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A new species of *Perinereis* (Polychaeta, Nereididae) from Florida, USA, with a key to all *Perinereis* from the American continent

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Abstract

Specimens belonging to a new species of *Perinereis* Kinberg, 1865 were collected from natural oyster reefs in an estuarine environment on Florida's southwest coast. The genus *Perinereis* includes more than 70 species, of which, *P. aibuhitensis* (Grube, 1878), *P. brevicirrata* (Treadwell, 1920), *P. camiguinoides* (Augener, 1922), *P. jascooki* Gibbs, 1972, *P. kuwaitensis* Mohammad, 1970, *P. singaporiensis* (Grube, 1878), *P. vancaurica* (Ehlers, 1868) and the new species have two short bars on Area VI and notopodial dorsal ligules that are not greatly expanded. The most geographically close species is *P. brevicirrata.* The new species can be distinguished from *P. brevicirrata* by the absence of a notopodial prechaetal lobe, Area V with 3 cones in a triangle, and Area VII-VIII with two well-defined rows of 33 paragnaths, the basal row having longer paragnaths in relation to the distal ones. The new species resembles *P. singaporiensis* based on the absence of notopodial prechaetal lobe; however, the two species differ in some morphological characteristics such as tentacular cirri length, shape of dorsal notopodial ligules, and falciger blades. A key to all American species of *Perinereis* is included.

Keywords

Annelida, polychaetes, Nereididae, new species, taxonomy, Florida, Western Atlantic

Introduction

Nereididae Blainville, 1818 is probably the most well known family of Polychaeta, with 44 genera and 677 species (Read and Fauchald 2012), although the number of species could be over estimated. The importance of this family is manifested by its high diversity and abundance in practically all marine benthic environments, from the supralittoral to the abyssal depth. One of the most diverse genera in the family is *Perinereis*, established by Kinberg (1865). *Perinereis* is characterized principally by the ornamentation of pharyngeal paragnaths in Area VI, which may be simple (short or long ribbon-shaped) or fragmented transverse bars. It is a genus consisting globally of around 74 species (Read and Fauchald 2012). Bakken and Wilson (2005) found that *Perinereis* may be polyphyletic. Twenty-two species are currently known from the Americas, and of those, seven have been reported from Eastern Tropical America: *P. anderssoni* Kinberg, 1865 described from Brazil; *P. cariacoensis* Liñero-Arana, 1983 and *P. mochimaensis* Liñero-Arana, 1983 from Venezuela; *P. cariboea* de León-González & olís-Weiss, 1998 from Mexican Caribbean, *P. floridana* Ehlers, 1868 from Florida, USA, *P. ponteni* Kinberg, 1865 from Brazil, and *P. vancaurica* Ehlers, 1868 from Thailand. The latter is reported for the region by many authors, including Fauvel (1919) from French Guiana, Wesenberg-Lund (1958) from Bonaire, Lana (1984) from Pontal do Sul and Pecas Island, Brazil, and Santos and Lana (2000) from Brazil.

In the present work, a new species of *Perinereis* from the west coast of Florida is described for the first time. Further, records of Indo-Pacific nereidids reported from the Americas, such as *P. vancaurica*, are evaluated.

Material and methods

The material analyzed for this study was collected in December 2010 by Florida Atlantic University, Department of Biological Sciences/Harbor Branch Oceanographic Institute from natural oyster reefs within Rookery Bay National Estuarine Research Reserve near Naples, Florida. Sampling in Rookery Bay took place as part of the BP Oil Spill Oyster Study, an impact study on the effects of an oil spill on the oyster reef systems in Florida, funded by the Florida Institute of Oceanography. Samples were hand collected at low tide using a 0.12 m^2 collection quad to a depth of 7.6 cm. The materials were screened through a 2.0 mm mesh sieve. The collection team, led by Dr Donna Devlin, included Dr Holly Nance, Dr Loren Coen, Pedro Lara, and Dana Smith. Specimens were fixed with formalin and preserved in 70% isopropyl alcohol, no stain was used. Material was deposited in the Los Angeles County Museum, Allan Hancock Foundation (LACM-AHF), the Zoologische Museum, Hamburg, Germany (HZM), the Polychaetological Collection of the Universidad Autónoma de Nuevo León (UANL), and the Florida Fish and Wildlife Conservation Commission – Fish and Wildlife Institute Invertebrate Collection, St. Petersburg, Florida (FSBC I). A key to all known American species of *Perinereis* is included.

Results

Systematics

Class Polychaeta Grube, 1850
Order Phyllodocida Örsted, 1843
Family Nereididae Blainville, 1818
Genus *Perinereis* Kinberg, 1865

***Perinereis rookeri* sp. n.**
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http://species-id.net/wiki/Perinereis_rookeri
Figures 1, 2

Type material. West coast of Florida, Naples, Rookery Bay, December 17-22, 2010 (holotype, UANL 7841), and 3 paratypes (HZM P-27422), FLW-Site3-Reef5-Rep2, 26°00.56'N, 81°44.90'W, 22/12/2010; One Paratype (LACM-AHF-4998), FLW-Site1-Reef2-Rep1, 26°01.55'N, 81°44.00'W, 17/12/2010; One Paratype (UANL 7842), FLW-Site3-Reef3-Rep2, 26°00.58'N, 81°44.24'W, 21/12/2010.

Additional material. West Coast of Florida, Naples, Rookery Bay, December 17–21, 2010. One specimen (FSBC I 106475) from FLW-Site1-Reef3-Rep2, 26°01.54'N, 81°44.23'W, 17/12/2010; and one specimen from FLW-Site3-Reef3-Rep2, 26°00.58'N, 81°44.24'W, 21/12/2010.

Description. Holotype complete, 84 chaetigers, 52 mm in length, 2.5 mm wide at chaetiger 10 (excluding parapodia); 3.72 mm wide at chaetiger 10 (including parapodia). Paratypes complete with 75-87 chaetigers, 42-65 mm long, and 0.8–2.7 mm wide at chaetiger 10 (excluding parapodia).

Prostomium slightly wider than long, antennae minute, about ⅓ length of prostomium. Two pairs of eyes of similar size in trapezoidal arrangement. Biarticulate palps globose, with four pairs of tentacular cirri, posterodorsal pair extending back to posterior margin of first chaetiger (Fig. 1 A).

Paragnaths black, cones on maxillary ring, cones and bars on oral ring, those of maxillary ring smaller. Area I= 2 cones in a line; Area II= 13 cones in 3 irregular rows; Area III= 18 cones in a quadrangular arrangement of 3 irregular rows, flanked by a left line of 3 cones and a right line of 5 cones; Area IV= 20 cones on the left, 17 cones on the right in a triangular patch, without bars; Area V= 3 cones in a triangle; Area VI= two short transverse bars; Area VII-VIII= 33 cones in two rows, basal row with slightly longer paragnaths in relation to those of the distal row (Fig. 1 A–B, 2 A–B).

First two parapodia uniramous, all others biramous. Parapodia of anterior region with short dorsal cirri, not longer than dorsal ligule, inserted basally, dorsal ligule subulate, notopodial ventral ligule subtriangular, without notopodial prechaetal lobe; neuropodia with superior lobe rounded, inferior lobe reduced, postchaetal lobe rounded, ventral ligule subulate, ventral cirri minute, inserted basally (Fig. 1 C). Parapodia of median and posterior region similar in shape, notopodia with short dorsal cirri inserted

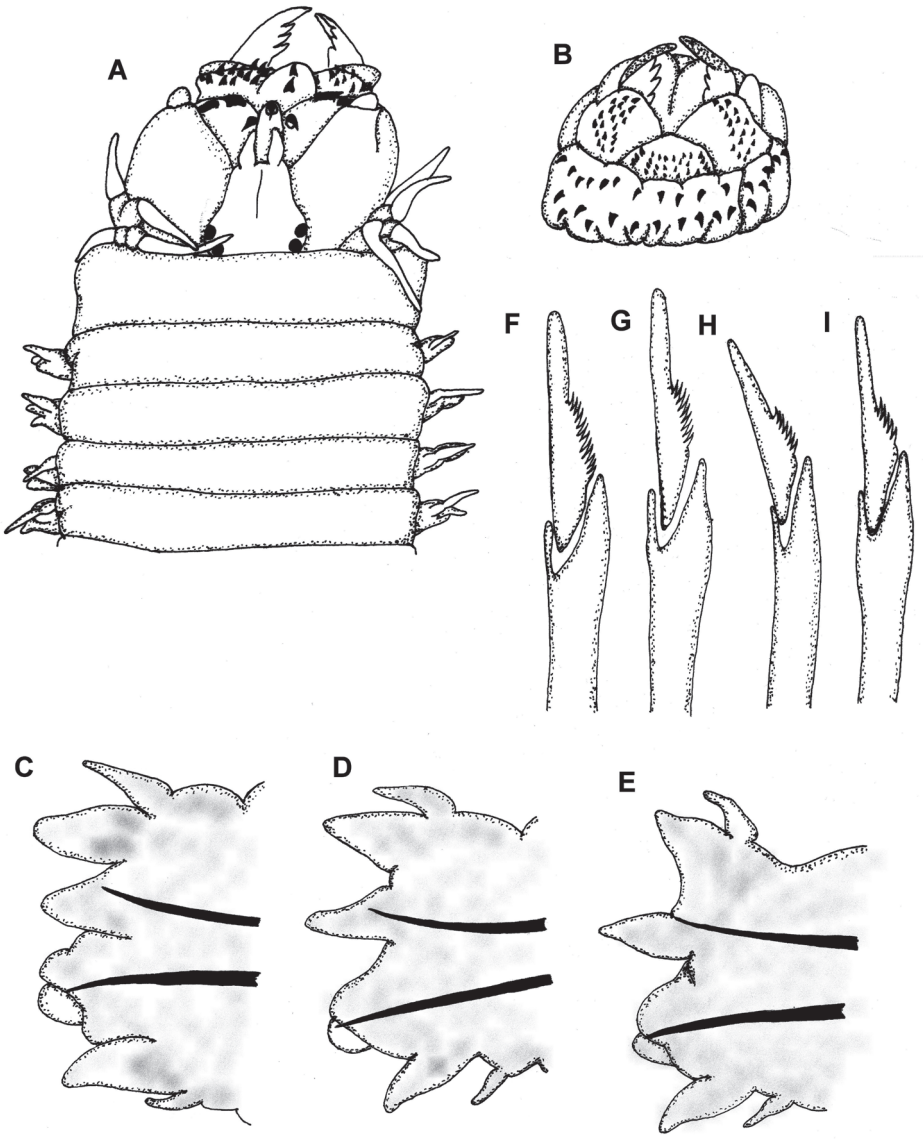

Figure 1. *Perinereis rookeri* sp. n. **A** Anterior end, dorsal view **B** Proboscis, ventral view **C–E** Parapodia of chaetigers 11, 30 and 61, anterior view **F** Supracicular neuropodial heterogomph falciger, chaetiger 11 **G** Infracicular neuropodial heterogomph falciger, chaetiger 11 **H** Supracicular neuropodial heterogomph falciger, chaetiger 61 **I** Infracicular neuropodial heterogomph falciger, chaetiger 61. Measures: **A–B**= 1 mm; **C–E**= 250μ; **F–I**= 30μ.

medially, dorsal ligule subtriangular, notopodial ventral ligule subulate (Fig. 1 D–E); neuropodial structures similar in shape along body.

Chaetation similar throughout body. Notochaetae all homogomph spinigers. Supracicular neurochaetae consisting of homogomph spinigers and heterogomph fal-

cigers, the latter with straight blades denticulate on the basal half (Fig. 1 F–G). Falciger blades of anterior and median parapodia longer than those of posterior ones. Infracicular neurochaetae consisting of heterogomph spinigers and heterogomph falcigers, the latter similar in shape and size gradation of dentition to supracicular ones (Fig. 1 H–I). Anterior and median spinigers slightly longer than posterior ones.

Pygidium with terminal anus and a pair of short cirri (1.2 mm long) inserted ventrally to anal opening.

Remarks. Type and non-type specimens exhibit variation in paragnath counts for Area I, as follows. A single specimen with 1 paragnath, two specimens with 3 in a triangle, and the rest with 2 paragnaths in a line.

Discussion. Hutchings et al. (1991) created an informal grouping of species belong to *Perinereis* based on the ornamentation of pharyngeal Area VI, and the development of the dorsal ligule. The species described here belongs to group 2A based on the presence of two short bars on Area VI and a dorsal ligule that is not greatly expanded. The following species belong to this group: *P. aibuhitensis* (Grube, 1878) from the Philippines, *P. brevicirrata* (Treadwell, 1920) from Southern Brazil, *P. camiguinoides* (Augener, 1922) from Juan Fernandez Island, *P. jascooki* Gibbs, 1972 from the Cook Islands, *P. kuwaitensis* Mohammad, 1970 from Kuwait, *P. singaporiensis* (Grube, 1878) from Singapore, and *P. vancaurica* (Ehlers, 1868) from Nicobar Islands.

This group can be further subdivided by the presence or size of the notopodial prechaetal lobe. *Perinereis aibuhitensis*, *P. jascooki*, *P. kuwaitensis*, and *P. singaporiensis*, possess only dorsal and median ligules, and the notopodial prechaetal lobe is reduced or absent. The absence of a notopodial prechaetal lobe places *Perinereis rookeri* sp. n. within this subgroup. *Perinereis rookeri* sp. n. and *P. singaporiensis* are the most similar; both species have Area III with a rectangular group of small paragnaths arranged in 4 irregular rows, flanked by 8 cones in two vertical lines. The two species differ by the length of the tentacular cirri, the shape of the dorsal ligule, and the dentition on the inner margin of the falciger blades. The longest tentacular cirrus of *P. singaporiensis* reaches chaetiger 4, while on *P. rookeri* sp. n. it reaches chaetiger 1. The dorsal notopodial ligule on *P. singaporiensis* is conical anteriorly and triangular on median and posterior notopodia, *P. rookeri* sp. n. has subulate dorsal ligules on anterior notopodia and subtriangular on median and posterior notopodia. The falciger blades on *P. singaporiensis* are subtriangular and denticulate on ¾ of their length, whereas those of *P. rookeri* sp. n. are subulate and denticulate for only ½ of their length. The data listed here were taken based on Hutchings et al. (1991), who reviewed the holotype of *P. singaporiensis*. They note that this material is in very poor condition, however the pharyngeal arrangement, shape of the falcigers and number of chaetal lobes agree with their description. The original description from Grube (1878) differs from the Australian specimens in that the longest tentacular cirrus extends to segment 5 and in the pharyngeal arrangement: Area I= 2 cones in line; Area III = 23 cones in transverse group with 2 cones on each side; Area V= 1 cone.

The range of *Perinereis brevicirrata* is the most geographically proximate to that of *Perinereis rookeri* sp. n., but the two can be readily distinguished morphologically.

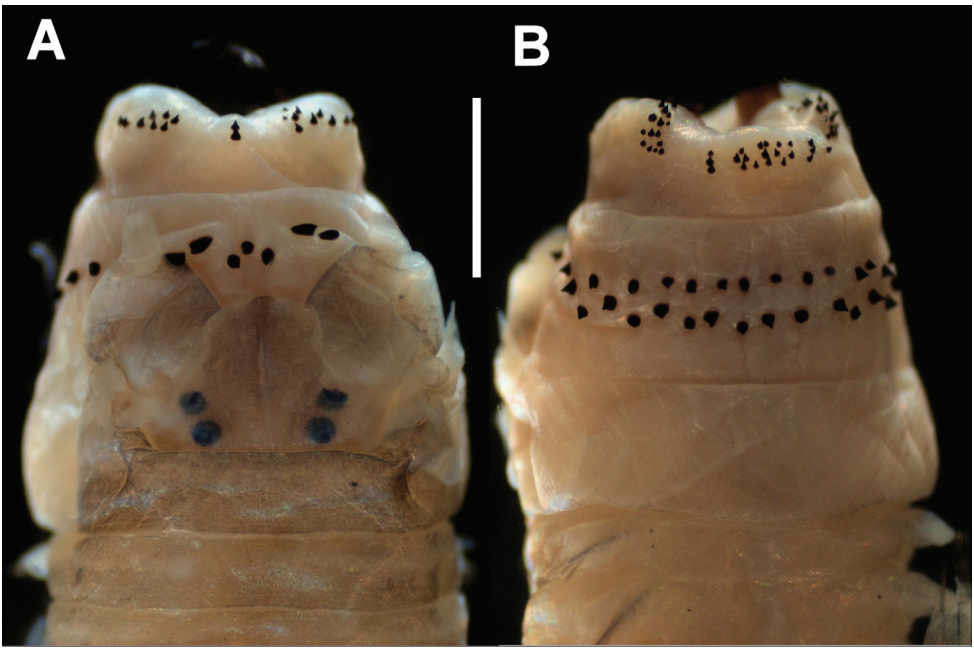

Figure 2. *Perinereis rookeri* sp. n. **A** Anterior end, dorsal view **B** Anterior end, ventral view. Measures: **A–B**= 1 mm.

P. brevicirrata has notopodial prechaetal lobes, Area V has 2 large cones, and Area VII-VIII has 3 lines of paragnaths. In *P. rookeri* sp. n. notopodial prechaetal lobes are absent, Area V has 3 cones in a triangle, and Area VII-VIII has two well-defined lines of 33 paragnaths.

It is likely that *Perinereis rookeri* sp. n. specimens have been previously misidentified or grouped into a higher taxonomic group during previous benthic macroinvertebrate studies along the west coast of Florida.

Many studies throughout southwestern Florida collected only one species of *Perinereis*, *P. floridana*, including a 1932 survey conducted around the Dry Tortugas (Monro 1933) and a 1963 to 1969 Tampa Bay study, which included oyster reef sampling sites (Taylor 1971). Many subsequent studies from southwestern Florida showed an absence of *Perinereis* species completely, including a 1957-1960 estuarine ecology study in north Florida Bay (Tabb and Manning 1961). No *Perinereis* species were reported from within Rookery Bay during a 1984 to 1985 study; however, specimens labeled as *Nereis* or *Neanthes* sp. A were documented. The research also noted a lack of previous benthic macroinvertebrate research conducted specifically within Rookery Bay (Thoemke and Gyorkos 1988). A 2006 study focused on epifaunal community development associated with artificial oyster reefs created near St. Petersburg also found no *Perinereis* specimens, although four unidentified Annelida species were reported (Dow 2008). In northwestern Florida, during a systematic faunal inventory within Pensacola Bay from 1961-1963, three species of *Perinereis* were recorded,

including *P. andersonni*, *P. floridana*, and an unidentified *Perinereis* species. All three species were considered rare, found only during the winter of 1962-1963 in areas with salinity at 20 ppt or greater and within a sandy-mud benthic habitat (Cooley 1978). Taxonomic checklists for Florida list *P. andersonni* and *P. floridana* as the only two species of *Perinereis* found within Florida waters (Perkins and Savage 1975, Camp et al. 1998, Fauchald et al. 2009).

Due to the probable association *Perinereis rookeri* sp. n. has with oyster reefs, it is likely that any occurrence in previous studies would have been rare. *Perinereis rookeri* sp. n. specimens, if previously collected, have presumably been misidentified or left at a higher taxonomic level in earlier research from Florida's west coast.

Etymology. This specific name is derived from Rookery Bay National Estuarine Research Reserve on the west coast of Florida where the species was first discovered.

Distribution. This species is known from the Gulf of Mexico on the west coast of Florida, within Rookery Bay National Estuarine Research Reserve near Naples, where it was collected in association with oyster reefs in estuarine environments.

Ecological comments. *Perinereis rookeri* sp. n. was collected solely from oyster reefs within Rookery Bay National Estuarine Research Reserve. The oyster reefs located in Rookery Bay are shallow, intertidal reefs located in water depths of 1.2-1.5 m at high tide, with approximately 80% of the reefs exposed during low tide. Salinity at the sites where this species was found ranged from 35 to 37 ppt.

Key to American species of *Perinereis*

1	Area VI with more than 2 bars.....**2**
–	Area VI with no more than 2 bars.....**4**
2	Posterior parapodia with dorsal ligule expanded; maxillary ring with few paragnaths (Area I and III without paragnaths); Area V with 1 paragnath; Area VI with 16 small paragnaths in a line.....***P. seridentata*** **(Hartmann-Schröder, 1959)**
–	Posterior parapodia without dorsal ligule expanded; numerous paragnaths in the maxillary ring.....**3**
3	Area IV with bars; Area V with 1–2 paragnaths; Area VI with 12 to 16 small bars in a transverse line .....***P. vallata*** **(Grube, 1857)**
–	Area IV without bars; Area V with 3 paragnaths; Area VI with 5 to 10 small cones in a transverse line.....***P. gualpensis*** **Jeldes, 1961**
4	Posterior parapodia with dorsal ligule not expanded **5**
–	Posterior parapodia with dorsal ligule expanded.....**8**
5	Notopodial prechaetal lobe present on anterior and median notopodia **7**
–	Notopodial prechaetal lobe absent **6**
6	Area VI with 1 transverse bar; Area V with 1-2 paragnaths in line; longest tentacular cirri reaching up to chaetiger 11 .....***P. floridana*** **Ehlers, 1868**
–	Area VI with 2 bars; Area V with 3 paragnaths in triangle; longest tentacular cirri reaching chaetiger 1 .....***P. rookeri*** **sp. n.**

7 Neuropodial heterogomph falcigers with short blades, with teeth on 3/4 of the inner edge. Longest tentacular cirri reaching chaetiger 3 to 5; Area I with 1 paragnath; Area V with 3 paragnaths...***P. camiguinoides*** **(Augener, 1922)**

– Neuropodial heterogomph falcigers with long blades, with teeth on 1/2 of the inner edge; longest tentacular cirri not exceed the length of the prostomium; Areas I and V with 2 paragnaths in a line...***P. brevicirrata*** **(Treadwell, 1920)**

8 Area VI with 2 transverse bars.....**9**

– Area VI with 1 transverse bar or a big conical paragnath.....**11**

9 Area VII-VIII with 8 paragnaths in a line; Area I with 4 paragnaths in a diamond; Area V with 1 paragnath.....
.....***P. osoriotafalli*** **de León-González & Solís-Weiss, 1998**

– Area VII-VII with two lines of paragnaths **10**

10 Area I with 2 paragnaths in a line; Area III with 7 paragnaths in an oval group; Area V bare; neuropodial heterogomph falcigers with short blades ....
.....***P. cariboea*** **de León-González & Solís-Weiss, 1998**

– Area I with 11 paragnaths in a group; Area III with 17 paragnaths in an oval group; Area V with 2 paragnaths; neuropodial heterogomph falcigers with long blades.....***P. mochimaensis*** **Liñero-Arana, 1983**[1]

11 Area VI with a short transverse bar or a big paragnath **12**

– Area VI with a long transverse bar **16**

12 Area VI with a big cone shaped paragnath **13**

– Area VI with a short transverse bar **14**

13 Anterior notopodia with notopodial prechaetal lobe; Area I with 1 paragnath; Area IV with 2 bars.....***P. monterea*** **(Chamberlin, 1918)**

– Notopodia without notopodial prechaetal lobe; Area I with 2 paragnaths in line and numerous small paragnaths on each side; Area IV without bars.....
..... ***P. falklandica*** **(Ramsay, 1914)**

14 Area IV usually with bars; notopodial prechaetal lobe absent; Area V with 3 paragnaths in triangle; Area VI with a short, straight bar .....
.....***P. pseudocamiguina*** **(Augener, 1922)**

– Area IV without bars, only paragnaths; notopodial prechaetal lobe may be present.....**15**

15 Notopodial prechaetal lobe evident on posterior notopodia; tentacular cirri long, reaching chaetiger 6–7; Area I and V with 1 paragnath.....
.....***P. villalobosi*** **Rioja, 1947**

– Notopodial prechaetal lobe absent; tentacular cirri short, reaching chaetiger 1; Area I with 4 paragnaths in a diamond; Area V with 3 paragnaths in a triangle..... ***P. anderssoni*** **Kinberg, 1865**

16 Area I with 2–3 paragnaths in line; Area V with 3 paragnaths in a triangle....**17**

– Area I with a large group of paragnaths; Area V with 1 paragnath.....**18**

17 Tentacular cirri short, reaching chaetiger 2; neuropodial heterogomph falcigers with short blades..... ***P. longidonta*** **Rozbaczylo & Castilla, 1973**

– Tentacular cirri long, reaching chaetiger 7 to 9; neuropodial heterogomph falcigers with long blades .....***P. helleri* (Grube, 1878)**[2]

18 Area VII–VIII with 7 small paragnaths in one line; Area I with a group of 7 paragnaths ..... ***P. bajacalifornica* de León-González & Solís-Weiss, 1998**

– Area VII–VIII with paragnaths in two lines **19**

19 Area I with an oval group of 11 paragnaths; dorsal cirri inserted medially on posterior parapodia; falcigers with a distal tooth directed down ....***P. elenacosoae* Rioja, 1947**

– Area I with a triangular group of 8 paragnaths; dorsal cirri inserted subdistally on posterior parapodia; falcigers distally pointed ...***P. ponteni* Kinberg, 1865**[3]

Notes

1 *P. mochimaensis* Liñero-Arana, 1983 and *P. cariacoensis* Liñero-Arana, 1983 differ in that *P. mochimaensis* has 5 transverse paragnaths in areas V and VI and posterior notopodial superior lobe larger. However, only one specimen of each was examined, one of them incomplete, and these are the only differences indicated. Therefore, until a revision is carried out we consider that *P. cariacoensis* could be a junior synonym of *P. mochimaensis*, which is why it was not included in the key.

2 *P. helleri* was described by Grube (1878) from the Philippines and was reported from Pascua Island, Chile by Rozbaczylo and Castilla (1973). The characters described for the Chilean specimens, such as pharyngeal arrangement, are similar to those from the Philippines and Australia, however, the descriptions of Pascua Island´s specimens were incomplete and were not accompanied by any illustration. Consequently, the presence of *P. helleri* in the Americas remains doubtful.

3 *Perinereis ponteni* Kinberg, 1865, was described from Rio de Janeiro, Brazil, the description was brief and very general. Hartman (1948) proposes a doubtful synonymy with *P. anderssoni*, however, both species can be easily distinguished by the presence of a long, ribbon shaped bar on the Area VI of *P. ponteni*, and a short bar on the same area in *P. anderssoni*. After the revision of one of the two existent syntypes, we consider that *P. ponteni* is valid.

Additional notes

Perinereis obfuscata was described from the Philippines by Grube (1878). Its occurrence has been documented from many coasts throughout the world, with great variability of morphological characters. The record of Rioja (1941) for western Mexico does not belong to this species; rather this record as well as that of Berkeley and Berkeley (1960) both from Guerrero, Mexico belong to *Perinereis elenacasoae* Rioja, 1947 (de León-González and Solís-Weiss 1998). For that reason *P. obfuscata* was not included in the key.

Perinereis vancaurica was originally described from the Nicobar Islands, Andaman Sea. The records for America are limited to the Atlantic (Fauvel 1919, Wesenberg-Lund 1958, Lana 1984, Santos and Lana 2000); however, the descriptions and illustrations provided in those works are insufficient to verify its presence in American waters. Lana (1984) provides a description and a figure of a median parapodium, but with only this information it is impossible to verify whether Lana´s specimens belongs to the Andaman Sea species; furthermore, in the discussion section Lana mentioned that *Perinereis brevicirrata* could be similar to *Perinereis vancaurica*, but both species can be distinguished clearly by the presence of notopodial prechaetal lobe in *P. brevicirrata* and the absence of the same lobe in *P. vancaurica*. For that reason *P. vancaurica* was not included in the key.

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RESEARCH ARTICLE

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A new species of the genus *Arhynchite* (Annelida, Echiura) from sandy flats of Japan, previously referred to as *Thalassema owstoni* Ikeda, 1904

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Abstract

A new echiuran, *Arhynchite hayaoi* **sp. n.**, is described from newly collected specimens from sandy flats of the Seto Inland Sea, Japan, together with many museum specimens, including those once identified as *Thalassema owstoni* Ikeda, 1904 or *A. arhynchite* (Ikeda, 1924). The new species is clearly distinguishable from its congeners by the smooth margin of gonostomal lips and lack of rectal caecum. Brief references are also made to the morphological distinction between the new species and *T. owstoni,* originally described from the deep bottom on the Japanese Pacific coast.

Keywords

Annelida, Echiura, new species, *Arhynchite hayaoi*, *Thalassema owstoni*, sandy flat, Seto Inland Sea

Introduction

Echiurans are a small group of marine coelomates, previously classified as a distinct phylum, but now often included in the Phylum Annelida on the basis of recent molecular phylogenetic analyses (McHugh 1997, Bleidorn et al. 2003, Struck et al. 2007, 2011).

The Japanese echiuran fauna was extensively studied by Prof. Iwaji Ikeda and Dr Hayao Sato in the early and middle parts of the last century, respectively, resulting in our present understanding of the known fauna consisting of ca 20 species (Nishikawa 1992). However, many taxonomic problems remain unsolved, one of which concerns an echiuran called "kouju" in Japanese (probably meaning "good bait"). This echiuran was once abundant and collected in great numbers from intertidal or subtidal sandy bottoms for fish bait in the Seto Inland Sea, Japan (Mori et al. 1932, Ishikawa 1938); however, its density has lately declined too greatly for such use (Nishikawa 2007, 2012, Saito et al. 2011).

The echiuran in the present study was first identified as *Thalassema mucosum* (currently accepted as *Anelassorhynchus mucosus* (Ikeda, 1904)) by Mori et al. (1932). It was soon referred to by Sato (1934), one of the above-mentioned specialists, as *T. owstoni* Ikeda, 1904, established for a damaged deep-water Japanese specimen, after his own examination of specimens newly collected from Onomichi Bay in the Seto Inland Sea. Although Sato's (1934) description lacked any information on their internal morphology or the reason for his corrected identification, his taxonomy has been followed by subsequent authors (Sato 1935, 1939, Ishikawa 1938, Stephen and Edmonds 1972, Nishikawa 1992, 2012).

We have compared echiurans newly collected from a sandy flat near Onomichi Bay with the specimens deposited in the Tohoku University Museum (TUM), collected from the bay in 1931 and labeled as "*Thalassema owstoni* Ikeda" and "kouji" (probably equivalent to "kouju"), probably by Sato, who then belonged to the Tohoku Imperial University, the predecessor of Tohoku University. We found the old and new specimens to be very similar. Further, we found a significant difference between the specimens and the description of *T. owstoni* Ikeda, 1904, although we attempted to examine its holotype and collect new specimens from the type locality, we have so far been unsuccessful. Thus, we herein describe "kouju" as a new species of the genus *Arhynchite* Satô, 1937.

Materials and methods

We collected new specimens from a sandy flat, named Hachi-no-higata, at the mouth of the Kamogawa River, Takehara, Hiroshima Prefecture, Japan in 2011. The specimens were relaxed with menthol, and minute pieces of proboscis were taken from the holotype and two paratypes and fixed with pure ethanol for future molecular analyses; all remaining material was fixed in 10% seawater formalin and then stored in 70% ethanol. Further materials have been retained at our Laboratory of Taxonomy, Toho University (LTTU), the Department of Zoology, University Museum, University of Tokyo (UMUTZ), or TUM. The type series, as well as the two non-type ones, are deposited in the National Museum of Nature and Science, Tsukuba, Japan (NSMT).

Observations, dissections, and drawings were made under a stereoscopic microscope. Trunk length (TL) and proboscis length (PL) were measured. General terminology was based on Stephen and Edmonds (1972) and Nishikawa (2004).

Taxonomy

***Arhynchite hayaoi* sp. n.**
urn:lsid:zoobank.org:act:598901D0-6F77-4F4B-AA50-343FEAD4F9E5
http://species-id.net/wiki/Arhynchite_hayaoi
New Japanese name: Setouchi-dochikuchi-yumushi
Figs 1, 2

Thalassema owstoni: Sato 1934, p. 249, figs 2 and 3; Satô 1939, p. 354.
Arhynchite arhynchite: Nishikawa 2001, pp. 137–138.

Specimens examined. Holotype: NSMT-Ec 100, mature male, TL 25 mm, PL >5 mm (proboscis damaged), Hachi-no-higata sandy flat at the mouth of the Kamogawa River, Hiroshima Pref., Japan (34°19.42'N, 132°53.88'E), May 18, 2011, collected by M. Tanaka and T. Nishikawa. **Paratypes:** NSMT-Ec 101–105, 3 males + 2 females, TL 28–40 mm, PL 6 mm, collection data as for the holotype. **Non-type specimens:** TUM Echiurida 2-11, labeled as "*Thalassema owstoni* Ikeda" probably by H. Sato, 8 males + 6 females + 1 specimen of unknown sex, TL 29–73 mm, proboscis absent, Onomichi Bay, Hiroshima Pref., Japan (34°24'N, 133°12'E), March 7, 1931, collected by Takashi Gamo; TUM Echiurida 1-5, labeled as "*Thalassema owstoni* Ikeda" and "kouji" probably by H. Sato, 2 males + 3 females + 1 of unknown sex, TL 31–62 mm, PL 16–33 mm, Onomichi Bay, Hiroshima Pref., Japan (34°24'N, 133°12'E), March 7, 1931, by Takashi Gamo; NSMT-Ec 106, 1 of unknown sex, TL 28 mm, proboscis absent, intertidal sandy flat at the mouth of the Kamogawa River, Hiroshima Pref., Japan (34°19.42'N, 132°53.88'E), July 8, 2006, by Masanori Sato; NSMT-Ec 107, 1 of unknown sex, TL 33 mm, proboscis absent, intertidal sandy to muddy flat on Ikarise Islet, located in a channel of Lake Hamana, Shizuoka Pref., Japan (34°41.08'N, 137°35.98'E), April 19, 2003, by Shoichi Kimura; UMUTZ-Ecur-2, 1 of unknown sex, TL 55 mm, proboscis absent, above low-water mark, Tomono-ura, Hiroshima Pref., Japan (34°22'N, 133°23'E), July 1882, by I. Ikeda, reported as *A. arhynchite* (Ikeda) by Nishikawa (2001); UMUTZ-Ecur-10, 1 of unknown sex, TL 38 mm, proboscis absent, Misaki, Sagami Bay, Kanagawa Pref., Japan (35°09'N, 139°36'E), collection data unknown, reported as *A. arhynchite* by Nishikawa (2001). **Specimens for comparison:** *A. arhynchite*; LTTU-Y009, 1 female + 3 of unknown sex, TL 42–74 mm, off Abashiri ,Hokkaido, Japan, 7–12 m depth, September 17, 2001, collected by Yasuhiro Kuwahara.

Diagnosis. Trunk up to 80 mm long in preserved specimens. Leaf-like gonostomal lips with smooth margins. Neurointestinal vessel unbifurcated. Ring vessel absent. Rectal caecum absent. Anal vesicles fastened basally to the trunk wall by mesenteries.

Description. In life, trunk colored pinkish yellow and proboscis pale yellow (Fig. 1). Coloration fading to pale white or beige after fixation with formalin.

In preserved specimens, TL ranging from 25 to 73 mm (n = 28) and PL ranging from 6 to 33 mm (n = 8). Proboscis, often detached from trunk, elongated and slight-

Figure 1. *Arhynchite hayaoi* sp. n., found at the type locality, with the proboscis extending toward the right.

ly expanded at its extremity, with its proximal end forming small lower cup around mouth. Trunk wall thickened and covered with numerous distinct papillae, especially prominent (up to 1 mm) at both extremities. Trunk musculature consisting of outermost circular, middle longitudinal, and innermost oblique layers, all of which continuous throughout.

Paired ventral setae of usual form, with strong interbasal muscle (Fig. 2A), but only very rarely single seta without interbasal muscle in 2 of 6 non-type specimens in TUM Echiurida 1-5.

Paired gonoducts situated slightly behind ventral setae (Fig. 2A). Gonostomes situated proximally, each with leaf-like gonostomal lip with smooth margin (Fig. 2B); lip plicated marginally, probably due to fixation in many non-type specimens (TUM Echiurida 1-5, 2-11).

Long and convoluted alimentary canal, filled with sand grains and elliptical fecal pellets, ca 2 mm in long axis (Fig. 2A, C). Anterior part of alimentary canal, so-called foregut, divided into pharynx, esophagus, gizzard, and crop (Fig. 2A). Intestine following foregut fastened to trunk wall with numerous thread-like mesenteries and divided into pre-siphonal, siphonal, and post-siphonal parts (Fig. 2A, C). Pre- and post-siphonal parts having a ciliated groove; elongated pre-siphonal part about twice as long as TL (Fig. 2A). Rectal caecum absent (Fig. 2C).

Vascular system composed of dorsal, neurointestinal, and ventral vessels, without ring vessel (Fig. 2A). Dorsal vessel attached to entire length of crop (Fig. 2A). Ventral vessel running along almost entire length of ventral nerve cord and terminating at posterior end of post-siphonal intestine near anus (Fig. 2A, C). Neurointestinal vessel, although injured in holotype, issuing from ventral vessel slightly behind gonostomal level and terminating at anterior end of intestine without bifurcation (Fig. 2A). In 6 non-type specimens (5 in TUM Echiurida 2-11 and 1 in TUM Echiurida 1-5), ventral vessel issuing additional branch forward at ventral origin of neurointestinal vessel,

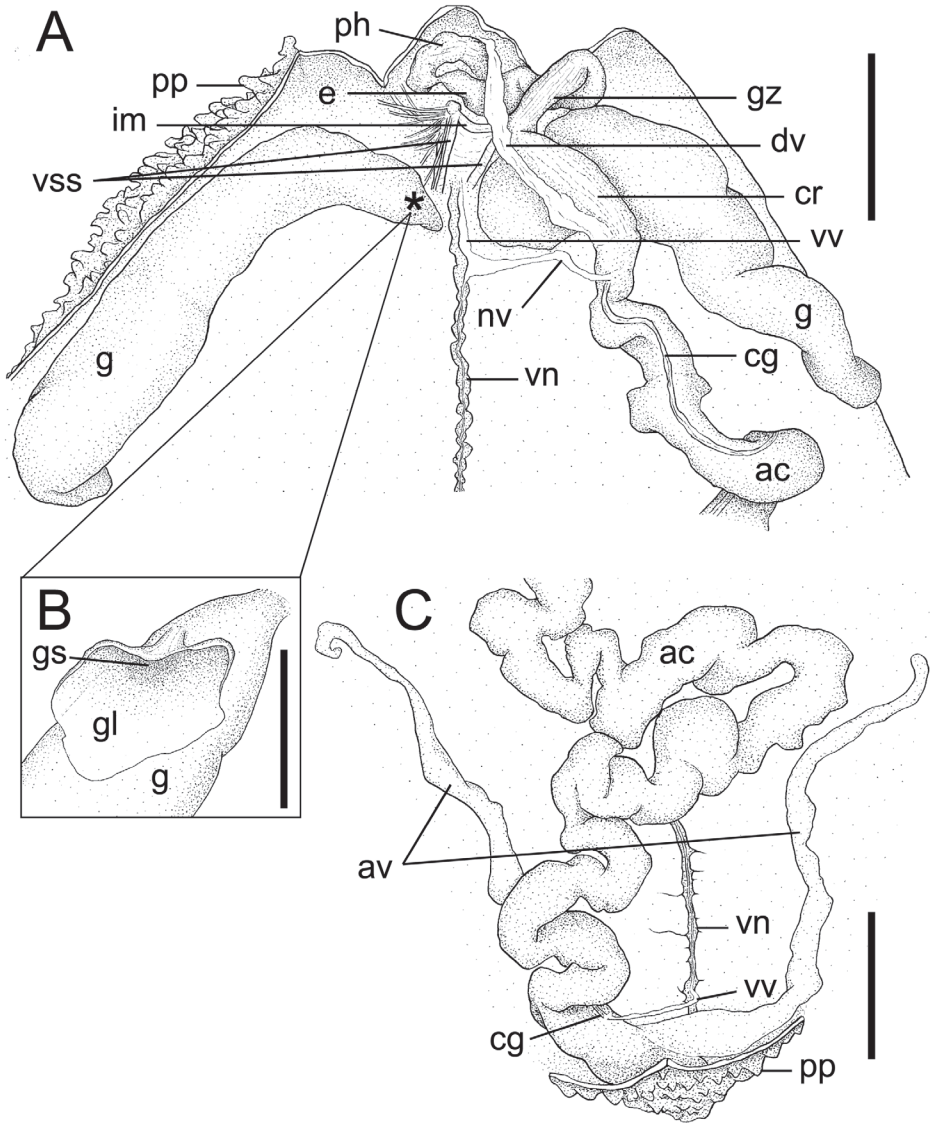

Figure 2. *Arhynchite hayaoi* sp. n., paratype (NSMT-Ec 104). **A** internal morphology of the anterior end of the trunk, dorsal view; an asterisk indicates the position of the gonostome **B** gonostome and gonostomal lip, magnified **C** internal morphology of the posterior end of the trunk, dorsal view. Abbreviations: **ac** alimentary canal; **av** anal vesicle; **cg** ciliated groove; **cr** crop; **dv** dorsal vessel; **e** esophagus; **g** gonoduct; **gl** gonostomal lip; **gs** gonostome; **gz** gizzard; **im** interbasal muscle; **nv** neurointestinal vessel; **ph** pharynx; **pp** papillae; **vn** ventral nerve cord; **vss** ventral setal sac; **vv** ventral vessel. Scales: **A** and **C** 5 mm; **B** 1 mm.

with the branch terminally forming small loop around interbasal muscle. Further, in another non-type specimen of TUM Echiurida 1-5, origin of neurointestinal vessel shifted far forward, crossing interbasal muscle but without additional branches.

Table 1. A comparison of all known species referred to the genus *Arhynchite.*

Species	Rectal caecum	Ring vessel	Bifurcation of neurointestinal vessel	Margin of gonostomal lip	Mesenteries mainly fastened to	Type locality	Sources
Arhynchite hayaoi sp. n.	absent	absent	absent	smooth	body wall	Seto Inland Sea, Japan	This study
Arhynchite arhynchite	absent	absent	barely detectable	with digitiform projections	body wall	Probably around Hokkaido, Japan	Ikeda (1924), Satô (1937), This study
Arhynchite californicus	absent	absent	absent	with digitiform projections	body wall	Monterey Bay, California, USA	Fisher (1949)
Arhynchite hiscocki	absent	absent	absent	with digitiform projections	intestine	Dunwich, Queensland, Australia	Edmonds (1960, 1987)
Arhynchite inamoenus	absent	absent	absent	with irregular serrations	unknown	Monterey Bay, California, USA	Fisher (1946)
Arhynchite pugettensis	absent	present	absent	with irregular serrations	body wall	Puget Sound, Washington, USA	Fisher (1949)
Arhynchite paulensis	present	absent	unknown	with irregular serrations	intestine	Araça Beach, São Paulo, Brazil	Amor (1971)
Arhynchite rugosus	present	unknown	unknown	smooth	unknown	Jiaozhou Bay, Shandong, China	Chen and Yeh (1958)

Paired simple anal vesicles, ca one-third of TL in holotype, while rarely attaining TL in other specimens, covered wholly with numerous microscopic ciliated funnels and fastened basally to trunk wall by some mesenteries (Fig. 2C).

Etymology. The specific name is dedicated to the late Dr Hayao Sato who made a significant contribution to the taxonomy of echiurans, sipunculans, and priapulids in Japan and adjacent waters.

Distribution. Hiroshima Pref. (Seto Inland Sea), Ikarise Islet at the entrance of Lake Hamana, and Misaki (Sagami Bay), Japan, intertidal to subtidal, sandy to muddy bottoms.

Remarks. Table 1 gives a comparison of all known species and the newly described species assigned to the genus *Arhynchite*. *A. hayaoi* sp. n. is distinguishable from *A. arhynchite*, the only congener recorded to date from Japanese coasts, by the absence of such digitiform projections or irregular serrations along the margin of the gonostomal lips as are present in *A. californicus* and *A. pugettensis*, respectively (Fisher 1949, pls. 30, 32), and by the complete lack of bifurcation in the neurointestinal vessel.

Nishikawa (2001) recorded *A. arhynchite* from Sagami Bay and the Seto Inland Sea. Our detailed re-examination of these specimens revealed that they are assignable to *A. hayaoi*, instead of *A. arhynchite*. Thus, it is possible that *A. hayaoi* is widely distributed in the Seto Inland Sea and the Pacific coasts of Middle Japan, whereas *A. arhynchite*, with its type locality probably originating near Hokkaido (Ikeda 1924, Satô 1937), is restricted to cold northern waters.

Discussion

T. owstoni was established by Ikeda (1904, pp. 62–63, figs 18, 96–97) based solely on the holotype, dredged from 180 fathoms (ca 330 m) deep in the Uraga Channel at the entrance of Tokyo Bay. Since then, no further specimens have been collected. According to the original description, "The specimen [= the holotype] is torn near the posterior end of the body" (p. 62), probably lacking the greater part of the alimentary canal, the anal vesicles, and the vascular system. Our efforts to locate the holotype of *T. owstoni* in order to gain more information have so far been unsuccessful. On the basis of the original description, however, this species is clearly distinguishable from *A. hayaoi* by the shape of the gonostomal lips (funnel-shaped in *T. owstoni* vs. leaf-like in *A. hayaoi*).

Thus, the taxonomic identity of *T. owstoni* remains unknown. Bock (1942) provisionally regarded this species as belonging to *Maxmuelleria* based on Ikeda's original description, following Wharton's key (1913, p. 261) that "Anal trees bear large funnels situated close together on long stalks." This taxonomic treatment, however, is not followed by subsequent authors (Stephen and Edmonds 1972, Saxena 1984, Biseswar 1988, Nishikawa 1992, 2012). Without new material or the rediscovery of the holotype, the identity of *T. owstoni* remains unresolved.

Thalassema fuscum Ikeda, 1904 is also similar to *A. hayaoi* in terms of living coloration (Ikeda 1904, p. 70 and fig. 21), the trunk surface densely covered with prominent papillae, and the occurrence of a single pair of gonoducts with the gonostomal lip expanded as a leaf. However, *T. fuscum* is distinguished from *A. hayaoi* by the existence of a conspicuous ring vessel and a bifurcated neurointestinal vessel, as well as by the absence of interbasal muscle. Our present understanding of the last feature comes from the fact that *T. fuscum*'s original description (Ikeda 1904, pp. 69–70) lacks any information on the muscle, but the taxonomic key of all species mentioned in Ikeda's monograph (1904, p. 82) clearly shows "No interbasal muscle" for *T. fuscum*.

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New records for the shallow-water chiton fauna (Mollusca, Polyplacophora) of the Azores (NE Atlantic)

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Abstract

Published records, original data from recent field work on all of the islands of the Azores (NE Atlantic), and a revision of the entire mollusc collection deposited in the Department of Biology of the University of the Azores (DBUA) were used to compile a checklist of the shallow-water Polyplacophora of the Azores. *Lepidochitona* cf. *canariensis* and *Tonicella rubra* are reported for the first time for this archipelago, increasing the recorded Azorean fauna to seven species.

Keywords

Azores, Mollusca, Polyplacophora, biodiversity, checklist

Introduction

The marine molluscs of the Archipelago of the Azores are probably the best studied marine invertebrate group from these Atlantic Islands. Several taxonomic, ecological, genetic, biogeographic and recent palaeontological studies have greatly improved our knowledge of this phylum (see Ávila 2005 and Ávila et al. 2000a, 2000b, 2011, 2012 and references therein), with more than 11% endemic species (Ávila et al. 2009). Amongst marine molluscs, trochid and rissoid gastropods (Ávila et al. 2011, 2012) and opisthobranchs (Pedro et al. 2011, Cordeiro et al. 2013) were recently given attention; in contrast, few studies deal specifically with chitons: Kaas and Van Belle (1981, 1985a, 1985b), Kaas (1985, 1991), and the more recent paper by Ávila and Albergaria (2002).

Polyplacophorans (or "chitons") include over 900 extant species worldwide that mostly live in shallow waters, usually on rocky substrates. They are oval in shape and dorso-ventrally flattened, neither tentacles nor eyes are present in the head region, and they possess eight distinctive overlapping shell plates or valves located on the dorsal side. These longitudinally arranged valves are surrounded by a muscular girdle, and the girdle covering or perinotum is ornamented with scales, spicules, bristles or other protuberances (Kaas and Van Belle 1985a; Schwabe 2010). Identification of chitons mainly depends on microscopic feature of the girdle and valves; species are differentiated by patterns in the raised sculpture of the dorsal surface of the valves (tegmentum), and the shape, size, and density of spicular processes of the perinotum. Additional important features are the radula (only visible via dissection) and gills (visible under magnification, externally on the ventral surface between the foot and the girdle).

The present work is based on a review of new material collected from all the islands of the Azores, and updates the published information, documenting for the first time the occurrence of the polyplacophoran molluscs *Lepidochitona* cf. *canariensis* (Thiele, 1909) and *Tonicella rubra* (Linnaeus, 1767) in these oceanic islands.

Materials and methods

A bibliographic review of the polyplacophoran species reported from the Atlantic Ocean was assembled. More than 1,060 lots from the marine mollusc reference collection of the Department of Biology of the University of the Azores (DBUA – São Miguel Island), corresponding to approx. 850 dives in all islands, were examined and the polyplacophorans sorted and identified from 63 lots (303 specimens and 5 valves; see Table 1). The mollusc collection of the Department of Oceanography and Fisheries of the University of the Azores (DOP/ML – Faial Island) was also surveyed for chitons. Specimens were studied using either a Nikon SMZ 1000 or a Leica M125 stereomicroscope with incandescent light sources (Volpi Intralux 4100) and digital camera attached, which fed images to a desktop computer. The taxonomic organization of species in this list follows the morphological systematics of Sirenko (2006), which is largely in agreement with molecular evidence (Okusu et al. 2003).

Table 1. Number of the sampling sites in the Reference Collection of the Department of Biology of the University of the Azores (DBUA) that yielded polyplacophorans, island and location of the sampling sites, depth range (m), number of Specimens (N. spc.), number of valves (N. valv.) and date.

DBUA	Island / seamount	Location	Depth range	N. spc.	N. valv.	Date
176	São Miguel	Ponta da Pirâmide	13 m	1	-	July-1988
190	Flores	Fajã Grande	intertidal zone	3	-	10-July-1989
191	Flores	Ponta Delgada	intertidal zone	1	-	July-1989
193	Flores	Santa Cruz (pool)	intertidal zone	1	-	09-July-1989
240	Flores	Santa Cruz	20 m	2	-	July-1989
332	Formigas Islets	West Bay	6–8 m	1	-	08-June-1990
337	Formigas Islets	Formigas	intertidal zone	7	-	06-June-1990
355	Formigas Islets	Formigas	15 m	-	1	03-July-1991
356	Formigas Islets	Formigas	intertidal zone	1	-	01-July-1991
410	Faial	Ilhéu Negro	10 m	1	-	24-July-1989
433	Faial	Baía de entre-os-montes	?	1	-	26-July-1989
457	Pico	Lajes do Pico	intertidal zone	1	-	July-1989
458	Pico	Lajes do Pico	intertidal zone	2	-	July-1989
459	Pico	Lajes do Pico	intertidal zone	1	-	July-1989
461	Pico	Lajes do Pico	intertidal zone	1	-	July-1989
465	Pico	Lajes do Pico	intertidal zone	-	2	July-1989
475	Pico	Lajes do Pico	intertidal zone	-	1	July-1989
486	Pico	Lajes do Pico	2–4 m	1	-	July-1989
524	Flores	Baixa da Calheta	intertidal zone	1	-	28-Oct-1990
551	Flores	Porto da Baleia	?	1	-	29-Oct-1990
554	Flores	Pontinhas	intertidal zone	6	-	28-Oct-1990
562	Flores	Pontinhas	intertidal zone	17	-	28-Oct-1990
569	Flores	Baixa do Porto	?	1	-	28-Oct-1990
574	Flores	Baixa do Porto	6–12 m	1	-	27-Oct-1990
577	Flores	Lajes das Flores	0–10 m	2	-	27-Oct-1990
625	São Miguel	São Roque	?	2	-	31-May-1991
637	São Miguel	Ponta da Galera	12 m	1	-	July-1989
662	Pico	Lajes do Pico	0–3 m	3	-	19-Aug-1995
667	Pico	Lajes do Pico	0–6 m	5	-	05-Aug-1996
671	Pico	Lajes do Pico	intertidal zone	1	-	18-Aug-1997
683	São Miguel	São Vicente, Capelas	10 m	1	-	02-July-1996
700	São Miguel	São Vicente, Capelas	0–10.4 m	2	-	17-July-1996
708/F	São Miguel	São Vicente, Capelas	8 m	1	-	19-July-1996
715	São Miguel	Cerco, Caloura	intertidal zone	3	-	26-Jan-1996
719	São Miguel	Vila Franca Islet	18 m	-	1	03-Mar-1997
721	São Miguel	Rosto do Cão Islet	15 m	1	-	15-May-1998
725	Flores	Angra do Heroísmo bay	intertidal zone	1	-	15-June-1998
730	São Miguel	Baía da Pranchinha	8.6 m	3	-	04-July-1990

DBUA	Island / seamount	Location	Depth range	N. spc.	N. valv.	Date
731	São Miguel	Baía da Pranchinha	13.8 m	1	-	04-July-1990
732	São Miguel	Baía da Pranchinha	13.8 m	5	-	04-July-1990
733	São Miguel	Baía do Rosto do Cão	9.5 m	1	-	04-July-1990
740	São Miguel	Baía do Rosto do Cão	intertidal zone	28	-	26-June-1990
741	São Miguel	Baía do Rosto do Cão	intertidal zone	8	-	06-July-1990
743	São Miguel	Baía do Rosto do Cão	intertidal zone	1	-	06-July-1990
744	São Miguel	Baía do Rosto do Cão	intertidal zone	87	-	06-July-1990
745	São Miguel	Baía do Rosto do Cão	intertidal zone	53	-	06-July-1990
746	São Miguel	Baía do Rosto do Cão	intertidal zone	16	-	06-July-1990
747	São Miguel	Baía do Rosto do Cão	intertidal zone	2	-	06-July-1990
748	São Miguel	Capelas	14 m	2	-	07-Oct-1996
751	São Miguel	Baía do Rosto do Cão	subtidal	1	-	05-May-1994
752	São Miguel	Fenais da Luz	intertidal zone	2	-	15-Apr-1992
767	São Miguel	São Vicente, Capelas	20.3 m	1	-	11-July-1997
793	São Miguel	São Vicente, Capelas	intertidal zone	1	-	19-July-1997
794	São Miguel	Ponta Delgada	?	2	-	20-Nov-1996
799	Flores	Santa Cruz	tide pool	1	-	July-1999
800	Pico	São João	15 m	1	-	July-1999
801	Faial	Monte da Guia	23 m	1	-	23-Aug-1999
803	Faial	?	3–6 m	3	-	Sep-1998
857	Pico	Monte	8–10 m	1	-	05-Aug-2005
858	Pico	Barca, Madalena	10 m	1	-	09-Aug-2005
891	D. João de Castro	seamount	20 m	1	-	31-Aug-2004
1047	Pico	Ribeiras harbour	4 m	1	-	07-Aug-2000
1056	São Miguel	Rosto do Cão Islet	intertidal zone	4	-	26-Mar-2012

Results

Systematic Part

Order LEPIDOPLEURIDA Thiele, 1909
Family HANLEYIDAE Bergenhayn, 1955

Animals ovate to elongate. Sculpture of the tegmentum varying from almost smooth to granular. Spicules and longer spines are present in the perinotum (Kaas and Van Belle 1985a). Unslit insertion plates on head valves, in some species also unslit insertion plates on tail valve and intermediate valves.

Genus *Hanleya* Gray, 1857

Tegmentum granulated. Overall, with the characteristics of the family.

***Hanleya hanleyi* (Bean in Thorpe, 1844)**
http://species-id.net/wiki/Hanleya_hanleyi
Figs 1–2

= *Hanleya debilis* Gray, 1857
= *Lepidopleurus carinatus* Dall, 1927
= *Hanleya dalli* Kaas, 1957

Records for the area. Van Belle (1984), Kaas and Van Belle (1985a), Ávila and Albergaria (2002).

Distribution and biotope. From the Barents Sea south to Algarve (Portugal), the Mediterranean Sea, Azores, Madeira, Canary Islands (Kaas 1991), near Iceland, Faroes Islands (Sneli et al. 2005), Greenland and the east coast of North America (Kaas and Van Belle 1985a). It lives from 15 to 555 meters depth (Kaas and Van Belle 1985a). Usually found feeding on coralline algae.

Material examined. Flores (Porto da Baleia: DBUA 551, 1 spm), Pico (Lajes do Pico, 0–3m: DBUA 662, 1 spm).

Fossil record. No fossil representatives are known from the Azores.

Description (abridged). Small (up to 22 × 13 mm), elongate oval, dorsal elevation ratio (intermediate valve height / valve width) up to ~0.3. Valves thick, not beaked and girdle narrow, with spicules. Intermediate valves rectangular. Tegmentum uniformly creamy white to light tan, occasionally with brown mineral deposits; uniformly sculpted with numerous large granules, arranged randomly on the lateral areas of the intermediate valves. Jugal (central) area distinct, with fine longitudinal riblets larger and more widely spaced than those in the pleural (outer) areas. Girdle perinotum covered in randomly distributed projecting spicules.

Remarks. This species is very rare in the Azores.

Order CHITONIDA Thiele, 1909
Family CALLOCHITONIDAE Plate, 1901

Small to large in size [up to 110 × 80 mm – *Eudoxochiton nobilis* (Gray, 1843)], oval, tegmentum with fine or no apparent granular sculpture, valves appear smooth but with neat rows of black, pigmented shell eyes. Terminal valves multi-slitted (large numbers of insertion teeth), intermediate valves with 1–4 slits on insertion plates. Perinotum with small spicules.

Genus *Callochiton* Gray, 1847

Small to medium size [up to 55 × 36 mm – *Callochiton dentatus* (Spengler, 1797)]; extra-pigmentary eyes present. Overall, with the characteristics of the family.

***Callochiton septemvalvis* (Montagu, 1803)**
http://species-id.net/wiki/Callochiton_septemvalvis

= *Chiton achatinus* Brown ,1827
= *Chiton doriae* Capellini, 1859
= *Chiton laevis* var. *navicula* Jeffreys, 1865
= *Callochiton achatinus euboecus* Kattoulas, Koukouras and Economidis, 1973
? *Chiton scytodesma* Scacchi, 1836
! *Chiton laevis* Pennant, 1777 *sensu* Montagu, 1803

Records for the area. Morton (1967), Kaas and Van Belle (1985a).

Distribution and biotope. All Atlantic coasts of Europe, from Scandinavia, Britain and Ireland, south to the Mediterranean Sea, Morocco (Kaas 1991), Azores and Canary Islands (Kaas and Van Belle 1985b). From shallow subtidal to 500 m depth, usually on red algae and other hard substrates (Poppe and Goto 1991). The animals can be extremely cryptic, grazing on the underside of stones and small boulders where their colours proved good camouflage.

Material examined. No material seen.

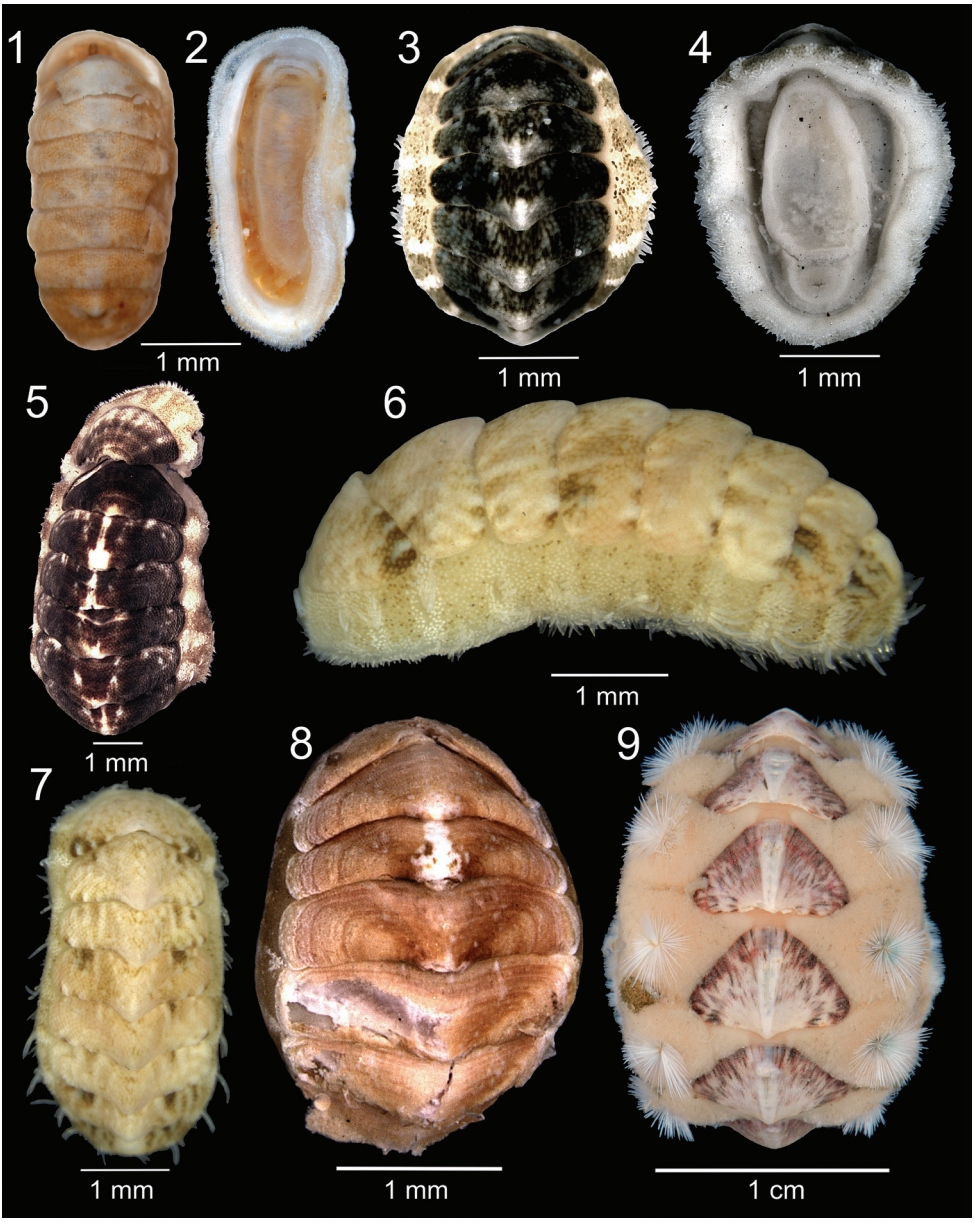
Fossil record. No fossil representatives are known from the Azores.

Description (abridged). Moderate size (up to 22 × 14 mm), dorsal elevation ratio = 0.35 to 0.46, oval, valves beaked. Tegmentum very finely granulose, orange to brick red, often with white markings, or with shades of green, bright yellow, or bright orange. Intermediate valves rectangular. Sculpture smooth and glossy to the naked eye, diagonally set with black dots (the pigment cups of the 'shell-eyes'); under magnification the valves are sculptured with small granules arranged in quincunx. Wide girdle, usually about 1/3 of the animal's total width and covered in spicules, with a short marginal fringe of spicules. The girdle is coloured yellow or orange with red markings.

Remarks. If this species does occur in the Azores, it must be very rare, as not a single specimen was found in the DBUA or DOP/ML collections. The species *C. septemvalvis* was originally described from an abnormal specimen with seven valves. Montagu (1803) believed its missing valve to be a characteristic of an undescribed species of chiton. Although that specimen did represent an undescribed species, normal individuals of *C. septemvalvis* have eight valves. Some authorities have criticised the name '*septemvalvis*' as being misleading, but as it was the first epithet used to describe a valid species, the name remains valid.

Family TONICELLIDAE Simroth, 1894

Small to medium in size [up to 55 × 36 mm – *Tonicella insignis* (Reeve, 1847)], oval to elongate oval. Valve tegmentum appears smooth or granulose but without separated sculpture elements, terminal valves with multi-slitted insertion plates, intermediate valves with usually one insertion slit on each side. Girdle perinotum covered in small spicules.



Figures 1–9. Shallow polyplacophorans from the Azores. **1–2** *Hanleya hanleyi* (Bean in Thorpe, 1844), DBUA 551 (Flores, Porto da Baleia) **3–4** *Lepidochitona* cf. *canariensis* (Thiele, 1909), DBUA 356 (Formigas Islets, intertidal) **5** *Lepidochitona piceola* (Shuttleworth, 1853), DBUA 743 (São Miguel Island, Baía do Rosto do Cão, intertidal) **6–7** *Lepidochitona simrothi* (Thiele, 1902), DBUA 459 (Pico, Lajes do Pico, intertidal) **8** *Tonicella rubra* (Linnaeus, 1767), DBUA 891 (D. João de Castro seamount, 20 m depth) **9** *Acanthochitona fascicularis* (Linnaeus, 1767), DBUA 667 (Pico, Lajes do Pico, 0–6 m depth).

Genus *Lepidochitona* Gray, 1821

Oval to elongate-oval, valve sculpture smooth to uniformly granular, girdle perinotum with irregular granules, most species with a short marginal fringe of blunt spicules.

Lepidochitona cf. *canariensis* (Thiele, 1909)

Figs 3–4

Trachydermon canariensis Thiele, 1909

Records for the area. This is the first record for the Azores.

Distribution and biotope. The Mediterranean Sea (Dell'Angelo and Tringali 2000), Morocco (Dell'Angelo and Smriglio 1999), Madeira, Canary Islands and Cape Verde (Kaas and Van Belle 1985b), Savage Islands (Ilhas Selvagens) (Albuquerque et al. 2009) to Mauritania (Anseeuw and Verstraeten 2009), and now the Azores (this work). Intertidal down to 20 m depth.

Material examined. Formigas Islets (intertidal zone: DBUA 337, 2 spm; DBUA 356, 1 spm), São Miguel (intertidal: DBUA 747, 1 spm).

Fossil record. No fossil representatives are known from the Azores.

Description (abridged). Small size (up to 8.5 × 5 mm), dorsal elevation ratio = 0.39 (Kaas and Van Belle 1985b). Tegmentum sculptured with diamond-shaped granules. Girdle narrow, densely covered in small calcareous pustules and scattered spines.

Remarks. This is a rare species, known only from a small number of specimens in the Azores.

Lepidochitona piceola (Shuttleworth, 1853)

http://species-id.net/wiki/Lepidochitona_piceola

Fig. 5

Chiton (Acanthopleura) piceolus Shuttleworth, 1853
Nuttalina piceolus Pilsbry, 1894
Nuttalina piceola Nierstrasz, 1906
Middendorfia piceola Bergenhayn, 1931

Records for the area. Kaas and Van Belle (1981, 1985b), Van Belle (1984), Kaas (1991).

Distribution and biotope. Azores and Canary Islands (Kaas and Van Belle 1985b). Intertidal.

Material examined. São Miguel (intertidal zone down to 14 m depth: DBUA 625, 1 spm; DBUA 743, 1 spm; DBUA 744, 23 spm; DBUA 745, 14 spm; DBUA 1056, 1 spm).

Fossil record. No fossil representatives are known from the Azores.

Description (abridged). Small size (up to 10 × 6 mm), dorsal elevation ratio = 0.31 (Kaas and Van Belle 1985b). Tegmentum with round quincuncially arranged granules, but valves generally strongly eroded, and sculpture usually preserved only along the anterior margins of the valves. Valves rather thick, with a strong apical callus. Girdle wide, approx. 40% of the total width.

Remarks. This species has been overlooked and confused with *Lepidochitona simrothi*. However, it is easy to separate these two species, as *L. piceola* does not have the long, smooth, curved needles characteristic of the girdle of *L. simrothi*. The only records before this work were those of Kaas and Van Belle (1985b) who reported the species from the intertidal of São Miguel Island, and Kaas (1991) who reported the species from the Formigas Islets (0-15 m depth).

***Lepidochitona simrothi* (Thiele, 1902)**

http://species-id.net/wiki/Lepidochitona_simrothi

Figs 6–7

Records for the area. Kaas and Van Belle (1981, 1985b), Van Belle (1984), Kaas (1991), Bullock (1995), Morton et al. (1998), Macedo et al. (1999), Ávila et al. (2000a,b), Ávila and Albergaria (2002).

Distribution and biotope. Azores (Kaas and Van Belle 1981; Ávila and Albergaria 2002) and Portugal (Zalvide et al. 2000). Littoral and sublittoral to 14 m depth.

Material examined. Faial (3–6 m depth: DBUA 803, 3 spm), Flores (all samples collected in the intertidal zone: DBUA 190, 3 spm; DBUA 191, 1 spm; DBUA 193, 1 spm; DBUA 524, 1 spm; DBUA 554, 6 spm; DBUA 562, 17 spm), Formigas Islets (intertidal zone: DBUA 337, 5 spm; DOP/ML 0032, 1 spm), Pico (0–3 m depth: DBUA 457, 1 spm; DBUA 458, 2 spm; DBUA 459, 1 spm; DBUA 461, 1 spm; DBUA 465, 2 valves; DBUA 475, 1 valve; DBUA 662, 2 spm); São Miguel (intertidal zone down to 14 m depth: DBUA 625, 1 spm; DBUA 715, 3 spm; DBUA 732, 3 spm; DBUA 740, 28 spm; DBUA 741, 8 spm; DBUA 744, 64 spm; DBUA 745, 39 spm; DBUA 746, 16 spm; DBUA 747, 1 spm; DBUA 793, 1 spm).

Fossil record. No fossil representatives are known from the Azores.

Description (abridged). Animal rather small (up to 8 × 4 mm), dorsal elevation ratio = 0.37 (Kaas and Van Belle 1985b), elongate oval in outline. Tegmentum with round granules. Tail valve very small. Girdle densely covered with small calcareous pustules and distinctive curved spines randomly scattered throughout perinotum armature.

Remarks. Specimens recorded by Hawkins et al. (1990: 27–28) and Azevedo (1991: 29) probably belong to this species but were not identified at species level. These specimens were not present in the DBUA collection and could not be examined by the authors. The image of *Lepidochitona* sp. (Macedo et al. 1999: 75) represents a specimen of *Lepidochitona simrothi*. This is the most common chiton in the Azores.

Genus *Tonicella* Carpenter, 1873

With the characteristics of the family. Valves with 'spongy' eaves (i.e. porous, penetrated laterally by large aesthete canals).

Tonicella rubra (Linnaeus, 1767)

http://species-id.net/wiki/Tonicella_rubra
Fig. 8

= *Chiton laevis* Pennant, 1777
= *Chiton minimus* Spengler, 1797
= *Chiton incarnatus* Reeve, 1848
= *Chiton latus* Leach, 1852
= *Chiton ruber* var. *oblonga* Jeffreys, 1865
= *Tonicella rubra* var. *index* Balch, 1906
= *Tonicella beringensis* Jakovleva, 1951
= *Tonicella granulata* Jakovleva, 1952
= *Tonicella zotini* Jakovleva, 1952
= *Tonicella beringensislucida* Sirenko, 1974
! *Chiton cinereus* Linnaeus, 1767 *sensu* Fabricius, 1780

Records for the area. This is the first record for the Azores.

Distribution and biotope. This species has an Arctic-circumboreal distribution, including the Arctic Ocean (Barents Sea, White Sea, Spitzbergen), the North Pacific (northern Japan), the western North Atlantic as far south as New London (Connecticut) (Kaas & van Belle 1985b) and the eastern Atlantic from Greenland and Scandinavia to Britain and Ireland (Kaas and van Belle 1985b), and now the Azores.

Material examined. Dom João de Castro seamount (20 m depth: DBUA 891, 1 spm).

Fossil record. No fossil representatives are known from the Azores.

Description (abridged). Up to 15 × 9 mm in the North Atlantic; dorsal elevation ratio = 0.29. Valves beaked, girdle narrow. Tegmentum appears smooth, with growth lines clearly visible under magnification. Colour orange to pinkish, generally with small reddish-brown blotches. Girdle relatively narrow and covered by small scales, appearing sandy to the naked eye, coloured like the tegmentum, but sometimes with white or cream markings particularly at the junctures between valves.

Remarks. The Dom João de Castro Bank (Lat 38º13.3'N, Long 26º36.2'W) is a shallow seamount (minimum depth = 13 m) located between the islands of São Miguel and Terceira. The last eruption was in December 1720 when a small island (~1 km long and 150 m high) was formed (Agostinho 1934). This island disappeared within a year and nowadays the seamount is capped by a submarine caldera (300 × 600 m) approx. 40 m deep, with strong hydrothermal activity in vents located at approx.20 m depth (Ávila et al. 2004; Cardigos et al. 2005).

Family ACANTHOCHITONIDAE Pilsbry, 1893

The broad girdle is covered by coarse spines and partially covers the valves. The valve tegmentum (dorsal aspect) is reduced relative to the articulamentum (ventral part covered by the girdle). Head valve usually with five slits in margin.

Genus *Acanthochitona* Gray, 1821

Girdle with large distinct bristles, clumps of long straight spicules, emerging from the girdle at the junctures between the valves on both sides.

***Acanthochitona fascicularis* (Linnaeus, 1767)**
http://species-id.net/wiki/Acanthochitona_fascicularis
Fig. 9

= *Acanthochites communis* Risso, 1826
= *Chiton fascicularis* var. *major* Philippi, 1836
= *Chiton fascicularis* var. *rubra* Issel, 1870
= *Acanthochites discrepans* var. *minorflava* Monterosato, 1878 *nomen nudum*
= *Acanthochites hamatus* Rochebrune, 1882
= *Anisochiton discrepans* var. *elongata* Dautzenberg, 1893
= *Anisochiton discrepans* var. *marmorata* Dautzenberg, 1893
= *Anisochiton discrepans* var. *nigrolineata* Dautzenberg, 1893
= *Acanthochites discrepans* var. *albina* Dautzenberg and Durouchoux, 1900
= *Anisochiton discrepans* var. *viridis* Pallary, 1902
= *Acanthochites discrepans* var. *violaceolimbata* Dautzenberg and Durouchoux, 1906
= *Acanthochiton discrepans* var. *angustivalva* Bergenhayn, 1931
= *Acanthochiton heterochaetus* Bergenhayn, 1931
= *Acanthochiton communis* var. *barashi* Leloup, 1969
= *Acanthochitona bonairensis* Kaas, 1972
? *Chiton echinotus* de Blainville, 1825
? *Acanthochites carinatus* Risso, 1826
! *Chiton crinitus* Pennant, 1777 *sensu* Sowerby, G.B. II, 1840
! *Chiton discrepans* Brown, 1827 *sensu* Sowerby, G.B. II, 1840

Records for the area. MacAndrew (1856), Dautzenberg (1927), Morton (1967), Van Belle (1984), Kaas (1985, 1991), Ávila and Albergaria (2002).

Distribution and biotope. Found in the North Atlantic from Ireland and Britain, south to Portuguese shores (Nobre 1931), Azores, Madeira, Selvagens (Albuquerque et al. 2009), Canary Islands and throughout the Mediterranean Sea (Kaas 1985, 1991). From the intertidal zone down to 50 m depth (Van Belle 1984).

Material examined. Faial (10–23 m depth: DBUA 410, 1 spm; DBUA 433, 1 spm; DBUA 801, 1 spm), Flores (intertidal zone down to 20 m depth: DBUA 240, 2 spm; DBUA 569, 1 spm; DBUA 574, 1 spm; DBUA 577, 2 spm; DBUA 725, 1 spm; DBUA 799, 1 spm), Formigas (6–15 m depth: DBUA 332, 1 spm; DBUA 355, 1 valve), Pico (intertidal zone down to 15 m depth: DBUA 486, 1 spm; DBUA 667, 5 spm; DBUA 671, 1 spm; DBUA 800, 1 spm; DBUA 857/DOP/ML 0050, 1 spm; DBUA 858/DOP/ML0051, 1 spm; DBUA 1047, 1 spm), São Miguel (intertidal zone down to 20 m depth: DBUA 176, 1 spm; DBUA 637, 1 spm; DBUA 683, 1 spm; DBUA 700, 2 spm; DBUA 708/F, 1 spm; DBUA 719, 1 valve; DBUA 721, 1 spm; DBUA 730, 3 spm; DBUA 731, 1 spm; DBUA 732, 2 spm; DBUA 733, 1 spm; DBUA 748, 2 spm; DBUA 751, 1 spm; DBUA 752, 2 spm; DBUA 767, 1 spm; DBUA 794, 2 spm; DBUA 1056, 3 spm).

Fossil record. No fossil representatives are known from the Azores.

Description (abridged). Rather large, up to 24 × 15 mm (DBUA 667). Overall colour is variable (black, blue, olive, orange, cream). Valves typically olive-green with reddish blotches; the wide jugal area is usually lighter (cream or beige) with dark longitudinal streaks. Visible portion of the valves is trapezoidal, little or no beak. The central area with faint longitudinal grooves; lateral areas covered with closely-spaced, small round granules in quincunx and forming radiating rows. Girdle broad and densely covered with short spicules, with 18 large tufts of spines arranged around the head and at the sutures. One specimen from the Azores had a girdle that appeared cyan blue in life. There is a distinct marginal fringe of small tapered spicules.

Remarks. This is the largest chiton in the Azores, commonly found under stones buried in pebbles or in sand, in shallow water, sometimes in groups of two or three specimens. *Acanthochitona fascicularis* is particularly variable in colour.

Discussion

Van Belle (1984) enumerated eight species of chitons from the Azores: *Hanleya hanleyi*, *Lepidochitona piceola*, *L. simrothi*, *Ischnochiton albus* [=*Stenosemus albus* (Linnaeus, 1767)], *Ischnochiton exaratus* [=*Stenosemus exaratus* (Sars, 1878)], *Placophoropsis atlantica* [=*Placiphorella atlantica* (Verrill & Smith in Verrill, 1882], *Acanthochitona fascicularis* and *Acanthochitona communis* (Risso, 1826) [=*Acanthochitona fascicularis* (Linnaeus, 1767)]. Of these, one was a synonym of *A. fascicularis*, and three were deep-water species (*Stenosemus exaratus*, *Stenosemus albus* and *Placiphorella atlantica*); therefore only four shallow-water species of chitons were reported from the Azores by this author. Ávila and Albergaria (2002) reported five species of Polyplacophora from the Azores and considered *Acanthochitona discrepans* (Brown, 1827), reported by MacAndrew (1856: 145), Dautzenberg (1889: 127) and Nobre (1924: 84; 1930: 61) but not cited by Van Belle (1984) as "highly questionable". No specimens of this species were found in this survey, so its status remains as a doubtful record. The presence of

Callochiton septemvalvis is based on a single historical observational record by Morton (1967) and no preserved specimens are known from the Azores. Nevertheless, we tentatively accept this record as likely since *C. septemvalvis* is widely distributed in the North Atlantic but highly cryptic, living in the very low intertidal to 160 m, and at low population densities (Jones and Baxter 1987). Kaas (1985: 580) reported *Acanthochitona crinita* (Pennant, 1777) from the Azores [(it exists) "from (…) Norway, S to the Cape Verde Archipelago"], but the same author unequivocally stated that this species is "not (present) in the Azores" (Kaas, 1991: 95). Notwithstanding recent reports from the area (Segers et al. 2009, Rolán 2011, Moreno and Gofas 2011), which are based solely on bibliographic records, we disregard this species as occurring in the archipelago and suggest that it should be eliminated from the Azores shallow-water marine mollusc checklist. Thus, the recorded Azorean shallow-water polyplacophoran fauna consists of seven living species, as no fossil chitons are known from the Azores. Four species (*Hanleya hanleyi*, *Callochiton septemvalvis*, *Tonicella rubra*, and *Acanthochitona fascicularis*) are common to the north-east Atlantic, but the ubiquitous northern European species *Lepidochitona cinerea* (Linnaeus, 1878) is absent and replaced by three other warmer-water species of the same genus. The summary presented here includes the first Azorean records of two species: *Lepidochitona* cf. *canariensis* and *Tonicella rubra*. The discovery of *Tonicella rubra* on a shallow, small (~18 ha area of summit) and young seamount (~300 y) leads us to believe that the chitons of the Azores are still poorly known when compared with other molluscan classes.

Acknowledgements

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RESEARCH ARTICLE

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Revealing the diversity of a once small taxon: the genus *Selenoribates* (Acari, Oribatida, Selenoribatidae)

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Abstract

Three new intertidal oribatid species, *Selenoribates elegans* **sp. n.**, *Selenoribates quasimodo* **sp. n.** and *Selenoribates satanicus* **sp. n.** are described from the archipelago of Bermuda. *Selenoribates elegans* **sp. n.** is characterized by its slender body shape, *S. quasimodo* **sp. n.** possesses a hunchback in lateral view and *S. satanicus* **sp. n.** exhibits two horn-like projections on its anterior gastronotic region. Based on these new findings, the number of *Selenoribates* species doubled at once and the distribution of this genus, formerly limited to the Mediterranean and the Red Sea, includes now occurrences in the Atlantic and Indo-pacific Ocean as well. The morphology of *S. quasimodo* **sp. n.** and *S. satanicus* **sp. n.** deviates conspicuously from the other known members of *Selenoribates*, thus indicating that not only the number of species but also the anatomy of this genus is more diverse than formerly supposed. Nymphs of *S. quasimodo* **sp. n.** show an interesting case of ontogenetic neotrichy, with gastronotic setae being duplicated with each moult.

Keywords

Bermuda, intertidal, juvenile instars, *Selenoribates*, biogeography

Introduction

The family of Selenoribatidae represents a group of littoral oribatid mites. These mites are air-breathing terrestrial organisms, but they have managed to colonize marine associated habitats and are now exclusively confined to intertidal zones of coastal areas (Pfingstl 2013). They show a transoceanic distribution and occur on shores of the tropics and subtropics (e.g. Schuster 1989, Procheş and Marshall 2001). At present, this family consists of seven genera, namely *Arotrobates* Luxton, 1992, *Carinozetes* Pfingstl and Schuster, 2012, *Psednobates* Luxton, 1992, *Rhizophobates* Karasawa & Aoki, 2005, *Schusteria* Grandjean, 1968, *Selenoribates* Strenzke, 1961 and *Thalassozetes* Schuster, 1963. *Rhizophobates* and *Schusteria* have been subject to taxonomic debates (e.g. Karasawa and Aoki 2005, Pfingstl and Schuster 2012) and the discreteness of some members of these genera is still unclear. The other genera are yet well delimited and the same applies to the genus type *Selenoribates*. Strenzke (1961) described the first species of this taxon, *Selenoribates foveiventris*, then Grandjean (1966) discovered *S. mediterraneus*, and finally Abd-El-Hamid (1973) added the third species, *S. ghardaqensis*. Since that time no further species have been detected and not even a single record of the already known species has been published. Accordingly the genus *Selenoribates*, with only three species, was supposed to be a small taxon with a restricted distribution in the Mediterranean and the Red Sea. The descriptions of the known species provided ample data on the morphology of the adults (Strenzke 1961, Grandjean 1966, Abd-El-Hamid 1973) but only one author (Grandjean 1966) described the nymphs of *S. mediterraneus*. Concerning the ecology and biology, virtually nothing is known about these species.

In the course of a recent study on intertidal oribatid mites from Bermuda, three new *Selenoribates* species could be discovered and this finding changes biogeographic and morphological aspects of this genus dramatically. Therefore this paper describes the morphology of the three new species, modifies the distribution pattern and tries to answer the question why the genus *Selenoribates* has vanished into thin air for more than forty years.

Material and methods

Intertidal algae growing on sandy and rocky substrate, as well as on roots of the black mangrove (*Avicennia germinans*) were collected on the archipelago of Bermuda during low tide and afterwards put in a Berlese-Tullgren apparatus for the extraction of mites. For investigation in transmitted light all animals were stored in ethanol (70% or pure ethanol), then heated in lactic acid (80°C for about 20 minutes) and afterwards embedded in BERLESE mountant. Observations, photographs and drawings were made with an Olympus BH-2 Microscope equipped with a drawing attachment. Image stacks were obtained by an Olympus E1 digital camera and layered with the Combine ZP software. Inscriptions of drawings were done according to Grandjean (1966, 1968).

Results

Family Selenoribatidae Schuster, 1963

Genus *Selenoribates* Strenzke, 1961

http://species-id.net/wiki/Selenoribates

Remarks. The following diagnosis summarizes the characters provided by Strenzke (1961), Grandjean (1966), Abd-El-Hamid (1973) and includes the characters of the present descriptions.

Small sized (198–308 × 119–185 μm) intertidal mites. Cerotegument granular. Interlamellar setae short or minute. Lamellar ridges present but short. Sensillus flagelliform and long. Pedotectum I small but robust, pedotectum II absent. Notogaster with 14 pairs of setae, c_3 absent. Obvious depressions, variable in number and shape, present on anterior part of notogaster. Two median epimeral cavities present. Epimeral setal formula 1-0-1-1. Genital plates with three-four pairs of setae. Aggenital setae absent. Two-three pairs of adanal setae and one-three pairs of anal setae. Legs monodactylous; claws with one or two proximoventral teeth. Juveniles plicate with large centrodorsal plate.

Selenoribates quasimodo sp. n.

urn:lsid:zoobank.org:act:CA3698B8-B235-4EAA-8DC3-E3F1DDDF7D84
http://species-id.net/wiki/Selenoribates_quasimodo

Type locality. Bermuda: Coney Island, 32°21'30"N, 64°42'59"W, lower intertidal area, sand and algae growing on mangrove roots, 18 October 2011.

Type specimen. Holotype: male, preserved in pure ethanol, deposition: Naturhistorisches Museum Wien, collection nr. NHMW 21884. Paratypes: two males, deposition: Senckenberg Museum für Naturkunde Görlitz, collection Nr. 11/48677.

Diagnosis. Red-brown sclerotized mites. Average length 228 μm, mean width 139 μm. Notogaster rounded in dorsal view, hunchbacked in lateral view. A large anteriorly arched depression on anterior part of notogaster. Lamellar ridges short. Interlamellar seta of normal length and spiniform. Fourteen pairs of spiniform notogastral setae. Uniform median epimeral cavity. Three pairs of genital, two pairs of adanal and two pairs of anal setae present. Legs monodactylous; claw of each leg large. Claw with one proximoventral and a proximodorsal tooth. No porose areas on femora discernable.

Description. Adult: Females (N=14), length: 222–244 μm (mean 231 μm), width: 136–152 μm (mean 142 μm); males (N=16), length: 212–238 μm (mean 226 μm), width: 131–147 μm (mean 137 μm)

Integument. Colour red brown. Cerotegument appears basically slightly granular. Cerotegument of prodorsum nearly smooth between bothridia, strongly granular anterior and lateral to lamellar ridges. Cerotegument of notogaster and venter slightly

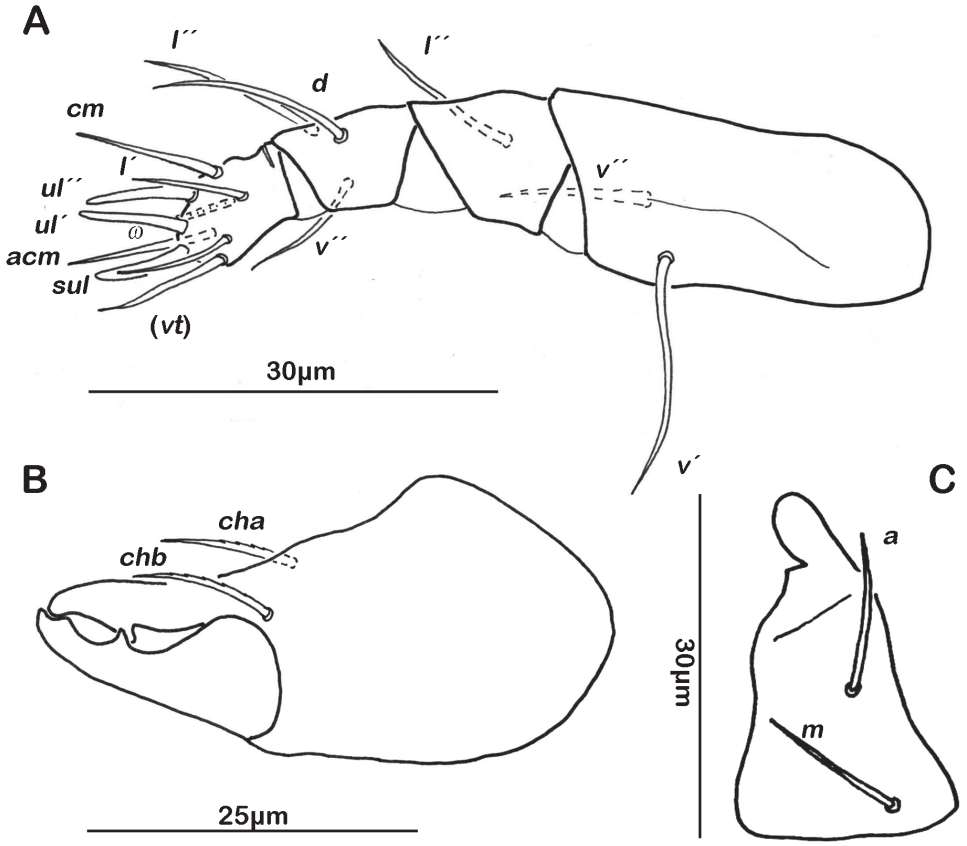

Figure 1. *Selenoribates quasimodo* sp. n. mouthparts. **A** left pedipalp antiaxial view **B** left chelicera antiaxial view **C** right rutellum ventral view.

granular. Cerotegument of lateral body parts generally finely granular, larger granules in areas surrounding acetabula. Cerotegument of legs slightly granular.

Prodorsum. Rostrum rounded in dorsal view, but slightly projecting anteroventrally in lateral view. Rostral setae (*ro*) short and smooth. Lamellar setae (*le*) and interlamellar setae (*in*) simple, short and smooth. Exobothridial setae (*ex*) minute. Lamellar ridge conspicuous, but short, not reaching insertions of lamellar setae. Bothridium large cup exhibiting a strongly projecting posterior ridge with three lobe-like protrusions overhanging anterior border of gastronotic region. Sensillus long (ca. 50µm) and flagelliform. Tutorium developed as slightly dorsally curved ridge.

Gnathosoma. Pedipalp pentamerous 0-2-1-3-9 (including solenidion) (Fig. 1A). Solenidion erect, not fused with eupathidium *acm*. Chelicera chelate, in lateral view forceps-like and each digit with two teeth, whereas from frontal view most distal teeth split into two symmetrical teeth (Fig. 1B). No porose area on proximal part of fixed digit discernable. Seta *cha* and *chb* dorsally slightly pectinate, both same length. Distal part of rutellum developed as thin triangular slightly curved inward mem-

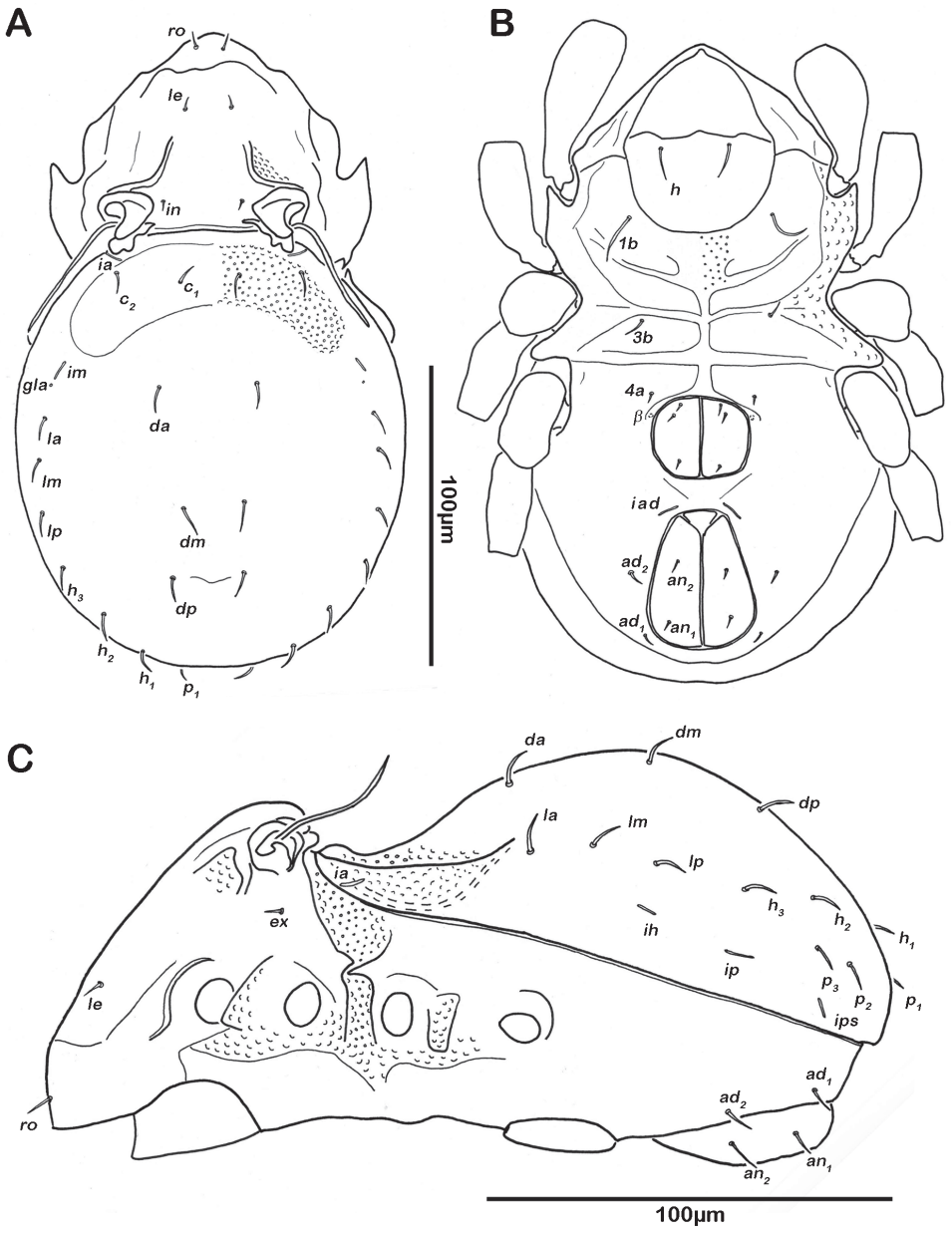

Figure 2. *S. quasimodo* sp. n. adult. **A** dorsal view **B** ventral view **C** lateral view.

brane (Fig. 1C). Setae *a* and *m* long and smooth. Mentum regular, setae *h* simple, thin and long.

Notogaster (Figs 2A, 3A). Rounded in dorsal view, hunchbacked in lateral view. Anterior margin of notogaster distinct. A large, arched depression on anterior part of notogaster showing obvious granulation. Fourteen pairs of simple notogastral

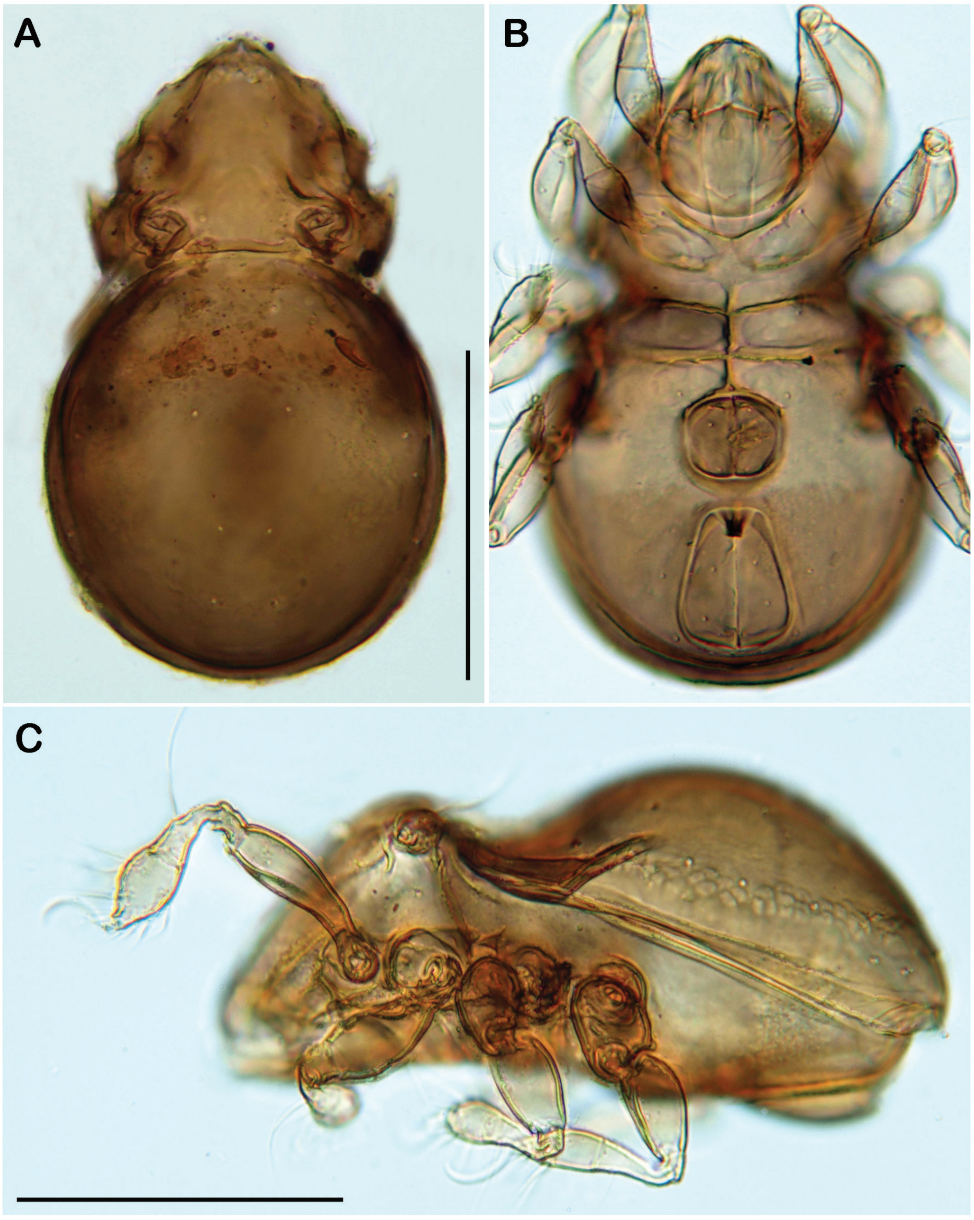

Figure 3. *S. quasimodo* sp. n. adult micrographs layered from 5–10 sequentially focused images. **A** dorsal view **B** ventral view **C** lateral view. Scale bars = 100 µm.

setae (approximate length 5–7 µm), $c_{1\text{-}2}$, *da*, *dm*, *dp*, *la*, *lm*, *lp*, $h_{1\text{-}3}$, $p_{1\text{-}3}$; c_3 absent. Notogastral setae sometimes completely covered by a layer of cerotegument. Porose areas or distinct pores absent. Five pairs of notogastral lyrifissures present; *ia* next to setae c_2 close and rectangular to anterior notogastral border; *im* slightly anterior and laterad of setae *la*; lyrifissures *ih, ip* and *ips* laterally close to lateroventral bor-

ders of notogastral plate. Opisthonotal gland openings (*gla*) located posteriorly to lyrifissures *im*.

Lateral aspect (Figs 2C, 3C). Pedotectum I small but thick, pedotectum II absent. Lateral parts of anterior margin of notogaster broad and deep, showing conspicuous granules. Enantiophyse consisting of two strong triangular teeth orientated against each other. Discidium developed as strong rectangular bulge between acetabulum III and IV.

Ventral region of idiosoma (Figs 2B, 3B). Epimeral setation 1-0-1-1, seta *1b* long reaching trochanter II, setae *3b* normal length and *4a* short. Internal borders of all epimera well visible, sternal apodemes II, sejugal and III well developed. A densely granulated median sternal cavity on epimeron I. Three pairs of short and fine genital setae, arranged in longitudinal rows, anterior two pairs close to each other. Insertion of tendon β next to anterior corners of genital orifice. Aggenital setae absent. Anal plates triangular. Preanal organ triangular in ventral view. Two pairs of short anal setae, $an_{1\text{-}2,}$ present. Two pairs of short and simple adanal setae $ad_{1\text{-}2}$ present, ad_3 absent. Lyrifissure *iad* obliquely, adjacent to anterior corners of anal orifice.

Legs. Monodactylous. Long hook-like claws with one conspicuous proximoventral and one minuscule proximodorsal tooth. Trochanters III and IV with an obvious triangular dorsodistal projection. Femora with slightly projecting ventral carinae. All tarsi with one proximal lyrifissure. No porose areas on femora discernable. Solenidia φ_1 on tibia I long and orientated backwards. Chaetome and Solenidia see Table 1.

Etymology. The specific name refers to Quasimodo, the famous bell-ringer of Victor Hugo's historical novel "Notre-Dame de Paris" (1831). This appellation is due to the hunchback of this species shown in lateral view (that does not necessarily mean the species is as ugly as the bell-ringer was supposed to be). The name is given as noun in apposition.

Juvenile instars - common features. Apheredermous. Colour light brown. Integument strongly plicate, except for centrodorsal plate. Thick layer of cerotegument covering whole body. Prodorsum triangular, rostrum rounded. Rostral and lamellar setae short and smooth. Exobothridial setae reduced to a circular vestigial structure. Interlamellar setae very short. Sensillus long and flagelliform. Bothridium large cup, laterally opened. Gnathosoma no obvious differences to adult instar. Hysterosoma slightly concave, plateau-like. Slightly plicate centrodorsal plate occupying two thirds of dorsal hysterosoma, bearing centrodorsal setae. Hysterosomal cupules not discernable in any instar. Large folds framing centrodorsal plate completely, showing fine granular surface. Orifice of opisthonotal gland laterad of seta ad_2. Integument surrounding anogenital area folded. Dorsal setae of tibiae and genua absent. No porose areas detectable in any stage.

Protonymph. Length (N=3): 172–209 µm (mean 191 µm)

Gastronotic region (Fig. 4A) with 24 pairs of notogastral setae; setae $c_{1\text{-}3}$, *da*, *dm*, *dp*, *la*, *lm* and *lp* duplicated, $h_{1\text{-}3}$ and $p_{1\text{-}3}$ normal. Centrodorsal setae *da*, *dm* and *dp* robust and dorsally serrate, all other setae simple and small.

Ventral region of idiosoma (Fig. 4B). Epimeral setation 1-0-1-0. One pair of short genital setae.

Table 1. Chaetome and solenidia of the new Selenoribates species. Presence of setae characterized by letters. ( ) = pairs of setae, – = no change with regard to preceding stage.

S. quasimodo sp. n.	instars	trochanter	femur	genu	tibia	tarsus	chaetome	solenidia
Leg I	protonymph	-	*d*, *d*, *l´*	(*l*), σ	(*l*), *v´*, φ_1	(*pv*), (*pl*), *s*, (*a*), (*u*), (*p*), (*tc*), (*ft*), ω_1, ω_2, ε	0-3-2-3-16	1-1-2
	tritonymph	-	-	-	φ_2	(*it*)	0-3-2-3-18	1-2-2
	adult	-	-	-	-	-	0-3-2-3-18	1-2-2
Leg II	protonymph	-	*d*, *l"*	(*l*), σ	*l´*, *v´*, φ	(*pv*), *s*, (*a*), (*u*), (*p*), (*tc*), (*ft*), ω	0-2-2-2-13	1-1-1
	tritonymph	-	*d*, *l´*	-	-	(*it*)	0-4-2-2-15	1-1-1
	adult	-	-	-	*l"*	-	0-4-2-3-15	1-1-1
Leg III	protonymph	-	*d*, *l´*	*l´*, σ	*l´*, φ	(*pv*), *s*, (*a*), (*u*), (*p*), (*tc*), (*ft*)	0-2-1-1-13	1-1-0
	tritonymph	-	-	-	-	-	0-2-1-1-13	1-1-0
	adult	*v´*	-	-	*v"*	-	1-2-1-2-13	1-1-0
Leg IV	protonymph	-	-	-	-	(*pv*), (*u*), (*p*), *ft´*	0-0-0-0-7	0-0-0
	tritonymph	-	*d*, *l´*	*l´*	*l´*, *v"*, φ	*s*, (*a*), (*tc*)	0-2-1-2-12	0-1-0
	adult	*v´*	-	-	-	-	1-2-1-2-12	0-1-0
S. satanicus sp. n.	instars	trochanter	femur	genu	tibia	tarsus	chaetome	solenidia
Leg I	adult	-	(*l*), *d*	(*l*), σ	(*l*), *v´*, φ_1, φ_2	(*pv*), (*pl*), *s*, (*a*), (*u*), (*p*), (*it*), (*tc*), (*ft*), ω_1, ω_2, ε	0-3-2-3-18	1-2-2
Leg II	adult	-	*d*, *d*, *l"*	(*l*), σ	(*l*), *v´*, φ	(*pv*), *s*, (*a*), (*u*), (*p*), (*it*), (*tc*), (*ft*), ω	0-3-2-3-15	1-1-1
Leg III	adult	*v´*	*d*, *l´*	*l´*, σ	*l´*, *v´*, φ	(*pv*), *s*, (*a*), (*u*), (*p*), (*tc*), (*ft*)	1-2-1-2-13	1-1-0
Leg IV	adult	*v´*	*d*, *l´*	*l´*	*l´*, (*v*), φ	(*pv*), *s*, (*a*), (*u*), (*p*), (*tc*), *ft´*	1-2-1-3-12	0-1-0
S. elegans sp. n.	Instars	trochanter	femur	genu	tibia	tarsus	chaetome	solenidia
Leg I	adult	-	(*l*), *d*	(*l*), σ	(*l*), *v´*, φ_1, φ_2	(*pv*), (*pl*), *s*, (*a*), (*u*), (*p*), (*it*), (*tc*), (*ft*), ω_1, ω_2, ε	0-3-2-3-18	1-2-2
Leg II	adult	-	*d*, *d*, *l"*	(*l*), σ	(*l*), *v´*, φ	(*pv*), *s*, (*a*), (*u*), (*p*), (*it*), (*tc*), (*ft*), ω	0-3-2-3-15	1-1-1
Leg III	adult	*v´*	*d*, *l´*	*l´*, σ	*l´*, *v´*, φ	(*pv*), *s*, (*a*), (*u*), (*p*), (*tc*), (*ft*)	1-2-1-2-13	1-1-0
Leg IV	adult	*v´*	*d*, *l´*	*l´*	*l´*, (*v*), φ	(*pv*), *s*, (*a*), (*u*), (*p*), (*tc*), *ft´*	1-2-1-3-12	0-1-0

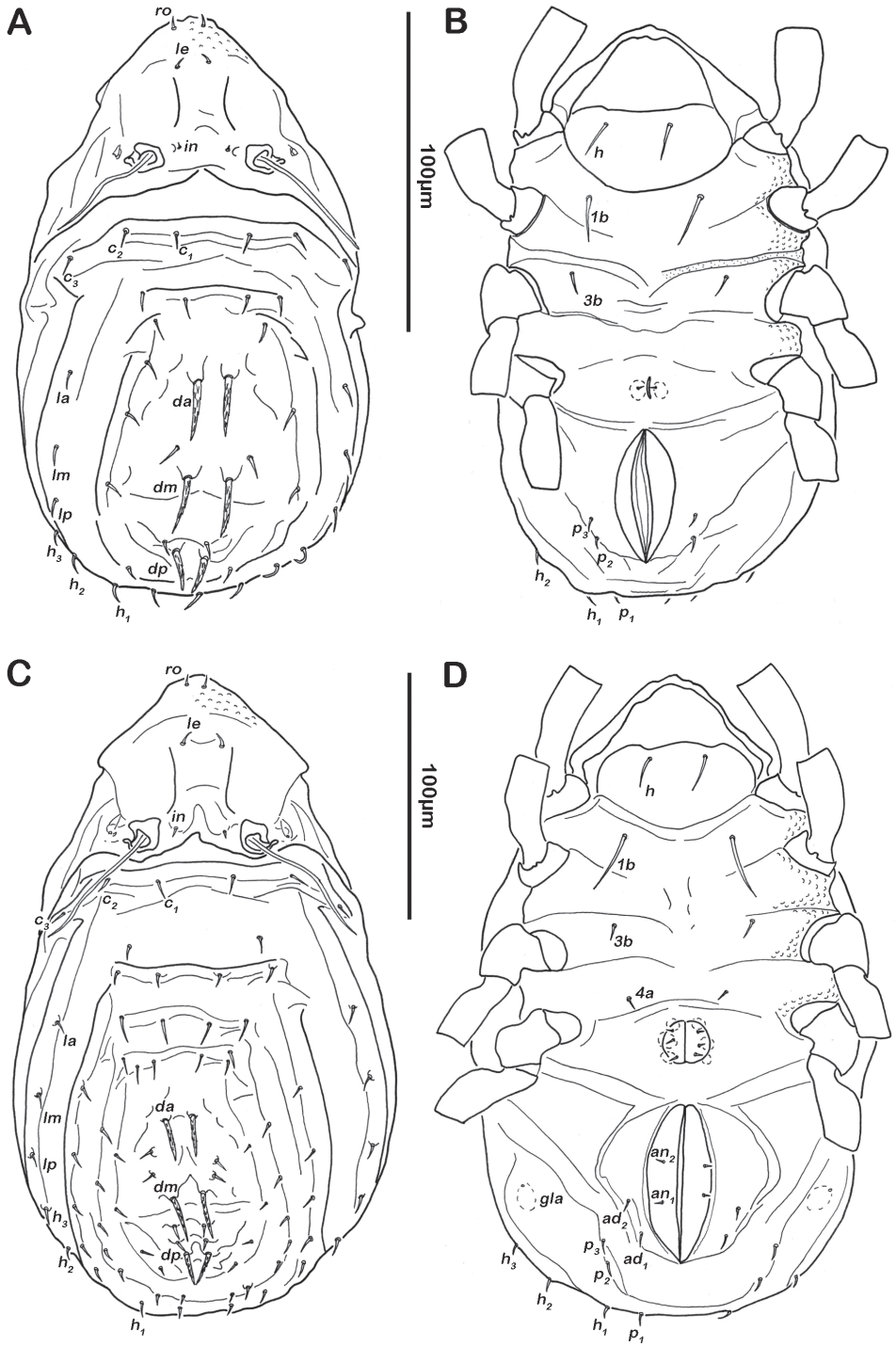

Figure 4. *S. quasimodo* sp. n. nymphs. **A** protonymph dorsal view **B** protonymph ventral view **C** tritonymph dorsal view **D** tritonymph ventral view.

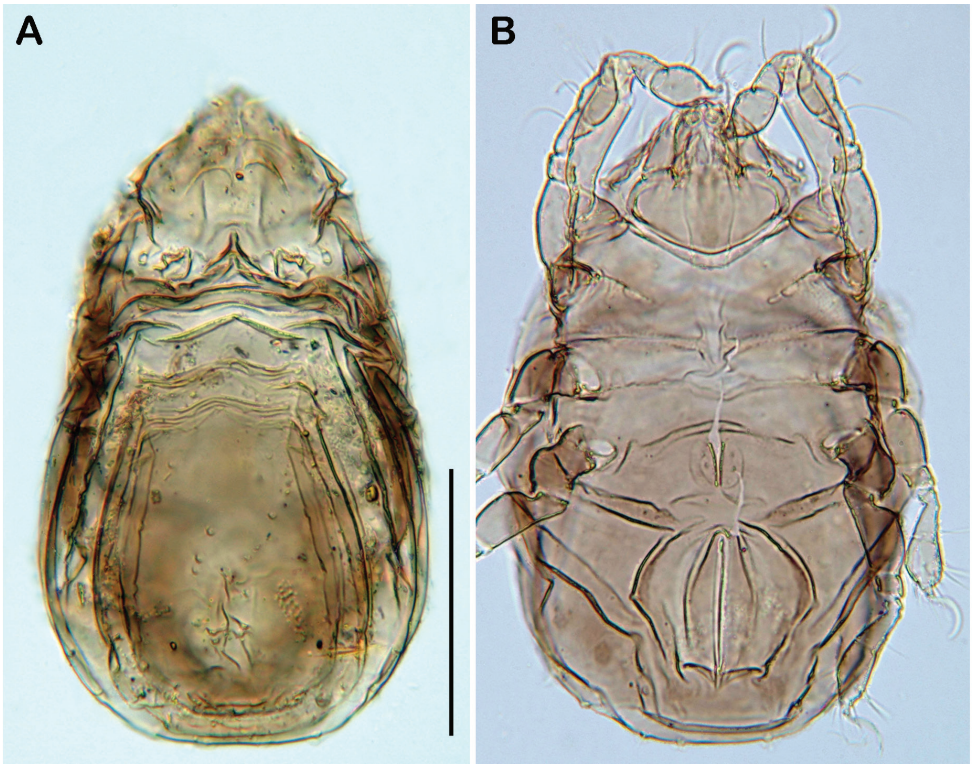

Figure 5. *S. quasimodo* sp. n. tritonymph, micrographs layered from 5–10 sequentially focused images. **A** dorsal view **B** ventral view. Scale bar = 100 μm.

Legs. Chaetome and Solenidia see Table 1.

Tritonymph. Length (N=9): 228–266 μm (mean 243 μm)

Gastronotic region (Fig. 4C, 5A). 44 pairs of notogastral setae, setae of series *c*, *d*, *l* and *h*-series further multiplied.

Ventral region of idiosoma (Fig. 4D, 5B). Epimeral setation 1-0-1-1. Three pairs of short genital setae in a longitudinal row. Two pairs of adanal setae $ad_{1\text{-}2}$. Two pairs of anal setae $an_{1\text{-}2}$.

Legs (Fig. 6). Chaetome and Solenidia see Table 1.

***Selenoribates satanicus* sp. n.**
urn:lsid:zoobank.org:act:30EC290D-FD6A-4E7B-B581-30F627ADC954
http://species-id.net/wiki/Selenoribates_satanicus

Type locality. Bermuda: Lover's Lake (marine pond), 32°22'03"N, 64°42'37"W, median eulittoral zone, green algae growing on sandy substrate among mangrove roots, 26 January 2012.

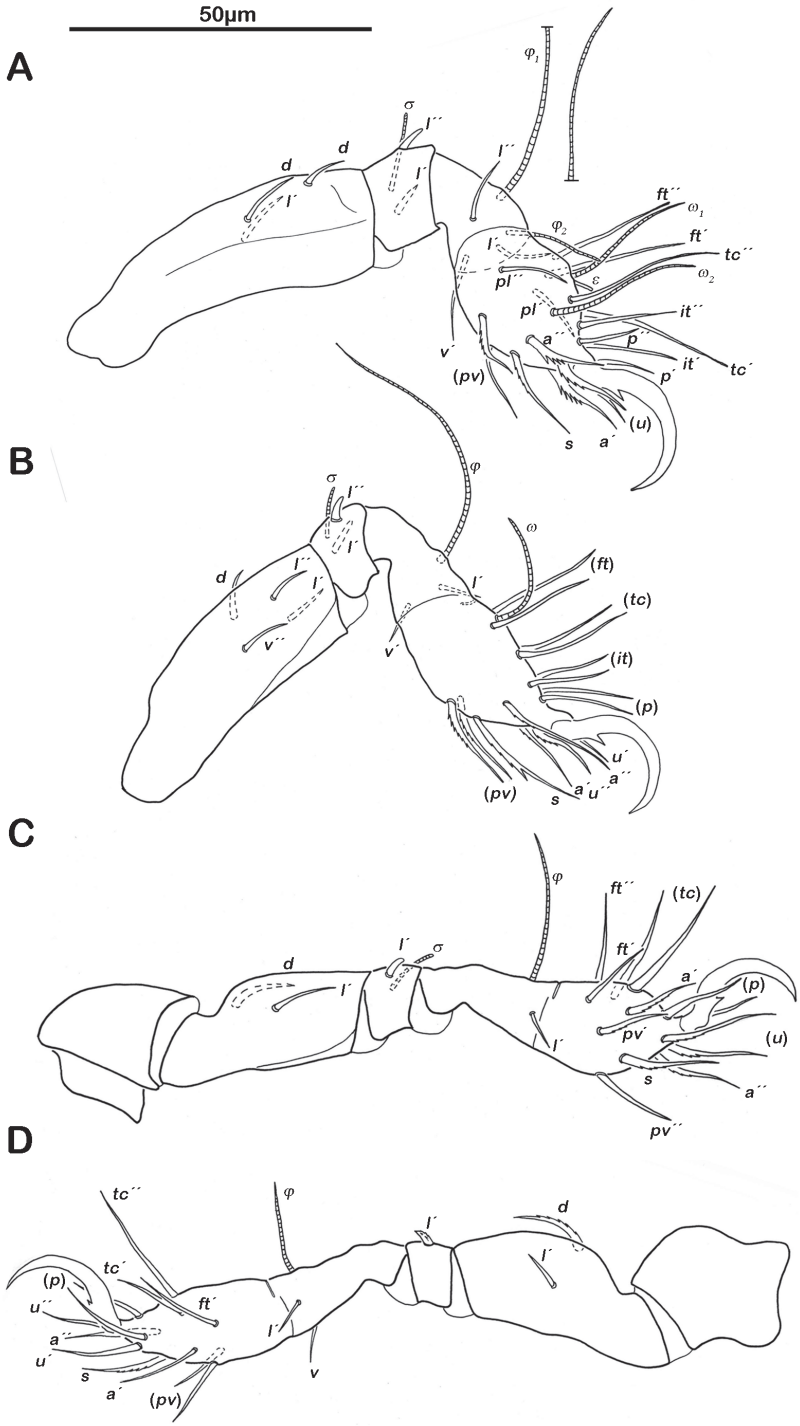

Figure 6. *S. quasimodo* sp. n. tritonymph legs. **A** right leg I antiaxial view **B** right leg II antiaxial view **C** left leg III antiaxial view **D** right leg IV antiaxial view.

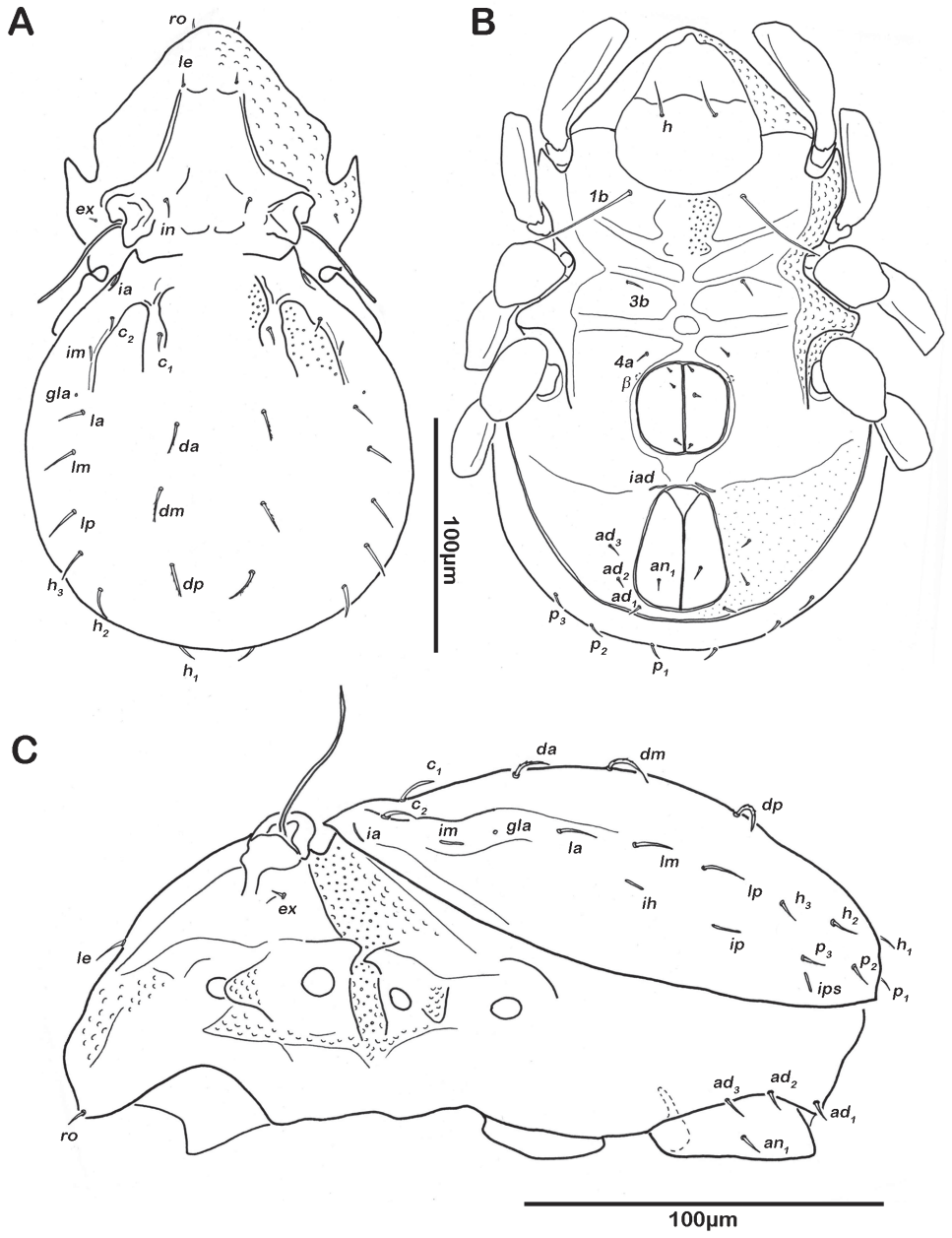

Figure 7. *Selenoribates satanicus* sp. n. adult. **A** dorsal view **B** ventral view **C** lateral view.

Type specimen. Holotype: female, preserved in pure ethanol, deposition: Naturhistorisches Museum Wien, collection nr. NHMW 21885. Paratypes: 1 female and 1 male, same locality as holotype; deposition: Senckenberg Museum für Naturkunde Görlitz, collection Nr. 12/48678.

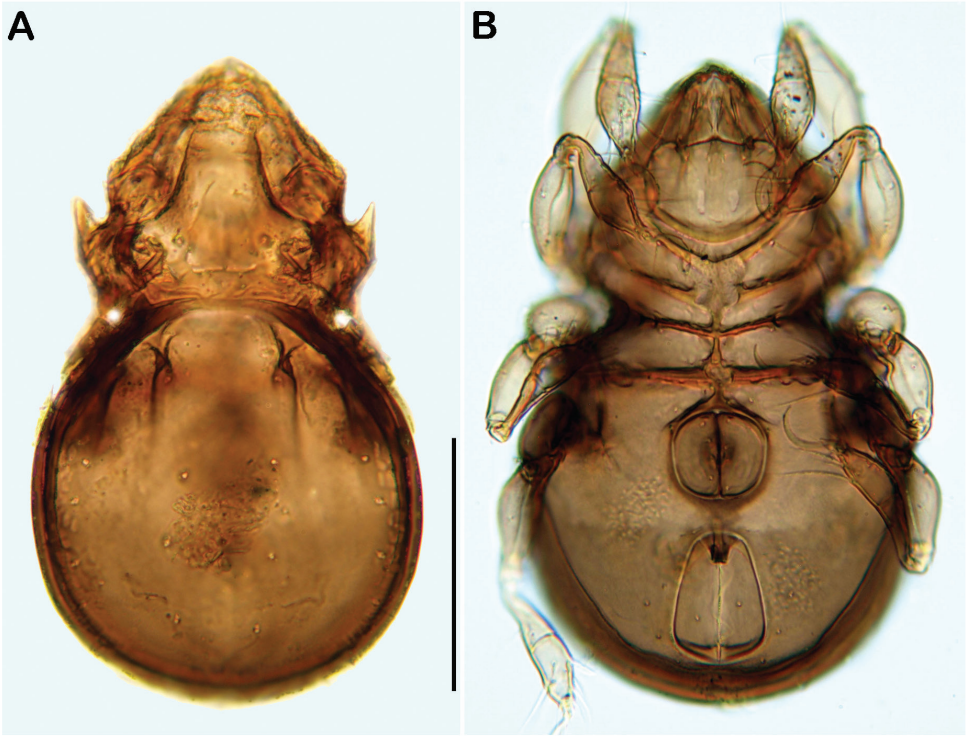

Figure 8. *S. satanicus* sp. n. adult micrographs layered from 5–10 sequentially focused images. **A** dorsal view **B** ventral view. Scale bar = 100 μm.

Diagnosis. Light brown sclerotized mites. Average length 283 μm, mean width 174 μm. Notogaster rounded in dorsal view, concave in lateral view. Lamellar ridges long reaching lamellar setae. On anterior border of notogaster a pair of horn-like structures. Three notogastral depressions, framed by longitudinal ridges. Fourteen pairs of spiniform notogastral setae. Two median epimeral cavities. Three pairs of genital setae. Three pairs of adanal and one pair of anal setae. Legs monodactylous with large claw. Claw with one proximoventral and one proximodorsal tooth.

Description. Adult: Females (N=6), length: 278–308 μm (mean 290 μm), width: 175–188 μm (mean 181 μm); males (N=5), length: 265–291 μm (mean 274 μm), width: 163–172 μm (mean 168 μm).

Integument. Colour light brown. Cuticle appears granular under dissecting microscope. Cerotegument of prodorsum and notogaster granular. Cerotegument of lateral parts generally finely granular, larger granules in areas surrounding acetabula. Ventral cerotegument generally finely granular, areas laterad of anal opening showing stronger granulation.

Prodorsum. Rostrum rounded in dorsal view, but slightly projecting anteroventrally in lateral view. Rostral setae (*ro*), lamellar setae (*le*) and interlamellar setae (*in*) short and simple. One pair of minute exobothridial setae (*ex*). Lamellar ridges conspicuous, reaching insertions of lamellar setae. Bothridium large cup with a projecting

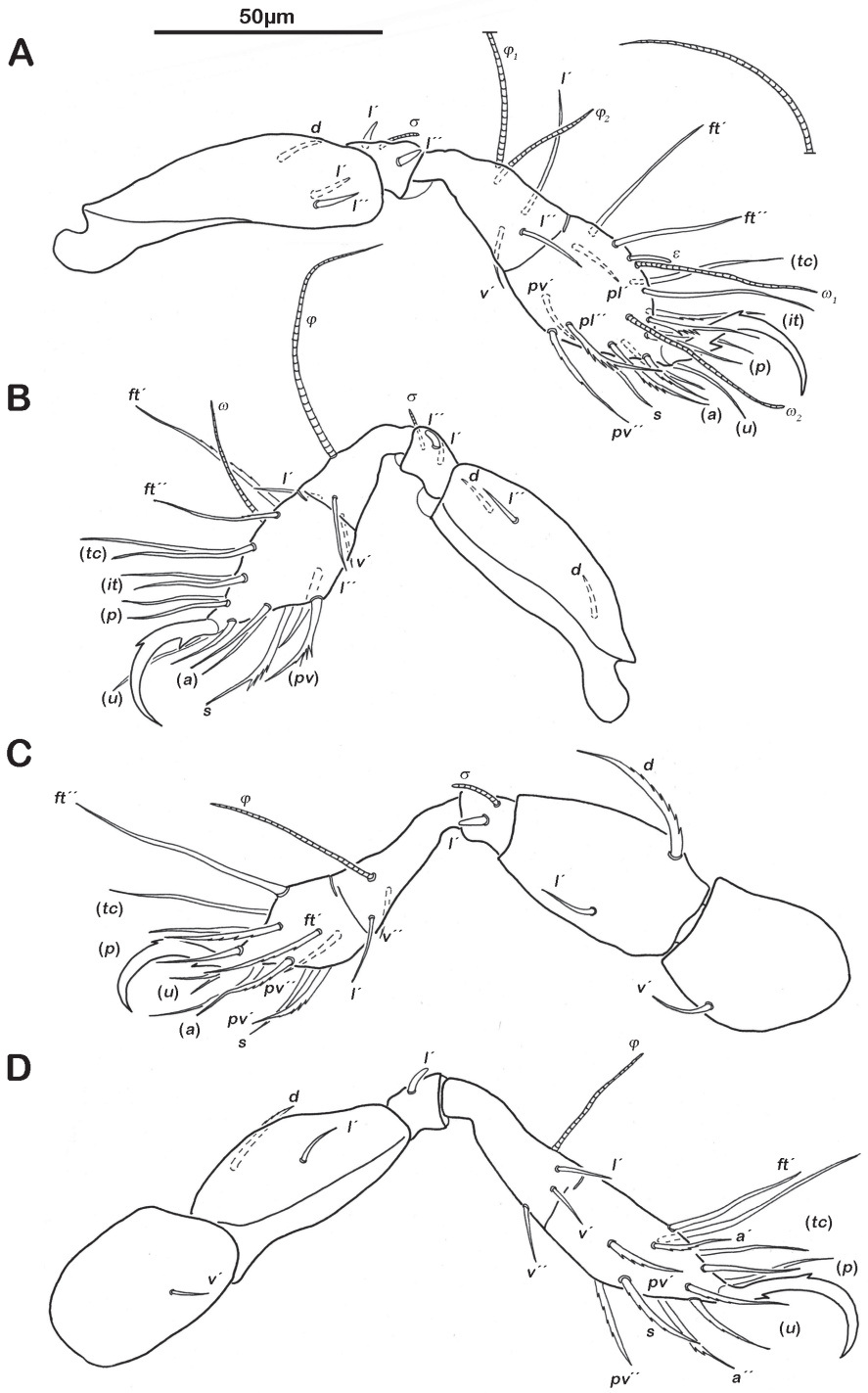

Figure 9. *S. satanicus* sp. n. legs. **A** right leg I antiaxial view **B** right leg II axial view **C** right leg III antiaxial view **D** left leg IV antiaxial view.

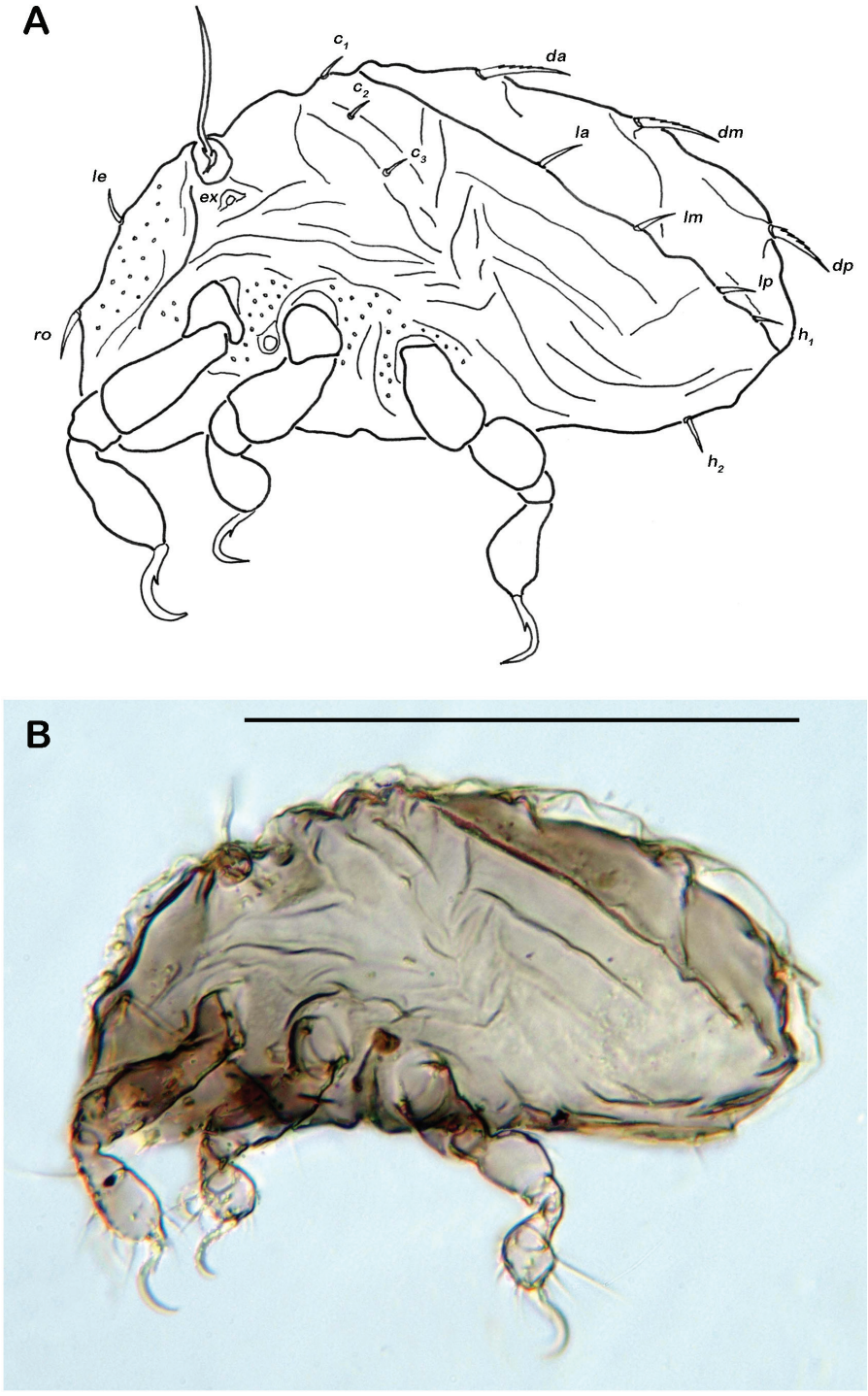

Figure 10. *S. satanicus* sp. n. larva. **A** lateral view **B** lateral view, micrograph layered from 5–10 sequentially focused images. Scale bar = 100 μm.

posterior ridge. Sensillus long (ca. 53 µm) and flagelliform. Tutorium weakly developed and small.

Gnathosoma. Pedipalp pentamerous 0-2-1-3-9 (including solenidion). Solenidion erect, not fused with eupathidium *acm*. Chelicera chelate, in lateral view forceps-like and each digit with two teeth, whereas from frontal view most distal teeth split into two symmetrical teeth. Distal part of rutellum developed as thin triangular slightly curved inward membrane. Setae *a* and *m* long and smooth. Mentum regular, setae *h* simple, thin and long.

Notogaster (Figs 7A, 8A). Rounded in dorsal view, concave in lateral view. Anterior margin of notogaster incomplete, medially interrupted. On anterior border of notogaster a pair of strongly anteriorly projecting horn-like structures, situated directly posterior of bothridia. Three notogastral depressions on anterior third of notogaster, framed by longitudinal ridges reaching transversal line of setae *la* and *da*. Cerotegument of depressions strongly granular. Fourteen pairs of notogastral setae, c_{1-2}, *da*, *dm*, *dp*, *la*, *lm*, *lp*, h_{1-3}, p_{1-3} (approximate length 10- 13 µm); c_3 absent. Setae *da-dp*, slightly serrate, all other setae smooth. Porose areas or distinct pores absent. Five pairs of notogastral lyrifissures present; *ia* anterior to seta c_2, in dorsal view hidden under anterior notogastral horn-like projection; *im* posterior of seta c_2; lyrifissures *ih, ip* and *ips* laterally close to lateroventral border of notogastral plate. Orifice of opisthonotal gland (*gla*) next to setae *la*.

Lateral aspect (Figs 7C, 8C). Pedotectum I small but thick, pedotectum II absent. Lateral sejugal furrow broad and deep, showing conspicuous granulation. Enantiophyse consisting of two strong triangular teeth orientated against each other. Anterior tooth slightly rounded. Discidium developed as strong triangular bulge between acetabulum III and IV.

Ventral region of idiosoma (Figs 7B, 8B). Epimeral setation 1-0-1-1, seta *1b* long reaching trochanter III, setae *3b* and *4a* short. Internal borders of all epimera well visible, sternal apodemes II, sejugal and III well developed. A densely granulated median sternal cavity on epimeron I and a second circular median cavity on a level with apodemes III. Three pairs of short and fine genital setae, arranged in longitudinal rows, anterior two pairs of setae close to each other. Insertion of tendon β next to anterior corners of genital orifice. Aggenital setae absent. Anal valves triangular. Preanal organ shaped triangular in ventral view. One pair of short anal setae, an_1, located on posterior half of anal valves. Three pairs of short and simple adanal setae ad_{1-3}. Lyrifissure *iad* obliquely, adjacent to anterior corners of anal orifice.

Legs (Fig. 9). Monodactylous. Long pointed hook-like claw with one conspicuous proximoventral and a minute proximodorsal tooth. Trochanters III and IV with a triangular dorsodistal projection. Femora exhibiting slightly projecting ventral carinae. All tarsi with one proximal lyrifissure. No porose areas on femora discernable. Solenidion φ_1 on tibia I long, orientated backwards. Chaetome and Solenidia see Table 1.

Larva. Length (N=1): 137 µm

Gastronotic region (Fig. 10). 11 pairs of notogastral setae; setae c_{1-3}, *da*, *dm*, *dp*, *la*, *lm*, *lp* and h_{1-2}, h_3 absent. Centrodorsal setae *da*, *dm* and *dp* robust and dorsally serrate, all other setae simple and small.

Ventral region of idiosoma. Epimeral setation 1-0-1. Claparède organ bladder-like. No protecting seta detectable.

Etymology. When the author regarded *S. satanicus* in dorsal view for the first time, the oval contour of the notogaster with its two anterior horn-like projections reminded him of the silhouette of the devil's face, therefore the specific name refers to the Hebraic name Satan and is given as adjective in the nominative singular.

***Selenoribates elegans* sp. n.**
urn:lsid:zoobank.org:act:F9258443-DBA2-408F-890D-2DC72CA9938D
http://species-id.net/wiki/Selenoribates_elegans

Type locality. Bermuda, Whalebone Bay, 32°21'55"N, 64°42'49"W, lower intertidal area, red algae on rocks, 22 November 2011.

Type specimen. Holotype: female, preserved in pure ethanol, deposition: Naturhistorisches Museum Wien, collection nr. NHMW 21886.

Diagnosis. Red-brown sclerotized mites. Average length 202 μm, mean width 115 μm. Notogaster oval in dorsal view, slightly concave in lateral view. Lamellar ridges absent. Interlamellar setae normal and minute. Two X-shaped ridges on anterior part of notogaster. Fourteen pairs of simple long notogastral setae. Two median epimeral cavities. Claw with two proximoventral and one proximodorsal tooth.

Description. Adult: Males (N=2), length: 200–203 μm (mean 201.5 μm), width: 108–122 μm (mean 115 μm).

Integument. Colour light brown. Cuticle showing dotted pattern. Cerotegument of notogaster granular, larger granules in centre of gastronotic plate. Cerotegument of lateral parts granular, with larger granulation in areas surrounding acetabula. Ventral region finely granular, denser granulation laterad of anal orifice.

Prodorsum. Cerotegument strongly granular. Rostrum rounded in dorsal view, but slightly projecting anteroventrally in lateral view. Rostral (*ro*) and lamellar setae (*le*) simple and short, interlamellar setae (*in*) very short. One pair of minute exobothridial setae (*ex*). Lamellar ridges absent. Bothridium large cup without posterior ridge. Sensillus long (ca. 48 μm), flagelliform.

Gnathosoma. Pedipalp pentamerous 0-2-1-3-9 (solenidion included). Solenidion erect, not fused with eupathidium *acm*. Chelicera chelate, forceps-like in lateral view, each digit with two teeth, whereas from frontal view most distal teeth split into two symmetrical teeth. Distal part of rutellum a thin triangular slightly inward curved membrane. Setae *a* and *m* long and smooth. Mentum regular, setae *h* simple, thin and long.

Notogaster (Figs 11A, 12A). Rounded in dorsal view, slightly concave in lateral view. Anterior margin of notogaster complete. On anterior part of notogaster a pair of small X-shaped ridges, close to seta c_1. Fourteen pairs of simple notogastral setae, c_{1-2}, *da*, *dm*, *dp*, *la*, *lm*, *lp*, h_{1-3}, p_{1-3} (approximate length 17-20 μm), setae c_3 absent. Porose areas or distinct pores absent. Five pairs of notogastral lyrifissures present; *ia* anterior to seta c_2; *im* posterior and laterad of seta *la*; lyrifissures *ih, ip* and *ips* laterally close to lateroventral border of notogastral plate. Orifice of opisthonotal gland (*gla*) posterior to seta c_2.

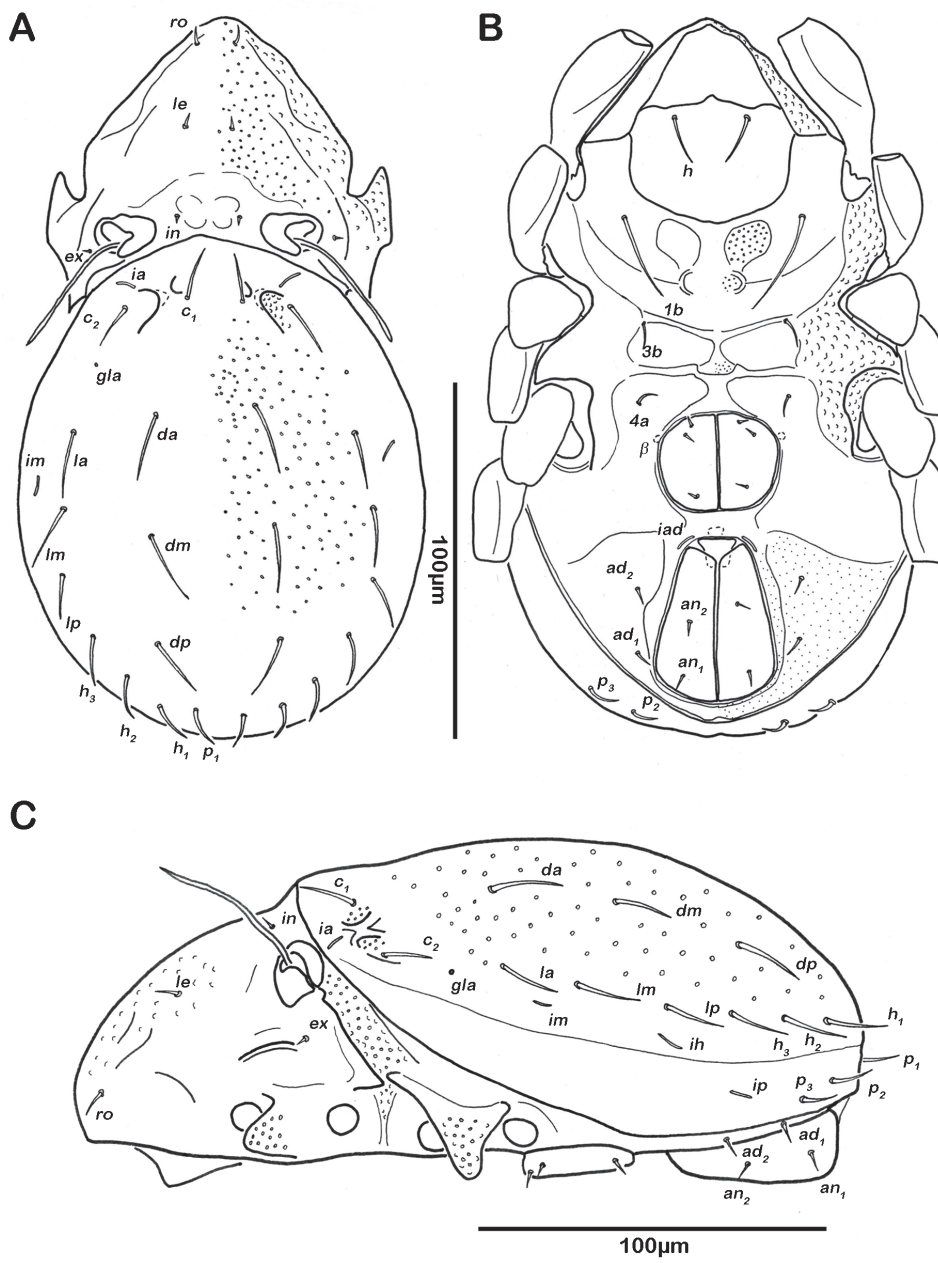

Figure 11. *Selenoribates elegans* sp. n. adult. **A** dorsal view **B** ventral view **C** lateral view.

Lateral aspect. Pedotectum I small but robust, pedotectum II absent. Enantiophyse consisting of two strong triangular and pointed teeth orientated against each other. Discidium developed as strong triangular projection between acetabulum III and IV.

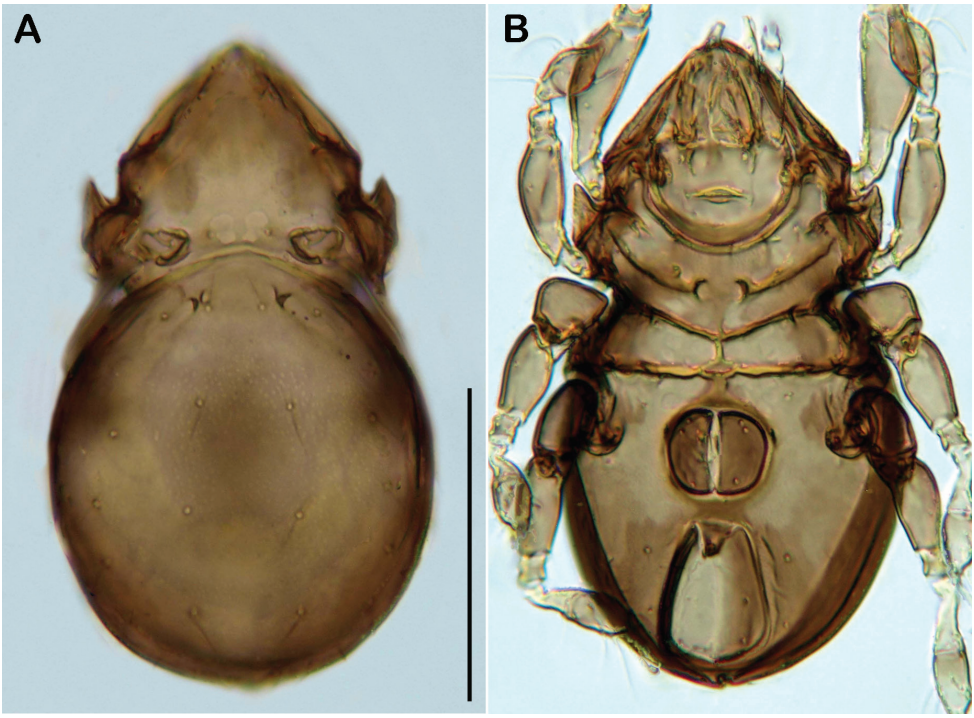

Figure 12. *S. elegans* sp. n. adult micrographs layered from 5–10 sequentially focused images. **A** dorsal view **B** ventral view. Scale bar = 100 μm.

Ventral region of idiosoma (Figs 11B, 12B). Epimeral setation 1-0-1-1, seta *1b* long reaching trochanter III, setae *3b* and *4a* of normal length and simple. Internal borders of all epimera well visible, sternal apodemes III and IV well developed. Median sternal cavity on epimeron I divided into two anterior symmetric parts and one unpaired posterior part, all parts strongly granulated. A second triangular median cavity on epimeron III on a level with apodeme 3. Three pairs of short and fine genital setae, arranged in longitudinal rows, anterior pairs close to each other. Insertion of tendon β adjacent to anterior corners of genital orifice. Aggenital setae absent. Anal plates triangular. Preanal organ triangular. Two pairs of short anal setae, $an_{1\text{-}2}$. Two pairs of short and simple adanal setae $ad_{1\text{-}2}$, ad_3 absent. Lyrifissure *iad* obliquely, next to anterior corners of anal valves.

Legs. Monodactylous. Long acute hook-like claw with two obvious proximoventral teeth, one close to the base of claw and one proximodorsal tooth. Cuticle finely granular. Femora with projecting ventral carinae. All tarsi with one proximal lyrifissure. Porose areas absent. Solenidia φ_1 on tibia I long, orientated backwards. Chaetome and solenidia see Table 1.

Etymology. The specific name is derived from the Latin word *elegans* meaning elegant and refers to the slender and delicate shape of the whole body. The name is given as adjective in the nominative singular.

Key to the *Selenoribates* species

1 Three depressions on anterior part of notogaster separated by two X-shaped ridges **2**
– Depressions and ridges shaped different **5**
2 Three pairs of anal, four pairs of genital setae ..... ***S. ghardaqensis* Abd-El-Hamid, 1973**
– Two pairs of anal setae and three pairs of genital setae **3**
3 Sensillus spatuliform ..... ***S. mediterraneus* Grandjean, 1966**
– Sensillus flagelliform **4**
4 Anterior median epimeral cavity simple and shaped circular; lamellar ridges short but conspicuous ..... ***S. foveiventris* Strenzke, 1961**
– Anterior median epimeral cavity divided into two anterior symmetric parts and one unpaired posterior part; lamellar ridges absent ..... ***S. elegans* sp. n.**
5 Three depressions on anterior part of notogaster separated by longitudinal ridges reaching transversal line of setae *la* and *da*; on anterior border of notogaster a pair of horn-like projections ..... ***S. satanicus* sp. n.**
– A single large depression on anterior part of notogaster, causing a hunchbacked appearance in lateral view ..... ***S. quasimodo* sp. n.**

Discussion

Grandjean (1966) mentioned three depressions separated by two X-shaped ridges on the anterior part of the gastronotic region as diagnostic character of the genus *Selenoribates*. The new species possess anterior notogastral depressions and sometimes ridges, but they differ in shape and size (Fig. 13). Especially *S. quasimodo* sp. n. diverges in this respect, showing a single large deepening without any ridges. Notogastral depressions may represent a synapomorphic character of this genus, but the detailed configuration has evolved in different ways. Moreover, Pfingstl and Schuster (2012) described *Carinozetes trifoveatus*, another selenoribatid species, also exhibiting three anterior gastronotic depressions and two X-shaped ridges, similar to that shown in most of the *Selenoribates* species. As *C. trifoveatus* is subject to the same selective constraints of the littoral environment, this character may have evolved convergently. However, median epimeral cavities are also present in *Carinozetes* Pfingstl & Schuster, 2012 and in *Thalassozetes riparius* Schuster, 1963, but the possession of two cavities is unique to the genus *Selenoribates*. Accordingly, this character state represents another synapomorphy of this taxon, whereas the specific shape of the cavities varies among species (Fig. 14), and hence represents a valuable trait for species discrimination. Comparing the new species with the already known members of *Selenoribates*, one interesting fact becomes obvious (Table 2). *Selenoribates elegans* sp. n. shows conformity in most of its morphological features with *S. foveiventris*, *S. mediterraneus* and *S. ghardaqensis*, whereas *S. quasimodo* sp. n. and *S. satanicus* sp. n. deviate conspicuously from the others as well as from each other. Although *S. elegans* sp.

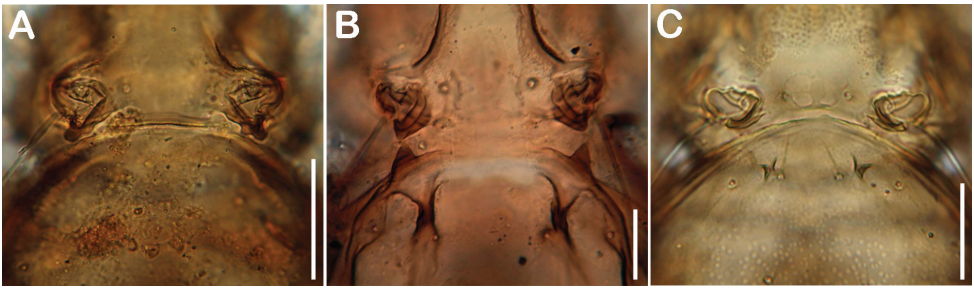

Figure 13. Comparison of cuticular structures on anterior part of gastronotic region. **A** *S. quasimodo* sp. n. **B** *S. satanicus* sp. n. **C** *S. elegans* sp. n. Scale bars = 30 μm.

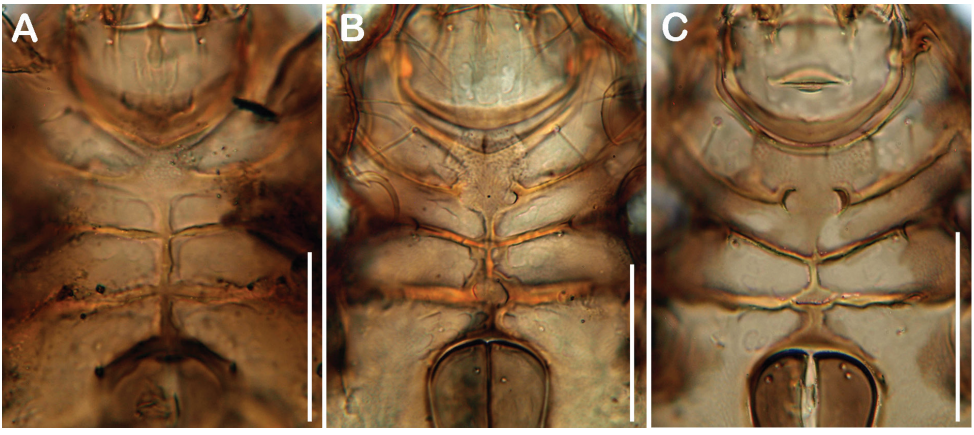

Figure 14. Comparison of ventral cavities. **A** *S. quasimodo* sp. n. **B** *S. satanicus* sp. n. **C** *S. elegans* sp. n. Scale bars 50 μm.

Table 2. Comparison of diagnostic morphological features of all Selenoribates species. ? = no information available; depr. = depression; X = X-shaped ridge.

	S. foveiventris	***S. mediterraneus***	***S. ghardaqensis***	***S. quasimodo***	***S. satanicus***	***S. elegans***
size (μm)	240-250	242-251	198-218	212-244	265-308	200-203
exobothridial seta	vestigial	minute	?	minute	minute	minute
lamellar ridges	short	short	short	short	long	absent
gastronotic structures	3 depr. 2X	3 depr. 2X	3 depr. 2X	1 depr.	3 depr.	3 depr. 2X
notogastral setae	14	14	14	14	14	14
epimeral setae	1-0-1-1	1-0-1-1	1-0-1-1	1-0-1-1	1-0-1-1	1-0-1-1
genital setae	3	3	4	3	3	3
anal setae	2	2	3	2	1	2
adanal setae	2	2	2	2	3	2
claw / ventral teeth	2	2	2	1	1	2

n. was found on Bermuda, together with the latter species, its morphology suggests that it is closer related to the species from the Mediterranean and the Red Sea. *Selenoribates quasimodo* sp. n. and *S. satanicus* sp. n. with their more complex morphological features,

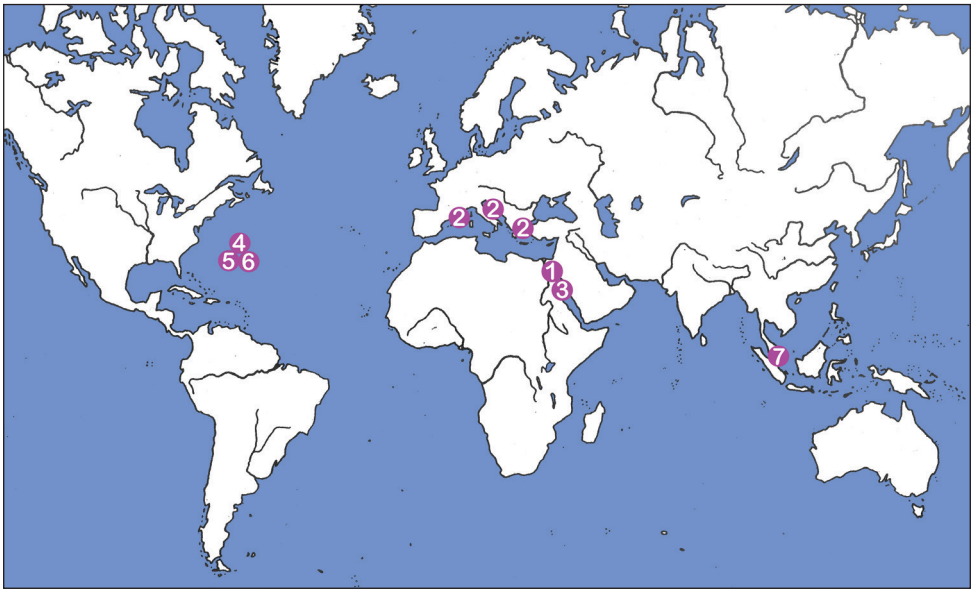

Figure 15. Map showing world distribution of the genus *Selenoribates*: **1** *S. foveiventris*, Egypt (Strenzke 1961) **2** *S. mediterraneus*, France, Croatia, Greece (Grandjean 1966) **3** *S. ghardaqensis*, Egypt (Abd-El-Hamid 1973) **4** *S. quasimodo* sp. n., Bermuda **5** *S. satanicus* sp. n., Bermuda **6** *S. elegans* sp. n., Bermuda **7** *Selenoribates* sp., Singapore (leg. Ilse Bartsch).

on the other hand, may represent members of another lineage within the genus *Selenoribates*. However, the new species are unambiguous members of *Selenoribates* and based on their morphology, the genus diagnosis provided by Grandjean (1966) should be slightly adjusted as it was done here in the results part.

Knowledge about juvenile morphology of this taxon is largely incomplete and only Grandjean (1966) gave a detailed description of the deuto- and tritonymph of *S. mediterraneus*. Unfortunately, only the proto- and tritonymph of *S. quasimodo* sp. n. and the larva of *S. satanicus* sp. n. were available for the present study, so a comprehensive comparison and analysis of the ontogeny is not feasible. Nevertheless, the instars of *S. quasimodo* sp. n. and *S. satanicus* sp. n. posses a centrodorsal plate framed by lateral and ventral folds, the typical habitus of selenoribatid juveniles, and further exhibit conformity in most aspects with the nymphs of *S. mediterraneus*, confirming the familial and generic relationship of the species. Besides that, the nymphs of *S. quasimodo* sp. n. show an interesting case of ontogenetic neotrichy with most of the gastronotic setae being duplicated with each moult so that their number increases from stage to stage. This type of neotrichy should be classified as a cosmiotrichy, as the placement of secondary setae follows a distinct arrangement (van der Hammen 1981). Neotrichy shown in juvenile stages is a rare but not unknown phenomenon in oribatid mites. Nymphs of *Hydrozetes parisiensis* exhibit secondary notogastral setae (Grandjean 1948), the juveniles of *Tricheremaeus nemossensis* also show neotrichy (Grandjean 1963) and the number of secondary setae is increasing from stage to stage

in the lohmanniid *Annectacarus mucronatus* (Grandjean 1950). But in all these examples the neotrichy persists throughout the adult stage, whereas in *S. quasimodo* sp. n. all the secondary setae get lost in the adults. However, to clarify the nature and the occurrence of this phenomenon in the genus *Selenoribates* it is necessary to investigate the complete development of all species.

The biogeographic distribution of the genus *Selenoribates* was formerly limited to the Mediterranean and the Red Sea, but the records of new species from Bermuda clearly demonstrate that members of this genus also exist on coasts of the Western Atlantic. Moreover, littoral samples from Singapore, kindly provided by Ilse Bartsch, also contained specimens of a yet undescribed *Selenoribates* species. These new findings suggest that members of this genus show a much wider distribution than formerly supposed (Fig. 15) probably occurring on most coasts of tropic and subtropic regions. However, not only the biogeography, but also the diversity of *Selenoribates* must be reconsidered based on the present data. Bermuda is, with ca. 55 km^2, one of the smallest countries of the world and harbours just as much *Selenoribates* species as the whole Mediterranean and the Red Sea together. Of course the Bermudian intertidal mite fauna may be derived from the Caribbean region and the species found on Bermuda may show a much wider distribution, but this clearly indicates that the real number of species may exceed the presently documented number by far. Pfingstl and Schuster (2012) already stated that within the Caribbean area, with its numerous islands, a relatively high diversity of selenoribatid species should be assumed and the same may apply to many other similar geographic regions, as for example the Indo-pacific area. However, if the genus *Selenoribates* is much more diverse than formerly known, the question arises why only a few species have been discovered yet and there are several possible answers to this question. First, *Selenoribates* specimens are relatively small for oribatid mites and may be easily overlooked, second, the littoral environment has been sampled only marginally in matters of oribatid mites and third, it is still unclear which microhabitat within the intertidal zone is usually occupied by *Selenoribates* species. Even in the present study specimens of this genus were found infrequently and in very small abundances. Accordingly it was not possible to assess if these mites are specifically associated with rocky or sandy substrate or with a specific alga etc. Nevertheless, further studies should answer the question of ecological needs and preferences and maybe then it will be easier to sample *Selenoribates* and reveal further species.

Acknowledgments

I am indebted to the Bermuda Institute of Ocean Sciences (BIOS) Inc. and its staff for the provision of research facilities and accommodation. I want to thank Wolfgang Sterrer for his valuable and continuous support. Special thanks to Reinhart Schuster, who discovered the first specimens of *Selenoribates quasimodo* 40 years ago, for his important advices and help in all respects. Thanks also to Ilse Bartsch providing samples from Singapore; the samples were collected during the Comprehensive Marine Biodi-

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Appendix

Table of localities. (doi: 10.3897/zookeys.312.5478.app) File format: Microsoft Excel file (xls).

Explanation note: Detailed information on sampling localities of the three new Selenoribates species.

Citation: Pfingstl T (2013) Revealing the diversity of a once small taxon: the genus *Selenoribates* (Acari, Oribatida, Selenoribatidae). ZooKeys 312: 39–63. doi: 10.3897/zookeys.312.5478 Table of localities. doi: 10.3897/zookeys.312.5478.app

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RESEARCH ARTICLE

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Agistemus aimogastaensis sp. n. (Acari, Actinedida, Stigmaeidae), a recently discovered predator of eriophyid mites *Aceria oleae* and *Oxycenus maxwelli*, in olive orchards in Argentina

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§ *urn:lsid:zoobank.org:author:2C8D7CCB-3013-459D-A606-F60CD0CE13E0*
| *urn:lsid:zoobank.org:author:068E86AE-4CA3-42CF-93BC-30D9D6E2E06E*

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Abstract

A new species, *Agistemus aimogastaensis*, is described with the aid of optical and Scanning Electron Microscopy. This mite is an important predator of two eriophyid mites (*Aceria oleae* and *Oxycenus maxwelli*) in olive orchards (*Olea europaea*, variety Arauco) in La Rioja Province. The problems related to eriophyids in olive orchards in Argentina are highlighted and photos of the damage on leaves and fruit are included.

Keywords

Agistemus aimogastaensis, new species, predator, *Aceria olea*, *Oxycenus maxwelli*, Olive orchards, Argentina

Introduction

Species of the genus *Agistemus* are considered important predators on phytophagous mites, scale insects and their eggs. Recently several studies have been done on agriculturally important crop plants, such as apple, pear and citrus orchards, blackberry fruits, coconut, coffee, and fig trees, grapevines, leguminous plants, Yerba mate trees, medicinal and ornamental plants as well as vegetable crops and the stored products of these plants (Ehara 1962; Gonzalez-Rodriguez 1961; Momen 2012; Liana and Juarez 2012; Momen 2011; Al-Atawi 2011; Marchetti and Juarez 2011; Saber and Rasmy 2010; Thakur et al. 2010; Roy et al. 2006, 2008, 2009; Fadamiro et al. 2009; Kawashima et al. 2008; Jamieson et al. 2008; Matioli et al. 2007; Gotoh and Shida 2007; Matioli and De Oliveira 2007; De Gouvea et al. 2007; El-Sawi and Momen 2006; Mineiro et al. 2006; De Vis et al. 2006; Bostanian et al. 2006; Putatunda 2005; Yousuf and Chouhan 2004; Arbabi and Singh 2002; Abou-Awad et al. 2000).

Little is known about *Agistemus* species as predators of eriophyid mites in Olive orchards (Momen 2012; Abou-Awad et al. 2010) and this is the first report of this genus from olive orchards in Argentina.

The genus *Agistemus* was erected by Summers (1960) based on type species *Caligonus terminalis* Quayle 1912. Grandjean (1944) published a work on the family Stigmaeidae, and established a series of characteristics with reference to legs and palp chaetotaxy. Further contributions to the present definition of the family were made by Gonzalez-Rodriguez (1961, 1963, 1965) and Summers and Ehara (1965).

Material and methods

All specimens were collected individually from tree surfaces (vegetative buds, leaves, inflorescences, or fruits) and preserved in 70% ethanol. Specimens studied by means of light microscopy were macerated in lactic acid and observed in the same medium, using the open-mount technique (cavity slide and cover slip) as described by Grandjean (1949) and Krantz and Walter (2009). Drawings were made using an Olympus BHC compound microscope (Rungis, France) equipped with a drawing tube. Some specimens were studied by means of a Scanning Electron Microscope (SEM). For this purpose, specimens preserved in ethanol were carefully rinsed by sucking them several times into a Pasteur pipette, and these were then transferred to buffered glutaraldehyde (2.5%) in Sörensen phosphate buffer: pH 7.4; 0.1 m for 2 hours. After postfixation for 2 hours in buffered 2% OsO_4 solution and rinsing in buffer solution, all specimens were dehydrated in a series of graded ethanols and dried in a critical point apparatus. Specimens were mounted on Al-stubs with double-sided sticky tape and then gold coated in a sputter apparatus (Alberti and Fernandez 1988; Alberti and Fernandez 1990a, 1990b; Alberti et al. 1991; Fernandez et al. 1991; Alberti et al. 1997; Alberti et al. 2007). For a study of the genito-anal plates and genital structures, specimens were dissected and monitored during the lactic acid maceration process

(in warm 70% lactic acid) before being stained with chlorazol black E, a well-known stain (Coineau 1974). Measurements taken: total length (tip of rostrum to posterior edge of notogaster) and width (widest part of notogaster) in micrometres (μm). Leg chaetotaxy studies made using standard, polarized and phase contrast microscopes. Setal formulae of the legs include the number of solenidia (in parentheses); Setal length measured with SEM.

Morphological terminology

Morphological terms and abbreviations used are those developed by Grandjean (1944), Summers (1960) and Gonzalez-Rodriguez (1963), Kethley (1990), We add the term: longitudinally aligned tiny round-convex elevations (*r.c.e*) in reference to structures on the postocular body.

New taxon description

***Agistemus aimogastaensis* sp. n.**
urn:lsid:zoobank.org:act:21DBBD18-3CF8-42B0-9F79-41FEC0BB98D2
http://species-id.net/wiki/Agistemus_aimogastaensis

Etymology. The specific epithet is dedicated to the city of Aimogasta, La Rioja, Argentina, where the specimens were found.

Material examined. Holotype female and 2 female paratypes, Aimogasta, Province de La Rioja, Argentina 11-NOV-2012 deposited in Instituto Nacional de Tecnologia Agropecauria (INTA), Aimogasta, La Rioja Argentina; 4 Paratype females, same date and locality as holotype deposited in Museum National d'Histoire Naturelle, Paris, France and 4 paratypes, same date and locality as holotype deposited in Geneva Natural History Museum, Switzerland. All preserved in 70% ethanol. All type specimens were collected from vegetative buds, leaves, inflorescences and fruit of *Olea europaea*, variety Arauco.

Diagnosis (adult female). Propodosomal plate: trapezoidal; ornamented with a faintly accentuated, polyhedral reticulate pattern; eyes clearly visible, ovoid convex, smooth; post ocular body triangular, rounded extremities, with series of longitudinally aligned small round-convex elevations, joined by thread–like strands. **Metapodosomal plate** hexagonal to polyhedral; ornamented with accentuated transverse polyhedral reticulate pattern. Wide area with fine transverse integumental striae, separating propodosomal and metapodosomal plates. **Humeral** and **intercalar** plates marginally. **Setae** *g*, ps_1, ps_2 similarly shaped, finely barbate, sharply tipped; ps_3 minutely dentate, truncate *g*, ps_1, ps_2 larger than ps_3 and very different in shape and appearance in optical and SEM. **Legs**: genua II, III, IV setal formula 0-0-0; leg IV lacks solenidion. Ambulacra with two claws and empodium with three pairs of bicapitate, fan shaped Y-raylets.

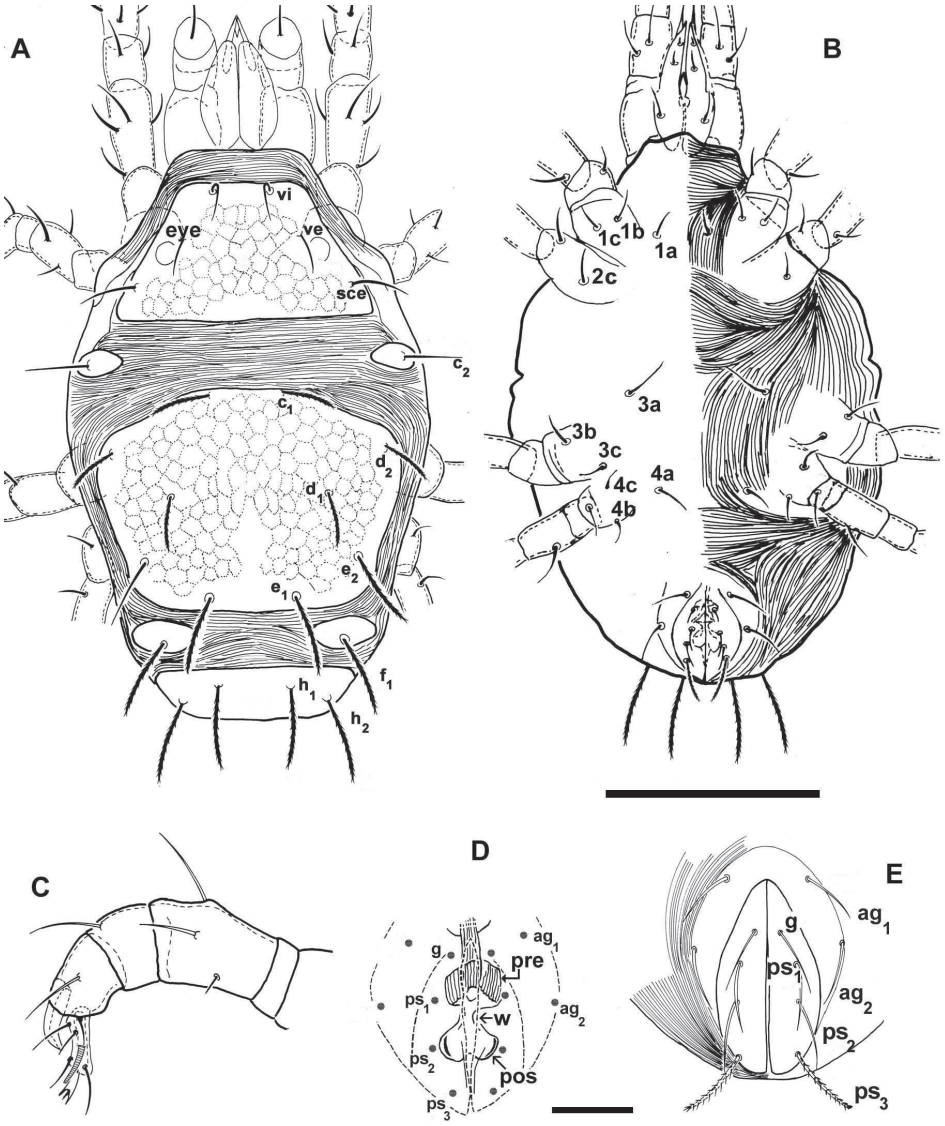

Figure 1. *Agistemus aimogastaensis* sp. n. Adult female, optical microscopy. **A** dorsal view **B** ventral view **C** palp **D** cuticular components of genital chamber; the anogenital covers are presented as indication of its relation to genital organs. E, anogenital covers. Abbreviations see Material and methods. Scale bars: **A**, **B**: 100 μm; **C**, **D**, **E**: 15 μm.

This species most closely resembles *Agistemus collyerae* Gonzalez-Rodriguez 1963, principally in relation to the setation of leg IV. However *A. aimogastaensis* can be easily differentiated from the latter on account of the disposition and shape of propodosomal, metapodosomal, humeral and intercalar plates; as well as the length and disposition of dorsal setae. Specific characters given by Gonzalez-Rodriguez for *A. collyerae* in relation to the unusual lengths of the ag_2 setae (pg_2 *sensu* Gonzalez-Rodriguez

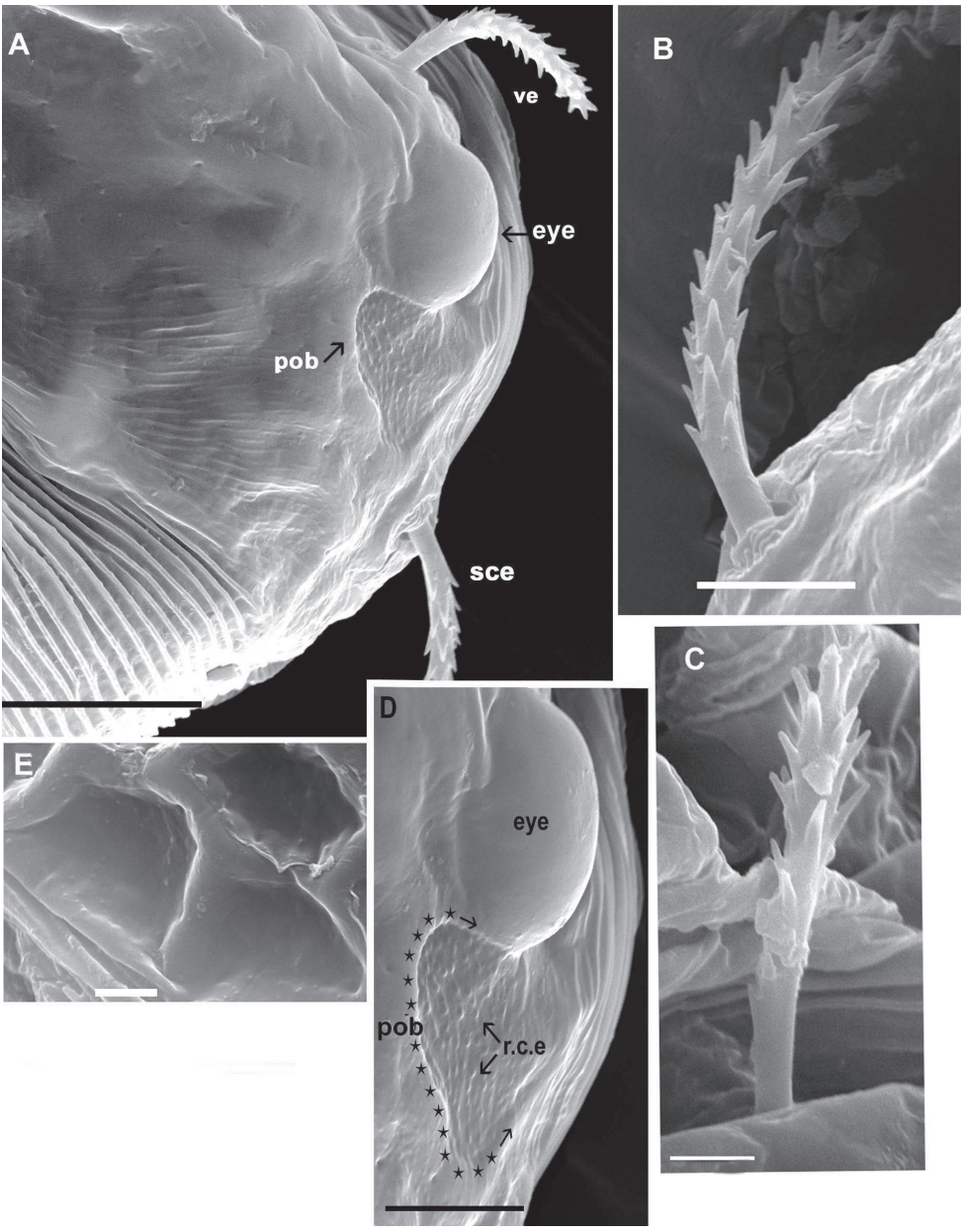

Figure 2. *Agistemus aimogastaensis* sp. n. Adult female, SEM. **A** eye and post ocular body, lateral view **B** external scapular setae (*sce*), lateral view **C** internal vertical setae (*vi*), lateral view **D** eye and postocular body, detail, lateral view (indicated by stars and arrow) **E** ornamentation, metapodosomal plate. Abreviations: see Material and Methods. Scale bars: **A**: 10μm; **B**, **D**, **E**: 5μm; **C**: 2μm.

1963) and *g* setae (g_1 sensu Gonzalez-Rodriguez 1963), and the equal lengths of the other setae ag_1, ps_1, ps_2 and ps_3 (g_2, g_3, g_4, pg_1, Fig. 8, Gonzalez-Rodriguez 1963) is very different to the situation found in *A. aimogastaensis*, where these setae are equal in size

and shape; but setae ps_3 (g_4 *sensu* Gonzalez-Rodriguez 1963) is completely different to the other setae, both in shape and length. Finally, another important character is the post–ocular body (*pob*) and the microsculpture around this zone. The *pob* in *A. aimogastaensis* is triangular with rounded extremities, and the microsculpture around this zone is smooth to fine integumental striations; in *A. collyerae* the *pob* is round and the surrounding microsculpture is a thin-walled network or reticulate.

Description. ***Measurements***: SEM: 325 (312–351) × 160 (152–173) Light microscopy: 336 (331–339) × 168 (166–174) (n=10).

Shape: ovoid (Figures 1A,B).

Colour: variable. Specimens observed in reflected light: orange-yellow, slightly shiny or white. We studied specimens of different colors and all were female.

Integument: (Figures 1A,B; 2A,D,E)

Microsculpture complicated, varying according to body region.

Propodosomal plate (P) polyhedral reticulate pattern: tiny accentuated polyhedral reticulated pattern, extending behind *vi* setal insertion and paraxially to *ve* and *sce* setal insertion, and paraxial to eye (*eye*) and post ocular body (*pob*). Near the eye and post ocular body and antiaxially to the *ve* and *sce* setal insertion smooth (Figs 2A,D). Existing paraxially to eye and *pob*, very fine integumental striae.

Metapodosomal (M) plate with polyhedral reticulate pattern, accentuate (Fig. 2D). Humeral plate (H), Intercalary plate (I), and Suranal plate (SA), more or less smooth (Fig. 1A).

Fine integumental striae covering zone between Propodosomal, Metapodosomal, Humeral, Intercalar and Suranal plates (Figs. 1A, 2A).

Fine integumental striae covering venter of idiosoma, epimeral zone smooth (Fig. 1B).

Legs: cuticular surface smooth.

Setation. All dorsal setae minutely denticulate and truncate (Fig.3C,D). Length: *vi* 12.60 (12.04-13.012); *ve* 13,78 (13.05-13.92); *sce* 18.80 (18.78-18.93); c_2 20.70 (19.89-21.01; c_1 19.5 (19.56-19.80); d_1 16.45 (16.43-16.48); e_1 18.1 (18.00-18.09); d_2 19.33 (19.23-19.92); e_2 17.80 (17.77-17.84); f_1 17.85 (16.01-17.69); h_1 14.20 (14.18-14.24); h_2 17.20 (17.16-17.24) .

Ventral setae: epimeric smooth (*1a*, *1b*, *1c*, *2a*, *3a*, *3b*, *3c*, *4a*, *4b*, *4c*); (ag_1, ag_2) and *g*, ps_1, ps_2, finely barbate (Fig.3E), sharply tipped; ps_3 minutely dentate, truncate (Fig.3F).

Length: ag_1 17.61 (17.58-17.66); ag_2 17.70 (17.68-17.75); *g* 17.25 (17.17-17.29); ps_1 17.40 (17.38-17.43); ps_2 18.20 (18.18-18.24); ps_3 17.05 (17.00-17.12).

In optical microscopy the dorsal setae and genital ps_3 appear as dark, while epimerics, paragenital and genitals (*g*, ps_1, ps_2) appear transparent. Scanning Electron Micrographs depicted in Figure 3.

Dorsal region (Figure 1A). Propodosomal plate (P) trapezoidal, with three pairs of setae: *vi* situated close to the anterior margin of plate; *ve* situated slightly anteriorly and paraxially to the eye and the postocular body (*pob*); *sce*, situated posteriorly and antiaxially to *pob*. All setae situated on very small protuberances.

Observation of eye and the postocular body (*pob*) (not shown on Fig.1A) is complex, because on mites not cleared the eye and the *pob* can both be observed, but in cleared animals only the eye is visible. Position of *ve* setae complicating observation in

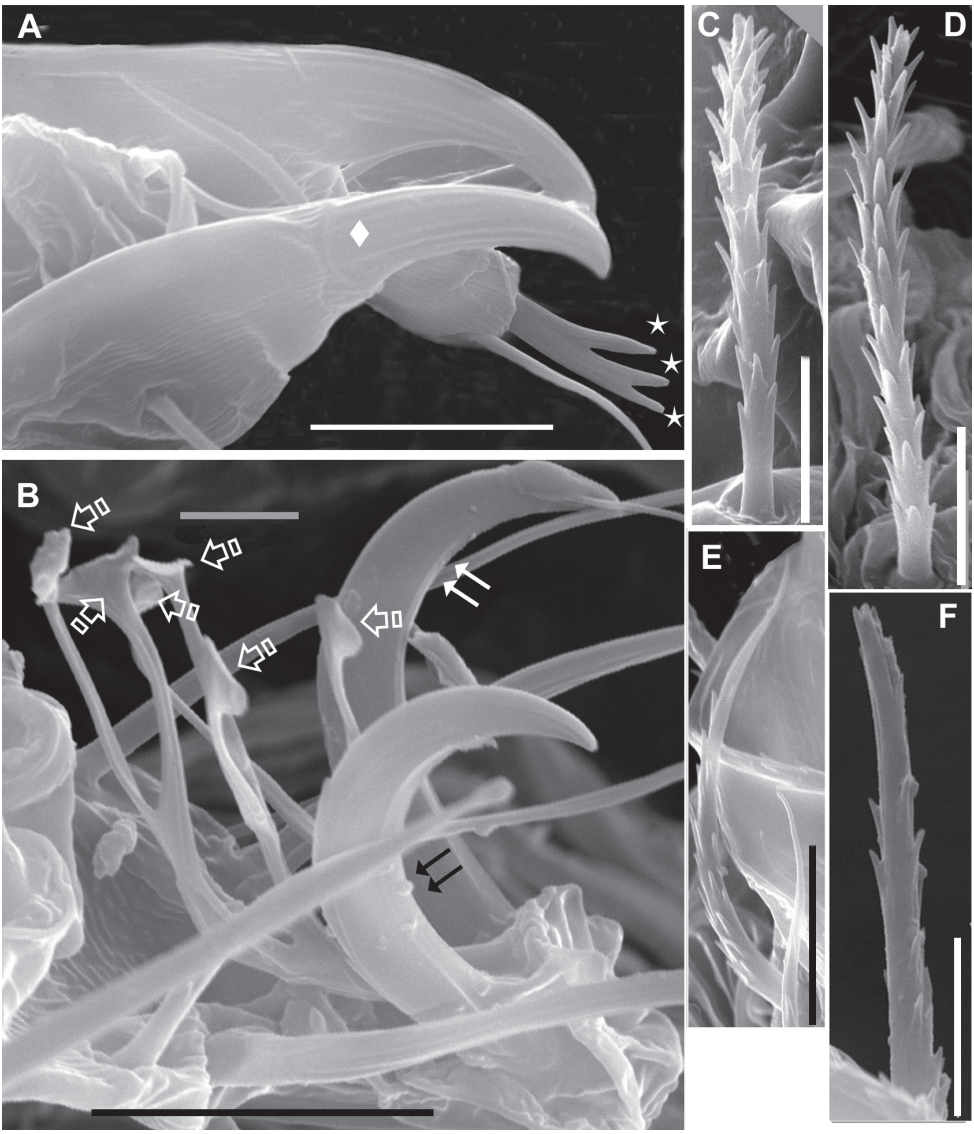

Figure 3. *Agistemus aimogastaensis* sp. n. Adult female, SEM. **A** palp, tibia and tarsus lateral view **B** ambulacrum leg I, lateral view **C** dorsocentral *a* setae **D** dorsolateral *la* setae **E** ps_2 setae. F ps_3 setae. Abreviations see material and Methods. Scale bars: **B**, **E**: 5µm; **A**, **C**, **D**, **F**: 5µm. Small stars indicate the association of eupathidia *ul'*, *ul"* and *sul*. Diamond indicates palp tibial claw. Double arrow, indicates claw, and special single arrow indicate capitate fan-shaped raylets.

optical microscopy. SEM permits observation of the eye in dorsal view (Fig.2A,D) as a smooth structure, ovoid and convex in lateral view; length: 9.55 (9.48-9.56) ; width: 6.28 (6.26-6.29) . The *pob* has a more or less triangular shape with rounded extremities (Fig.2A, D); 5.81(5.79-5.83) in length and 5.34 (5.32-5.37) in width; a series of longitudinally aligned slightly rounded-convex elevations (*r.c.e*) present, joined by

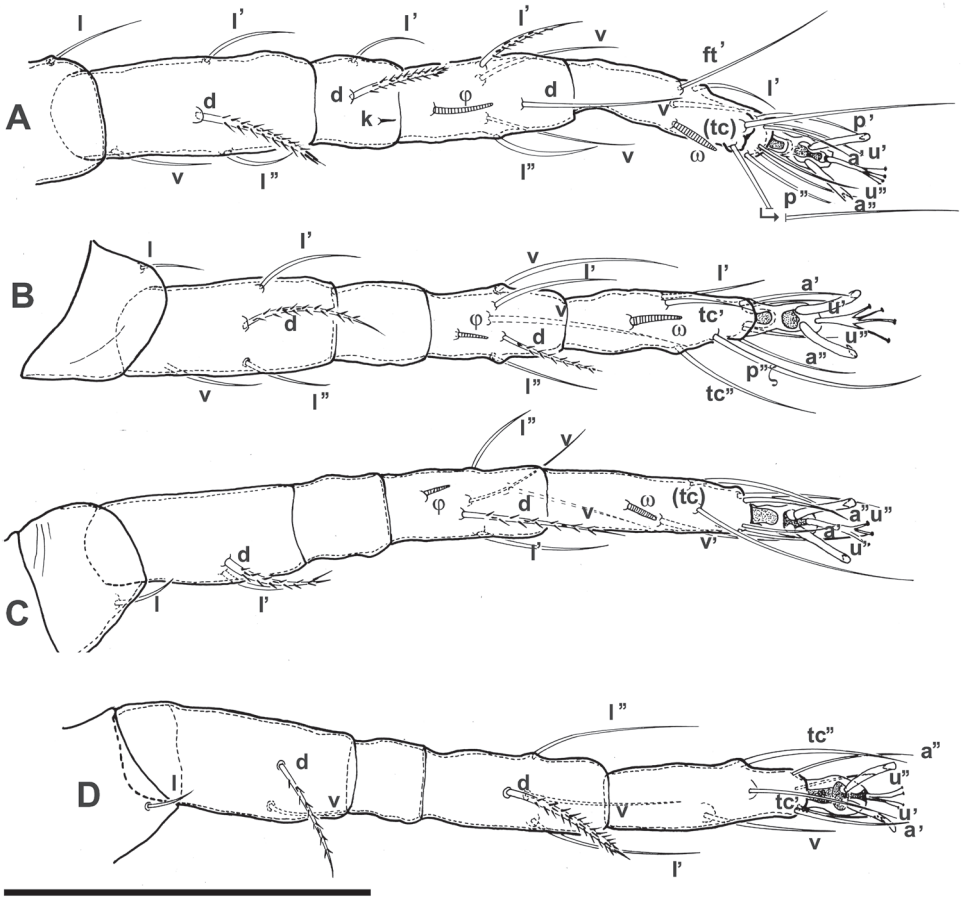

Figure 4. *Agistemus aimogastaensis* sp. n. Adult female, legs. All legs in dorsal view. Abbreviations: see Materials and Methods. Scale bar **A–D**: 50 μm.

thread–like strands. In recently mounted specimens (observed in optical microscopy), the *pob* presenting small red-yellow spots, disappearing quickly; possibly these spots are the *r.c.e* observed in SEM.

Propodosomal and metapodosal plates separated by a relatively large expanse of fine integumental striae (Fig. 1A, 2A).

Humeral plate (H) ovoid, situated antiaxially to P-plate and slightly antiaxially to M-plate; setae c_2 insertion situated slightly paraxially to d_2 insertion level (Fig. 1A).

Metapodosomal plate (M) hexagonal to polyhedral.

Dorsocentral setae: insertions c_1 and e_1 situated on the same longitudinal level; d_1 insertion situated antiaxially to c_1 and e_1 insertion level. Dorsolateral setae: d_2 insertion situated externally and close to plate margin, posteriorly to c_1 insertion level but anteriorly to d_1 insertion level; e_2 situated slightly paraxially to the d_2 insertion level and posteriorly and antiaxially to d_1 insertion level (Fig. 1A).

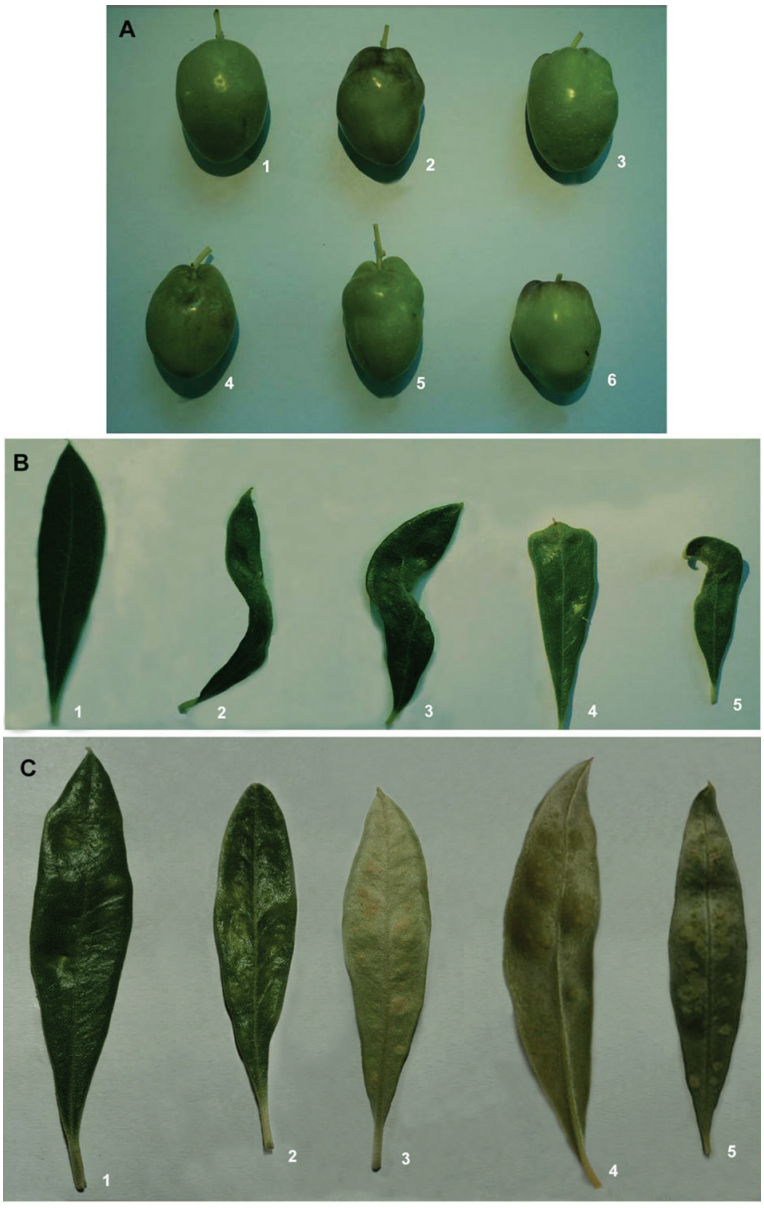

Figure 5. Malformations induced by eriophyid mites on leaves and fruit. **A** affected leaves **B** affected fruit. The upper left fruit is normal, others with malformations **C** young fruit attacked by *A. oleae* **D** detail of attack in **C.**

Intercalary plates (I) ovoid, situated near the body margin (Fig. 1A); f_1 setal insertion situated paraxially to e_2 insertion level and antiaxally to e_1 insertion level.

Ventral region. Epimera well defined (Fig. 1B). Setal formulae: 3-1-3-3. Anogenital region clearly discernible. Two pairs of paragenital setae: ag_1, ag_2; and four pairs

of setae: *g*, and three anal setae ps_1, ps_2, ps_3 (see Setation). *g*, ps_1, ps_2 and ps_3 differing in shape (See Setation).

Cuticular components of the genital chamber with *preatrium* (*pre*), saucer-shaped structure, longitudinal striate and *postatrium (post)* bilobed; between *pre* and *pos* a constriction or waist (*w*) (Fig. 1D).

Legs (Figure 4A–D). All legs with ambulacrum, composed of two claws with small tooth, and an empodium with three pairs of capitate fan-shaped raylets (resembling leaves of *Ginkgo biloba* tree) (Fig. 3B).

Setal formulae (solenidia in parentheses) I (1-4-2(1)-5(1)-11(1)); setae *k* on genu I; II (1-4-0-5(1)-8(1)); III (1-2-0-5(1)-7(1)); IV (1-2-0-4-7).

Setal formulae of palp (3-1-2-8(1)) (Fig.1C); tarsus with four eupathidia and solenidion ω; (*ul*) ζ, *sul* ζ united in fork, with typical characteristics of Stigmaeidae (Grandjean 1944). Palp tibial claw present (Fig.3A).

Remarks. The post ocular body, delimited by red-yellow spots, is clearly visible in fresh recently prepared specimens, but these spots disappear quickly making it difficult to view; this situation is similar to observations made on *Hydrozetes lemnae* (Oribatida, Hydrozetidae) and at the base of the ultrastructural studies of secondary eye (Alberti and Fernandez 1988, 1990a,b).

Our observations on cuticular components of the genital chamber using optical microscopy must be indicated as relative, and we stress that their value for taxonomic studies is limited as their main significance is only to confirm adulthood [as indicated by Summers and Ehara (1965)].

Problems with Olive orchards in Argentina related to eriophyid mites and their predator *Agistemus aimogastaensis* sp. n.

The Olive industry in Argentina is significant, with several provinces such as Mendoza, San Juan, San Luis, La Rioja and Catamarca producing olive fruit and their derivatives, though levels of production may vary. Olive production plays a very important socio-economic role as principal provider of employment in La Rioja and Catamarca Provinces.

In olive orchards eriophyid mites are considered a secondary pest (International Olive Council 2007; Spooner et al. 2007) relating to young trees, and a problem in greenhouses or in zones with high humidity and temperature (Spooner et al. 2007). Regrettably, in Argentina, this problem has high incidence and produces large losses in olive industry yield, reaching up to 20%.

The predominant species of eriophyid mites found in Catamarca and La Rioja Provinces on *Olea europaea* (variety Arauco) are *Aceria oleae* and *Oxycemus maxwelli*. Of these two, *A. olea* is predominant with a maximum on leaves and fruit in April and November. These two eriophyid mites cause a significant impact on regional economies due to significant fruit and leaf malformations (Figure 5).

The predator *Agistemus aimogastaensis* was found in these two provinces in large numbers, principally in relation to the population level of eriophyid mites.

The possibility exists of using this predator as biological control measure of problematic eriophyid mites. Our laboratory observations show that *A. aimogastaensis* is a voracious predator, principally on *A. olea*. All ontogenetic stages prey on the mites. Several studies on different predation aspects are being conducted.

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RESEARCH ARTICLE

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First record of the aphid genus *Jacksonia* Theobald (Hemiptera, Aphididae, Aphidinae) from China, with description of one new species

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Abstract

The aphid genus *Jacksonia* Theobald is reported in China for the first time, from Shaanxi, with the description of a new species, *Jacksonia gibbera* Qiao, Li, Zhang & Su, **sp. n.**, found on an unidentified plant belonging to the Leguminosae/Fabaceae. A key to species of *Jacksonia* is provided.

Keywords

Jacksonia, Aphididae, new record genus, new species, China

Introduction

The aphid genus *Jacksonia* was erected by Theobald (1923), with a description of the type species *Jacksonia papillata*. It was distinguished by the peculiar shape of the siphunculi, constricted at the middle, without a flange or any reticulation, and well-developed antennal tubercles which are converging, rough and very broad. Until now, this genus is represented by only three known species in the world (Ghosh 1986; Heie 1994; Raychaudhuri 1980; Remaudière and Remaudière 1997; Favret 2013). After identifying the specimens from Shaanxi, China, and comparing the original descriptions of the known species, one new species of *Jacksonia* is reported from China, *Jacksonia gibbera* Qiao, Li, Zhang & Su, sp. n. It was collected on an unidentified species of Leguminosae (Fabaceae).

Taxonomy

***Jacksonia* Theobald, 1923**
http://species-id.net/wiki/Jacksonia

Jacksonia Theobald 1923: 19. Type species: *Jacksonia papillata* Theobald, 1923; 19–20 & Figs A–E, by monotypy.

Jacksonia Theobald: Eastop and Hille Ris Lambers 1976: 229; Miyazaki 1971: 112; Raychaudhuri 1980:154; Ghosh 1986: 92; Heie 1994: 43; Remaudière and Remaudière 1997: 105; Blackman and Eastop 2006: 1183.

Generic diagnosis. In apterous viviparous female: Body broadly elongate. Head scabrous, with dense spinules or warts on dorsum and venter. Antennal tubercles well developed, strongly converging, broad and covered with many warts; medial frontal tubercle indistinct. Antennae 6-segmented, shorter than body, antennal segments I-V with distinct warty imbrications, primary rhinaria non-ciliated or ciliated. Ultimate rostral segment wedge-shaped, with 2 or 3 accessory setae. Distal 2/3 of femora and bases of tibiae with warty imbrications, hind tibiae of nymphs without spinules. First tarsal chaetotaxy 3, 3, 2, or 3, 3, 3. Antennal and dorsal body setae short, blunt or acute at apex. Dorsum of body scabrous; pale or with dark bands on abdominal tergites VI-VII. Siphunculi cylindrical, wide at base, narrow at middle and again becoming wide, with oblique or central aperture lacking a flange, with scabrous imbrications. Distance between 6th and 7th spiracles much less than that between 5th and 6th. Cauda tongue-shaped, with blunt apex, shorter than siphunculi, with 4-6 setae. Anal and genital plates broadly circular, genital plate with 6-19 posterior setae and 2 anterior setae.

In alate viviparous female: Dorsum of head smooth or sparsely to densely spinulose, venter smooth. Frontal setae with acute apices. Antennal segments I-V with normal imbrications, segments III-V with small or large round or transverse oval secondary rhinaria. Fore wings with two-forked medial veins, hind wings with 2 oblique

veins. Abdominal tergites with brown or blackish brown spino-pleural and marginal patches, spino-pleural patches on tergites III-V usually fused to form a large dorsal patch. Others similar to apterae.

Distribution. India, Japan, Europe and newly recorded from China (Shaanxi). In Blackman and Eastop (aphidsonworldsplants.info): India (*J. campanulata*); in regions with temperate oceanic climates throughout the world, including many oceanic islands (e.g. Iceland, Faroes, Azores, Auckland Is., Macquarie Is., South Georgia) (*J. papillata*).

Host plants. On various species of Poaceae (*Dactylis*, *Deschampsia*, *Festuca*, *Poa*), but also with species described from *Campanula* and an unidentified plant belonging to the Leguminosae/Fabaceae. Other recorded hosts are likely to be casual occurrences (Blackman and Eastop 2006).

Comments. This genus is related to *Myzus* Passerini, 1860, but apterae can be distinguished from the latter by the peculiarly shaped siphunculi and the very broad antennal tubercles. The genus is also very similar to *Xenosiphonaphis* Takahashi, 1961, in having very broad antennal tubercles and flangeless siphunculi, but in *Xenosiphonaphis,* the inner apex of the antennal tubercles is only slightly converging. The alatae also differ: in *Jacksonia*, the basal halves of the siphunculi are without spinules, transverse wrinkles or grooves while those of *Xenosiphonaphis* have transverse wrinkles or grooves on the basal half.

***Jacksonia gibbera* Qiao, Li, Zhang & Su, sp. n.**
urn:lsid:zoobank.org:act:50411893-02D1-4A72-80BB-C97308737D08
http://species-id.net/wiki/Jacksonia_gibbera
Figures 1–27

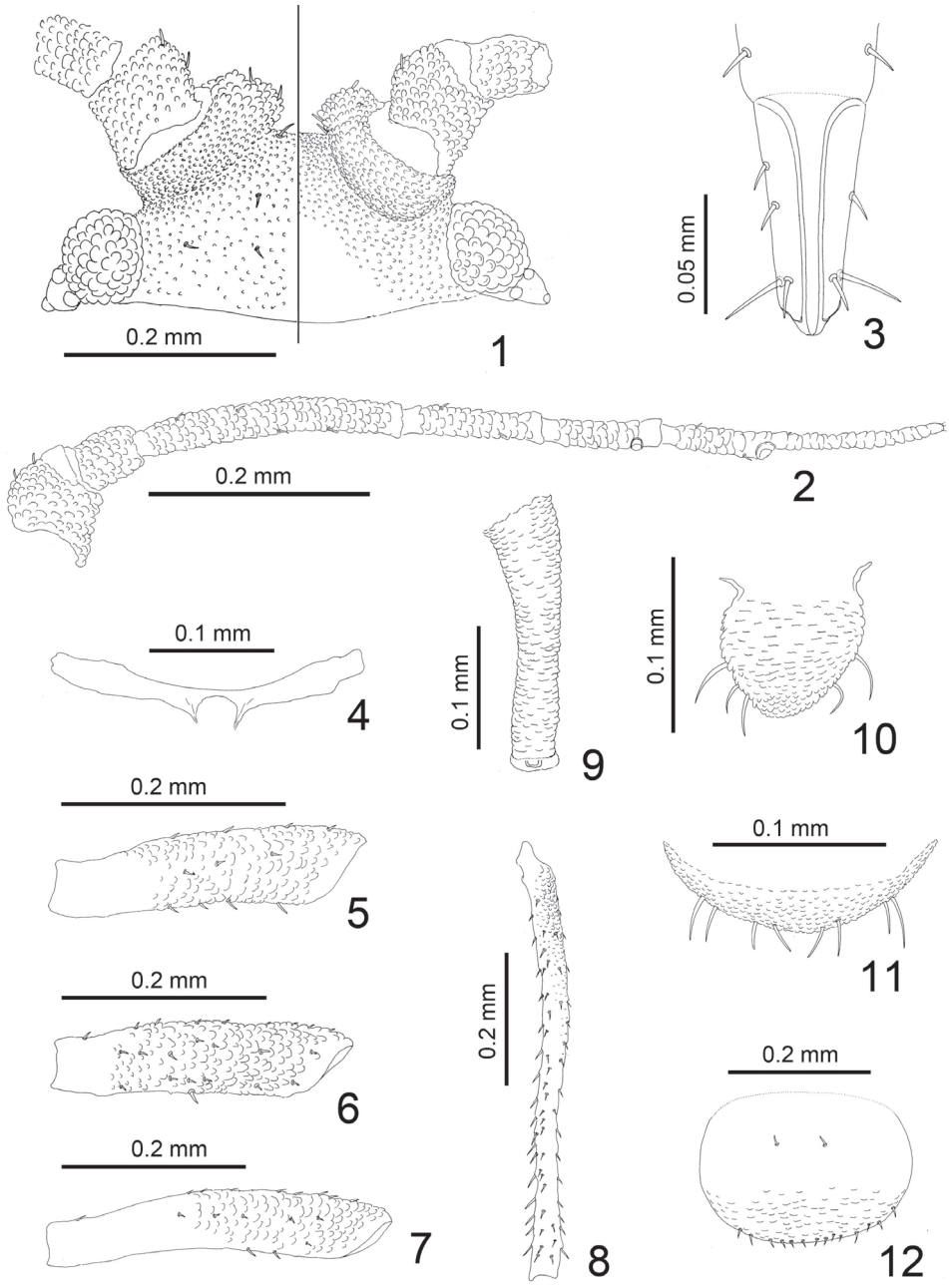
Locus typicus. China (Shaanxi, altitude 3620 m).

Etymology. The new species is named for the slightly elongated distal half of the siphunculi; "*gibbera*" (Latin) means "gibbous or humpy".

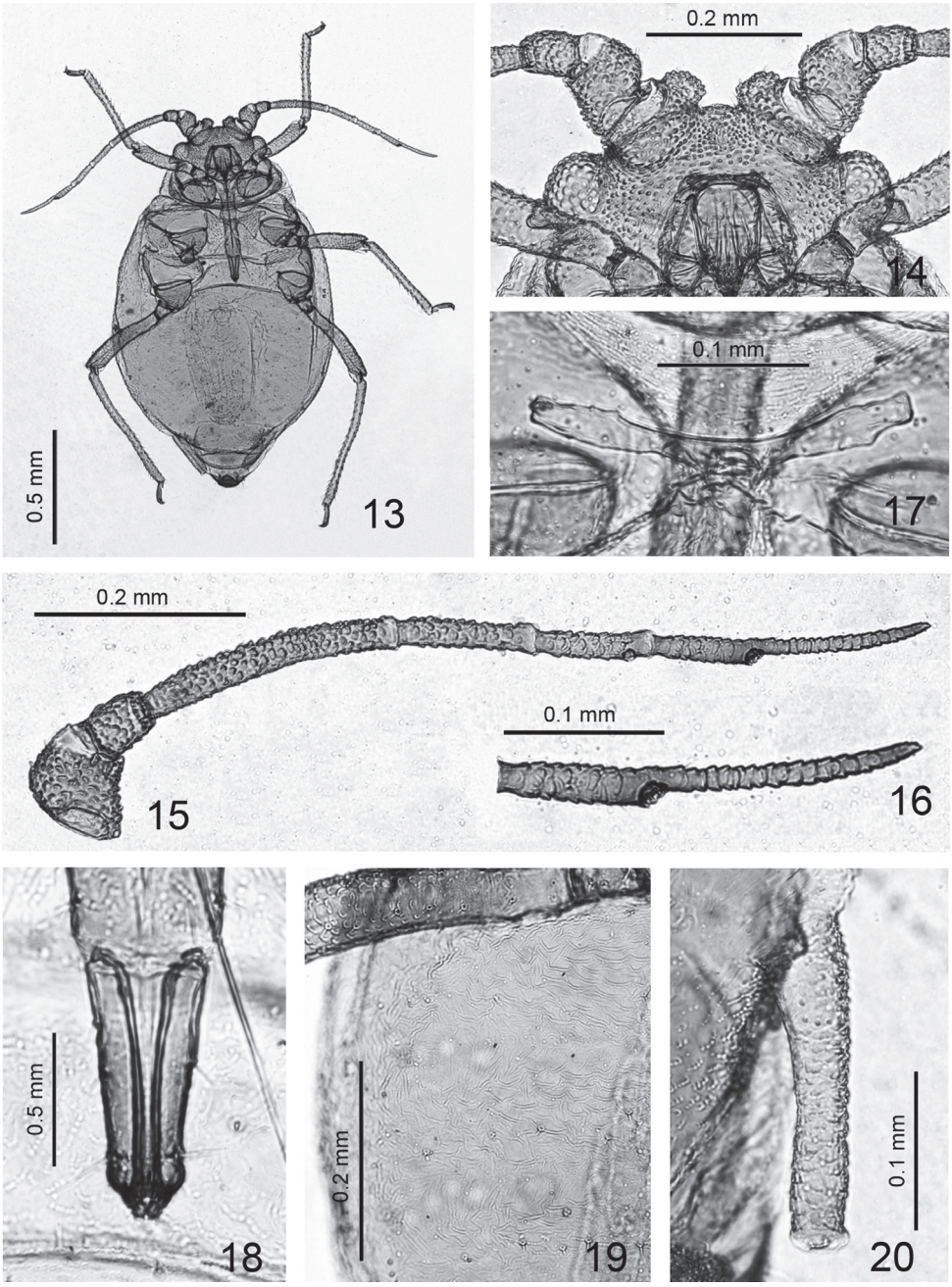
Specimens examined. Holotype: apterous viviparous female, **CHINA:** Shaanxi (Zhouzhi County, Houzhenzi Town, Mount Qinling, altitude 3620 m), 21 Jun. 1999, No. 12309-1-1, on an unidentified plant of Leguminosae (Fabaceae), coll. T.L. He. *Paratypes*: 2 apterous viviparous females and 4 nymphs, with the same collection data as holotype.

Description. *Apterous viviparous females*: Body oval, 1.42–1.62 mm long, 0.82–0.95 mm wide. Green in life. In mounted specimens, body pale; apical parts of base of antennal segment VI and processus terminalis, apex of rostrum and tarsi brown, other parts pale (Fig. 13).

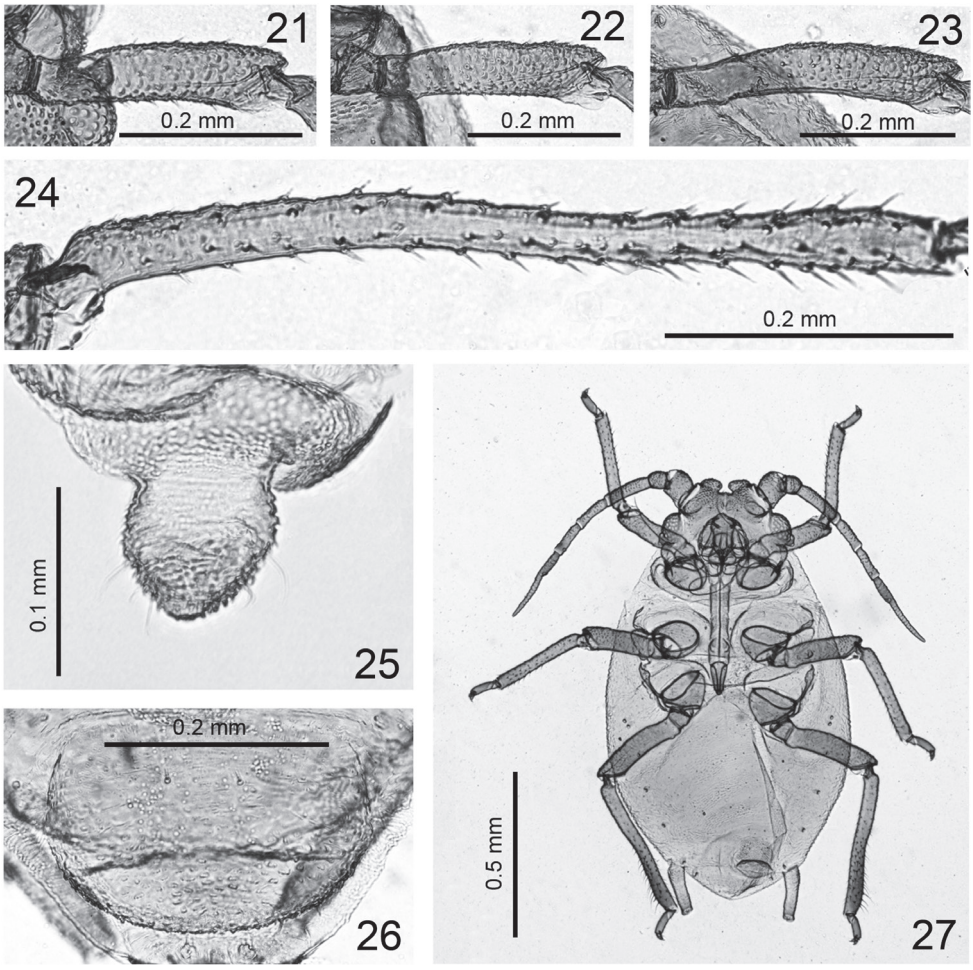
Head: Head scabrous, with dense spinules or warts on dorsum and venter, but warts on dorsal median area of head are sparse (Figs 1, 14). Dorsal setae of head very short, blunt or slightly expanded at apex. Head with one pair of frontal setae and two pairs on antennal tubercles, two pairs of dorsal setae between antennae, two pairs of dorsal setae between eyes. Frontal setae approximately as long as dorsal setae of head, 0.005–0.012 mm, 0.2–0.5 of basal diameter of antennal segment III. Antennal tuber-



Figures 1–12. *Jacksonia gibbera* Qiao, Li, Zhang & Su, sp. n. Apterous viviparous female: **1** dorsal (left) and ventral (right) views of head **2** antenna **3** ultimate rostral segment **4** mesosternal furca **5** fore femur **6** mid-femur **7** hind femur **8** hind tibia **9** siphunculus **10** cauda **11** anal plate **12** genital plate.



Figures 13–20. *Jacksonia gibbera* Qiao, Li, Zhang & Su, sp. n. Apterous viviparous female: **13** whole body **14** ventral view of head, antennal tubercles and antennal segments I-II **15** antenna **16** antennal segment VI **17** mesosternal furca **18** ultimate rostral segment **19** detail of abdominal cuticle **20** siphunculus.



Figures 21–27. *Jacksonia gibbera* Qiao, Li, Zhang & Su, sp. n. Apterous viviparous female: **21** hind femur **22** mid-femur **23** hind femur **24** hind tibia **25** cauda **26** genital plate **27** 3th instar nymph.

cles well developed, very broad, converging, with dense warts; medial frontal tubercle indistinct (Figs 1, 14). Antennae 6-segmented, segments I-V and base of segment VI with distinct warty imbrications (Figs 2, 15), processus terminalis with weak imbrications (Fig. 16), segment III slightly constricted at base (Figs 2, 15); antenna 0.87–0.88 mm long, 0.54–0.61 times length of body; segment III 0.26–0.27 mm, lengths of segments I-VI: 27-31, 19-22, 100, 46-47, 42-46, 32-38+52-61, respectively; processus terminalis 1.60–1.77 times base of segment. Antennal setae short and blunt, segments I-VI each with 3, 1, 6-7, 4, 4, 2+3 setae, respectively, apex of processus terminalis with three short setae; length of setae on segment III 0.005–0.007 mm, 0.22–0.30 times as long as basal diameter of the segment. Primary rhinaria not ciliated, secondary rhinaria absent (Fig. 2). Rostrum (Figs 3, 18) reaching between mid- and hind coxae, ultimate rostral segment wedge-shaped, 0.11–0.12 mm long, 2.15–2.53 times as long as its

basal width, 1.30–1.44 times as long as second hind tarsal segment, with three pairs of primary setae and two or three accessory setae.

Thorax: Dorsum of thorax with wrinkles, more distinct toward marginal area of body; pronotum with one pair of spinal and one pair pleural setae, respectively, marginal setae indistinct; metanotum with one pair of spinal, two pairs of pleural and one pair of marginal setae, respectively. Mesosternal furca with a short stem (Figs 4, 17). Spiracles small, reniform-shaped, closed; distance between 6th and 7th spiracles much less than that between 5th and 6th. Legs: distal 2/3–4/5 part of femora with distinct warty imbrications (Figs 5–7, 21–23), outer of basal part of tibia with warts (Figs 8, 24), others smooth. Hind femur 0.35–0.38 mm long, 1.28–1.46 times antennal segment III; hind tibia 0.55–0.61 mm long, 0.35–0.42 times length of body; setae on hind tibia long, thick and pointed, 0.025–0.030 mm long, 0.77–1.00 times as long as middle width of the segment. First tarsal chaetotaxy: 3, 3, 3. Second hind tarsal segment 0.08 mm long.

Abdomen: Abdominal tergites I-VI with wrinkles, more distinct toward marginal area of body (Fig. 19); posterior area of siphunculi with distinct spinules, tergites VII-VIII with sparsely spinulose transverse stripes; venter with spinulose transverse stripes. Dorsal setae of body very short, blunt or slightly capitate at apex, ventral setae short and acute. Abdominal tergites I-VII each with one pair of spinal setae, tergites I, V-VII each with one pair of marginal setae, tergites II-III each with two pairs of marginal setae, tergite IV with three pairs of marginal setae; tergite VIII with two dorsal setae. Length of marginal setae on tergite I about as long as dorsal setae on tergite VIII, 0.005 mm, 0.2 of basal diameter of antennal segment III. Siphunculi cylindrical (Figs 9, 20), constricted in middle, inner side of distal half slightly elongated; with dense imbrications, flangeless, ends of siphunculi truncated, with pore in central area; 0.20–0.21 mm long, 0.13–0.14 times as long as body, 3.42–4.32 times as long as its basal width, 2.2–2.3 times cauda. Cauda tongue-shaped, blunt at apex (Figs 10, 25), 0.09–0.094 mm long, 0.075–0.088 mm wide, with 4–5 setae. Anal plate semi-circular (Fig. 11), with 10 setae. Genital plate broadly circular (Figs 12, 26), with 10–14 posterior setae and two anterior setae.

Hind tibiae in immatures (third instar) without spinules, smooth (Fig. 27).

Host plant. An unidentified plant belonging to the Leguminosae/Fabaceae. It colonises the undersides of the leaves of the host plant.

Taxonomic notes. The new species is similar to the type species *Jacksonia papillata* Theobald, but apterae differ from this and *J. campanulata* by the characters given in the key below. The fourth species, *Jacksonia sikkimensis* Ghosh, Basu & Raychaudhuri, is known only from alate viviparous females.

Key to species of *Jacksonia* (apterous viviparous females)

1 Antennae shorter than 0.6 times body length; siphunculi constricted in middle, with distinct sculpture or spinules; abdominal tergites with wrinkles, polygonal reticulations absent..... **2**

– Antennae approximately 0.8 times body length; siphunculi subcylindrical without any medial constriction, smooth without sculptures or spinules; abdominal tergites with distinct polygonal reticulations (based on Chakrabarti and Raychaudhuri 1978: 97) ....***Jacksonia campanulata*** **Chakrabarti & Raychaudhuri**

2 Siphunculi 1.5–1.8 times cauda, scaly, with a rather small terminal, slightly oblique aperture (turned inwards); dorsum of head with dense warts uniformly distributed; primary rhinaria ciliated; only intersegmental abdominal areas with wrinkles; first tarsal chaetotaxy 3, 3, 2 (based on Ghosh 1986: 92–93; Heie 1994: 43–44) ..... ***Jacksonia papillata*** **Theobald**

– Siphunculi about 2.2-2.3 times cauda, with imbrications, slightly expanded on inner side of distal half, with a terminal, central aperture; dorsal median area of head with few warts; primary rhinaria not ciliated; whole abdominal tergites with wrinkles; first tarsal chaetotaxy 3, 3, 3..... .....***Jacksonia gibbera*** **Qiao, Li, Zhang & Su, sp.n.**

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RESEARCH ARTICLE

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A new species of *Amphibulus* Kriechbaumer (Hymenoptera, Ichneumonidae, Cryptinae) from Beijing with a key to species known from the Oriental and Eastern Palaearctic regions

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Abstract

A new species, *Amphibulus melanarius* Zong, Sun & Sheng, **sp.n.**, belonging to the tribe Phygadeuontini of the subfamily Cryptinae (Hymenoptera: Ichneumonidae), collected from Beijing, China, is reported. A key to the species of the genus *Amphibulus* Kriechbaumer, 1893 known in the Oriental and Eastern Palaearctic Regions is provided.

Keywords

Phygadeuontini, *Amphibulus*, new species, key, taxonomy, China

Introduction

Amphibulus Kriechbaumer, 1893, belonging to the subtribe Endaseina of tribe Phygadeuontini (Hymenoptera, Ichneumonidae, Cryptinae), comprises 26 described species

(Yu et al. 2012), of which two are from the Oriental Region (one also from the Eastern Palaearctic Region) (Luhman 1991), three from the Eastern Palaearctic, two from the Western Palaearctic, six from the Nearctic, 15 from the Neotropical and one from the Afrotropical Regions (Yu et al. 2012).

The European species of the genus *Amphibulus* were revised by Sawoniewicz (1990). A revision with 22 new species and a key to the world species was produced by Luhman (1991). Two species have been reported from China (Luhman 1991; Sheng 1999, 2009). A key to the genera of Endaseina found in China, including *Carinityla* Sheng & Sun, 2010, was provided by Sheng and Sun (2013). The status of *Amphibulus* was defined by Townes (1970) and Luhman (1991).

In this article a new species of *Amphibulus*, collected in Beijing, situated at the southern border of the Eastern Palaearctic part of China, is reported.

Materials and methods

Specimens were collected with intercept traps (Li et al. 2012) in the forests of Mentougou and Yanqing, Beijing (CHINA). The forest of Mentougou is composed of mixed deciduous angiosperms and evergreen conifers, mainly comprising *Pinus tabuliformis* Carr., *Larix gmelinii* var. *principis-rupprechtii* Mayr, *L. principis-rupprechtii* Mayr, *Betula dahurica* Pall., and *Quercus wutaishanica* Blume. The forest of Yanqing is composed of mixed deciduous angiosperms, mainly *Lespedeza bicolor* Turcz., *Vitex negundo* var. *heterophylla* (Franch.) Rehd., *Spiraea teniana* var. *mairei* (H. Lév.) L. T. Lu, *Ulmus pumila* L., *Populus* spp., *Salix* spp., and a few *Pinus tabulaeformis* Carr. and *Platycladus orientalis* (L.).

Images of whole bodies were taken using a CANON Power Shot A650 IS. Other images were taken using a Cool SNAP 3CCD attached to a Zeiss Discovery V8 Stereomicroscope and captured with QCapture Pro version 5.1. Morphological terminology is mostly based on Gauld (1991). Wing vein nomenclature follows Mason (1986, 1990).

Type specimens are deposited in the Insect Museum, General Station of Forest Pest Management (GSFPM), State Forestry Administration, Shenyang, People's Republic of China.

Taxonomy

***Amphibulus* Kriechbaumer, 1893**
http://species-id.net/wiki/Amphibulus

Amphibulus Kriechbaumer 1893. Entomologische Nachrichten, 19(8):122. Type-species: *Amphibulus gracilis* Kriechbaumer.

Diagnosis. *Amphibulus* can be distinguished from all other genera of Endaseina by the combination of the following characters: lower tooth of mandible shorter than upper tooth; median tubercle at upper edge of face small and rounded; posterior edge of mesoscutum with transverse suture, which is unusually conspicuous and complete; scutoscutellar groove without median longitudinal carina; sternaulus reaching to posterior margin of mesopleuron, anterior half deep and often sculptured; median dorsal carina of first tergite weak or absent.

Key to species of *Amphibulus* Kriechbaumer known from the Oriental and Eastern palaearctic regions

1 Male **2**
– Female **5**
2 Area spiracularis and area lateralis combined. Tergites 2–6 orange. (Pakistan) ..... ***A. salicis* Luhman**
– Area spiracularis and area lateralis separated by distinct carina. Tergites 2–6 black, or at most tergites 2–3 orange **3**
3 Lower end of occipital carina joining hypostomal carina at base of mandible. Fore wing with ramulus present as stub or swelling. Tergites 2–3 mostly orang. (Female unknown) (Korea) ..... ***A. bicolor* Luhman**
– Lower end of occipital carina joining hypostomal carina distinctly above base of mandible. Fore wing ramulus absent or at most present as a slight swelling. Tergites 2–3 black or mostly black **4**
4 Flagellomeres 10 and 11 with distinct tyloids. Propodeum without apophysis, area superomedia about as long as wide. Apices of tergites 2–6 yellowish. (China, Japan) ..... ***A. orientalis* Luhman**
– Flagellomeres 10 to 13 with distinct tyloids. Propodeum with apophysis, area superomedia distinctly longer than wide. Apices of tergites 2–6 entirely black. (Female unknown) (China) ..... ***A. albimaculatus* Sheng**
5 Area spiracularis and area lateralis combined. Clypeus about 2.5× as wide as long. Coxae black. Tergites 2–6 orange. ..... ***A. salicis* Luhman**
– Area spiracularis and area lateralis separated by carina. Clypeus at least 3.0× wider than long. Coxae red, orange or brown, or at least with orange or brown spots. Tergites 2–6 black, dark orange or brown **6**
6 First sternite reaching level of spiracle; postpetiole approximately as wide as long. Body mostly brownish or dark orange. Flagellomeres 9–11 white. Median portion of hind tarsus pale yellowish ..... ***A. orientalis* Luhman**
– First sternite reaching to about half way to spiracle; postpetiole approximately 1.4× as wide as long. Body almost entirely black. Flagellomeres 5–10 (11) white. Hind tarsus brown to brownish black. (Male unknown) (China) ..... ***A. melanarius* Zong, Sun & Sheng, sp.n.**

***Amphibulus melanarius* Zong, Sun & Sheng, sp.n.**
urn:lsid:zoobank.org:act:2173C040-6C15-45ED-962F-46E47F511D50
http://species-id.net/wiki/Amphibulus_melanarius
Figures 1–11

Etymology. The specific name is derived from the body being entirely black.

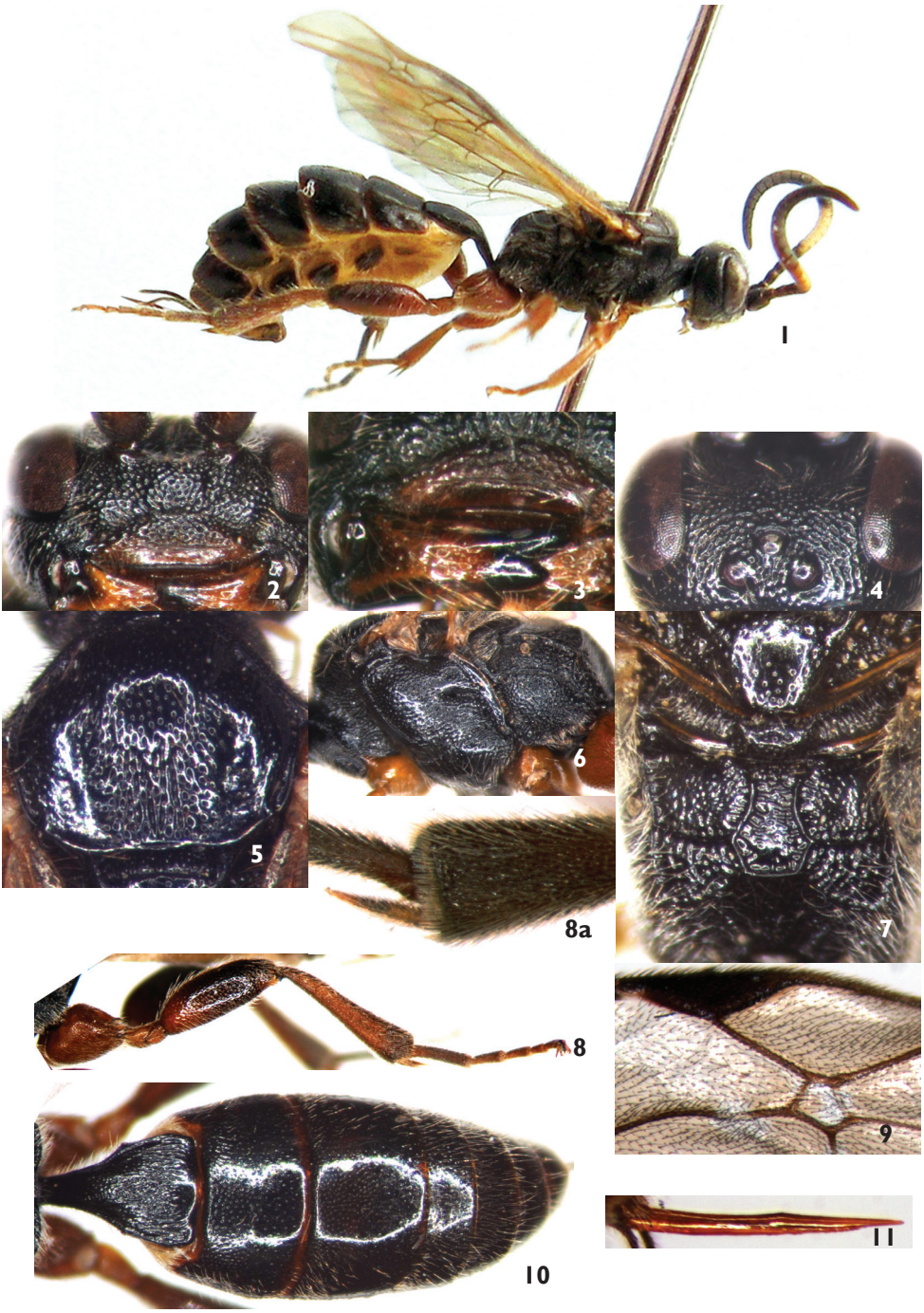
Types. Holotype, female, CHINA: Mentougou, 800 to 900 m, Beijing, 22 June 2011, leg. Shi-Xiang Zong. Paratypes: 4 females, same data as holotype except 15 to 22 June 2011. 1 female, CHINA: Songshan Natural Reserve, 672m, Yanqing, Beijing, 27 June 2011, leg. Shi-xiang Zong. 2 females, same data as holotype except 9 June 2012.

Diagnosis. Clypeus 3.0 to 3.3× as wide as long. Area spiracularis and area lateralis separated by carina. First sternite reaching about half distance to spiracle. Postpetiole approximately 0.75× as long as wide, with dense longitudinal wrinkles. Head except mandibles and clypeus, mesosoma and all tergites black. Flagellomeres 5 to 10 (11) white. Coxae red.

Description. Female (Figs 1–11). Body length 6.5 to 7.5 mm. Fore wing length 5.5 to 6.0 mm. Ovipositor sheath length approximately 1.0 mm.

Head. Face and clypeus with dense brown hairs. Face (Fig. 2) 2.6 to 2.7 times as wide as long, median portion slightly convex; with dense punctures. Clypeus 3.0 to 3.3× as wide as long, basal half with dense punctures, apical half smooth and shiny, with unclear, indistinct striations; subapical portion distinctly raised as a transverse ridge; apical margin deeply depressed, median section almost truncate. Mandible (Fig. 3) distinctly elongate, shiny, with sparse, fine punctures; base distinctly concave centrally; upper tooth evidently longer than lower tooth. Subocular sulcus indistinct. Malar space 0.55 to 0.6 times as long as basal width of mandible. Gena in dorsal view 1.1 to 1.2× as long as width of eye, with uneven, fine punctures, distance between punctures 0.5 to 4.0× their diameter. Vertex (Fig. 4) slightly shining, with irregular elongate punctures. Postocellar line 0.83 to 0.88× as long as ocular-ocellar line. Upper portion of frons almost flat, with dense punctures, distance between punctures 0.2 to 1.0× their diameter; mediocentral portion with fine transverse wrinkles; lower portion concave, smooth, shiny, with median longitudinal carina. Antenna with 25 or 26 flagellomeres, median portion of flagellum, flagellomeres 5 to 21, slightly widened; apical half cylindric. Ratios of lengths from first to fifth flagellomeres: 1.1:1.0:1.1:0.9:0.8. Apical truncation of scape 15 to 18 degrees from transverse. Occipital carina complete, lower end joining hypostomal carina at base of mandible.

Mesosoma. Anterior margin of pronotum with fine longitudinal wrinkles; lateromedian portion with transverse wrinkles; upper posterior portion with punctures, distance between punctures 0.5 to 1.5× their diameter. Anterior and lateral portions of mesoscutum (Fig. 5) smooth, shiny, with fine, sparse, indistinct punctures; posterior median portion with punctures and longitudinal wrinkles. Scutoscutellar groove with fine, short longitudinal wrinkles, without median longitudinal carina. Scutellum (Fig. 7) almost flat, shiny, with sparse, uneven punctures. Postscutellum trans-



Figures 1–11. *Amphibulus melanarius* Zong, Sun & Sheng, sp.n. Holotype. Female **1** Habitus, lateral view **2** Head, anterior view **3** Mandible **4** Head, dorsal view **5** Mesoscutum **6** Mesopleuron **7** Scutellum, postscutellum and propodeum **8** Hind leg **8a** Inner apical portion of hind tibia **9** Areolet **10** Metasoma, dorsal view **11** Ovipositor, lateral view.

versely convex, anterior portion transversely concave; with sparse punctures. Upper and anterior portions of mesopleuron (Fig. 6) with distinct punctures; mediocentral portion rough, with elongate punctures; lower posterior portion with transverse wrinkles. Epicnemial carina reaching to subtegular ridge. Speculum small, smooth, shiny. Metapleuron convex, with dense, elongate punctures. Submetapleural carina complete, anterior end strongly convex. Hind leg (Fig. 8) with dense brown setae. Apical truncation of hind tibia approximately transverse, internal side with dense, fine fringe of setae at the apex (Fig. 8a). Ratios of lengths of first to fifth hind tarsomeres are 3.8:2.0:1.7:1.0:1.5. Fore wing with vein 1cu-a distal to 1/M by about 0.5 to 1.5× width of vein. Areolet (Fig. 9) receiving vein 2m-cu approximately at posterior 0.3. 2m-cu almost vertical, with a wide bulla. Hind wing vein 1-cu 2.3 to 3.0× as long as cu-a. Propodeum (Fig. 7) completely areolated. Area basalis and area superomedia combined, with irregular punctures and short wrinkles; area externa with fine, indistinct punctures; area dentipara with indistinct punctures; area petiolaris with dense elongate punctures; remainder roughly sculptured. Propodeal spiracle small, circular.

Metasoma (Fig. 10). First tergite approximately 1.35 to 1.5× as long as apical width. Postpetiole approximately 0.75 as long as wide, with dense, fine longitudinal wrinkles. Dorsolateral and ventrolateral carinae complete. Spiracle circular, small, located approximately at posterior 0.3 of first tergite. Second tergite 0.5 to 0.6× as long as wide, with fine punctures, punctures on posterior portion much sparser and finer than that on anterior portion. Third tergite 0.6 to 0.7× as long as wide, anterior portion with fine, indistinct punctures, posterior almost smooth. Tergites 4 and 5 with dense brown hairs. Ovipositor (Fig. 11) with weak subapical nodus.

Color (Fig. 1). Black, except the following: anterior profiles of scape and pedicel, basal portion and anterior profile of apical half of flagellum slightly reddish black. Flagellomeres 5 to 10 (11) white. Apical portion of clypeus, mandible except base and teeth, maxillary and labial palpi, tegula, front and middle legs, hind coxa, trochanter, and base and ventral profile of femur, basal portion of hind tibia red to reddish brown. Dorsal surface of hind femur and apical portion of hind tibia dark brown. Hind tarsus brown to brownish black. Pterostigma and wing veins brownish black.

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