

New records of the bryozoan *Metrarabdotos* from the Pirabas Formation (Lower Miocene), Pará State, Brazil

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ABSTRACT

The Pirabas Formation in Pará State, Brazil, contains a very rich and diverse fauna of Early Miocene age, including several groups of invertebrates and vertebrates. Previous studies of bryozoans from Brazil included two species of *Metrarabdotos* ones, but these need revision. The present study describes three new species of *Metrarabdotos* (*M. aquaeguttum* sp. nov., *M. elongatum* sp. nov., *M. capanemensis* sp. nov.) collected from two outcrops: Atalaia Beach at Salinópolis city and B-17 Mine at Capanema city.

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Keywords: new species; Lower Miocene; Brazil; Caribbean Biogeographic Province; Bryozoans

Submission: 20 July 2016 Acceptance: 12 June 2017

INTRODUCTION

Bryozoans are important fossils for geological reconstructions. They have broad stratigraphical distributions and provide evidence for biogeographic, phylogenetic, and environmental interpretations. Studies including bryozoans in Brazilian sedimentary basins are scarce (White, 1887; Maury, 1925; Barbosa, 1957, 1959a, 1959b, 1967, 1971; Távora and Fernandes, 1994; Távora et al., 2010a; Zagorsek et al., 2014; Ramalho et al., 2015), and some need to be revised.

The cheilostome bryozoan genus *Metrarabdotos* Canu, 1914 comprises 38 fossil and six living species (Bock, 2014). These species, including both fossil and living representatives, are exclusively tropical and northern subtropical (Rosso, 2005; Cheetham et al., 2007). Cheetham (1967) considered that *Metrarabdotos* probably originated in the Gulf of Mexico region in the Late Eocene and subsequently migrated through the Caribbean and Western Atlantic to Europe and Africa. In the Americas, it has been recorded from southeastern sectors of North America, Central America, and

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Ramalho, Laís V., Távora, Vladimir A., and Zagorsek, Kamil. 2017. New records of the bryozoan *Metrarabdotos* from the Pirabas Formation (Lower Miocene), Pará State, Brazil. *Palaeontologia Electronica* 20.2.32A: 1-11
palaeo-electronica.org/content/2017/1915-metrarabdotos-from-pirabas

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northern Venezuela and Dominican Republic in the Caribbean (Cheetham et al., 2001; 2007). Six species have been described from Brazil, comprising five recent species – *Metrarabdotos jani* Winston et al., 2014, *M. sergipensis* Santana et al., 2009, *M. gulo* (Marcus, 1955), *M. unguiculatum* Canu and Bassler, 1928, and *M. tuberosum* Canu and Bassler, 1928 - and one fossil species - *M. moniliferum* (Milne Edwards, 1836) (Canu and Bassler, 1928; Marcus, 1955; Barbosa, 1967; Távora and Fernandes, 1994; Cheetham et al., 2007; Santana et al., 2009; Távora et al., 2010a; Winston et al., 2014). *Metrarabdotos moniliferum* was recorded from Miocene sediments of the Marajó Basin (Barbosa, 1967), but those specimens need to be re-examined as the species was originally described from Pliocene deposits from near the North Sea and the English Channel (Rosso, 2005; Cheetham et al., 2007). The recent species *M. gulo* was regarded by Cheetham et al. (2007) as a possible synonym of *M. auriculatum* Canu and Bassler, 1923 and *M. tuberosum* Canu and Bassler, 1928, but this can't be ascertained because the holotype of *M. gulo* has not been located (Cheetham et al., 2007, p. 41-42).

The present study describes three taxa collected from the Pirabás Formation, showing that *Metrarabdotos* is relatively well represented in this formation.

MATERIAL AND METHODS

Study Area

The Pirabás Formation (Maury, 1925), represents one of the most important documentations of a marine transgressive event in northern Brazil during the Miocene (Távora et al., 2013; Antonioli et al., 2015). It crops out discontinuously in the northern Brazilian states of Pará, Maranhão, and Piauí, providing some of the best marine fossil occurrences for the entire Cenozoic. Following Rossetti and Góes (2004) and Távora et al., (2010b), it deposited along the southern limit of the Caribbean Miocene paleobiogeographic province. Samples were collected from outcrops at four different areas (Figure 1): Atalaia Beach (Salinópolis city), B-17 Mine (Capanema city), Fortaleza Island, and Aricuru (Maracanã city). *Metrarabdotos* colonies were found only in samples from the first two localities.

The samples were treated following Zargorsek and Vávra (2000), at the Laboratório de Oceanografia Geológica (Universidade Federal do Rio Grande - FURG) and Laboratório de Paleonto-

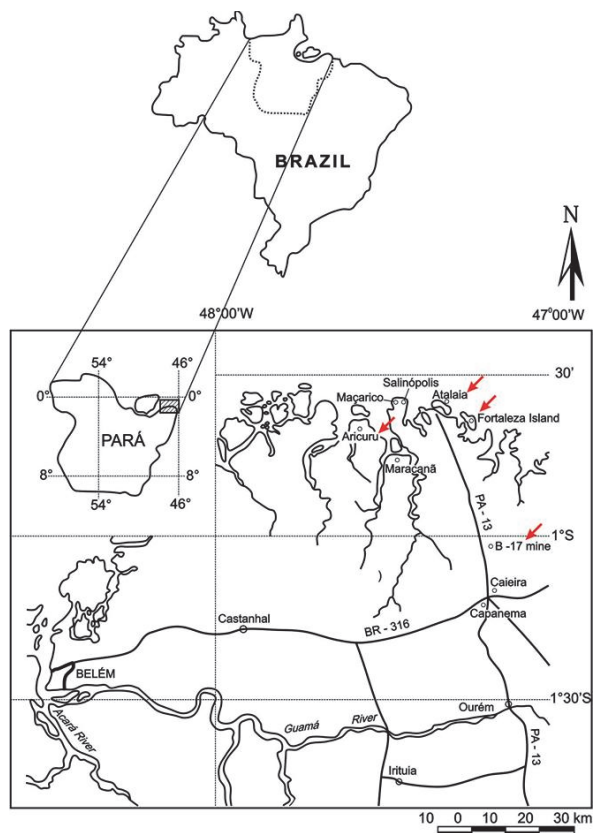


FIGURE 1. Map of the study area showing the four outcrops (arrows).

logia (Universidade Federal do Pará - UFPA). Scanning Electron Microscopy was undertaken at the Museu Nacional (Rio de Janeiro, BR - Centro de Microscopia Eletrônica), Universidade Federal do Pará (Belém, BR), the Natural History Museum (London, UK), and the Universidad de Malaga (Spain). Measurements (N = 10, if not indicated otherwise) are given in micrometers as ranges with the mean in bracket square: minimum-maximum [mean]. The material is stored in the paleontological collections of the Geoscience Museum (UFPA) under the code number MG-6303-I. The comparisons (measurements and features) among species discussed in this study were made from the original description of each species and other descriptions available from literature such as Canu and Bassler (1919), Canu and Bassler (1928), Cheetham (1968), and Cheetham et al. (2007).

RESULTS

Taxonomy

We mainly followed the glossary for *Metrarabdotosidae* reported by Cheetham et al. (2007) and

on the website (www.bryozoa.net) but, following Ostrovsky (2014) we preferred ooecium rather than ovicell.

Suborder FLUSTRINA Smitt, 1868
 Superfamily LEPRALIELLOIDEA Vigneaux, 1949
 Family METRARABDOTOSIDAE Vigneaux, 1949
 Genus *METRARABDOTOS* Canu, 1914

Diagnosis. From Cheetham, Sanner, and Jackson (2007) modified. Colonies rigidly erect or encrusting. Frontal shield imperforate except for areolae on proximal and lateral margins. Primary orifice with distal shelf. Secondary orifice with one to three denticles on or just below proximal lip. No oral spines. Adventitious avicularia with different size and orientations, single or paired, dimorphic. Mandibles hinged on complete pivotal bars. Ordinary avicularia single or paired on autozoecia, present or absent on ovicellate autozoecia; special avicularia can be present on zoecia adjacent to the ooecium and/or in zoecia located along branch edges. Ooecium nearly as large as a zooid, sometimes even larger, fused skeletally with the maternal zoecium.

Remarks. Cheetham, Sanner, and Jackson (2007) did not refer to ooecia, which are larger than zooids. However, in *M. elongatum* sp. nov. we found ooecia larger than maternal zooid, while this species without any doubt belongs to genus *Metrarabdotos*. We therefore modified the diagnosis in this sense.

Metrarabdotos aquaeguttum sp. nov.

Figure 2.1-4

zoobank.org/943B93BE-B715-4836-B69D-904BEFF17AA

Examined specimens. Holotype: MG-6303-I-a: fertile fragment; 9 mm long x 4 mm wide; Paratype: Atalaia Beach (Salinópolis city): MG-6303-I - b, fertile branch fragment, 5 mm long x 4 mm wide; MG-6303-I - c, fertile branch fragment, 5 mm long x 3 mm wide; MG-6303-I - d, fertile branch fragment, 6 mm long x 4 mm wide; MG-6303-I - e, infertile branch fragment, 3 mm long x 4 mm wide; B- 17 mMine (Capanema city) MG-6303-I - f, fertile branch fragment, 10 mm long x 4 mm wide; MG-6303-I - g, fertile branch fragment, 3 mm long x 4 mm wide.

Etymology. The name *aquaeguttum* is the latinization for “water drop,” referring to the shape of the ordinary avicularia in this species.

Diagnosis. Colony erect forming rigid, flat branches, each branch with 12-20 longitudinal zooidal series. Orifice tridentulate. Ordinary avicularia paired, rarely single, very small, drop-like, located alongside latero-distal margins of the ori-

fice, directed proximally and slightly curved inwards; special avicularia approximately three times longer than ordinary ones, elongated with a rounded spatulate tip, located distally to the orifice. Ooecium elongated, semi elliptical to triangular, with about 15 narrow ribs, usually separated each other by two-to-three rows of pores.

Description. Colony erect forming rigid, flat branches, each branch with 12-20 longitudinal zooidal series (Figure 2.1).

Autozoecia elongate (400–833 [average 647] μm length x 125–300 [233] μm width), frontal wall flat, smooth, or slightly granular with 17-23 areolar pores around lateral and proximal margins (Figure 2.2). Peristome slightly elevated, hiding the primary orifice. Secondary orifice longitudinally elongate, oval (100–200 [155] μm long x 100–143 [118] μm wide) with a broad, irregular sinus, one median denticle (frequently broken) (Figure 2.2-4), and a pair of lateral denticles.

Ordinary avicularia on autozoecia as well as in ovicellate zoecia, frequently paired, rarely single, almost equal in size (56–89 [68] μm long), smaller than regular areolar pore, drop-like shaped: premandibular portion rounded, located level to the distal edge of peristome, rarely at its mid length; mandibular portion triangular with pointed rostrum; directed proximally and slightly curved inwards (Figure 2.2-4). Special avicularia approximately three times (in average) longer than the ordinary ones usually developed on zoecia adjacent to ooecia (Figure 2.3-4) and on marginal zoecia (Figure 2.2), usually paired with an ordinary avicularium; mandibular portion elongate, rostrum with slightly curved sides, and rounded spatulate tip; size can be very variable in the same colony (122–400 [254] μm length); pivotal bar frequently broken. Premandibular and part of mandibular portion located above the distal margin of the peristome, mandibular portion directed proximally, often slightly towards midline.

Maternal zooid long (800–1150 [964] μm including the ooecium) with very narrow, transversally elongated orifice, proximal lip moderately developed, not thickened, and distal lip lightly upturned medially to form a curved proximal border of the ooecium; a pair of ordinary avicularia in maternal zoecia have comparable shape and size (56–89 [73] μm long) than those found on autozoecia and are placed at the lateral ends of the orifice, pointing proximally and slightly medially (Figure 2.4); ooecium longer than wide (400–571 [492] μm long and x 300–500 [412] μm wide), semi elliptical to triangular, surface moderately convex, sculp-

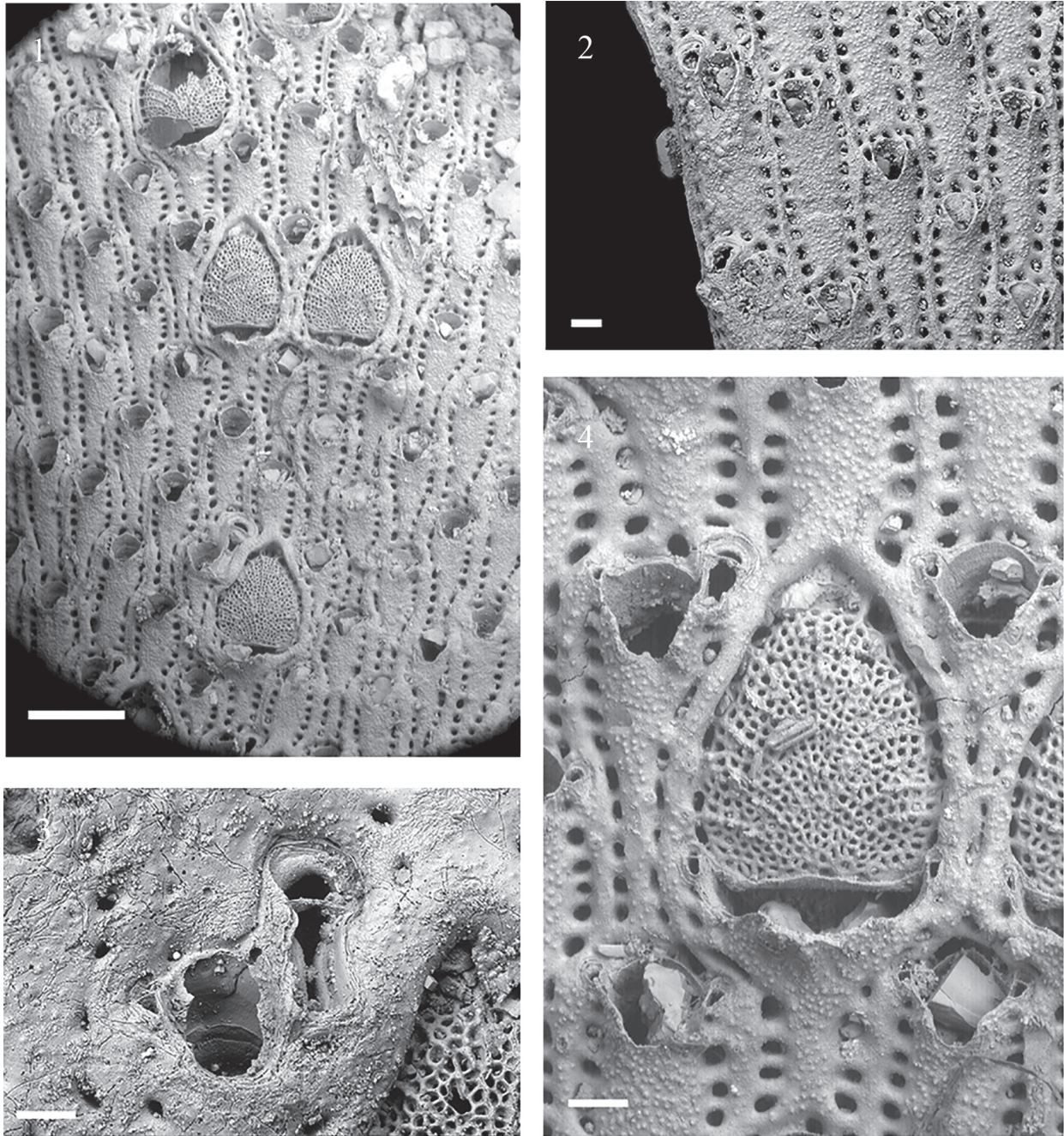


FIGURE 2. *Metrarabdotos aquaeguttum* sp. nov. 1. General view of the colony fragment with infertile and fertile zoecia. 2. Detail of a branch edge showing special and ordinary avicularia. 3. Detail of zooids adjacent to a maternal one showing orifice, special avicularium paired with an ordinary one, and part of the oecium. 4. Detail of maternal zoid with a complete oecium, ordinary avicularia, and a zooid adjacent to maternal one, with a special avicularium. Scale bars equal 1: 500 μm ; 2: 100 μm ; 3: 40 μm ; 4: 200 μm . 1, 4: MG-6303-I-b; 2: MG-6303-I-c; 3: MG-6303-I-a.

tured by 15 thin diverging and slightly arcuated ribs, separated from each other by two-to-three rows of pores (Figure 2.1, 2.4). Areolar pores uniform around the margin, except at the distal region where they are slightly larger (Figure 2.1, 2.4).

Remarks. This species shows a great variability in size and shape of the special avicularia, but the other characters (ordinary avicularia, orifice and oecium) are more stable.

Metrarabdotos aquaeguttum is distinguished from the other species described here principally by the shape, size, and location of the ordinary avicularium. *M. elongatum* sp. nov. has larger ordinary avicularia, rostrum elongate, straight or with one side curved ending in a rounded to quadrate tip; avicularia of maternal zooecia are larger and more inwardly directed. *Metrarabdotos tuberosum* Canu and Bassler, 1928 described previously to Brazil and *M. auriculatum* Canu and Bassler, 1923, which has a similar ordinary avicularia, differ from *M. aquaeguttum* as they have a bidenticulate orifice (lacking the median denticle). The next two species have ordinary avicularia with similar shape and occupying almost the same position than *M. aquaeguttum* but they can be distinguished as *M. floridanum* (Cheetham, 1968) has larger autozoecia, a bifid median denticle, smaller (81–185 µm length) special avicularia with straight rostrum, maternal zooid with distal lip moderately to strongly upturned and proximal lip thickened by coarser tubercles, oecium larger (609 µm long x 585 µm wide) with strong and granulated ribs; and *M. micropora* (Gabb and Horn, 1862) has secondary orifice with short, blunt lateral denticles commonly visible in frontal view; some ordinary avicularia placed midline and proximally, mandibular portion sub-triangular, rostrum straight and slightly rounded tip; special avicularia smaller in size (special: 83–156 µm long), with rostrum elongate, straight and with rounded tip; oecium slightly wider than long (531 µm long x 583 µm wide) with strong, coarsely granulated ribs.

Range. Lower Miocene.

Occurrence. Pirabas Formation: Atalaia Beach, Salinópolis city and B-17 Mine, Capanema city, Pará state.

Metrarabdotos elongatum sp. nov.

Figure 3.1-6

zoobank.org/2CE3BC56-8BBB-4D10-888C-E032CAE9F443

Referred specimens. Holotype: MG-6303-I - i, B-17 Mine, fertile branch fragment, 10 mm long x 4 mm wide; Paratype: Atalaia Beach (Salinópolis city): MG-6303-I - h, fertile branch fragment, 4 mm long x 3 mm wide; MG-6303-I - l, infertile branch fragment, 4 mm long x 3 mm wide; MG-6303-I - m, fertile branch fragment, 8 mm x 5 mm; MG-6303-I - n, infertile branch fragment, 5 mm long x 5 mm wide; MG-6303-I - o, fertile branch fragment, 4 mm long x 5 mm wide; MG-6303-I - p, infertile branch fragment, 41 mm long x 12 mm wide; MG-6303-I - q, fertile branch fragment, 5 mm long x 4 mm wide; MG-6303-I - r, fertile branch fragment, 11 mm long x 5 mm wide.

B-17 Mine (Capanema city): MG-6303-I - j, infertile branch fragment, 2 mm long x 3 mm wide; MG-6303-I - k: fertile branch fragment, 6 mm long x 4 mm wide; MG-6303-I - s, fertile branch fragment, 8 mm long x 5 mm wide.

Etymology. The name *elongatum* is the latinized word for “elongate,” referring to the shape of the rostrum of the avicularium.

Diagnosis. Colony erect, bilamellate; orifice circular to ellipsoidal, tridenticulate. Ordinary avicularia often paired, pre-mandibular portion located above or level to distal margin of the orifice, rarely midline or proximally; rostrum elongated, straight or with one side curved, ending in a curved triangular or quadrate-spatulate tip. Special avicularia large on zooecia adjacent to oecia and slightly smaller on common zooecia; pre-mandibular portion placed very distally to secondary orifice; mandibular portion elongate, narrower in the middle part and ending in a spatulate or rounded tip. Oecium longer than wide, the surface moderately flat and perforated by pores between weak ribs.

Description. Colony erect, bilamellate with 14-21 zooecia disposed alternately in longitudinal series (Figure 3.1).

Ordinary autozooids rectangular, longer than wide (409–733 [578] µm long x 144–277 [208] µm wide). Frontal wall finely tuberculate, flat; 15-23 sunken areolae around the lateral and proximal border (Figure 3.2). Primary orifice hiding by the peristome; secondary orifice almost circular to ellipsoidal, almost as long as wide (100–167 [134] µm long x 100–180 [131] µm wide) with a broad U-shaped sinus bearing a prominent median denticle (Figure 3.2-3) and a pair of lateral denticles (orifice tridenticulate) (Figure 3.4).

Ordinary avicularia (67–229 [130] µm long) paired in most zooecia, including the maternal ones almost equal in size and position (Figure 3.2-3), infrequently single; pre-mandibular portion frequently placed above or level to the distal margin of the secondary orifice, rarely midline or more proximally; mandibular portion elongate, the tip touching lining the lateral margin of the orifice; rostrum straight to curved and narrowed but ending in a curved triangular or quadrate-spatulate tip, directed proximally and sometimes slightly inward; crossbar complete (Figure 3.2-3). Special avicularia variable in size (122–356 µm long), longer on zooecia adjacent to oecia, and slightly smaller on common zooecia. Avicularia on the marginal zooecia usually comparable to those of the central zooecia, sometimes slightly longer (Figure 3.1, 3.5-6). Special avicularia with pre-mandibular region

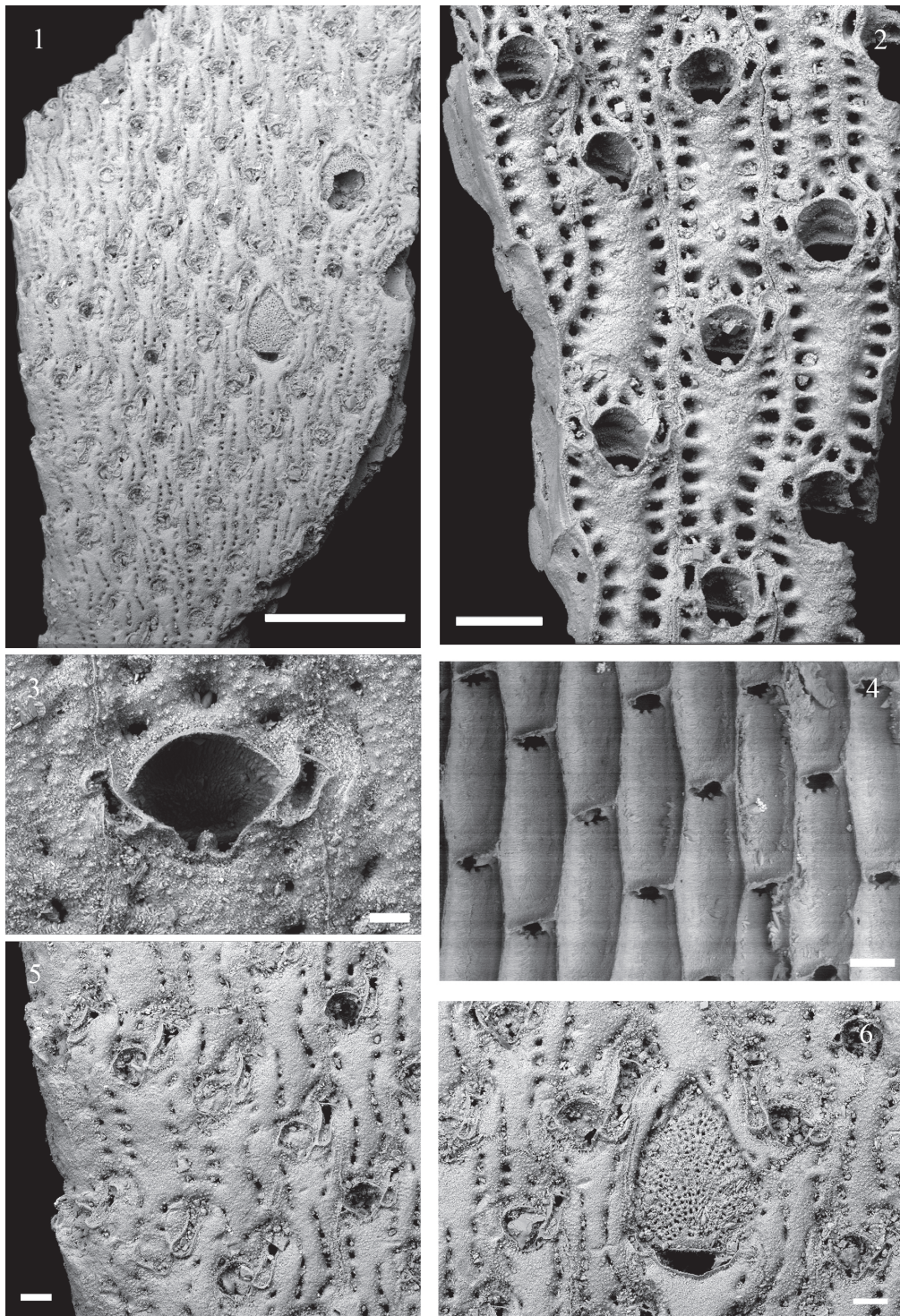


FIGURE 3. *Metrarabdotos elongatum* sp. nov. 1. General view of a fragment showing some fertile and infertile zoecia. 2. Detail of some zoecia showing orifice with median denticles, paired avicularia, and areolar pores. 3. Detail of the secondary orifices showing a median denticle and a pair of laterally ordinary avicularia. 4. Internal view of some zoecia showing tridenticulate orifices. 5. Detail of the branch edge showing zoecia with large ordinary avicularia. 6. A maternal zooid with complete oecium and paired ordinary avicularia surrounded by zoecia, each with a special avicularium paired with an ordinary one, and by infertile zoecia with paired ordinary avicularia. Scale bars equal 1: 500 μm ; 2, 4-5: 200 μm ; 3: 20 μm ; 6: 100 μm . 1, 6: MG-6303-l-i; 2: MG-6303-l-p; 3: MG-6303-l-s; 4: MG-6303-l-l; 5: MG-6303-l-h.

placed very distally in relation to the orifice, and their proximal portion is in the midline of the orifice; mandibular portion elongate, ending in a spatulate or rounded tip; rostrum straight or with one or both sides curved and tip directed (lining) to orifice (proximally and medially). Maternal zooecia elongated (704–1267 [938] μm long) with crescent-like orifices (180–400 [242] μm wide) (Figure 3.1, 3.6), distal lip poorly developed, upturned forming the narrow and straight proximal border of the ooeonium, proximal lip not protruded, smooth; one pair of ordinary avicularia located near the proximal corners, unequal in size (76–114 [100] μm long), similar in shape to those on the zooecia; directed proximally and inward (Figure 3.6). Ooeonium longer than wide (360–533 [470] μm long x 322–467 [367] μm wide), with a sub-triangular to arcuate distal end; surface moderately flat perforated by pores between weak ribs, and bordered by larger areolar pores, mostly along the distal end (Figure 3.1, 3.6).

Remarks. The elongate shape, size, and position of the ordinary avicularia distinguish this species from others described in this study and from those previously known. *Metrarabdotos colligatum* Canu and Bassler, 1919 has similar special avicularia but it can be distinguished for the secondary orifice with two or rarely three denticles, the smaller ordinary avicularium that is triangular and placed level to the orifice; the absence of avicularia associated to ooeonia.

Range. Lower Miocene.

Occurrence. Pirabas Formation: Atalaia Beach, Salinópolis city, and B-17 Mine, Capanema city, Pará state.

Metrarabdotos capanemensis sp. nov.

Figure 4.1-3

zoobank.org/CF64D724-C6F1-44DC-93AA-F32507CE7517

Referred specimens. Holotype: MG-6303-I-t; B-17 Mine; fertile branch fragment; 5 mm long x 3 mm wide; Paratype: MG-6303-I-u, B-17 Mine; fertile branch fragment; 2 long mm x 2 mm wide.

Etymology. The name *capanemensis* refers to Capanema, the city near B-17 Mine, where this species was found.

Diagnosis. Colony erect, bilaminar; orifice without median denticle. Ordinary avicularia paired, falciform, located proximally, and lining the secondary orifice. Special avicularia large, elongated, narrow and with rounded tip, sparse, apparently not associated to zooecia adjacent to maternal ones.

Description. Colony erect, bilaminar; available branch fragments 2-5 mm long x 2-3 mm wide.

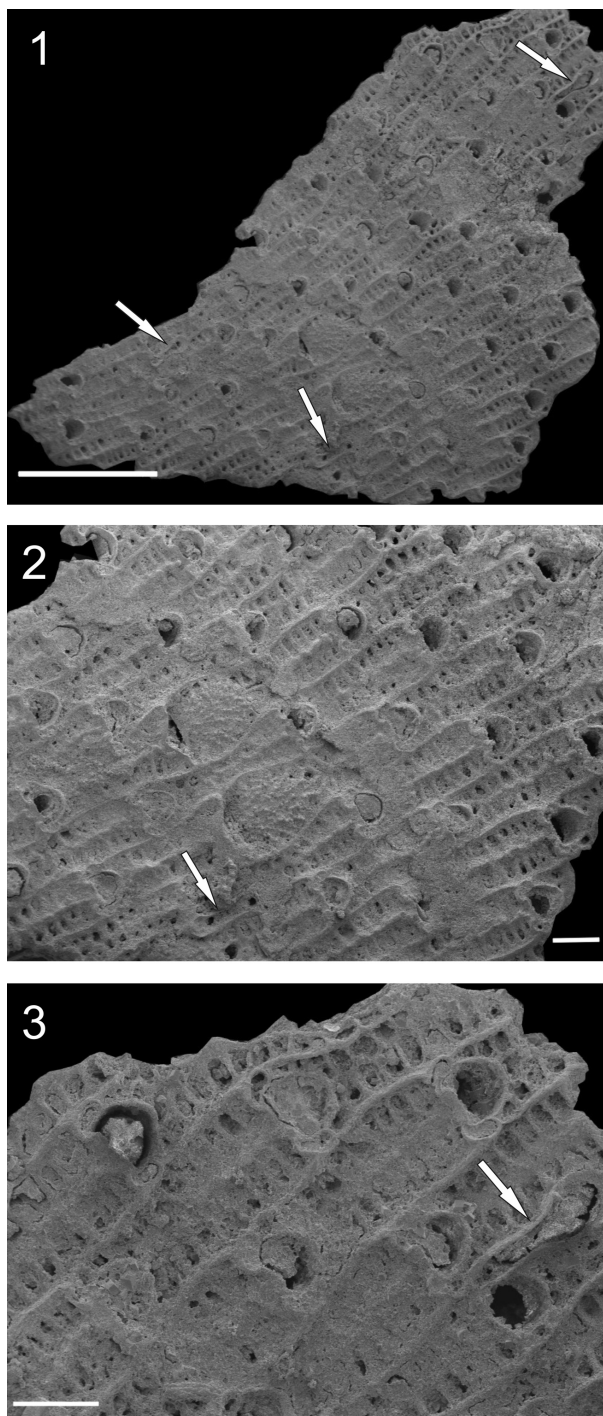


FIGURE 4. *Metrarabdotos capanemensis* sp. nov. 1. General view of a colony showing fertile and infertile zooecia. 2. Detail showing two maternal zooecia bearing complete ooeonia, flat ordinary zooecia and a large special avicularium below the maternal zoid. 3. Some zooecia with paired, ordinary proximally located avicularia and one elongated special avicularium. Note the frontal shield with elliptical areolar pores and a median longitudinal keel. Scale bars equal 1: 1000 μm ; 2-3: 200 μm . 1-3: MG-6303-I-t. Arrows indicate special avicularia.

Autozoecia rectangular (489–667 [600] μm long x 222–267 [253] μm wide) with flat frontal wall, often developing a median keel. 14–19 areolar pores on each autozoecium, very large, elliptical, and transversally elongated leaving only a thin medial portion of unperforated frontal surface (Figure 4.1–3). Primary orifice hidden by the peristome; secondary orifice slightly wider than long (120–147 [149] μm long x 133–160 [149] μm wide; N = 6) with proximal border almost straight or sometimes convex (Figure 4.2–3), lacking median denticles.

Ordinary avicularia paired (93–107 [105] μm long), falciform, with extremely curved mandibular part situated proximally, lining the secondary orifice (Figure 4.2–3). Special avicularia very large (440–467 [453] μm long; N = 3) almost as long as autozoecia, elongated, directed proximally; rostrum elongated, narrow and with rounded tip; pre-mandibular portion and part of the mandibular portion located very distally to the orifice and nearly at the midlength of the distal zoecium, the tip of the mandibular portion ending near to the proximal margin of the orifice or slightly proximally (Figure 4.1–3). Special avicularia sparse, apparently not associated to zoecia adjacent to maternal ones (Figure 4.1–3).

Maternal zoecia large (911–956 [933] μm long; N = 3) with proximal lip enlarged developing lateral protuberances; ooecium slightly longer than wide (400–467 [433] μm long x 356 μm wide; N = 3) with frontal shield perforated by minute pores and prominent, curved ribs (Figure 4.2).

Remarks. The two available specimens consist of unilaminar fragments, resulting from the separation of colony branches along the median lamina. The presence of special avicularia very large and elongated, straight along the zooidal boundaries and very distally placed, pointed proximally, as well as the ordinary falciform avicularia lining the secondary orifice, distinguish *M. capanemensis* sp. nov. from all other species of the genus.

Another similar species is *M. kugleri* Cheetham, 1968, which has ordinary avicularia directed inward and proximally on proximal margin of the secondary orifice, but the ordinary avicularia are triangular, usually single and larger (140–152 μm long), special avicularia placed on zooids adjacent to ooecia, orifice with broad, rounded V-shaped sinus, and three deep-set denticles; smaller areolar pores.

Range. Lower Miocene.

Occurrence. Pirabas Formation: B-17 Mine, Capanema city, Pará state.

DISCUSSION AND CONCLUSION

The *Metrarabdotos* species described from Pirabas sections show high variability in the size, shape, and location of ordinary avicularia as well as the special avicularia. The size, shape, and position of the ordinary avicularia dividing, however, Pirabas *Metrarabdotos* from the other species from other localities. The presence of ordinary avicularia in majority of the known species of *Metrarabdotos* is almost unknown or has the minute importance for their taxonomy (see Cheetham et al., 2007). All the species described here have well developed ordinary avicularia and their morphology play the important role in distinguishing them. The presence and diversity of ordinary avicularia can be therefore regarded as specific for the Pirabas species and perhaps evolved in this environment.

The high variability of one feature in one locality has also been observed in other species of *Metrarabdotos* (Cheetham et al., 1999). The evolution of Metrarabdotosidae expresses high parallel and convergent evolution depending of the local environment, which made the species identification quite complex and difficult.

The distribution of the described species is not homogenous. In Atalaia beach only two species *M. aquaeguttum* sp. nov., and *M. elongatum* sp. nov. were found whereas at Capanema all species co-occurred; *Metrarabdotos aquaeguttum* sp. nov. is the most common species in Atalaia beach together with *M. elongatum* sp. nov. The lithological setting at the B-17 Mine includes carbonatic and carbonatic-siliciclastic facies, and the fossil content presents typical species of lagoonal environment as dominance of benthic foraminifera *Ammonia beccarii*, *Criboelphidium poeyanum* and *Elphidium galvestonense*, the ostreidae *Crassostrea distans*, the mytilidae *Mytilus canoasensis*, the vidali pectinids, the bivalvs *Amusium papyraceum*, *Chlamys indissolubilis*, *C. (Argopecten) daidela*, and *C. (A.) tetristriata*, the crabs *Acanthocarpus obscurus*, *Callapa circularis*, *Portunus haitensis*, *P. spinimanus*, and *Tetraxanthus rathbunae*, the balanidae *Balanus eburneus* and *B. improvisus*, the echinoid *Abertella complanata*, the crustaceans and the *Thalassinoides* ichnofossils (Távora et al., 2010; Távora et al., 2013). Besides that, the occurrence of marine taxa at the B-17 Mine related to benthic foraminifera *Amphistegina*, *Bolivina*, *Cibicides* and *Archaias*, the bivalvs *Clementia* and *Ventricolaria*, the gastropods *Tritonidea*, *Trophon* and *Cypraea*, the decapod crustacean *Pinnixa*, and the echinoids *Cidaris* and *Prionocidaris* as well

as the presence of *Metrarabdotos* with very fragmented colonies and poorly preserved also show evidences of transport and abrasion, suggesting they were allochthonous, and they were transported from the marine environment to a lagoonal site of burial through tidal channels during strong storms (Távora et al., 2004; Távora et al., 2013; Távora and Reis, 2015).

Fossil occurrences of *Metrarabdotos* are very useful to locate subtropical and tropical provinces in the past as recent species of the genus occur within the tropical zone and fossil species have a narrow distribution, which apparently was thermally controlled (Cheetham, 1967; Rosso, 2005; Cheetham et al., 2007; Zagorsek et al., 2011). Thus, as expected, the presence of *Metrarabdotos* corroborates previous inferences of a tropical palaeoenvironment for the Pirabas Formation (Távora and Fernandes, 1999; Távora et al., 2004; Távora et al., 2010b; Távora et al., 2013).

Despite *Metrarabdotos* species of the Pirabas Formation resemble those found in the Caribbean biogeographical province in Tropical West Atlantic, Dominican Republic, Venezuela, Panamá, and Trinidad. Species described here have unique features and, to the best of our knowledge, seem to be endemic to the Pirabas Formation. The distinctness of the bryozoan association occurring in this formation is corroborated by the co-occurrence of further three species *Hippopleurifera barbosae* Ramalho et al., 2015, *H. confusa* Ramalho et al., 2015, and *Pirabasoporella atalaiaensis* Zagorsek et al., 2014 so far known exclusively from this area (Zagorsek et al., 2014; Ramalho et al., 2015). Reis (2005) and Távora et al. (2010b) also showed similarities between faunas from the Pirabas Formation and the Caribbean biogeographical province analyzing echinoderm, coral, ostracod, and fish communities. However, Aguilera and Páes (2012) based on the whole Pirabas Formation fauna, concluded that diversity as well as pale oceanographic condition and ecosystems were distinctive and different from those of Caribbean biogeographical province.

Further study is needed for a better understanding of this complex South American Miocene Formation.

ACKNOWLEDGEMENTS

We thank the Departamento Nacional de Produção Mineral (DNPM) for permission to sample the material in Brazil, and “Cimentos do Brasil S.A. - Cibrasa” for authorization to collect at the B-17

Mine. We are grateful to A.P. Correa and C.N. Lamarão (Instituto de Geociências, Laboratório de Microscopia Eletrônica de Varredura, UFPA), A.G. Veiga (Centro de Microscopia Eletrônica do Museu Nacional - Rede Temática Monitoramento Ambiental Marinho, SAPE 4600225483), and Goyo (Centro de microscopia of the Malaga University) for SEM pictures; to Dr. P.D. Taylor, Dr. S. Gofas and Dra. C. Salas, and Dr. L. Calliari for the infrastructure at Natural History Museum (London), Universidad de Malaga (Spain), and Universidade Federal do Rio Grande (Brazil), respectively. To Paul Taylor for suggestions and review in this manuscript. This research was supported by Post-doctoral Fellowship—CNPq for LVR (Science without Border Program - Number: 203242/2014-9) and by the Grant Agency of the Czech Republic for KZ, project number 205/09/0103: “Shallow water ecosystems from the Middle Miocene of the Central Paratethys: Succession and interactions between inorganic and organic elements of the ecosystems.”.

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