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

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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: Myobioidae) 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-
Bochkov A.V.

**Table 1:** States of some characters in tritonymphs of the tribes Elephantulobiini and Protomyobiini

| Mite genera       | Characters | Legs I | Claw formula of legs I-IV |
|-------------------|------------|--------|--------------------------|
| **ao1**           | **n**      |        |                          |
| **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                        | 2-1-1-1 |
| **Gymnomyobia**   | +          | +      | S                        | 2-1-1-1 |
| **Placomyobia**   | +          | +      | S                        | 2-1-1-1 |

**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.

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).
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.
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.

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’l’Ti 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      | dTa | l'Ta | l"Ta | l'Ta | l"Ta | vTa | dTi | l'Ti | l"Ti | dFG | l'FG | l"FG | 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     | 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        | 1     | 6    | 5    | 2       | 1    |
| 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 & O'Connor, 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' of tibia I absent .................................. 3
— Seta l' of tibia I present .................................. Elephantsulobia Fain, 1972 (Figures 1 and 2)

3. Ventral setae n of subcapitulum absent. Setae 1c present. 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 .............................................

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-gena 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-gena 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-gena III and IV with 2 setae each. .................. Chimarrogalobia Uchikawa, 1986
— Setae $c1$ present. Tarsus II with 1 claw. Femora-gena 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: *Blarinoa 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.