

Ostracoda (Crustacea) from the Archipelago of São Pedro and São Paulo, Equatorial Atlantic, with emphasis on a new Hemicysteridae genus

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ABSTRACT. The present study is a further contribution to the systematic knowledge of the shallow water marine ostracodes from the Brazilian oceanic islands. A total of 14 species belonging to 10 genera and eight families is herein identified. One new genus and species are described and illustrated: *Berguecythere insularis* gen. nov., sp. nov. In addition to this new taxon, the abundant species *Loxocorniculum tricornatum* Krutak, 1971, widely distributed in recent sediments in the Gulf of Mexico, Caribbean, north and northeast of Brazil and the Rocas Atoll, along with the cosmopolitan tropical ostracode *Triebelina sertata* Triebel, 1948, were also identified at specific level. The remaining 11 species were left at the genus level, and should provide new species. Ecological, zoo- and paleozoogeographical aspects were also briefly discussed.

KEYWORDS. Taxonomy, new species, morphology, Atlantic Ocean.

RESUMO. Ostracoda (Crustacea) do Arquipélago de São Pedro e São Paulo, Atlântico Equatorial, com ênfase em novo gênero de Hemicysteridae. O presente estudo é uma contribuição para o conhecimento da sistemática dos ostracodes marinhos rasos das ilhas oceânicas brasileiras. Um total de 14 espécies pertencentes a 10 gêneros e oito famílias é aqui identificado. Um novo gênero e espécie são descritos e ilustrados: *Berguecythere insularis* gen. nov., sp. nov. Além desse novo táxon, foram também identificados *Loxocorniculum tricornatum* Krutak, 1971, espécie abundante amplamente distribuída em sedimentos recentes do Golfo do México, Caribe, norte e nordeste do Brasil e no Atol das Rocas, e o ostracode cosmopolita tropical *Triebelina sertata* Triebel, 1948. As 11 espécies restantes foram deixadas em nível de gênero e devem fornecer novas espécies. Aspectos ecológicos e zoo- e paleozoogeográficos também foram brevemente discutidos.

PALAVRAS-CHAVE. Taxonomia, nova espécie, morfologia, Oceano Atlântico.

The Archipelago of São Pedro and São Paulo (ASPSP) was discovered in 1511 when a Portuguese fleet consisting of six caravels bound for India then recorded its first shipwreck. Darwin, in his trip on the HMS Beagle around the world, visited this small archipelago in 1832, and he marveled at what he saw. He listed all the fauna he could find, but not a single plant or even lichen could be found by him. Since the last century, this archipelago is considered a site of ecological interest and also strategic for the Brazilian territory. On June 25, 1998, the Brazilian government inaugurated a scientific station in the Belmont islet, the largest of all, starting a successful research program called PROARQUIPELAGO (MARINHA DO BRASIL/SECIRM, 2009).

As discussed by many authors, high levels of endemism in oceanic islands and islets can be a result of allopatric speciation due to physical isolation. The deep ocean is an effective barrier to the dispersal of benthic invertebrates with life cycles restricted to shallow waters such as benthic ostracodes, which are not good swimmers and do not have a planktotrophic larval stage.

There is consensus among most authors (e.g. LARWOOD & WHATLEY, 1993), that areas isolated over millions of years have higher levels of endemism than those with continual or intermittent shallow submarine connections with the mainland or other islands. Although the other three Brazilian oceanic islands, i.e., Fernando de Noronha Archipelago, Trindade/Martim Vaz and the Rocas Atoll have submarine connections with the

mainland (see COIMBRA & CARREÑO, 2012), the ASPSP fits well in the first case since it is distant ~1,100 km from the coast of Brazil and its rocks rise from a depth of ~3,800 m (MOTOKI *et al.*, 2009). This isolation is a major contributor to the high endemism among benthic invertebrates in this archipelago (see AMARAL *et al.*, 2009; MORAES *et al.*, 2009; OLIVEIRA *et al.*, 2009). However, little is known about its ostracode fauna (see ANTONIETTO *et al.*, 2012).

This study is a contribution to the knowledge of the ostracodes from the ASPSP, with emphasis on the description of the endemic taxon *Berguecythere insularis* gen. nov., sp. nov. Furthermore, are identified and illustrated the remaining species (most in open nomenclature) recorded in this archipelago. Finally, aspects of the ecology and zoogeography of these microcrustaceans are also briefly discussed.

MATERIAL AND METHODS

The Archipelago of São Pedro and São Paulo (ASPSP) consists of a few islets, being the four largest (Cabral, São Pedro, São Paulo and Belmonte) arranged in a semicircle forming a shallow cove with maximum depth of ~15 m (Figs 1, 2), whose bottom is composed by bioclastic sediments and archipelago weathered rocks. In fact, this archipelago is the top of a submarine morphological elevation whose base is at ~3,800 m water depth. It is the only location on the Atlantic Ocean where the abyssal mantle is exposed above sea level, since it



Fig. 1. Location map of the Brazilian oceanic islands and archipelagos showing the distance to the nearest continental cities (modified from ALMEIDA, 2006; COIMBRA & CARREÑO, 2012).

is not formed by volcanic rocks, but by plutonic ones (BONATTI, 1990; HEKINIAN *et al.*, 2000). It covers an emerged area of approximately 1.7 ha, with maximum length of ~400 m and a maximum height of 18 m above sea level (EDWARDS & LUBBOCK, 1983; SICHEL *et al.*, 2008). The ASPSP is devoid of beaches and drinking water, and only its main islet has a very few developed kind of undergrowth.

This archipelago is separated from the Brazilian continental shelf by deep ocean, whose depths range from 2,000 to 4,000 m, and in its nearest surroundings

the top of some seamounts are located just 100 m below the surface (MORAES & MURICY, 2007). The South Equatorial Current, that is the main current in this area, flows superficially from east to west with a maximum speed of $1.5 \text{ m}\cdot\text{s}^{-1}$. Below it, between 40 and 150 m depth, the South Equatorial Undercurrent carries water in the opposite direction, with speed of up to $0.7 \text{ m}\cdot\text{s}^{-1}$ (STRAMMA & ENGLAND, 1999). Together, these two currents generate a pattern of high complexity with a great influence on the island ecosystem, causing nutrient enrichment of waters (CAMPOS *et al.*, 2009). The average temperature of the surface water varies between 28.3°C , in summer, and 26.4°C , in winter (MACEDO-SOARES *et al.*, 2009).

The ostracodes for this study come from the analysis of 22 samples (four barren for ostracodes) hand collected in three different areas in the cove of the ASPSP by free diving at depths ranging from 2 to 11 m (Fig. 2; Tab. I). All the material examined was collected by Cláudia Pinto Machado, Fernando Erthal and Sandro Monticelli Petró, with the help of the Brazilian Navy crew, during 15 days in July/August 2010. In the field, all samples were stored in plastic bottles and fixed in alcohol 70%.

In order to collect Ostracoda on algae, wherever possible some bunches were wrapped within a plastic bag and this portion of the algae was cut off from the plant. Unfortunately, together with the algae some sediment was collected. This was due to the rough waters of the cove and also for our limited experience in field work in such bad conditions. Furthermore, it is noteworthy that even ostracodes that were living on bottom sediments may occasionally float after death and be recovered with the water that surrounds the fronds of algae. For these reasons many isolated valves and even

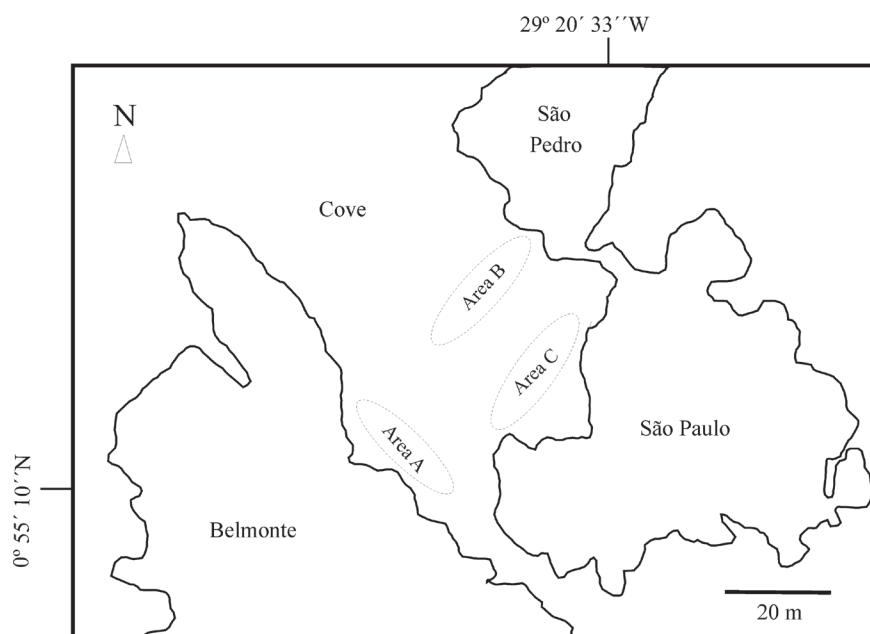


Fig. 2. Sampling areas in the cove of the Archipelago of São Pedro and São Paulo, Equatorial Atlantic. For more details see Table I.

Tab. I. Number, location, substrate and depth of samples recovered from the cove of the Archipelago of São Pedro and São Paulo, Equatorial Atlantic.

Sample number	Area of collection in the cove	Substrate (Algae/ Sediment)	Depth (~m)
M 1001-N	Area A	Algae (<i>Caulerpa racemosa</i>)	2
M 1002-N	Area A	Algae sp.1	2
M 1003-N	Area A	Sediment	5
M 1004-N	Area A	Sediment	5
M 1005-N	Area A	Sediment	5
M 1008-N	Area A	Sediment	5
M 1010-N	Area A	Sediment	10
M 1011-N	Area A	Algae sp.1	3
M 1012-N	Area B	Sediment	11
M 1014-N	Area B	Sediment	11
M 1017-N	Area A	Algae sp.1	2
M 1018-N	Area A	Algae sp.1	2
M 1021-N	Area A	Algae (<i>Caulerpa racemosa</i>)	2
M 1022-N	Area C	Algae sp.1	4
M 1023-N	Area C	Algae (<i>Caulerpa racemosa</i>)	4
M 1025-N	Area C	Algae (<i>Caulerpa racemosa</i>)	4
M 1026-N	Area C	Algae sp. 2	-
M 1030-N	Area C	Algae sp. 2	5
M 1031-N	Area C	Algae (<i>Caulerpa racemosa</i>)	5
M 1032-N	Area C	Algae (<i>Caulerpa racemosa</i>)	5
M 1035-N	Area C	Algae (<i>Caulerpa racemosa</i>)	5
M 1036-N	Area C	Algae sp. 2	5

some empty carapaces were recovered together these algae. In the laboratory, the algal material was washed through a 0.250 mm mesh and all specimens (living and dead) were picked under stereomicroscope. Live specimens were stored in vials containing alcohol 70%, and empty carapaces and isolated valves were glued in micropaleontological slides. Single valves were also counted as one specimen.

Each sediment sample, before washed and sieved through a mesh of 0.250 mm was fractionated to 20 ml. Procedures for the storage of living and dead specimens followed the same protocols above described for the algae material. Single valves were also counted as one dead specimen.

The ostracods herein examined are held in the collections of the 'Museu de Paleontologia', Universidade Federal do Rio Grande do Sul (UFRGS), Section of Ostracoda. The figured material is identified by the prefix MP-O. All SEM photographs were taken at the Centro de Microscopia Eletrônica' at UFRGS. The only specimen of the genus *Cytherella* was lost during preparation for SEM.

Morphological abbreviations: LV, left valve; RV, right valve; c, carapace; v, valve; ♀, female; ♂, male.

Faunal analysis. This work allowed the recognition of 14 species, 10 genera and eight families totaling 5,552 specimens recovered from 18 samples, 11 of which were taken from seaweed areas and only seven from the bottoms covered exclusively by sediments (Tab. II; Figs 3-66). A group of four samples

(seaweeds) was barren for ostracodes (M1018-N, M1021-N, M1022-N and M1035-N).

It is consensus among experts that shallow benthic marine ostracodes live in plants or sediments (see a review in WHATLEY & WALL, 1975 for the relationship between ostracodes and seaweeds). However, it is also well known that many of them can be found alive in both substrates. In the cove of the ASPSP only the species of Paradoxostomatidae was recorded living exclusively or predominantly in areas covered by seaweeds. *Xestoleberis* sp. 1 was found surviving only in samples taken from areas covered exclusively by sediments. All remaining species, although they also occurred in vegetated areas, were most common in sediments.

Loxocorniculum tricoratum Krutak, 1971 is by far the most abundant ostracode species in the ASPSP (75.9%) being represented by 1,150 living specimens and 3,064 isolated valves. Most of the living ones (1,056 specimens) were recovered from bottoms covered only by sediments. *Keijcyoidea* sp. and *Xestoleberis* sp. 2 were the second and third most abundant ostracodes herein recorded (9.7% and 3.2%, respectively), respectively, being their living specimens much more common in areas devoid of seaweeds (Tab. II).

Cytherella sp. and *Triebelina* sp. were recorded only by very few juvenile valves, mainly in sediments devoid of seaweeds. *Paradoxostoma* sp. 3, also equally very rare, registered two living specimens, being only one adult in a sample from a seaweed area. These three species are the rarest ostracodes recorded in the ASPSP.

The other two species of *Paradoxostoma* were recorded mainly from living specimens. *Paradoxostoma* sp. 1 dwells only in seaweed areas while *Paradoxostoma* sp. 2, although much more abundant in this same substrate, was also encountered living on bottoms covered only by sediments. This is not surprising since this genus belongs to the cosmopolitan family Paradoxostomatidae which is more diverse and abundant on plants.

For all species in this study, the dominance of juveniles on adults could be observed, except for *Xestoleberis* sp. 2. The living ostracodes represent 30% of total specimens recovered, taken out *Cytherella* sp. and *Triebelina* sp. not found alive.

TAXONOMY

Family Hemicytheridae
Subfamily Hemicytherinae

Berguecythere gen. nov.

Type species: *Berguecythere insularis* sp. nov., by monotypy.

Diagnosis. A subquadrate to subrectangular hemicytherid genus with a surface covered by reticulate ornament whose peripheral fossae can be secondarily punctate. An ear-shaped ridge, which starts around the

Tab. II. Occurrence and abundance of living and dead ostracode species recorded at the Archipelago of São Pedro and São Paulo, Equatorial Atlantic.

Samples	<i>Kejicyoidea</i> sp.	<i>Cytherella</i> sp.	<i>Propontocypris</i> sp.	<i>Neonesidea</i> sp.	<i>Triebelina</i> sp.	<i>Triebelina sertata</i>	<i>Berguecythere insularis</i> sp. nov.	<i>Microcythere</i> sp.	<i>Loxocorniculum tricoratum</i>	<i>Paradoxostoma</i> sp. 1	<i>Paradoxostoma</i> sp. 2	<i>Paradoxostoma?</i> sp. 3	<i>Xestoleberis</i> sp. 1	<i>Xestoleberis</i> sp. 2
M 1001-N ¹	-	-	-	-	-	-	-	x	-	-	-	-	-	x
M 1002-N ¹	-	-	-	-	-	-	-	-	-	-	-	-	-	x
M 1003-N ²	x	-	x	x	x	x	x	x	x	-	x	x	x	-
M 1004-N ²	x	-	x	x	x	x	x	x	x	x	x	-	x	x
M 1005-N ²	x	x	x	x	-	-	x	-	x	-	-	-	x	x
M 1008-N ²	-	-	-	-	-	-	-	-	x	-	-	-	-	-
M 1010-N ²	x	-	x	x	-	x	x	x	x	-	x	x	x	x
M 1011-N ¹	x	-	-	-	-	-	-	-	x	-	-	-	-	x
M 1012-N ²	x	-	x	x	x	x	x	-	x	-	-	-	x	x
M 1014-N ²	x	-	x	-	-	x	x	x	x	-	-	-	x	x
M 1017-N ¹	-	-	-	-	-	-	-	-	-	-	-	-	-	x
M 1023-N ¹	x	-	-	-	-	-	x	-	x	x	x	-	x	x
M 1025-N ¹	x	-	x	x	-	x	-	x	x	-	x	x	x	x
M 1026-N ¹	-	-	-	-	-	-	-	-	-	-	-	x	-	-
M 1030-N ¹	x	-	x	-	x	x	x	-	x	x	x	x	x	x
M 1031-N ¹	x	-	x	x	-	-	x	-	x	-	-	-	x	x
M 1032-N ¹	x	-	-	-	-	-	x	-	x	-	x	-	x	x
M 1036-N ¹	x	-	x	x	-	-	-	x	x	x	x	-	x	x
Living	153	-	100	44	-	18	34	17	1,150	21	57	2	16	69
Dead (valves)	386	1	73	68	6	45	44	2	3,064	3	9	4	56	110
Total	539	1	173	112	6	63	78	19	4,214	24	66	6	72	179
Relative abundance %	9.71	0.02	3.12	2.02	0.11	1.13	1.40	0.34	75.9	0.43	1.19	0.11	1.30	3.22

¹Substrate covered by algae; ²Substrate covered by sediments.

central area, gives rise to a postero-dorsal protrusion. Internally, a very well-developed hemiamphidont hinge, the posterior terminal element of the RV being a dentate bar with 6-7 small teeth and a smooth distal area. Central muscle scars a row of four adductor with the dorso-median one subdivided; three frontal scars. Large duplicature with narrow anterior and posterior vestibular areas. Radial pore-canals numerous, straight, mostly simple with some intercalated branching ones.

Etymology. *Berguecythere* was named in honor to the Brazilian ostracodologist Cristianini Trescastro Bergue, a particular friend of the authors, in recognition of his precious contributions to the knowledge of fossil and Recent marine ostracodes.

Geographical and stratigraphical distribution. At present only in the ASPSP, Equatorial Atlantic.

Berguecythere insularis sp. nov.

(Figs 28-41)

Aurila sp. 1 ANTONIETTO *et al.*, 2012:42-43, Fig. 7: 10-19; Table 12.

Type material. Holotype, MP-O-2433, LV, ♀, length: 0.44 mm; height: 0.25 mm. Paratypes. MP-O-2434, RV, ♀, length: 0.42 mm; height: 0.23 mm; MP-O-2435, RV, ♀, length: 0.42 mm; height: 0.23 mm; MP-O-2436, LV, ♀, length: 0.46 mm; height: 0.25 mm; MP-O-2437, LV, ♂, length: 0.44 mm; height: 0.23 mm; MP-O-2438, RV, ♂, length: 0.43 mm; height: 0.22 mm; MP-O-2439, carapace, ♀,

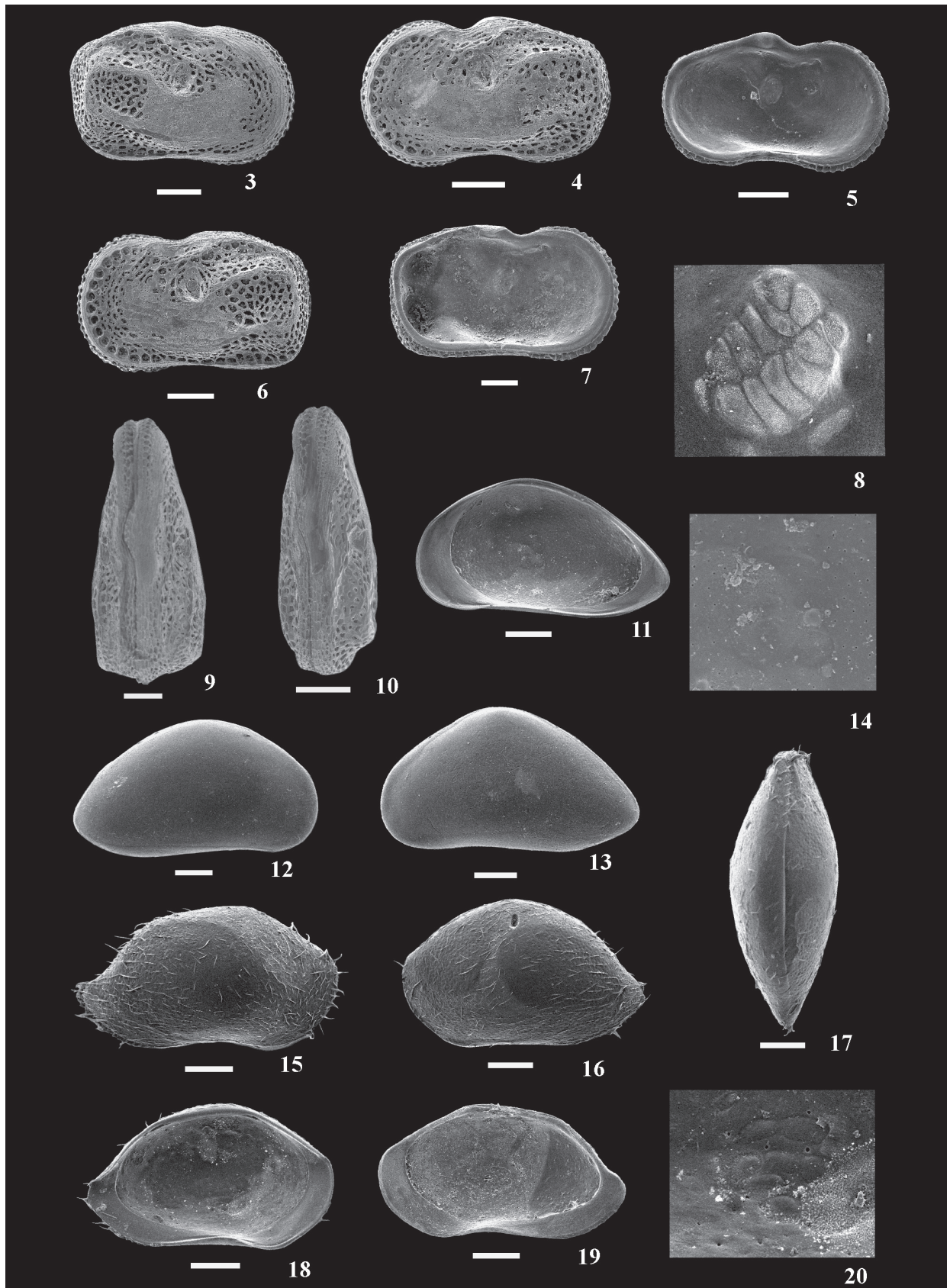
width: 0.20 mm; length: 0.44 mm; MP-O-2440, carapace, ♂, width: 0.18 mm; length: 0.45 mm; MP-O-2441, LV, juvenile, length: 0.37 mm; height: 0.21 mm; MP-O-2442, LV, juvenile, length: 0.31 mm; height: 0.18 mm; MP-O-2443, RV, juvenile, length: 0.25 mm; height: 0.14 mm; MP-O-2444, RV, ♀, length: 0.42 mm; height: 0.23 mm.

Etymology. From Latin origin, *insularis* = of an island, because of its first record being restricted to an archipelago.

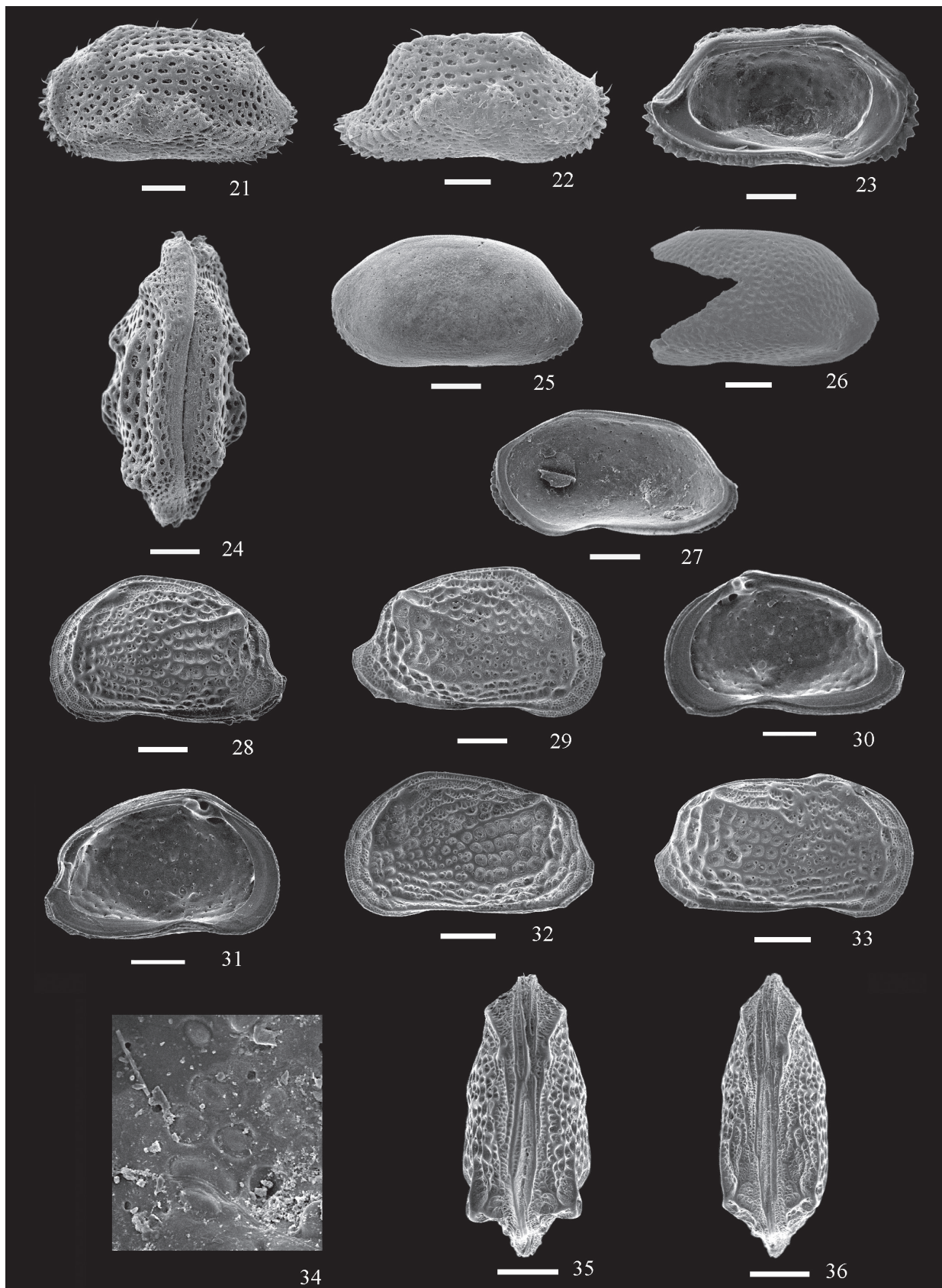
Type locality. Archipelago of São Pedro and São Paulo, Equatorial Atlantic.

Occurrence. See Table III.

Description. A thick-shelled genus of the subfamily Hemicytherinae, subquadrate to subrectangular in lateral view. Greatest height at the anterior cardinal angle. Anterior margin obliquely rounded. Posterior margin caudate in RV and subcaudate in LV. Dorsal margin somewhat convex in LV and subrectilinear in RV. Ventral margin with conspicuous oral concavity. Surface covered with reticulate ornament with the peripheral fossae secondarily gently punctate. A delicate ridge, which starts at the ventral end, runs parallel to the anterior margin, crosses the well-developed eye tubercle, and becomes more slender along the dorsal margin. An ear-shaped ridge starts around the central area and ascends to its heaviest width in front at the posterior



Figs 3-20. *Keijcyoidea* sp.: 3, MP-O-2411, RV, ♀; 4, MP-O-2412, LV, ♂; 5, MP-O-2413, LV, ♂, internal view; 6, MP-O-2414, LV, ♀; 7, MP-O-2415, LV, ♀, internal view; 8, MP-O-2415, LV, ♀, central muscle scars, not in scale; 9, MP-O-2416, c, ♀, dorsal view; 10, MP-O-2417, c, ♂, dorsal view. *Propontocypris* sp.: 11, MP-O-2418, internal view; 12, MP-O-2419, RV; 13, MP-O-2420, LV; 14, MP-O-2418, central muscle scars, not in scale. *Neonesidea* sp.: 15, MP-O-2421, RV; 16, MP-O-2422, LV; 17, MP-O-2423, c, dorsal view; 18, MP-O-2424, LV, internal view; 19, MP-O-2425, RV, internal view; 20, MP-O-2425, central muscle scars, not in scale. The scale of all specimens = 100 µm, if no other indication.



Figs 21-36. *Triebelina sertata* Triebel, 1948: 21, MP-O-2426, LV; 22, MP-O-2427, RV; 23, MP-O-2428, LV, internal, view; 24, MP-O-2429, c, dorsal view. *Triebelina* sp.: 25, MP-O-2430, LV; 26, MP-O-2431, LV; 27, MP-O-2432, RV, internal view. *Berguecythere insularis* gen. nov., sp. nov.: 28, MP-O-2433, LV, ♀; 29, MP-O-2434, RV, ♀; 30, MP-O-2435, RV, ♀, internal view; 31, MP-O-2436, LV, ♀, internal view; 32, MP-O-2437, LV, ♂; 33, MP-O-2438, RV, ♂; 34, MP-O-2436, LV, ♀, central muscle scars, not in scale; 35, MP-O-2439, c, ♀, dorsal view; 36, MP-O-2440, c, ♂, dorsal view. The scale of all specimens = 100 µm, if no other indication.

Tab. III. Occurrence of adults and juveniles of *Berguecythere insularis* gen. nov., sp. nov. in the cove of the Archipelago of São Pedro and São Paulo, Equatorial Atlantic.

Sample	Substrate	Adults	Juveniles
M1003- N	Sediment	2v	16c; 5v
M1004- N	Sediment	1v	2c; 4v
M1005- N	Sediment	-	1v
M1010- N	Sediment	2v	5c; 1v
M1012- N	Sediment	-	4c; 6v
M1014- N	Sediment	1v	5c; 3v
M1023- N	Algae (<i>Caulerpa racemosa</i>)	-	1v
M1025- N	Algae (<i>Caulerpa racemosa</i>)	1v	2c; 6v
M1030- N	Algae sp. 2	1v	5v
M1031- N	Algae (<i>Caulerpa racemosa</i>)	1v	2v
M1032- N	Algae (<i>Caulerpa racemosa</i>)	-	1v
Total		9v	34c; 35v

cardinal angle. From there it descends as a short stretch and turns forward and then disappears near the mid-length. This ear-shaped ridge gives rise to a postero-dorsal protrusion more developed in RV. Normal pore-canals sieve-type. In dorsal view acuminate anteriorly, maximum width posteriorly. In internal view, hinge robustly developed, hemiamphidont, the posterior terminal element of the RV being a dentate bar with 6-7 small teeth and a smooth distal area. Calcified inner lamella well-developed with narrow vestibulae at each end. Radial pore-canals numerous, straight, mostly simple with some intercalated branching ones. Selvage conspicuous and parallel to the outline. Adductor muscle scars a row of four scars, the dorso-median one subdivided. Three frontal scars. Sexual dimorphism conspicuous; male more elongate and less wide, and with a more secondarily reticulate dorsal region.

Remarks. The genus *Tenedocythere* Sissingh, 1972 (see a revision in BONADUCE *et al.*, 1986) is a tropical cosmopolitan hemicysterid genus with some external features in common with *Berguecythere* gen. nov. It has a coarse reticulate ornamentation, strongly dominating antero-posterior ribs and a peripheral rib that is frequently lacking posteriorly.

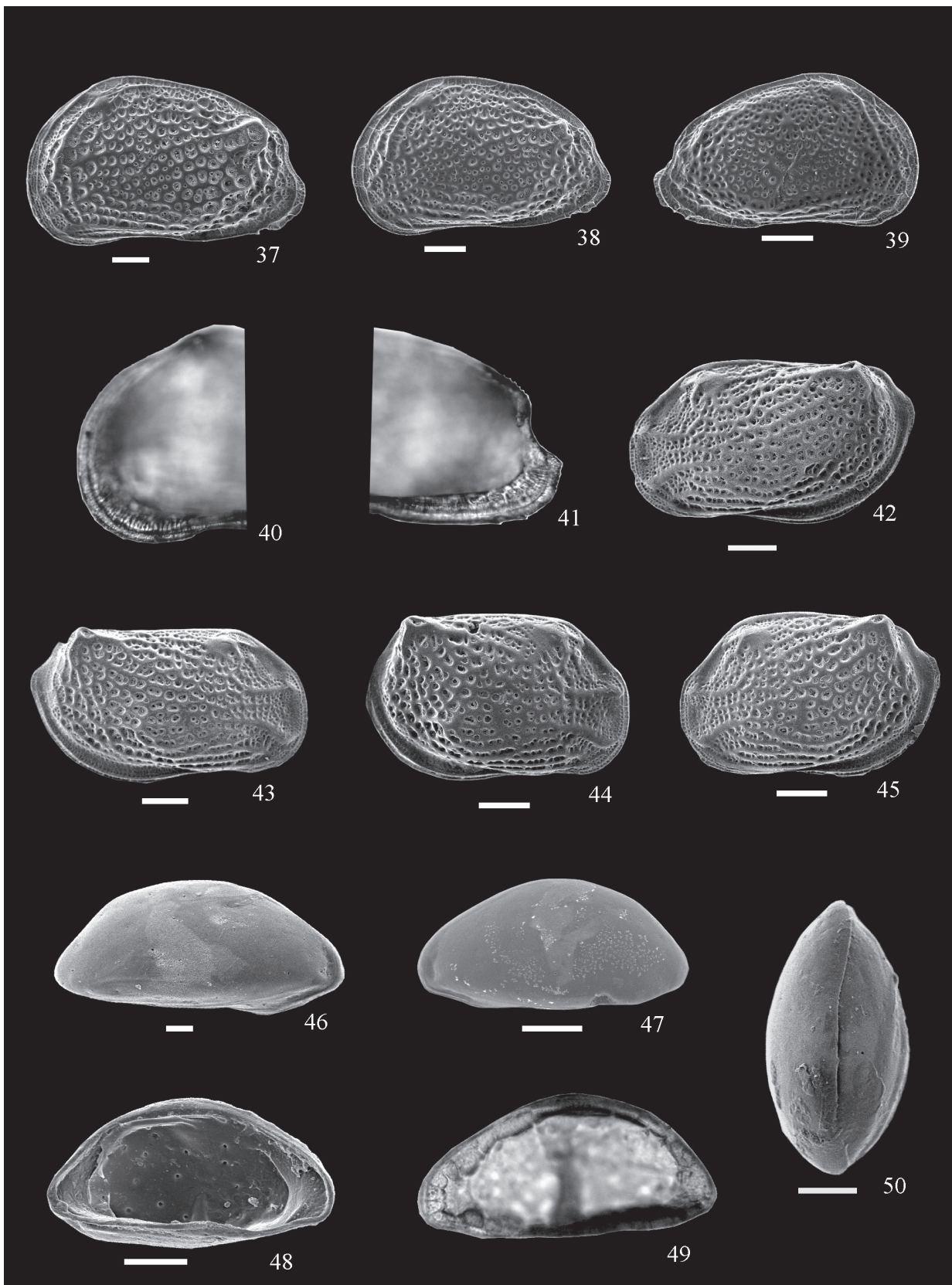
Tenedocythere does not have a hemiamphidont hinge and its central muscle scars consist of a vertical row of four subrectangular scars and two suboval frontal scars.

Falklandia, a hemicysterid monotypic genus described by WHATLEY *et al.* (1987) from the southernmost South Atlantic, resembles somewhat *Berguecythere* gen. nov. and possesses a hemiamphidont hinge; however, the posterior terminal element of the RV is constituted exclusively by a dentate bar with 5-7 small oval teeth which increase in size distally. Furthermore, the two central adductor scars of *Falklandia* are subdivided. Externally, the two genera can be distinguished mainly by the reticulation with fossae secondarily punctate (four puncta per fossa is the most common) and the antero-lateral excrescence (in female LV) of *Falklandia*.

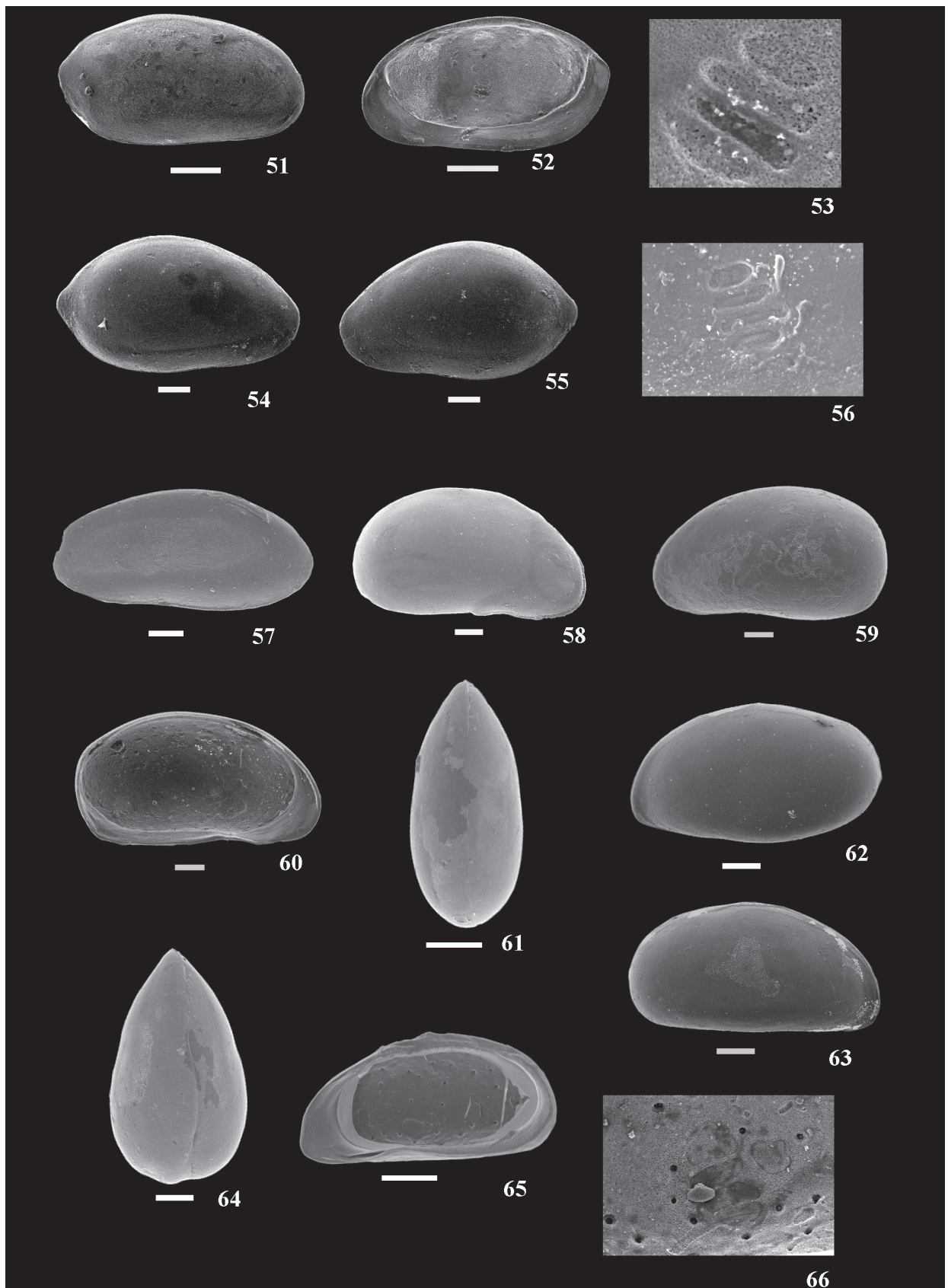
Finally, some of the more elongate species of *Aurila* Pokorný, 1955, resemble *Berguecythere insularis* sp. nov. Nevertheless, this new taxon does not have auriline dentition; possesses fewer radial pore-canals, some of which bifurcate distally; and features a well-developed postero-dorsal protrusion. Central muscle scars of *Aurila* a row of four adductors with the dorso-median, and rarely the ventro-median, divided into two; frontal scars three, sometimes only two (sec. HARRISON *et al.*, 2000). Moreover, some years before, JELLINEK (1995) concluded that all species of *Aurila* have just the dorso-median adductor scar divided in two and three frontal scars. It is noteworthy that in that paper, which was unknown to HARRISON *et al.* (2000), JELLINEK (1995) discussed many similarities and dissimilarities of 11 hemicysterid (Aurilini) genera, and they all have *Aurila*-tooth (posterior anti-slip tooth in LV). Not only this hinge feature is absent in the new genus and new species herein described, as already discussed above, but also *Berguecythere insularis* sp. nov. has only the dorso-median adductor scar subdivided; the frontal scars are three in number.

Tab. IV. Comparison of the species identified in this paper and the ones registered by ANTONIETTO *et al.* (2012).

This paper	ANTONIETTO <i>et al.</i> (2012)
<i>Keijcyoidea</i> sp.	<i>Keijcyoidea praecipua</i> (Bold, 1963)
<i>Cytherella</i> sp.	no recorded
<i>Propontocypris</i> sp.	<i>Propontocypris (Ekpontocypris) pirifera?</i> (Mueller, 1894)
<i>Neonesidea</i> sp.	<i>Neonesidea tenera?</i> (Brady, 1886)
<i>Triebelina</i> sp.	<i>Triebelina cf. intermedia</i> Witte, 1993
<i>Triebelina sertata</i> Triebel, 1948	<i>Triebelina sertata</i> Triebel, 1948
<i>Berguecythere insularis</i> gen. nov., sp. nov.	<i>Aurila</i> sp. 1
<i>Microcythere</i> sp.	<i>Xestoleberis?</i> sp. 3
<i>Loxocorniculum tricornatum</i> Krutak, 1971	<i>Loxoconcha (Loxocorniculum) tricornata</i> (Krutak, 1971)
<i>Paradoxostoma</i> sp. 1	<i>Paradoxostoma</i> sp. 1
<i>Paradoxostoma</i> sp. 2	<i>Paradoxostoma</i> sp. 2
<i>Paradoxostoma?</i> sp. 3	no recorded
<i>Xestoleberis</i> sp. 1	<i>Xestoleberis toni?</i> Wouters, 2003
no recorded	<i>Xestoleberis</i> sp. 1
<i>Xestoleberis</i> sp. 2	<i>Xestoleberis</i> sp. 2



Figs 37-50. *Berguecythere insularis* gen. nov., sp. nov.: 37, MP-O-2441, LV, juvenile; 38, MP-O-2442, LV, juvenile; 39, MP-O-2443, RV, juvenile; 40, MP-O-2444, RV, ♀, anterior marginal pore-canals, not in scale; 41, MP-O-2444, RV, ♀, posterior marginal pore-canals, not in scale. *Loxocorniculum tricornatum* Krutak, 1971: 42, MP-O-2445, LV, ♂, scale bar = 100 µm; 43, MP-O-2446, RV, ♂, scale bar = 100 µm; 44, MP-O-2447, RV, ♀, scale bar = 100 µm; 45, MP-O-2448, LV, ♀, scale bar = 100 µm. *Microcythere* sp.: 46, MP-O-2449, RV, scale bar = 20 µm; 47, MP-O-2450, LV; 48, MP-O-2451, LV, internal view; 49, MP-O-2452, RV, duplicature, transmitted light, not in scale; 50, MP-O-2453, c, dorsal view. The scale of all specimens = 50 µm, if no other indication.



Figs 51-66. *Paradoxostoma* sp. 1: 51, MP-O-2454, RV, scale bar = 100 μm; 52, MP-O-2455, RV, internal view, scale bar = 100 μm; 53, MP-O-2455, RV, central muscle scars, not in scale. *Paradoxostoma* sp. 2: 54, MP-O-2456, RV; 55, MP-O-2457, LV; 56, MP-O-2457, LV, central muscle scars, not in scale. *Paradoxostoma* sp. 3: 57, MP-O-2458, LV. *Xestoleberis* sp. 1: 58, MP-O-2459, LV; 59, MP-O-2460, RV; 60, MP-O-2461, LV, internal view; 61, MP-O-2462, c, dorsal view, scale bar = 100 μm. *Xestoleberis* sp. 2: 62, MP-O-2463, RV; 63, MP-O-2464, LV; 64, MP-O-2465, c, dorsal view; 65, MP-O-2466, RV, internal view; 66, MP-O-2466, LV, central muscle scars, not in scale. The scale of all specimens = 50 μm, if no other indication.

DISCUSSION

Taxonomic remarks. ANTONIETTO *et al.* (2012) published a preliminary identification of 13 species for the ASPSP. In the same work, they present synonymic lists and zoogeographical considerations. Except for *Cytherella* sp. and *Paradoxostoma* sp. 3, all the other species herein registered were also figured by ANTONIETTO *et al.* (2012). However, it is believed that those authors have committed some misidentifications, as discussed below (see also Tab. IV).

ANTONIETTO *et al.* (2012) presented an emended diagnosis to the species *Keijcyoidea praecipua* (Bold, 1963). According to those authors, the species herein presented as *Keijcyoidea* sp. would be co-specific with *K. praecipua*. In fact, as pointed out by them, the original material studied by BOLD (1963) was very poor (six specimens) with only one carapace which was described as male. ANTONIETTO *et al.* (2012) supposed that all Bold's specimens look very similar to the males of *Keijcyoidea* registered in the Archipelago of São Paulo and São Pedro, and believed that the true females of *K. praecipua* were described for the first time in their study. Furthermore, in the paper of ANTONIETTO *et al.* (2012), the material of *Cytherelloidea praecipua* Bold, 1963 figured and described by ALLISON & HOLDEN (1971), SWAIN & GILBY (1974) and TEETER (1975) were considered co-specific with the specimens of *Keijcyoidea* recorded by them. However, in the opinion of the present authors, the material described and illustrated by ALLISON & HOLDEN (1971) possesses a quite different central muscle scars pattern, smaller dimensions (being much narrower in dorsal view), and conspicuous differences in ornaments. SWAIN & GILBY (1974) figured a left side of a complete carapace of a large species identified by them as *C. praecipua*, but with a complete different size, outline and ornamentation when compared with the Bold's original material and the specimens illustrated and described by ANTONIETTO *et al.* (2012). TEETER (1975) presented a very poor figure of a male carapace that resembles the male figured by BOLD (1963) and possesses dimensions compatible with it. Although included in the synonymic list of ANTONIETTO *et al.* (2012), nothing was discussed by them about *C. praecipua* identified by HULINGS (1967). However, the material studied by the latter author was not described and the two figures are so bad that, based only on them, it is impossible to make any comparison. Finally, the few specimens identified as *K. praecipua* by COIMBRA *et al.* (1992) are quite similar to that illustrated by BOLD (1963). Nevertheless, the left valve photographed has the reticulate row parallel to the anterior margin bearing a larger number of fossae being each fossa smaller than that presented in Bold's figures.

ANTONIETTO *et al.* (2012) recorded 109 specimens of propontocypridids identified as *Pontocypris (Ekpontocypris) pirifera?* (Mueller, 1894).

A comparison of that material with this species revealed important differences, including the outline, the number and pattern of the central muscle scars and the valve overlap. As has already been suggested by BOTTEZINI & MACHADO (2011), this species is probably new.

Neonesidea sp. was firstly identified by ANTONIETTO *et al.* (2012) as *Neonesidea tenera?* (Brady, 1886) emended Maddocks, 1969. Moreover, the members of the informal group *N. tenera*, still insufficiently known, possess similar carapace morphology and until now it has been registered just outside of Atlantic waters. In the opinion of the present authors, further studies are necessary before *Neonesidea* sp. can be identified with confidence.

Triebelina sp. was tentatively identified by ANTONIETTO *et al.* (2012) as *Triebelina cf. intermedia* Witte, 1963 based on one juvenile valve. The material herein recorded was also constituted only by few juveniles, so the attribution of these specimens to *T. intermedia*, even with some doubts, is precipitated.

Microcythere sp. was erroneously identified as *Xestoleberis?* sp. 3 by ANTONIETTO *et al.* (2012). All its internal features fit well to the diagnosis of *Microcythere* Mueller, 1894.

ANTONIETTO *et al.* (2012) discussed the morphological similarities and dissimilarities among *Xestoleberis* sp. of COIMBRA *et al.* (1992), *Xestoleberis* sp. of KEYSER & SCHÖNING (2000) and *Xestoleberis toni* Wouters, 2003 and classified (with doubt) the species herein identified just as *Xestoleberis* sp. 1 as *X. toni*. However, in the opinion of the present authors *Xestoleberis* sp. 1 differs in outline and general shape compared with *X. toni*.

Zoo- and paleozoogeographical remarks. Marine benthic ostracodes have no planktotrophic larvae, and their dispersal and potential of colonization of isolated oceanic islands has important limiting factors, such as depth, changes in water temperature and duration of the journey (CRONIN, 1988). Migration can be active or passive. Colonization of shallow marine areas occurs when active ostracodes migrate "step by step" from one region to another or by invasion and adaptation of deep water faunas (for the latter case see WHATLEY *et al.*, 1997). For passive colonization have been suggested the following strategies: (i) the ostracodes "travel" on floating algae, their holdfasts and attached sediments from one location to another by surface currents; (ii) the ostracodes and/or their eggs are eaten by migratory seabirds (or transported in their feathers and feet as proposed by BOLD, 1976) and scattered along their routes; (iii) the transoceanic vessels transport and distribute ostracodes retained in their ballast water. However, TEETER (1973) proposed that only (i) and (iii) hypothesis are feasible. Regarding the hypothesis (ii), he considered it unlikely due to the depth in which benthic marine ostracodes live, the absence of desiccation resistant eggs in marine species, and the lack of correspondence between the routes of

migratory birds and the distribution patterns of shallow marine ostracodes. TEETER (1973) also highlighted that other means of dispersal of benthic ostracodes reported in the literature, including the intestinal tract of fishes and transport by wind, are also unlikely. In the opinion of the present authors, the hypothesis (iii), although supported by TEETER (1973) and WITTE (1993), is also not the main mechanism to explain many patterns of ostracode geographic distribution, since as shown by CRONIN (1988), COIMBRA *et al.* (1999) and MACHADO *et al.* (2005), to name only three examples, the study of fossils has revealed that many Recent species already had wide distribution before the advent of modern civilization.

The ostracode fauna from the ASPSP, when compared with other Atlantic isolated islands, shows a much smaller number of species. COIMBRA & CARREÑO (2012), based on a small number of samples, recorded 21 ostracode species from Trindade Island (20°30'S, 29°18'W) and 23 species from Rocas Atoll (03°52'S, 33°09'W), while herein only 14 species were registered. WOUTERS (2003) described 13 species recovered from five intertidal samples collected from the island São Vicente (16°36'N, 24°34'W), Archipelago of Cabo Verde. Thus, it is understood that the material of WOUTERS (2003) represents only a fraction of the total species of shallow marine Ostracoda inhabiting the more than ten islands and inlets of Cabo Verde.

VAN HARTEN & WITTE (1993) attribute differences in ostracode diversity between East Atlantic and Indo-West Pacific to allopatric speciation controlled by sea level oscillations in the Neogene and Quaternary. The relation between area and faunistic diversity is an important factor controlling speciation of tropical shallow marine ostracodes, and may help explain for example why the Indo-West Pacific and the tropical West Atlantic are much more diversified than the East Atlantic. The East Atlantic is essentially a continuous continental margin with a comparatively uniform coastline while the first two are favored by an also vast but jagged coast as well as by several archipelagos, islets and seamounts (especially the Indo-West Pacific). Therefore, it is also very likely that the tiny area of the ASPSP together with its great isolation, contribute to the low diversity of ostracode registered there. Finally, it is worth remembering that the Trindade Island and Rocas Atoll are not only much larger than ASPSP, but also components of two chains of seamounts associated with the Trindade-Vitória Alignment and the Fernando de Noronha Fracture Zone, respectively (COIMBRA & CARREÑO, 2012). Thus, it was expected that these latter two oceanic islands have a greater diversity of Ostracoda than the ASPSP.

Triebelina sertata is the only species in common between ASPSP and the Trindade Island. This is a well-known tropical cosmopolitan relict species whose origin is in the shallow-waters of the Indo-Pacific Ocean. In

relation to the Rocas Atoll, two species are shared between the two islands: *T. sertata* and *Loxocorniculum tricordatum*. The last one is a species well known since the Miocene in the Caribbean region, and widely distributed in Recent sediments in the Gulf of Mexico, north and northeast of Brazil and the Rocas Atoll (COIMBRA *et al.*, 2009; COIMBRA & CARREÑO, 2012). Compared to Cabo Verde, apparently there are no species in common between the ASPSP and that archipelago. However, as already discussed above, further taxonomical studies are still needed on the shallow marine ostracodes of both Cabo Verde and the ASPSP.

It is worthy of note the absence of some tropical pandemic ostracodes such as *Kotoracythere inconspicua* (Brady, 1880) and *Keijia demissa* (Brady, 1868) in the material herein examined. Especially these two species are very well-known warm-water ostracode with numerous records in all oceans and even on the Brazilian (COIMBRA & FAUTH, 2002) and African (WITTE, 1993) warm-water shelves and in other Atlantic isolated tropical islands (e.g. Archipelago of Cabo Verde). However, despite being pandemic, these two species are normally a minor component in the ostracode faunas where they occur. Thus, considering the tiny area of the cove of the ASPSP and sampling effort carried out there, it is believed that *K. inconspicua* and *K. demissa* do not actually form part of the local benthic community.

FINAL CONSIDERATIONS

The benthic ostracode fauna of the cove of the ASPSP is not very rich, but considering the small area focused and the relatively large sampling effort carried out by this study, it is believed that the 14 species herein found closely represent the totality of species living there. The fact that (i) a significant number of species has been left in open nomenclature, (ii) one taxa is described as new genus and species (*Berguecythere insularis*), (iii) and the only two species already known to science (*Loxocorniculum tricordatum* and *Triebelina sertata*) have a large distribution in tropical oceans, strengthens the initial hypothesis that this ostracode fauna should possess a significant degree of endemism.

Considering the above discussion and the extensive review of the literature on living and Neocenoic shallow-marine ostracodes conducted by the authors, it is very likely that the species left in open nomenclature represent new taxa. Thus, the endemism in the study area should be real in Ostracoda, as occurs for other better known benthic marine invertebrates (although less intense) from the ASPSP (see MORAES, 2011; VIEIRA *et al.*, 2012). This endemicity could be explained especially by the absence of planktotrophic larval stages in marine benthic ostracodes and by the isolation of this archipelago, which unlike other Brazilian oceanic islands has no shallow submarine connections with the mainland, and is also far from other

islands. Additionally, the system of surface currents of the Atlantic Ocean, although not explained in detail in this paper, should not lead to colonization of the ASPSP by passive dispersion of ostracodes on algae and associated holdfasts and sediments, which could also explain the absence of very common cosmopolitan shallow-water tropical species. However, this topic deserves further discussion in an ongoing research, which will also include the identification and description of the remaining species.

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