. Setae *se*, *c2*, *e2*, and *f1* present. . . . . *Blarinobia* Jameson, 1955 (Figure 5A, B)
— Subcapitular setae *ao1* widened membranous. Setae *se*, *c2*, *e2*, and *f1* absent. . . . . *Placomyobia* Jameson, 1970 (Figure 6C, D)

13. Setae *se*, *c2*, *e1*, *e2*, *f1*, *f2*, *2b*, and *2c* present. . . . . *Crocidurobia* Jameson, 1970
— Setae *se*, *c2*, *e1*, *e2*, *f1*, *f2*, *2b*, and *2c* absent. . . . . *Eutalpacarus* Jameson, 1949 (Figure 5C, D)

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Appendix 1

List of examined species of the tribes Elephantulobiini and Protomyobiini

Elephantulobiini: *Elephantulobia elephantuli* Fain, 1972, 1 TN from *Elephantulus brachyrhynchus* (Smith, 1836) (Macroscelidea: Macroscelidae), KENYA, Guasso Nyiro, 20 June 1909, coll. E. Heller; *Elephantulobia sudanensis* Fain & Lukoschus, 1976, 1 TN from *Elephantulus rufescens* (Peters, 1878) (Macroscelidea: Macroscelidae), KENYA, Guasso Nyiro, 14 June 1909, coll. Loring.

Protomyobiini: Afromyobiina: *Limnogalobia limnogale* Fain & Lukoschus, 1976, 1 TN paratype from *Limnogale mergulus* Major, 1896 (Afrosoricida: Tenrecidae), MADAGASCAR, Antisarabe, 1902, coll. Calvas; Amorphacarina: *Blarinobia simplex* (Ewing, 1938), 1 TN from *Blarina brevicauda* (Say, 1823) (Soricomorpha: Soricidae), USA, Rhode Island, Cranston, 23 August 1956, coll. Mulhearn; *Eutalpacarus himizu* Jameson, 1963, 1 L, 1 PN, 1 TN from *Urotrichus talpoides* Temminck, 1841 (Soricomorpha: Talpidae), JAPAN, Nagano, Hakuba, 5 May 1973, coll. K. Uchikawa; *Eutalpacarus inflatus* Jameson, 1963, 1 DN and 1 TN from *Dymecodon pilirostris* (True, 1886) (Soricomorpha: Talpidae), JAPAN, Nagano, Hakuba, 18 July 1973, coll. K. Uchikawa; *Gymnomyobia nectogale* Fain & Lukoschus, 1976, 1 TN paratype from *Nectogale elegans* Milne-Edwards, 1870 (Soricomorpha: Soricidae), CHINA, Mouping, other data unknown; *Placomyobia wilsoni* Jameson, 1970, 2 TN from *Anourosorex squamipes* Milne-Edwards, 1872 (Soricomorpha: Soricidae), MYANMAR, Mount Carin, 25 July 1932, other data unknown; Protomyobiina: *Netogalobia sinensis* Fain & Lukoschus, 1976, 2 TN from *Nectogale elegans* Milne-Edwards, 1870 (Soricomorpha: Soricidae), CHINA, Mouping, other data unknown.