

A new genus of mite: *Albertibarbutia* gen. nov. (Acari, Trombidiformes, Barbutiidae)

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Abstract

The mite species *Barbutia arasbaraniensis* MOHAMMAD-DOUSTARESHARAF & BAGHERI, 2021, until now only known from four specimens from Iran, was discovered in epilithic crustose lichen on the Königstuhl mountain in Heidelberg in Germany. It is designated as the type species of the new taxon *Albertibarbutia* gen. nov. Based on the new collection material, a supplementary description of the species is provided and facets of its taxonomy and morphology are discussed. The homologies of the setae and solenidia of both the legs and the pedipalps of *Albertibarbutia* are indicated. The family Barbutiidae ROBAUX, 1975 is rediagnosed, its phylogenetic relationships are commented on and it is here re-recorded for Germany for the first time.

Kurzfassung

Eine neue Milbengattung: *Albertibarbutia* gen. nov. (Acari, Trombidiformes, Barbutiidae)

Die Milbenspezies *Barbutia arasbaraniensis* MOHAMMAD-DOUSTARESHARAF & BAGHERI, 2021, bisher nur bekannt durch vier Exemplare aus dem Iran, wurde in einer felsengeborenen Krustenflechte auf dem Berg Königstuhl in Heidelberg entdeckt. Sie wird als die Typusart des neuen Taxons *Albertibarbutia* gen. nov. designiert. Basierend auf dem neuen Fundmaterial wird ihre Beschreibung ergänzt und Facetten ihrer Taxonomie und Morphologie werden diskutiert. Die Homologien der Borsten und Solenidien der Beine sowie der Pedipalpen von *Albertibarbutia* werden dargestellt. Die Familie Barbutiidae ROBAUX, 1975 wird neu diagnostiziert, ihre phylogenetischen Beziehungen werden besprochen und sie wird hier erstmalig für Deutschland nachgewiesen.

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1 Introduction

The Barbutiidae ROBAUX, 1975 is a rarely encountered family of small, elongate, slender mites. The family is currently monogeneric, containing only the type genus *Barbutia* OUDEMANS, 1927 with its type species *Stigmaeus (Macrostigmaeus) anguineus* BERLESE, 1910 and at the present time comprises eight species, including the fossil *B. theroni* KHAUSTOV *et al.*, 2021 from late Eocene Rovno amber. In the present publication, the

occurrence of the recently discovered species *Barbutia arasbaraniensis* MOHAMMAD-DOUSTARESHARAF & BAGHERI, 2021 in Heidelberg in South-west Germany is reported and commented on. This is the first record of this species for Europe and also the first record of the family Barbutiidae for Germany. The original description of *Barbutia arasbaraniensis* is supplemented on the basis of the specimens from Heidelberg, and several morphological differences between the Iranian specimens, based on the description of the latter by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021), and the mites from Heidelberg are discussed. The family Barbutiidae is rediagnosed. *Albertibarbutia* with its designated type species *Barbutia arasbaraniensis* is proposed as a new genus within the Barbutiidae.

2 Material and methods

Two female deutonymphs of *Barbutia arasbaraniensis* were collected by the author in November 2007 on the Königstuhl mountain in Heidelberg, Germany at an altitude of 430 m from leprose crustose lichens, mostly *Lepraria membranacea* (DICKSON) VAINIO, growing on sandstone rock of the Lower Triassic Buntsandstein lithostratigraphic unit. Three more female deutonymphs of the species were collected at the same site and habitat in April 2016. The mites were fixed in 70 % ethanol, macerated in 40-80 % lactic acid and examined and photographed under a laboratory bright field compound microscope. An unmacerated mite was also examined. Descriptions and measurements are based on specimens mounted in temporary cavity slides or on semi-permanent slides. The species identification is based on a detailed comparison of the collected Heidelberg Barbutiidae to the previously published descriptions of all known species of the family Barbutiidae. The identification of the lichen is based primarily on WIRTH (1995). The general morphological terms used in this paper derive from KRANTZ (2009) and WALTER *et al.* (2009). The notation which is applied to the setae of the idiosoma and legs follows the system developed by GRANDJEAN over many years (cf. TRAVÉ & VACHON 1975),

as revised by KETHLEY (1990) and NORTON (1977) respectively. The notation of the chaetotaxy of the palps is based on that of GRANDJEAN (1946) as applied to the Barbutiidae by FAN *et al.* (2003). An explanatory list of the abbreviations and notations employed in the present text and in the figures follows the literature list. References to the body length in the text refer to the combined length of the gnathosoma and idiosoma. Five unmacerated specimens of *Barbutia arasbaraniensis* in a microvial in 70% ethanol (SMNK-ACAR 0001), as well as a series of photographs and videos of the Heidelberg mites are deposited as voucher material in the Acarology Collection of the Department of Zoology of the State Museum of Natural History Karlsruhe.

3 Results

3.1 Proposal of a new genus of Barbutiidae

Order Trombidiformes REUTER, 1909

Suborder Prostigmata KRAMER, 1877

Family Barbutiidae ROBAUX, 1975

Albertibarbutia gen. nov.

Type species: *Barbutia arasbaraniensis* MOHAMMAD-DOUSTARESHARAF & BAGHERI, 2021. This species is described in the following publication:

MOHAMMAD-DOUSTARESHARAF, M. & BAGHERI, M. (2021): Description of *Barbutia arasbaraniensis* sp. nov. (Acari: Trombidiformes: Barbutiidae) based on the deutonymph and male specimens from Iran. – Persian Journal of Acarology 10(1): 9-17.

The holotype deutonymph female and a paratype adult male of the type species of *Albertibarbutia* are located in the Acarological Collection of the Department of Plant Protection at the University of Maragheh, Maragheh, Iran. The type locality is the Abbasabad region, Arasbaran forest, North East Azerbaijan Province, Iran. The type and paratype specimens were collected by M. MOHAMMAD-DOUSTARESHARAF on September 3, 2017 from rotten wood at an altitude of 1310 m above sea level.

Etymology: The genus is named in honour of the distinguished German zoologist and acarologist GERD ALBERTI (1943-2016) who contributed considerably to the knowledge of the anatomy, morphology and ultrastructure of the Acari, including also the Trombidiformes. He taught and did research at the Ruprecht Karl University of Heidelberg from 1980 to 1996, about five kilometers away from the site where the Baden-Württemberg specimens of the new genus were discovered.

Diagnosis

Female deutonymphs of *Albertibarbutia* gen. nov. are unique among female deutonymphs in the family Barbutiidae in displaying the following combination of characters: setal count of the femora of legs I-IV is: 3, 1, 0, 0; genu of leg I with three setae and sensillum *k*; tibia III and tibia IV with one seta each; tarsus of leg I with only one solenidion $\omega 1$, and with $\omega 2$ absent; each coxa III with only a single seta, namely seta *3b*; palptibia with only one seta; palptibial claw slender, thorn-like and without a ventral spine; palptarsal solenidion ω very long, as long as the palptibial claw; palptarsal eupathidia very long, as long as the palptibial claw; interior scapular seta *sci* inserted anterior to both the eyes and anterior to the insertion point of the external vertical seta *ve*. Female deutonymphs of *Albertibarbutia* are unique amongst female deutonymphs in their family in possessing only two pairs of aggenital setae: *ag1* and *ag2*.

None of the five species of *Barbutia* for which female deutonymphs are known, including the type species of *Barbutia*, possess any one of these seventeen listed distinguishing characteristics of *Albertibarbutia*, depicted in figures 1-4, and neither do the adult females of *B. longinqua* FAN, WALTER & PROCTOR, 2003 and *B. cubensis* KHAUSTOV & TOLSTIKOV, 2022, whose female deutonymph is not known. In eleven of these differing traits where the female deutonymphs of the genus *Barbutia* show: femur I with four setae; genu of leg I with five setae and sensillum *k*; tarsus of leg I with solenidia $\omega 1$ and $\omega 2$; presence of three pairs of aggenital setae; palptibia with two setae; palptibial claw thick and with a ventral spine present; palptarsal solenidion ω short, half as long as the palptibial claw or less; palptarsal eupathidia both short, half the length of the palptibial claw or less; insertion of seta *sci* posteriad that of the eyes and posteriad seta *ve*, the character state within the female deutonymphs of the sister genus *Barbutia* shows no interspecific variability and is identical to that of the female adult where known, namely in *B. perretae*, *B. australia*, *B. iranensis* and *B. cubensis* based on the results of ROBAUX (1975), FAN *et al.* (2003), BAGHERI *et al.* (2010), DÖNEL-AKGÜL (2016) and KHAUSTOV & TOLSTIKOV (2022).

The presence of a ventral spine on the palptibial claw has up to now been considered to be a major defining character of the Barbutiidae, while the arrangement of the insertion of seta *sci* relative to seta *ve* and to the eyes as seen in *Albertibarbutia* is not only unknown in other Barbutiidae, but also exceptionally rare in the

Raphignathoidea KRAMER, 1877 (FAN & ZHANG 2005: p. 129, Fig. 4) where it is known from within the family Cryptognathidae OUDEMANS, 1902 such as in *Cryptognathus amalfitanii* PORTA, 2019 (cf. PORTA 2019: Fig. 5) and in some Caligonellidae GRANDJEAN, 1944 (KHAUSTOV 2021).

Female deutonymphs of *Albertibarbutia*, in addition to the numerous differences already mentioned, may be further distinguished from those of *Barbutia anguineus*, which is the type species and the morphological reference taxon for its genus, in that they possess two setae less on tibia II, one seta less on the tarsus of leg II, two setae less on tarsus III, two setae less and also a solenidion absent on tarsus IV, as well as considerably shorter idiosomal setae *sci*, *c2* and *d2*, based on a comparison of *Albertibarbutia* with the description of *Barbutia anguineus* by BERLESE (1910), SUMMERS (1964), ROBAUX (1975), DOĞAN & DÖNEL (2009), BAGHERI *et al.* (2014) and also the comments on this species by WOOD (1973: p. 89), who confirmed that the description of the taxon by SUMMERS (1964), based on mites collected in California in North America, fits the three female specimens of the species originating from Italy, which are kept in the BERLESE Collection in Florence.

3.2 Taxonomy of the *Albertibarbutia* specimens from Heidelberg

3.2.1 Family Barbutiidae ROBAUX, 1975

Diagnosis

Female deutonymph: with the general characteristics of the order Trombidiformes REUTER, 1909; body soft, fusiform, finely striated, elongate and minute with a length including both the idiosoma and gnathosoma of about 230-420 µm; gnathosoma projecting anteriorly of the propodosoma, chelicerae slender, elongate, not retractile, medially fused at their bases and subterminally separate, with short styletiform movable digits and reduced anteriorly sheath-like fixed digits; cheliceral setae absent; peritremes minute, each single chambered and originating dorsally on anterior edge of fused cheliceral bases; palp stout, with 5 segments and very short compared to idiosomal length; setal counts from palptrochanter to palptarsus, including the two terminal simple unfused tarsal eupathidia: 0, 2, 1, 1-2+claw, 4-6+ ω ; palptibial claw prominent, similar in length to, or only slightly shorter than free part of palptarsus and generally with a conspicuous ventral tooth; palptarsus with the simple setae *va* and *lp* as well as the terminal eupathidia *acm* ξ and *ul* ξ present;

none, one or both of the palptarsal setae *ba*, *bp* present, with one or both of these being vestigial if present; subcapitulum with two pairs of adoral setae *or1*, *or2* and one pair of subcapitular setae *m*, with setal pair *n* absent; anterior margin of subcapitulum truncate, broad and straight in ventral view with lateral lips slightly flared; one pair of eyes and one pair of postocular bodies present; dorsal idiosoma with 13 pairs of smooth, flagelliform setae: *vi*, *ve*, *sci*, *sce*, *c1*, *c2*, *d1*, *d2*, *e1*, *e2*, *f1*, *h1*, *h2*; dorsal shields absent; sejugal groove distinct; coxae of legs II and III very far apart with the distance between them being about 0,4 times the idiosomal length; genital and anal opening longitudinally arranged and separate; genital and anal shields present, but former weakly developed; other ventral shields absent; genital setae absent; eugenital setae absent; genital papillae absent; ovipositor absent; adanal setae absent; ventral opisthosoma with three or rarely with two pairs of aggenital setae; ventral seta *1a* inserted close to coxa I, seta *3a* inserted distinctly anterior to coxa III, and setae *4a* between the coxae IV; two pairs of minute peglike supracoxal setae *ep*, *el*, inserted anterolaterad to prodorsum; legs short; chaetotaxy of legs I-IV is: trochantera 1, 1, 1, 1; femora 3-4, 3, 0-2, 0-2; genua 3+k or 5+k, 0, 0, 0; tibiae 5+ ϕ , 2+ ϕ or 4+ ϕ , 1-3, 1-3; tarsi 10+2 ω or 7+2 ω or 10+ ω ; 7+ ω or 6+ ω , 7+ ω or 6+ ω or 5+ ω , 7+ ω or 5+ ω or 5; all leg femora and tarsi undivided; tarsus of leg I abruptly rounded in dorsal perspective; pretarsi each with two claws and an empodium; each leg claw subterminally with one or two pairs of short, capitate tenent hairs; empodium minute, with one to three pairs of minute, capitate, tenent hairs.

This diagnosis of the family Barbutiidae builds on those of previous authors, particularly those of SUMMERS (1964: p. 191) for female deutonymphs and ROBAUX (1975: p. 487) as well as FAN *et al.* (2003: p. 108) for adult Barbutiidae, includes relevant data from KHAUSTOV & TOLSTIKOV (2022) and applies completely to the specimens from Heidelberg. The adult female of the Barbutiidae differs from the female deutonymph in possessing a pair of genital setae (FAN *et al.* 2003, DÖNEL-ARĞÜL 2016) as well as in possessing a higher number of setae on the coxae II, III and tibiae III, IV. The chaetotaxy formulae of the legs I-IV of the adult females (only known of the genus *Barbutia*) are: trochantera 1, 1, 1, 1; femora 4, 3, 2, 2; genua 5+k, 0, 0, 0; tibiae 5+ ϕ , 4+ ϕ , 2-4, 2-3; tarsi 10+2 ω or 8+2 ω , 6+ ω , 6+ ω , 6+ ω or 6. The adult male, known from four, but described in de-

tail for only three species, may be distinguished from the female deutonymph in displaying the following traits: genital and anal openings fused; aedeagus present; one pair of aggenital setae; pseudanal setae *ps1*, *ps2* very short, stubby and peglike. The setal and solenidial count per leg and segment is identical in the male adult and the female deutonymph of *Albertibarbutia arasbaraniensis* (MOHAMMAD-DOUSTARESHARAF & BAGHERI 2021), whereas in *Barbutia australia*, the male shows less setae on femur I, genu I and tarsus I than the female deutonymph based on the data of FAN *et al.* (2003). The setal count of these leg segments is also less in the adult male than in the adult female in *B. cubensis* according to the results of KHAUSTOV & TOLSTIKOV (2022), although in one of four femora of leg I of the two males examined by these authors, the setal count equalled that of the females.

3.2.2 *Albertibarbutia arasbaraniensis*

(MOHAMMAD-DOUSTARESHARAF & BAGHERI, 2021)

Diagnosis

Female deutonymph: With the characteristics of the family Barbutiidae and those of the genus *Albertibarbutia*; internal vertical setae *vi* (20 - 25 μm) four to five times the length of the internal scapular setae *sci* (5 μm); external vertical setae *ve* (60-65 μm) short and measuring 1,5 to 1,8 times the length of the external scapular setae *sce* (35-44 μm); each seta *sci* inserted anterior to both the eyes and anterior to seta *ve* in dorsal view; hysterosomal setae *c1* (19-24 μm), *c2* (23-25 μm), *d1* (12-15 μm), *d2* (15-18 μm), *f1* (15-20 μm) short; posterior hysterosomal setae *h1* (91-100 μm) and *h2* (86-92 μm) elongate; aggenital area with only two pairs of aggenital setae; *ag2* (30-33 μm) three to four times as long as *ag1* (8-11 μm); palptarsus with very long solenidion ω (4,0-4,5 μm) and long eupathidia *acm\xi* (3,5 μm), *ul'\xi* (3,5 μm); palptibial claw extremely slender and without a ventral spine; setation of coxae I-IV: 2, 1, 1, 0, excluding setae *1a*, *3a*, *4a*; counts of setae and solenidia on free segments of legs I-IV are: trochanters: 1, 1, 1, 1; femora: 3, 1, 0, 0; genua 3 + *k*, 0, 0, 0; tibiae 5 + ϕ , 2 + ϕ , 1, 1; tarsi: 10 + ω 1, 6 + ω , 5 + ω , 5.

Differential diagnosis

The female deutonymph of *Albertibarbutia arasbaraniensis* differs from those of *Barbutia anguineus* (BERLESE, 1910), *B. perretae* ROBAUX, 1975,

B. australia FAN, WALTER & PROCTOR, 2003, and *B. iranensis* BAGHERI, NAVAEI-BONAB & UECKER-MANN, 2010 as well as from the adult female of *B. longinqua* FAN, WALTER & PROCTOR, 2003 and *B. cubensis* in showing each of the following characteristics of the legs: one or two setae less on the femur of each leg; genu I with two setae less; tibiae III and IV each with one or two setae less; tarsus I without solenidion ω 2. Some more differences in leg setation exist when the deutonymph of *Albertibarbutia arasbaraniensis* is compared to that of each of these species individually. *Barbutia theroni* differs from *Albertibarbutia arasbaraniensis* in showing higher setal counts on femora I, II, III, genu I and tibia IV, as well as in possessing a solenidion ω 2, based on the description of the former by KHAUSTOV *et al.* (2021). Among Barbutiidae female deutonymphs only *A. arasbaraniensis* possesses one seta on each coxa III (excluding seta *3a*). The female deutonymph of *A. arasbaraniensis* contrasts to those of all species of *Barbutia* and also to the adult females of *B. longinqua* and *B. cubensis* in possessing only two instead of three aggenital setae, based on the species descriptions in SUMMERS (1964), ROBAUX (1975), FAN *et al.* (2003), BAGHERI *et al.* (2010), MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021), KHAUSTOV *et al.* (2021) and KHAUSTOV & TOLSTIKOV (2022).

Only female deutonymphs of *Albertibarbutia arasbaraniensis*, *Barbutia anguineus*, *B. iranensis* and *B. theroni* are known to possess a very long aggenital seta *ag2* whose length is 2,5 times or more than that of *ag1*. The two known deutonymphs of *Barbutia iranensis*, based on BAGHERI *et al.* (2010) show much longer internal scapular setae *sci* (10 μm) and shorter internal vertical setae *vi* (10 μm), with these being of equal length, than *Albertibarbutia arasbaraniensis* and also may be distinguished from the latter by possessing external vertical setae *ve* almost identical in length to the external scapular setae *sce*. The female deutonymph of *Barbutia anguineus* sensu SUMMERS (1964) differs from *A. arasbaraniensis* in its much longer seta *ve* measuring about 150 μm .

Comments

The foregoing diagnosis and differential diagnosis of *Albertibarbutia arasbaraniensis* both apply fully to the specimens from Heidelberg. The species diagnosis of *A. arasbaraniensis* deutonymph females presented above is up to date with respect to the number of species included, as well as more detailed than those given by

MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021). The latter provide a short species key but no differential diagnosis of *A. arasbaraniensis*.

3.3 Supplementary data on the morphology of *Albertibarbutia arasbaraniensis*

In this section I will only cover aspects of the morphology of *A. arasbaraniensis* not addressed by the excellent paper of MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021) as well as several differences which I found to exist between the description of the Iranian specimens by these authors and the *A. arasbaraniensis* from Germany which I examined. The Heidelberg specimens are depicted in figures 1-5.

Dimensions

The *A. arasbaraniensis* female deutonymphs from Heidelberg with a body length of 370 μm are somewhat shorter than the ones from Iran which measure 400-403 μm according to MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021). The propodosoma is distinctly narrower than the hysterosoma, which in the German specimens reaches its maximum width of 113 μm somewhat posterior to the insertions of the setal pair *c2*, thereby roughly corresponding to the 100 μm and 105 μm widths of the specimens described by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021). It should be noted though, that only two deutonymph females from Iran are known. The idiosoma is approximately cylindrical in cross section, with its maximum height of about 82 μm in lateral view, reached at the region of the insertions of setae *3a*, being somewhat less than its greatest width.

Anteriad the eyes the propodosomal height diminishes and drops off strongly between the insertions of setae *vi* and the cheliceral basis. The gnathosomal region is of much lower height than the idiosoma and this enables the styliform chelicerae and the palps to enter small cavities.

Idiosoma

The original description of *A. arasbaraniensis* by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021) does not comment on the colour of this species. The body colour is only known for a single species of Barbutiidae so far, namely *Barbutia perretae*, alcohol preserved specimens of which were described by ROBAUX (1975: p. 484) as being red-pink in appearance. Living specimens of *A. arasbaraniensis* from Heidelberg display an orange red colour. After a prolonged storage in 70 % ethanol the pigment eventually fades and the animal turns white.

The idiosomal setal lengths of the Heidelberg mites, measured in a single representative slide-mounted specimen were as follows: Dorsal setae: *vi* (20 μm), *ve* (64 μm), *sci* (5 μm), *sce* (44 μm), *c1* (19 μm), *c2* (23 μm), *d1* (12 μm), *d2* (15 μm), *e1* (12 μm), *e2* (23 μm), *f1* (18 μm), *h1* (91 μm), *h2* (86 μm). Ventral setae: *1a* (56 μm), *1b* (9 μm), *1c* (18 μm), *2b* (18 μm), *3a* (42 μm), *3b* (15 μm), *4a* (15 μm), *ag1* (11 μm), *ag2* (32 μm), *ps1* (9 μm), *ps2* (9 μm), *ps3* (8 μm). These dimensions correspond very closely to those of the two Iranian *A. arasbaraniensis* female deutonymphs.

In the *Albertibarbutia arasbaraniensis* from Iran the supracoxal setae are nowhere mentioned or drawn by MOHAMMAD-DOUSTARESHARAF & BAGHERI



Figure 1. *Albertibarbutia arasbaraniensis* female deutonymph from Heidelberg: composite image. – All photographs and illustrations: RAYMOND A. LAMOS.

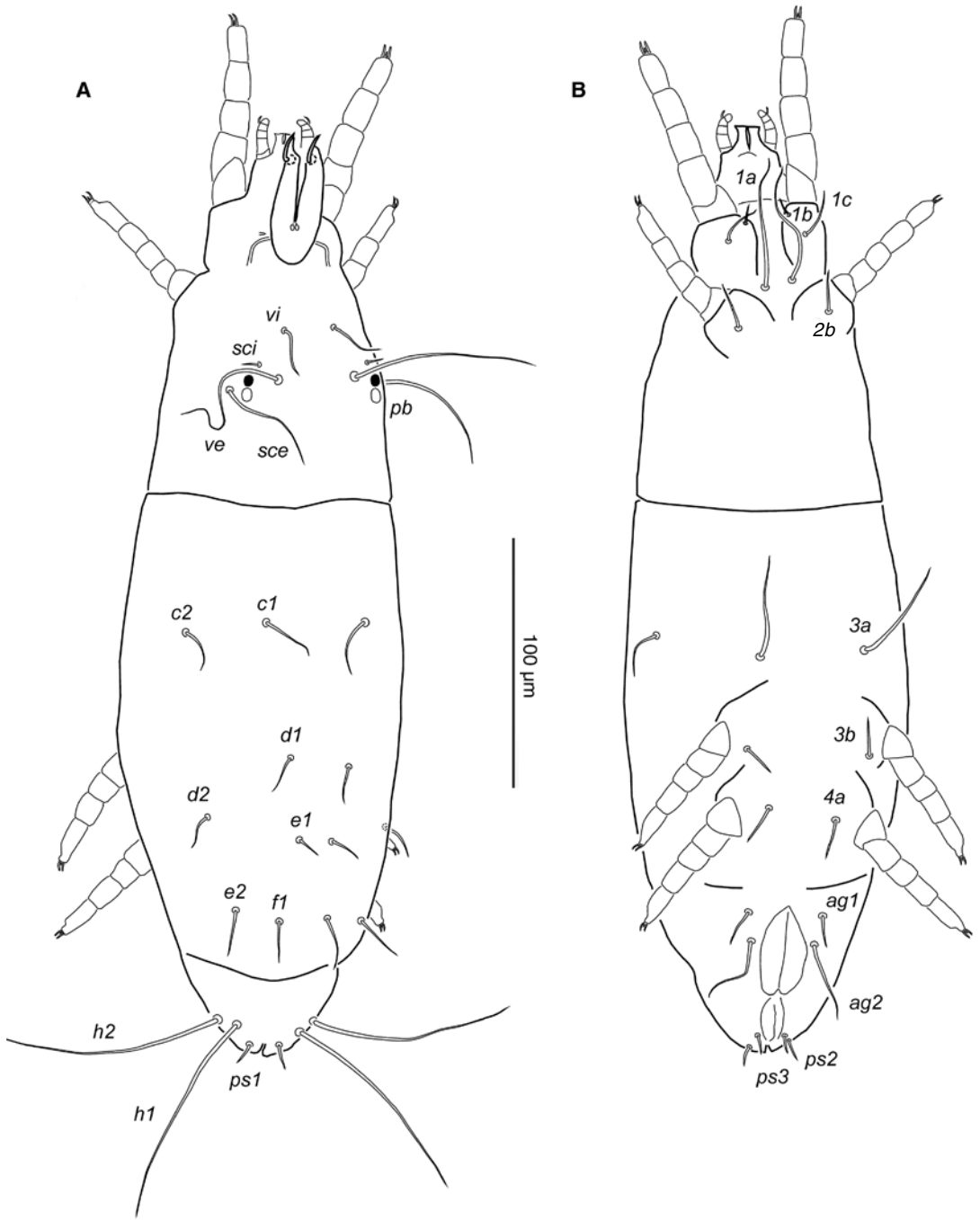


Figure 2. *Albertibarbutia arasbaraniensis* female deutonymph: A – dorsal view; B – ventral view.

(2021). One pair each of the very short spiniform supracoxal setae *ep* and *el*, inserted anterolaterad the prodorsum, are visible in the Heidelberg specimens of this species.

The idiosomal striation pattern of the Heidelberg Barbutiidae approximately corresponds to that illustrated by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: Figs 1, 2) and is typical of its family. As may be seen in figure 5 the longitudinal striae are very densely arranged in the Heidelberg specimens, much denser than depicted by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: Figs 1, 2) for the Iranian specimens. Between the insertions of the setae *c2* and *3a* for example, measured at an angle perpendicular to the striae, their density is about 17 per 10 μm in the Heidelberg mites.

Gnathosoma

The homologies of the chaetotaxy of the palp of *A. arasbaraniensis*, with the trochanter being without setae, are as follows: femur [*d*, *v'*]; genu [*d*]; tibia [*d*]; tarsus [*acm\xi*, *ul'\xi*, *va*, *lp*, ω]. The identity of the tarsal eupathidia within the Barbutiidae has first been given by FAN *et al.* (2003: p. 113, Fig. 5) for *Barbutia australia*. Their nomenclature has been slightly modified by KHAUSTOV & TOLSTIKOV (2022), whose naming system is adopted here. In the Heidelberg specimens the presumptive eupathidion *acm\xi* was inserted slightly more proximally than the other eupathidion, which supports this identification. It seems conceivable that the second, more distally inserting tarsal eupathidion may represent a cryptic fusion of two or three eupathidia of the trio *sul\xi*, *ul'\xi* and *ul''\xi*. Within the Raphignathoidea a fusion of these 3 palptarsal setae is known from within the Stigmaeidae OUDEMANS, 1931 (KHAUSTOV 2014) such as in the genus *Stigmaeus* KOCH, 1836, where the distally three pronged eupathidium still clearly indicates a partial fusion, or in *Pseudostigmaeus* WOOD, 1967 where the terminal prongs are exceedingly small or vestigial (FAN *et al.* 2016). However, the electron microscope derived image presented by KHAUSTOV & TOLSTIKOV (2022: p. 63, Fig. 6.4) shows the two very short palptarsal eupathidia of *Barbutia cubensis* to be of similar size and shape and without any sign of a setal fusion having taken place. Since I also saw no sign of setal fusion in *Albertibarbutia arasbaraniensis*, I here follow the approach of KHAUSTOV & TOLSTIKOV (2022) to *Barbutia cubensis* in identifying the second, more distally inserted palptarsal eupathidion of *Albertibarbutia* as being *ul'\xi*.

The basal setae *ba* and *bp* were not mentioned or depicted by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021) in their description of *Albertibarbutia arasbaraniensis*. I also did not observe these setae in the Heidelberg specimens of this species. Nevertheless, vestigial setae *ba*, *bp* may be present in this taxon.

MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: Fig. 6) draw the anterior palptarsal seta *va* of the female deutonymph as being relatively short, reaching anteriorly only as far as the tips of the eupathidia. In the Heidelberg specimens the setae *va* are about 1,5 times as long as the Iranian ones instead and extend considerably beyond the tips of the eupathidia. Similarly in their figure 6, these authors show the palpgenual seta *d* as being of moderate length and measuring about 7 μm in the Iranian specimens. This seta was at least twice as long in the German mites examined.

The insertions of the adoral setae differ in the Heidelberg and Iranian specimens of *Albertibarbutia arasbaraniensis*. In the former the seta *or1* is inserted distinctly medially to the laterally inserted *or2* in ventral view. In the Iranian specimens instead, based on MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: Figs 4, 14) the adoral setae *or1* are inserted laterally with respect to these setae. In my opinion the setae *or1* in MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: Figs 4, 14) represent setae *or2* instead, and vice versa. Even so, the setae *or1* are inserted more laterally than in the Heidelberg mites. The subcapitular setae *m* of the Iranian specimens also are distinctly shorter than those of the Heidelberg ones.

Legs

The leg chaetotaxy of the Barbutiidae from Heidelberg fits that of the Iranian *A. arasbaraniensis* well with regard to its leg setal and solenidial counts and the insertion points of the solenidia and setae on the trochanter to tarsus of the legs. In the publications dealing with the Barbutiidae so far, the majority of authors, including MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021), do not identify the leg setae by name, other than the solenidia, with the only exception being FAN *et al.* (2003: p. 115, Fig. 9), although here half of the tarsal setae of the figured first leg are not labelled, KHAUSTOV *et al.* (2021) and KHAUSTOV & TOLSTIKOV (2022). Since *A. arasbaraniensis* is characterized by a reduced setal and solenidial count on the legs compared to species of *Barbutia*, it is very informative to homologue the chaetotaxy of this species. This is done in the following table:

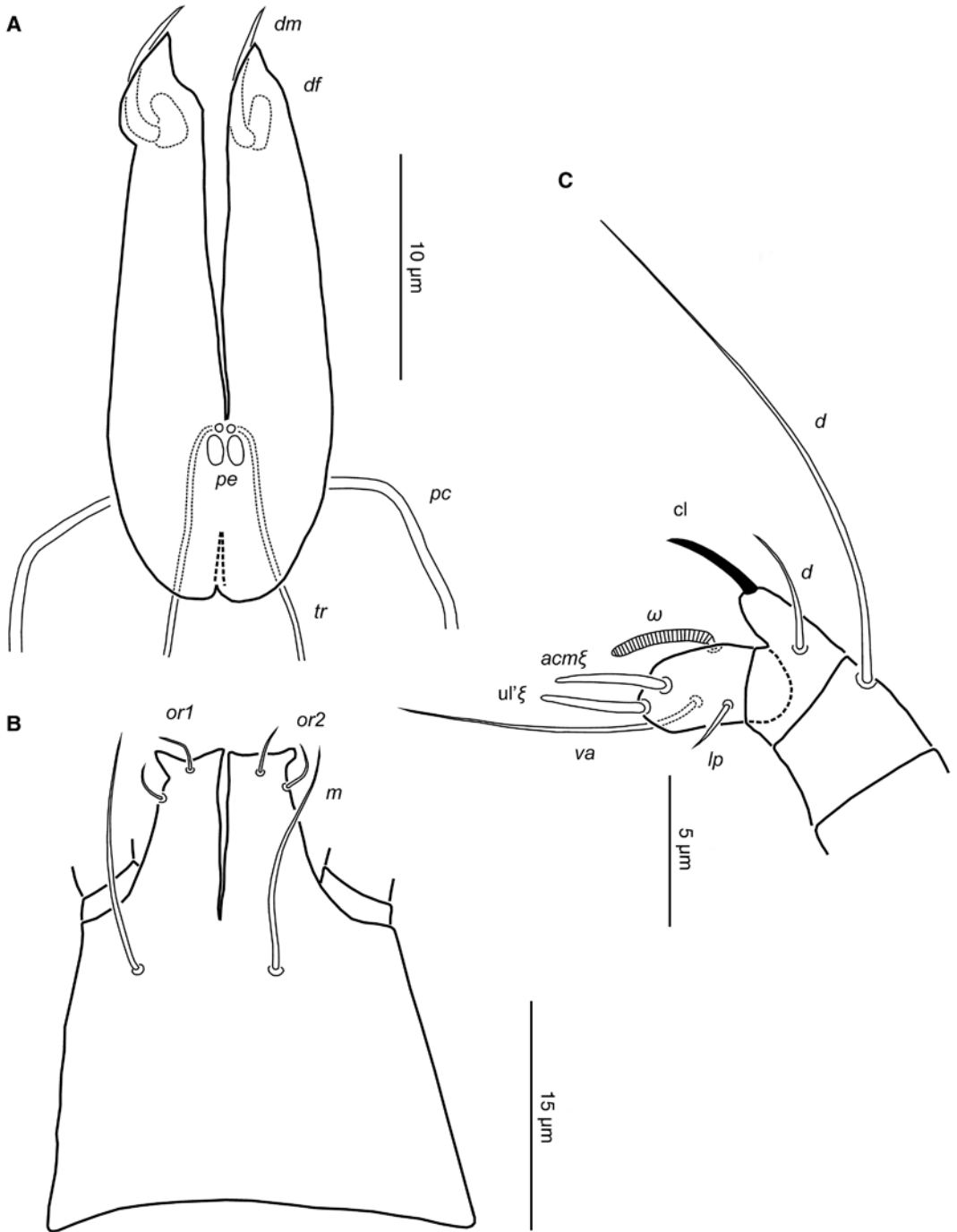


Figure 3. *Albertibarbutia arasbaraniensis* female deutonymph: A – chelicerae, dorsal view; B – subcapitulum, ventral view; C – genu to tarsus of pedipalp, lateral view.

Table 1. Setae and solenidia inserting on the trochanter to tarsus of legs I-IV of female deutonymphs of *Albertibarbutia arasbaraniensis*. Tr=trochanter, Fe=femur, Ge=genu, Ti=tibia, Ta=tarsus.

Leg	Tr	Fe	Ge	Ti	Ta
I	v'	$d, (l)$	$d, (l), k$	$d\xi, (l), (v), \varphi$	$(ft), (tc\xi), (p\xi), (u), (a), \omega^1$
II	v'	l''	–	d, l', φ	$(tc), (a), (u), \omega$
III	v'	–	–	d	$tc, (a), (u), \omega$
IV	v'	–	–	d	$tc, (a), (u)$

The homologies presented in table 1 for the tarsi of the legs are at variance in several ways with those given by KHAUSTOV *et al.* (2021) for *Barbutia theroni*. I interpret the setae identified by these authors in their species as being primiventral setae on legs I, II and IV as well as setae in analogous positions in other Barbutiidae, as being ultimate setae instead.

KHAUSTOV *et al.* (2021) in their whole mount illustrations of *B. theroni* do not depict or label any proral setae or antiaxial fastigial seta ft'' on the tarsi of the first pair of legs. These three setae, present in *Albertibarbutia arasbaraniensis*, appear to be absent in *Barbutia theroni*, although obtaining reliable setal scores from a single fossil specimen in amber is an arduous endeavour.

In a very recently published work, KHAUSTOV & TOLSTIKOV (2022) slightly modify the naming of the leg setae for *Barbutia*, and their system agrees excellently with the one employed in the present publication. I regard the setal identity of the anterolateral setae on tarsi II-IV in the Barbutiidae as being highly likely but not as being absolutely certain, however.

In the Paratydeidae investigated by FUANGARWORN (2015), KHAUSTOV (2017), KHAUSTOV *et al.* (2019) and LAMOS (2021) apparently homologous setae inserting in similar positions, slightly distal to the ultimate setae on the leg tarsi II-IV, were identified as proral setae.

Except for KHAUSTOV & TOLSTIKOV (2022), who describe a pair of proral setae on each tarsus of the first pair of legs of *Barbutia cubensis*, the presence of these setae has so far not been documented for the Barbutiidae. However, unlabelled short thickened distal setae representing proral setae, inserting in exactly the same relative position on the tarsus of leg I as in *A. arasbaraniensis*, have been portrayed by FAN *et al.* (2003: p. 124, Fig. 38) for female deutonymphs of *Barbutia australia*. In the Iranian *A. arasbaraniensis*

female deutonymph and adult male illustrated by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: Figs 7, 17) the pair of short unlabelled setae corresponding to ($p\xi$) on the tarsus of the first leg are present but are not depicted as being eupathidial. The distally abruptly rounded tarsi of the leg I, being almost perpendicular to the proximal-distal leg axis in lateral view, probably has made the identification of these setae difficult up to now. MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: Figs 7, 17) in their unlabelled tibial seta $d\xi$ of leg I do not indicate this seta as being eupathidial, as is the case in the Heidelberg specimens.

The seta v' of trochanter III is the longest of the trochanteral leg setae and is twice the length of the short seta v' of trochanter IV in the description of *A. arasbaraniensis* given by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: Figs 9, 10). In the Heidelberg specimens the trochanteral setae of legs III and IV were instead both long and of similar length. On the tarsus of leg II the seta tc'' is about twice as long in the Heidelberg specimens as it is in the Iranian specimens and distally reaches far beyond the tenent setae. Similarly, the seta tc on the legs III and IV are considerably longer in the female deutonymphs from Heidelberg. The dorsal seta d on the genu of the legs III and IV is much longer in the Königstuhl mites than in those of the *A. arasbaraniensis* female deutonymphs from Iran.

The claws of the Heidelberg specimens as illustrated in Fig. 4 are distinctly shorter than those of the Iranian ones drawn by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: Figs 7-10) and also differ from the latter in their strongly curved hook shape and in the much more distally inserted tenent hairs when the legs are observed in dorsal or lateral view.

In many of the morphological differences between the Iranian and Heidelberg representatives of *Albertibarbutia arasbaraniensis* mentioned, the character state seen in the German specimens appears to show the state that is typical of the Barbutiidae and it is very probable that with only two slide-mounted Iranian female deutonymphs being available for study purposes to MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021), it was not possible to measure all structures and setal lengths correctly in these. Already SUMMERS (1964: p. 191) points out that the idiosomal setae of Barbutiidae may be so finely attenuate that it is impossible to reliably determine their length, while KHAUSTOV & TOLSTIKOV (2022) comment in detail on the considerable variation in the lengths

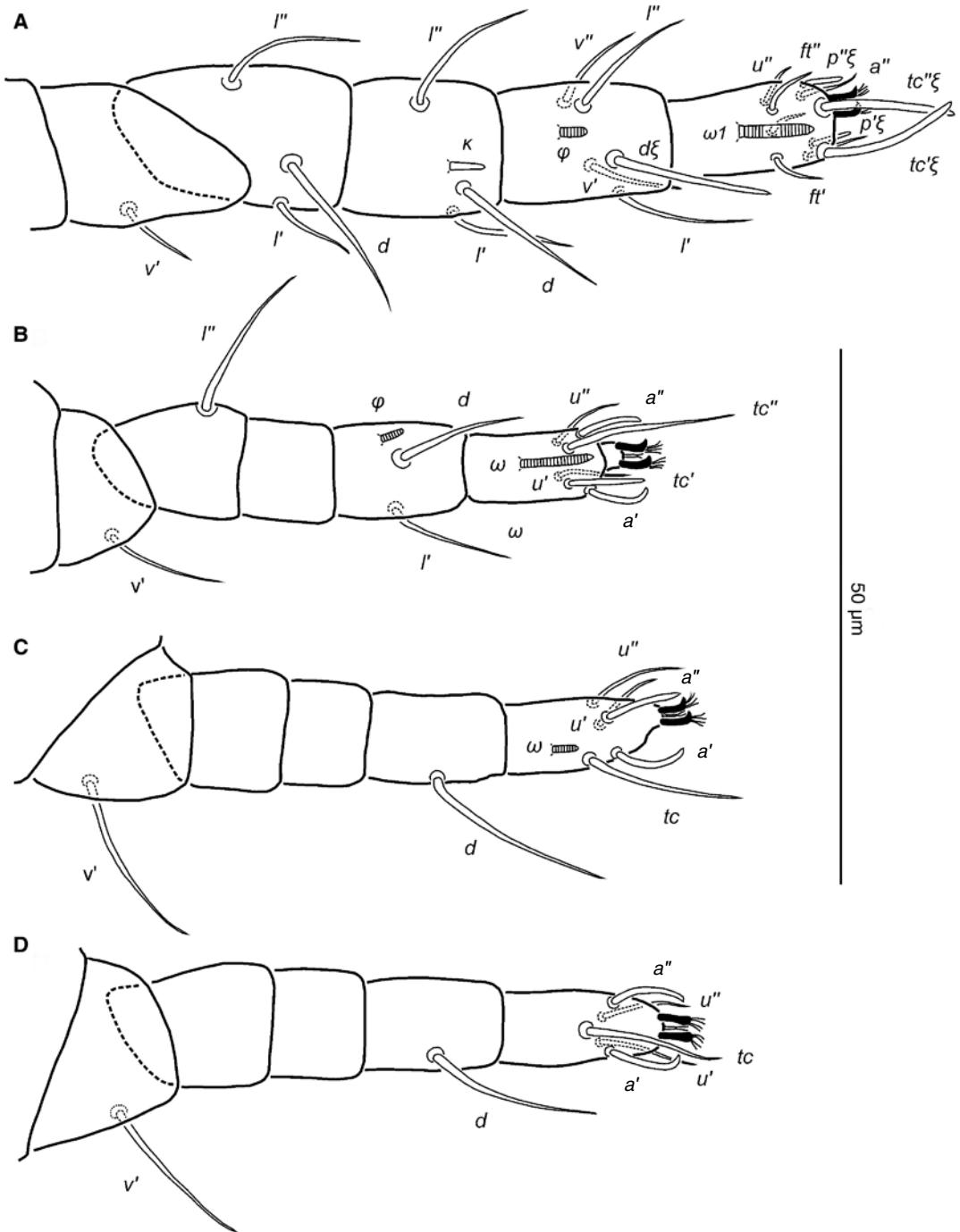
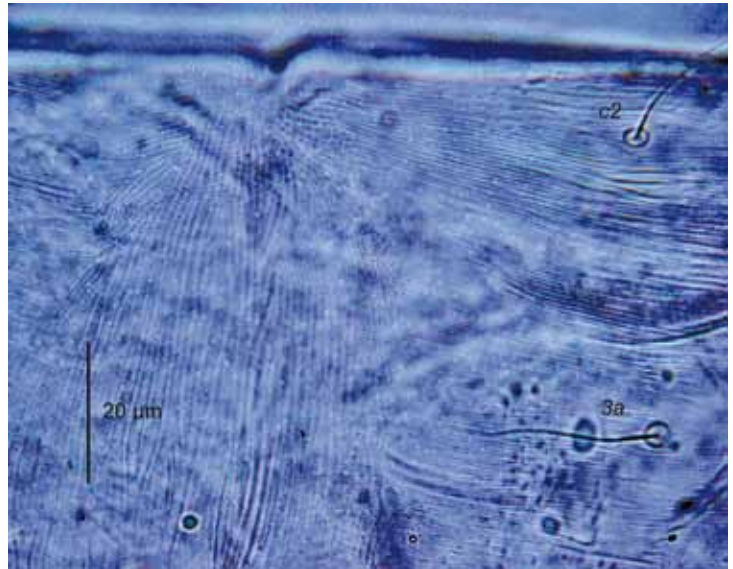


Figure 4. *Albertibarbutia arasbaraniensis* female deutonymph: A – leg I; B – leg II; C – leg III; D – leg IV. All in dorsal view.

Figure 5. *Albertibarbutia arasbaraniensis* female deutonymph: focusing on the ventral structures of part of the idiosoma in dorsal view, showing the widely spaced horizontal striation on both sides of the sejugal groove, the narrowly spaced longitudinal striae characteristic of most of the idiosoma, as well as the transitional pattern where the elevated striae are represented by series of tiny tubercles or granules.



of some idiosomal setae in the Barbutiidae species which they examined. I therefore here treat the Heidelberg specimens as being conspecific to the Iranian ones. However, if future studies should confirm that traits such as the short palptarsal seta *va* and the short palpgenual seta *d* indeed characterize the Iranian population of *A. arasbaraniensis*, then the individuals from Heidelberg would undoubtedly represent a new, second species of *Albertibarbutia*.

4 Discussion

Ontogeny of Barbutiidae

In the taxonomic papers dealing with Barbutiidae so far only deutonymph females and/or adults have been described, including one “incompletely developed adult male” of *Barbutia australia* described by FAN, WALTER & PROCTOR (2003: p. 117). Protonymphs have thus so far not been discovered in the Barbutiidae. The complete ontogeny of the family has never been addressed in detail though, and it is conceivable that protonymphs may exist in this taxon. Within the superfamily Raphignathoidea KRAMER, 1877, to which the Barbutiidae appear to belong (WALTER *et al.* 2009, ZHANG *et al.* 2011, BERON 2020), the existence of a larval and two nymphal stages is however the general rule (WALTER *et al.* 2009: p. 294), with the only exception other than the Barbutiidae being apparently the genus *Raphignathus* DUGES, 1834 and the family Xenocaligonellididae GONZÁLEZ-

RODRÍGUEZ, 1978 which both have three nymphal stages based on FAN & ZHANG (2005), and the Camerobiidae SOUTHCOTT, 1957 in which some newer research suggests that only one nymphal stage may be found in any one species and that it is frequently difficult to clearly distinguish between protonymph and female deutonymph as well as between deutonymph and adult (PAREDES-LEÓN *et al.* 2016). The acarologists FAN & ZHANG (2005: p. 13) mention that protonymphs may be distinguished from the deutonymphs in the Raphignathoidea by the following characteristics: presence of one pair of subcapitular setae, absence of genital setae and setae *4a*, as well as the possession of less setae in the aggenital area and on the leg segments. In the Barbutiidae both deutonymphs and adults show the presence of only subcapitular setae *m*, with *n* being absent, and the genital setae are still absent in the female deutonymph. Therefore, the first two developmental stage distinguishing characteristics listed by FAN & ZHANG (2005) are not applicable to this family.

Some of the diagnostic traits of female deutonymphs of *Albertibarbutia arasbaraniensis*, namely the reduced aggenital setation, the very low numbers of setae on the leg segments and the absence of solenidion $\omega 2$ on the tarsus of leg I when compared to the female deutonymphs of *Barbutia*, may perhaps suggest that the holotype deutonymph female of *Albertibarbutia*

arasbaraniensis may possibly represent a protonymph instead. However, where protonymphs are known in the Raphignathoidea such as for example in the Caligonellidae GRANDJEAN, 1944 (AKYOL 2018, 2021), the Mecognathidae GERSON & WALTER 1998 (FAN & ZHANG 2005), the Raphignathidae KRAMER, 1877 (FAN & YIN 2000), the Eupalopsellidae WILLMANN, 1952 (FAN *et al.* 2000) and the Stigmaeidae (ARRUDA-FILHO & MORAES 2003, DOĞAN & DOĞAN 2020), only one pair of aggenital setae is found in the protonymph in virtually all cases, with these setae being completely missing in the protonymphs of the Camerobiidae such as in *Neophyllobius cibyci* PAREDES-LEON *et al.*, 2016, based on its authors.

A single aggenital setal pair in the protonymph is also found in the family Paratydeidae BAKER, 1949 (LAMOS 2021), which has also been considered by some such as WALTER & PROCTOR (2001) to be related to the Barbutiidae. The presence of two pairs of aggenital setae in all of the presumptive deutonymph females of *Albertibarbutia arasbaraniensis* examined very strongly suggests that these are indeed truly deutonymphs. This conclusion is also supported by the presence of the ventral idiosomal seta 4a in the female deutonymphs of this species, and by the identical setal and solenidial counts of the legs I-IV of the female deutonymphs and adult males of *A. arasbaraniensis* based on the data provided by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021) as well as by the present study.

Tenent hairs of Barbutiidae

It has been generally assumed for a long time that two pairs of tenent hairs are located on each leg claw of Barbutiidae deutonymphs and adults, and that three pairs of tenent hairs are found on each empodium (FAN *et al.* 2003: p. 108; DOĞAN & DÖNEL 2009: p. 232; WALTER *et al.* 2009: p. 295; MOHAMMAD-DOUSTARESHARAF & BAGHERI 2021: p. 9). Of the papers published on the Barbutiidae however, only two, those by SUMMERS (1964: p. 191, 192) in his written text for *Barbutia anguineus* and FAN *et al.* (2003: Figs 28-31, Figs 48-51) for *B. australia* and *B. longinqua* actually describe in words or depict their species respectively with two pairs of tenent hairs on each leg claw. SUMMERS (1964: p. 192) stated that one or possibly two pairs of tenent hairs were located on each empodium on the legs of the female deutonymph of *Barbutia anguineus* from California which he observed. In a slightly later paper (SUMMERS 1966: p. 247) he writes "Empodium minute, with pos-

sibly 2 pairs of capitate raylets". In none of the papers on Barbutiidae published up to the end of 2021, is there any direct evidence at all that three pairs of tenent hairs are inserted on the leg empodium in any species of this family.

MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: p. 12, Figs 7-10; p. 14, Figs 17-20) illustrate the legs of the female deutonymph and also of the male adult of *Albertibarbutia arasbaraniensis* from Iran as possessing three tenent hairs on each leg claw as well as a single pair of tenent hairs on each empodium, which contradicts the introduction of their paper. In the specimens of this species from Heidelberg which I examined, two pairs of tenent hairs were apparently visible on each claw of the first pair of legs in a single photo sequence. Usually however, only two distally capitate tenent setae were observed per claw, in the instances where these could reasonably clearly be seen. Mostly I did not manage to observe any tenent hairs to be inserted on the empodia, since the latter were exceptionally difficult to see clearly in the slide-mounted specimens. Only in two instances was it possible to confirm the presence of two quite short tenent hairs on each of the empodia examined. Their appearance was extremely similar to that depicted by MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021: p. 12, Figs 7-10).

The claw tenent hairs of Barbutiidae may lie very close together or even overlap with each other and be extremely difficult to keep apart when perceived under a light microscope as may be seen in the illustration of the pretarsus of the first leg of *B. anguineus* by SUMMERS (1964: p. 187, Fig. 6) where only three tenent hairs seem to be visible on each claw. It is likely that the discrepancy in claw tenent setal counts between the illustrations of *Albertibarbutia arasbaraniensis* from Iran and the data for the Heidelberg material similarly result from such methodological issues. Although the tenent hairs of the Heidelberg *Albertibarbutia arasbaraniensis* mostly displayed an appearance on both the empodia and claws similar to that illustrated by KHAUSTOV & TOLSTIKOV (2022: Figs 2, 3) for *Barbutia cubensis*, the available data from light microscopy for the Heidelberg and the Iranian (MOHAMMAD-DOUSTARESHARAF & BAGHERI 2021) specimens strongly suggests instead that female deutonymphs of *A. arasbaraniensis* possess three tenent hairs or perhaps more likely, two pairs of tenent hairs on each leg claw and also show a single pair of tenent hairs on each short empodium.

It is necessary to perform a thorough scanning electron microscope study of the pretarsus of *Albertibarbutia arasbaraniensis* so as to obtain fully dependable data on the morphology of the tenent hairs and also on the tenent hair scores on the claws and empodia of legs I-IV of this species.

The tenent hairs of the claws of Barbutiidae have been illustrated as being distally thickened or very strongly expanded, sometimes giving the impression of being split into two at their distal-most section or having a flattened tip similar to the head of a nail in lateral view, when inspected at high magnification under a light microscope such as seen in the figures of the legs in the publications of BAGHERI *et al.* (2010) and MOHAMMAD-DOUSTARESHARAF & BAGHERI (2021). The tenent hairs of the *Albertibarbutia* from Heidelberg are of similar appearance.

A valuable contribution by KHAUSTOV & TOLSTIKOV (2022) sheds light on the ultrastructure of the tenent hairs of Barbutiidae. These authors present informative electron microscope photographs of these structures, but do not comment on them in their written text, other than calling them chaetoids and pointing out that these are present on the claws and that three pairs of chaetoids are located on each empodium of *Barbutia cubensis*. The figures 7C and 8A-D given by KHAUSTOV & TOLSTIKOV (2022) demonstrate that both the claw- and empodial tenent hairs of *Barbutia cubensis* and extremely likely also those of *Albertibarbutia* and other members of its family are clusters of spatulate microtrichia very similar in their design and in their substrate attachment function to those of the *Bryobia* C. L. KOCH, 1836 species discussed and depicted by WOLFF (2015: p. 54-55, Fig. 2.16 N, Q).

WOLFF (2015: p. 54) notes that each of the microtrichia consists of two microfibrils and that proximally these combine to form a slender shaft while distally these two microfibrils diverge and a very thin membrane is spanned up between them. This causes the distal tip of the microtrichia to possess a V-shaped or capitate appearance, viewed from a perspective at a right angle to the membrane. Based on the photographs in KHAUSTOV & TOLSTIKOV (2022: Figs 7, 8) the shafts of the adjacent microtrichia in *Barbutia cubensis* are fused along most of their length and their V-shaped tips show a spatial overlap. These authors do not elaborate on the number of claw tenent hairs being present in the species they examined and indeed in the photographs they present it is not easy to identify any distinct

clusters of microtrichia, which may be termed tenent hairs. In *Bryobia* a claw tenent hair typically consists of several microtrichia, but these may only be readily distinguishable at the basal region of the tenent hair. This also seems to apply to Barbutiidae. Based on the image provided by KHAUSTOV & TOLSTIKOV (2022: Fig. 8D) three tenent setae appear to be present on a claw of leg III of *Barbutia cubensis*.

It is noteworthy, that while tenent hairs on the leg empodia are a phylogenetically very ancient structure in the Acari, being for example present already in the gall mites of the family Eriophyoidea NALEPA, 1898 as may be seen in CHETVERIKOV *et al.* (2017), the existence of tenent hairs on the claws has only exceptionally rarely been documented within the Prostigmata.

Claw tenent hairs of Barbutiidae are considerably shorter than those typically found in the Tetranychoidae DONNADIEU, 1875. The tenent hairs which were detected by BOCHKOV (2008) on the claws of the legs II-IV of two species of Stigmocheylidae KETHLEY, 1990, placed in the infraorder Anystina VAN DER HAMMEN, 1972 by ZHANG *et al.* (2011), are very short, but may be distinguished from those of Barbutiidae in that they are arranged in a lateral row of about ten tenent setae on both sides of each of the two claws present per leg, along most of the length of the claws. Empodia are absent in this family (BOCHKOV 2008). This existence of claw tenent setae in *Stigmocheylus* BERLESE, 1910 therefore appears to be a case of parallel evolution. Such phenotypic parallelisms are of course also indicative of genetic relatedness.

Within the hyporder Raphignathina KETHLEY, 1982 claw tenent hairs very similar in their make-up to those of the Barbutiidae are also present in at least some representatives of the reptile-parasitic, morphologically highly derived family Pterygosomatidae OUDEMANS, 1910 such as in the genera *Pimeliaphilus* TRÄGÄRDH, 1905 and *Hirstiella* BERLESE, 1920 based on BOCHKOV & O'CONNOR (2006: p. 204, 206). Morphologically unusual claw tenent structures have also been described for the recently erected water beetle-parasitic family Dytiscacaridae HAJIQANBAR & LINDQUIST, 2018 by MORTAZAVI *et al.* (2018).

Phylogeny of the Barbutiidae

The evolutionary relationships of the Barbutiidae are so far not resolved and have not been addressed in any detail since the contribution of FAN *et al.* (2003: p. 108) who, in a brief section on this topic, conclude that based on morphol-

ogical data it is a family that is located between the Raphignathoidea and the Tetranychosidea.

A paper by KLIMOV *et al.* (2018), dealing with the phylogenetic origin and relationships of the Eriophyoidea, provides evidence impacting on the hypothesis of FAN *et al.* (2003). These authors compared the DNA sequences of six gene loci of each of 198 taxa belonging to a total of 113 families of Acari. The genes examined were three genes coding for nuclear protein, one gene encoding a mitochondrial protein as well as two genes encoding ribosomal RNA. An unidentified species of *Barbutia* from Cuba was included in this molecular study, according to the maximum likelihood based phylogenetic trees presented in their figures 3-4 and the supplementary data but is not mentioned in the remainder of the paper. This species was later described as *Barbutia cubensis* by KHAUSTOV & TOLSTIKOV (2022).

In the figure 3 of KLIMOV *et al.* (2018) which shows a computer-generated maximum likelihood phylogeny of Acari, *Barbutia* is shown to be a sister group to a clade comprising a species of a new unnamed family and a *Cyclurobia* species, which belongs to the Pterygosomatidae. This cluster containing *Barbutia* is indicated to be the sister group of another small clade containing a *Eustigmaeus* sp. belonging to the Stigmaeidae as well as a species of *Homocaligus* of the family Homocaligidae. This group of members of five families is figured by KLIMOV *et al.* (2018) to be itself the sister group of a huge clade containing members of the Tetranychidae, Raphignathidae and Caligonellidae, in addition to diverse other Raphignathina, including numerous parasitic mites. *Barbutia* is depicted as being one of the most basal taxa of the Raphignathina in figure 3 of KLIMOV *et al.* (2018). In figure 4 of these authors, which derives from the "protein only partition" instead of from both the ribosomal DNA and protein, *Barbutia* is shown to be basal to all other Raphignathina, with its sister group being the clade containing a member each of the families Stigmaeidae and Homocaligidae. The new Raphignathae family mentioned in figure 3 does not appear in figure 4, and the *Cyclurobia* species which is shown as being closely related to *Barbutia* in figure 3, is here depicted as being phylogenetically more distantly positioned to *Barbutia* instead. The mite families subsumed under the Raphignathoidea by FAN & ZHANG (2005) and ZHANG *et al.* (2011) are shown to arise from three ancestral sources in KLIMOV *et al.* (2018: Figs 3, 4), making this superfamily polyphyletic.

The new family associated with *Hydaticus pictus* listed by KLIMOV *et al.* (2018: Fig. 3) actually refers to the Dytiscacaridae HAJIQANBAR & LINDQUIST, 2018, which are subelytral parasites of dytiscid water beetles, based on the data published in MORTAZAVI *et al.* (2018). It is noteworthy that this taxon, like the Pterygosomatidae and the Barbutiidae, also possesses claw tenent structures, with these being described as being sclerotized and hook-like, and thereby different in appearance to those of the Barbutiidae by MORTAZAVI *et al.* (2018), who view the claw tenent structures of the leg pretarsi of the Dytiscacaridae as being a major autapomorphy of this family.

A comparison of the claws and claw tenent hairs of the Dytiscacaridae and of *Barbutia cubensis* as depicted by KHAUSTOV & TOLSTIKOV (2022) shows great similarities between these taxa, however. At least the distal structures of the claws of *Dytiscacarus americanus* MORTAZAVI *et al.*, 2018 which are shown striated in MORTAZAVI *et al.* (2018: p. 699, Figs 3B-E) seem to clearly represent clusters of fused spatulate microtrichia forming tenent hairs arranged approximately similarly to those in *Barbutia* as figured by KHAUSTOV & TOLSTIKOV (2022: Fig. 8B). Both taxa also possess some short spine-like processes, apparently lightly modified microtrichia missing a distal expansion, about midway between the tarsal surface and the distal tip of the tenent seta. This presence of claw tenent hairs in both Barbutiidae and Dytiscacaridae and of these having a common basic design suggests that this is a shared evolutionarily derived character of these two mite families. An electron microscopical study of the claws of Dytiscacaridae appears necessary though, to fully confirm these observations.

It is reasonable to interpret the presence of claw tenent hairs in Barbutiidae, Dytiscacaridae and Pterygosomatidae and to a much lesser extent in the Tetranychosidea as being a shared derived character and indicative of genetic relatedness, with this being only a tiny part of the evidence concerning the true phylogeny of the Raphignathina. The potential issue of evolutionary convergence in the origin of claw tenent hairs, especially in parasitic taxa, is evident.

KHAUSTOV & TOLSTIKOV (2022: p. 64) mention that they consider Barbutiidae and Stigmaeidae to be closely related, but do not elaborate on this. I agree with this assessment, especially when considering Stigmaeidae such as the genus *Eryngiopus* SUMMERS, 1964, species of which display a very strong reduction and absence of

idiosomal shields as shown for example in MOHAMMAD-DOUSTARESHARAF *et al.* (2019). The actual statistical probability, measured in terms of the branch bootstrap support, of the Barbutiidae, Stigmaeidae and Homocaligidae comprising a monophyletic group is high in KLIMOV *et al.* (2018: Fig. 4), whereas the statistical support for the Barbutiidae, Dytiscacaridae and Pterygosomatidae comprising a monophyletic clade is not very strong in figure 3 of KLIMOV *et al.* (2018). Additional morphological and genetic data may provide further evidence to demonstrate the phylogenetic affinities of Barbutiidae to the Dytiscacaridae and Pterygosomatidae.

The evolution of the Raphignathina requires much more detailed examination. Not only based on genetic data, but also based on their morphology the poorly defined superfamily Raphignathoidea sensu ZHANG (2011) may require splitting into two or more groups or clades, with the erection of a new superfamily Stigmaeioidea OUDEMANS, 1931 containing the morphologically highly diverse Stigmaeidae, the Homocaligidae, the Barbutiidae, and perhaps also the Pterygosomatidae and the Dytiscacaridae. This would vindicate the classification of *Barbutia* by OUDEMANS (1931).

Homology of the spine of the palptibial claw of Barbutiidae

A short thorn or spine located ventrally on the claw of the palp is characteristic of the deutonymph female of *Barbutia* as well as of the adult males and adult females of this genus where these have been described. The spine is located at about the midpoint of the length of the claw and is directed towards the palptarsus. In the genus *Albertibarbutia* this structure is absent. I here argue that the spine of the palptibial claw of *Barbutia* may be homologous to a palptibial lateral seta *l'* which has been strongly modified in evolution and has apparently basally fused to the palptibial claw. With regard to *Albertibarbutia* I suggest that the palptibial lateral setae *l'* have ontogenetically been lost completely and that therefore the palptibial claw in this genus also misses a ventral spine.

In *Albertibarbutia arasbaraniensis*, as in the species of the genus *Barbutia* no lateral setae *l'* or *l''* are located on the palpfemur and palpgenu, such as they are typically found in species of Stigmaeidae and other Raphignathoidea (FAN & ZHANG (2005). In the genus *Barbutia*, when compared to the representatives of many other families of

Raphignathoidea, the setation of the two most distal palp segments is similarly reduced. On the palptibia of *Barbutia* only two setae are present, namely setae *d* and *l''*, in addition to the conspicuous palptibial claw which is itself an evolutionary derived highly modified seta, but not treated as one nomenclatorily. The seta *l'* of the palptibia, generally present in for example the Stigmaeidae and most other Raphignathoidea, as deduced from the figures from, for instance, FAN & ZHANG (2005), is absent in all representatives of the Barbutiidae. In *Albertibarbutia arasbaraniensis* the complete absence of the palptibial lateral setae is most striking. Here only a single dorsal seta *d* is inserted on each palptibia and no lateral seta is found on them.

A modification of the lateral seta *l'* of the palptibia into a spine-like structure and even into an accessory claw in addition to the palptibial claw has been observed in numerous members of the speciose and morphologically exceedingly diverse family Stigmaeidae. Here taxa with a spinelike palptibial seta *l'* such as *Stigmaeus mitrofanovi* KHAUSTOV, 2014, based on its namegiver, exist alongside species with a normal setiform lateral seta *l'* of the palptibia. In other taxa of Stigmaeidae an accessory claw is present in exactly the same location as that which would be expected for the seta *l'*, but the seta *l'* is treated as being absent. This causes some confusion since in species where a structure is consistently identified as accessory claw, even if it is setiform, such as in FAN & ZHANG (2005) the tibial setal count is lower than in the identical species for which the same structure is identified as a seta. KHAUSTOV (2014) names the structures identified as accessory claw of the palpal tibia by FAN & ZHANG (2005) throughout as being setae *l'*, even if they are very thick or spine-like. In all instances in the literature which I studied of a single accessory claw being found inserted on the palptibia in the Stigmaeidae, the lateral seta *l'* was absent with only setae *d* and *l''* found. The evidence for the homology of the palptibial seta *l'* with the palptibial accessory claw within the family Stigmaeidae is therefore extremely strong.

The spine of the palptibial claw in the genus *Barbutia* presumably differs morphologically from the accessory claw of the Stigmaeidae in that in the former, where the palptibial spine has been illustrated, it appears to originate directly from the body of the palptibial claw itself (ROBAUX 1975: p. 483, Fig. 2c; FAN *et al.* 2003: p. 117, Fig. 16; DOĞAN *et al.* 2016: p. 175, Fig. 2e), whereas in

the Stigmaeidae the palptibial claw and the accessory claw are distinct entities and not fused (eg. in KHAUSTOV 2014), although authors such as BAGHERI & ZAREI (2012: p. 443, Fig. 3) who describe the new *Stigmaeus miandoabiensis* depict a fusion of the accessory and the palptibial claw in this species.

In the Barbutiidae it therefore seems to be the case that during ontogeny the palptibial claw and the palptibial lateral seta *l'* have undergone a partial fusion, resulting in a palptibial claw with a ventral spine in those instances where the genetic developmental program for seta *l'* has been phenotypically expressed. KHAUSTOV & TOLSTIKOV (2022: Fig. 6D) in a scanning electron microscopy image of the gnathosoma of *Barbutia cubensis* show the part of the palptibial claw distal to the ventral spine to be distinctly longitudinally striated whereas the ventral spine itself and the proximal part of the palptibial claw both show a smooth surface. The hypothesis of homology of the ventral spine of the palptibial claw proposed in this section needs to be further tested.

First record of the Barbutiidae for Germany

So far the occurrence of the family Barbutiidae in Germany has only been noted to be the case by VÖLKL & BLICK (2004: p. 53) who base this claim on a contribution by VITZTHUM dating from 1929. The great German acarologist VITZTHUM (1929: p. 52) indeed lists the genus *Barbutia* in a publication dealing with the mite fauna of Central Europe. However, he does not present a citation for this record and does not comment specifically on the occurrence or geographical distribution of the genus. The work also includes numerous species only known from Italy at the time. VITZTHUM (1929) does not specify the genus *Barbutia* as having been found in Germany itself. It is unclear whether this listing is based on VITZTHUM's own identification of collected material or not. It is also very conceivable that VITZTHUM (1929) included taxa in his work that were not yet detected, but merely expected to occur in Central Europe. Furthermore, a listing of a taxon for Central Europe also manifestly does not in itself imply that this taxon has been found in more than one country or in all countries of this geographic region. In the case of *Barbutia* the listing by VITZTHUM (1929) is therefore no evidence at all that this genus has actually been recorded from Germany itself.

The type locality of *Barbutia anguineus*, the only member of its genus known at the time when VITZTHUM's work dating to 1929 was published, is

San Vincenzo in the province of Livorno in Tuscany in Italy, according to BERLESE (1910: p. 208), who here names the species *Stigmaeus (Macrostigmaeus) anguineus*. VITZTHUM (1929) does not comment on the geographical area which he includes in Central Europe. The concept of Central Europe has never been clearly defined and various interpretations are possible, even today. In a prominent German reference encyclopaedia, the *Brockhaus Kleines Konversations-Lexikon* of the year 1911, the Livorno region and Pisa are included in Central Europe.

It is unlikely that VITZTHUM (1929) included the genus *Barbutia* in his faunal compilation of mites of Central Europe solely based on the record for Italy by BERLESE (1910). In his literature list he includes references to two contributions by BERLESE dating to 1910 from Volume 6 of the journal *Redia*, but does not list the publication from the same volume in which the description of *B. anguineus* by BERLESE was published. In VITZTHUM's (1929: p. 50-52) key to the family Raphignathidae, in which he includes *Barbutia*, he characterizes this genus as possessing more than two broad median shields dorsally and as missing eyes. *Barbutia* and *Albertibarbutia* however both display a complete absence of median dorsal shields, and also possess eyes. In my opinion this makes it very improbable that the mites referred to as being *Barbutia* by VITZTHUM (1929) actually belong to that genus or, else very strongly suggests that he did not examine a member of the genus himself.

VITZTHUM's (1929: p. 52) characterization of the genus *Barbutia* is apparently a direct translation of the genus diagnosis given by OUDEMANS (1927: p. 262), who also does not specify the origin of the mite material he bases his diagnosis on. In an earlier paper OUDEMANS (1923: p. 146) similarly does not refer to any material examined by himself or anybody else other than BERLESE (1910) of *Barbutia anguineus* (BERLESE, 1910), the type species of *Barbutia*. OUDEMANS (1923) here treats this species as being one of two belonging to the genus *Macrostigmaeus* BERLESE, 1910. In his genus definition of *Macrostigmaeus*, OUDEMANS (1923: p. 145) writes in the Dutch language that: "Bij het type. twee grote rugschilden achter elkander". Translated this means: "In the type, two large dorsal shields which are one behind the other", with the type species being *Macrostigmaeus serpentinus* BERLESE, 1910. This implies that he correctly noticed that dorsal idiosomal shields are absent in *Barbutia anguineus*. A de-

termination key to genera of Raphignathidae in the 1927 paper by OUDEMANS (p. 261) however, erroneously indicates that *Barbutia* is situated in the group of taxa which display more than two broad median dorsal idiosomal shields, implying that the shields here are positioned one behind the other. VITZTHUM (1929) appears to have copied this mistake by OUDEMANS (1927).

In the third contribution in which he mentions *Barbutia*, OUDEMANS (1931: p. 253) transfers the genus from the Raphignathidae to the newly erected Stigmaeidae, but again gives no statement as to the geographical distribution of the genus. No preserved mite specimens or drawings of *Barbutia*, *Macrostigmaeus* or of a species named *Stigmaeus anguineus* are found in the Oudemans Collection of the Rijksmuseum van Natuurlike Historie in Amsterdam (BUITENDIJK 1945).

The known records of the family Barbutiidae occurring in Europe are very scarce. *Albertibarbutia arasbaraniensis* is only known from this region from the present publication. Besides the specimen from Italy described by BERLESE (1910), *Barbutia anguineus* has been collected at a single site in Wrocław in Poland (DOĞAN *et al.* 2014), and also in the Crimean Peninsula (WAINSTEIN & KUZNETSOV 1978; KHAUSTOV & SERGEYENKO 2014), while a single individual of *Barbutia theroni* is known from the Western part of the Ukraine (KHAUSTOV *et al.* 2021). An unidentified species belonging to the genus *Barbutia* was detected by KULIKOVA (2016) in the landscape reserve Codrii Tigheci in Moldova. The specimens of *B. anguineus* found in the Kose Mountain in Gümüşhane Province in Turkey by DOĞAN & DÖNEL (2009) as well as the records of *Barbutia iranensis* for this country from Resadiye and Corum by DÖNEL-AKGÜL (2016) and from the Harsit Valley by DOĞAN *et al.* (2016) all originate from the Black Sea region of Turkey, and therefore from that part of this transcontinental country which belongs to Asia and not to Europe.

Nowhere in the literature which I studied have I managed to find any evidence that a species belonging to the Barbutiidae has so far been reported for Germany. This also applies to the huge work of VITZTHUM published in 1940-1943 where *Barbutia* is mentioned on p. 76 and p. 804. Based on the currently known occurrence data of Barbutiidae, the discovery of *Albertibarbutia arasbaraniensis* in Heidelberg is therefore the first published record of the family Barbutiidae for Germany.

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List of abbreviations and notations

Dorsal idiosoma

<i>c1</i>	seta of innermost 1st pair in the 1st row on the hysterosoma
<i>c2</i>	seta of outer 2nd pair in the 1st row on the hysterosoma
<i>d</i>	seta in the 2nd row on the hysterosoma
<i>e1</i>	seta of innermost 1st pair in the 3rd row on the hysterosoma
<i>e2</i>	seta of outer 2nd pair in the 3rd row on the hysterosoma
<i>f1</i>	seta of innermost first pair in the 4th row on the hysterosoma
<i>h1</i>	seta of innermost 1st pair in the 5th row on the hysterosoma
<i>h2</i>	seta of outer 2nd pair in the 5th row on the hysterosoma
<i>sce</i>	external scapular seta
<i>sci</i>	internal scapular seta
<i>ve</i>	external vertical seta
<i>vi</i>	internal vertical seta

Ventral idiosoma

<i>1a</i>	seta of 1st pair associated with the coxae of leg I
<i>1b</i>	seta of 2nd pair associated with the coxae of leg I
<i>1c</i>	seta of 3rd pair associated with the coxae of leg I
<i>2a</i>	seta associated with the coxae of leg II
<i>3a</i>	seta of 1st pair associated with the coxae of leg III, but inserted between coxae II and III
<i>3b</i>	seta of 2nd pair associated with the coxae of leg III
<i>4a</i>	seta associated with the coxae of leg IV
<i>ag1</i>	aggenital seta of anterior 1st pair
<i>ag2</i>	aggenital seta of 2nd pair
<i>ps1</i>	pseudanal seta of 1st pair
<i>ps2</i>	pseudanal seta of 2nd pair
<i>ps3</i>	pseudanal seta of 3rd pair

Gnathosoma

<i>acm</i>	anteroculminal seta of palptarsus
<i>ba</i>	anterior basal seta of palptarsus
<i>bp</i>	posterior basal seta of palptarsus
<i>d</i>	dorsal seta of palptarsus and palptibia

<i>df</i>	fixed digit of chelicera
<i>dm</i>	mobile digit of chelicera
<i>ep</i>	supracoxal seta of palproxa
<i>lp</i>	lateral seta of palptarsus
<i>m</i>	anterior subcapitular seta
<i>or1</i>	adoral seta of 1st pair of subcapitulum
<i>or2</i>	adoral seta of 2nd pair of subcapitulum
<i>pe</i>	peritreme
<i>pc</i>	podocephalic canal
<i>sej</i>	sejugal groove
<i>sp</i>	palptibial claw
<i>sul</i>	subulminal seta of palptarsus
<i>tr</i>	trachea
<i>ul</i>	ulminal seta of palptarsus
<i>va</i>	ventral seta of palptarsus
<i>ω</i>	solenidion of palptarsus

Legs

<i>a</i>	anterolateral seta of tarsus
<i>d</i>	dorsal seta
<i>el</i>	supracoxal seta of coxa of leg I
<i>ft</i>	fastigial seta of tarsus
<i>l</i>	lateral seta
<i>p</i>	proral seta of tarsus
<i>tc</i>	tectal seta of tarsus
<i>u</i>	unguinal seta of tarsus
<i>v</i>	ventral seta
<i>k</i>	sensillum
<i>φ</i>	tibial solenidion
<i>ω</i>	tarsal solenidion
<i>ω1</i>	anterior solenidion of tarsus I
<i>ω2</i>	posterior solenidion of tarsus I

An abbreviation of the name of a seta followed by a single prime symbol ' such as in *u'* indicates that the seta is here inserted on the anterior surface if the mite is imagined with the legs or palps perpendicular to the long axis of the body. Analogously a setal name associated with a double prime as in *u''* signifies that a seta in the same leg or palp position is here inserted on the posterior surface. Where a setal notation is placed in parentheses as in (*v*) this refers to a setal pair and in this case would be the equivalent of writing: *v'* and *v''*. The zeta symbol ξ positioned behind a setal abbreviation as in *tc''ξ* shows that the seta is an eupathidion.