Sanidaster in freshwater sponges: an unexpected spicule for the birotuled Genus *Corvoheteromeyenia* Ezcurra de Drago, 1979

Ulisses PINHEIRO  
Universidade Federal de Pernambuco, Centro de Ciências Biológicas,  
Departamento de Zoologia – Laboratório de Porífera – LABPOR, Av. Nelson Chaves, s/n,  
C. Universitária, Recife, Pernambuco State, CEP 50373-970 (Brazil)  
uspinheiro@hotmail.com

Carlos SILVA  
Universidade do Estado da Bahia, Rua da Gangorra, 503,  
General Dutra, Paulo Afonso, Bahia State, CEP 48.608-240 (Brazil)  
felix.caio3@gmail.com

Ludimila CALHEIRA  
Universidade Federal de Pernambuco, Centro de Ciências Biológicas,  
Departamento de Zoologia – Laboratório de Porífera – LABPOR, Av. Nelson Chaves, s/n,  
C. Universitária, Recife, Pernambuco State, CEP 50373-970 (Brazil)  
calheiralaurindo@gmail.com

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ABSTRACT  
*Corvoheteromeyenia* Ezcurra de Drago, 1979 is exclusively known from Neotropical Region with two species recorded: *C. australis* (Bonetto & Ezcurra de Drago, 1966) and *C. heterosclera* (Ezcurra de Drago, 1974). The genus is characterized by the presence of birotuled gemmuloscleres inserted radially embedded in the gemmule, by megascleres which are exclusively oxeas, occasionally sparsely microspined and pseudobirotuled microscleres present in two distinct series. A total of twelve specimens were collected in São Francisco Basin (Bahia State, Brazil) and identified as belonging to *Corvoheteromeyenia*. Based on this material, we record *C. heterosclera* for São Francisco Basin. Additionally, we describe a new species of *Corvoheteromeyenia* that differs from other species of genus by having gemmulosclere sanidaster. Sanidaster display an intermediate morphology between the birotule and rodlike (acanthostrongyle) spicular type. The gemmulosclere sanidaster found here could be interpreted as malformations due to environmental conditions, since malformations in gemmuloscleres had previously been observed in experimental conditions in some freshwater sponges exposed to heavy metal. However, in these conditions only 50% of gemmoscleres were malformed, and in *C. sanidastosclera* n. sp., 100% of gemmoscleres were sanidasters. Thus we do not believe that this morphology of spicules was the result of exposure to chemical compounds in the environment. This result reinforces the idea of Penney & Racek (1968) that the segregation of Spongillidae Gray, 1867 into two groups based on the form of gemmoscleres as proposed by Vejdovsky (1887) is no longer justified.

KEY WORDS  
Freshwater sponges, gemmuloscleres, taxonomy, Bahia, Neotropical Region, new species.
INTRODUCTION

The first classification of freshwater sponges was proposed by Gray (1867), creating the order Potamospingida and the family Spongillidae (misspelling of Spongillidae) to include all genera studied by Bowerbank (1863). Carter (1881) downgraded the taxon Potamospingida to family and proposed the group Spongillina. Vejdovsky (1887) formalized Spongillina as subfamily Spongillinae, and created subfamily Meyeninae, to group the species with birotuled gummuloscleres. However, when Penney & Racek (1968) proposed the genus Radiospingilla, they noticed that some species present birotuled gummuloscleres and others gummuloscleres with rodlike shape (acanthostrongyle). Thus, did not make sense the segregation between both subfamilies. Only recently, the suborder Spongillina (order Haplosclerida) was proposed by Hajdu (2015) base on molecular data. Corvoheteromeyenia Ezcurra de Drago, 1979 is exclusively known from Neotropical Region with two species recorded: C. australis (Bonetto & Ezcurra de Drago, 1966) and C. heterosclera (Ezcurra de Drago, 1974), the former reported from Argentina and South Brazil, and the latter from Costa Rica, Venezuela, Curaçao, Argentina (Parana Basin) and Northeast Brazil (Maranhão, Rio Grande do Norte and Pernambuco States). The genus is characterized by gummuloscleres inserted radially in the gemmules; megaloscleres which are exclusively oxeas, occasionally sparsely microspined; and pseudobirotuled microscleres present in two distinct series.

MATERIAL AND METHODS

Material studied was collected from tanks of a fish farm in Paulo Afonso municipality, Bahia State, on the shores of São Francisco River (09°22’38”S, 38°13’58”W) (Fig. 1). The specimens were removed with a spatula and preserved in ethanol (70%). The identification to species was carried out through analysis of spicules and gemmules using Light Microscopy (LM) and Scanning Electron Microscopy (SEM) according to the methods described by Hajdu et al. (2011). Measurements of spicules (n=30) were made for megaloscleres, microscleres, gummuloscleres and gemmules of all specimens (minimum-mean-maximum for spicule lengths, width of shaft and width of pseudo-rotules, when possible; length of the spines of gummuloscleres), for comparison with other Corvoheteromeyenia species. The size category of gummuloscleres were determined with Sturges’ algorithm (Sturges 1926) to define spicule categories. A total of 100 spicules were measured of the specimen (UPPEPOR 1771). The specimens were deposited in the Porifera Collection of the Universidade Federal de Pernambuco, Recife, Brazil (UPPEPOR), and Muséum national d’Histoire naturelle, Paris, France (MNHN).

RÉSUMÉ


Corvoheteromeyenia Ezcurra de Drago, 1979 est trouvé exclusivement dans la région néotropicale, où il est connu par deux espèces: C. australis (Bonetto & Ezcurra de Drago, 1966) et C. heterosclera (Ezcurra de Drago, 1974). Le genre est caractérisé par la présence de gummulosclères birotulées insérées radialement dans la gemmule; de mégasclères uniquement composées d’oxes, occasionnellement couvertes par des microépines; et des microsclères pseudobirotulées présentes en deux séries distinctes. Douze spécimens ont été collectés dans le bassin du São Francisco (Bahia, Brésil) et identifiés comme appartenant au genre Corvoheteromeyenia. Ce matériel nous permet de signaler la présence de C. heterosclera dans le bassin du São Francisco. De plus, nous décrivons une nouvelle espèce de Corvoheteromeyenia qui diffère des autres espèces du genre par la présence de gummulosclères sanidastes. Les sanidastes ont une morphologie intermédiaire entre les formes birotulées et les formes de bâtonnet (acanthostrongyles). La présence de gummulosclères sanidastes pourrait être interprétée comme une malformation due aux conditions environnementales, puisque des malformations des gummulosclères ont déjà été observées en conditions expérimentales, quand certaines éponges d’eau douce étaient exposées à des métaux lourds. Cependant, seulement 50% des gummulosclères étaient alors malformées, alors que chez C. sanidastosclera n. sp. 100% des gummulosclères sont sanidastes. Ainsi nous ne croyons pas que la morphologie de ces spicules soit un résultat d’une exposition aux composés chimiques dans l’environnement. Nos résultats renforcent l’hypothèse de Penney & Racek (1968) selon laquelle la séparation des Spongillidae Gray, 1867 en deux groupes d’après la forme de leurs gummulosclères comme proposée par Vejdovsky (1887) n’est plus justifiée.
A total of twelve specimens were collected and identified as belonging to *Corvoheteromeyenia*. The description of the new species, measurements of the spicules and gemmules, and the distribution of *Corvoheteromeyenia* are presented in Table 1.

Systematics

A total of twelve specimens were collected and identified as belonging to *Corvoheteromeyenia*. The description of the new species, measurements of the spicules and gemmules, and the distribution of *Corvoheteromeyenia* are presented in Table 1.

Table 1. — Records and comparative micrometric data of the species of *Corvoheteromeyenia* Ezcurra de Drago, 1979; values are in micrometers (μm), expressed as follows: minimum–maximum or minimum-mean-maximum length/width of shaft // length of the rotule, when possible; length of the spines of gemmuloscleres; and diameter of gemmules; *, two categories; 1, Bonetto & Ezcurra de Drago (1966); 2, Tavares et al. (2003); 3, Volkmer-Ribeiro & Paula (2000); 4, Debrot & van Soest (2001); 5, Volkmer-Ribeiro & Machado (2009); 6, Ezcurra de Drago (1974).

<table>
<thead>
<tr>
<th>Species</th>
<th>Locality</th>
<th>Megascleres</th>
<th>Microscleres pseudobirotule</th>
<th>Gemmuloscleres</th>
<th>Gemmules</th>
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<tr>
<td><em>C. sanidastosclera</em></td>
<td>Bahia State, Brazil</td>
<td>Acanthoxea</td>
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<td>Type 2 (long shaft)</td>
<td>Sanidaster or Birotule</td>
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<td>(Holotype UFPEPOR 1105)</td>
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<td><em>C. sanidastosclera</em></td>
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<td><em>C. heterosclera</em></td>
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<td>(Bonetto &amp; Ezcurra de Drago, 1966)</td>
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<td>13-20 / 17-26 / 3 // 10</td>
<td>32-70 / 2.5</td>
<td>2-5 // 457-543-77.5 /</td>
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<td>32-70 / 2.5</td>
<td>61-69 // 8-20 // 6 //</td>
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<td>55-59 / 2</td>
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<td><em>C. heterosclera</em></td>
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<td>22-70</td>
<td>60-75 / 18-20 //</td>
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<td>150-300 / 5-8</td>
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Remarks

The emended definition of *Corvoheteromeyenia* was made necessary by the description of the new species, which in addition to birotuled gemmuloscleres also had sanidaster gemmuloscleres.

Corvoheteromeyenia heterosclera

(Ezcurra de Drago, 1974)

(Figs 2A-C; 3)
DIAGNOSIS. — Encrusting sponge, with oxeas megascleres smooth or microspined; pseudobirotule microscleres present in two types; birotuled gemmuloscleres inserted radially in the gemmules.

ECOLOGY. — The specimens were collected in clear waters of artificial environment, in fish farm tanks walls measuring 1.5 m³ and 800 m³, that are supplied with water from São Francisco River, with depth ranging from 10 cm to 1 m.

DESCRIPTION
The shape of this sponge is encrustant, less than 5 mm thick, it can achieve more than one metre in length. Surface is hispid and reticulated with anastomosing ridges projections, and circular oscules. Colour in life is light green (Fig. 2A-C), turning grayish green after preservation in ethanol 70%. Consistency soft and compressible. Oxeas megascleres are smooth (rare) or microspined (predominant) (199.7-297.8-373.5 / 9.7-12.6-16.1 μm), with few conical spines sparsely arranged on the shaft (Fig. 3A, B). Pseudobirotule microscleres of two types (Fig. 3C, D): type 1 (12.9-19.6-35.4 / 1.6-3.1-4.8 // 3.2-6.1-12.9 μm), short shaft, smooth, thin, tip terminated with three to five hooks for each pseudo-rotule. Pseudo-rotules are concave, with hooks curved towards the shaft of the spicule (Fig. 3C); and the type 2 (32.2-64.4-96.6 / 4.8-6.5-9.7 μm), long shaft, with a variable number of spines, microspined in the central portion, with discreet hooks forming pseudo-rotules (Fig. 3D). Birotuled gemmuloscleres (Fig. 3E) (54.7-69.4-80.5 / 4.8-7.5-12.9 // 1.6-2.2-3.2 μm), inserted radially in the theca of gemmules (Fig. 3H). Present two circular and identical rotules which can vary between concave to slightly flat, with marginal minutes spines. The shaft can has smooth or compound spines (with secondary minutes spines). Gemmules (512.2-552-611.8 μm) abundant, spread throughout the sponge body, from the surface to the base, spherical (Fig. 3F). Foramen single and circular (Fig. 3G). Gemmular theca trilayered well developed (Fig. 3H), inner layer present compact sporigin, where gemmuloscleres are embedded radially.

REMARKS
The genus Corvoheteromeyenia was proposed by Ezcurra de Drago (1979) to allocate two species of Corvomeyenia: C. australis (Bonetto & Ezcurra de Drago, 1966) and C. heterosclera (Ezcurra de Drago, 1974). Ezcurra de Drago (1979) noticed differences between the South American species and those of the other genus, based on gemmuloscleres and microscleres, and designated C. australis as the type species.

The differences between Corvoheteromeyenia species are very controvert. Just one year after have been described C. heterosclera, Bonetto et al. (1975) proposed this species as junior synonym of C. australis. However, Ezcurra de Drago (1979) recognized some differences: C. australis had variations in the size and shape (rotules) of gemmuloscleres, while C. heterosclera presents lower size variation and one type of rotules. On the other hand, Tavares et al. (2003) and Machado et al. (2012) reported two categories of gemmoscleres as diagnostic character of C. australis.

In the present material, the Sturges algorithm (Fig. 4) showed only one size category of gemmuloscleres, with gradient of variation in the size and shape of rotules. These results agree partially to Ezcurra de Drago definition, although we do not see rotules with curved hooks. Unfortunately, as the type ma-
Sanidaster spicule in new Corvoheteromeyenia species

Material of both species are unavailable (Muricy et al. 2011) we prefer to identify the present material as *C. heterosclera* until the review of these species be done.

**Corvoheteromeyenia sanidastosclera** n. sp. (Figs 2C, D; 5)

**TYPE LOCALITY.** — São Francisco Basin, Paulo Afonso Municipality, Bahia State, Brazil, in tanks fish farm.

**TYPE SPECIMENS.** — *Holotype.* UFPEPOR1105, São Francisco Basin, Paulo Afonso Municipality, Bahia State, Brazil, in tanks fish farm tanks, (09°22'30"S, 38°13'58"W), C. Silva coll., 06.IV.2010.

*Paratypes.* UFPEPOR1113, UFPEPOR1116, UFPEPOR1132 and MNHN.DCL4110, São Francisco Basin, Paulo Afonso Municipality, Bahia State, Brazil, in fish farm tanks, (09°22'30"S, 38°13'58"W), C. Silva coll., 06.IV.2010.

**DIAGNOSIS.** — Sponge encrusting to slightly massive, with megascleres that are exclusively microspined oxeas; pseudobirotuled microscleres present in two distinct types; gemmuloscleres present as sanidasters inserted radially in the gemmules.

**ECOLOGY.** — The specimens were collected in clear waters of artificial environment, in fish farm tanks walls measuring 1.5 m³ and 800 m³, that are supplied with water from São Francisco River, with depth ranging from 10 cm to 1 m.

**ETYMOLOGY.** — The specific epithet refers to of morphology of the sponges’ gemmuloscleres: sanidaster.

**DESCRIPTION OF HOLOTYPE**

UFPEPOR1105 is encrusting, forming a thin layer on the substrate. Colour is dark green *in vivo* and beige in ethanol. Megascleres acanthoxea (234.2-269.1-310.7 / 9.7-12.7-19.1 μm), microscleres with two types of pseudobirotules: type 1 (short shaft), (11.9-18.4-26.3 / 2.4 // 3.6-4.9-7.2 μm) more abundant than type 2 (long shaft), (31.1-48.6-71.7 / 2.4-3.9-4.8 μm), sanidaster gemmuloscleres (71.7-82.8-95.6 / 4.8-7.3-19.1 // 3.2-6.3-9.7 μm), gemmules (406.3-466.4-501.9 μm).

**DESCRIPTION**

*C. sanidastosclera* n. sp. is characterized by presence of sanidaster gemmuloscleres (acanthostrogyles with tuberculate spines, Fig. 5E). The shape of this sponge ranges from encrustant to slightly massive, not exceeding 1 cm of thickness. Colour dark green *in vivo* and becoming light green (Fig. 2C, D) or beige in ethanol. Consistency soft, easily torn. Gemmules distributed throughout the sponge but concentrated near the substrate. Megascleres fusiform, slightly curved oxeas (225.4-307.7-373.5 / 6.4-12.8-19.3 μm), smooth or with recurved sparse microspinations, ranging from simple to compound (Fig. 5A, B). Pseudobirotuled microscleres of two types (Fig. 5C, D): type 1, (11.9-18.9-35.4 / 2.4-3.0-3.2 // 3.6-6.2-9.7 μm) most common, with three or four large hooks forming rotules and a short shaft that can be smooth.
or spined (Fig. 5C); and type 2, (31.1-56.6-90.2 / 2.4-5.9-9.7 μm), less common with more discreet hooks forming rotules and a longer shaft than type 1, with simple to compound microspines distributed equitably along the shaft (Fig. 5D).

Gemmuloscleres sanidasters (51.5-80.9-96.6 / 4.8-7.4-19.1 / 3.2-6.1-9.7 μm), inserted radially on the theca of gemmules (Fig. 5H) with tuberculated spines distributed along the shaft which often have secondary small spines near the tips. Spines along the gemmulosclere are perpendicular to the shaft and might be spirally arranged; spines near the tips are often oblique to the shaft. Occasionally, sanidasters have spines near the tips clustered end resembling a birotule but with the shaft exceeding the rotule (Fig. 5E). Gemmules (406.3-552.7-627.9 μm) abundant, greenish, spherical, free or normally located in the basal part of sponge (Fig. 5F). Foramen single and circular (Fig. 5G). Gemmular theca tri-layered (Fig. 5H); outer layer with emerging tips of sanidaster; pneumatic layer well developed, with network of regular spongin fibers; gemmuloscleres radially embedded; inner layer well developed with compact spongin.

**REMARKS**

The sanidaster gemmuloscleres found here could be interpreted as malformations due to environment conditions. Mysing-Gubala & Poirrier (1981) observed malformations in gemmuloscleres of *Ephydatia fluviatilis* (Linnaeus, 1759) when submitted to cadmium (Cd) and mercury (Hg) in experimental conditions. In this case, 33% and 50% of gemmuloscleres were malformed when the sponges were exposed to Cd and Hg respectively. Although, in *Corvoheteromeyenia sanidastosclera* n. sp. 100% of gemmuloscleres are sanidasters, and we do not believe that this morphology of spicules could be a result of a possible chemical compounds exposure in the environment. Although, we did not measure the chemical composition of the water, we believe that this water has not been contaminated by heavy metal, since these fish farm...
tanks are used for human feeding. Besides, we collected *Corvoheteromeyenia heterosclera* in the same locality (specimens above), which have 100% birotule gemmuloscleres (Fig. 2C).

*Corvoheteromeyenia sanidastosclera* n. sp. is characterized by the presence of sanidaster gemmoscleres which differentiates it from *C. australis* and *C. heterosclera* that have birotuled gemmuloscleres.

Except for experimental conditions in *Ephydatia fluviatilis* explained above, sanidaster had been reported just once in freshwater sponges by Volkmer-Ribeiro & Watanabe (1983) in the description of *Sanidastra yokotonesis* Volkmer-Ribeiro & Watanabe, 1983. In the occasion, the authors interpreted this find as a possible phylogenetic relationship with the family Latruncullidae Topsent, 1922 (order Poecilosclerida) and reinforced the hypothesis of polyphyletic origin of freshwater sponges from different marine sponges stocks. In subsequent works, Manconi & Pronzato (1996, 2002) reported *Sanidastra yokotonesis* from Mediterranean. They disagree with polyphyletic's hypothesis of Volkmer-Ribeiro & Watanabe (1983). Additionally, they didn't use the term “sanidaster” for the gemmuloscleres, because they believe that these spicules are a freak oxea.

On the other hand, Samaai & Kelly (2002) provided an excellent illustration, which shows that the sanidaster spicules are found in different phylogenetic taxa. In this sense, we believe that the spicule sanidaster has had a homoplasic origin and do not represent a character with a phylogenetic signal. Like other spicules, as “birotule” which is used to unrelated taxa (for example, family Iotrochotidae Dendy, 1922 marine sponges, and Spongillidae Freshwater sponges). Thus, there is no sense in using sanidasters only to marine sponges. Here we prefer to use the term “sanidaster” to describe the morphology of the spicule.

The new species shares with other species of *Corvoheteromeyenia* megascleres oxeas, and two categories of pseudobirotuled microscleres, which allowed this species to be allocated in
this genus. Ezcurra de Drago (1979) reinforces that gemmuloscleres are the most important diagnostic character in Corvoheteromeyenia, when differentiated C. australis and C. beterosclera by the former present variation in the shape and size of rotules against stable shape and size of rotules in the latter. In this way, C. sanidastosclera n. sp. do not have rotules in its gemmuloscleres. Beside, the gemmuloscleres of the new species have spines longer than others species (Table 1) and with different morphology, with tuberculate spines in the new species against conical spines in others species.

The saniderast gemmuloscleres found in C. sanidastosclera n. sp. also implies an intermediate stage between those freshwater sponges with acanthoshrongyle and birotule gemmuloscleres. In the sanidasters the spines are reaching the tips of the spicules and forming a birotule-like saniderast. This finding again reinforces the idea of Penney & Racek (1968) that the segregation of Spongillidae into two groups based on the morphology of gemmuloscleres as proposed by Vejdovsky (1887) is not longer justified. In Radiospongilla acanthoshrongyles and birotules are present in different species, whereas in Corvoheteromeyenia sanidastosclera n. sp. the pattern is present within a single species.

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