

## Oribatid mites (Acari: Oribatida) from the coastal region of Portugal. VI. *Chamobates*, *Protozetomimus*, *Protoribates*, *Oribatula*.

Gerd Weigmann

Free University, Institute of Zoology, Koenigin-Luise-Str. 1–3, 14195 Berlin, Germany  
e-mail: weigmann@zedat.fu-berlin.de

### Abstract

Two new species of Oribatida were found in coastal habitats in South-West Portugal and four remarkable species are redescribed. *Chamobates roynortoni* sp. n. (Chamobatidae), is described, originating from a coastal bush area of the Ribeira de Aljezur, Algarve. Three remarkable species were recorded in a floodplain alder forest of the Ribeira de Aljezur: *Chamobates dentatus* Mihelčič, 1956, is redescribed and the recently described *Oribatula polytuberculata* Ermilov et al., 2012, (Oribatulidae) is figured. In the same habitat large populations of *Protoribates hakonensis* Aoki, 1994, and *P. tohokuensis* Fujikawa, 2003 (Haplozetidae), originally described from Japan were found for the first time in Europe. The latter species is closely related to *P. robustior* (Jacot, 1937) from North America. *Protozetomimus behanae* sp. n. from a floodplain area of Rio Mondego, North Portugal, is described and compared with congeners. The different taxonomic and systematic opinions on the genus in the literature are discussed, resulting in the proposal that *Protozetomimus* is a distinct genus of Ceratozetidae.

**Keywords:** Taxonomy, systematics, new species, Chamobatidae, Ceratozetidae, Haplozetidae, Oribatulidae

### 1. Introduction

This sixth article on the taxonomy of new and remarkable species from habitats of the coastal region of Portugal deals with species of the genera *Chamobates*, *Protoribates* and *Oribatula* from the estuary region of the Algarve. Additionally a new *Protozetomimus* species from a floodplain area of Rio Mondego, northern Portugal, is described and compared with a specimen of the type species *P. acutirostris* (Mihelčič, 1957). The two *Protoribates* species from a floodplain forest of Ribeira de Aljezur were not conspecific with other congeners from the Iberian peninsula (cf. Pérez-Iñigo 1993) and species from central and western Europe. This fact required comparisons with non-European *Protoribates* species. I am grateful to Prof. Roy Norton for making available the study of several North American species which are insufficiently described up to now. The systematic conception of oribatid families follows Norton & Behan-Pelletier (2009).

## 2. Materials and Methods

Most samples from coastal areas of Portugal were collected by the author from 2008 to 2011. Samples R1-3 were collected 1999 by Mrs. Helena Barrocas, Coimbra.

Po 113–115: Samples from upper floodplain of Ribeiro de Aljezur, West-Algarve (37,3226° N, 8,8162° W), 5 km upstream from sea shore. 11 September 2004. Moist to wet *Alnus* and *Salix* stock with shrubberies on gley-soil.

Po143–146: Samples from estuary region of Ribeiro de Aljezur, West-Algarve (37,3433° N, 8,8377° W), north-eastern riverside. 2 November 2008. A bushy area on a large rock, about 5 m higher than the surrounding area.

Po 150–161: Samples from estuary region of Ribeiro de Aljezur, West-Algarve (37,3416° N, 8,8422° W), south-western riverside. 6 April 2008. A bushy area on a rock slope, about 5–10 m above water level.

Po 206–217: Samples from upper floodplain of Ribeiro de Aljezur, West-Algarve, same site as Po 113ff. 30 November 2011.

R 1–3: Samples from the Low Mondego area (near Montemor-o-Velho, Northern Portugal, 40,16° N, 8,67° W) in an agricultural soil. The area is a typical crop area, the samples were taken in a corn field next to the Mondego river.

Samples Po113–217 covered about 50 cm<sup>2</sup> each. The mites were extracted using a modified Tullgren apparatus. The specimens were preserved in ethanol and after clearing in lactic acid they were studied in cavity slides. The morphological terminology follows mainly the introduction in Norton & Behan-Pelletier (2009) and Weigmann (2006). The anogenital setation formula, e. g. 6-1-2-3, indicates the pairs of setae of the sequence from genital, aggenital, anal to adanal setae. The epimeral setation formula indicates the pairs of setae from the first to the fourth epimere.

## 3. Results

### 3.1. *Chamobates roynortoni* sp. n.

#### Material examined

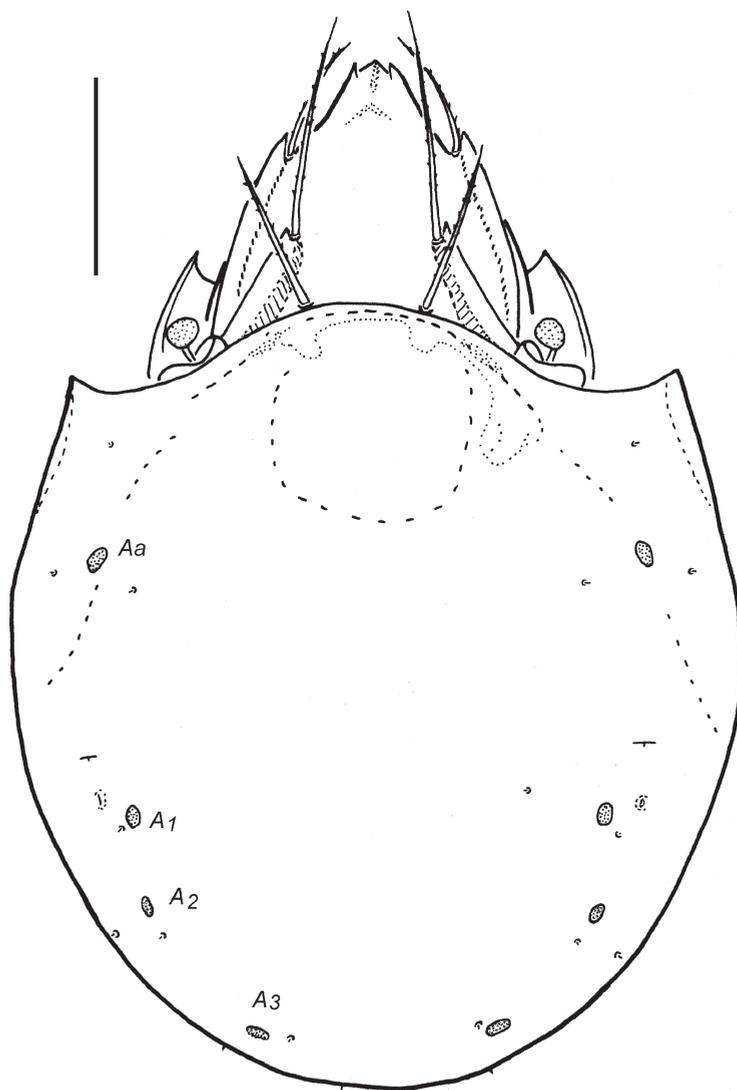
**Holotype:** Adult female, sample Po 146; preserved in ethanol, deposited in the collections of the Senckenberg Museum für Naturkunde Görlitz (SMNG). Paratypes from sample Po 146: one adult male, deposited in SMNG; nine paratype specimens and two specimens from sample Po160 in the collection of the author.

#### Diagnosis

Body length 475–545 µm. Anterior edge of rostrum tridentate; interlamellar seta large, barbed; lamellar seta on prodorsum at small lamellar dens, barbed; rostral seta large, barbed; sensillus stalk short, sensillus head longish claviform, granulated. Notogaster with 10 pairs of minute setae, four pairs of small roundish porose areas. Ventral setae moderately long, fine, barbed. Anogenital setation formula 6-1-2-3. Mentum short-scutelliform, with longitudinal striation.

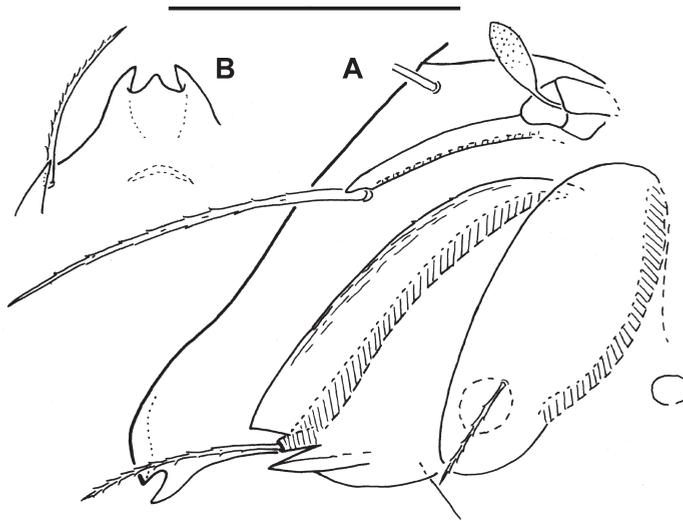
#### Description

**General characters:** Body length range 475–545 µm; females 510–545 µm (mean 521 µm, n = 6), males 477–515 µm (mean 496 µm, n = 4); length-width ratio about 1.45:1 (width behind pteromorphs). Body colour reddish brown, cuticle smooth, cerotegument not obviously developed.



**Fig. 1** *Chamobates roynortoni* sp. n. Dorsal aspect, legs omitted.  
Abbreviations: *Aa-A<sub>3</sub>* – porose areas. Scale bar 100  $\mu$ m.

**Prodorsum:** Anterior rostrum edge with two rounded incisions, forming three teeth (Figs 1, 2). Lamella typical for the genus, narrow with small distal dens; tutorium moderately broad with fine dorsal teeth and with striation, reaching base of rostral seta, distal tip right-angled (Fig. 2A). Most prodorsal setae robust setiform, barbed; rostral seta about 70  $\mu$ m long, interlamellar seta about 110  $\mu$ m long, lamellar seta about 130  $\mu$ m long; exobothridial seta reduced to alveole. Sensillus moderately long (about 40  $\mu$ m, lateral aspect Fig. 2A), stalk short, head longish claviform, granulated. Genal tooth distinctly developed.



**Fig. 2** *Chamobates roynortoni* sp. n. **A:** Prodorsum, lateral aspect; **B:** Rostrum, dorso-frontal aspect. – Scale bar 100  $\mu$ m.

**Notogaster:** Shape broad-ovoid, pteromorph large with rounded edge; clear lenticulus area visible (Fig. 1). Ten pairs of minute notogaster setae in typical positions; four pairs of porose areas, *Aa* largest (15  $\mu$ m), *A*<sub>1</sub> to *A*<sub>3</sub> roundish and small (diameter about 10  $\mu$ m).

**Ventral region:** Structure and setation typical for genus (cf. Weigmann 2006); setae moderately small and barbed, mostly 10–20  $\mu$ m long, epimeral seta *Ic* largest (about 40  $\mu$ m); epimeral setation formula 3-1-3-3; anogenital setation formula 6-1-2-3. Discidium with acuminate custodium. Mentum with tectum, with longitudinal striation (Fig. 3A).

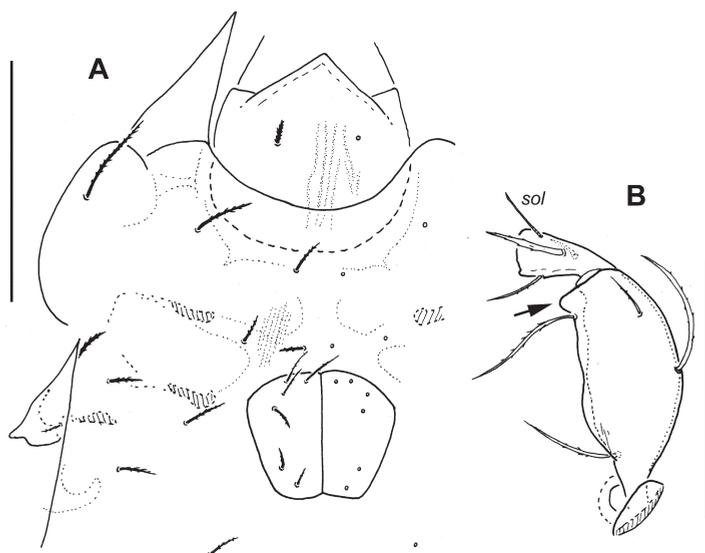
**Legs:** Tarsi hetero-tridactylous; ventral edge of femur II distally with very short tooth-like blade (Fig. 3B); setation not studied in detail.

**Distribution and ecology:** Found in two samples from bushy areas on rock at the southern and northern estuary side of Ribeiro de Aljezur, South-West Algarve.

**Derivatio nominis:** The new species *roynortoni* is named after the outstanding oribatologist Roy A. Norton from Syracuse, USA, in friendship.

#### Remarks

*Chamobates roynortoni* sp. n. is one of the *Chamobates* species with a tridentate anterior rostrum edge. The short claviform sensillus differentiates it from all other tridentate congeners which have long-stalked sensillus and narrower sensillus head (these include: *C. alpinus* Schweizer, 1956, from Switzerland; *C. birulai* Kulczynski, 1902, Spitsbergen, Siberia and Europe; *C. caucasicus* Shaladybina, 1969, Caucasus and Crimea; *C. cuspidatiformis* Trägårdh, 1904, in Shaladybina 1975, North-Sweden; *C. tricuspидatus* Willmann, 1953, Austria). The new species shares with *C. caucasicus* the scutelliform shape of the mentum, but *C. caucasicus* is clearly smaller (360–430  $\mu$ m long). *Chamobates alpinus* and *C. tricuspидatus* are described insufficiently and are probably junior synonymo of *C. birulai* (cf. Weigmann 2006). *Chamobates cuspidatiformis* is probably also a junior synonym of *C. birulai*; while the measurements in the original descriptions seem different (420  $\mu$ m instead of 390  $\mu$ m after Trägårdh 1904: p. 17), the currently known size range of *C. birulai* is inclusive (390–465  $\mu$ m; cf. Beck & Woas 1991; Kulczynski 1902). *Chamobates roynortoni* sp. n. is the single tridentate *Chamobates* species with Iberian distribution.



**Fig. 3** *Chamobates roynortoni* sp. n. **A:** Ventral aspect, anterior part; **B:** Femur and genu II. Abbreviation: *sol* – solenidium, arrow indicates ventral blade of femur. – Scale bars **A:** 100  $\mu$ m, **B:** 50  $\mu$ m.

### 3.2. *Chamobates dentatus* Mihelčič, 1956

#### Material examined

121 specimens from samples Po 113–115 and Po 212–213: 10 specimens deposited in the collections of the Senckenberg Museum für Naturkunde Görlitz (SMNG), preserved in ethanol; the other specimens in the collection of the author.

#### Diagnosis

Body length 60–730  $\mu$ m. Anterio-median edge of rostrum rounded with lateral teeth having mutual distance about 25  $\mu$ m; distal dens of lamella comparably long (about 30  $\mu$ m); rostral, lamellar and interlamellar setae large, barbed; sensillus stalk short, sensillus head longish claviform, nearly smooth. Notogaster with 10 pairs of setal alveoles, four pairs of ovoid porose areas, *Aa* distinctly larger than others. Ventral setae moderately long, fine, barbed. Anogenital setation formula 6-1-2-3. Mentum large-scutelliform.

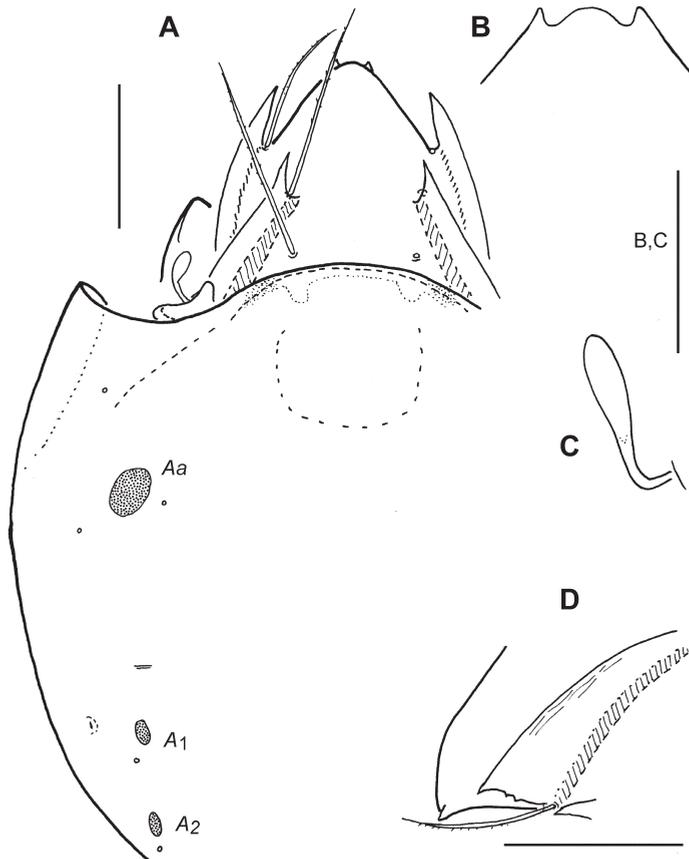
#### Redescription

**General characters:** Body length range 610–730  $\mu$ m; females 630–730  $\mu$ m (mean 677  $\mu$ m,  $n = 7$ ), males 610–670  $\mu$ m (mean 638  $\mu$ m,  $n = 8$ ); length-width ratio about 1.4:1 (width behind pteromorphs). Body colour dark reddish-brown, cuticle smooth, cerotegument not obviously developed.

**Prodorsum:** Anterio-median rostrum edge convexly rounded with lateral teeth having mutual distance about 25  $\mu$ m (Fig. 4B). Lamella typical for genus, distal dens comparably long (about 30  $\mu$ m); tutorium moderately broad, reaching base of rostral seta, with striation; distal tip acute-angled, distal edge irregular (undulating or with fine teeth; Fig. 4D). Most prodorsal setae robust setiform, barbed; rostral seta about 90  $\mu$ m long, interlamellar seta about

140  $\mu\text{m}$  long, lamellar seta about 130  $\mu\text{m}$  long; exobothridial seta reduced to alveole. Sensillus moderately small (about 50  $\mu\text{m}$ ; lateral aspect Fig. 2A), stalk short, head longish claviform, smooth. Genal tooth distinctly developed.

**Notogaster:** Shape broad-ovoid, clear lenticulus area visible (Fig. 4A). Ten pairs of small setal alveoles in typical positions; four pairs of porose areas, Aa largest, about 35  $\mu\text{m}$  in diameter with variable orientation,  $A_1$  to  $A_3$  ovoid and small (diameter about 15  $\mu\text{m}$ ). Pteromorph large, with fine striation.



**Fig. 4** *Chamobates dentatus*. **A:** dorsal aspect; **B:** Rostrum, dorso-frontal aspect; **C:** Sensillus, **D:** prodorsum, lateral aspect.

Abbreviations: Aa- $A_2$  – porose areas. Scale bars **A, D:** 100  $\mu\text{m}$ ; **B, C:** 50  $\mu\text{m}$ .

**Ventral region:** Structure and setation typical for the genus; setae barbed and moderately long, up to 45  $\mu\text{m}$ ; epimeral setation formula 3-1-3-3; anogenital setation formula 6-1-2-3. Discidium with acuminate custodium. Mentum with large tectum, with longitudinal striation on mentum and epimeres.

**Legs:** Tarsi hetero-tridactylous; ventral edge of femur II distally with very short tooth-like blade; setation not studied in detail.

**Distribution and ecology:** Sampled in a river floodplain of Ribeiro de Aljezur, South-West Algarve, Portugal. Original reference (Mihelčič 1956b, Pérez-Iñigo 1972) from moist gley-soil of a floodplain forest with oaks, near Santander in Spain. Some other localities from Spain were cited by Pérez-Iñigo (1993).

#### Remarks

The author was not able to borrow type material from the Mihelčič-Collection in the Museo Nacional de Ciencias Naturales Madrid, but the identity of the Portuguese specimens with *C. dentatus* (as redescribed by Pérez-Iñigo 1972) is most probably. *Chamobates dentatus* is similar to *C. subglobulus* (Oudemans, 1900) in size and some morphological details. Diagnostic characters of both species and *C. roynortoni* sp. n. are presented in Table 1.

**Tab. 1:** Distinguishing characters of three *Chamobates* species.

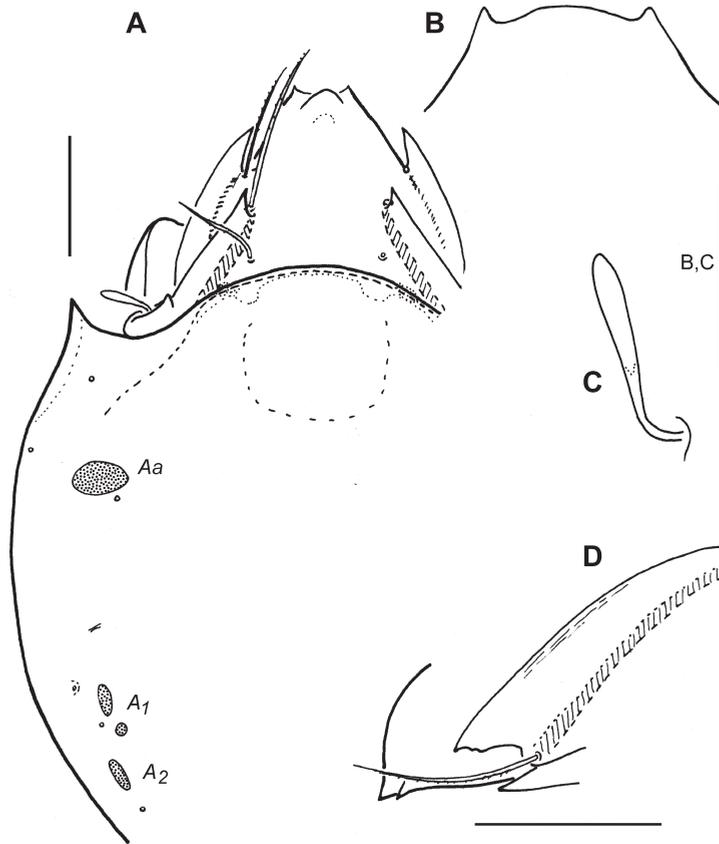
	<i>C. roynortoni</i> n. sp.	<i>C. dentatus</i>	<i>C. subglobulus</i>
<b>Body length range</b>	475–545 µm	610–730 µm	630–740 µm
<b>Rostrum edge</b>	tridentate, distance lat. teeth ~15 µm	rounded, dist. lateral teeth ~25 µm	slightly rounded, dist. lateral teeth ~45 µm
<b>Sensillus</b>	thick fusiform head, length ~40 µm	longish claviform head, length ~55 µm	narrow fusiform head, length ~60 µm
<b>Tutorium</b>	dist. tip ~ right-angled	dist. tip acute-angled, dist. edge irregular	dist. tip acute-angled, dist. edge irregular
<b>Lamellar dens</b>	short	long, ~ 30 µm	moderately long
<b>Notogastral setae</b>	very short	alveoles only	alveoles only
<b>Porose area <i>Aa</i></b>	small oval, Ø 12 µm	large oval, Ø 35 µm	large oval, transverse, Ø 36 µm
<b>Porose area <i>A<sub>1</sub></i></b>	small, undivided	Small, undivided	small, often two-part

*Chamobates subglobulus* is a palaeartic species with a xerophilous tendency, common in Europe mostly in forest soils, in moss cushions and on bark of trees (e.g. van der Hammen 1952, Strenzke 1952 (as *C. lapidarius*), Mahunka & Mahunka-Papp 2004, Weigmann 2006) in contrast to the humiphilous *C. dentatus*. The range of body length is given as 630–740 µm in redescrptions from central and eastern Europe (see Weigmann 2006). Pérez-Iñigo (1972, 1993) and Subías (1977) reported Iberian findings of *Chamobates* cf. *subglobulus* from dry habitats with a body length smaller than 600 µm, but these authors had doubts about the identification. The morphological characters in table 1 refer to specimens of *C. subglobulus* from Germany which concur with other redescrptions (Willmann 1931, as *C. lapidarius*; Shal'dybina 1975, Pavlitshenko 1994). For a better comparison, the main characters of *C. subglobulus* are illustrated in Figure 5 (specimen from Germany). Additional characters are: Pteromorphs, mentum and epimeral area with fine striation; mentum with tectum of median size; discidium with acuminate custodium; tarsi hetero-tridactylous; femur II with short tooth-like blade distally (similar in *C. roynortoni* sp. n. and *C. dentatus*).

### 3.3. *Protozetomimus behanae* sp. n.

#### Material examined

**Holotype:** Adult female, from sample series R1–3 of Rio Mondego floodplain; preserved in ethanol, deposited in the collections of the Senckenberg Museum für Naturkunde Görlitz (SMNG). **Paratypes:** From same locality; one adult male, deposited in SMNG; 1 specimen in the Canadian National Collection in Ottawa; 8 specimens in the collection of the author.



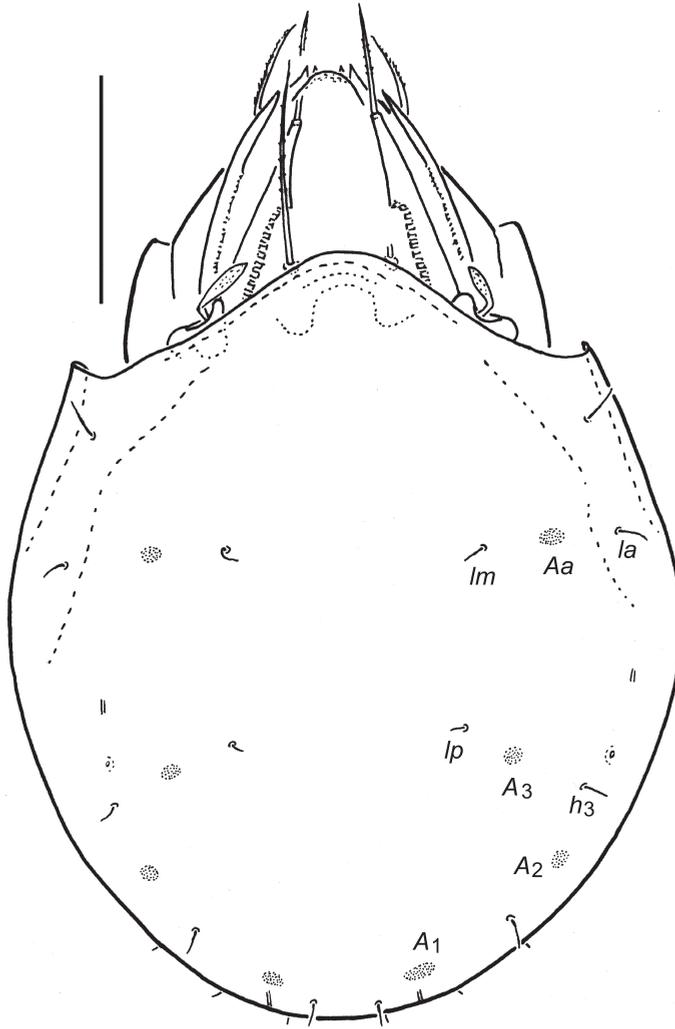
**Fig. 5** *Chamobates subglobulus*. **A**: dorsal aspect; **B**: Rostrum, dorso-frontal aspect; **C**: Sensillus, **D**: prodorsum, lateral aspect. Abbreviations: *Aa-A<sub>2</sub>* – porose areas. Scale bars **A, D** 100 µm; **B, C** 50 µm.

### Diagnosis

Body length 410–465 µm, notogaster broad-ovoid, maximal width about 290 µm; anterior edge of rostrum with two pairs of sharp teeth, separated by irregular undulating margin; lamellae slightly converging, cuspis very long, tapering to width of lamellar seta; prodorsal setae robust setiform, barbed; sensillus about 50 µm long, barbed head longish, flat, tip rounded in frontal aspect. Tutorium long, moderately broad, distally with long pointed tip; genal tooth distinctly developed. Anterior border of notogaster rounded, pteromorph immovable, forming a large blade, bent ventrally. Ten pairs of small and fine notogastral setae, four pairs of porose areas in normal positions, about 10 µm in diameter. Mentum with lateral corners.

### Description

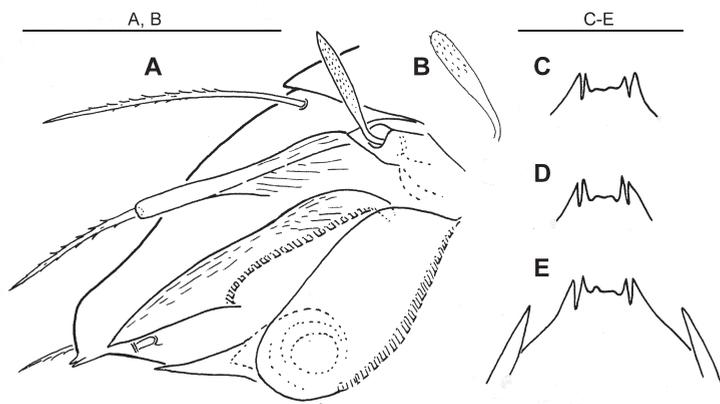
**General characters:** Body length range 410–465 µm; females 425–465 µm (mean 452 µm, *n* = 5), males 410–440 µm (mean 424 µm, *n* = 6); length-width ratio about 1.4:1. Body colour reddish brown, cuticle smooth, cerotegument not obviously developed.



**Fig. 6** *Protozetomimus behanae* sp.n. Dorsal aspect, legs omitted.

Abbreviations: *Aa-A<sub>3</sub>* – porose areas; *la, lm, lp, h<sub>3</sub>* – notogastral setae. Scale bar 100  $\mu$ m.

**Prodorsum:** Anterior rostrum edge with two sharp incisions, separating a lateral pair of protruding teeth from a broad median lobe; this lobe with a second pair of protruding teeth separated by irregular undulating margin (Fig. 8; variability in figs C–E). Lamella moderately narrow, slightly converging; lamellar cusp as long as fixed part of lamella, distally tapering to width of lamellar seta. Tutorium long, moderately broad, tutorial cusp forms long acuminate tooth, nearly reaching level of anterior rostrum edge (Fig. 7A). Prodorsal setae robust setiform, barbed; lamellar and rostral seta about 60  $\mu$ m long, interlamellar seta about 100  $\mu$ m long, exobothridial seta reduced to alveole. Sensillus moderately long, about 50  $\mu$ m, stalk short, head longish and flattened, pointed in lateral aspect, rounded in frontal aspect, barbed (Figs 7A, B). Genal tooth strong, pointed.



**Fig. 7** *Protozetomimus behanae* sp.n. **A**: Prodorsum, lateral aspect; **B**: Sensillus, frontal aspect, **C–E**: Variability of anterior rostrum edge, dorso-frontal aspect. Scale bars **A, B** 100  $\mu\text{m}$ ; **C, D, E** 50  $\mu\text{m}$ .

**Notogaster:** Anterior border of notogaster rounded, pteromorph immovable, forming a large blade, bent ventrally (Fig. 6). Ten pairs of small and fine notogastral setae, longest about 16  $\mu\text{m}$ , p-setae shortest. Four pairs of porose areas, about 10  $\mu\text{m}$  in diameter; area *Aa* positioned between *lm* and *la*, *A<sub>1</sub>* between *lp* and *h<sub>3</sub>*. Five pairs of lyrifissures, as usual in Ceratozetidae.

**Ventral region:** Mentum of subcapitulum without tectum, with lateral corners (Fig. 8). Epimeral setation formula 3-1-3-3; setae mostly fine and short, seta 1b slightly enlarged, *Ic* distinctly enlarged (about 25  $\mu\text{m}$  long). Custodium moderately long. Cuticle of epimeres and genital plates smooth. Ano-genital setatios typical for genus (6-1-2-3), mostly fine and short; first three pairs of genital setae slightly elongated, in transversal alignment. With postanal porose area.

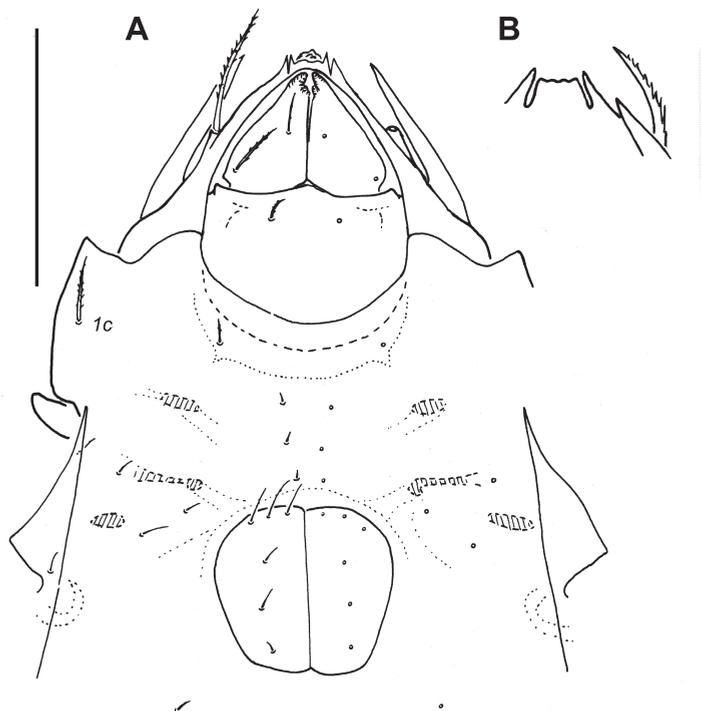
**Legs:** All tarsi with heterotridactylous claws. Setation very similar to that of *P. acutirostris* (as described in Pérez-Iñigo 1991); genua I and II with ventral tooth, femur II with ventral blade, tibia II and genu II each with broadened seta *l''*.

**Distribution and ecology:** Found in four samples from an agricultural floodplain area, Rio Mondego, North Portugal.

**Derivatio nominis:** The new species *behanae* is named after the distinguished oribatologist Valerie Behan-Pelletier from Ottawa, Canada in friendship.

### Discussion

**Genus diagnosis:** The new species corresponds in several characters with the Iberian type-species *Protozetomimus acutirostris* (Mihelčič, 1957) as carefully redescribed by Pérez-Iñigo (1991). The common characters are proposed as a revised diagnosis of *Protozetomimus* Pérez-Iñigo, 1991: (1) broad body shape with protruding rounded anterior border of notogaster; (2) narrow lamellae slightly convergent, long and anteriorly tapering lamellar cusp (narrower in *acutirostris*); (3) very long tutorium with long pointed cusp; (4) rostral seta inserting next to the tutorial cusp; (5) sensillus longish and flattened, pointed in lateral aspect, rounded in frontal aspect, barbed; (6) 10–11 pairs of fine notogastral setae; (7) *Ic* the largest epimeral seta; (8) anterior three genital setae pairs in transversal alignment; (9) custodium tip reaching pedotectum I; (10) all tarsi with three claws; (11) seta *l''* on genu and tibia of leg II large spiniform; (12) genua



**Fig. 8** *Protozetomimus behanae* sp.n. **A:** Ventral aspect, anterior part. **B:** *P. acutirostris*. Anterior rostrum edge with tip of tutorium and rostral seta, dorso-frontal aspect.

Abbreviation: *Ic* – epimeral seta *Ic*. Scale bars **A** 100  $\mu\text{m}$ , **B** 50  $\mu\text{m}$ .

of legs I and II with anteroventral tooth; (13) anterior rostrum edge with two sharp incisions, separating a lateral pair of protruding teeth from a broad median lobe. The latter character is the most specific one and can be regarded as an apomorphic key character for the genus.

**Specific characters:** *Protozetomimus behanae* sp. n. differs from *P. acutirostris* in the following characters: (a) the median lobe of the anterior rostrum edge shows a pair of acuminate teeth (additionally to the teeth laterally the incisions) and between these an undulating edge; – in *P. acutirostris* is no additional pair of teeth on the lobe (Fig. 8B; from a Portuguese specimen). (b) the porose area *Aa* is situated between the setae *lm* and *la* in *P. behanae* sp. n.; – more anterior between *lm* and *c*<sub>2</sub> in *P. acutirostris*. (c) the body length range is slightly different: in *P. behanae* sp. n. 410–465  $\mu\text{m}$ ; – in *P. acutirostris* 400–440  $\mu\text{m}$  (after Pérez-Iñigo 1991), one single specimen from Portugal (shore of Rio Minho; own finding from 1971, unpublished) is 386  $\mu\text{m}$  long.

Without discussing details, Pérez-Iñigo (1991) wrote: ‘it is possible that *Ceratozetes bulanovae* Kulijev, 1962 and *C. kirgistica* Shaldybina, 1970 belong to this genus’. The following species are discussed which were attached by Subías (2011) to *Protozetomimus*: *Ceratozetes bulanovae* from Caucasus; *Ceratozetes polpaicoensis* Hammer, 1962, from Chile; *Ceratozetella kirgistica* from Kirgizia; *Ceratozetes genaensis* Mahunka & Mahunka-Papp, 2006, from Switzerland.

*Ceratozetes bulanovae*, as presented in the *Ceratozetes* key of Shaladybina (1975: p. 295 ff, Fig. 727), generally resembles *Protozetomimus acutirostris*, but has clearly 11 pairs of notogastal setae; no details of the anterior rostrum edge is given. Therefore the synonymization of this species with *P. acutirostris* by Subías (2011) is questionable without further study.

The systematic position of *Ceratozetella kirgistica* and *Ceratozetes polpaicoensis* within *Protozetomimus* is similarly unsubstantiated. In both species the anterior rostrum edge is divided into three teeth, but no broad median lobe is described; the tutorium of both species is somewhat shorter; in *kirgistica* the lamellar cusp is provided distally with a small lateral tooth. The species characters, as described in the original papers and in Shaladybina (1975; for *kirgistica*) are consistent with membership in the genus *Ceratozetes* following the recent diagnosis (Behan-Pelletier & Eamer 2009).

The characters of *Ceratozetes genavaensis* match well with the diagnosis of *Protozetomimus* above, and therefore the assignment by Subías (2011) can be confirmed. The anterior rostrum edge has a pair of lateral teeth and a broad median lobe; specifically this lobe has lateral corners (not protruding teeth as in *P. behanae* sp. n.); the lamella, the tutorium and the insertion of the rostral seta show no remarkable difference with *P. acutirostris*. Besides the different shape of the anterior rostral lobe, the main species characters of *P. genavaensis* are: the flat and distally rounded sensillus provided with distal teeth; epimeral setae *1a*, *2a* and *3a* erect, penicillate with long cilia; 11 pairs of notogastal setae ( $c_1$  present additionally). The presence of seta  $c_1$  is not sufficient reason to exclude *P. genavaensis* from *Protozetomimus*. Comparatively, *Ceratozetes* also includes species with either 10 or 11 pairs of notogastral setae. According to some former authors, these setations were characteristic of '*Ceratozetella*' (with 11 pairs) and '*Ceratozetes* s. str.' (with 10 pairs), respectively, but no other diagnostic characters exist, so Behan-Pelletier & Eamer (2009) synonymized *Ceratozetella* Shaladybina, 1966 with *Ceratozetes* Berlese, 1908.

**Systematic position of the genus:** Pérez-Iñigo (1991) compared *Protozetomimus* with *Ceratozetes* and *Zetomimus* Hull, 1916, and found it to share characters with each of the latter genera. He considered the most important difference with *Zetomimus* to be: 'the indented anterior margin of rostrum with large lateral teeth, in having all the tarsi provided with tridactylous heterodactylous apotele, and in the situation of seta  $lp$  with respect to area  $A_1$  (it is placed a little anterior the level of area  $A_1$ )'. As a result, Pérez-Iñigo questioned the validity of the family Zetomimidae as being distinct from Ceratozetidae and included *Protozetomimus* within Ceratozetidae. Subías (2004, 2012) followed the proposals partly and listed *Zetomimus* within Ceratozetidae, but considered *Protozetomimus* as a subgenus of *Zetomimus*.

From a phylogenetic aspect, most characters used by Pérez-Iñigo (1991) to compare the genera *Ceratozetes*, *Protozetomimus* and *Zetomimus* are altogether plesiomorphic or homoplasious. The only exception is the special structure of the anterior edge of the rostrum, with lateral teeth and a median broad lobe, which can be regarded as apomorphy of *Protozetomimus*. This apomorphic rostrum character is regarded by the author (following Pérez-Iñigo 1991) as sufficient to establish the genus, defined additionally by a typical combination of characters, each of which can be observed in other genera of Ceratozetidae. Theoretical aspects of the presented argumentation, concerning the use of apomorphic and plesiomorphic characters for systematic proposals, can be found in a recent paper (Weigmann 2010).

Since 1991 our knowledge of Zetomimidae has increased significantly (e.g. Behan-Pelletier 1998, Behan-Pelletier & Eamer 2003, Norton & Behan-Pelletier 2009). A strong argument for its validity is the aberrant structure of the juveniles compared with those of Ceratozetidae (see also Weigmann & Deichsel 2006), but unfortunately juveniles of *Protozetomimus* are

undescribed. Behan-Pelletier & Eamer (2003) compared the juvenile and adult characters of Zetomimididae with those of related poronotic families and gave detailed diagnoses of zetomimid genera. The main diagnostic characters of adult Zetomimididae are the following (selected from the diagnosis in Behan-Pelletier & Eamer 2003: 22): (1) apheredermous poronotic Brachypylina, with character states of the Ceratozetoidea; (2) lamellar cusp tapering to width of lamellar seta; (3) tutorium with well-developed triangular cusp; (4) genital opening often displaced anteriorly so that epimeral setae  $2a$  and  $3a$  in almost transverse alignment; (5) spermapositor (male genital sclerite) large, subequal in length to that of genital plate (ratio 0.9:1 to 1.25:1); (6) genital papilla  $Va$  of male subequal in size and shape to  $Vm$  and  $Vp$  (as in female), or  $Va$  narrow and conical; (7) lateral apophysis present on mentum of subcapitulum.

The main diagnostic characters of adult Zetomimus are the following (selected from the diagnosis in Behan-Pelletier & Eamer 2003: 30; character 10 added by the author): (8) 4 pairs of porose areas, porose area  $A_1$  positioned medially on notogaster; (9) notogastral seta  $lp$  positioned posteriorly or posteromedially to  $A_1$ ; (10) genital setae in longitudinal row; (11) seta  $l''$  on genu II short, spiniform; (12) legs I and II monodactylous or tridactylous, legs III and IV tridactylous.

Comparing the characters of *Protozetomimus acutirostris* after Pérez-Iñigo (1991) and of *P. behanae* sp.n. with the diagnostic characters of Zetomimididae and Zetomimus as listed in the last paragraph above, there is no convincing congruence which gives reason to include *Protozetomimus* into either Zetomimus or Zetomimididae. In particular, the supposed apomorphic characters (4) to (9) for these taxa are not present in *Protozetomimus*.

Therefore, *Protozetomimus* is not a near relative of Zetomimus but rather is regarded as a genus of Ceratozetidae. At present, it comprises three adequately described species: *Protozetomimus acutirostris*, *P. genaensis* and *P. behanae* sp. n.

### 3.4. *Protoribates tohokuensis* Fujikawa, 2003

#### Material examined

487 females from the sample series Po 206–217, soil and litter in a floodplain forest.

#### Diagnosis

Body length of Portuguese specimens 510–590  $\mu\text{m}$ , Japanese specimens 486–586  $\mu\text{m}$ . Rostrum anteriorly truncate (in dorsal aspect), with rounded ventral lobe; prodorsal setae robust and long; sensillus with long and narrow-fusiform head, unilaterally barbed. Notogastral setae very small (1–3  $\mu\text{m}$ ); porose area  $Aa$  largest,  $A_1$  shifted medially, associated with seta  $lp$ ,  $A_2$  between setae  $h_2$  and  $h_3$ ,  $A_3$  behind seta  $h_1$  and near  $p_1$ . Adanal setae  $ad_2$  and  $ad_3$  relatively long (5–40  $\mu\text{m}$ ); discidium with elongated custodium. Femora of legs II–IV with ventral blade; all legs monodactylous.

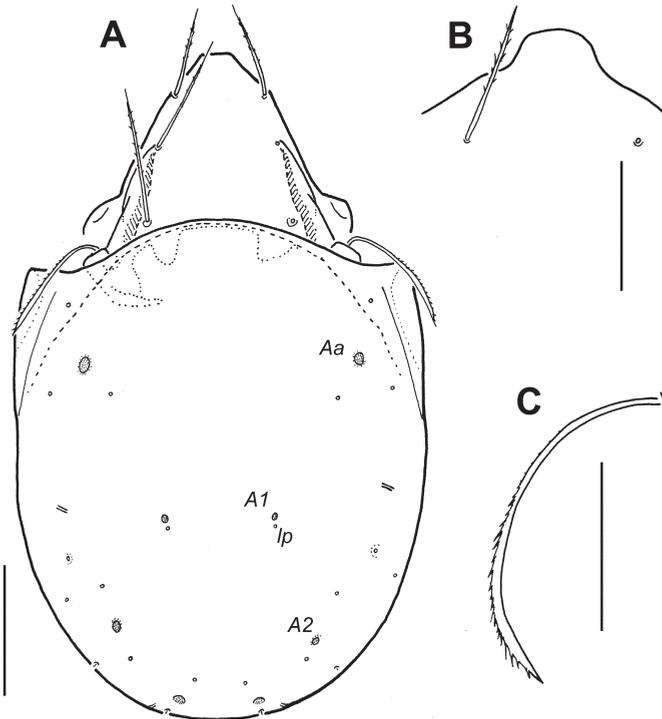
#### Redescription

**General characters:** Body length 510–590  $\mu\text{m}$  (mean 545  $\mu\text{m}$ ,  $n=16$ ), Japanese specimens 486–586  $\mu\text{m}$ ; length-width ratio 1.6:1. Only females found. Body colour reddish brown, cuticle smooth, cerotegument not obviously developed.

**Prodorsum:** Anterior rostrum edge truncate (in dorsal aspect, Fig. 9A), with rounded ventral lobe (in frontal aspect, Fig. 9B), anterio-laterally with flat excavation of the ventral border in the region of pedipalps; prodorsal setae robust and shortly barbed,  $ro$  about 60–70  $\mu\text{m}$  long,  $le$  about 80–90  $\mu\text{m}$  and  $in$  100–120  $\mu\text{m}$ . Sensillus about 115  $\mu\text{m}$  long, unilaterally barbed,

with long and narrow fusiform head, width less than twice that of stalk (Fig. 9C). Tutorium a narrow transverse ridge (as typical for the genus); exobothridial seta small or reduced to alveole.

**Notogaster:** Shape broadly-ovoid (Fig. 9A), pteromorph large, bent downwards, hinged as typical (hinge line often difficult to see). Ten pairs of very small notogastral setae (1–3  $\mu\text{m}$  long); four pairs of small roundish porose areas, area *Aa* largest, *A*<sub>1</sub> shifted mediad, associated with seta *lp* posterior or median at the area, *A*<sub>2</sub> between setae *h*<sub>2</sub> and *h*<sub>3</sub>, *A*<sub>3</sub> behind seta *h*<sub>1</sub> and near *p*<sub>1</sub>; five pairs of lyrifissures as usual.



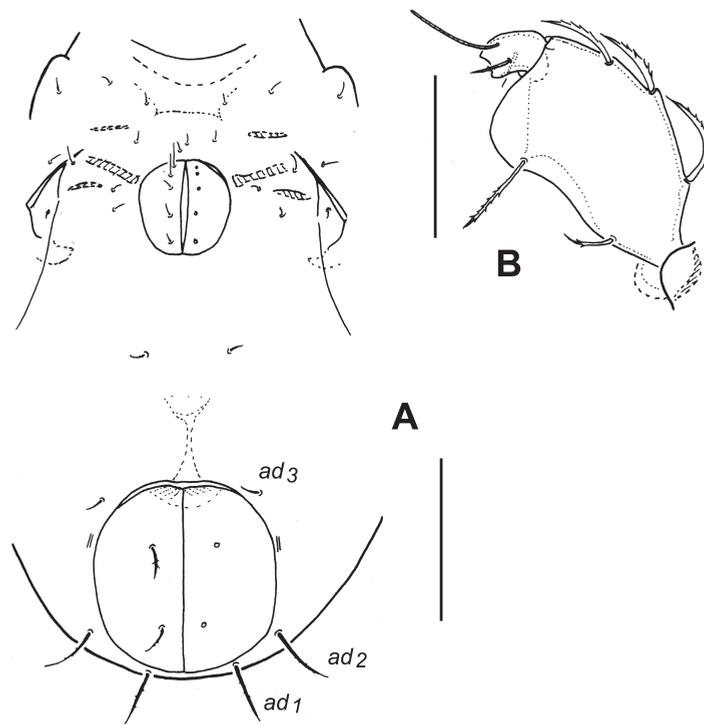
**Fig. 9** *Protoribatodes tohokuensis*. **A:** Dorsal aspect, legs omitted; **B:** Anterior rostrum edge in dorso-frontal aspect; **C:** Sensillus.

Abbreviations: *Aa*–*A*<sub>2</sub> – porose areas; *lp* – notogastral seta. Scale bars **A** 100  $\mu\text{m}$ ; **B**, **C** – 50  $\mu\text{m}$ .

**Ventral region:** Epimeral setation formula 3-1-3-3 (3c and 4c difficult to see). Five pairs of genital setae and one pair of aggenital setae small; anal and adanal setae enlarged, sparsely barbed; *ad*<sub>1</sub> about 40  $\mu\text{m}$  long, *ad*<sub>2</sub> about 35  $\mu\text{m}$ , *ad*<sub>3</sub> about 18  $\mu\text{m}$ , anal setae about 20  $\mu\text{m}$ . Discidium with elongated custodium (Fig. 10A).

**Legs:** All tarsi monodactylous; setation not studied in detail. Femora of legs II–IV with ventral blade (Fig. 10B).

**Distribution and ecology:** Originally described from Japan, found in litter layer of old beech forest (Fujikawa 2003). Portuguese findings in soil surface layer of a river floodplain *Alnus* forest, South-West Algarve, are the second ones, as far as known by the author.



**Fig. 10** *Protoribates tohokuensis*. **A**: Ventral aspect, legs omitted; **B**: Femur and genu of leg II. Abbreviations:  $ad_1$ - $ad_3$  – adanal setae. Scale bars **A** 100  $\mu$ m, **B** 50  $\mu$ m.

### Remarks

The taxonomic concept and classification of the genus *Protoribates* Berlese, 1908 (*Protoribates* s. lato) have been controversial and variable in the literature. Following the discussion in Weigmann et al. (1993), the junior synonymy of *Xylobates* Jacot, 1929 with *Protoribates* is generally accepted (Bayartogtokh 2000, Bajejo et al. 2003, Weigmann 2006, Subías 2012). The basic diagnostic characters used by Balogh & Balogh (1984: 268) for *Xylobates* are suitable now for *Protoribates* and include the following: (1) dorsosejugal suture present; (2) generally notogaster with four pairs of roundish porose areas; (3) pteromorph movable; (4) sensillus long, setiform or narrow-fusiform or lanceolate at tip; (5) 10(-12) pairs of notogastral setae (or alveoli); (6) one pair of aggenital setae; (7) five pairs of genital setae.

Primarily the genus *Protoribates* was defined as monodactylous (Berlese 1908) which persists as definition of *Protoribates* (*Protoribates*) in the sense of Subías (2012) in contrast to *Protoribates* (*Triaungius*) Kulijev, 1978, differentiated only by tridactyly. Curiously, the type species of *Protoribates*, *P. dentatus*, Berlese, 1883, has variable numbers of claws: leg I is usually monodactylous, legs II–IV are mostly heterotridactylous, but exceptionally mono- or bidactylous (Weigmann et al. 1993). Even though all other species of *Protoribates* (*Protoribates*) (as listed in Subías 2012) are strictly monodactylous, the genus definition can not include monodactyly because the type species is variable in this respect. Consequently Bajejo et al. (2003) synonymized the closely related tridactylous genus *Brasilobates* Pérez-Iñigo & Baggio, 1980, with *Protoribates*. Subías (2012: 15) regarded *Brasilobates* as a junior synonym of *Protoribates* (*Triaungius*) (based on the insufficiently described tridactylous Caucasian species *Schelorbates fallax* Kulijev, 1968). *Triaungius* must be regarded as a synonym of *Protoribates* as well, because the tridactyly is not a differentiating apomorphic character. The following discussion is limited to the type species and monodactylous *Protoribates* species.

Within the genus *Protoribates*, as characterized above, we can observe three types of long unilaterally barbed sensilli: (a) setiform sensillus (cf. *P. lophotrichus* (Berlese, 1904) in Miko et al. 1994); (b) narrow-fusiform sensillus, gradually broadened in the distal half, with maximum width not more than twice the width of the stalk (cf. Fig. 9C); (c) distinctly broadened lanceolate head in the distal part of sensillus (cf. Fig. 11B).

*Protoribates tohokuensis* belongs to the species group with narrow-fusiform sensillus. This character is also realized in the type species *P. dentatus*, which differs from *P. tohokuensis* mainly in the variable numbers of claws, rounded rostrum, lateral position of porose area  $A_1$ , short seta  $ad_2$ , and short custodium.

By the kindness of Prof. Norton, I had the possibility to study a slide with several specimens of *P. robustior* (Jacot, 1937), which was originally described as an American subspecies *Xylobates capucinus robustior* (Jacot 1937), then elevated to species rank by Norton & Kethley (1989). *Protoribates robustior* appears as the nearest known relative to *P. tohokuensis* as judged by their similar body length range of 463–525  $\mu\text{m}$  (in *tohokuensis* 510–590  $\mu\text{m}$ ), an equal shape of the sensillus, an equally elongated custodium, and elongated adanal setae  $ad_2$  and  $ad_1$  of about 2–35  $\mu\text{m}$  length (vs. about 5–40  $\mu\text{m}$  in *tohokuensis*) compared with shorter  $ad_3$  setae. The rostrum shape is clearly different: in *robustior* the anterior rostral outline is rounded, without the lateral excavation observed in *tohokuensis*. One might consider *P. tohokuensis* as a palaeartic subspecies of *P. robustior*, but there is no compelling reason to do so.

*Protoribates crassisetiger nipponicus* (Fujita, 1989) from Japan differs from *P. tohokuensis* mainly in having a rounded rostrum, thickened lamellar seta, and more broadened distal part of sensillus. *Protoribates naganoensis* (Fujita, 1989) from Japan differs mainly in having a rounded rostrum, smaller body size (398–477  $\mu\text{m}$  length), 12 pairs of notogastral setae, and less enlarged adanal setae. *Protoribates taira* Fujikawa, 2006 from Japan differs mainly in having a smaller body size (about 340  $\mu\text{m}$  length), short setae  $ad_1$  and  $ad_2$ , and more broadened distal part of sensillus with long barbs.

The Spanish species *Protoribates vastus* (Mihelčič, 1956) is highly confusing. The description in Mihelčič (1956a) – as *Peloribates vastus* – is insufficient and partly incorrect, compared with the redescription based on type specimens by Pérez-Iñigo (1974). Compared to the latter information, this species is similar to *P. tohokuensis* regarding the sensillus shape and the median position of  $A_1$  near seta  $lp$ ; the latter character differs from *P. dentatus* which makes the synonymization of *P. vastus* with *P. dentatus* by Subías (2012) questionable. However, later Pérez-Iñigo (1993) figured this species differently – as *Xylobates vastus* – with distally broadened sensillus and unusual positions of notogastral porose areas  $A_2$  and  $A_3$ . The original slides of Mihelčič must be restudied, but a loan request at the Museo Nacional de Ciencias Naturales Madrid was not successful. Prof. Subías, Madrid, regards the respective slides of Mihelčič as unavailable (personal communication).

### 3.5. *Protoribates hakonensis* Aoki, 1994

#### Material examined

80 females from sample series Po 206–217; soil and litter in a floodplain forest.

#### Diagnosis

Body length of Portuguese specimens 342–427  $\mu\text{m}$ , Japanese specimens 358–402  $\mu\text{m}$ . Rostrum anteriorly rounded; prodorsal setae robust and long; sensillus with lanceolate head in the distal third, unilaterally with few barbs. Notogastral setae small (about 5  $\mu\text{m}$ ); porose area  $Aa$  largest,  $A_1$  shifted mediad, associated with seta  $lp$ ,  $A_2$  near seta  $h_2$ ,  $A_3$  anterior seta  $p_1$ . Adanal setae  $ad_2$  and  $ad_3$  moderately prolonged (16–24  $\mu\text{m}$ ); discidium with very short custodium tip. Femora of legs II–IV with ventral blade; all claws monodactylous.

#### Redescription

**General characters:** Body length 342–427  $\mu\text{m}$  (mean 384  $\mu\text{m}$ ,  $n=14$ ), Japanese specimens 358–402  $\mu\text{m}$ ; length-width ratio 1.7:1. Only females found. Body colour pale reddish-brown, cuticle smooth, cerotegument not obviously developed.

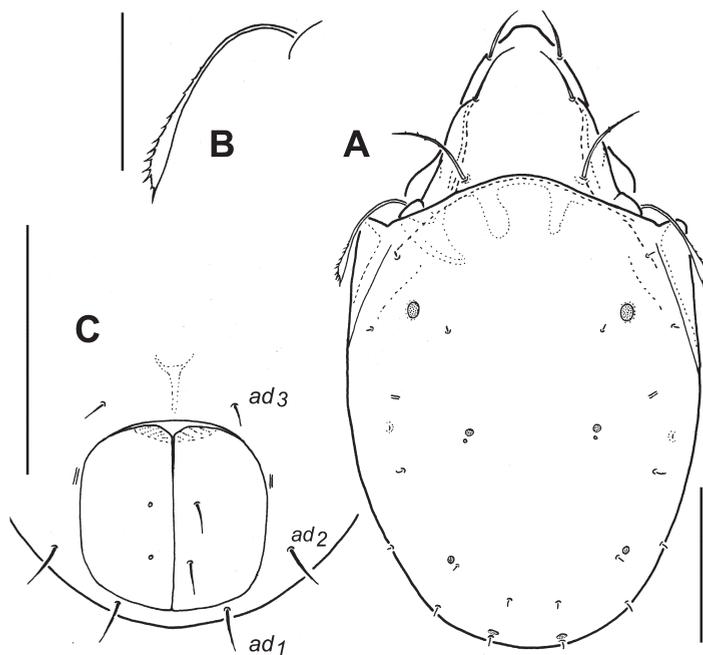
**Prodorsum:** Anterior rostral edge rounded; prodorsal setae robust, *ro* about 30–40  $\mu\text{m}$  long, smooth; *le* about 30–40  $\mu\text{m}$ , smooth; *in* about 55–80  $\mu\text{m}$ , barbed. Sensillus about 80  $\mu\text{m}$  long, with lanceolate head in distal third, unilaterally with few barbs (Fig. 11B). Tutorium a narrow transverse ridge (as typical); exobothridial seta small.

**Notogaster:** Shape broad-ovoid (Fig. 11A), pteromorph large, bent downwards, hinged (hinge line often difficult to see; not figured by Aoki 1994). Anterior edge of pteromorph near bothridium with small excavation. Ten pairs of small notogastral setae, about 5  $\mu\text{m}$  long; four pairs of small roundish porose areas, area *Aa* largest, *A*<sub>1</sub> shifted mediad, associated with seta *lp*, *A*<sub>2</sub> near seta *h*<sub>2</sub>, *A*<sub>3</sub> anterior seta *p*<sub>1</sub>; five pairs of lyrifissures as usual.

**Ventral region:** Mentum of subcapitulum without tectum, as typical for the genus. Epimeral setation formula 3-1-3-3 (*3c* and *4c* difficult to see). Five pairs of genital setae and one pair of aggenital setae small; adanal setae slightly enlarged, *ad*<sub>1</sub> about 40  $\mu\text{m}$  long, *ad*<sub>2</sub> about 35  $\mu\text{m}$ , *ad*<sub>3</sub> about 18  $\mu\text{m}$ , anal setae about 20  $\mu\text{m}$  (Fig. 11C). Discidium with very short custodium.

**Legs:** All tarsi monodactylous; femora of legs II–IV with ventral blade, tibia I ventrally with small tooth in proximal part.

**Distribution and ecology:** Originally described from Central Japan, found in soil layer of Hakone Botanical Garden of Wetlands (Aoki 1994). Portuguese findings in soil surface layer of a river floodplain *Alnus* forest, South-West Algarve, are the second ones, as far as known by the author.

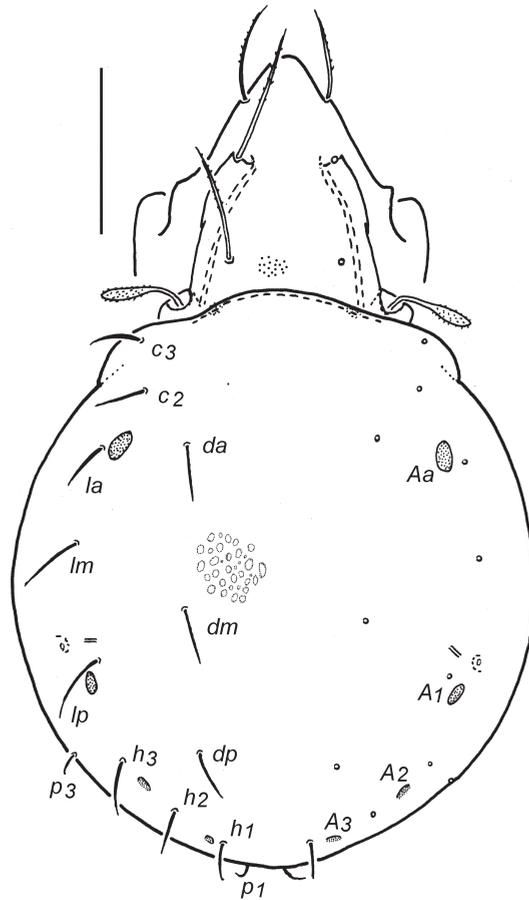


**Fig. 11** *Protoribates tohokuensis*. A: Dorsal aspect, legs omitted; B: Sensillus; C: Ventral aspect, posterior part.

Abbreviations: *ad*<sub>1</sub>-*ad*<sub>3</sub> – adanal setae. Scale bars A, C 100  $\mu\text{m}$ ; B 50  $\mu\text{m}$ .

### Remarks

The Portuguese record of *P. hakonensis* is the first in the western Palaearctic. In Central Europe and the Iberian Peninsula, there is no well described *Protoribates* species known that is similar to *P. hakonensis* with regard to body size and sensillus shape. Some eastern palaeartic species resemble *P. hakonensis*: *Protoribates bayanicus* Bayartogtokh, 2000, from Mongolia differs mainly in the short adanal setae, short prodorsal setae and more barbs on sensillus; *P. brevisetosus* Fujita, 1989, from Japan differs mainly in the very short lamellar seta and the special shape of the sensillus head; *P. gracilis* Aoki, 1982, from Japan differs mainly in the short lamellar seta and very short barbs on the strongly swollen lanceolate sensillus head; *P. shirakamiensis* Fujikawa, 2003, from Japan differs mainly in the unusual positions of notogastral setae and porose area  $A_1$ , and short setae  $le$ ,  $ad_1$ ,  $ad_2$ .



**Fig. 12** *Oribatula polytuberculata*. Dorsal aspect, legs omitted.  
Abbreviations:  $Aa$ - $A_3$  – porose areas;  $c_3$ - $p_1$  – notogastral setae. Scale bar 100  $\mu$ m.

### 3.6. *Oribatula polytuberculata* Ermilov, Shtanchaeva, Subías & Orobitg, 2012

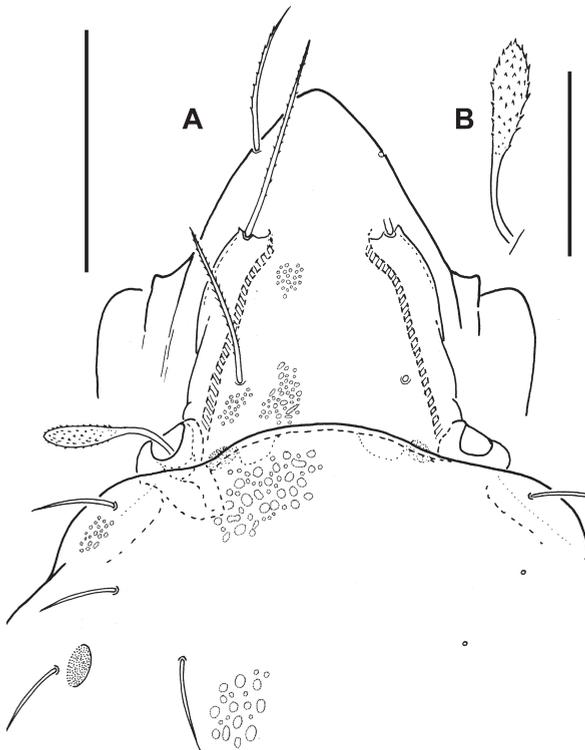
The manuscript of this publication included a description of this species as a new one. In the time of the reviewing process, the author got the recent paper of Shtanchaeva et al. (2012) with the detailed description of a new species from São Luis, South-West Portugal, about 50 km northern the own record. The species identity is undoubtedly. Therefore the description is omitted, and only a revised diagnosis, the remarks and the figures are presented in the following.

#### Material examined

Five specimens from samples 212–216; preserved in ethanol, deposited in the collection of the author.

#### Diagnosis

Body length range 475–495  $\mu\text{m}$  (after Shtanchaeva et al. 2012: 440–525  $\mu\text{m}$ ). Surface of prodorsum and notogaster with distinct pattern of irregular granulation, smaller on the prodorsum; anal region and anal plates with short longitudinal striae; middle area of ventral plate with pits. Lamella distally broadened with small lateral tooth besides insertion of lamellar seta. Sensillus with long stalk, head longish claviform with short barbs. With thirteen pairs of moderately long and nearly smooth setiform notogastral setae. Four pairs of oval porose areas on notogaster. Humeral blade distinct.

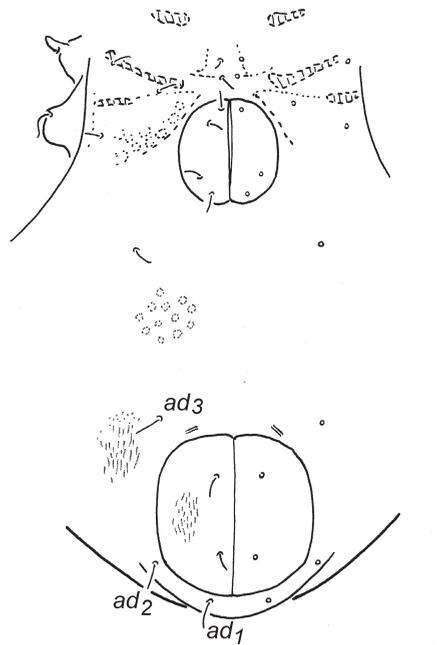


**Fig. 13** *Oribatula polytuberculata*. **A**: Prodorsum and anterior part of notogaster, legs omitted; **B**: Sensillus. Scale bars **A** 100  $\mu\text{m}$ , **B** 50  $\mu\text{m}$ .

**Distribution and ecology:** Found in four samples from soil surface layer of a river floodplain *Alnus* forest, South-West Algarve. Original records from São Luís, South-West Portugal (Shtanchaeva et al. 2012) in soil under *Cistus ladaniferus*.

#### Remarks

Only few described *Oribatula* species have a distinct integument pattern on prodorsum and notogaster. E.g. *Oribatula repetita* Subías, 2004 (nom. nov. for *O. lineata* Bayartogtokh & Aoki, 1997, from Mongolia) has a fingerprint-like notogastral pattern which is present also in *O. lamellata* (Mahunka, 1985) from South Africa; *O. torrijosi* Subías, Ruiz & Kahwash, 1990, from Spain, has an irregular vermiform notogastral pattern (this species is present in samples of this studies on rocky area in the estuary of Ribeiro de Aljezur). The morphology of the distally broadened lamella in *O. polytuberculata* is similar to that in *O. torrijosi* and *O. tibialis* (Nicolet, 1855) as redescribed in Wunderle et al. (1990) and Weigmann (2006), but with a small distal tooth which is absent in *O. tibialis* and *O. torrijosi*.



**Fig. 14** *Oribatula polytuberculata*. Anogenital region, ventral aspect, legs omitted. Abbreviations:  $ad_1$ - $ad_3$  – adanal setae. Scale bar 100  $\mu$ m.

#### 4. Acknowledgements

The author is grateful to his colleague Roy A. Norton, Syracuse, for specimens and the loan of microscopical slides of some North-American *Protoribates* species which allowed comparisons with the Iberian species. Sincerely thanks to Helena Barrocas, Coimbra, for the specimens of *Protozetomimus behanae* sp. n. and to two anonymous referees who provided helpful remarks and linguistic proposals.

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