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Revision of the rhinoceros beetle genus *Oryctophileurus* Kolbe with description of a new species, the male of *O. varicosus* Prell, and notes on biogeography (Scarabaeoidea, Dynastinae, Phileurini)

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Abstract

The genus *Oryctophileurus* is reviewed and its validity is supported by a combination of the following apomorphic characters: a single cephalic horn with lateral carina, pronotal cavity with ocellate punctures and two teeth or tubercles close behind the anterior pronotal margin. The male of *Oryctophileurus varicosus* Prell, 1934, is described for the first time. A new species, *Oryctophileurus guerrai* Perger & Grossi **sp. n.**, from subhumid Tucuman-Bolivian forest in the Southern Bolivian Andes is described. The new species is distinguished from its closest relative, *O. armicollis* Prell, 1911, by a narrower distance between the inner teeth of the dorsal pronotal protuberances and a reduced area of weakly developed ocellate punctures above the posterolateral pronotal margin. The occurrence of *Oryctophileurus* species in areas of endemism along the eastern slope of the tropical Andes suggests that these populations represent biogeographic "relicts", and the discovery of *Oryctophileurus guerrai* **sp. n.** in the southern Bolivian Andes suggests that this area is underrated with respect to insect diversity and endemism.

Resumen

El género *Oryctophileurus* es revisado y su validez confirmada por la combinación de los siguientes caracteres apomórficos: un cuerno cefálico con carina lateral, cavidad pronotal con orificios ocelados y dos dientes o tubérculos detrás del margen anterior pronotal. El macho de *Oryctophileurus varicosus* Prell, 1934, es descrito por primera vez. Una nueva especie *Oryctophileurus guerrai* Perger & Grossi **sp. n.** es descrita del bosque subhúmedo Tucumano-Boliviano en el sureste de los Andes. La nueva especie se distingue por su parentesco más cercano a *O. armicollis* Prell, 1911, por la estrecha distancia entre los dientes interiores de las protuberancias en la región dorsal pronotal y una reducida área con escasos orificios ocelados debajo del margen posterolateral pronotal. Las especies de *Oryctophileurus* ocurren en áreas de endemismo a lo largo de la Vertiente este de los Andes tropicales y sugieren que estas poblaciones representan relictos biogeográficos, y el descubrimiento de *Oryctophileurus guerrai* Perger & Grossi **sp. n.** en el sudeste de los Andes Bolivianos indica que esta área está subestimada en cuanto a la diversidad y endemismo de insectos.

Keywords

Andes, Melolonthidae, Neotropical, relictual species, South America, Tucuman-Bolivian forest

Palabras clave

Andes, bosque Tucumano-Boliviano, especies relictas, Melolonthidae, Neotropical, Sud América

Introduction

The evolution of exaggerated morphological traits such as cephalic and pronotal horns in male rhinoceros beetles (Dynastinae) has been of interest to biologists for centuries (Rowland and Miller 2012). The Neotropical genera *Oryctophileurus* Kolbe, 1910, and *Amblyodus* Westwood, 1878, belong to the few taxa that lack pronounced gender dimorphism: although less developed, the females bear cephalic horns as well (Grossi and Grossi 2011). However, despite this exceptional feature, both taxa are rarely treated in the scientific literature, presumably because of the difficult accessibility of their forest habitats or a cryptic way of life.

Oryctophileurus was established by Kolbe (1910) to stabilize the generic taxonomy of *Phileurus nasicornis* Burmeister, 1847, a species recorded from Colombia. Prell (1911) described a second species, *O. armicollis,* from Peru based on two males. The third species of the genus, *O. varicosus,* was described from a female only without locality record (Prell 1934). Subsequent literature on the taxonomy of *Oryctophileurus* is restricted to redescriptions of the type specimens by Endrödi (1977, 1985) and a cladistic analysis of Phileurini that included *O. armicollis* and *O. varicosus* (Ide 1998).

Ide (1998) recognized a noticeable similarity between *Oryctophileurus* and *Amblyodus,* and Grossi and Grossi (2011) subsequently suggested synonymizing *Oryctophileurus* with the latter. However, the taxonomic position of *Oryctophileurus* has not been revised so far.

The purpose of this contribution is to stabilize the taxonomy of this group through the careful examination of all species originally described in *Oryctophileurus* and *Amblyo-*

dus. A new species of *Oryctophileurus* from the southern Bolivian Andes and the male of *Oryctophileurus varicosus* are described the first time, and their biogeography is reviewed and briefly discussed.

Material and methods

We examined 13 specimens deposited in the collection of the Museum für Naturkunde (Humboldt Universität), Berlin, Germany (ZMHB); the Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil (MZSP); and the Everardo and Paschoal Grossi Private Collection (Nova Friburgo, RJ, Brazil) (EPGC).

Additional specimens were collected during a biodiversity survey headed by the first author in the southern Bolivian Andes, in the northwestern buffer zone of the Tariquía Flora and Fauna National Reserve, department of Tarija, Bolivia. Several transects of about 6 km of subandine, subhumid, semi-deciduous Tucuman-Bolivian forest (Navarro and Ferreira 2011) were surveyed from November to December 2010. The study area and transect images were obtained from Google Earth 2012 and Landsat imagery courtesy of NASA Goddard Space Flight Center and the U.S. Geological Survey (Fig. 1A–C). Collected specimens are deposited in the Colección Boliviana de Fauna (La Paz, Bolivia) (CBF).

Morphological characters were examined with a stereomicroscope, and specimens were sexed via genital dissection. Morphometric measurements were taken with a digital caliper. Body length was measured from the apex of the clypeus to the apex of the pygidium.

A map (Fig. 1A) with the known distribution of treated taxa is included to facilitate the interpretation of biogeographical relationships. Distributional data from the literature is only considered when based on properly identified specimens. Records of *Oryctophileurus* species from Central America (Endrödi 1977; Lachaume 1992) need to be confirmed and are not considered here.

The following abbreviations were used: department, dep.; province, prov.; municipality, muni.

Systematics

Oryctophileurus Kolbe, 1878

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

Type species. *Phileurus nasicornis* Burmeister, 1847 (original combination) (Fig. 3).

Species of *Oryctophileurus* are distinguished from other Phileurini by a combination of the following apomorphic characters: a single cephalic horn with lateral carina, pronotal cavity with ocellate punctures and two teeth or tubercles close to the anterior pronotal margin, teeth vertically positioned at about the same level as the outer eye margins.

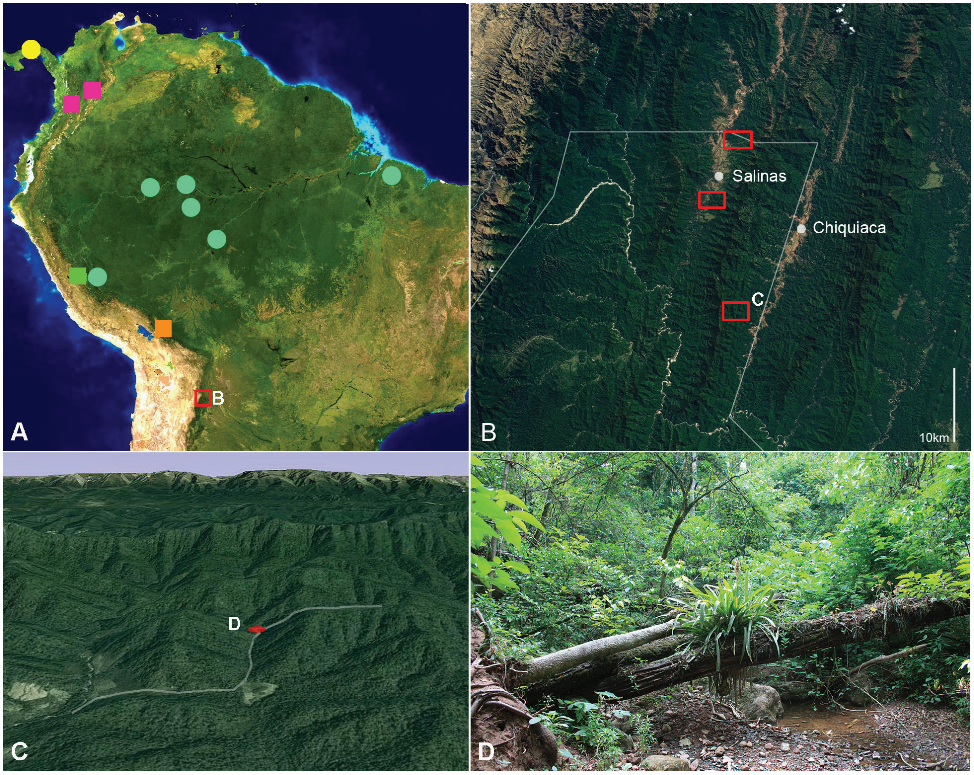

Figure 1. A map of distributional locations of South American *Amblyodus* and *Oryctophileurus* species (partly adapted from Grossi and Grossi (2011), only most southern distribution of *A. taurus* shown), yellow, *A. taurus*; light blue, *A. castroi*; magenta , *O. nasicornis*; green, *O. varicosus*; orange, *O. armicollis* (no data for Peru); red, *O. guerrai* **B** Andean and Subandean area of Tarija department, Bolivia; border of Tariquía National Reserve indicated by white line; surveyed areas by red rectangles **C** survey transect (indicated white) with collection location (highlighted red) of *O. guerrai* **D** habitat of *O. guerrai* in the bottom of a moist gully.

Taxonomy and discussion. The following characters were cited by Endrödi (1985) for *Oryctophileurus*, *Amblyodus*, *Microphileurus* Kolbe, *Metaphileurus* Kolbe, *Trioplus* Burmeister, and *Goniophileurus* Kolbe and are here not considered as generic: outer side of mandible tridentate; antenna 10-jointed; elytra with punctate rows; proleg sexually monomorphic, protarsus not thickened in male. *Oryctophileurus* and *Amblyodus* are distinguished from the other mentioned genera by large horns, a distinctly developed and posteriorly carinate pronotal cavity and four external teeth on the protibia (Endrödi 1985; Ide 1998). However, in *Amblyodus* the two cephalic horns lack the lateral carina, the punctures in the pronotal cavity are predominately fused to short, transverse ridges, and the teeth close to the anterior pronotal margin are absent. Except for the horn number, these generic differences between *Oryctophileurus* and *Amblyodus* have not been recognized by previous workers.

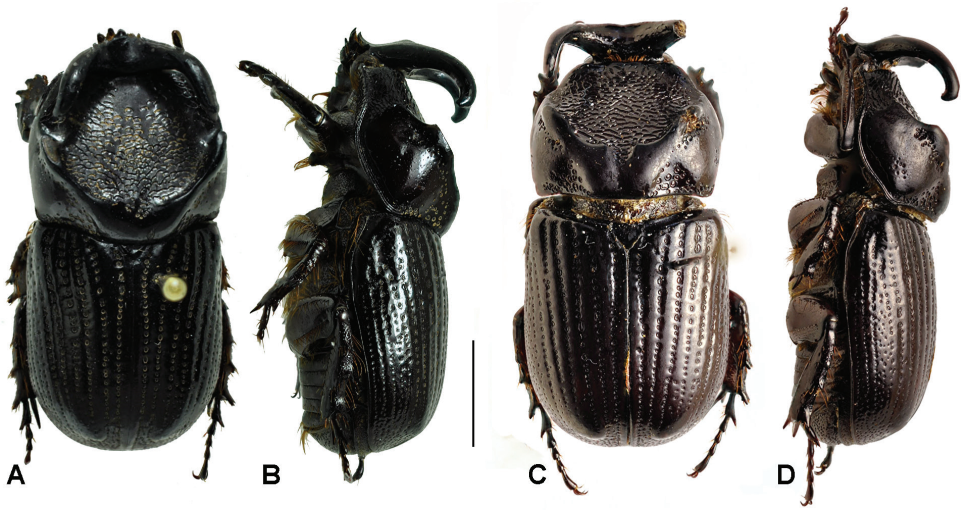

Figure 2. Dorsal and lateral habitus of males. **A** and **B** *A. taurus* Westwood, 1878 **C** and **D** *A. castroi* Grossi & Grossi, 2012, scale bar 5 mm.

Based on the combination of apomorphic characters of *Oryctophileurus* that lacks in *Amblyodus* we suggest retaining the genus *Oryctophileurus*.

Key to species of *Oryctophileurus*

1 Horn on frons not projecting above anterior edges of pronotal protuberance (Figs 3B, D). Distance between inner teeth of dorsal pronotal protuberance (Figs 3A, C) narrower than distance between eyes. Development of horn and pronotal protuberance equal in both sexes. Color dark brown .... ***O. nasicornis* (Burmeister)**

– Horn on frons projecting above anterior edges of pronotal protuberance in both sexes. Horn longer in males than in females of the same size. Color black **2**

2 Development of pronotal protuberance subequal in both sexes. Elytral striae and interstitial punctures arranged in irregular lines, punctures enlarged (Figs 4A, C) .... ***O. varicosus* Prell**

– Pronotal protuberance more strongly developed in males than females of the similar size. Elytral striae and interstitial punctures arranged in regular lines.. **3**

3 Distance between inner teeth of dorsal pronotal protuberance in male wider than width between eyes (Fig. 7A); in females separated by a concavity with ocellate punctures (Fig. 6C). Pronotal concavity accounts for 40–50 % of the dorsal pronotal surface in males. Ocellate punctures above posterior-lateral pronotal margin continuous (Fig. 7C) .... ***O. armicollis* Prell**

– Distance between inner teeth of dorsal pronotal protuberance in male as wide as width between eyes (Fig 7B), in females separated by a small fissure only (Fig. 8C). Anterior pronotal concavity accounts for about 30% of the dorsal pronotal surface in males. Area of ocellate punctures above posteriolateral pronotal margin reduced laterally (Fig. 7D), punctures small, shallow and sparse .... ***O. guerrai* Perger & Grossi sp. n.**

Oryctophileurus nasicornis (Burmeister, 1847)

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

Fig. 3

Material examined. Colombia: Cauca dep., Cauca Valley: 1 male with body length 19 mm, det. Endrödi 1976 (ZMHB); Boyacá dep., Muzo muni.: 1 female with body length 20 mm, S. Apollin coll., det. Ohaus, revised by Endrödi (1977) (ZMHB).

Diagnosis. Color dark brown, moderately shining. Horn on frons not projecting above anterior edges of pronotal protuberance, weakly recurved, in female with truncate apex; ocular canthus rounded in male, and subquadrate in female. Pronotum broadly rounded, more in female. Distance between inner teeth of dorsal pronotal protuberance narrower than distance between eyes. Pronotal protuberance on same level with elytra. Development of horn and pronotal protuberance equal in both sexes. Elytra striate, with five well defined discal striae; striae regular, at sides weakly defined; punctures regular, about the same size of those at disc. Meso and metatibiae with 4 to 5 distal teeth. Pygidium regularly convex in both sexes, more in female, and densely and finely wrinkled. Parameres with basal half broad, apex slender, straight.

Geographical distribution. The species is known only from the Cauca Valley in Colombia, which is surrounded by the parallel, peninsula-like projections of the Andean Cordillera Occidental and Cordillera Central and the Muzo municipality which is situated on the eastern slope of the Cordillera Oriental (Fig. 1A). These areas include wet premontane forest and, to a lesser extent, upper montane forests and paramos (Espinal 1992).

Oryctophileurus varicosus Prell, 1934

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

Figs 4; 5C–D

Type material examined. Peru: holotype, female, body length 20.4 mm, unknown locality (ZMHB).

Additional material examined. Peru: Junin dep.: Satipo prov., Chanchamayo Valley: 1 male with body length 20 mm (EPGC); Satipo prov., Rio Tambo valley, Paraíso Tuncama, ~1300 m a.s.l.: 1 female with body length 19.4 mm, (EPGC); Rios Pichis & Perene, 600–900 m a.s.l., Soc. Geog. De Lima col., 1 male (MZSP).

Diagnosis. Color black, moderately shining to shining. Enlarged elytral punctures. Punctures and elytral striae arranged in irregular lines (Figs 4A, C). Horn widely

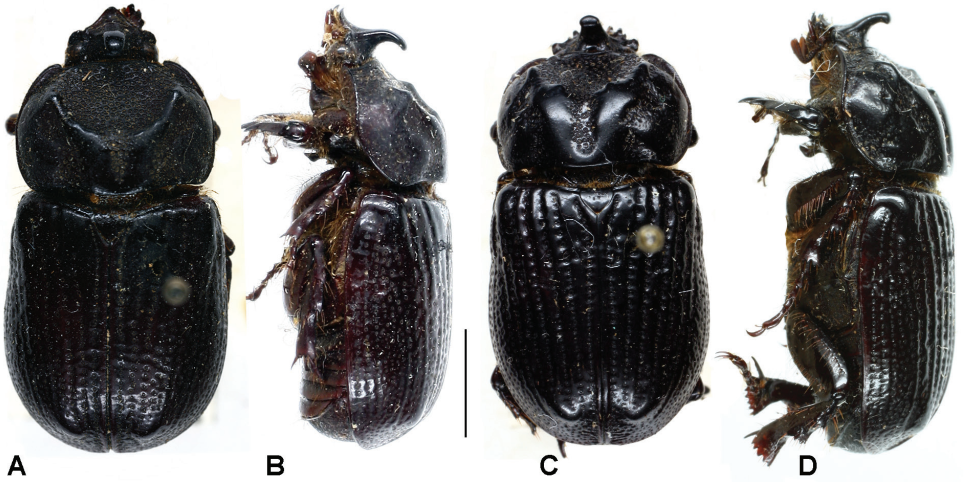

Figure 3. Dorsal and lateral habitus of *Oryctophileurus nasicornis* (Burmeister, 1847) **A** and **B** male **C** and **D** female, scale bar 5 mm.

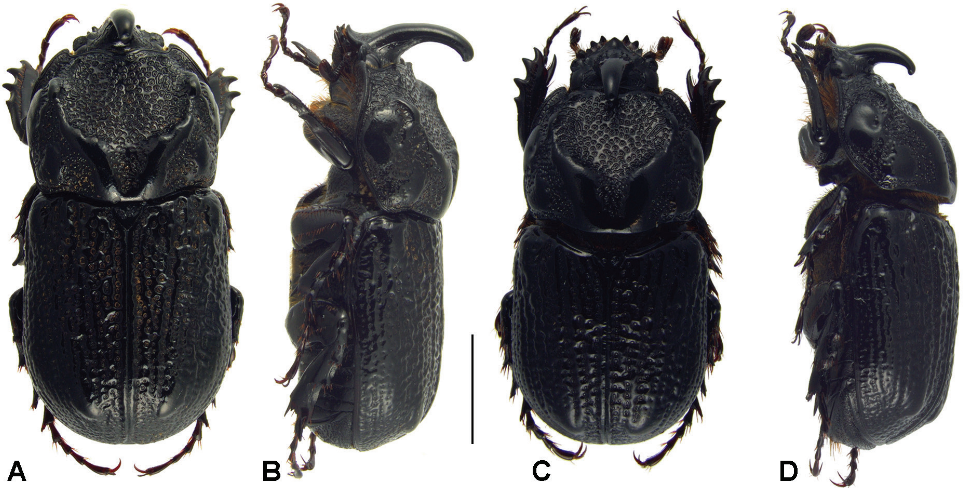

Figure 4. Dorsal and lateral habitus of *Oryctophileurus varicosus* Prell, 1934, **A** and **B** male **C** and **D** female, scale bar 5 mm.

projected above body in male. Pronotal protuberance comparably flat and developed as in female.

Description. Male. (Figs 4A, B). Body elongate, cylindrical. Surface entirely black, glabrous, moderately shiny to shiny; dorsally almost totally punctate; punctures ocellate, moderate to very large. Legs, sterna, second abdominal ventrite, and basal margin of pygidium setose.

Head. Surface laterally wrinkled, in frontal view rugose. Clypeus subtriangular, apex rounded and emarginated, weakly reflexed; clypeal carina absent; sides concave. Canthus widely rounded and extending into middle of eye. Frons with long, recurved,

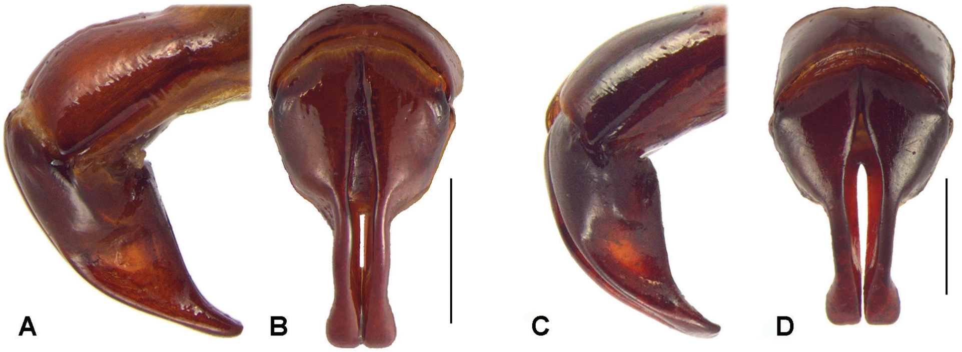

Figure 5. Dorsal and lateral view of aedeagus. **A** and **B** *Oryctophileurus armicollis* Prell, 1911 **C** and **D** *Oryctophileurus varicosus* Prell, 1934, scale bar 1 mm.

cylindrical horn with narrow apex; each side of horn with elongated, weak carina, anterior surface with slightly concave furrow, furrow reaching apex. Mandible tridentate, teeth upturned. Mentum with longitudinal furrow wider anteriorly and posterior concavity narrow with subparallel sides.

Pronotum. Shape subquadrate, narrower than elytra together. Discal area covered by ocellate punctures combined with C-shaped, coalescent punctures; discal surface flat and declivous anteriorly (Fig. 4A, B); anterior and lateral margins complete with a marginal bead, concave at middle; posterior marginal bead absent. Pronotal disc carinate, carina convex, smooth; anterior carina more pronounced; near anterior border with a conspicuous tubercle present in each anterolateral corner; posterior carina joined posteriorly on pronotal margin, bisinuous. Anterior angle acute, posterior rounded. Middle apex laterally with smooth convex carina, intercalated by rugose area and coarse punctures. Prosternal process long, trapezoidal, concave at base and posteriorly produced; base with a spine like posterior process.

Elytra. Striae irregular, and not defined, even laterally; punctures ocellate, irregular, larger on discal area and becoming smaller laterally and posteriorly; elytral apices densely punctate, punctures small to moderate; apical umbone convex, smooth. Scutellum triangular, densely punctate; punctures ocellate, moderate in size. Pygidium. In lateral view widely convex; surface totally punctate; punctures smaller and denser near anterior margin and sides, sparser and larger to apex; apex with marginal bead.

Legs. Protibia with 4 external teeth; basal tooth smaller. Apex of mesotibia with 4 teeth. Apex of metatibia with 5 teeth.

Aedeagus. Shape symmetrical (Fig. 5D), narrowing abruptly at middle; apex inflated, rectangle shaped, truncate; sides subparallel. In lateral view surface concave and with, acute, small projection near lateral base (Fig. 5C).

Geographical distribution. *O. varicosus* was described by Prell (1934) from an unknown locality in Peru. Records from Rio Pichis (600–900 m a.s.l.), Chanchamayo Valley (Junin dep., Satipo prov.) and Paraíso Tuncama (same province) at~1300 m a.s.l. (Fig. 1A) suggest that this species occurs in the Peruvian Yungas and adjacent subandine transitional forest. The forest in this area is classified as evergreen premontane, subhumid to humid, South Yungas forest (Josse et al. 2003).

Remarks. The records cited here are the only known specimens. Endrödi (1977) described the holotype as a male possibly based upon the fact that it has a horn. Endrödi (1985) correctly redescribed the type specimen as a female, indicating that the male was unknown as was pointed out in the original description by Prell (1934). Ide (1998) cited a male specimen from Rios Pichis & Perene, Peru, which was, however, not described. We describe here the male of *O. varicosus* for the first time.

Oryctophileurus armicollis **Prell, 1911**

http://species-id.net/wiki/Oryctophileurus_armicollis
Figs 5A–B; 6; 7A, C

Type material examined. Peru: holotype, male, body length 18.5 mm (ZMHB).

Additional material examined. Bolivia: La Paz dep., Nor Yungas prov., Caranavi, I-2003, 2 males with body length 18 mm and 20 mm and 1 female with body length 18 mm (EPGC); Route Coroico-Caranavi, XII-2008, 1 male (EPGC); La Paz dep., Calisaia, V-1925, G.L. Harrington col., 1 male (MZSP); Beni dep., Cosincho, VIII-1925, G.L. Harrington col., 1 female (MZSP).

Diagnosis. Color black, strongly shining. Head anteriorly flat, not concave; canthus subquadrate, in some specimens weakly projected forward; horn in males strongly recurved, on about the same level or slightly higher than posterior pronotal protuberance. Mentum with longitudinal furrow flat and wide, as well as posterior margin. Distance between inner teeth of dorsal pronotal protuberance in male wider that width between eyes (Fig. 6A); in females separated by a concavity with occelate punctures; pronotal concavity accounts for about 40–50 % of dorsal pronotal surface in males. Ocellate punctures above posterior-lateral pronotal margin continuous (Fig. 7C). Each elytron with 10 striae; punctures ocellate, sometimes coalescent and elongated, decreasing in size to sides; interstriae smooth, convex. Striae and interstitial punctures arranged in regular lines Mesotibia with 3 to 5 apical teeth; metatibia with 4 to 6 apical teeth. Pygidium in males distinctly more convex than in females, moderately punctate, denser at base and sides. Aedeagus symmetric (Fig. 5A); parameres with apex rounded to subtriangle shaped (Fig. 5B).

Geographical distribution. *Oryctophileurus armicollis* is known from Peru (Prell 1911; location not specified) and the Andean (Nor Yungas, La Paz dep.) and Subandean (Cosincho, Beni dep.) areas of Bolivia (Fig. 1A). The ecosystem between 800 and 2000 m a.s.l. in this area is considered as South Yungas submontane, subhumid forest (Josse et al. 2003) and receives an annual precipitation between 1500–6000 mm (Ibisch et al. 2003a). The locality data suggests that this species is closely associated with the Bolivian Yungas forest and might also occur in the Peruvian Yungas forest.

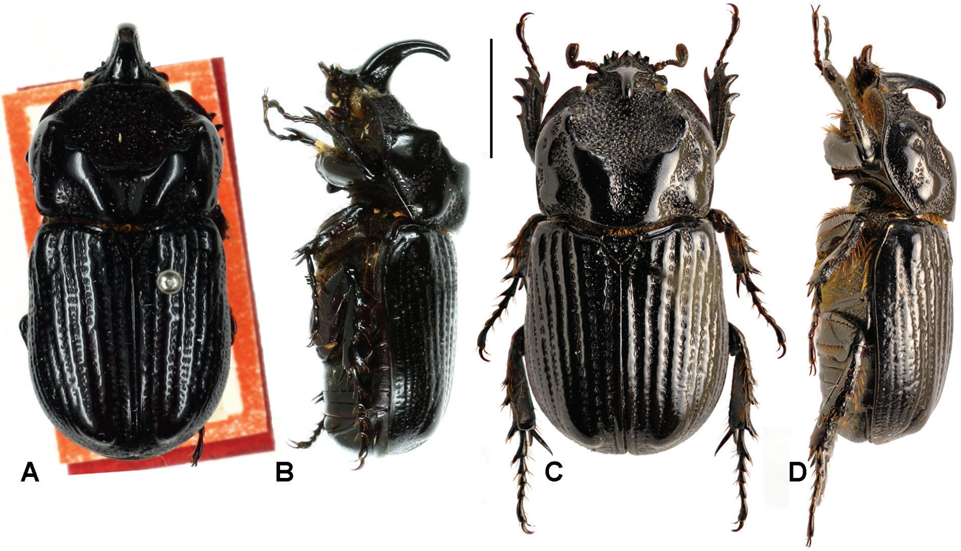

Figure 6. Dorsal and lateral habitus of *Oryctophileurus armicollis* Prell, 1911, **A** and **B** holotype male, body length 18.5 mm **C** and **D** female, body length 18 mm, scale bar 5 mm.

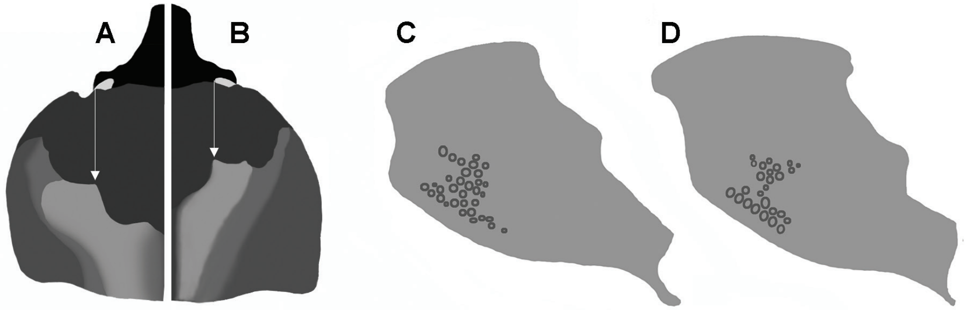

Figure 7. Pronotum of males with body length 20 mm, dorsal, higher areas light, inner teeth of transversal pronotal carina indicated by white arrow : **A** *Oryctophileurus armicollis* Prell **B** *O. guerrai*; ocellate punctures at posteriolateral pronotal surface, character state does not differ between sexes **C** *O. armicollis* **D** *O. guerrai*.

Oryctophileurus guerrai Perger & Grossi, sp. n.

http://zoobank.org/71F1D594-7DC9-41E0-93DE-704DEDE75470
http://species-id.net/wiki/Oryctophileurus_guerrai
Figs 7B, D; 8

Type material. Holotype: male, "Bolivia / Tarija / O`Connor province / Tariquía National Reserve / S21°59'01, W64°12'30 / 1008 m a.s.l. / Tucuman-Bolivian subhumid forest / gully close to small mountain river / 25-XI-2011 / R. Perger leg." Allotype: female, same location data as the holotype, 20-XI-2011, F. Guerra leg.

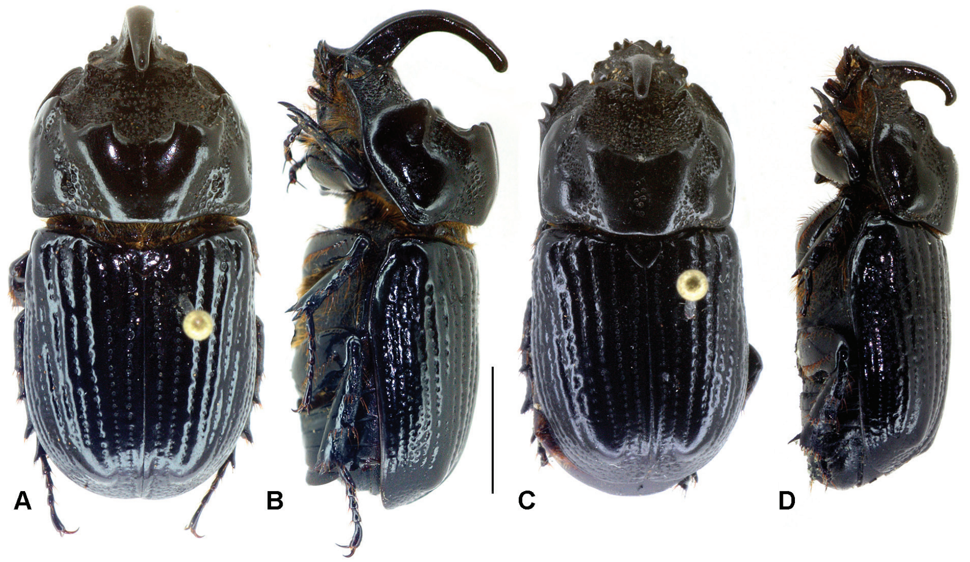

Figure 8. Dorsal and lateral habitus of *Oryctophileurus guerrai* sp. n., **A** and **B** holotype male, body length 20 mm **C** and **D** allotype female, body length 19 mm, scale bar 5 mm.

Diagnosis. *Oryctophileurus guerrai* sp. n. is distinguished from the morphologically similar *O. armicollis* by the distance between the inner teeth on the dorsal pronotal protuberance (in males as wide as width between eyes) (Figs 7B, 8A) and in females by the inner teeth separated by only a small fissure (Fig. 8C). In smaller males (body length 18.5 mm) of *O. armicollis* the distance between the inner teeth of the pronotal protuberance is wider than the width between the eyes and in larger males (body length 20 mm) as wide as the distance between the outer eye margins (Fig. 6A). In females of *O. armicollis* the inner teeth of the pronotal protuberance are separated by a comparably wide, continuous, parallel concavity containing ocellate punctures (Fig. 6C).

In both sexes of *O. guerrai* the ocellate punctures above the posteriolateral pronotal margin are smaller, shallower and sparser than in *O. armicollis* and the area of ocellate punctures above posteriolateral pronotal margin is reduced laterally (Figs 7D; 8B, D). In both sexes of other *Oryctophileurus* species the pronotum posteriolaterally has a continuous area of distinctly developed, ocellate punctures.

In the male *O. guerrai* the pronotal protuberance is dorsally higher and the cephalic horn longer (Fig. 8B) than in similar-sized *O. armicollis* (Fig. 6B) and *O. nasicornis* (Fig. 3B). In *O. nasicornis*, both characters are less produced. In the male of *O. varicosus* (Fig. 4B), with its slightly larger body, the pronotum is much flatter than in the male of *O. guerrai*.

Description. Holotype male (Figs 8A, B). Body length 20 mm, width 9 mm. Body elongate, cylindrical, head and pronotum brownish black dorsally, elytra black, body ventrally dark brown, dorsal surface glabrous. Legs, sterna, second abdominal ventrite and basal margin of pygidium setose.

Head. Surface smooth, finely punctate. Clypeus subtriangular, laterally emarginated, slightly upturned, and with acute apex. Cephalic horn recurving over pronotum, attenuate, apex narrowly rounded; surface at base coarsely punctate, with a lateral carina. Mandible tridentate with inner tooth more acute; teeth upturned. Antenna 10 segmented; club with antennomeres subequal in length.

Pronotum (Figs 7B, D; 8A, B). Shape subtrapezoidal, evenly rounded laterally, smooth, with 2 impressions posteriolaterally; posterior edges slightly obtuse. Basal half smooth, longitudinally ridged, dorsally bulging until transverse median carina, with 2 dorsolateral, coarsely punctate concavities on both sides; transverse median carina with 4 obtuse teeth, 2 inner teeth dorsally with small concavity, distance between inner teeth of dorsal pronotal protuberance as wide as width between eyes; anterior half of pronotum strongly concave, with ocellate punctures, 2 obtuse teeth close to anterior pronotal border, teeth at same level with lateral eye margins when seen from dorsal and lateral views. Prosternal process trapezoidal, concave at the base, posteriorly produced; base with spine-like process posteriorly.

Elytra. Surface smooth, with continuous, slightly convex carinae, weakly impressed interstriae, and with ocellate punctures. Pygidium. Shape convex in lateral view; surface densely punctate; punctures ocellate, moderately sized, elongate near basal margin.

Legs. Protibia with 4 teeth, basal tooth weakly developed. Meta- and mesotibia apically with 3 broaden, shovel-shaped teeth, each tooth additionally furnished with small, apical teeth. The specimen was found dead with damaged abdomen, soft parts and genitalia missing.

Female allotype (Figs 8C, D). Similar to male except by the following features: body length 19 mm, width 8.2 mm; head with cephalic horn less developed, reaching only dorsal pronotal protuberances when seen in lateral view; pronotum longer than high, dorsal longitudinal pronotal concavity about as narrow as width of cephalic horn, uppermost teeth of dorsal pronotal protuberances obtuse, separated by a small fissure.

Derivation of specific epithet. The species is named after our friend and colleague, Fernando “Fideo” Guerra, for his lifetime commitment to the investigation of the Bolivian fauna. His participation in the actual survey in the southern Bolivian Andes has led to the discovery and description of several previously unknown taxa (e.g., Perger and Guerra 2012), and he was also the first to collect an individual of *Oryctophileurus guerrai*, sp. n.

Geographical and ecological distribution. *O. guerrai* is known only from the northwestern area of Tariquía National Reserve (Tarija department) in the southern Bolivian Andes (Fig. 1). The forest in the this area is considered subandine subhumid, semi-deciduous, Tucuman-Bolivian forest (TBF) (Navarro and Ferreira 2011) with a mean annual temperature of 18.7 °C and an annual rainfall of 1334 mm (SENAMHI 2007). *Oryctophileurus guerrai* is likely endemic to TBF (see discussion below) and might also occur in the northern limit (Santa Cruz department) and the Argentinean portion of this forest type (Jujuy, Salta and Tucuman departments).

The two individuals of the new species were collected in a narrow valley (elevation 1008 m a.s.l.) (Fig. 1C). The female was observed during the day on the floor of the densely vegetated, moist gully (Figs 1C, D). The male was found dead in a similar habitat. No individuals of the species were observed in subhumid forest along the slopes and during eight nights of sampling with a light trap close to the collection area. Like the other species of this genus, which are only known from few individuals, *O. guerrai* might be rare or has a cryptic way of life.

Remarks. As in males of other dynastine taxa with exaggerated secondary sexual traits (e.g., Eberhard 1979; Rowland 2003), the cephalic horn and pronotal structures of *O. armicollis* males (and likely in the males of other *Oryctophileurus* species) vary allometrically. Larger males have larger horns and pronotal armature with respect to their body length. Accordingly, such characters should be compared in specimens having a similar size. Nevertheless, the distance between the inner pronotal protuberance teeth appears to be positively allometric in *O. armicollis*, since it is wider in larger males (body length 20 mm) than in smaller males (body length 18.5 mm). In the male (body length 20 mm) of *O. guerrai* the inner pronotal protuberance teeth are separated by a gap (Fig. 6B) that is narrower than in the smaller male of *O. armicollis* (body length 18.5 mm), indicating that the ratio of body length/ pronotal protuberance teeth distance is never overlapping inter-specifically between similar-sized individuals.

Biogeographical affinities

While the two *Amblyodus* species occur in Amazon lowland forest (*A. castroi* Grossi & Grossi) and Central American mountain forests (*A. taurus* Westwood) (Grossi and Grossi 2011), the known distributional pattern suggests that the species of *Oryctophileurus* are closely associated with forest habitat in the Andean area (Fig. 1).

As proposed for other Andean taxa (see Hoorn et al. 2010 and Rull 2011 for reviews), the diversification of *Oryctophileurus* might be related to the creation of heterogeneous edaphic mosaics and dispersal barriers by the uplifting of the Andes in the mid-Miocene, marine incursions into the Amazon basin, and the subsequent quaternary climatic cycling. High diversity and endemism in the Andean area are further explained by climatic stability due to orographic rain barriers and lower extinction rates during periods of drastic climatic changes (Fjeldså et al. 1999). The collection locations of *Oryctophileurus* species along the eastern slope of the tropical Andes correspond with peak concentrations of endemics (see Swenson et al. 2012; WWF 2012), suggesting that *Oryctophileurus* species represent biogeographic relicts that persisted during periods of ecological change.

Oryctophileurus in the Southern Bolivian Andes

The discovery of *O. guerrai* extends the known distributional range of the genus more than 600 km southwards. In view of the mainly tropical Andes distribution of *Oryctophileurus* species, the presence of this genus in the southern Bolivian Andes, close to the Argentinean border, is surprising. Because of a change in orientation of the mountain ranges at the elbow of the Andes and local topographic features, the TBF is distinguished from Bolivian Yungas forest (BYF) by a more pronounced and prolonged dry season, occasionally accompanied by frost periods (Fjeldså et al. 1999), and less annual precipitation and humidity (Ibisch et al. 2003a; Killeen et al. 2007). Corresponding with a general decrease in biodiversity (Schulenberg and Awbrey 1997; Ibisch et al. 2003b; Churchill and Lozano 2009), several scarabaeoid genera such as *Dynastes* Kirby, *Sphaenognathus* Buquet, *Scortizus* Westwood, and *Cantharolethrus* Thomson, meet their southern distributional limit at the elbow of the Andes (see Paulsen 2010 for distributional maps).

Nevertheless, the discovery of *Oryctophileurus guerrai* and other endemic TBF representatives of butterfly genera (Gareca and Blandin 2011; Blandin and Gareca 2011) and tiger beetle genera (Perger and Guerra 2012) with diversity center in the northern tropical Andes suggests that the assumed decrease in species richness in some groups is the result of sampling bias and the TBF belongs to the important areas of insect endemism along the eastern slope of the Andes.

This hypothesis should be tested in further studies because human impact and low protection status of such ecoregion (see Schulenberg and Awbrey 1997; Ibisch et al. 2003a) might not only threat already known but also many undiscovered endemics with extinction.

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References

Blandin P, Gareca Y (2011) A new subspecies of *Morpho* (*Grasseia*) *godartii* Guérin-Méneville, [1844], discovered in sub-humid forests from southern Bolivian Andes (Lepidoptera, Nymphalidae). Bulletin de la Société Entomologique de France 116(3): 291–300.

Churchill SP, Lozano R (2009) Bryophytes of the Tucumán-Bolivian Montane forest. Tropical Bryology 30: 19–42.

Endrődi S (1977) Monographie der Dynastinae 8. Tribus: Phileurini, amerikanische Arten I. (Coleoptera). Folia Entomologica Hungarica 30(1): 7–45.

Endrődi S (1985) The Dynastinae of the World. Dr W. Junk, Dordrecht, Netherlands, 800 pp.

Espinal LS (1992) Geografía ecológica de Antioquia: Zonas de vida. Editorial Léalon, Medellín, Colombia, 146 pp.

Fjeldså J, Lambin E, Mertens B (1999) Correlation between endemism and local ecoclimatic stability documented by comparing Andean bird distributions and remotely sensed land surface data. Ecography 22: 63–78. doi: 10.1111/j.1600-0587.1999.tb00455.x

Gareca Y, Blandin P (2011) *Morpho* (*Morpho*) *helenor* (Cramer) (Lepidoptera, Nymphalidae, Morphinae) in Bolivia: Geographical distribution and ecological plasticity, with a description of a new subspecies. Zootaxa 3130: 30–56.

Grossi PC, Grossi EJ (2011) A new species of *Amblyodus* Westwood, 1878 (Coleoptera, Melolonthidae, Dynastinae) from South America. ZooKeys 75: 21–28. doi: 10.3897/zookeys.75.884

Hoorn C, Wesselingh F, Steege HT, Mora A, Sevink J, Sanmartin I, Sanchez-Meseguer A, Anderson CL, Figueiredo J, Jaramillo C, Riff D, Negri FR, Hooghiemstra H, Lundberg JG, Stadler T, Sarkinen T, Antonelli A (2010) Amazonia through time: Andean uplift, climate change, landscape evolution and biodiversity. Science 330: 927–931. doi: 10.1126/science.1194585

Ibisch PL, Beck SG, Gerkmann B, Carretero A (2003a) La diversidad biológica: ecorregiones y ecosistemas. In: Ibisch PL, Mérida G (Eds) Biodiversidad: La riqueza de Bolivia. Estado de conocimiento y conservación. Ministerio de Desarrollo Sostenible. Editorial Fundación Amigos de la Naturaleza (FAN), Santa Cruz, Bolivia, 47–88.

Ibisch PL, Gerkmann B, Kreft S, Beck SG, Herzog SK, Köhler J, Müller R, Reichle S, Vásquez R (2003b) Consideraciones comparativas de patrones interecoregionales de diversidad de especies y de endemismo. In: Ibisch PL, Mérida G (Eds) Biodiversidad: La riqueza de Bolivia. Estado de conocimiento y conservación. Ministerio de Desarrollo Sostenible. Editorial Fundación Amigos de la Naturaleza (FAN), Santa Cruz, Bolivia, 148–161.

Ide S (1998) Sistemática e evolução dos géneros neotropicais de Phileurini (Coleoptera: Scarabaeidae: Dynastinae). Tese de Doutorado, Universidade de São Paulo, Brasil, 159 pp.

Josse C, Navarro G, Comer P, Evans R, Faber-Langendoen D, Fellows M, Kittel G, Menard S, Pyne M, Reid M, Schulz K, Snow K, Teague J (2003) Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems. NatureServe, Arlington, VA, 47 pp.

Killeen TJ, Douglas M, Consiglio T, Jørgensen PM, Mejía J (2007) Dry and wet spots in the Andean hotspot. Journal of Biogeography 34: 1357–1373. doi: 10.1111/j.1365-2699.2006.01682.x

Kolbe H (1910) Über die Phileurinen Amerikas. Bulletin et Annales de la Societe Royale Belge d'Entomologie 54: 330–354.

Lachaume G (1992) Dynastidae Américains. Cyclocephalini-Agaocephalini-Pentodontini-Oryctini-Phileurini. Les Coléoptères du Monde 14. Sciences Nat, Venette, France 56: 83–89.

Navarro G, Ferreira W (2011) Mapa de Sistemas Ecológicos de Bolivia, escala 1:250 000. Edición CD-ROM. RUMBOL SRL-The Nature Conservancy (TNC), Bolivia.

Paulsen MJ (2010) Annotated checklist of the New World Lucanidae, version 3.0. http://www-museum.unl.edu/research/entomology/Guide/Scarabaeoidea/Lucanidae/Lucanidae-Catalog/LucanidaeC.htm

Perger R, Guerra F (2012) Two new tiger beetle (Coleoptera, Carabidae, Cicindelitae) species from the Tucuman-Bolivian forest in the National Tariquía Reserve, Bolivia. Zootaxa 3434: 49–58.

Prell H (1911) Beiträge zur Kenntnis der Dynastinen. Entomologische Zeitschrift 25: 105–107.

Prell H (1934) Beiträge zur Kenntnis der Dynastinen (XII). Beschreibungen und Bemerkungen. Entomologische Blätter für Biologie und Systematik der Käfer 30: 55–60.

Rowland JM (2003) Male horn dimorphism, phylogeny and systematics of rhinoceros beetles of the genus *Xylotrupes* (Scarabaeidae, Coleoptera). Australian Journal of Zoology 51: 213–258. doi: 10.1071/ZO02013

Rowland JM, Miller KB (2012) Phylogeny and systematics of the giant rhinoceros Beetles (Scarabaeidae: Dynastini). Insecta Mundi 0263: 1–15.

Rull V (2011) Neotropical biodiversity: timing and potential drivers. Trends in Ecology & Evolution 26: 508–513. doi: 10.1016/j.tree.2011.05.011

Schulenberg T, Awbrey K (1997) A rapid assessment of the humid forests of South Central Chuquisaca, Bolivia. RAP Working Papers 8, Conservation International, 84 pp.

SENAMHI (Servicio Nacional de Meteorología e Hidrología) (2007) Resumen Climatológico 2001–2007 de la Estación Saykan – Las Perulas, Provincia O´Connor, Departamento Tarija, Bolivia, 11 pp.

Swenson JJ, Young BE, Beck S, Comer P, Cordova JH, Dyson J, Embert D, Encarnacion F, Ferreira W, Franke I, Grossman D, Hernandez P, Herzog SK, Josse C, Navarro G, Pacheco V, Stein BA, Timana M, Tovar A, Tovar C, Vargas J, Zambrana-Torrelio CM (2012) Plant and animal endemism in the eastern Andean slope: Challenges to conservation. BMC Ecology 12(1): 1–18. doi: 10.1186/1472-6785-12-1

World Wildlife Fund (2012) Cauca Valley montane forests. In: Cleveland CJ (Ed) Encyclopedia of Earth. Environmental Information Coalition, National Council for Science and the Environment, Washington, D.C. http://www.eoearth.org/article/Cauca_Valley_montane_forests

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RESEARCH ARTICLE

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A new species of the genus *Karnyothrips* (Thysanoptera, Phlaeothripidae) from China

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Abstract

Karnyothrips cyathomorphus **sp. n.** (Phlaeothripidae: Phlaeothripinae) is described as a new apterous species in the genus *Karnyothrips* Watson 1923, and it represents the fourth species of the genus to be recorded from China. A key to the Chinese species is given.

Keywords

Litter thrips, Phlaeothripidae, *Karnyothrips*, new species, China

Introduction

The genus *Karnyothrips*, belonging to the *Haplothrips* lineage in Phlaeothripinae, was established by Watson for the species *Karynia weigeli*, a synonym of *K. flavipes* (Jones). Currently 47 species have been described in the genus (ThripsWiki 2013), of which three species are recorded from China (Mirab-balou et al. 2011). *K. flavipes* is widely distributed in the world, *K. melaleucus* (Bagnall) is distributed in tropics and subtropics, and *K. robustus* Okajima has been found only in Japan and Taiwan of China.

The *Karnyothrips* species usually live on live plant leaves, branches and dead forest litter, where they feed on micro-invertebrates or fungi. Recently, a distinct new species of *Karnyothrips* has been found while studying the litter thrips fauna in subtropical and tropical China. Specimens were mounted into Canada balsam and deposited in the Insect Collection, Department of Entomology, South China Agricultural University (SCAU).

The diagnosis of the genus includes the following features (Watson 1922; Mound and Marullo 1996; Okajima 2006): head longer than broad, rarely produced in front of eyes; antennae eight segmented, segments VII and VIII broadly joined, segment III variable in shape and usually shorter than segment IV; maxillary stylets especially long and extended into base of postocular setae, maxillary bridge present; pronotum anteromarginal setae often reduced; basantra and ferna usually developed; fore wing if developed, constricted medially, duplicated cilia present; anal setae especially long, much longer than tube.

Key to *Karnyothrips* species in China

1 Tergite IX S_1 setae longer than tube length, apex pointed [Taiwan, Yunnan, Guizhou, Fujian, Guangdong, Guangxi, Hainan]...***K. melaleucus* (Bagnall)**
– Tergite IX S_1 setae shorter than tube length, apex expanded........................**2**
2 Antennal segment III with a ring-like swelling at base [Guangdong]..***K. cyathomorphus* sp. n.**
– Antennal segment III without a ring-like swelling at base **3**
3 Antennal segment III with 2 sense cones [Sichuan, Hunan, Guangdong, Guangxi, Hainan, Fujian] ....***K. flavipes* (Jones)**
– Antennal segment III with 3 sense cones [Taiwan]......***K. robustus* Okajima**

Taxonomy

Karnyothrips cyathomorphus sp. n.

http://zoobank.org/1ED76766-7E7B-4CEC-8045-3037DD74D9A9
http://species-id.net/wiki/Karnyothrips_cyathomorphus
Figs 1–8

Specimens examined. Holotype: female. **CHINA**: Guangdong Province, Guangzhou, Botanical Garden of South China Agricultural University (23°09'25"N, 113°21'18"E), from leaf-litter, 15.xii. 2004, leg. Jun Wang. **Paratypes:** 2 females and 3 males, same data as holotype; 1 female and 4 males, same locality, habitat and collector, 20.xi.2004; 1 male; Longdong (23°14'07"N, 113°24'05"E), from leaf-litter of *Acacia mangium* plantations, 5.xii.2007, leg. Jun Wang.

Description. Female apterous (Figs 1). Body color brown; head dorsum, pronotum, mesonotum anterior margin, and tube brown, abdominal each tergite anterior margin in middle a little brown the others yellow. Antenna brown, but segment III somewhat paler. All femur brown, tibia and tarsus yellow, fore tibia outer margin a lot darker.

Head: dorsum (Figs 3) about 1.4 times as long as broad and little projecting in front of eyes, dorsal surface smooth in the middle and between the eyes, only transverse line sculpture at basal and two sides area; postocular setae distinctly shorter than eye length, apex expanded; cheeks margins subparallel, gradually broader and not constricted behind eyes; eyes round, about 0.3 times as long as head length; ocelli small and posterior far away separated; antennae eight-segmented (Fig. 8) about 1.7 times as long as head length, smooth on surface of each segment; segment III short and constricted at base with a pronounced ring-like swelling; segments III–IV with 2 and 4 sense cones respectively; segment VII elongate and shorter than segment IV, segments VII and VIII broadly joined; maxillary stylets long and extended into base of postocular setae, gradually nearer in the middle, maxillary bridge present.

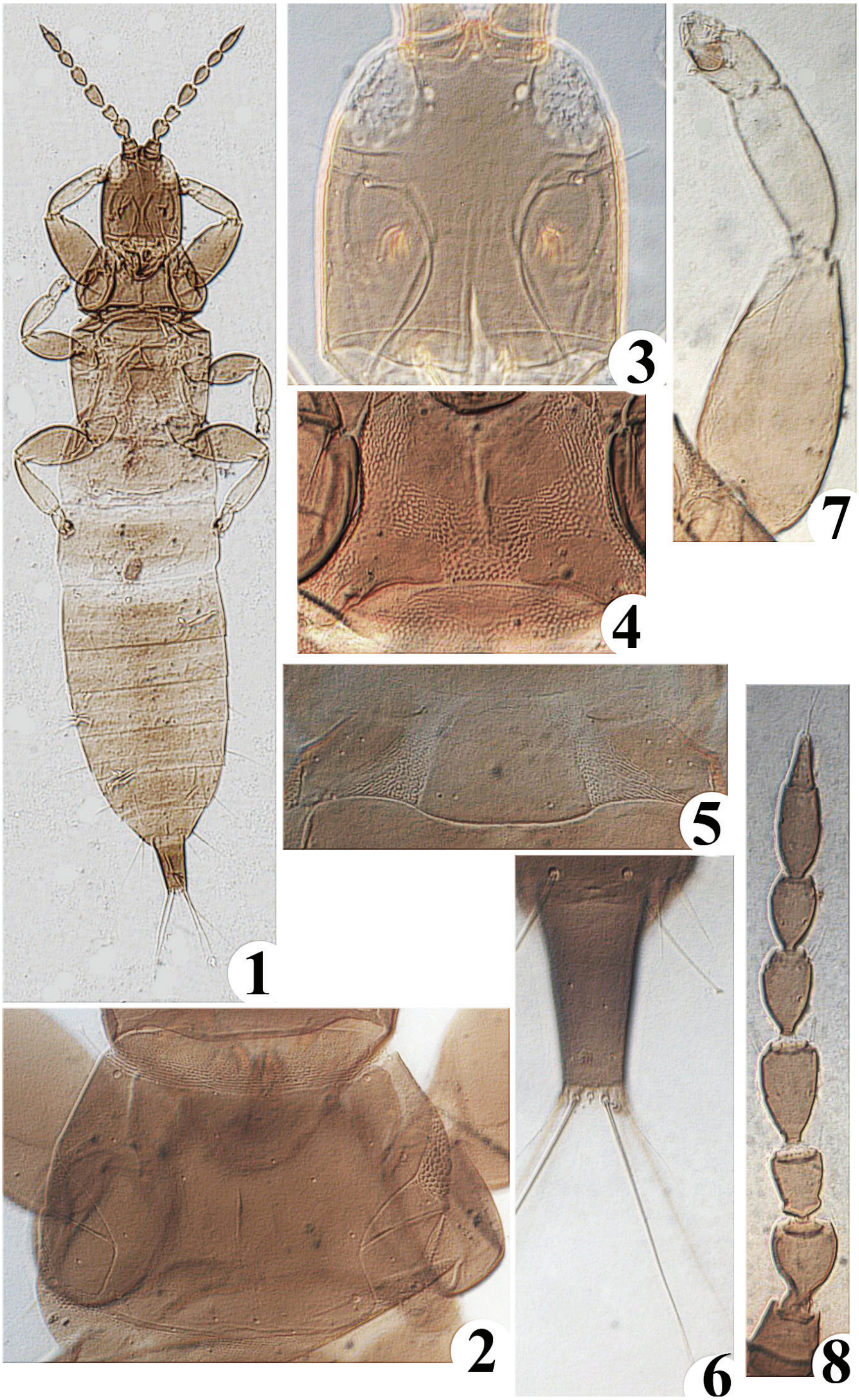
Thorax: Pronotum (Fig. 2) at middle 0.8 time as long as head length, surface smooth, with median longitudinal line; notopleural sutures complete; anteromarginal setae reduced; anteroangulars, midlaterals, posteroangulars and epimeral setae developed, apex expanded; basantra and ferna developed (Fig. 4); all femur enlarged, fore tarsus without tooth.

Abdomen: Pelta (Fig. 5) semicircle-shaped and sculptured anteriorly, smooth medially and posteriorly, without lateral lobes, a pair of campaniform sensilla present; tergites II–VII each with two pairs of developed wing-retaining setae; S_1 setae on tergite IX (Fig. 6) shorter than tube length, apex expanded, S_2 setae longer than tube, apex sharp; tube almost 0.6 times as long as head length, 1.6 times of tube width; anal setae long and about 1.5 times as long as tube length.

Measurements, holotype female in micrometers. Total body length 1275; head L/W (153/140); eyes length 48, diameter of ocelli 5; distance of posterior ocelli 34; pronotum median length 119, width 231; tube length 89, tube maximum width 56, apex width 35. Antennal segments I–VIII length (width) as follows: 25(29); 33(26); 26(21); 40(25); 35(21); 31(19); 38(15); 23(11). Postocular setae 34; antennal terminal setae 20; pronotum anteroangular setae 31, midlateral setae 31, posteroangular setae 31, epimeral setae 39; tergum IX S_1 setae 64, S_2 setae 125.

Apterous male: Color and structure similar to apterous female. Major setae on head, pronotum and abdomen capitate except that setae S_2 on tergite IX are short and pointed, and S_3 finely acute (Fig. 6). Fore femur well developed and fore tarsal with small tooth (Fig. 7). Abdominal sternites without any glandular area.

Measurements, paratype male in micrometers. Total body length 1263; head L/W (144/138); eyes length 48, diameter of ocelli 4; distance of posterior oceelli 34; pronotum median length 110, width 213; tube length 85, tube maximum width 56, apex width 38. Antennal segments I–VIII length (width) as follows: 19(28); 29(25);



Figures 1–8. *Karnyothrips cyathomorphus* sp. n. **1** slide mounted apterous adult (dorsal view), female **2** pronotum, female **3** head, female **4** basantra and ferna, female **5** pelta, female **6** abdominal tergum IX and tube, male **7** fore leg, male **8** antenna, female.

26(21); 39(25); 34(21); 29(19); 38(14); 24(11). Postocular setae 29; antennal terminal setae 16; pronotum anteroangular setae 28, midlateral setae 28, posteroangular setae 28, epimeral setae 35; tergum IX S_1 setae 60, S_2 setae 26.

Etymology. The specific epithet is a combination of Latin words cyatho and morphus, referring to the shape of antennal segment III.

Distribution. China (Guangdong).

Remarks. *Karnyothrips cyathomorphus* sp. n. resembles *K. inflatus* Okajima in having a sub-basal ring-like swelling on antennal segment III, but it can be distinguished from the latter by the following features: (1) no wing; (2) antennal segment IV with 4 sense cones, antennal segment VII shorter than segment IV; (3) pelta semicircle-shaped and smooth medially and posteriorly. The new species is also similar in appearance to *Priesneria kellyana* Bagnall which is apterous and antennal segment III with a sub-basal ring-like swelling, but *P. kellyana* has only one sensorium on antennal segment III and two sensoria on segment IV, and a glandular area on abdominal sternite IX (Pitkin 1973; Mound and Minaei 2007) which can be used for differentiating this new species.

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References

Mirab-balou M, Tong XL, Feng JN, Chen XX (2011) Thrips (Insecta: Thysanoptera) of China. Check List (Journal of Species Lists and Distribution) 7(6): 720–744.

Mound LA, Marullo R (1996) The Thrips of Central and South America: An Introduction. Memoirs on Entomology, International 6: 1–488.

Mound LA, Minaei K (2007) Australian thrips of the *Haplothrips* lineage (Insecta: Thysanoptera). Journal of Natural History 41(45–48): 2919–2978. doi: 10.1080/00222930701783219

Okajima S (2006) The Insects of Japan. Volume 2. The suborder Tubulifera (Thysanoptera). Touka Shobo Co. Ltd., Fukuoka, 720 pp.

Pitkin BR (1973) A revision of the Australian Haplothripini, with descriptions of three new species (Thysanoptera: Phlaeothripidae). Journal of the Australian Entomological Society 12: 315–339. doi: 10.1111/j.1440-6055.1973.tb01680.x

ThripsWiki (2013) ThripsWiki - providing information on the World's thrips. http://thrips.info/wiki/ [Accessed 3 September 2013]

Watson JR (1922) Another camphor thrips. Florida Entomologist 6: 6–7. doi: 10.2307/3492799

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RESEARCH ARTICLE

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A new species of *Tangius* from north India (Coleoptera, Staphylinidae, Pselaphinae)

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Abstract

Tangius indicus **sp. n.** (Batrisitae: Batrisini) is described and illustrated from the Indian States of Meghalaya (Khasi Hills, type locality) and West Bengal (Darjeeling). Specimens of the new species are similar to those of the recently described *T. glabellus* Yin & Li from Tibet, Southwest China, and can be separated only by minor differences of the male features.

Keywords

Batrisina, taxonomy, *Tangius*, new species

Introduction

The batrisine genus *Tangius* Yin & Li (Yin et al. 2012) was recently established for a single species *T. glabellus* Yin & Li, from southeast Tibet (= Xizang A. R.). Characters distinguishing it from the allied genera *Dendrolasiophilus* Nomura, *Maajappia* Nomura, and *Songius* Yin & Li were described.

When visiting the Natural History Museum of Geneva, Switzerland (May, 2013), the first author sorted a small series of north Indian *Tangius* specimens out of the large pselaphine collection. A second species of the genus, closely allied to *T. glabellus*, was recognized based on differences in male characters. In this paper we describe the new species, provide illustrations of its major diagnostic features, and distinguish it from the previously described *T. glabellus*.

Material and methods

The type series is housed in the Muséum d'histoire naturelle de la Ville de Genève, Switzerland (**MHNG –** G. Cuccodoro).

The collection data of the referred material are quoted verbatim. A slash (/) is used to separate different labels. Authors' notes are included in '[]'.

Measurements are in millimeters. The following abbreviations are applied: **AL**–length of the abdomen along the midline; **AW**–maximum width of the abdomen; **EL**–length of the elytra along the sutural line; **EW**–maximum width of the elytra; **HL**–length of the head from the anterior clypeal margin to the occipital constriction; **HW**–width of the head across eyes; **PL**–length of the pronotum along the midline; **PW**–maximum width of the pronotum. Length of the body equals HL + PL + EL + AL + length of the occipital constriction.

Taxonomy

Key to males of *Tangius*

1 Antennomeres VII–IX subcylindrical, as long as wide to slightly transverse (Fig. 2A); mesotibiae distinctly concave along mesal margin before preapical denticle (Fig. 2F); apex of median lobe broadly rounded on the left side (Fig. 2M). (north India: Meghalaya, West Bengal) .... ***T. indicus* sp. n.**

– Antennomeres VII–IX asymmetrically trapezoidal, distinctly transverse (Yin et al. 2012: 59, fig. 6); mesotibiae have straight mesal margins before preapical denticle (Yin et al. 2012: 59, fig. 13; Fig. 2G); apex of median lobe angularly rounded on the left side (Fig. 2L). (Southwest China: Xizang) .... ***T. glabellus* Yin & Li**

Tangius indicus Yin & Li, sp. n.

http://zoobank.org/49049A5A-07D6-452C-A3AA-FF5E0689E84B
http://species-id.net/wiki/Tangius_indicus
Figs 1, 2A–F, H–K, M–N

Type material (6 ♂♂, 3 ♀♀)**. Holotype: INDIA:** ♂, labeled 'INDIA, Meghalaya, Khasi Hills, 28.X, Mawphlang, 1800 m, Besuchet-Löbl, 78. / Holotype [red], *Tangius*

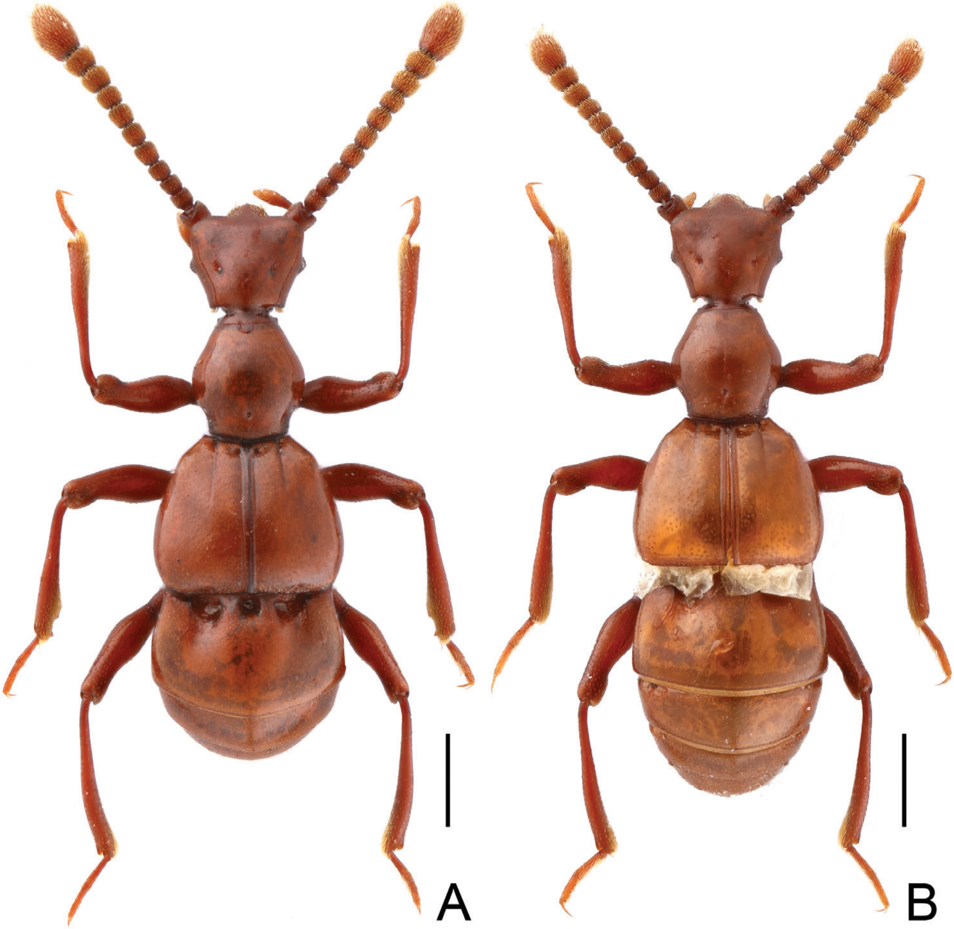

Figure 1. Dorsal habitus of *Tangius indicus*. **A** male **B** female. Scales (mm): 0.5.

indicus sp. n., det. Yin & Li 2013, MHNG'. **Paratypes: INDIA:** 4 ♂♂, 3 ♀♀, same label data as holotype [1 ♂ totally disarticulated and preserved in Euparal on plastic boards; 1 ♂ with left antenna and abdomen missing]; 1 ♀, labeled 'INDIA: Darjeeling, distr., 13 km N. Ghoom, 1500 m, 15.X.1978, I. Löbl, Bes. nr. 15, litter'. Each paratype bear a type label as 'Paratype [yellow], *Tangius indicus* sp. n., det. Yin & Li, 2013, MHNG'.

Description. Male (Fig. 1A). Length 2.91–2.97 mm. Surface almost glabrous. Head trapezoidal, slightly transverse, HL 0.61–0.62 mm, HW 0.64–0.65 mm; clypeus covered with sparse short setae anteriorly; Antennomeres II–X (Fig. 2A) each subcylindrical, apical antennomeres nearly oval, enlarged. Each eye composed of about 35 facets. Pronotum about as long as wide, PL 0.62–0.63 mm, PW 0.61–0.62 mm; roundly expanded at lateral margins; pronotal apex and base narrowed and truncate. Elytra (Fig. 2I) wider than long, EL 0.79–0.81 mm, EW 1.00–1.03 mm; inner two ba-

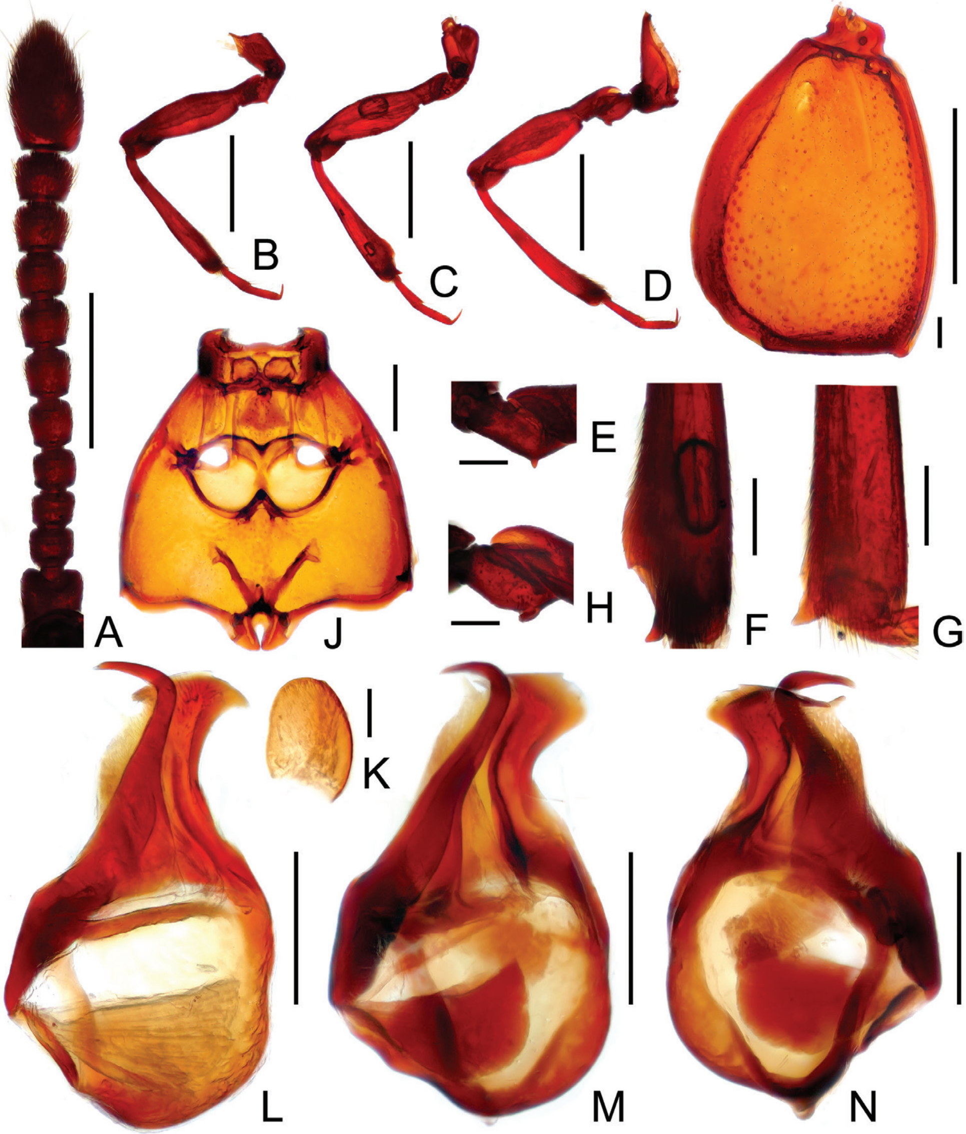

Figure 2. Male diagnostic features of *Tangius indicus* (**A–F, H–K, M–N**) and *T. glabellus* (**G, L**). **A** antenna **B** fore leg **C** mid leg **D** hind leg **E** protrochanter **F, G** apical portion of mesotibia **H** metatrochanter **I** left elytron **J** meso- and metaventrites **K** sternite IX **L, M** aedeagus, in dorsal view **N** same, in ventral view. Scales (mm): **A, B, C, D, I** = 0.5; **J, L, M, N** = 0.2; **E, F, G, H, K** = 0.1.

sal foveae close; discal suture extending to less than half elytral length. Hind wings fully developed. Metaventrite (Fig. 2J) with posterior margin narrowly and deeply notched medially. Protrochanters (Figs 2B, E) with small ventral denticle at middle; mesotibiae (Figs 2C, F) with broadly concave mesal margin before triangular preapical spine;

metatrochanters (Figs 2D, H) with blunt ventral projection near apex; all femora with ringed sulcus near base. Abdomen slightly wider than long, AL 0.81–0.83 mm, AW 1.03–1.07 mm; sternite IX (Fig. 2K) nearly oval. Aedeagus (Figs 2M, N) length 0.57 mm; median lobe asymmetric, apex rounded, with sharp, weakly-sclerotized projection at right side; dorsal lobe well-sclerotized, slender, curved rightwards near apex.

Female (Fig. 1B). Identical to male except antennomeres shorter, and mesotibiae lacking distal concavity and preapical tooth.. Measurements: BL 2.73–2.81 mm, HL 0.51–0.52 mm, HW 0.53–0.54 mm, PL 0.53–0.54 mm, PW 0.52–0.54 mm, EL 0.66–0.68 mm, EW 1.00–1.03 mm, AL 0.91–0.95 mm, AW 1.06–1.07 mm.

Comparative notes. The new species is closely allied to *T. glabellus* in sharing similar body size, general habitus, including the unusual head shape, and aedeagal structure (Figs 2L, M). Males of these two species can be best separated by the subcylindrical antennomeres VII–X in *T. indicus,* and the mesotibiae being broadly concave just before the preapical denticle (Fig. 2G), while *T. glabellus* has asymmetric, transversely trapezoidal antennomeres VII–X, and the mesotibiae with straight mesal margins (Fig. 2G). The females of *T. indicus* have relatively longer antennomeres than those of female *T. glabellus*.

Distribution. North India: Meghalaya, West Bengal.

Biology. One female paratype was collected from sifted litter, as inferred from the label data. Members of this genus are supposed to be inquilines of ants as they exhibit obvious morphological adaptions to myrmecophily, e.g. smooth body surface, compressed antennae, reduction of foveae, etc. The type series of *T. glabellus* was collected from the colony of an unidentified ant nesting under a fallen tree.

Etymology. The specific epithet refers to the country where the type series were collected.

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References

Yin ZW, Li LZ, Zhao MJ (2012) Contributions to the knowledge of the myrmecophilous pselaphines (Coleoptera, Staphylinidae, Pselaphinae) from China. I. *Tangius glabellus* gen. et sp. nov. from Tibet. Zootaxa 3397: 55–61.

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RESEARCH ARTICLE

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GenSeq: An updated nomenclature and ranking for genetic sequences from type and non-type sources

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Abstract

An improved and expanded nomenclature for genetic sequences is introduced that corresponds with a ranking of the reliability of the taxonomic identification of the source specimens. This nomenclature is an advancement of the "Genetypes" naming system, which some have been reluctant to adopt because of the use of the "type" suffix in the terminology. In the new nomenclature, genetic sequences are labeled "genseq," followed by a reliability ranking (e.g., 1 if the sequence is from a primary type), followed by the name of the genes from which the sequences were derived (e.g., genseq-1 16S, COI). The numbered suffix provides an indication of the likely reliability of taxonomic identification of the voucher. Included in this ranking system, in descending order of taxonomic reliability, are the following: sequences from primary types – "genseq-1," secondary types – "genseq-2," collection-vouchered topotypes – "genseq-3," collection-vouchered non-types – "genseq-4," and non-types that lack specimen vouchers but have photo vouchers – "genseq-5." To demonstrate use of the new nomenclature, we review recently published new-species descriptions in the ichthyological literature that include DNA data and apply the GenSeq nomenclature to sequences referenced in those publications. We encourage authors to adopt the GenSeq nomenclature (note capital "G" and "S" when referring to the nomenclatural program) to provide a searchable tag (e.g., "genseq"; note lowercase "g" and "s" when referring to sequences) for genetic sequences from types and other vouchered specimens. Use of the new nomenclature and ranking system will improve integration of molecular phylogenetics and biological taxonomy and enhance the ability of researchers to assess the reliability of sequence data. We further encourage authors to update sequence information on databases such as GenBank whenever nomenclatural changes are made.

Keywords
GenBank, genetics, molecular phylogenetics, systematics, taxonomy

Introduction

The use of genetic sequences has been increasing with each passing year (Benson et al. 2005; Strasser 2011); unfortunately, the separation between voucher specimens and genetic sequences is similarly growing. With increasing frequency, the link between the genetic sequences being used in analyses and the organisms from which they came is not being reported (Pleijel et al. 2008). GenBank and other depositories are excellent sources of genetic sequences that have a strong system for accurately identifying genetic data being submitted (e.g., COI cannot be mislabeled as 16S), but little is done to check the accuracy of the identity of the organism from which the sequences were obtained (Federhen et al. 2009). The taxonomic determination remains solely the responsibility of the submitter of the sequences. Erroneous identifications are difficult to discover, and the perpetuation of the error in subsequent uses of the sequence data is nearly impossible to stop. Once a sequence is published, the identification rarely is questioned unless another sequence from the same gene and species is noted to be substantially different, or sequences from putatively unrelated taxa are very similar (e.g., Baldwin et al. 2009). Likewise, an identification may be questioned if a BLAST (*Basic Local Alignment Search Tool,* in GenBank) search or phylogenetic analysis reveals a sequence to be in an unexpected region of a similar species or in an unexpected part of a phylogeny.

Although an institutional catalog number for the specimen (the ‘voucher’) from which a sequence is obtained is often requested when a sequence is submitted, it is not obligatory. Most sequences available on GenBank lack this information. Sequences available from databases such as GenBank have little reference to the source of the genetic materials other than the title and authors of the original publication. Unfortunately, original publications also often lack information about the original specimens necessary to validate their identification. To remedy this deficiency and to remind researchers about the importance of providing and accurately identifying DNA voucher specimens, we propose a new genetic nomenclature based on a ranking of various source specimens. We also suggest various ways in which the link between specimens and genetic sequences can be made more transparent.

Chakrabarty (2010) proposed the ‘Genetypes’ nomenclature to help flag genetic materials from type specimens in scientific papers and other outlets. This classification allowed researchers to more readily find sequences from type specimens where there is certainty that a specimen was vouchered and little doubt (none for primary types) that the voucher was correctly identified. The unfortunate use of the word “type” in the Genetypes nomenclature (e.g., “hologenetype” for sequences from a holotype) led some to think that the sequences were being designated as representative genetic types for the species just as type specimens are. That was not the intention; rather, the intent was to emphasize the reliability of those sequences because of the reliable taxonomic identification associated with type specimens. The sequences themselves are not unique identifiers (name-bearers) of the species, and the "type" suffix is not included in the new GenSeq nomenclature. The goal of the new nomenclature remains the same as that of the original: to assess the reliability of sequence data by increasing the transparency of links between specimens, taxonomy, sequence data, and molecular evolutionary analyses.

The GenSeq nomenclature combines the term "genseq" with a hyphen and a number from 1 to 5 reflecting the reliability ranking we provide in Table 1. Sequences from primary type specimens are referred to as genseq-1, with the 1 reflecting the highest reliability rank. In addition to these terms, the gene region(s) should be reported with the GenSeq reference; for example, "genseq-1 mitogenome, genseq-2 16S, ND2", or "genseq-5 UCE chr11_2436". The hyphen between "genseq" and the number must be included to allow search engines such as Google to search the entire text string because these searches treat hyphens as spaces. Note that in reference to the nomenclatural program we use capital letter "G" and "S" (e.g., GenSeq), and all lowercase letters (e.g., genseq-1) when referring to specific sequences.

Many GenSeqs can be created from a single specimen and can be from a single gene fragment, multiple fragments, or an entire genome; for instance, "genseq-2 COI" and "genseq-2 COII, ND2," could be added from the same paratype voucher at a later date, as could GenSeqs from other specimens of this species (e.g., other paratypes, the holotype) from which DNA was extracted. This nomenclature is simply a flag to alert molecular biologists and taxonomists that sequences are available from type specimens and some confidently identified non-types (see below). We suggest that researchers preferentially use these sequences in molecular evolutionary analyses, as doing so should bolster confidence in conclusions based on the sequence data (Fig. 1). Tabulating the GenSeq nomenclature with GenBank numbers and catalog numbers for vouchers will provide subsequent workers with easy access to this information (Table 2). We suggest that authors report the GenSeq in either the *Systematic Accounts* section or *Materials and Methods* section of a manuscript. For these sections, an additional example of how the GenSeq nomenclature could be reported for type specimens is: "One of the paratypes (USNM 139024) was sequenced (GenBank accession number JZ254935) and therefore constitutes a genseq-2 cytochrome *b.*"

The "genseq" suffix will flag genetic sequences in any manuscript so that authors can better assess the reliability of the taxonomic identification of specimens used to obtain those sequences. A sequence from a holotype provides the highest reliability of taxonomic identification and is therefore awarded the highest ranking in the system (genseq-1; Table 1). Although secondary types are not name-bearing specimens, in most cases identifications of secondary types are at least as trustworthy, and generally more so, than those from non-types, which may have been identified by non-experts or that may lack vouchered specimens. For this reason, sequences from secondary types are given the second highest ranking (genseq-2). Sequences from vouchered topotypes—individuals collected from the type locality of a species—are given the third

Table 1. Ranking Sequence Reliability. Ranking of source materials of genetic sequences based on reliability of taxonomic identification. Examples of the source material are listed in the third column with the last column providing the corresponding GenSeq nomenclature.

Reliability Ranking	Source Materials	Examples	Corresponding GenSeq Nomenclature
Highest 1ST	Primary Types	Holotype, Lectotype, Syntype, Isosyntype, Neotype, Isotype	genseq-1
2nd	Secondary Types	Paratype, Paralectotypes, etc.	genseq-2
3rd	Topotypes (vouchered), or non-type specimens listed in original description or redescription	Topotype, Non-type specimen listed in original description or redescription	genseq-3
4th	Collections-vouchered non-types (not from original description or redescription)	Vouchered specimen	genseq-4
5th	Photo voucher only	No specimen voucher but photo voucher available	genseq-5
Lowest	No voucher	Non-vouchered	No classification

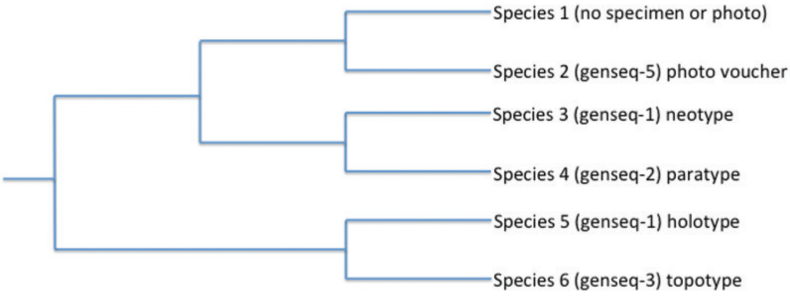

Figure 1. Example of how the GenSeq ranking system of sequences from various sources (Table 1) can be used to assess the trustworthiness of data used to reconstruct phylogenetic relationships. The rankings (the # in the "genseq-#") make it clear that the relationship recovered between Species 3 and Species 4, from primary and secondary types, should be trustworthy because the taxonomic identifications of the voucher specimens are considered to be highly reliable. In contrast, the recovered sister relationship between Species 1 and Species 2 may be less trustworthy because of the weak reliability rankings of these sequences from non-types. Species 1 lacks both a specimen or photo voucher and therefore does not have a GenSeq ranking.

highest ranking as are individuals not designated as types in the original description but are identified as belonging to the new taxon in that same manuscript (both genseq-3).

The genseq-3, -4, and -5 categories (Table 1) represent a departure and expansion from the previous Genetypes nomenclature. Because most species included in mo-

Table 2. Example Reporting Table. Examples of how links between genetic sequences and vouchers in institutional collections could be displayed as a table in publications reporting new sequences.

Species	Specimen Catalog #	GenBank #		GenSeq Nomenclature
		COI	ND1	
Typhleotris mararybe	LSUMZ 13636 (a holotype)	HM590594	HM590606	genseq-1 COI, ND1
Paretroplus tsimoly	AMNH 229558 (a paratype)	JZ590596	NA	genseq-2 COI
Nandopsis haitiensis	UMMZ 236321 (a topotype)	BK590595	BK590607	genseq-3 COI, ND1
Halieutichthys intermedius	FMNH 96353 (a non-type specimen voucher)	AY722169	AY722306	genseq-4 COI, ND1
Equulites absconditus	NMNH 12345PV2 (a photo voucher)	NA	BG34621	genseq-5 ND1

lecular analyses will not have type specimens available for sequencing, it is important to expand the genetic nomenclature and ranking to forecast the reliability of other sources of sequences. A sequence from a vouchered specimen that was not included in the type series but that is identified in the original description of the species as a member of the new taxon should be flagged as "genseq-3." The "3" is used as a suffix in this case again to reflect that it belongs to the third highest category of reliability (Table 1). Sequences from vouchered specimens from a redescription of a resurrected species should also be flagged "genseq-3." Sequences from non-type specimens that are not mentioned in the original description, or redescription, but that are confidently identified by an expert should be flagged "genseq-4" with the "4" suffix again reflecting the 4th highest ranking of reliability. Finally, "genseq-5" is a flag for sequences that lack any specimen voucher but that have a well-documented and publically available photo voucher. A photo voucher is not ideal but is necessary when the organism is still alive, highly endangered, extremely large, or extremely small (e.g., a larva where the entire sample must be used to obtain sufficient DNA).

In cases where the term "genseq-[3, 4, or 5]" category is used to identify sequences that are from a non-type specimen, the specimen should be identified by an authority and deposited in a reputable natural history collection. Both specimen and photo vouchers would be included in the "hologenophore" category of biological vouchers described by Pleijel et al. (2008: 369), which indicates that the voucher is the same individual organism from which (in molecular biology) the genetic data were derived. As the GenSeq nomenclature applies only to hologenophores, the remaining categories of biological vouchers of Pleijel et al. (2008), in which the voucher is not the same individual from which (in molecular biology) the genetic sequences were derived, are not relevant to the GenSeq nomenclature.

To better understand how sequences from type specimens are currently being reported in the scientific literature, we conducted a survey of recent publications describing new species of fishes that included DNA data. Fishes were chosen in part because we are ichthyologists, but also because fishes are described at a rate that is the highest among vertebrates (Lundberg et al. 2000). After tabulating new species from the relevant publications, we apply the GenSeq nomenclature to sequences referenced in those publications.

Methods

We used a Google Scholar search (www.scholar.google.com) to find papers published between 2010 and 2011 using the search term "new fish species DNA." The retrieved papers were reviewed for any mention of sequences obtained from a holotype or paratypes. Because many papers did not link the GenBank #'s with the voucher's catalog number, we conducted a corresponding search on GenBank (http://www.ncbi.nlm.nih.gov/) to determine whether those catalog numbers were reported there.

Each species recovered from the Google Scholar search was entered into the GenBank "nucleotide" search-engine field. If a catalog number of a holotype or paratype(s) was recovered in either the original paper or with GenBank, it was reported in Table 3. In cases where the link between voucher and sequence was unclear, authors of the descriptions were contacted to clarify the link. We only report examples where the genetic sequences could be positively linked to the catalog number of the holotype or paratypes. (Other forms of GenSeqs were not searched for in this initial case study.)

Results

The Google Scholar search produced 47 publications from 2010 and 2011 that included descriptions of new species of fishes and used sequence data. Only 13 of those papers indicated that sequences were derived from a type or non-type specimen (Table 3). Of the remaining 34 publications there was either no clear link between catalog numbers of vouchers and sequences (even after a query e-mail was sent to a corresponding author), or, rarely, it was made clear in the paper that no types were among those sequenced.

Of the 13 publications in Table 3, only three reported the catalog number of the type specimens along with the GenBank #'s, both in the manuscript and on GenBank. Six others reported both numbers only in the paper, and two reported the catalog number solely on GenBank. The two remaining papers (of the 13) were verified to have sequences from a primary or secondary type only after a query e-mail to the corresponding author. These authors did not supply the catalog numbers of the voucher specimens from which GenBank sequences were obtained either in their manuscript or on GenBank.

Table 3. Results of Search for Sequences from Types. GenSeq nomenclature applied to DNA sequences of fishes described from 2010–2011. The data were mined from GenBank and Google Scholar. Institutional abbreviations follow Sabaj-Perez (2012) except GSDNA which is the Natural History Gallery of Casalina. ❖ indicates that the catalog number of the voucher was reported with the genetic sequences in the published original description. ○ indicates that the catalog number of the voucher was recorded in GenBank with the sequences. Lack of either symbol indicates that the authors were e-mailed to find the link between a voucher and a sequence.

Species (Group)	**Citation**	**Type of type**	Voucher catalog	**GenBank #**	**GenSeq**
Bathygobius antilliensis (Teleostei: Gobiidae)	Tornabene et al. 2010 ❖○	Holotype	AMNH 251650	HM748393	genseq-1 COI
		Paratypes	16 examples	16 examples	genseq-2 COI
Bathygobius geminatus (Teleostei: Gobiidae)	Tornabene et al. 2010 ❖○	Holotype	USNM 398105	HM748368	genseq-1 COI
		Paratypes	AMNH 251648	HM748389	genseq-2 COI
			USNM 398102	HM748357	
			USNM 398103	HM748365	
			USNM 398106	HM748369	
			USNM 398107	HM748373	
			USNM 398109	HM748375	
			USNM 398112	HM748379	
Chimaera opalescens (Chondrichthyes: Holocephali)	Luchetti et al. 2011 ❖○	Paratypes	MNHN 2007-1557	GU244532	genseq-2 COI
			MNHN:2007-1555	GU244533	
			MNHN:2007-1567	GU244534	
			MNHN:2007-1579	GU244531	
Callopanchax sidibei (Nothobranchiidae: Epiplateinae)	Sonnenberg and Busch 2010	Holotype	ZFMK 41613	GU553012	genseq-1 16S
Hypsolebias guanambi (Cyprinodontiformes: Rivulidae)	Costa et al. 2011 ❖○	Paratypes	UFRJ 6782.1	HQ833483	genseq-2 CytB
			UFRJ 6782.2	HQ833484	
			UFRJ 6782.3	HQ833485	
			UFRJ 6782.4	HQ833486	
Petrocephalus similis (Osteoglossomorpha: Mormyridae)	Lavoue 2011 ○	Holotype	CU 95318	JF438961	genseq-1 CytB
		Paratypes	CU 93218.1	JF438960	genseq-2 CytB
			CU 93218.2	JF438962	
			CU 93218.3	JF438964	
			CU 93218.4	JF438963	
			CU 93219	JF438965	
Starksia sangreyae (Teleostei: Labrisomidae)	Baldwin et al. 2011 ❖	Holotype	USNM 398932	HQ600872	genseq-1 COI
		Paratypes	USNM 398939	HQ600865	genseq-2 COI
			USNM 398933	HQ600873	
			USNM 398936	HQ600868	
			USNM 398934	HQ600875	
			USNM 398935	HQ600874	
			USNM 398938	HQ600866	
			USNM 398940	HQ600864	

Species (Group)	**Citation**	**Type of type**	Voucher catalog	**GenBank #**	**GenSeq**
Starksia springeri (Teleostei: Labrisomidae)	Baldwin et al. 2011 ❖	Paratypes	USNM 399658	HQ600878	genseq-2 COI
			USNM 399659	HQ600876	
Starksia weigti (Teleostei: Labrisomidae)	Baldwin et al. 2011 ❖	Paratypes	USNM 399649	HQ600886	genseq-2 COI
			USNM 399653	HQ600934	
			USNM 399652	HQ600935	
			USNM 399651	HQ600936	
			USNM 399656	HQ600927	
			USNM 399655	HQ600932	
Starksia williamsi (Teleostei: Labrisomidae)	Baldwin et al. 2011 ❖	Paratypes	USNM 397396	HQ543039	genseq-2 COI
Starksia robertsoni (Teleostei: Labrisomidae)	Baldwin et al. 2011 ❖	Paratypes	USNM 399909	HQ600961	genseq-2 COI
			USNM 399911	HQ600960	
Starksia greenfieldi (Teleostei: Labrisomidae)	Baldwin et al. 2011 ❖	Paratypes Topotypes	USNM 398922	HQ600924	genseq-2 COI genseq-3 COI
			USNM 398921	HQ600925	
			USNM 398920	HQ600947	
Esox flaviae (Esociformes, Esocidae)	Lucentini et al. 2011 ❖	Holotype	GSDNA1	HM563688.1 (COI)	genseq-1 COI, CytB
				JN190460 (cytB)	
Milyeringa brooksi (Teleostei: Gobiiformes)	Chakrabarty 2010 ❖○	Paratype	LSUMZ 13637	HM590607 (ND2), HM590601 (cytB), HM590595 (COI)	genseq-2 ND2, CytB, COI
Leptoderma macrophthalmum (Otocephala: Alepocephalidae)	Byrkjedal et al. 2011 ❖	Holotype	ZMUB 19686	AP011500	genseq-1 mitogenome
Sparisoma rocha (Actinopterygii: Labridae)	Pinheiro et al. 2010	Paratype	ZUEC 6349	GU985520 (16S)	genseq-2 16S, 12S
				GU985521 (12S)	
Halichoeres rubrovirens (Perciformes: Labridae)	Rocha et al. 2010 ○	Paratype	CIUFES 0317	GU938858	genseq-2 CytB
			CIUFES 1279	GU938859	
			CIUFES 1474	GU938860	
			CIUFES 1475	GU938861	
			USNM 397005	GU938862	

Species (Group)	Citation	Type of type	Voucher catalog	GenBank #	GenSeq
Betadevario ramachandrani (Cyprinidae: Danioninae)	Pramod et al. 2010 ❖	Paratype	NRM 57780	GU327623 (cytB) GU327622 (Rho)	genseq-2 CytB, rhodopsin
Crenicichla hu (Teleostei: Cichlidae)	Piálek et al. 2010 ❖	Paratype	MACN-ict 9430.1	GQ328038 (trnQ, trnM, ND2, trnW, trnA)	genseq-2 trnQ, trnM, ND2, trnW, trnA
			MACN-ict 9430.2	GQ328039 (trnQ, trnM, ND2, trnW, trnA)	

This is not a complete list of descriptions of new species of fishes with genetic sequences from type specimens. There are likely some publications that were not found via GoogleScholar or that would have been found in other search engines because of the nature of the scripts used in those searches. This search on descriptions of new species of fishes using sequence data is only a rough proxy for other groups of organisms.

Discussion

GenSeq is a nomenclatural label for sequence data from confidently identified vouchered specimens. By explicitly flagging gene sequences from type materials, the new nomenclature will enable researchers to utilize sequences from the best-identified specimens when available. In particular, "genseq-1" and "genseq-2" flags will highlight sequences (see Table 1) from GenBank that, due to their direct link to primary and secondary type specimens, will be more credible than sequences from specimens with less certain identifications. Type materials remain essential for taxonomic comparisons, but sequence data from type materials have not been fully incorporated into these comparisons (see references in Chakrabarty 2010; present study).

The burden of linking specimens (even type specimens) to sequences from the publications of others is one reason for the creation of this expanded nomenclature. Authors often do not provide a clear link between voucher specimens and the sequences obtained from them. Presumably authors publishing on taxonomy and molecular phylogenetics would be much better at providing a clear link between the two, but as made evident from the results of this study, these authors often fail to make this link. Unfortunately, many authors simply make a statement similar to the following: "the sequences obtained from this study were given the GenBank #'s XX12428-XX12531," which tells no one which sequence belongs to which specimen (or even which species). These data are even more poorly reported on GenBank, where few researchers provide catalog numbers of the vouchers from which the sequences were obtained. A clear link between the specimens' catalog number and the sequences' GenBank #'s should either be made in a table (as in Table 2), or the voucher's catalog numbers should be listed in GenBank with the genetic sequences. Ideally, both tasks should be done to maximize transparency.

The GenSeq nomenclature also incorporates sequences from non-type materials because many species will never have their type specimens sequenced. This could be because some collections will not want the morphological integrity of the type specimen to be diminished by the removal of a subsample for DNA extraction, or because the specimen has been fixed in formalin (as is the case for most fish, reptile, and amphibian specimens), or by some other preservation method and will no longer yield sufficient amounts of DNA. An example of how one of the non-type flags (viz., genseq-3, genseq-4, genseq-5) can be used is in cases of a taxonomic treatment in which a formerly synonymized species is resurrected and there is not a type specimen that will yield DNA. Sequences from a fresh specimen for the resurrected species should be flagged as "genseq-3." Because the identification of the voucher is tied to the work of a taxonomist resurrecting a species (i.e., the first reviser), other researchers should have high confidence in its correct identification. Although not type material, such specimens and sequences from them should be regarded as highly likely to be correctly identified.

A Google Scholar search of the usage of the former Genetypes nomenclature, revealed 24 citations from 2010–2013 for sponges, fungi, fishes, amphibians, birds, mammals, and insects. Without a search term (in this case Genetypes), finding sequences that are derived from type specimens requires reading original publications or looking up sequences in a database. As our results indicate, authors are often inconsistent in how this information is reported, if they choose to report it at all. The benefits of having a search term like "genseq-#" embedded in a manuscript can be demonstrated by doing a simple Google Scholar search on a similar label, such as "holotype;" such a search can be rendered even more specific by adding a scientific name, e.g., "holotype *Typhleotris mararybe*." Our new genetic terminology will enable researchers to conduct searches such as "genseq-# + *Genus species,*" which will help them locate genetic sequences from well-documented, and likely properly identified, vouchered specimens.

Ultimately, the GenSeq approach will benefit all forms of taxonomic research as molecular phylogenetics becomes integrated with taxonomy and as technology improves in molecular biology. We remind researchers about the importance of vouchers and reporting taxonomic changes to databases such as GenBank. Taxonomic changes, misidentifications, and other changes to sequences need to be reported before they are perpetuated erroneously in the literature. If a species has sequences on GenBank and that species is later split into two species, the taxonomy should be updated by the authors on GenBank. Without this update, the original GenBank sequences that represent the new species in the split, rather than the existing one, may be used erroneously by unsuspecting researchers.

To expand usage of GenSeq flags for genetic sequences, a summary of this nomenclature should be incorporated into the "Instruction to Authors" for taxonomic journals. Harrison et al.'s (2011) editorial was used to explain the usage of the Genetypes nomenclature to authors using the *Journal of Fish Biology*. We suggest that the following text be added to the author guidelines of taxonomic journals where sequences are reported:

> **Sequence data:** Manuscripts containing novel amino acid sequences (e.g. primer sequences) will only be accepted if they carry an International Nucleotide Sequence Databases (INSD) accession number from the European Biology Laboratory (EMBL), GenBank Data Libraries (GenBank) or DNA Data Bank of Japan (DDBJ). [Name of Journal] strongly recommends that authors include institutional catalog numbers for specimens preserved in collections, and information identifying sequences that are derived from type specimens (see below) when they deposit data in genetic databanks. Database [GenBank] accession [catalog] numbers should be included in the Materials and Methods section. If specimens were not vouchered (tissued specimens should be vouchered when possible!), photographs and collection locality data for tissued specimens must be provided.
>
> A nomenclature for genetic sequences for types and confidently identified non-type specimens has been proposed by Chakrabarty et al. (2013); a sequence from a holotype is identified as genseq-1, one from a paratype is identified as genseq-2, one from a topotype is genseq-3, etc. The genetic marker(s) used should also be incorporated into the nomenclature (e.g. genseq-2 COI).

Authors who wish to report GenSeqs in a web interface (in addition to in a published manuscript and on GenBank) may choose the widely used Animal Diversity Web (ADW; http://animaldiversity.ummz.umich.edu/). The editors of this website suggest that the "Other Comments" field can be used to report GenBank links of GenSeqs (Tanya Dewey pers. comm.). For help creating an ADW page for a new taxon using the GenSeq nomenclature, please contact the first author of this paper.

In the future, we hope the GenSeq nomenclature will be widely used and eventually incorporated into GenBank and other large genetic databases. Incorporation is not currently possible with GenBank's user-driven interface which would allow too much human error in labeling sequences (pers. com., Scott Federhen, GenBank; Federhen et al. 2009). To be more specific, a user may apply the label "genseq" erroneously, and there is currently no accuracy-checking system within GenBank to correct that error. Our hope is that usage of this nomenclature will increase the rigor of evolutionary analyses using molecular sequences and remind authors to provide a clear link between sequences and vouchers.

Acknowledgments

We thank all the authors who were contacted and provided additional information about the sequences in Table 3. Two anonymous reviewers provided excellent suggestions that have been incorporated into this final publication. We would like to acknowledge Dr. Tanya Dewey (Animal Diversity Web) and Andy Bentley (University of Kansas) for their comments. We would like to also acknowledge the Louisiana State University Office of Strategic Initiatives 2012 Summer Research Experience for Undergraduates Program and the LSU Initiative for Maximizing Diversity for allowing MW to participate in this project. Financial support for this project was obtained from a National Science Foundation Grant to PC (DEB 0916695).

References

Baldwin CC, Weigt LA, Smith DG, Mounts JH (2009) Reconciling genetic lineages with species in western Atlantic *Coryphopterus* (Teleostei: Gobiidae). In: Lang MA, Macintyre IG, Rützler K (Eds) Proceedings of the Smithsonian Marine Science Network Symposium. Smithsonian Contributions to the Marine Sciences 38, 113–140.

Baldwin CC, Castillo CI, Weigt LA, Victor BC (2011) Seven new species within western Atlantic *Starksia atlantica*, *S. lepicoelia*, and *S. sluiteri* (Teleostei, Labrisomidae), with comments on congruence of DNA barcodes and species. ZooKeys 79: 21–72. doi: 10.3897/zookeys.79.1045

Benson DA, Karsch-Mizrachi I, Lipman DJ, Ostell J, Wheeler DL (2005) GenBank. Nucleic Acids Research 34: D16–D20. doi: 10.1093/nar/gkj157

Byrkjedal I, Poulsen JY, Galbraith J (2011) *Leptoderma macrophthalmum* n. sp., a new species of smooth-head (Otocephala: Alepocephalidae) from the Mid Atlantic Ridge. Zootaxa 2876: 49–56.

Chakrabarty P (2010) Genetypes: a concept to help integrate molecular systematics and traditional taxonomy. Zootaxa 2632: 67–68. http://www.mapress.com/zootaxa/2010/f/zt02632p068.pdf

Costa WJ, Amorim PF (2011) A new annual killifish species of the *Hypsolebias flavicaudatus* complex from the São Francisco River basin, Brazilian Caatinga (Cyprinodontiformes: Rivulidae). Vertebrate Zoology 61: 99–104.

Federhen S, Hotton C, Mizrachi I (2009) Comments on the paper by Pleijel et al. (2008): vouching for GenBank. Molecular Phylogenetics and Evolution 53: 357–358. doi: 10.1016/j.ympev.2009.04.016

Harrison IJ, Chakrabarty P, Freyhof J, Craig JF (2011) Correct nomenclature and recommendations for preserving and cataloguing voucher material and genetic sequences. Journal of Fish Biology 78: 1283–1290. doi: 10.1111/j.1095-8649.2011.02979.x

Lavoue S (2011) A new species of *Petrocephalus* Marcusen 1854 (Osteoglossomorpha: Mormyridae) from the Sanaga River basin, Cameroon. Zootaxa 2934: 20–28.

Luchetti EA, Iglesia SP, Sellos DY (2011) *Chimaera opalescens* n. sp., a new chimaeroid (Chondrichthyes: Holocephali) from the north-eastern Atlantic Ocean. Journal of Fish Biology 79: 399–417. doi: 10.1111/j.1095-8649.2011.03027.x

Lucentini L, Puletti ME, Ricciolini C, Gigliarelli L, Fontaneto D, Lanfaloni L, Bilò F, Natali M, Panara F (2011) Molecular and Phenotypic Evidence of a New Species of Genus *Esox* (Esocidae, Esociformes, Actinopterygii): The Southern Pike, *Esox flaviae.* PLoS One 6: 1–14. doi: 10.1371/journal.pone.0025218

Luchetti EA, Iglésias SP, Sellos DY (2011) *Chimaera opalescens* n. sp., a new chimaeroid (Chondrichthyes: Holocephali) from the north-eastern Atlantic Ocean. Journal of Fish Biology 79: 399–417. doi: 10.1111/j.1095-8649.2011.03027.x

Lundberg JG, Kottelat M, Smith GR, Stiassny MLJ, Gill AC (2000) So many fishes, so little time: An overview of recent ichthyological discoveries in continental waters. Annals of the Missouri Botanical Garden 87: 26–62. doi: 10.2307/2666207

Piálek L, Rican O, Casciotta J, Almiron A (2010) *Crenicichla hu*, a new species of cichlid fish (Teleostei: Cichlidae) from the Parana basin in Misiones, Argentina. Zootaxa: 33–46.

Pinheiro HT, Gasparini JL, Sazima I (2010) *Sparisoma rocha*, a new species of parrotfish (Actinopterygii: Labridae) from Trindade Island, south-western Atlantic. Zootaxa 2493: 59–65.

Pleijel F, Jondelius U, Norlinder E, Nygren A, Oxelman B, Schander C, Sundberg P, Thollesson M (2008) Phylogenies without roots? A plea for the use of vouchers in molecular phylogenetic studies. Molecular Phylogenetics and Evolution 48: 369–371. doi: 10.1016/j.ympev.2008.03.024

Pramod PK, Fang F, Devi KR, Liao T, Indra TJ, Beevi KS, Kullander SO (2010) *Betadevario ramachandrani*, a new danionine genus and species from the Western Ghats of India (Teleostei: Cyprinidae: Danioninae). Zootaxa 2519: 31–47.

Rocha LA, Pinheiro HT, Jasparini JL (2010) Description of *Halichoeres rubrovirens*, a new species of wrasse (Labridae: Perciformes) from the Trindade and Martin Vaz Island group, southeastern Brazil, with a preliminary mtDNA molecular phylogeny of New World *Halichoeres*. Zootaxa 2422: 22–30.

Sabaj Pérez MH (Ed) (2010) Standard symbolic codes for institutional resource collections in herpetology and ichthyology: an Online Reference. Verson 1.5 (4 Oct 2010). Electronically accessible at http://www.asih.org/, American Society of Ichthyologists and Herpetologists, Washington, D.C.

Sonnenberg R, Busch E (2010) Description of *Callopanchax sidibei* (Nothobranchiidae: Epiplateinae), a new species of killifish from southwestern Guinea, West Africa. Bonn Zoological Bulletin 57: 3–14.

Strasser BJ (2011)The Experimenter's Museum: GenBank, Natural History, and the Moral Economies of Biomedicine. Isis 102: 60–96. doi: 10.1086/658657

Tornabene L, Baldwin C, Weigt LA, Pezold F (2010) Exploring the diversity of western Atlantic *Bathygobius* (Teleostei: Gobiidae) with cytochrome-c subunit oxidase-I, with descriptions of two new species. Aqua, International Journal of Ichthyology 16: 141–170.

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RESEARCH ARTICLE

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New and little known species of oribatid mites of the family Haplozetidae (Acari, Oribatida) from Ecuador

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§ *http://zoobank.org/9B52EC8E-ACDA-40ED-AAF7-F9A7024938EA*
| *http://zoobank.org/D8AFFFE0-F030-49D1-8023-37D714A1F827*
¶ *http://zoobank.org/68CFE4F1-462F-4E3A-A579-732C9C57404C*

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Abstract

We described two new species, *Haplozetes paraminimicoma* **sp. n.** and *Protoribates ecuadoriensis* **sp. n.** from Ecuador. Additionally, a detailed supplementary description of *Trachyoribates* (*Rostrozetes*) *glaber* (Beck, 1965) is given on the basis of Ecuadorian specimens, which was known previously only from Peru. An annotated checklist of all identified taxa of Haplozetidae from Ecuador is presented.

Keywords

Oribatida, Haplozetidae, new species, *Haplozetes*, *Protoribates*, supplementary description, *Trachyoribates* (*Rostrozetes*) *glaber* (Beck, 1965), Ecuador

Introduction

The present study is based on the oribatid mite materials collected from the tropical rain forest soils in Ecuador, between 2008 and 2010. This paper is part of our continuing studies (see Ermilov et al. 2013a–c), and it includes the data on the family Haplozetidae. An annotated checklist of identified taxa is presented below.

In the course of taxonomic identification of the haplozetid mites, we found two new species belonging to the genera *Haplozetes* Willman, 1935 and *Protoribates* Berlese, 1908.

The genus *Haplozetes* was proposed by Willmann (1935) with *Peloribates vindobonensis* Willmann, 1935 as the type species. Subsequently, Grandjean (1936) redefined the type species, and ascertained generic status of *Haplozetes* and proposed the family Haplozetidae. This status has been accepted later by many authors (e.g. Balogh 1963, 1965, 1972; Shaldybina 1975; Balogh and Balogh 1984, 1992; Pérez-Iñigo 1993; Bayartogtokh 2000; Weigmann 2006; Murvanidze and Weigmann 2012). Recently, Subías (2004) treated *Haplozetes* as a subgenus of *Indoribates* Jacot, 1929, without justifying this action. We do not agree with the latter author's concept, and, therefore, consider here *Haplozetes* as an independent genus. This is one of the smallest genera of oribatid mites and currently comprises only 15 nominal species and one subspecies (Subías 2004, updated 2013).

The other genus studied here, *Protoribates* Berlese, 1908 is well defined by Weigmann et al. (1993), and is comparatively species rich as about 50 species were assigned to this genus (Subías 2004, updated 2013).

The third genus studied by us, *Trachyoribates* encompasses two subgenera, *Trachyoribates* Berlese, 1908 and *Rostrozetes* Sellnick, 1925, species of both of which are mainly distributed in the tropical regions (see Subías 2004, updated 2013).

The main purpose of our paper is to describe and illustrate two new species of *Haplozetes* and *Protoribates*. Also, a detailed supplementary description of *Trachyoribates* (*Rostrozetes*) *glaber* (Beck, 1965) is presented on the basis of Ecuadorian specimens.

Materials and methods

The study materials are derived from the following two collecting sites:

Ec-1: Southern Ecuador, 3°70'S, 78°58'W, Bombuscaro, Podocarpus National Park, 1050 m a.s.l., upper organic soil layer in mostly undisturbed rain forest, 01.10.2008, 01.04.2009 and 01.08.2010, collected by F. Marian and D. Sandmann.

Ec-2: Southern Ecuador, 3°58'S, 79°50'W, Estación Científica San Francisco, 2000 m a.s.l., upper organic soil layer in mostly undisturbed rain forest, 01.09.2008 and 01.04.2009, collected by F. Marian and D. Sandmann.

Specimens were studied in lactic acid, mounted in temporary cavity slides for the duration of the study, and then stored in 70% ethanol in vials. Body length was measured in lateral view, from the tip of rostrum to the posterior edge of ventral plate. Notogastral width refers to the maximum width in dorsal aspect. Lengths of body setae were measured in lateral aspect. All body measurements are given in micrometers. General terminology used in this paper follows that summarized by Norton and Behan-Pelletier (2009).

Checklist of identified Ecuadorian Haplozetidae

- *Haplozetes paraminimicoma* sp. n. Locality: Ec-1, Ec-2.
- *Protoribates iracemae* Pérez-Íñigo & Baggio, 1994. Locality: Ec-1. The species is recorded for the first time from Ecuador.
- *Protoribates paracapucinus* (Mahunka, 1988). Locality: Ec-1, Ec-2. The species is recorded for the first time from Ecuador and the Neotropical region.
- *Protoribates ecuadoriensis* sp. n. Locality: Ec-1, Ec-2.
- *Trachyoribates* (*Rostrozetes*) *glaber* (Beck, 1965). Locality: Ec-1. The species are recorded for the first time from Ecuador.

Descriptions of new species

Haplozetes paraminimicoma sp. n.

http://zoobank.org/F82D5CC5-9CCB-4B9B-B7EA-C3A03197634C
http://species-id.net/wiki/Haplozetes_paraminimicoma
Figs 1, 2

Diagnosis. Body size 332–348 × 215–249. Body surface smooth. Rostral and lamellar setae of medium long, with short cilia. Interlamellar setae short, smooth. Sensilli spindle-form, ciliate. Tutoria almost reaching of rostral margin, extending beyond level of insertions of rostral setae. Notogastral setae short, smooth. Genital plates with five pairs of setae. Epimeral, genital and aggenital setae with short cilia. Anal and adanal setae minute. Leg tarsi monodactylous. Leg tarsi I with 19 setae (*l”* absent).

Description. *Measurements*. Body length: 348 (holotype), 332–348 (four paratypes); notogaster width: 232 (holotype), 215–249 (four paratypes).

Integument. Body color light brownish. Body surface smooth. Anterior part of pteromorphs striate.

Prodorsum. Rostrum rounded. Lamellae (*Lam*) located dorso-laterally, longer than half of prodorsum, reaching insertions of lamellar setae. Rostral (*ro*, 28–32) and lamellar (*le*, 32–36) setae setiform, with several short cilia. Interlamellar setae short (*in*, 8–12), thin, smooth. A pair of elongate, narrow porose areas *Ad* present latero-posterior to interlamellar setae (well visible in dissected specimen). Exobothridial setae (*ex*, 12–16) thin, with one or two cilia. Sensilli longest setae on prodorsum (*ss*, 94–106), spindle-form, with long stalk, lanceolate head and thin, point tip; distal part of stalk and sensillar head ciliate. Tutoria (*tu*) thin, almost straight, extending insertions of rostral setae, with small, free tooth (*t*) distally. Sublamellar lines (*Slam*) present, short,

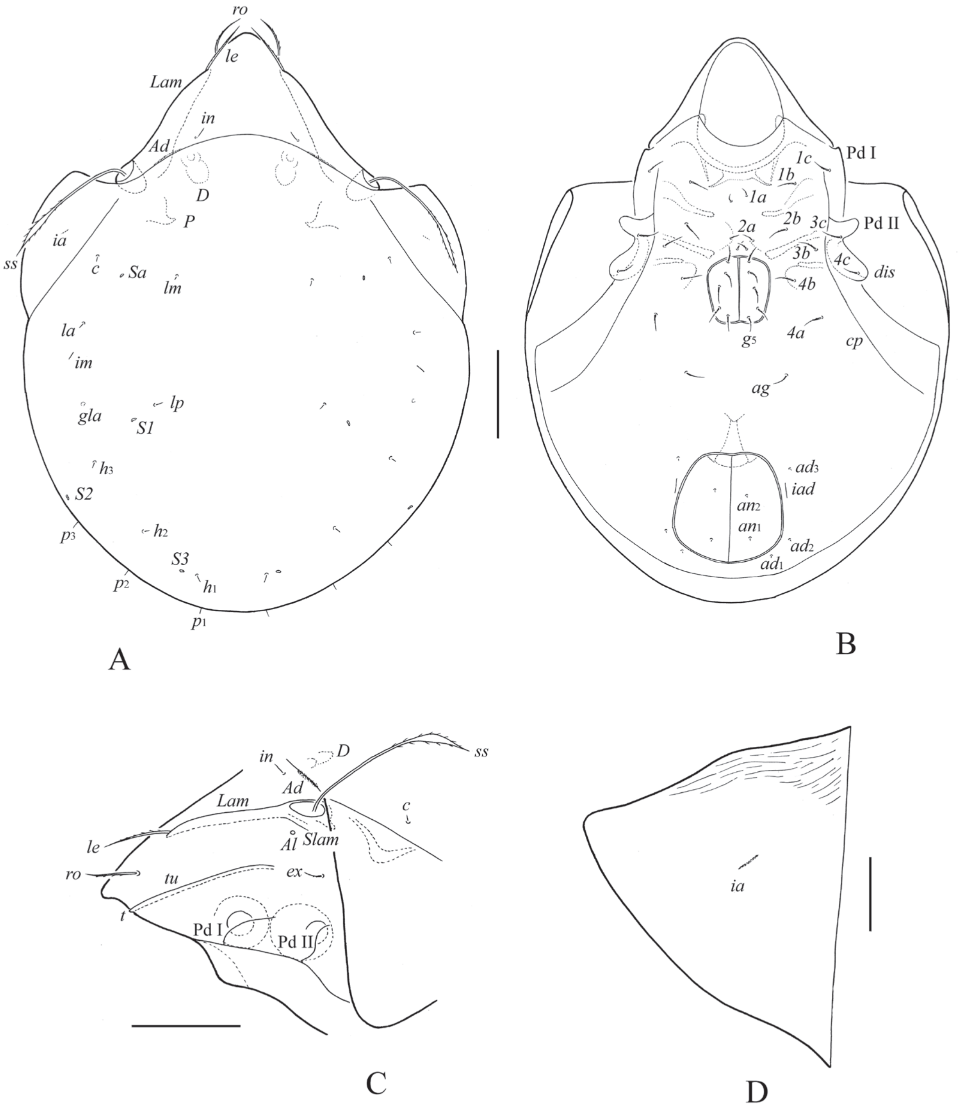

Figure 1. *Haplozetes paraminimicoma* sp. n., adult: **A** body dorsally **B** body ventrally (gnathosoma and legs not illustrated) **C** prodorsum and anterior part of notogaster laterally **D** left pteromorph. Scale bar (**A–C**) 50 µm, scale bar (**D**) 20 µm.

thin, poorly visible. Sublamellar porose areas (*Al*) small, rounded (4). Porose areas *Am* and *Ah* not observed.

Notogaster. Anterior notogastral margin convex medially. Dorsophragmata (*D*) and pleurophragmata (*P*) distinct. Pteromorphs sub-triangular. Ten pairs of notogastral setae short (6), thin, smooth. Four pairs of sacculi (*Sa*, *S1*, *S2*, *S3*) with small openings; *Sa* consisting of two adjacent parts, *S1* and *S2* irregular elongate oval, *S3* sub-triangular.

Table 1. Leg setation and solenidia of *Haplozetes paraminimicoma* sp. n.

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	*v’*	*d*, (*l*), *bv”*, *v”*	(*l*), *v’*, *σ*	(*l*), (*v*), φ_1, φ_2	(*ft*), (*tc*), (*it*), (*p*), (*u*), (*a*), *s*, (*pv*), *v’*, (*pl*), *e*, ω_1, ω_2
II	*v’*	*d*, l_1’, l_2’, *bv”*, *v”*	(*l*), *v’*, *σ*	(*l*), (*v*), *φ*	(*ft*), (*tc*), (*it*), (*p*), (*u*), (*a*), *s*, (*pv*), ω_1, ω_2
III	*l’*, *v’*	*d*, *l’*, *ev’*	*l’*, *σ*	*l’*, (*v*), *φ*	(*ft*), (*tc*), (*it*), (*p*), (*u*), (*a*), *s*, (*pv*)
IV	*v’*	*d*, *ev’*	*d*, *l’*	*l’*, (*v*), *φ*	*ft”*, (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)

Roman letters refer to normal setae (*e* to famulus), Greek letters to solenidia. Single prime (‘) marks setae on anterior and double prime (“) setae on posterior side of the given leg segment. Parentheses refer to a pair of setae.

Lyrifissures (*ia*, *im*, *ip*, *ih*, *ips*) and opisthonotal gland openings (*gla*) located typically for the genus (see Beck 1964; Bayartogtokh 2000). Postanal porose area not observed.

Gnathosoma. Subcapitulum longer than wide (82 × 61). Subcapitular setae setiform, with short cilia; *h* (12) shorter than *m* (28) and *a* (16). Two pairs of adoral setae (or_1, or_2, 12) setiform, straight, densely ciliate. Palps (69) with setation 0–2–1–3–9(+*ω*). Solenidion thickened, weakly dilated distally, coupled with eupathidium (*acm*). Chelicerae (82) with two setiform, ciliate setae; *cha* (28) longer and thicker than *chb* (18). Trägårdh’s organ (*Tg*) conical.

Epimeral and lateral podosomal regions. Apodemes 1, 2, 3 and sejugals well developed. Epimeral setal formula 3–2(1)–3–3; setae setiform, with short cilia. Setae *2b* present in holotype and two paratypes. Medial setae *1a*, *2a*, *3a* (8–10) shorter than others (16–20). Pedotecta I (*Pd* I), II (*Pd* II), discidia (*dis*) and circumpedal carinae (*cp*) developed typically for the genus (see Beck 1964; Bayartogtokh 2000).

Anogenital region. Five pairs of genital (g_1–g_5, 12) and one pair of aggenital (*ag*, 16) setae setiform, with short cilia. Two pairs of anal (an_1, an_2, 4) and three pairs of adanal (ad_1–ad_3, 4) setae minute. Lyrifissures *iad* in paraanal position.

Legs. All tarsi with one strong, dorsally weakly serrate claw. Morphology of leg segments, setae and solenidia typical for genus (see Beck 1964; Bayartogtokh 2000), hence only tarsus I is illustrated. Formulae of leg setation and solenidia: I (1–5–3–4–19) [1–2–2], II (1–5–3–4–15) [1–1–2], III (2–3–1–3–15) [1–1–0], IV (1–2–2–3–12) [0–1–0]; homology of setae and solenidia indicated in Table 1.

Material examined. Holotype (female) and four paratypes (two females and two males): Ec-1.

Type deposition. The holotype (in ethanol) is deposited in the collection of the Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia; two paratypes (in ethanol) are deposited in the collection of the Siberian Zoological Museum, Novosibirsk, Russia; two paratypes (in ethanol) are in the personal collection of the first author.

Etymology. The prefix *para* is Latin meaning “near” and refers to the similarity between the new species and the species, *Haplozetes minimicoma* Beck, 1964.

Remarks. In having the combination of main morphological characters (sensilli spindle-form, ciliate; interlamellar, notogastral and ano-adanal setae short; leg tarsi

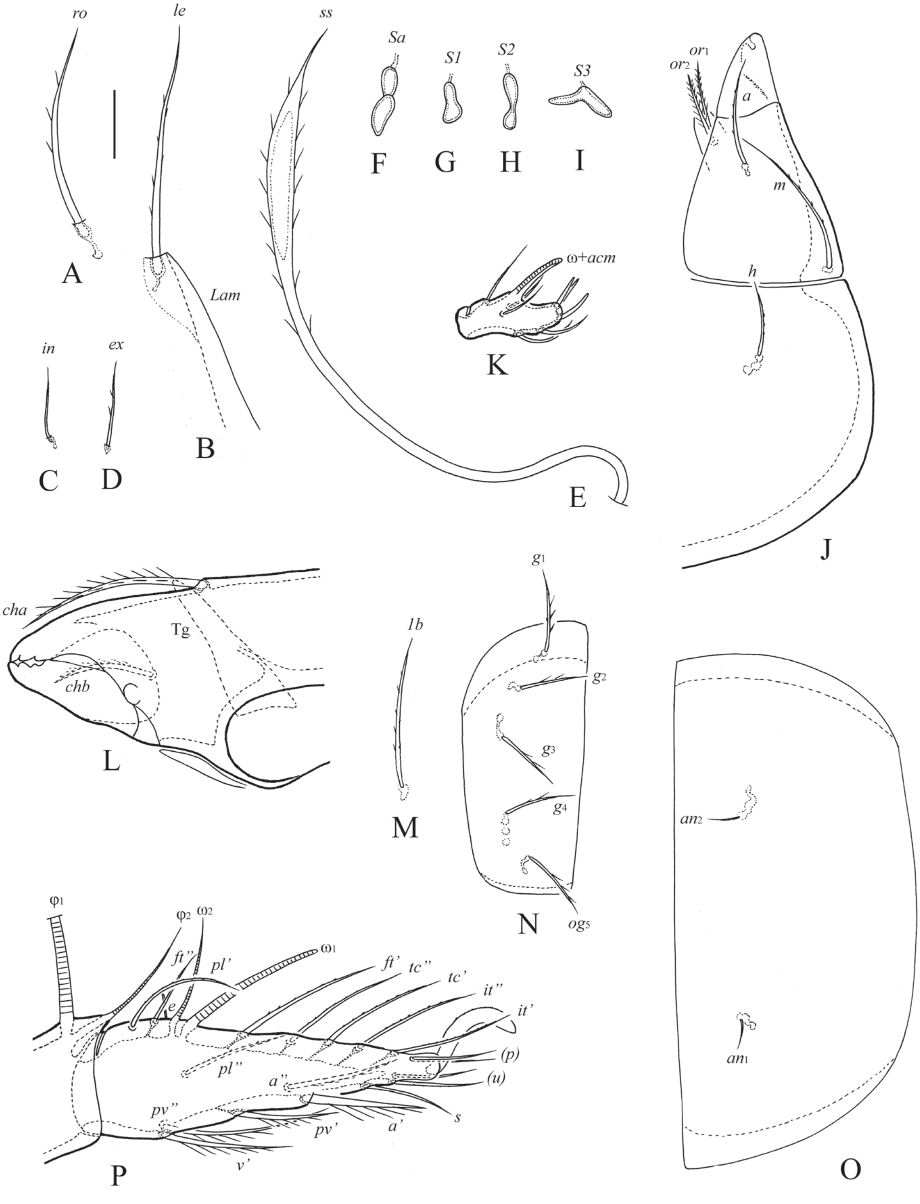

Figure 2. *Haplozetes paraminimicoma* sp. n., adult: **A** rostral seta **B** lamellar seta and anterior part of lamella **C** interlamellar seta **D** exobothridial seta **E** sensillus **F** sacullus *Sa* **G** sacullus *S1* **H** sacullus *S2* **I** sacullus *S3* **J** left half of subcapitulum **K** palptarsus **L** anterior part of chelicera **M** epimeral seta *1b* **N** right genital plate **O** left anal plate **P** tarsus and anterior part of tibia of leg I, left, paraxial view. Scale bar 10 µm.

with one claw), *Haplozetes paraminimicoma* sp. n. is most similar to *Haplozetes minimicoma* Beck, 1964 from the Neotropical region and India (see Beck 1964), however the new species clearly differs from the latter by the presence of five pairs genital setae (versus four), smooth body surface (versus microfoveolate), long tutoria, extending insertions of rostral setae (versus not reaching), longer, ciliate genital and epimeral setae (versus short, smooth), and the absence of setae *l”* on leg tarsi I (versus present).

***Protoribates ecuadoriensis* sp. n.**

http://zoobank.org/B13B53C5-6850-4437-A493-5E7885A44D58
http://species-id.net/wiki/Protoribates_ecuadoriensis
Figs 3, 4

Diagnosis. Body size 547–647 × 332–431. Prodorsal setae long, setiform, barbed. Exobothridial setae minute. Sensilli with long stalk, lanceolate head and thin, point tip; distal part of stalk and sensillar head ciliate. Sublamellar porose areas large, oval. Notogastral porose areas of medium size, oval. Notogastral setae short. Adanal setae ad_1 longer than ad_2, ad_2 longer than ad_3. Legs monodactylous. Leg tarsi I, II with large dorsal tubercles. Tarsi I with 20 setae.

Description. *Measurements*. Body length: 630 (holotype), 547–647 (five paratypes); notogaster width: 415 (holotype), 332–431 (five paratypes).

Integument. Body color light brownish to brown. Body surface microgranulate (visible only under high magnification).

Prodorsum. Rostrum rounded. Lamellae located dorso-laterally, not longer than half of prodorsum, hardly reaching insertions of lamellar setae. Rostral (49–57), lamellar (86–94) and interlamellar setae (123–135) setiform, barbed. A pair of elongate, narrow porose areas *Ad* present latero-posterior to interlamellar setae (visible under high magnification in dissected specimen). Exobothridial setae minute (4), thin, smooth. Sensilli (102–108) with long stalk, lanceolate head and thin, pointed tip; distal part of stalk and sensillar head ciliate. Tutoria short, narrow, slightly arched distally. Sublamellar lines short, very thin, straight, poorly visible. Sublamellar porose areas large, oval (20 × 16). Porose areas *Am* and *Ah* not observed.

Notogaster. Anterior notogastral margin convex medially. Dorsophragmata and pleurophragmata distinct. Pteromorphs sub-triangular. Ten pairs of notogastral setae short (4–6), thin, smooth. Four pairs of porose areas of medium size, oval: *Aa* (16–20 × 12–16) slightly larger than *A1*, *A2* and *A3* (10–14 × 8–12). Setae *lp* inserted posteriorly to *A1*. Lyrifissures (*ia*, *im*, *ip*, *ih*, *ips*) and opisthonotal gland openings located typically for the genus (see Weigmann et al. 1993; Miko et al. 1994). Postanal porose area absent.

Gnathosoma. Subcapitulum longer than wide (147–164 × 102–110). Subcapitular setae setiform, barbed; *h* and *a* (both 24–28) longer than *m* (10–14). Two pairs of adoral setae (16–20) setiform, barbed. Palps (90) with setation 0–2–1–3–9(+ω). Solenidion thickened, coupled with eupathidium. Chelicerae (147–164) with two setiform, barbed setae; *cha* (41–45) longer and thicker than *chb* (24–28). Trägårdh’s organ conical.

Epimeral and lateral podosomal regions. Apodemes 1, 2, 3 and sejugals well developed. Epimeral setal formula 3–1–3–3; setae setiform, slightly barbed. Medial setae

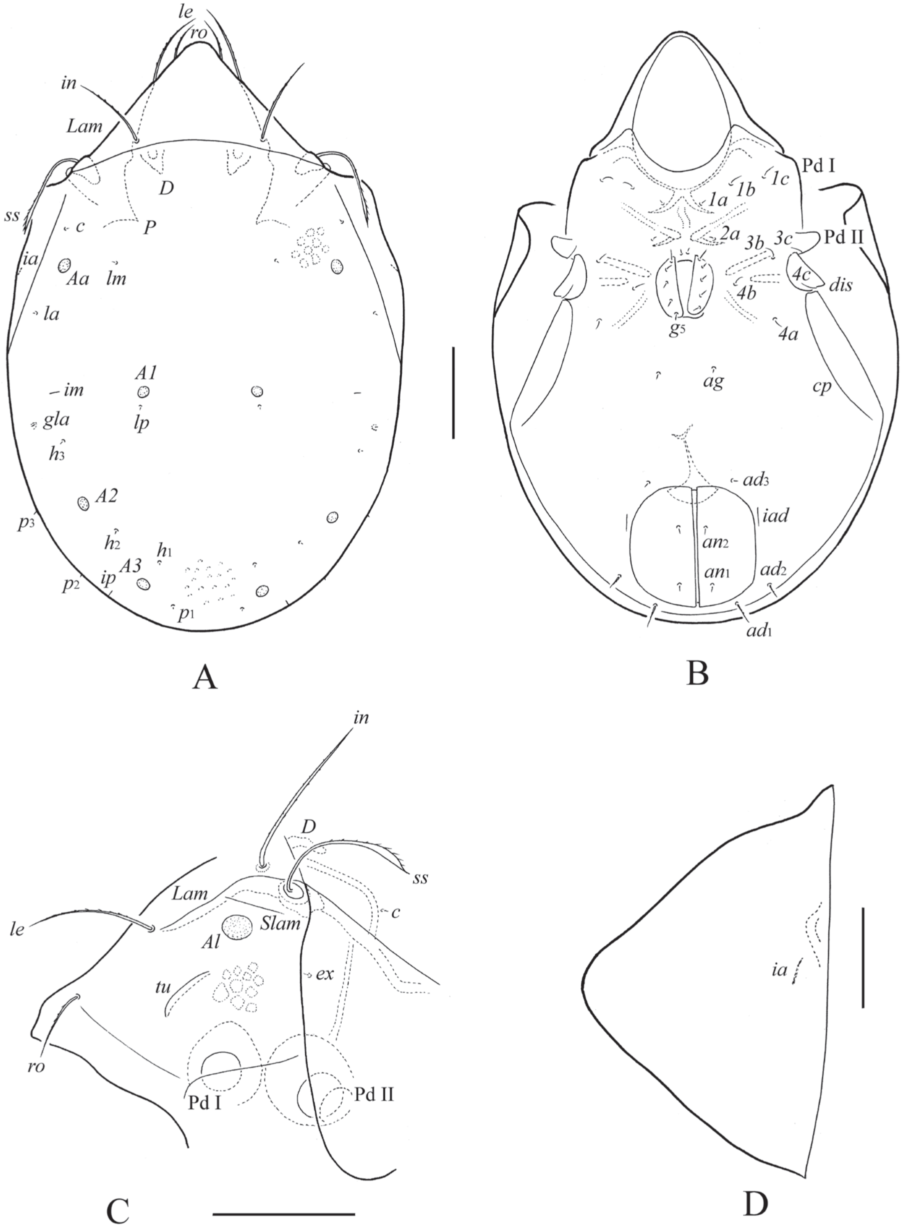

Figure 3. *Protoribates ecuadoriensis* sp. n., adult: **A** body dorsally **B** body ventrally (gnathosoma and legs not illustrated) **C** prodorsum and anterior part of notogaster laterally **D** left pteromorph. Scale bar (**A–C**) 100 µm, scale bar (**D**) 50 µm.

1a, *2a*, *3a* (12–14) shorter than others (20–24). Pedotecta I, II, discidia and circumpedal carinae developed typically for the genus (see Weigmann et al. 1993; Miko et al. 1994). Custodia indistinct, widely blunt.

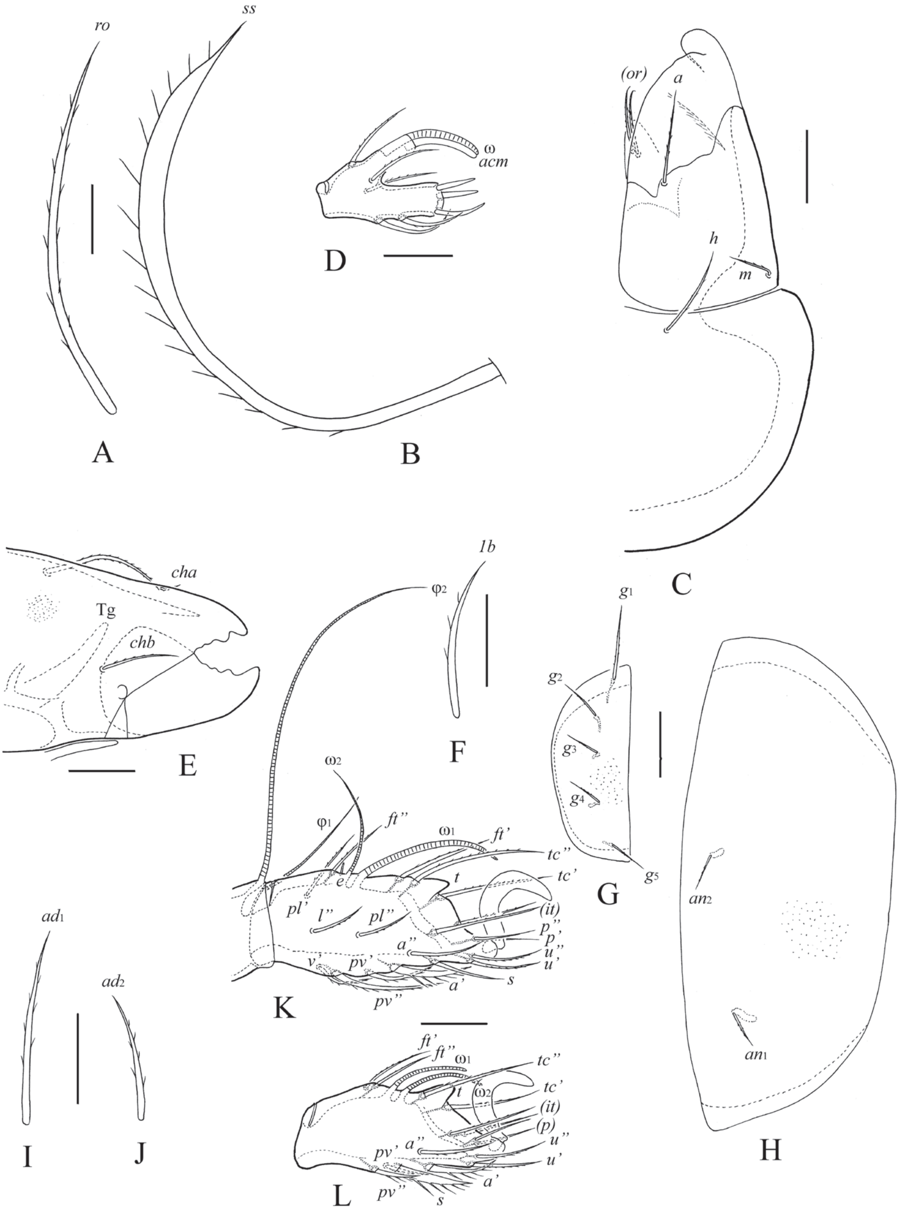

Figure 4. *Protoribates ecuadoriensis* sp. n., adult: **A** rostral seta **B** sensillus **C** left half of subcapitulum **D** palptarsus **E** anterior part of chelicera **F** epimeral seta *1b* **G** right genital plate **H** left anal plate **I** adanal seta ad_1 **J** adanal seta ad_2 **K** tarsus and anterior part of tibia of leg I, right, antiaxial view **L** tarsus of leg II, right, antiaxial view. Scale bar (**A, B, D, F, I, J**) 10 µm, scale bar (**C, E, G, H, K, L**) 20 µm.

Anogenital region. Five pairs of genital (g_1, 18–24, g_2–g_5, 12–16), one pair of aggenital (12), two pairs of anal (12) and three pairs of adanal (ad_1, 22–24, ad_2, 14–16, ad_3, 12) setae setiform, slightly barbed. Lyrifissures *iad* in paraanal position.

Table 2. Leg setation and solenidia of *Protoribates ecuadoriensis,* sp. n. (same data for *Trachyoribates* (*Rostrozetes*) *glaber*).

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	*v’*	*d*, (*l*), *bv”*, *v”*	(*l*), *v’*, σ	(*l*), (*v*), φ_1, φ_2	(*ft*), (*tc*), (*it*), (*p*), (*u*), (*a*), *s*, (*pv*), *v’*, (*pl*), *l”*, *e*, ω_1, ω_2
II	*v’*	*d*, l_1’, l_2’, *bv”*, *v”*	(*l*), *v’**,σ	(*l*), (*v*), φ	(*ft*), (*tc*), (*it*), (*p*), (*u*), (*a*), *s*, (*pv*), ω_1, ω_2
III	*l’*, *v’*	*d*, *l’*, *ev’*	*l’*, σ	*l’*, (*v*), φ	(*ft*), (*tc*), (*it*), (*p*), (*u*), (*a*), *s*, (*pv*)
IV	*v’*	*d*, *ev’*	*d*, *l’*	*l’*, (*v*), φ	*ft”*, (*tc*), (*p*), (*u*), (*a*), *s*, (*pv*)

See Table 1 for explanations. * – seta *v’* absent in *Trachyoribates* (*Rostrozetes*) *glaber*.

Legs. All tarsi monodactylous. Morphology of leg segments, setae and solenidia typical for genus (see Weigmann et al. 1993; Miko et al. 1994), but tarsi I, II with large dorsal tubercles (*t*). Formulae of leg setation and solenidia: I (1–5–3–4–20) [1–2–2], II (1–5–3–4–15) [1–1–2], III (2–3–1–3–15) [1–1–0], IV (1–2–2–3–12) [0–1–0]; homology of setae and solenidia indicated in Table 2.

Material examined. Holotype (female) and five paratypes (two females and three males): Ec-1.

Type deposition. The holotype (in ethanol) is deposited in the collection of the Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia; three paratypes (in ethanol) are deposited in the collection of the Siberian Zoological Museum, Novosibirsk, Russia; two paratypes (in ethanol) are in the personal collection of the first author.

Etymology. The specific name "*ecuadoriensis*" refers to the country of origin, Ecuador.

Remarks. In having the combination of main morphological characters (monodactylous legs; body of medium size; prodorsal setae long, simple, barbed; sensilli long, with lanceolate, ciliate head; four pairs of porose areas oval; adanal setae ad_1 longer than ad_2, ad_2 longer than ad_3), *Protoribates ecuadoriensis* sp. n. is most similar to *Protoribates oblongus* (Ewing, 1909) from the Nearctic region (see Ewing 1909; Jacot 1937), however, the new species clearly differs from the latter by the presence of large tubercles on dorsal side of leg tarsi I and II.

Supplementary description of a little-known species

Trachyoribates (*Rostrozetes*) *glaber* (Beck, 1965)

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

Figs 5, 6

Diagnosis. Body size 307–365 × 199–232. Body surface foveolate. Rostral and lamellar setae of medium size, slightly barbed; interlamellar setae short, thin, smooth. Sensilli clavate; sensillar head with several barbs distally. Tutoria fused distally to prolamellar lines. Anterior notogastral margin regular convex. Notogastral setae of medium size, smooth. Postanal porose area present. Ventral setae short, smooth. Legs monodactylous.

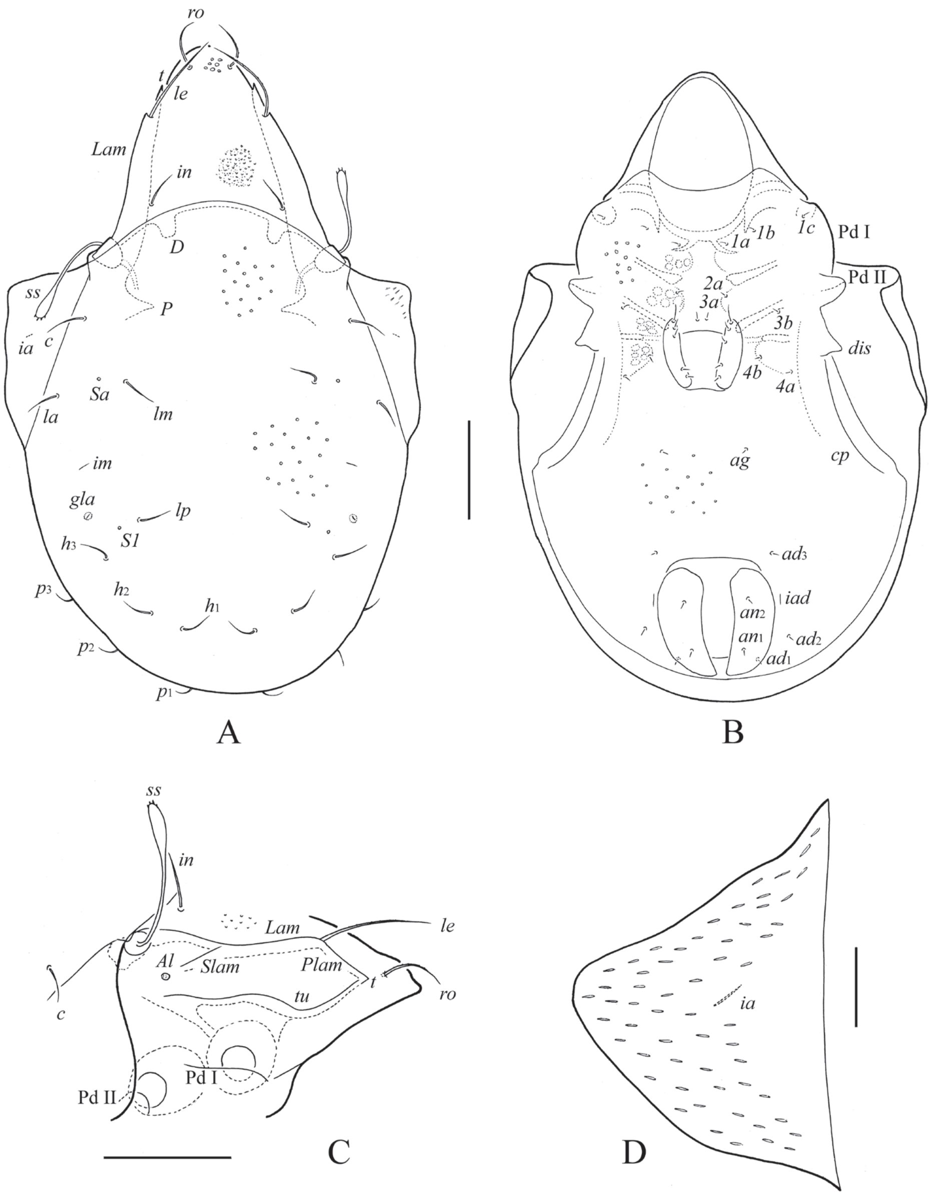

Figure 5. *Trachyoribates* (*Rostrozetes*) *glaber* (Beck, 1965), adult: **A** body dorsally **B** body ventrally (gnathosoma and legs not illustrated) **C** prodorsum and anterior part of notogaster laterally **D** left pteromorph. Scale bar (**A–C**) 50 µm, scale bar (**D**) 20 µm.

Description. *Measurements*. Body length: 307–365 (eight specimens); notogaster width: 199–232 (eight specimens).

Integument. Body color light brownish. Body surface foveolate (diameter of foveolae up to 4 on rostrum, up to 3 on notogaster and ventral side, up to 2 on medio-basal part

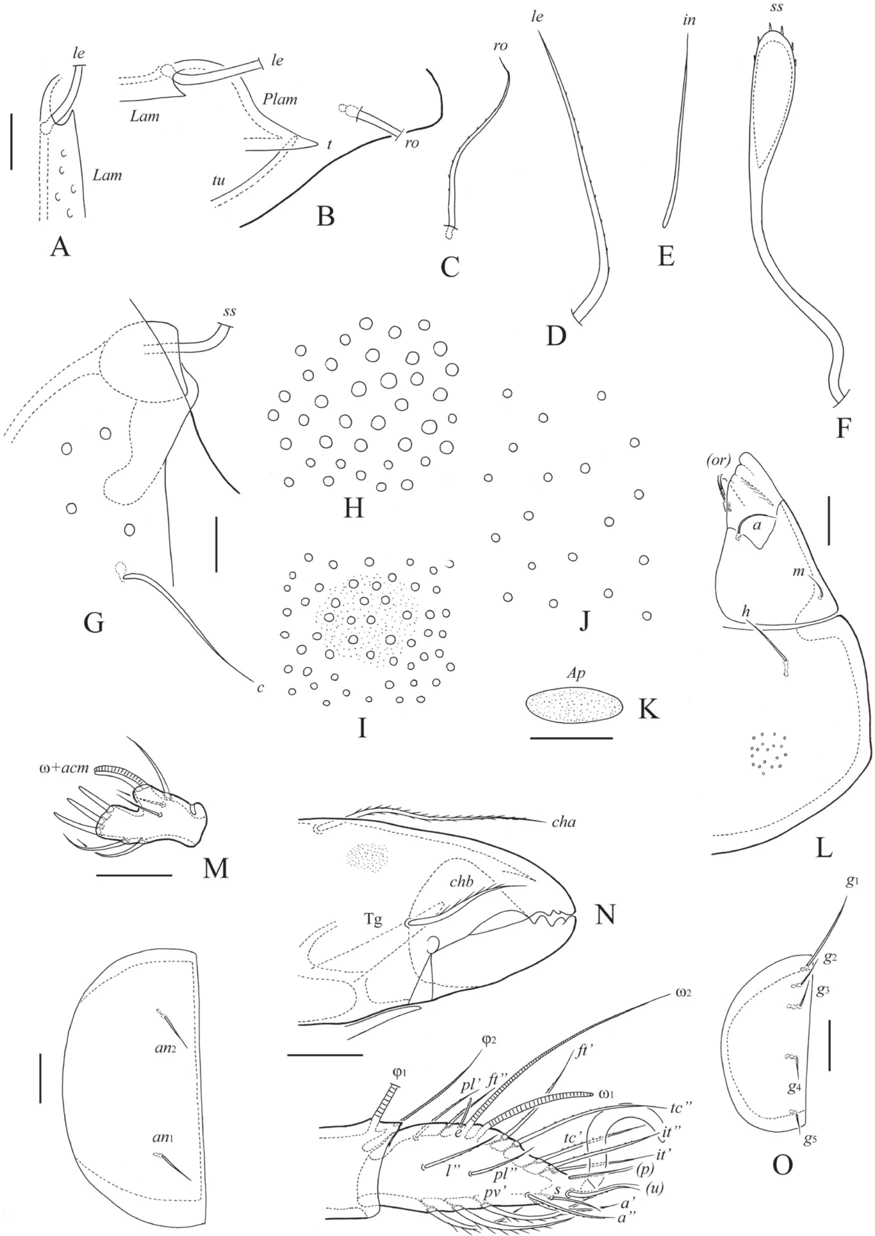

Figure 6. *Trachyoribates* (*Rostrozetes*) *glaber* (Beck, 1965), adult: **A** anterior part of lamella (medio-distal part of lamellar seta not illustrated) **B** anterior part of lamella and tutoria, and prolamellar line dorsolaterally (medio-distal part of rostral and lamellar seta not illustrated) **C** rostral seta **D** lamellar seta **E** interlamellar seta **F** sensillus **G** bothridium and notogastral seta *c* **H** foveolae on rostrum **I** foveolae in central part of prodorsum **J** foveolae on notogaster **K** postanal porose area **L** left half of subcapitulum **M** palptarsus **N** anterior part of chelicera **O** right genital plate **P** right anal plate **Q** tarsus and anterior part of tibia of leg I, right, antiaxial view. Scale bar 10 μm.

of prodorsum). Foveolae located densely on prodorsum, but sparse on notogaster and ventral side. Also microgranules present on prodorsum.

Prodorsum. Rostrum rounded. Lamellae located dorso-laterally, longer than half of prodorsum, reaching insertion of lamellar setae. Prolamellar lines well developed. Rostral (32–41) and lamellar (49–57) setae setiform, slightly barbed. Interlamellar setae thin, smooth, shorter (28–32) and thinner than lamellar setae. A pair of elongate, narrow porose areas *Ad* present latero-posterior to interlamellar setae (visible only in dissected specimen). Exobothridial setae and their alveoli absent. Sensilli longest setae on prodorsum (61–73), with long stalk and clavate head; sensillar head with several barbs distally. Tutoria long, fused distally to prolamellar lines forming point tip (*t*), not reaching to insertions of rostral setae. Sublamellar lines short, thin, straight. Sublamellar porose areas small, rounded (4–8). Porose areas *Am* and *Ah* not observed.

Notogaster. Anterior notogastral margin regular convex. Dorsophragmata and pleurophragmata distinct. Pteromorphs sub-triangular. Notogastral setae represented by 10 pairs; they of medium size (p_1–p_3, 16–20; others, 24–32), thin, smooth. Four pairs of sacculi (*Sa*, *S1*, *S2*, *S3*) with small openings, but *S2* and *S3* visible only in dissected specimens. Lyrifissures and opisthonotal gland openings located typically for the genus (see Beck 1965). Postanal porose area oval (12 × 4).

Gnathosoma. Subcapitulum longer than wide (73–82 × 61–69). Subcapitular setae setiform, smooth; *h* (12) longer than *m* (6) and *a* (10). Two pairs of adoral setae (8) setiform, slightly barbed. Palps (41–45) with setation 0–2–1–3–9(+ω). Solenidion thickened, attached with eupathidium. Chelicerae (73–82) with two setiform, ciliate setae; *cha* (28–32) longer than *chb* (16–20). Trägårdh's organ conical.

Epimeral and lateral podosomal regions. Apodemes 1, 2, 3 and sejugals well developed. Epimeral setal formula 3–1–3–3; setae short (4–6), setiform, smooth. Pedotecta I, II, discidia and circumpedal carinae developed typically for the genus (Beck 1965).

Anogenital region. Five pairs of genital (g_1, 14, g_2–g_5, 6–8), one pair of aggenital (6–8), two pairs of anal (6–8) and three pairs of adanal (6–8) setiform, thin, smooth. Lyrifissures *iad* in paraanal position.

Legs. All tarsi with one strong, smooth claw. Formulae of leg setation and solenidia: I (1–5–3–4–20) [1–2–2], II (1–5–2–4–15) [1–1–2], III (2–3–1–3–15) [1–1–0], IV (1–2–2–3–12) [0–1–0]; homology of setae and solenidia indicated in Table 2.

Material examined. Eight specimens (five females and three males): Ec-1.

Remarks. Actually the name of this species was first made available by Beck (1963) as *Rostrozetes glaber*, but its description was published later (Beck 1965). Judging on his brief description and illustrations, we identified our species as identical with *Trachyoribates* (*Rostrozetes*) *glaber*, known from Ecuador and Peru (see Beck 1965).

Acknowledgements

We cordially thank Prof. Dr. Roy A. Norton (State University of New York, College of Environmental Science and Forestry, Syracuse, USA) who studied for us the specimens of *Protoribates oblongus* from personal collection, and Prof. Dr. Gerd Weigmann (Free University of Berlin, Institute of Zoology, Berlin, Germany) for valuable comments.

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References

Balogh J (1963) Identification keys of Holarctic oribatid mites (Acari) families and genera. Acta Zool. Acad. Sci. Hung. 9: 1–60.

Balogh J (1965) A synopsis of the world oribatid (Acari) genera. Acta Zool. Acad. Sci. Hung. 11 (1–2): 5–99.

Balogh J (1972) The Oribatid Genera of the World. Akademiai Kiadó, Budapest, 1–188.

Balogh J, Balogh P (1984) A review of the Oribatuloidea Thor, 1929 (Acari: Oribatei). Acta Zool. Acad. Sci. Hung. 30(3–4): 257–313.

Balogh J, Balogh P (1992) The Oribatid Mites Genera of the World. The Hungarian National Museum Press, Budapest. Vol. 1: 263 pp.

Bayartogtokh B (2000) Three species of Haplozetidae (Acari: Oribatida: Haplozetidae) from Mongolia. Int. J. Acarol. 26(1): 11–24. doi: 10.1080/01647950008683631

Beck L (1963) Zur Ökologie und Taxionomie der neotropischen Bodentiere I. Zur Oribatiden-Fauna Perus. Zool. Jahr. (Syst.) 90: 299–392.

Beck L (1964) Beiträge zur Kenntnis der neotropischen Oribatidenfauna 4. *Haplozetes* und *Peloribates* (Arach., Acari). Senck. Biol. 45(2): 161–183.

Beck L (1965) Über variabilität und wertigkeit morphologischer merkmale bei adulten Oribatiden (Arachnida, Acari) am beispiel der gattung *Rostrozetes* Sellnick, 1925. Abh. Senck. Natur. Gesellschaft 508: 1–64.

Ermilov SG, Sandmann D, Maraun M (2013a) Two new species of *Schalleria* (Acari: Oribatida: Microzetidae) from Ecuador, with a key to all species of the genus. Int. J. Acarol. 39 (3): 200–208. doi: 10.1080/01647954.2012.762040

Ermilov SG, Sandmann D, Marian F, Maraun M (2013b) Three new species of oribatid mites (Acari: Oribatida) from Ecuador. Acarologia 53(1): 111–123. doi: 10.1051/acarologia/20132075

Ermilov SG, Sandmann D, Marian F, Maraun M (2013c) Three new species of the genus *Sternoppia* (Acari: Oribatida: Sternoppiidae) from Ecuador. Zootaxa 3641(5): 565–576. doi: 10.11646/zootaxa.3641.5.5

Ewing HE (1909) The Oribatoidea of Illinois. Bul. Illinois State Lab. Nat. Hist. 7: 337–389.

Grandjean F (1936) Observations sur les Oribates (10e série). Bul. Mus. 2: 246–253.

Jacot AP (1937) New moss-mites, Chiefly Midwestern II. Amer. Mid. Natur. 18(2): 237–250. doi: 10.2307/2420500

Miko L, Weigmann G, Nannelli R (1994) Redescription of *Protoribates lophotrichus* (Berlese, 1904) (Acarina, Oribatida). Redia 77(2): 251–258.

Murvanidze M, Weigmann G (2012) Two new species of oribatid mites (Acari, Oribatida) *Haplozetes longisacculus* and *Scutovertex armazi* from Georgia (Caucasus). Acarina 20 (2): 167–172.

Norton RA, Behan-Pelletier VM (2009) *Oribatida*. Chapter 15. In: Krantz GW, Walter DE (Eds) A Manual of Acarology. Texas Tech Univ. Press, Lubbock, 430–564.

Pérez-Iñigo C (1993) Acari, Oribatei, Poronota. Fauna Iberica. Museo de Ciencias Naturales, Madrid, 320 pp.

Shaldybina ES (1975) Family Haplozetidae. In: Ghilyarov MS (Ed). A Key to the Soil Inhabiting Mites. Nauka Press, Moscow, 268–275. [in Russian]

Subías LS (2004) Listado sistemático, sinonímico y biogeográfico de los ácaros oribátidos (Acariformes: Oribatida) del mundo (excepto fósiles). Graellsia 60 (número extraordinario): 3–305. Actualized electronic version in May 2013. 570 pp.

Weigmann G (2006) Hornmilben (Oribatida). Die Tierwelt Deutschlands, 76. Teil. Goecke & Evers, Keltern, 520 pp.

Weigmann G, Miko L, Nannelli R (1993) Redescription of *Protoribates dentatus* (Berlese, 1883) with remarks about the genus *Protoribates* (Acarina, Oribatida). Redia 76 (1): 39–55.

Willmann C (1935) IV. Die Milbenfauna – Oribatei. In: Jaus I: Faunistisch-ökologische Studien im Anningergebiet, mit besonderer Berücksichtigung der xerothermen Formen. Zool. Jahrb. (Syst.) 66(5): 331–344.

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RESEARCH ARTICLE

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Molecular phylogenetic evidence supports a new family of octocorals and a new genus of Alcyoniidae (Octocorallia, Alcyonacea)

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Abstract

Molecular phylogenetic evidence indicates that the octocoral family Alcyoniidae is highly polyphyletic, with genera distributed across Octocorallia in more than 10 separate clades. Most alcyoniid taxa belong to the large and poorly resolved Holaxonia–Alcyoniina clade of octocorals, but members of at least four genera of Alcyoniidae fall outside of that group. As a first step towards revision of the family, we describe a new genus, *Parasphaerasclera* **gen. n.**, and family, Parasphaerascleridae **fam. n.**, of Alcyonacea to accommodate species of *Eleutherobia* Pütter, 1900 and *Alcyonium* Linnaeus, 1758 that have digitiform to digitate or lobate growth forms, completely lack sclerites in the polyps, and have radiates or spheroidal sclerites in the colony surface and interior. Parasphaerascleridae **fam. n.** constitutes a well-supported clade that is phylogenetically distinct from all other octocoral taxa. We also describe a new genus of Alcyoniidae, *Sphaerasclera* **gen. n.**, for a species of *Eleutherobia* with a unique capitate growth form. *Sphaerasclera* **gen. n.** is a member of the *Anthomastus–Corallium* clade of octocorals, but is morphologically and genetically distinct from *Anthomastus* Verrill, 1878 and *Paraminabea* Williams & Alderslade, 1999, two similar but dimorphic genera of Alcyoniidae that are its sister taxa. In addition, we have re-assigned two species of *Eleutherobia* that have clavate to capitate growth forms, polyp sclerites arranged to form a collaret and points, and spindles in the colony interior to *Alcyonium*, a move that is supported by both morphological and molecular phylogenetic evidence.

Keywords
Alcyonium, *Eleutherobia*, Parasphaerascleridae, *Parasphaerasclera*, *Sphaerasclera*, Indo-Pacific, taxonomy

Introduction

The anthozoan sub-class Octocorallia comprises a clade of approximately 350 genera and 3400 species of soft corals, gorgonians and sea pens that are found throughout marine environments worldwide (Daly et al. 2007; Williams and Cairns 2013). The current morphology-based taxonomic classification of Octocorallia recognizes three orders, with the majority of families and species belonging to Alcyonacea Lamouroux, 1816 (soft corals, gorgonians and stoloniferans) (Daly et al. 2007). Attempts to further subdivide this very large taxon into smaller orders or sub-ordinal groups have been fraught with difficulty (McFadden et al. 2010). Molecular phylogenetic reconstructions of Octocorallia have confirmed that most of the morphologically defined sub-ordinal groups that have traditionally been recognized (Bayer 1981, Fabricius and Alderslade 2001)—as well as a majority of families—represent polyphyletic assemblages (Berntson et al. 2001; McFadden et al. 2006, 2010; McFadden and Ofwegen 2012). Analyses based on mitochondrial genes (McFadden et al. 2006), nuclear ribosomal genes (Berntson et al. 2001), and both (Brockman and McFadden 2012, McFadden and Ofwegen 2012) instead support the division of Octocorallia into two major clades, Holaxonia–Alcyoniina and Calcaxonia–Pennatulacea, plus a third, smaller clade, *Anthomastus–Corallium* (McFadden et al. 2006, 2010). The phylogenetic relationships among the family-level clades that comprise the morphologically heterogeneous mix of soft corals (Alcyoniina), gorgonians (Holaxonia, Scleraxonia) and stoloniferous forms (Stolonifera) belonging to Holaxonia–Alcyoniina remain unresolved (McFadden et al. 2006, 2010), hindering efforts to revise their taxonomy.

Among the many families of octocorals that appear from molecular phylogenetic analyses to be polyphyletic, the soft coral family Alcyoniidae stands out as one of the most phylogenetically heterogeneous (McFadden et al. 2006, 2010). Alcyoniidae is also a morphologically eclectic taxon, as it has frequently been the repository for genera that lack the specific diagnostic characters of other, more narrowly circumscribed families (Daly et al. 2007). Genera of Alcyoniidae are distributed across Octocorallia in at least 10 distinct clades, with the majority belonging to the poorly resolved Holaxonia–Alcyoniina clade (McFadden et al. 2006). Although the family clearly requires taxonomic revision, increased phylogenetic resolution along the backbone of Holaxonia–Alcyoniina will be necessary in order to determine which clades of Alcyoniidae should be reassigned to different families, and what the diagnostic morphological characters of those families might be.

Several genera of Alcyoniidae fall entirely outside of Holaxonia–Alcyoniina, and belong instead to two small clades located near the base of Octocorallia (McFadden et al. 2006). These include *Anthomastus* Verrill, 1878 and *Paraminabea* Williams & Alderslade, 1999, both of which belong to the *Anthomastus–Corallium* clade (McFadden et al. 2006, Brockman and McFadden 2012). Sufficient molecular phylogenetic evidence now exists to suggest that several species in the alcyoniid genera *Eleutherobia* Pütter, 1900 and *Alcyonium* Linnaeus, 1758 comprise a second clade that also lies outside of Holaxonia–Alcyoniina and is well separated from all other genera of Alcyoniidae. Here we present corroborating morphological evidence to support the description of a new family and genus of Alcyonacea to accommodate this unique clade. In addition, we designate a new genus and combination for a species of *Eleutherobia* that belongs to the *Anthomastus–Corallium* clade, and reassign two other species of *Eleutherobia* to *Alcyonium*.

Methods

Collection

Specimens of *Eleutherobia* and *Alcyonium* suitable for molecular analyses were collected in South Africa in 2008 and Palau in 2005 and 2010 (Table 1). Following collection using SCUBA, colonies were preserved in 70% EtOH; tissue sub-samples to be used for molecular analyses were preserved in >90% EtOH. Specimens of *E. flammicerebra* Williams, 2003 were collected by dredge from New Caledonia during the 2008 Terrasses cruise (R/V Alis), conducted as part of the MNHN/IRD Tropical Deep-Sea Benthos cruises, 2003–2012 (Bouchet et al. 2008). Vouchers have been deposited at the Naturalis Biodiversity Center (formerly Rijksmuseum van Natuurlijke Historie, Leiden (RMNH)), and the Muséum national d'Histoire naturelle, Paris (MNHN). Additional material was obtained from the Museum and Art Gallery of the Northern Territory, Darwin, Australia (NTM), the Florida Natural History Museum, Gainesville (UF), the Zoological Museum, University of Copenhagen (ZMUC), and the Zoologische Staatsammlung München, Germany (ZSM) (Table 1).

Morphological analysis

Sclerites were obtained by dissolving tissues from the upper and lower regions of a colony in 10% sodium hypochlorite (household bleach). Sclerites were rinsed well with deionized water, dried, and mounted on stubs for SEM. They were imaged using a JEOL JSM-6480LV scanning electron microscope operated at 10 kV.

Molecular phylogenetic analyses

Extraction of DNA from ethanol-preserved tissue samples, PCR amplification, and sequencing of the *mtMutS* (*msh1*) and *COI* genes followed the protocols published in McFadden et al. (2011). In addition, we sequenced an approximately 810 nt frag-

Table 1. Specimens of *Alcyonium*, *Parasphaerasclera* gen. n. and *Sphaerasclera* gen. n. included in molecular phylogenetic and morphological analyses. For GenBank accession numbers see Appendix. For abbreviations, see Methods section.

Genus & Species	Authority	Museum & Cat. No.	Collection Location	Year
Alcyonium	Linnaeus, 1758			
A. bocagei	(Saville Kent, 1870)	RMNH Coel. 39672	Portugal, Sagres	1994
A. coralloides	(Pallas, 1766)	RMNH Coel. 39678	France, Marseilles	1994
A. digitatum	Linnaeus, 1758	RMNH Coel. 39671	Isle of Man	1991
A. glomeratum	(Hassall, 1841)	RMNH Coel. 39668	France, Iles des Glenans	1994
A. haddoni	Wright & Studer, 1889	ZSM 20061191	Chile, Canal Pitt Chico	2006
A. hibernicum	Renouf, 1931	RMNH Coel. 39661	Isle of Man	1991
A. palmatum	Pallas, 1766	RMNH Coel. 39685	NE Spain	1996
A. varum	McFadden & Ofwegen, nom. n.	ZSM 20061195	Chile, Paso del Abismo	2006
A. sidereum	Verrill, 1922		USA, Massachusetts	1989
A. variabile	(Thomson, 1921)	RMNH Coel. 40800	South Africa, Algoa Bay	1998
A. variabile	(Thomson, 1921)	RMNH Coel. 41530	South Africa, Algoa Bay	2008
A. variabile	(Thomson, 1921)	RMNH Coel. 41531	South Africa, Algoa Bay	2008
***Parasphaerasclera* gen. n.**				
P. aurea	(Benayahu & Schleyer, 1995)	RMNH Coel. 40205	South Africa, Park Rynie	2008
P. aurea	(Benayahu & Schleyer, 1995)	RMNH Coel. 40799	South Africa, Park Rynie	2008
P. aurea	(Benayahu & Schleyer, 1995)	RMNH Coel. 41535	South Africa, Aliwal Shoal	2008
P. aff. *grayi*	(Thomson & Dean, 1931)	NTM C14092	Palau, Babeldaob	2005
P. aff. *grayi*	(Thomson & Dean, 1931)	RMNH Coel. 40920	Palau, Pelelieu	2010
P. rotifera	(Thomson, 1910)	UF3890	South Africa, East London	1999
P. valdiviae	(Kükenthal, 1906)	RMNH Coel. 40206	South Africa, Algoa Bay	2008
P. valdiviae	(Kükenthal, 1906)	RMNH Coel. 41532	South Africa, Algoa Bay	2008
P. valdiviae	(Kükenthal, 1906)	RMNH Coel. 41534	South Africa, Algoa Bay	2008
***Sphaerasclera* gen. n.**				
S. flammicerebra	(Williams, 2003)	MNHN-IK-2012-12004	New Caledonia	2008
S. flammicerebra	(Williams, 2003)	ZMUC-ANT- 000256	Mauritius	1929

ment of the 28S nuclear ribosomal gene using primers 28S-Far and either 28S-Rar or 28S-Rab (McFadden and Ofwegen 2013). Sequence data were aligned to a previously compiled reference dataset of 130 octocorals and anthozoan outgroup taxa (McFadden and Ofwegen 2012; Appendix) using the L-INS-i method in MAFFT (Katoh et al. 2005). Modeltest 3.0 (Posada and Crandall 1998) was used to select appropriate models of evolution for maximum likelihood analyses that were run for 100 bootstrap replicates using GARLI 2.0 (Zwickl 2006). The 28S rDNA and mitochondrial gene (*mtMutS* + *COI*) datasets were analyzed separately, and in a combined analysis with different models of evolution applied to separate data partitions (mt genes: TVM+I+G; 28S: GTR+I+G). Bayesian analyses were run using MrBayes v. 3.2.1 (Ronquist et al. 2012) with the same data partitions; because MrBayes does not support the TVM model, however, a GTR+I+G model was applied separately to each partition. Analyses were run for 6,000,000 generations (until runs had converged and standard deviation of split partitions < 0.01) and sampled every 500 generations, with a burn-in of 25% and default Metropolis coupling parameters.

Results

Molecular phylogenetic analyses

The separate maximum likelihood analyses of the 28S rDNA and mitochondrial gene alignments generated phylogenies that were congruent with one another (with the sole exception of some internal relationships within Pennatulacea), but were poorly resolved overall. The partitioned analyses of the combined mt + 28S dataset had much higher support values for many of the deeper nodes within the tree, and it is these analyses that we present (Fig. 1) and discuss here. As has been demonstrated previously based on analyses of similar datasets (Brockman and McFadden 2012, McFadden and Ofwegen 2012), the combined gene analyses supported the division of the majority of octocorals among two major clades, Holaxonia–Alcyoniina and Calcaxonia–Pennatulacea (Fig. 1). In addition, there was strong support from both maximum likelihood and Bayesian methods for three small clades that fell outside of Holaxonia–Alcyoniina but whose relationships to Calcaxonia–Pennatulacea and to one another remain unresolved. These include the previously recognized *Anthomastus–Corallium* clade (McFadden et al. 2006, Brockman and McFadden 2012), a clade comprising a heterogeneous mix of scleraxonians plus the stoloniferan genus *Telestula* Madsen, 1944, and a clade consisting of several species of the alcyoniid genera *Eleutherobia* and *Alcyonium* (Fig. 1). The stoloniferan genus *Cornularia* Lamarck, 1816 was recovered as the sister taxon to all other octocorals.

Members of family Alcyoniidae were distributed throughout Holaxonia–Alcyoniina in nine distinct clades (Fig. 1). Some of these clades included only alcyoniid genera, while others supported close relationships among alcyoniids and genera classified in different families. There was insufficient resolution of the deeper nodes within Holaxonia–Alcyoniina to infer the phylogenetic relationships of any of these nine clades to one another. In addition, four genera of Alcyoniidae fell entirely outside of Holaxonia–Alcyoniina (Fig. 1). These included *Paraminabea* and *Anthomastus*, both of which belonged to the *Anthomastus–Corallium* clade, as well as several species of *Eleutherobia* and *Alcyonium* that formed a distinct, well-supported clade whose relationship to the Calcaxonia–Pennatulacea, *Anthomastus–Corallium* and Scleraxonia–*Telestula* clades was poorly resolved. This clade included *Eleutherobia aurea* Benayahu & Schleyer, 1995, *E. rotifera* (Thomson, 1910), *E.* aff. *grayi* (Thomson & Dean, 1931), and *Alcyonium valdiviae* Kükenthal, 1906. Two of the species of *Eleutherobia* we sequenced were not included in this clade: *E. variabile* (Thomson, 1921) fell into a clade with northern hemisphere members of the genus *Alcyonium*, while *E. flammicerebra* Williams, 2003 belonged to the *Anthomastus–Corallium* clade, phylogenetically distinct from both *Paraminabea* and *Anthomastus* (Fig. 1).

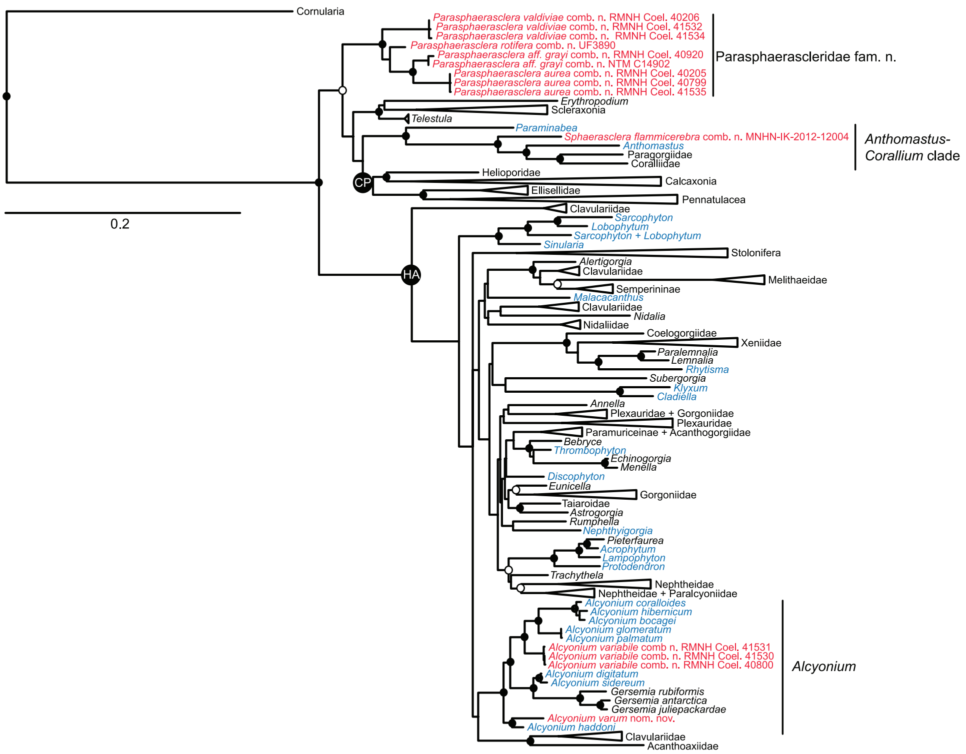

Figure 1. Maximum likelihood tree of Octocorallia based on combined, partitioned analysis of *mtMutS*, *COI* and 28S rDNA sequences. Taxa belonging to family Alcyoniidae are shown in blue; new combinations proposed herein are shown in red. Solid circles at nodes indicate strong support from both maximum likelihood (bootstrap values >70%) and Bayesian inference (posterior probability > 0.95); open circles indicate moderate support (bootstrap values >50%, Bayesian pp > 0.95). Strongly supported clades that include no alcyoniid taxa have been collapsed to triangles to facilitate readability. HA: Holaxonia–Alcyoniina clade; CP: Calcaxonia–Pennatulacea clade. Hexacorallian taxa used as outgroups are not shown. For a list of all reference taxa and sequences included in the analysis see Appendix.

Taxonomic section

Alcyonacea Lamouroux, 1816
Alcyoniidae Lamouroux, 1812

Alcyonium Linnaeus, 1758

Alcyonium has long served as a repository for species that lack characters to support their placement in other more narrowly circumscribed genera. Over time the diagnosis of the genus has been broadened to include almost every possible colony growth form observed within Alcyoniidae (Williams 1988) as well as a diversity of different sclerite types and arrangements. In recent years the heterogeneity of this genus has been acknowledged (Alderslade 2000; Williams 2000a), and a number of new genera have been erected to accommodate species whose characters clearly differ from those of the type species, the northern hemisphere *A. digitatum* Linnaeus, 1758. Molecular phylogenetic analyses have supported the taxonomic distinction of new genera such as *Klyxum* Alderslade, 2000, *Rhytisma* Alderslade, 2000, *Lampophyton* Williams, 2000, and *Discophyton* McFadden & Hochberg, 2003 (Fig. 1), all of them established to accommodate species formerly placed in *Alcyonium*.

Phylogenetic evidence suggests that genus *Alcyonium* should be further restricted to species in which the polyp sclerites are arranged as a collaret and points and the sclerites of the coenenchyme are in two distinct layers, a surface layer consisting of predominantly radiates or clubs, and an inner layer of spindles or rods (Alderslade 2000). The colony growth form may be lobate, digitate, capitate or encrusting, and the sclerites are usually colored. Adoption of this restricted, phylogenetically supported diagnosis will necessitate not only the removal of additional species from *Alcyonium*, but also the inclusion of species currently placed in several other genera. For example, despite their placement in three different families, the genera *Bellonella* Gray, 1862 (Alcyoniidae), *Eleutherobia* Pütter, 1900 (Alcyoniidae), *Anthothela* Verrill, 1879 (Anthothelidae) and *Gersemia* Marenzeller, 1878 (Nephtheidae) all include species with sclerite characters that suggest a close affinity with *Alcyonium.* Molecular phylogenetic evidence supports a paraphyletic relationship between *Alcyonium, Gersemia*, and *Anthothela* (McFadden et al. 2006), as well as the inclusion of a species of *Eleutherobia* in *Alcyonium sensu stricto* (Fig. 1).

Williams (2003) reassigned *Alcyonium variabile* (Thomson, 1921) to *Eleutherobia* subsequent to his modification of that genus to accommodate the capitate *E. flammicerebra* Williams, 2003. The capitate growth form of *E. variabile* differs from the lobate to digitate forms characteristic of most northern hemisphere species of *Alcyonium* (McFadden et al. 2001). Similar to other species of *Alcyonium sensu stricto*, however, *E. variabile* has polyp sclerites arranged to form a distinct collaret and points, radiates and club-like forms in the surface layer of the polyparium and stalk, and long spindles in the interior of the polyparium (Williams 1986, 1992). Molecular phylogenetic analyses strongly support the inclusion of *E. variabile* in *Alcyonium sensu stricto* (Fig. 1), therefore we transfer this species back to that genus and re-instate the combination *Alcyonium variabile* (Thomson, 1921) comb. n.

Bellonella studeri Thomson, 1910, a species with a clavate to capitate growth form similar to that of *A. variabile* comb. n., was reassigned to *Eleutherobia* by Verseveldt and Bayer (1988). The sclerites of *E. studeri* are very similar to those of *A. variabile* comb. n. Both species have polyps with spindles arranged to form a collaret and points, capstan-like radiates in the surface of the polyparium and stalk, and sclerites in the colony interior that are predominantly slender spindles (Williams 1992). Material of *E. studeri* was not available for molecular phylogenetic analysis, but based on its morphological similarity to *A. variabile* comb. n. we suggest that this species also belongs in *Alcyonium*, and propose the new combination *Alcyonium studeri* (Thomson, 1910) comb. n. Verseveldt and Bayer (1988) suggested that Thomson's (1910) *Metalcyonium clavatum* (non Pfeffer, 1889) might be a synonym of *A. studeri* comb. n. Whether or not that is the case, *M. clavatum* also appears from Thomson's (1910) description to belong to *Alcyonium*.

Our molecular phylogenetic analyses included a specimen of *Alcyonium roseum* Ofwegen, Häussermann & Försterra, 2007, a species recently described from Chile. We note that that name is pre-occupied by *A. roseum* (Tixier-Durivault, 1954), and hereby designate the Chilean species *Alcyonium varum* nom. nov. Etymology: from the Latin *varus*, crooked or bow-legged, denoting the shape of the sclerites in the polyps (Ofwegen et al. 2007).

***Sphaerasclera* gen. n.**

http://zoobank.org/3DF0B00F-CB14-4B4C-A28A-0AF019EA35E4
http://species-id.net/wiki/Sphaerasclera
Figs 2–3

Type species. *Eleutherobia flammicerebra* Williams, 2003, by original designation.

Diagnosis. Soft corals with a capitate growth form, with a distinct, spherical polyparium raised on a sterile stalk. Polyps monomorphic. Anthocodial sclerites absent. Sclerites of colony surface and interior are large, tuberculate spheroids and smaller radiates. Sclerites permanently colored. Azooxanthellate.

Etymology. From the Latin/Greek *sphaera-* meaning a sphere or ball and Greek *sclero-*, hard, denoting the large, spheroidal sclerites that characterize this genus. Gender: fem.

Remarks. Williams's (2003) assignment of *E. flammicerebra* to *Eleutherobia* necessitated emending the diagnosis of that genus to include capitate growth forms. *E. flammicerebra* does share other character states—such as monomorphic polyps that lack sclerites and tuberculate spheroids and radiates in the surface of the polyparium and stalk (Figs 2–3)—with some species of *Eleutherobia*. Molecular phylogenetic analyses suggest that *E. flammicerebra* is, however, not closely related to morphologically similar members of *Eleutherobia* such as *E. rotifera* (Thomson, 1910) but instead falls into the *Anthomastus–Corallium* clade of octocorals (Fig. 1). Based on its distinctive colony growth form and unique phylogenetic position, we hereby designate a new genus, *Sphaerasclera*, and new combination, *Sphaerasclera flammicerebra* (Williams, 2003) for this species.

Unlike all other members of the *Anthomastus–Corallium* clade, *Sphaerasclera* gen. n. appears to have monomorphic rather than dimorphic polyps. As discussed by Williams (2000b), however, siphonozooids may be difficult to detect in contracted, preserved material. The large, densely packed, spherical sclerites in the coenenchyme of *S. flammicerebra* comb. n. obscure the finer details of the colony surface, and also make this species very difficult to section for histological study of the polyps. For now we concur with Williams (2003) that the species is monomorphic, but entertain the possibility that future observation of living specimens might reveal the presence of siphonozooids.

Although *Sphaerasclera* gen. n. differs by having monomorphic polyps, it does share other morphological characters with *Paraminabea* and *Anthomastus*, the two genera with which it is most closely allied phylogenetically (Fig. 1). *Anthomastus* likewise includes species with capitate growth forms, but in that genus the autozooids have sclerites, and the sclerites in the surface and interior of the colony include rods and needles in addition to radiates (Bayer 1993). Like *Sphaerasclera* gen. n., *Paraminabea* lacks sclerites in the polyps and its coenenchymal sclerites are predominantly radiates and spheroids (Williams and Alderslade 1999). The colony growth form of *Paraminabea*, however, is digitiform, hemispherical or lobate rather than capitate. Moreover, *Paraminabea* has a unique molecular synapomorphy, a mitochondrial gene rearrangement that distinguishes it from all other genera of octocorals (Brockman and McFadden 2012). Screening of mitochondrial gene junctions suggests that *S. flammicerebra* comb. n. and *Anthomastus* both retain the ancestral octocoral mt gene order, and do not share the derived state found in *Paraminabea* (Brockman and McFadden 2012).

Paraminabea and *Anthomastus* are both classified in family Alcyoniidae, and for convenience we have also assigned *Sphaerasclera* gen. n. to that family. All other genera of Alcyoniidae, however, belong to the Holaxonia–Alcyoniina clade of Octocorallia, far removed phylogenetically from the *Anthomastus–Corallium* clade (Fig. 1). In addition to *Paraminabea*, *Anthomastus* and *Sphaerasclera* gen. n., the *Anthomastus–Corallium* clade also includes all members of Coralliidae Lamouroux, 1812 and Paragorgiidae Kükenthal, 1916, two families of gorgonians that have historically been assigned to the sub-ordinal group Scleraxonia. Although it is clear from the phylogenetic evidence that the soft coral taxa that fall within this clade should be removed from Alcyoniidae, we defer their reassignment to another family pending an in-depth analysis of the morphological character states shared among the seemingly heterogeneous genera and families that are united within *Anthomastus–Corallium*.

Our records extend the known geographic distribution of *S. flammicerebra* comb. n. from Palau (Williams 2003) to New Caledonia and Mauritius. The colony growth forms and sclerites of specimens from these widespread localities closely match that of the type material from Palau (Figs 2–3).

Parasphaerascleridae fam. n.

http://zoobank.org/82E6711B-C21A-4EE4-828E-F4EBBC4CA7BD
http://species-id.net/wiki/Parasphaerascleridae

Type genus. *Parasphaerasclera* McFadden & Ofwegen, gen. n.

Included genera. *Parasphaerasclera* gen. n.

Diagnosis. Soft corals with a digitiform, digitate or lobate growth form, usually with a sterile stalk although this may be indistinct. Polyps monomorphic. Permanent calyces absent, although retracted polyps may remain visible as small mounds on the polyparium surface. Anthocodial sclerites absent. Sclerites of colony surface and interior predominantly radiates and tuberculate spheroids, occasionally rods and crosses. Sclerites permanently colored. Azooxanthellate.

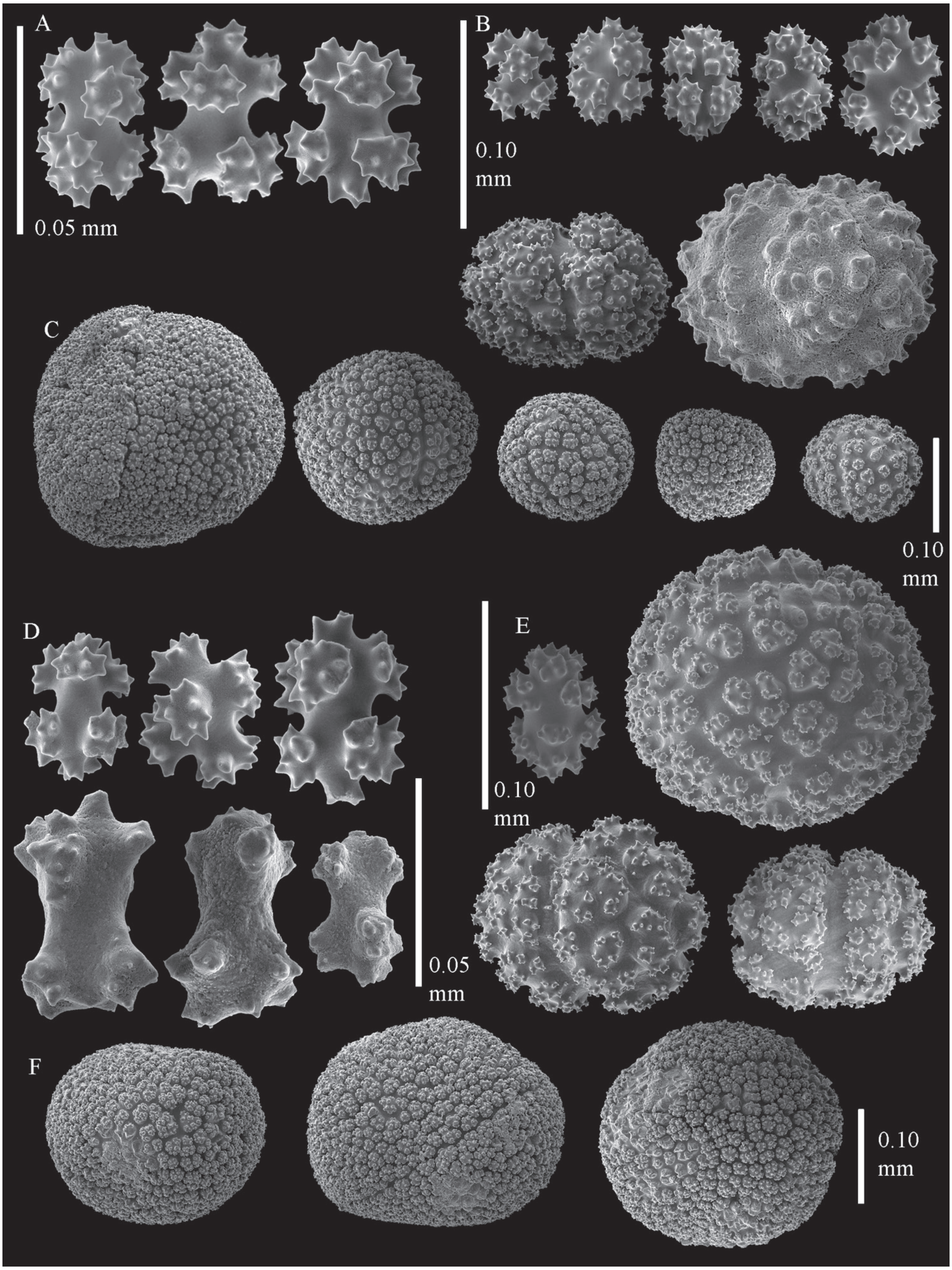

Figure 2. Sclerites of *Sphaerasclera flammicerebra* comb. n. MNHN-IK-2012-12004. **A–C** Surface layer of polyparium **A** Small radiates (0.05 mm scale bar) **B** Larger radiates and two small spheroids **C** Large tuberculate spheroids **D–F** Interior of polyparium **D** Small radiates (0.05 mm scale bar) **E** Larger radiate and three small spheroids **F** Large tuberculate spheroids.

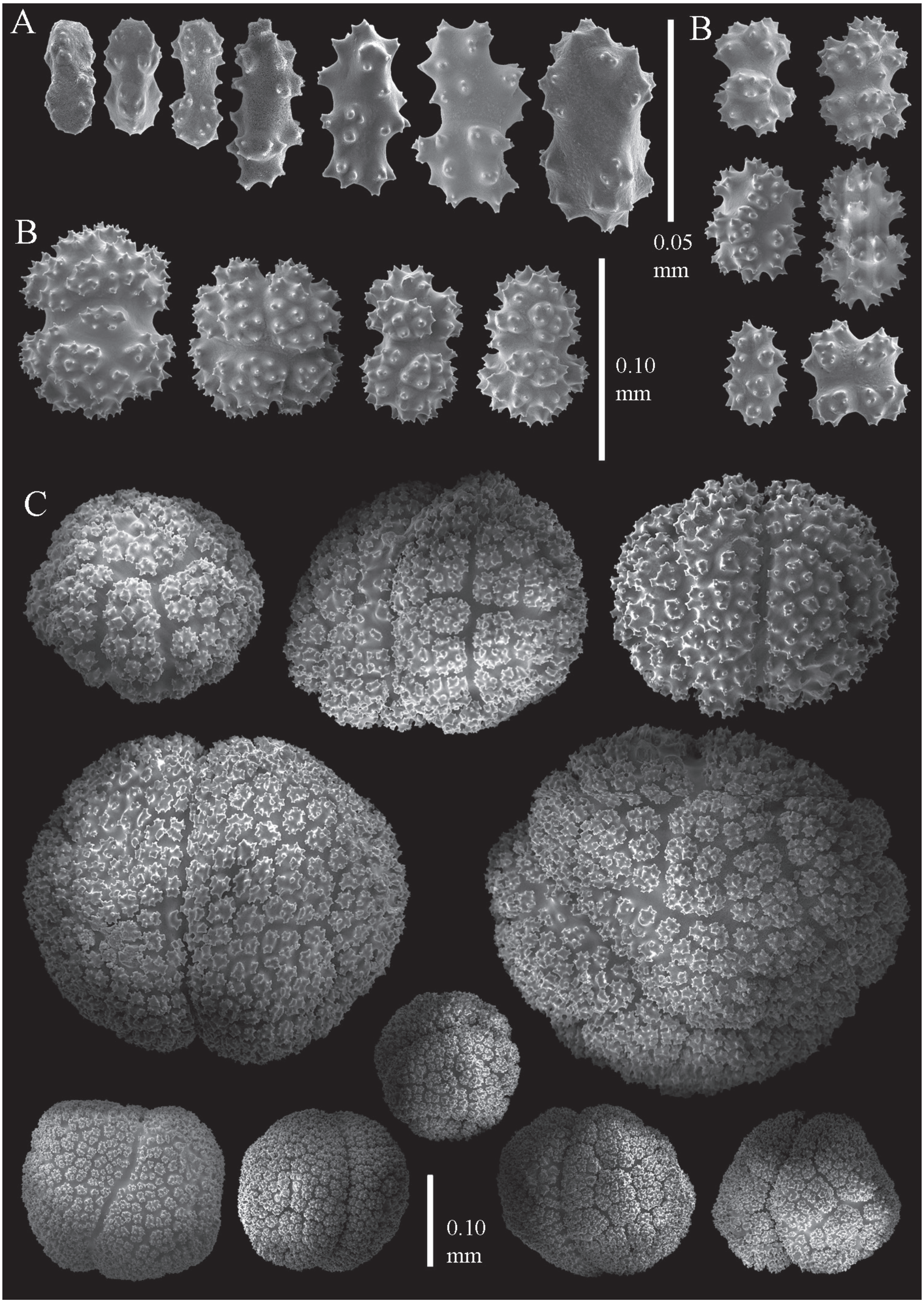

Figure 3. Sclerites of *Sphaerasclera flammicerebra* comb. n. ZMUC-ANT-000256. Sclerites of polyparium. **A**. Small radiates (left of 0.05 mm scale bar) **B** Larger radiates **C** Large tuberculate spheroids of colony surface and interior.

Remarks. As diagnosed by Verseveldt and Bayer (1988) and modified by Williams (2003), the alcyoniid genus *Eleutherobia* Pütter, 1900 encompasses species with a diversity of sclerite forms and arrangements. Species within this genus are united primarily by their digitiform to lobular colony growth forms, although the diagnosis was recently emended to include capitate forms (Williams 2003). A subset of the species within *Eleutherobia* have in common a complete lack of sclerites in the polyps, and the sclerites in the surface and interior of the colony are predominantly small radiates and spheroids (Figs 4–9). Molecular analyses unite these species in a clade far removed phylogenetically from other genera of Alcyoniidae (Fig. 1), thus we describe a new family to accommodate them. Parasphaerascleridae fam. n. falls outside of the large Holaxonia–Alcyoniina clade of Octocorallia to which the majority of soft corals belong (McFadden et al. 2006). Although several other genera of Alcyoniidae also lie outside of Holaxonia–Alcyoniina (e.g., *Paraminabea*, *Anthomastus*, *Sphaerasclera* gen. n.), they are united with the scleraxonian families Coralliidae and Paragorgiidae in the *Anthomastus–Corallium* clade (McFadden et al. 2006). Paraphaerascleridae fam. n. does not belong to that clade.

***Parasphaerasclera* gen. n.**

http://zoobank.org/F0625B3D-65FD-4B94-A535-2FFA46D84AD1
http://species-id.net/wiki/Parasphaerasclera
Figs 4–9

Type species. *Alcyonium rotiferum* Thomson, 1910, by original designation.

Diagnosis. As for the family.

Etymology. From the Greek root *para-*, meaning beside or alongside of *Sphaerasclera* gen. n. These two genera share similar sclerite complements and forms, and both were previously considered to belong to *Eleutherobia*. Gender: fem.

Remarks. All species of *Eleutherobia* that have digitiform to digitate or lobate growth forms, lack polyp sclerites, and have radiates or spheroids in the colony surface and interior are hereby reassigned to *Parasphaerasclera* gen. n. These include *Parasphaerasclera albiflora* (Utinomi, 1957) comb. n., *P. aurea* (Benayahu & Schleyer, 1995) comb. n., *P. grayi* (Thomson & Dean, 1931) comb. n., *P. nezdoliyi* (Dautova & Savinkin, 2009) comb. n., *P. rotifera* (Thomson, 1910) comb. n., and *P. zanahoria* (Williams, 2000) comb. n. Although molecular data to support their inclusion in this clade are only available for *P. aurea*, *P.* aff. *grayi* and *P. rotifera*, the other three species all share the diagnostic morphological characters of the family (Utinomi 1957, Imahara 1977, Williams 2000b, Dautova and Savinkin 2009). These six species are morphologically distinct from the type species of *Eleutherobia*, *E. rigida* (=*E. japonica*, Pütter, 1900), which has polyp sclerites arranged as a collaret and points of spindles; radiates, spindles and club-like sclerites in the colony surface; and spindles in the interior coenenchyme (Verseveldt and Bayer 1988).

We also reassign two species of *Alcyonium* to *Parasphaerasclera* gen. n., *P. morifera* (Tixier-Durivault, 1954) comb. n. and *P. valdiviae* (Kükenthal, 1906) comb. n. The inclusion of *P. valdiviae* comb. n. in *Parasphaerasclera* gen. n. is supported by both molecular phylogenetic (Fig. 1) and morphological evidence. *P. valdiviae* comb. n. lacks polyp sclerites, the sclerites found in the surface of the colony are compact radiates and spheroids (Figs 6–7), and it shares with *P. rotifera* comb. n. a growth form in which a conspicuous stalk gives rise to either branched or digitate lobes (Verseveldt and Williams 1988).

P. morifera comb. n., another species for which we lack molecular data, shares many morphological characters with other species of *Parasphaerasclera* gen. n. Verseveldt and Bayer (1988) synonymized *Nidalia morifera* Tixier-Durivault, 1954 with *Eleutherobia rotifera*, but Williams (1992) later maintained the distinction between them. He reassigned *N. morifera* not to *Eleutherobia* but rather to *Alcyonium*, based on its lack of permanent calyces. Although Verseveldt and Bayer's (1988) diagnosis of *Eleutherobia* stated "Anthocodiae retractile within calyces" (p. 27), Benayahu and Schleyer (1995) noted that some of the species included in the genus lacked permanent calyces. Williams and Little (2001) subsequently emended the diagnosis of *Eleutherobia* to "calyces absent, although retracted polyps often form low rounded to conspicuous protuberances" (p. 198). *P. morifera* comb. n. is strikingly similar to *P. aurea* comb. n.; both species have a digitiform to lobular growth form with a short, indistinct stalk, and the sclerites in the colony surface are compact radiates and spheroids (Figs 4A, 5A). The only difference between the two species is the presence of "double-deltoids" in the colony interior of *P. aurea* comb. n. (Figs 4B, 5B) (Benayahu and Schleyer 1995).

It is possible that another South African species of *Alcyonium*, *A. distinctum* Williams, 1988, may also belong to this genus. Like other species of *Parasphaerasclera* gen. n. it lacks sclerites in the polyps, and the sclerites in the stalk surface are tuberculate spheroids and radiates (Williams 1988, 1992). The colony growth form is lobate, with lobes arising from a short, thick stalk, somewhat resembling *P. valdiviae* comb. n. Unlike other species of *Parasphaerasclera* gen. n., however, in *A. distinctum* the sclerites are restricted to the stalk surface: there are no sclerites in the lobes (polypary) and interior of the colony (Williams 1988). In addition, the sclerites are not colored, and the bright purple color of living colonies is the result of an alcohol-soluble pigment. Material is not currently available for molecular analysis, so we cannot yet confirm the placement of *A. distinctum* in *Parasphaerasclera* gen. n.

A number of specimens of *Parasphaerasclera* gen. n. are known that differ somewhat from the descriptions of any of the nominal species listed above, and may represent additional, undescribed species of the genus. For example, there is considerable variation among those specimens of *P. grayi* comb. n. that have been described and illustrated in the literature. Thomson and Dean's original description (1931: 37) is rather confusing and sclerites were not depicted. The lectotype of *P. grayi* that was designated and described by Verseveldt and Bayer (1988, figs. 24, 25) has sclerites in the colony surface that consist of 8-radiates (0.06–0.08 mm in length), crosses, and rods with tuberculate processes. The sclerites of the colony interior in-

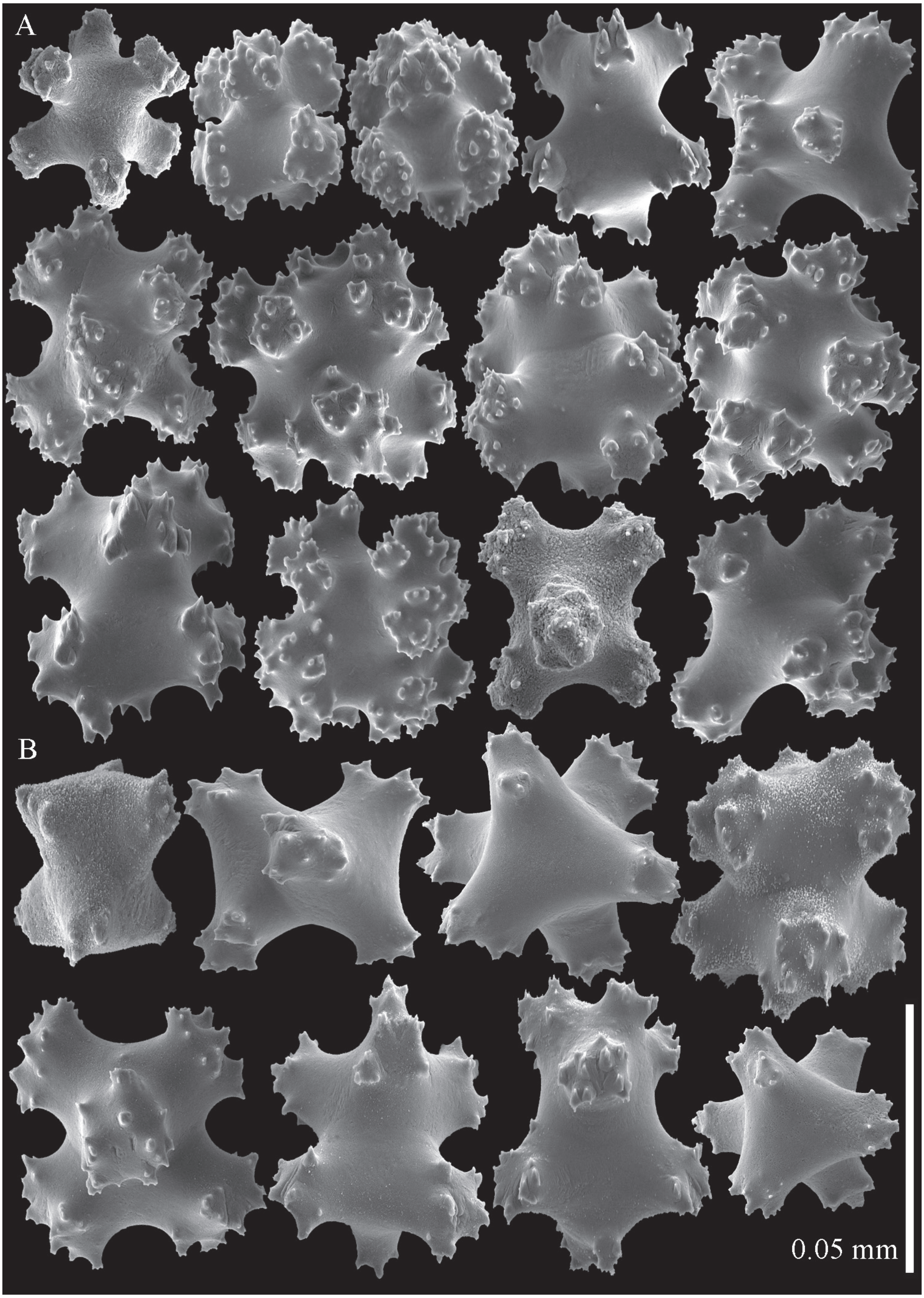

Figure 4. Sclerites of *Parasphaerasclera aurea* comb. n., RMNH Coel. 40779. **A** Surface of polyparium **B** Interior of polyparium.

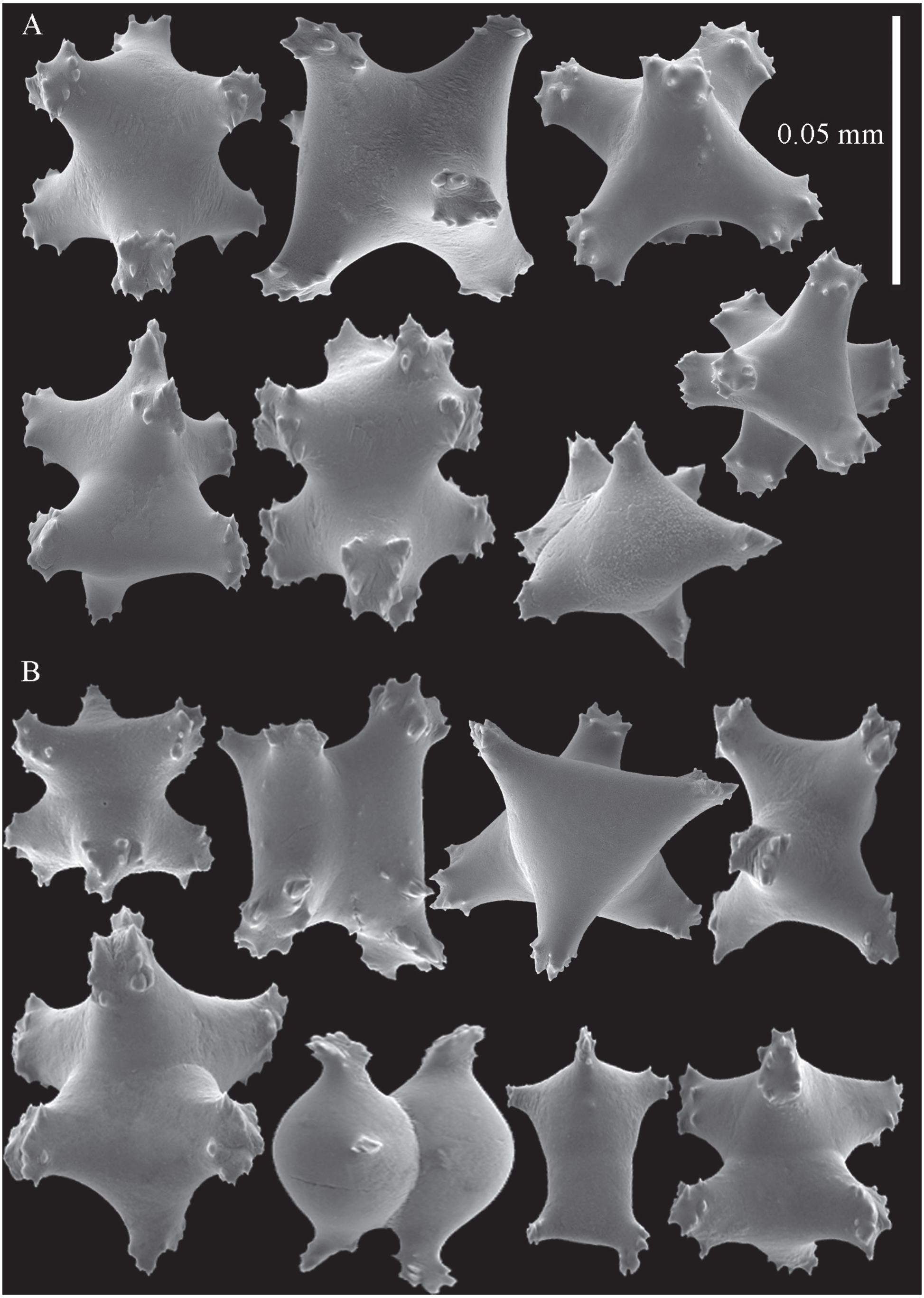

Figure 5. Sclerites of *Parasphaerasclera aurea* comb. n., RMNH Coel. 40779. **A** Surface of stalk **B** Interior of stalk.

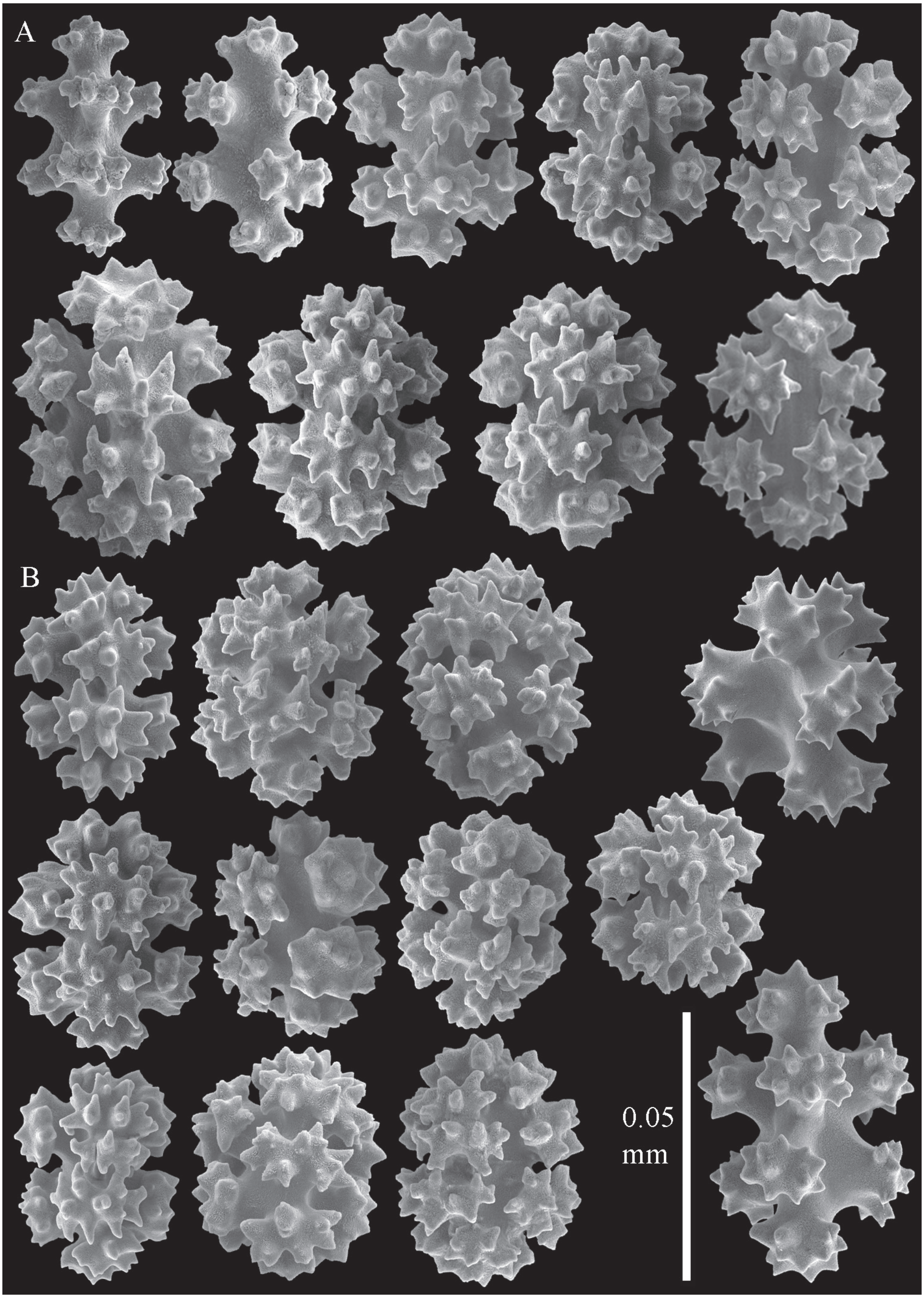

Figure 6. Sclerites of *Parasphaerasclera valdiviae* comb. n., RMNH Coel. 40206 **A** Surface layer of polyparium **B** Interior of polyparium.

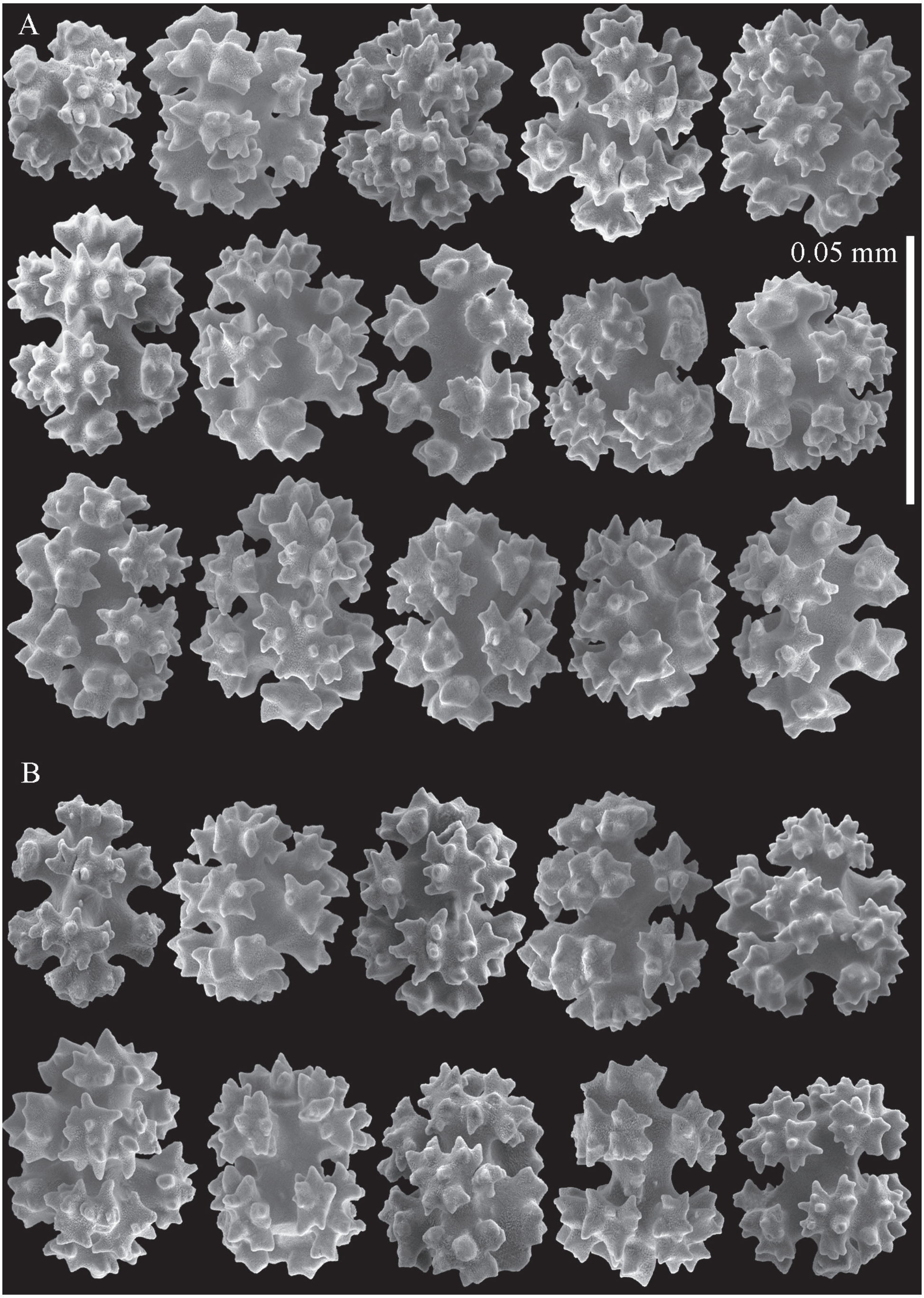

Figure 7. Sclerites of *Parasphaerasclera valdiviae* comb. n., RMNH Coel. 40206 **A** Surface layer of stalk **B** Interior of stalk.

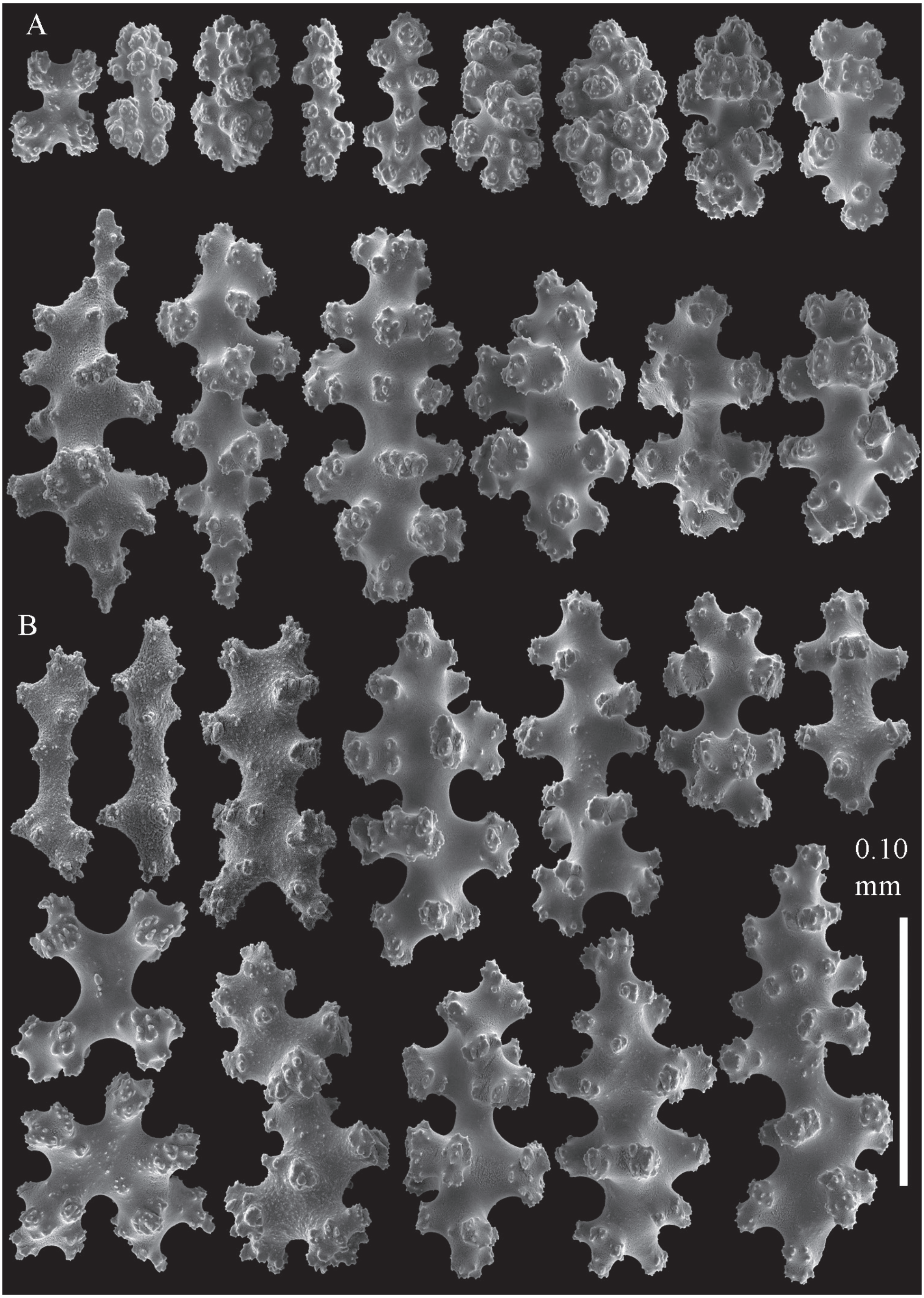

Figure 8. Sclerites of *Parasphaerasclera* aff. *grayi* comb. n. RMNH Coel. 40920 **A** Surface layer of polyparium **B** Interior of polyparium.

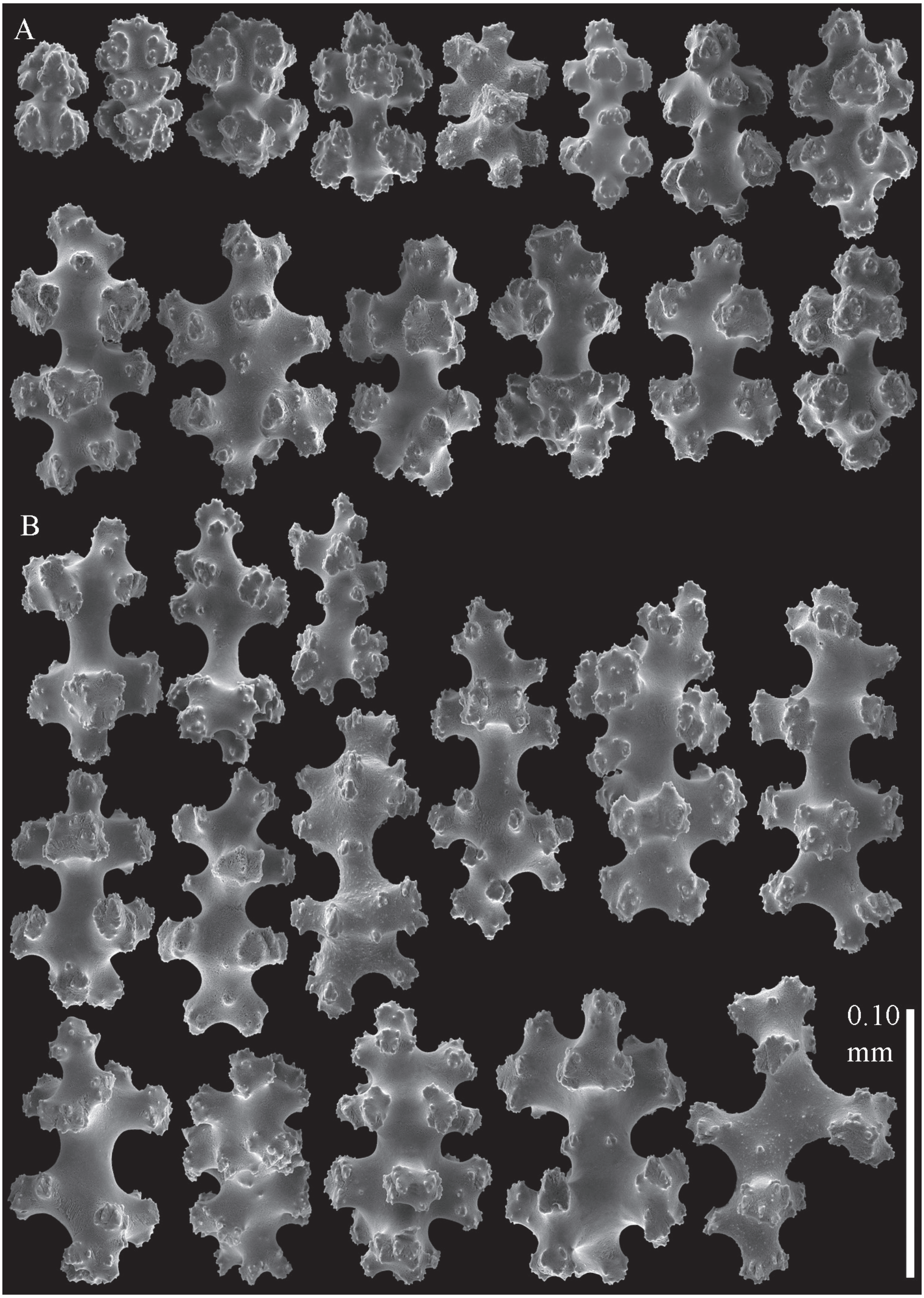

Figure 9. Sclerites of *Parasphaerasclera* aff. *grayi* comb. n. RMNH Coel. 40920 **A** Surface layer of stalk **B** Interior of stalk.

clude particularly distinctive rod-like forms with smooth waists and high processes, up to 0.18 mm in length. Williams (2001) subsequently re-described *P. grayi* based on specimens from the Solomon Islands. His specimens include 7- and 8-radiates (0.06–0.08 mm long) and crosses similar to those of the lectotype, but the rod-like sclerites in the colony interior are considerably smaller (most 0.07–0.08 mm long) and lack smooth waists (Williams 2001, figs 5–8). In contrast, specimens of *P. grayi* from Vietnam that were later re-described and illustrated by Dautova and Savinkin (2009, figs. 5–7) include "rather smooth" (p. 10) rods that more closely resemble those depicted by Verseveldt and Bayer (1988), but are somewhat smaller, up to 0.14 mm long. The specimens from Palau that we have sequenced and identified here as *P.* aff. *grayi* have tuberculate rods that lack a smooth waist (Figs 8–9), similar to those of Williams's specimens. In our specimens, however, the rods are considerably larger (to 0.16 mm long). In addition, although the radiates in the colony surface of *P.* aff. *grayi* from Palau are similar in size to those of other *P. grayi* specimens, they are more compact and some approach ovals in form (Figs 8A, 9A). This range of variation in sclerite form and size observed among the different specimens attributed to *P. grayi* suggests that more than one species may be involved. It remains to be determined if *P.* aff. *grayi* from Palau is the same as *P. grayi sensu* Williams (2001) from the Solomons, and if either of these forms is conspecific with Dautova and Savinkin's (2009) material from Vietnam. The latter most closely matches the *P. grayi* lectotype of Verseveldt and Bayer (1988).

Parasphaerasclera gen. n. is most similar morphologically to the alcyoniid genera *Paraminabea* and *Sphaerasclera* gen. n. All three genera lack sclerites in the polyps and have spheroids or radiates in the colony surface and interior. The polyps of *Paraminabea*, however, are dimorphic, while those of *Parasphaerasclera* gen. n. are monomorphic. The unique capitate growth form of *Sphaerasclera* gen. n. distinguishes it from all species of *Parasphaerasclera* gen. n., which are digitiform to digitate or lobate. *Parasphaerasclera* gen. n. is also easily distinguished from the alcyoniid genera *Eleutherobia* and *Alcyonium sensu stricto*, both of which have sclerites arranged to form a collaret and points in the polyps, and spindles or rods in the colony interior.

Discussion

Following the taxonomic changes we have made here, eleven species remain in *Eleutherobia*. The morphological heterogeneity of these species and their similarities to some other genera suggest that further taxonomic revisions are likely to be necessary. Six of the remaining species of *Eleutherobia* have polyps with a distinct collaret and points of spindles; radiates, spindles and club-like sclerites in the colony surface; and spindles in the interior coenenchyme. These species likely belong to *Alcyonium sensu stricto*. Included among them is the type species of *Eleutherobia*, *E. rigida* (=*E. japonica*, Pütter, 1900), as well as *E. grandiflora* (Kükenthal, 1906), *E. rubra* (Brundin, 1896), *E. somaliensis* Verseveldt & Bayer 1988, *E. splendens* (Thomson & Dean, 1931), and *E.*

unicolor (Kükenthal, 1906). Another four species of *Eleutherobia* likewise have a collaret and points of spindles but have tuberculate radiates, spheroids and irregular forms in the colony surface, and spindle-like sclerites with narrow pointed ends and thick waists in the colony interior (Verseveldt and Bayer 1988). Included in this group are *E. dofleini* (Kükenthal, 1906), *E. duriuscula* (Thomson & Dean, 1931), *E. flava* (Nutting, 1912), and possibly *E. sumbawensis* Verseveldt & Bayer 1988. Whether these species also might belong to *Alcyonium* or to a different genus cannot be determined at present. *E. vinadigitaria* Williams & Little, 2001, a species that has needle-like spindles in the polyps and no sclerites in the colony interior, is unlike any other species of *Eleutherobia*. Acquisition of material suitable for molecular phylogenetic analysis will greatly facilitate future efforts to determine the appropriate taxonomic placement of these species.

Until such time as the phylogenetic relationships among the species that remain in *Eleutherobia* can be determined, we modify the most recent diagnosis of the genus (Williams 2003) as follows:

Alcyoniid soft corals, usually digitiform (conical to cylindrical), sometimes digitate to lobate or clavate; polyparium arising from a common unbranched stalk. Polyps monomorphic. Calyces absent, although retracted polyps may form low rounded or mound-like protuberances of the coenenchyme. Anthocodial sclerites present, arranged in points or collaret and points. Coenenchymal sclerites mostly derived from radiates, although spindles, barrels, tuberculate spheroids, rod-like forms or crosses sometimes present. Color permanent and contained in the sclerites. Azooxanthellate.

Conclusions

Molecular phylogenetic analyses of a number of species belonging to the alcyoniid genera *Eleutherobia* and *Alcyonium* have highlighted the heterogeneity of these two taxa as well as some overlap between them. As an initial effort to align the morphology-based taxonomic classification of species in these genera with molecular phylogenetic evidence of their evolutionary affinities we have reassigned two species of *Eleutherobia* with capitate growth forms, polyp sclerites arranged as a collaret and points, and spindles in the colony interior to *Alcyonium*; assigned a phylogenetically unique species with monomorphic polyps and a capitate growth form to a new genus of Alcyoniidae, *Sphaerasclera* gen. n.; and designated a new family, Parasphaerascleridae fam. n., and genus, *Parasphaerasclera* gen. n., to accommodate species with monomorphic polyps that lack sclerites in the polyps and have predominantly radiates and spheroids in the colony surface and interior. These are the first of many taxonomic revisions that will be required to reconcile the classification of genera currently assigned to Alcyoniidae with their phylogenetic relationships. Whereas the revisions we have made herein are well supported by both morphological and molecular phylogenetic evidence, considerably more evidence of both types will be necessary before we can begin to make taxonomic sense of the poorly resolved relationships among the many additional alcyoniid genera that belong to the Holaxonia–Alcyoniina clade of octocorals.

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References

Alderslade P (2000) Four new genera of soft corals (Coelenterata: Octocorallia), with notes on the classification of some established taxa. Zoologische Mededelingen Leiden 74: 237–249.

Bayer FM (1981) Key to the genera of Octocorallia exclusive of Pennatulacea (Coelenterata: Anthozoa), with diagnoses of new taxa. Proceedings of the Biological Society of Washington 94: 878–901.

Bayer FM (1993) Taxonomic status of the octocoral genus *Bathyalcyon* (Alcyoniidae: Anthomastinae), with descriptions of a new subspecies from the Gulf of Mexico and a new species of *Anthomastus* from Antarctic waters. Precious Corals & Octocoral Research 1: 3–13.

Benayahu Y, Schleyer M (1995) Corals of the south-west Indian Ocean II. *Eleutherobia aurea* spec. nov. (Cnidaria, Alcyonacea) from deep reefs on the KwaZulu-Natal coast, South Africa. Oceanographic Research Instititute Investigational Reports 68: 1–12.

Berntson EA, Bayer FM, McArthur AG, France SC (2001) Phylogenetic relationships within the Octocorallia (Cnidaria: Anthozoa) based on nuclear 18S rRNA sequences. Marine Biology 138: 235–246. doi: 10.1007/s002270000457

Bouchet P, Héros V, Lozouet P, Maestrati P (2008) A quarter-century of deep-sea malacological exploration in the South and West Pacific: Where do we stand? How far to go? In: Héros V, Cowie RH, Bouchet P (Eds) Tropical Deep-Sea Benthos 25, vol 196: 9–40.

Brockman SA, McFadden CS (2012) The mitochondrial genome of *Paraminabea aldersladei* (Cnidaria: Anthozoa: Octocorallia) supports intramolecular recombination as the primary mechanism of gene rearrangement in octocoral mitochondrial genomes. Genome Biology and Evolution 4: 882–894. doi: 10.1093/gbe/evs074

Daly M, Brugler MR, Cartwright P, Collins AG, Dawson MN, Fautin DG, France SC, McFadden CS, Opresko DM, Rodriguez E, Romano S, Stake J (2007) The phylum Cnidaria: A review of phylogenetic patterns and diversity 300 years after Linnaeus. Zootaxa 1668: 1–766.

Dautova TN, Savinkin OV (2009) New data on soft corals (Cnidaria: Octocorallia: Alcyonacea) from Nha Trang Bay, South China Sea. Zootaxa 2027: 1–27.

Fabricius K, Alderslade P (2001) Soft Corals and Sea Fans: a Comprehensive Guide to the Tropical Shallow-water Genera of the Central West-Pacific, the Indian Ocean and the Red Sea. Australian Institute of Marine Science, Townsville, 264 pp.

Imahara Y (1977) Alcyoniid octocorals from Suruga Bay, the Pacific coast of central Japan. Annotationes Zoologicae Japonenses 50: 31–35.

Katoh K, Kuma K, Toh H, Miyata T (2005) MAFFT version 5: improvement in accuracy of multiple sequence alignment. Nucleic Acids Research 33: 511–513. doi: 10.1093/nar/gki198

McFadden CS, Ofwegen LP van (2012) Stoloniferous octocorals (Anthozoa, Octocorallia) from South Africa, with descriptions of a new family of Alcyonacea, a new genus of Clavulariidae, and a new species of *Cornularia* (Cornulariidae). Invertebrate Systematics 26: 331–356. doi: 10.1071/IS12035

McFadden CS, Ofwegen LP van (2013) A second, cryptic species of the soft coral genus *Incrustatus* (Anthozoa: Octocorallia: Clavulariidae) from Tierra del Fuego, Argentina, revealed by DNA barcoding. Helgoland Marine Research 67: 137–147. doi: 10.1007/s10152-012-0310-7

McFadden CS, Donahue RM, Hadland BK, Weston R (2001) A molecular phylogenetic analysis of reproductive trait evolution in the soft coral genus *Alcyonium*. Evolution 55: 29–42. doi: 10.1093/icb/icq056

McFadden CS, France SC, Sánchez JA, Alderslade P (2006) A molecular phylogenetic analysis of the Octocorallia (Coelenterata: Anthozoa) based on mitochondrial protein-coding sequences. Molecular Phylogenetics and Evolution 41: 513–527. doi: 10.1016/j.ympev.2006.06.010

McFadden CS, Sánchez JA, France SC (2010) Molecular phylogenetic insights into the evolution of Octocorallia: a review. Integrative and Comparative Biology 50: 389–410.

McFadden CS, Benayahu Y, Pante E, Thoma JN, Nevarez PA, France SC (2011) Limitations of mitochondrial gene barcoding in the cnidarian sub-class Octocorallia. Molecular Ecology Resources 11: 19–31. doi: 10.1111/j.1755-0998.2010.02875.x

Ofwegen LP van, Häussermann V, Försterra G (2007) The genus *Alcyonium* (Octocorallia: Alcyonacea: Alcyoniidae) in Chile. Zootaxa 1607: 1–19.

Posada D, Crandall KA (1998) Modeltest: testing the model of DNA substitution. Bioinformatics 14: 817–818. doi: 10.1093/bioinformatics/14.9.817

Ronquist F, Teslenko M, van der Mark P, Ayres D, Darling A, Höhna S, Larget B, Liu L, Suchard MA, Huelsenbeck JP (2012) MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choice across a large model space. Systematic Biology 61: 539–542. doi: 10.1093/sysbio/sys029

Thomson JA, Dean LMI (1931) The Alcyonacea of the Siboga Expedition with an addendum to the Gorgonacea. Siboga Expedition Monograph 13d: 1–227.

Thomson JS (1910) The Alcyonaria of the Cape of Good Hope and Natal. Alcyonacea. Transactions of the Royal Society of Edinburgh XLVII, part III: 549–589, pls I–IV.

Utinomi H (1957) The alcyonarian genus *Bellonella* from Japan, with descriptions of two new species. Publications of the Seto Marine Biological Laboratory 6: 147–168, pls. 9–10.

Verseveldt J, Bayer FM (1988) Revision of the genera *Bellonella*, *Eleutherobia*, *Nidalia* and *Nidaliopsis* (Octocorallia: Alcyoniidae and Nidaliidae), with descriptions of two new genera. Zoologische Verhandelingen Leiden 245: 1–131.

Verseveldt J, Williams GC (1988) A redescription of the soft coral *Alcyonium valdiviae* Kükenthal, 1906, with the description of a new species of *Litophyton* Førskal, 1775, from southern Africa (Octocorallia, Alcyonacea). Annals of the South African Museum 97: 315–328.

Williams GC (1986) Morphology, systematics, and variability of the southern African soft coral *Alcyonium variabile* (J. Stuart Thomson, 1921) (Octocorallia, Alcyoniidae). Annals of the South African Museum 96: 241–270.

Williams GC (1988) Four new species of southern African octocorals (Cnidaria: Alcyonacea), with a further diagnostic revision of the genus *Alcyonium* Linnaeus, 1758. Zoological Journal of the Linnean Society 92: 1–26. doi: 10.1111/j.1096-3642.1988.tb01524.x

Williams GC (1992) The Alcyonacea of Southern Africa. Stoloniferous octocorals and soft corals (Coelenterata, Anthozoa). Annals of the South African Museum 100: 249–358.

Williams GC (2000a) Two new genera of soft corals (Anthozoa: Alcyoniidae) from South Africa, with a discussion of diversity and endemism in the southern African octocorallian fauna. Proceedings of the California Academy of Sciences 52: 65–75.

Williams GC (2000b) A new species of the soft coral genus *Eleutherobia* Pütter, 1900 (Coelenterata: Alcyoniidae) from the Tonga Islands. Proceedings of the California Academy of Sciences 52: 159–169.

Williams GC (2001) First record of a bioluminescent soft coral: description of a disjunct population of *Eleutherobia grayi* (Thomson and Dean, 1921) from the Solomon Islands, with a review of bioluminescence in the Octocorallia. Proceedings of the California Academy of Sciences 52: 209-225.

Williams GC (2003) Capitate taxa of the soft coral genus *Eleutherobia* (Octocorallia: Alcyoniidae) from Palau and South Africa; a new species and a new combination. Zoologische Verhandelingen Leiden 345: 419–436.

Williams GC, Alderslade P (1999) Revisionary systematics of the western Pacific soft coral genus *Minabea* (Octocorallia: Alcyoniidae), with descriptions of a related new genus and species from the Indo-Pacific. Proceedings of the California Academy of Sciences 51: 337–364.

Williams GC, Cairns S (2013) Systematic list of valid octocoral genera. http://research.calacademy.org/redirect?url=http://researcharchive.calacademy.org/research/izg/orc_home.html [accessed 29 August 2013]

Williams GC, Little SA (2001) A new species of the soft coral genus *Eleutherobia* Pütter, 1900 (Octocorallia: Alcyoniidae) from South Africa. Proceedings of the California Academy of Sciences 52: 195–208.

Zwickl DJ (2006) Genetic algorithm approaches for the phylogenetic analysis of large biological sequence datasets under the maximum likelihood criterion. Ph.D. thesis, University of Texas, Austin, Texas.

Appendix

Taxa and sequences included in phylogenetic analysis. (doi: 10.3897/zookeys.346.6270.app) File format: Microsoft Excell file (xls).

Explanation note: Taxa and sequences included in phylogenetic analysis. Museum accession numbers of sequenced specimens given when known. NA: no accession.

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Nomenclatural changes in the tribe Empoascini of the subfamily Typhlocybinae (Hemiptera, Cicadellidae)

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Abstract

One genus and species are synonymized in the tribe Empoascini of the subfamily Typhlocybinae. *Bhatasca* Dworakowska, 1995 is a junior synonym of *Alebrasca* Hayashi & Okada, 1994, *Bhatasca rectangulata* Qin & Zhang, 2011 is a junior synonym of *Alebrasca actinidiae* Hayashi & Okada, 1994. Furthermore, *Bhatasca expansa* is (necessarily) transferred to the genus *Alebrasca*.

Keywords

Homoptera, Auchenorryncha, taxonomy, leafhopper, synonym, China

Introduction

Empoascini is a large tribe in the leafhopper subfamily Typhlocybinae, comprising more than 1000 species and nearly 70 genera worldwide. However, the status of some established genera and species in this tribe remains dubious or misleading and needs further revision. In this study, one genus and one species are recognized as junior synonyms and we also propose one new combination in Empoascini. The purpose of the present paper is to clarify the taxonomy of the tribe.

Nomenclatural changes and notes

Family Cicadellidae
Subfamily Typhlocybinae
Tribe Empoascini

Alebrasca Hayashi & Okada, 1994

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

Alebrasca Hayashi & Okada, 1994: 267. Type species: *Alebrasca actinidiae* Hayashi & Okada, 1994, by original designation.

Bhatasca Dworakowska, 1995: 143. Type species: *Bhatasca expansa* Dworakowska, 1995, by original designation. **syn. n.**

Remarks. Dworakowska (1995) established the genus *Bhatasca* based on the type species *B. expansa* Dworakowska, 1995 from Tsyr-feng in Taiwan, and Qin et al. (2011) described *B. rectangulata* based on the generic diagnosis provided by Dworakowska (1995). Until now, only two species were included in the genus, widely distributed in mainland China (Hunan, Henan, Gansu, Sichuan, Fujian, Zhejiang, Jiangxi) and Taiwan. Based on investigation of the descriptions and illustrations by Hayashi and Okada (1994) and Dworakowska (1995) and *Bhatasca* material deposited in the Entomological Museum, Northwest A&F University (NWAFU), we recognize the genus *Bhatasca* Dworakowska is a junior synonym of *Alebrasca* Hayashi & Okada.

Alebrasca actinidiae Hayashi & Okada, 1994

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

Alebrasca actinidiae Hayashi & Okada, 1994: 269.

Bhatasca rectangulata Qin & Zhang, 2011: 54. **syn. n.**

Remarks. After checking the type specimens of *Bhatasca rectangulata*, we found the characters of wing, basal abdominal apodemes and male genitalia described by Qin et al. (2011) in mainland China are the same as those of the species described by Hayashi and Okada (1994). Furthermore, the distribution of *Bhatasca rectangulata* has nearly same latitude as the type locality of *Alebrasca actinidiae* Hayashi & Okada in Japan (central Honshu). Therefore, synonymy of the two species is confirmed here.

Alebrasca expansa **(Dworakowska, 1995), comb. n.**
http://species-id.net/wiki/Alebrasca_expansa

Bhatasca expansa Dworakowska, 1995: 145.

Remarks. Dworakowska (1995) described this species in *Bhatasca* from Taiwan. We here transfer it to *Alebrasca* mainly based on the characters of the head, the venation of fore- and hindwing, the basal abdominal apodemes and especially the configuration of the male genitalia.

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References

Dworakowska I (1995) *Szara* gen. nov. and some other Oriental Empoascini (Insecta: Auchenorrhyncha: Cicadellidae: Typhlocybinae). Entomol. Abh. Mus. Tierk. Dresden 56(7): 129–160.

Hayashi M, Okada T (1994) A new typhlocybine leafhopper (Homoptera: Cicadellidae) feeding on kiwi-fruit. Appl. Entomol. Zool. 29(2): 267–271.

Qin DZ, Liu Y, Zhang YL (2011) A taxonomic study of Chinese Empoascini (Hemiptera: Cicadellidae: Typhlocybinae) (II). Zootaxa 2923: 48–58.