Journal of the Marine Biological Association of the United Kingdom, 2018, 98(7), 1685–1688.
doi:10.1017/S0025315417001084

Giving up on elaborate dermal ossicles: a new genus of ossicleless Apodida (Holothuroidea)

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In this paper we describe a new genus and a new species of Chiridotidae based on specimens collected in shallow water off the South-eastern Brazilian coast. Gymnopipina ikamiaba *gen. nov. et sp. nov. is characterized by the complete absence of dermal ossicles in the body, and it differs from the other ossicleless apodids in the number of tentacles and of Polian vesicles, and in the morphology of the calcareous ring. Although not formally tested with a phylogenetic framework, apodids have apparently lost their dermal ossicles multiple times. If these reversions hold true,* Gymnopipina *gen. nov. represents the fourth independent loss of dermal ossicles in the class Holothuroidea. An identification key to the Brazilian apodid species is also provided.*

Keywords: Chiridotinae, Brazil, taxonomy, new species, shallow water, biodiversity

Submitted 14 December 2016; accepted 17 May 2017; first published online 30 June 2017

INTRODUCTION

Holothuroids are echinoderms characterized by the reduction of the endoskeleton into small plates that are bound together by connective tissue (e.g. calcareous ring) and dermal ossicles widespread in the body. According to Miller *et al.* (2017), there are two major clades of holothuroids: the Apodida, characterized by the absence of tubefeet that were lost in the early evolution of the group, and the Actinopoda, characterized by the presence of shield-shaped tentacles. The apodids have some of the simple ossicles found in other holothuroids such as rods, hooks and miliary granules, but they have also developed elaborate wheel and anchor-shaped ossicles in the body wall, which are unique to this order (although they have been found in echinoids and ophiocistoids; Mortensen, 1940; Reich & Kutscher, 2014). The formation and function of most dermal ossicles are not well understood but studies have shown that anchors are important for locomotion (Berrill, 1966; Heffernan & Wainwright, 1974). Apodids rely on peristaltic movements to explore the seafloor and in the absence of tubefeet, the synaptid apodids use their anchors to hold on to the substratum.

Some apodids have reduced their endoskeleton even further, giving up on anchors and wheels; three genera have completely lost their dermal ossicles. In this paper, we describe a new genus and a new species of ossicleless Apodida, based on shallow water specimens collected off the South-eastern Brazilian coast. The biodiversity of apodid holothuroids in Brazil is increased to eight species; an identification key with diagnostic traits is provided.

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MATERIALS AND METHODS

The classification of holothuroids to lower taxonomic ranks relies mostly on the composition and shape of their dermal ossicles. However, since this species has lost ossicle formation, our classification relied only on the morphology of its calcareous ring and its internal morphology.

The methods used to examine the specimens followed Samyn *et al.* (2006). The internal morphology was analysed using the software Image-Pro Express (v. 6.0) linked to an Olympus CX31-RTSF optical microscope. We also performed scanning electron microscopy (SEM) (JEOL JSM-6390LV) to analyse if there were minute ossicles.

Specimens are deposited in the Museu de Zoologia at Universidade de São Paulo, Brazil (MZUSP).

RESULTS

SYSTEMATICS

Order APODIDA Brandt, 1835
Family CHIRIDOTIDAE Östergren, 1898
Subfamily CHIRIDOTINAE Östergren, 1898

DIAGNOSIS

Amended herein after Smirnov (2012): Chiridotidae with 12 or 18 tentacles. Ossicles are chiridotid wheels assembled in papillae and/or rods, or completely lacking. Radial segments

of calcareous ring with perforation or deep notch on upper side. 1–30 Polian vesicles.

Genus *Gymnopipina* gen. nov. Souto & Martins

DIAGNOSIS
Chiridotinae with 12 tentacles and one Polian vesicle. Ciliated funnels lacking. Ossicles absent from body wall, tentacles and muscles.

TYPE SPECIES
Gymnopipina ikamiaba sp. nov. Souto & Martins, by monotypy.

ETYMOLOGY
Name derived from the Greek *gymno* (meaning 'naked') in reference to the absence of dermal ossicles in the body, and from the Portuguese *pepino-do-mar* (meaning 'sea cucumber'). Gender feminine.

REMARKS
Gymnopipina gen. nov. was classified as a Chiridotidae because of its short anterior projections in the calcareous ring, and madreporite sitting at the end of the long stone canal. However, this genus lacks ciliated funnels, which are usually present (although sometimes reduced) in chiridotids.

There are three genera of apodid holothuroids without dermal ossicles: *Gymnopipina* gen. nov. differs from the Synaptidae *Anapta* by having one Polian vesicle (*vs* many) and no long terminal digit on tentacles; from *Rhabdomolgus* by having 12 tentacles (*vs* 10) with digits (*vs* without digits); and from the Myriotrochidae *Achiridota* by having short anterior processes in the calcareous ring (*vs* large processes). Among the Chiridotidae with reduced dermal ossicles, *Gymnopipina* gen. nov. differs from *Paradota* and *Neotoxodora* by the absence of ciliated funnels and ossicles (*vs* presence of minute rods in the tentacles and body wall, respectively); and from *Kolostoneura* by having 12 tentacles (*vs* 10) and perforations on the radial plates of the calcareous ring, and by lacking ciliated funnels and ossicles (*vs* presence of minute rods in the tentacles). *Gymnopipina* gen. nov. differs from all other chiridotid genera by lacking dermal ossicles.

Gymnopipina ikamiaba sp. nov. Souto & Martins
(Figures 1 & 2)

TYPE MATERIAL
Holotype: São Sebastião, SP, Brazil, March 1956, 6.5 cm long (MZUSP 1514). Paratypes: same collection data as Holotype, five specimens 2–2.5 cm long (MZUSP 1515).

DIAGNOSIS
As for genus.

ETYMOLOGY
Named after the brave indigenous women who lived in the pre-colonized Amazon forest and were killed trying to protect their land.

DESCRIPTION
Body vermiform (Figure 1A, B), 6.5 cm long. 12 peltate tentacles (Figure 1C), each with 5 pairs of digits, distal pair larger than others (Figure 1D). Calcareous ring with 10 broad and delicate plates, posterior projections lacking (Figure 2A). Posterior region of plates flat to slightly concave, and anterior region W-shaped. Radial plates with anterior perforation for insertion of radial nerves (Figure 2A, B); interradial plates with a short anterior projection/tooth. Radials and interradials not necessarily intercalated, but complete arrangement of plates could not be observed because plates dissociated very quickly. Ciliated funnels absent, stone canal single and long, madreporite circular (Figure 2C). One Polian vesicle (Figure 2D). Longitudinal musculature in five bands along body; transversal muscles in multiple circular bands (Figure 2E). Gonad tufts with central trunk and simple branches, attached to body wall between middle region of body and calcareous ring (Figure 2F). Ossicles lacking from muscles, body wall and tentacles. Colour in ethanol brown.

TYPE LOCALITY
São Sebastião, São Paulo State, Brazil.

BATHYMETRY
Bathymetric data of the collecting site is not available but the maximum depth of the type locality is 40 m (Pires-Vanin *et al.*, 2014).

KEY TO APODID SPECIES FROM THE BRAZILIAN COAST

1. Body wall ossicles present 2
— Body wall ossicles lacking *Gymnopipina ikamiaba* gen. nov. et sp. nov.
2. Body wall with wheels *Chiridota rotifera* (Pourtalès, 1851)
— Body wall with anchors and anchor plates 3
3. Anchor stocks branched 4
— Anchor stocks unbranched 5
4. Anchor arms smooth *Euapta lappa* (Müller, 1850)
— Anchor arms toothed *Protankyra benedeni* (Ludwig, 1881)
5. Miliar granules present 6
— Miliar granules absent *Leptosynapta brasiliensis* Freire & Grohmann, 1989
6. Miliar granules are C and O-shaped *Epitomapta roseola* (Verrill, 1874)
— Miliar granules are rosettes 7
7. Anchor stock and vertex untoothed *Synaptula secreta* Ancona-Lopez, 1957
— Anchor stock and vertex toothed *Synaptula hydriformis* (Lesueur, 1824)

Loss of dermal ossicles in the Apodida

With the description of *Gymnopipina* gen. nov., there are at least four genera whose dermal ossicles have been completely lost. Smirnov (2016) suggested that such losses occurred independently in multiple lineages; however, this hypothesis has not been formally tested within a phylogenetic framework. In his morphological phylogeny of the apodids, Kerr (2001) excluded the genera without ossicles because they were poorly known or considered 'clearly derived' (Kerr, 2001, p. 54). Miller *et al.* (2017) reconstructed a phylogeny based on

https://doi.org/10.1017/S0025315417001084 Published online by Cambridge University Press

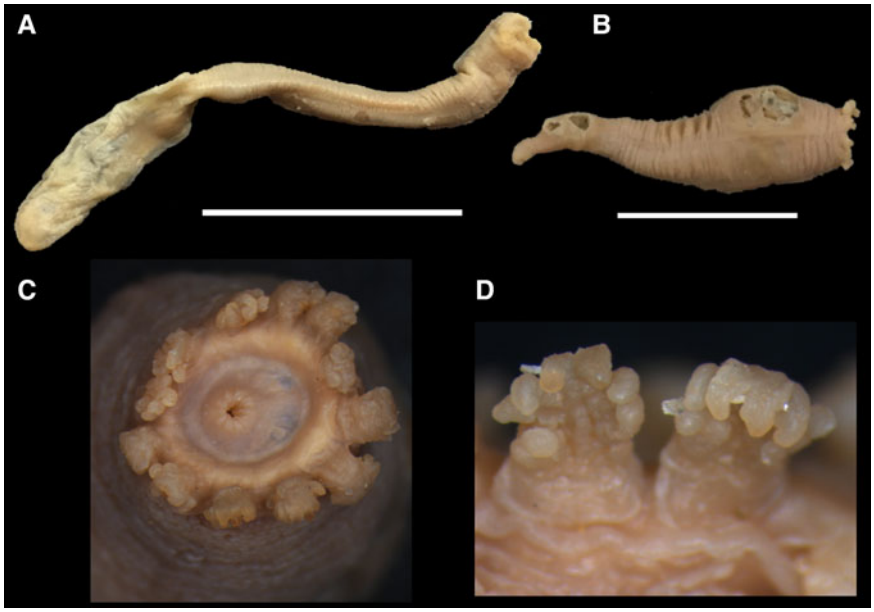

Fig. 1. *Gymnopipina ikamiaba* gen. nov. et sp. nov.: (A) lateral view of holotype (MZUSP 1514) and (B) paratype (MZUSP 1515); and (C) apical view of mouth and peltate tentacles; and (D) detail of tentacle digits. Scale bars: A, 4 cm; B, 2 cm.

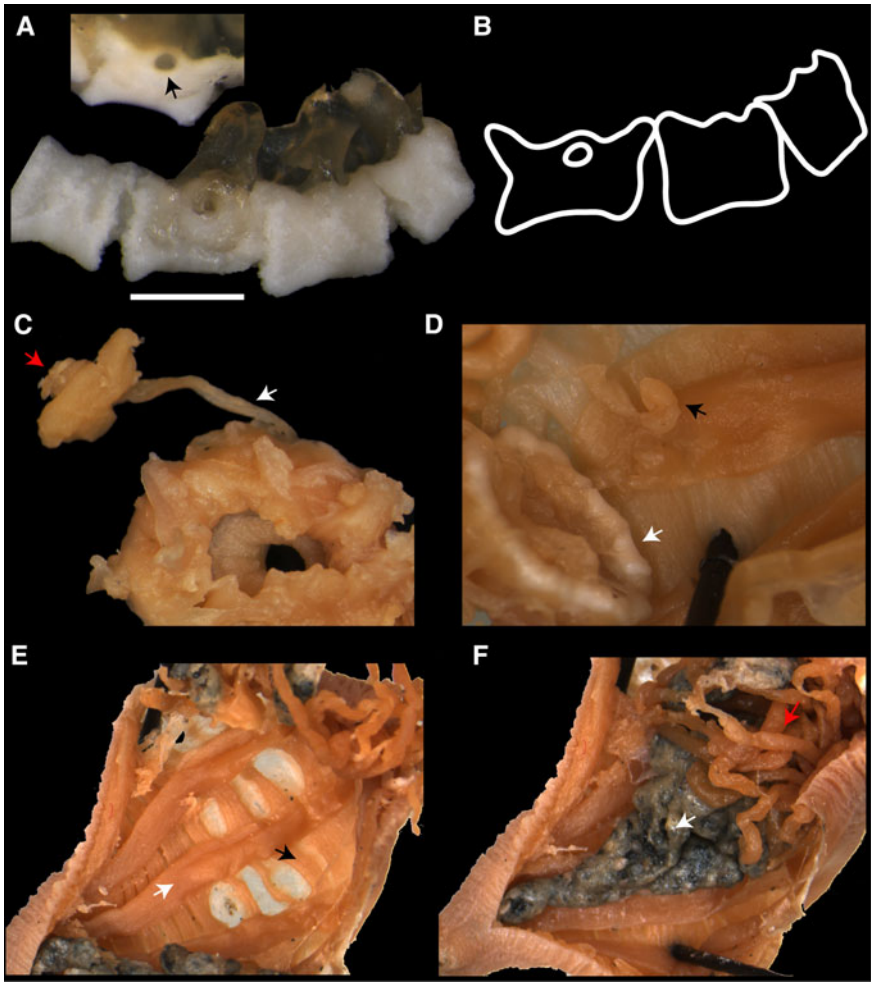

Fig. 2. *Gymnopipina ikamiaba* gen. nov. et sp. nov. (MZUSP 1515): (A) calcareous ring after bleaching (arrow in upper image indicates the perforation for insertion of radial nerve); (B) drawing of calcareous ring; and detail of the internal morphology, including (C) madreporite (red arrow) and stone canal (white arrow); (D) posterior region of calcareous ring (white arrow) and Polian vesicle (black arrow); (E) longitudinal musculature (white arrow) and circular muscle bands (black arrow); and (F) gonads (red arrow) and digestive tract (white arrow). Scale bar: A, 1 mm.

https://doi.org/10.1017/S0025315417001084 Published online by Cambridge University Press

molecular data but they included only one of the genera that lack ossicles.

Convergences and parallelisms seem to be fairly common in holothuroids (Smirnov, 2016; Miller *et al*., 2017) and comprehensive phylogenetic analyses to the order and family levels are needed to elucidate the evolution of the holothuroid endoskeleton.

ACKNOWLEDGEMENTS

We thank Alexey Smirnov and an anonymous reviewer for providing constructive suggestions to the manuscript; Marcos Tavares (MZUSP) for providing access to the echinoderm collection; and the Instituto Gonçalo Moniz (FIOCRUZ/BA) for SEM analysis.

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