Archaeofauna 28 (2019): 105-118

Sambaquis as a proxies of late Holocene mollusk diversity on the coast of Rio de Janeiro, Brazil

Los Sambaquis como registros de diversidad de moluscos holocénicos en la costa de Río de Janeiro, Brasil

SARA CHRISTINA PÁDUA, EDSON PEREIRA SILVA &
MICHELLE REZENDE DUARTE*

Laboratório de Genética Marinha e Evolução, Departamento de Biologia Marinha, Instituto de Biologia, Universidade Federal Fluminense, Outeiro São João Batista, s/n, Centro, Niterói, Rio de Janeiro, CEP: 24001-970, Brazil.

*Corresponding author: michellerezendeduarte@yahoo.com.br

(Received *29 April 2018*; Revised *25 September 2018*; Accepted *27 November 2018*)

ABSTRACT: Efficiency of archaeozoological vestiges from shell mounds to recover biodiversity patterns were tested using a meso-scale inventory (150 archaeological sites from Rio de Janeiro Coast) of malacological vestiges from sambaquis against an inventory of present times mollusk species recorded for the same area. Statistical analysis were done using Taxonomic Distinctness tests and Trophic Diversity inferences. No statistical significant differences were found between past (sambaquis) and present day inventories of malacofauna. It is concluded that sambaquis can be valuable proxies of mollusks biodiversity from Late Holocene. Furthermore, it is supported that the incorporation of information from archaeozoological vestiges to biodiversity studies can bring a historical and evolutionary perspective for the field.

KEYWORDS: MOLLUSKS, TAXONOMIC DISTINCTNNES, FEEDING GUILDS, SHELL MOUNDS, FUNCTIONAL DIVERSITY, ARCHAEOZOOLOGY

RESUMEN: Se evaluó la eficiencia de los vestigios arqueozoológicos de sambaquis para la recuperación de información sobre la biodiversidad del Holoceno. Fueron usados dos inventarios malacológicos de mesoescala: sambaquis (150 sitios arqueológicos de la costa de Río de Janeiro) y el inventario de especies de moluscos actuales registradas para la misma área. El análisis estadístico se realizó utilizando pruebas de distinción taxonómica e inferencias de diversidad trófica. No se encontraron diferencias estadísticamente significativas entre los inventarios pasados (sambaquis) y los inventarios actuales de malacofauna. Se concluye que los sambaquis pueden ser usados para la obtención de valiosa información sobre la biodiversidad de moluscos del Holoceno tardío. Además, se sustenta que la incorporación de información de vestigios arqueozoológicos a los estudios de biodiversidad puede aportar una perspectiva histórica y evolutiva para esta disciplina.

PALABRAS CLAVE: MOLUSCOS, DISTINCIÓN TAXONÓMICA, GREMIO TRÓFICO, SAMBAQUIS, DIVERSIDAD TRÓFICA, ARQUEOZOOLOGÍA

http://doi.org/10.15366/archaeofauna2019.28.009

INTRODUCTION

Sambaquis (the Tupi language designation for shell mounds) are archaeological sites which were built from 8000 to 1000 year BP. They are found in almost all coastal areas around the world and, in Brazil, they are particularly frequent between the states of Espírito Santo and Santa Catarina (Lima *et al*., 2002). The structure of a shell mound is composed of layers of sediments, charcoal, lithic materials and fauna remains (Lima *et al*., 2003). It is acknowledged that these layers were artificially deposited by prehistoric populations (Scheel-Ybert *et al*., 2009; Villagran & Giannini, 2014). Therefore, this construction was deliberate and very much certainly followed cultural drives.

The large volume and the frequent concentration of human burials inside the mounds leads researchers to interpret their formation as building endeavors, although their function is still a matter of debate (Villagran & Giannini, 2014). However, it is well established that they are always found near embayment, bays and lagoons, in the interface between marine and terrestrial, salt and fresh water environments, which are environmental conditions that characterize localities with high biodiversity. Probably due to that, biological remains are abundantly found in shell mounds and indicate the use of mollusks, crustaceans, sea urchins, fishes, birds and mammals in prehistoric human culture (Lima, 2000; Villagran & Giannini, 2014).

As sambaquis are recognized as artificial buildings, most of the information of the fauna and flora therein is regarded to be too biased to be useful for inferences about patterns of biodiversity and are mainly used as records of the cultural uses of the resources (Baisre, 2010). However, biological remains found in shell mounds must come from the flora and fauna existing at the time of the creation of these archaeological sites (Lindbladh *et al*., 2007; Villagran & Giannini, 2014). Therefore, shell mounds are also repository of information on living fauna existing during the late Holocene. Based on that, some recent studies have been using shell mounds to describe the fauna composition of the Holocene, especially mollusks and fishes (Souza *et al*., 2010a, 2012, 2016; Mendes *et al*., 2014, 2018; Beauclair *et al*., 2016).

Furthermore, some studies have also been trying to demonstrate that despite its nature of artificial accumulation (and due to that its limitations as samplers' of biological diversity), the signal from biodiversity present in sambaquis surpasses the noise (Faria *et al*., 2014; Silva *et al*., 2017). Here such endeavor is developed in order to enforce the argument that sambaquis can be used as proxy of late Holocene biodiversity.

An ecological proxy (i.e., representative) is a data sampler. Information on past environmental conditions which can be not directly assessed can be inferred from sources as diverse as farmer's records, naturalist's journey dailies, corals seasonal layers, fluctuations of glaciers and ice caps and growth rings in plant and animals. The aim of the present study is to test sambaquis usefulness as proxies' of the late Holocene biodiversity despite their peculiar and quite evident feature of being a set of organisms artificially accumulated following factors as diverse as culture, preferences, technical level, food taboos, the way material were discarded and/or utilized and, added to all that, the differences of preservation potential of the species in these sites. For doing so measures of taxonomic distinctness and functional diversity were used. All tests were performed for mollusks which are quite abundant in sambaquis. The region studied was the coast of Rio de Janeiro, Brazil.

MATERIAL AND METHODS

Inventories

Two inventories were used for testing the hypothesis that sambaquis are able to recover patterns of biodiversity from the late Holocene. The first inventory was produced based on Souza *et al*. (2010b, 2011). This inventory refers to species from late Holocene registered for one hundred and fifty sambaquis from Rio de Janeiro state coast (Table 1). The second inventory refers to living species and was created based on Rios (1994, 2009), which is the most complete census of the Brazilian malacological fauna, and was complemented with data from the «World Register of Marine Species» (WoRMS, 2018) on line database. The following criteria were used to select the species integrating the living species inventory: (a) distribution of the species in the area comprised between the same latitudes of Rio de Janeiro coast studied by Souza *et al*. (2010b, 2011); (b) shell larger than 5 mm;

(c) not being exclusive to oceanic islands; (d) benthic; and, (e) occurring until 20 m in depth. Figure 1 shows the geographical location of the studied area.

MUNICIPALITY	Nº	SITES SORTED
Angra dos Reis	1.	Sambaqui da Caieira
	2.	Sambaqui da Caieira II (Ilha de Cunhambebe)
	3.	Sambaqui do Algodão (Alexandre)
	4.	Sítio do Bigode I
	5.	Sítio do Bigode II
	6.	Sítio do Major
	7.	Sítio do Peri
	8.	Sítio do Ulá
	9.	Sítio Ilha da Fitinha
	10.	Sítio Ilha de São Jorge
	11.	Sítio Ilhota do Leste
Araruama	12.	Sítio Beira Mar
Armação dos Búzios	13.	Amarras
	14.	Sambaqui da Ponta do Geribá
	15.	Sítio Arqueológico da Praia de Geribá
	16.	Sítio Duna Geribá (Geribá I)
	17.	Sítio Geribá II
Arraial do Cabo	18.	Abrigo Praia dos Anjos
	19.	Massambaba II
	20.	Sambaqui do Morro da Concha
	21.	Sítio Arqueológico da Ponta da Cabeça
	22.	Sítio Arqueológico Dunas da Praia Seca
	23.	Sítio Colônia de Pesca ZP-05
	24.	Sítio do Boqueirão
	25.	Sítio Ilha de Cabo Frio
	26.	Sítio Praia dos Anjos
	27.	Sítio Usiminas
Cabo Frio	28.	Ilha das Palmeiras
	29.	Sambaqui Boca da Barra
	30.	Sambaqui da Ilha do Vigia
	31.	Sambaqui da Salina Peroano
	32.	Sambaqui de Campos Novos
	33.	Sambaqui do Forte
	34.	Sambaqui do Morro do Índio
	35.	Sambaqui do Tambor
	36.	Sambaqui Duna Boa Vista
	37.	Sambaqui da Fazenda da Malhada
	38.	Sambaqui Fernandes do Couto
	39.	Sítio Arco-Íris
	40.	Sítio Arqueológico do Cemitério de Cabo Frio
	41.	Sítio Arqueológico do Rio Una I
	42.	Sítio Arqueológico do Rio Una II
	43.	Sítio da Malhada
	44.	Sítio do Meio
	45.	Sítio do Nacil
	46.	Sítio Novo Portinho
Casimiro de Abreu	47.	Sambaqui da Vila Nova
	48.	Sambaqui do Gravatá (Barra de S. João)
Duque de Caxias	49.	Sítio do Km 18 (Estrada de Ferro Leopoldina)
Itaboraí	50.	Sambaqui Sampaio I
Itaguaí	51.	Sambaqui da Santa Cruz
	52.	Sítio da Estrada de Ferro
Macaé	53.	Sambaqui da Imbetiba
	54.	Sambaqui do Ury
	55.	Sambaqui dos Marimbondos
	56.	Sítio da Ilha de Santana
	57.	Sambaqui da Ponta do Pirata
	58.	Sambaqui de Sernambetiba
	59.	Sambaqui do Amourins
	60.	Sambaqui do Arapuan
	61	Sambaqui do Cordovil
	62.	Sambaqui do Fernando
	63.	Sambaqui do Guapi
	64.	Sambaqui do Guaraí-Mirim
	65.	Sambaqui do Imenezes
	66.	Sambaqui do Rio das Pedrinhas
	67.	Sambaqui Porto da Estrela
	68.	Sítio Saracuruna
Mangaratiba	69.	Sambaqui do Saí
	70.	Sítio Guaíba
Maricá	71.	Sítio Maricá 2
	72.	Sítio Maricá 4
	73.	Sítio Jaconé
Niterói	74.	Sambaqui da Boa Vista
	75.	Sítio Arqueológico de Itaipú
	76.	Sítio de Camboinhas
	77.	Sítio Horto Florestal
Paraty	78.	Abrigo Paratimirim I
	79.	Abrigo Ponta do Leste II
	80.	Sambaqui do Araújo
	81.	Sambaqui do Forte
	82.	Sambaqui do Pouso
	83.	Sambaqui Mamanguá
	84.	Sambaqui Olho D'Água (dos Praxedes)
	85.	Sítio Caixa D'Aço I
	86.	Sítio Ilha Comprida II
	87.	Sítio Praia de Fora
	88.	Toca da Mambucaba
	89.	Toca do Cassununga (Sítio Jabaquara)
	90.	Sítio Trindade I (Sambaqui do Severo)
	91.	Sítio Trindade II
	92,	Sítio Trindade III (Sambaqui da Trindade)

Rio das Ostras	93.	Sambaqui da Tarioba
Rio de Janeiro	94.	Aldeamento Tupi da Tropa de Reforço
	95.	Aldeia Tupi da Estação Rádio da Marinha
	96.	Aldeia Tupi do Instituto de Pesquisas da Marinha
	97.	Sambaqui Capão da Bananeira
	98.	Sambaqui Capão da Benta
	99.	Sambaqui Capão do Surucaí
	100.	Sambaqui Casqueiro de Araçatiba
	101.	Sambaqui da Beira da Estrada
	102.	Sambaqui da Cabeça de Índio II
	103.	Sambaqui da Embratel
	104.	Sambaqui da Itapuca
	105.	Sambaqui da Matriz
	106.	Sambaqui da Panela do Pai João
	107.	Sambaqui da Praia do Malhador
	108.	Sambaqui da Vila Mar
	109.	Sambaqui das Piteiras (ou Anil)
	110.	Sambaqui das Pixunas
	111.	Sambaqui do Aterrado da Pedra
	112.	Sambaqui do Atolador
	113.	Sambaqui do Caminho do Cajazeiro
	114.	Sambaqui do Capão do Gentio
	115.	Sambaqui do Capão do Pau Ferro
	116.	Sambaqui do Capãozinho
	117.	Sambaqui do Cerâmio
	118.	Sambaqui do Curral das Pedras
	119.	Sambaqui do Meio
	120.	Samabaqui do Piai
	121.	Sambaqui do Piracão
	122.	Sambaqui do Piraquê
	123.	Sambaqui do Poço das Pedras
	124.	Sambaqui do Porto da Cinza
	125.	Sambaqui do Posto 5
	126.	Sambaqui do Telégrafo
	127.	Sambaqui do Telles
	128.	Sambaqui do Vaso
	129.	Sambaqui do Zé Espinho
	130.	Sambaqui Porto das Pitangueiras
	131.	Sítio da Ilha do Tatu
	132.	Sítio de Manguinhos
	133.	Sítio do Rangel
	134.	Sítio do Recreio dos Bandeirantes
	135.	Sambaqui do Zé Garoto
	136.	Sítio da Ilha do Pontal
S. Pedro D'Aldeia	137.	Sítio Botafogo (Corondó)
Saquarema	138.	Sambaqui da Beirada
	139.	Sambaqui da Madressilva
	140.	Sambaqui da Ponte do Girau
	141.	Sambaqui da Pontinha
	142.	Sambaqui de Barreira
	143.	Sambaqui de Jaconé
	144.	Sambaqui de Saquarema
	145.	Sambaqui do Boqueirão
	146.	Sambaqui do Moa
	147.	Sambaqui do Saco
	148.	Sambaqui Manitiba I
	149.	Sambaqui Mario Nunes
	150.	Sambaqui Yatch Club

TABLE 1

List of shellmounds studied.

Taxonomic Distinctness

Biodiversity is a quite complex concept which include more than simply the number of species (or the species richness) of a given site, area or region. The most basic limitation of species richness is that it assumes that all species, independently of their taxonomic distinction, have the same contribution to diversity. Thus, two species from the same genera are considered as diverse as a species of gastropod and other of bivalves. One way to bypass these problems is to consider for each species in an inventory its Linnean classification. Therefore, the species are considered in their evolutionary history or phylogeny (Clarke & Warwick, 1998).

A «master list» was composed summing up the two inventories previously produced. Therefore, this master list has all mollusks species from de inventory of sambaquis composed based on Souza *et al*. (2010b, 2011) and also the species of the inventory of species of marine mollusks recorded for the state of Rio de Janeiro based on Rios (1994, 2009) and WoRMS (2018). Taxonomic classification was compiled for each species from this master list and that constitute the first data matrix. A second matrix was built up displaying presence and absence data for all species compiled in the «master list».

To compare the patterns of biodiversity through their phylogenetic diversity, two indices were used. The first one, average taxonomic distinctness (AvTD), or delta+, is defined as the average taxonomic path length between any two randomly chosen species, traced through a Linnaean classification of the full set of species involved (Clarke & Warwick, 1998). Five taxonomic levels (species, genus, family, order and class) were used with step lengths between them used as units. The second taxonomic diversity index used, variation in taxonomic distinctness (VarTD), or lambda+, reveals

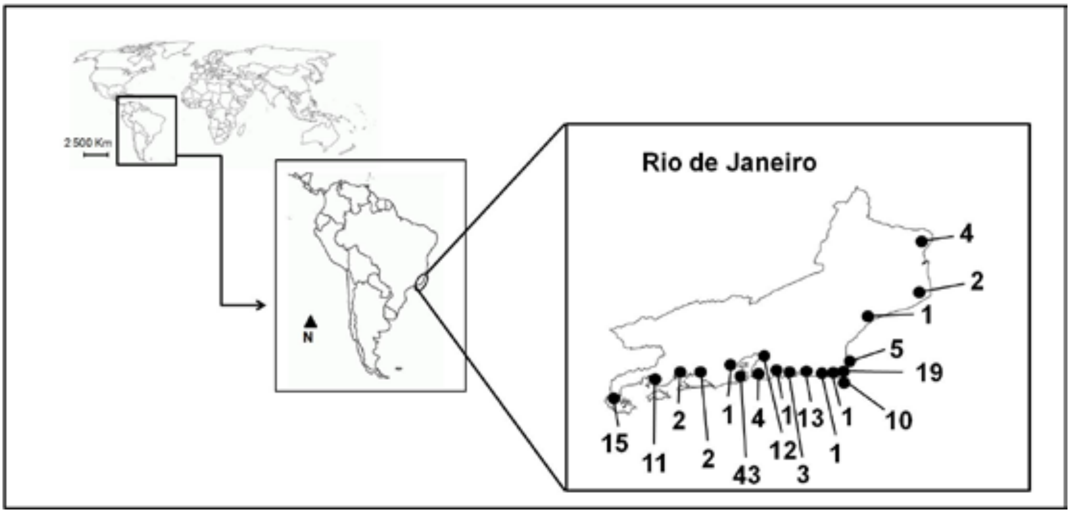

FIGURE 1

Map of the state of Rio de Janeiro showing the location of archaeological sites analyzed. Showed numbers refer to the number of sambaquis registered for each location and herein used for producing the malacological list of the species from Late Holocene.

the evenness of the distribution of taxa across the hierarchical taxonomic tree. More precisely, this index provides additional information regarding the extent to which particular taxa are over or under-represented in the samples. Both, AvTD and VarTD, are measures independent of sample size, number of species and the value of AvTD within a sample unit.

Funnel plots with 95% confidence limits for delta+ and lambda+ were constructed according to Clarke & Warwick (1998). In this approach, a randomization test is used to detect the expected delta+ and lambda+ values derived from a regional species pool (master list). If the measured value for Sambaquis falls outside the 95% probability limits, then statistically it cannot be considered representative of the «master list». These indexes were calculated using Primer-E v.5 (Clarke & Warwick, 1998).

Functional Diversity

Another way for inferring biodiversity is through a functional approach. Highly diverse biological communities include all or many of the feeding guilds (herbivorous, carnivorous, saprophagous, deposit-feeders, suspension-feeders etc.), what reflects the trophic complexity of the environment (Baiser *et al*., 2011).

Sambaquis are artificial constructions, therefore, they have the species therein accumulated following bias such as species with large sizes and high nutrition values (carnivores, for example). This fact would have as an effect that some functional guild would be much more represented than others, deviating the list of species obtained from sambaquis from another built by random sampling. Based on this assumption, it was tested the null hypothesis that the signal of functional diversity in sambaquis was low compared with the noise associated to their nature of artificial accumulations. The alternative hypothesis to be tested was that despite the noise associated with no random accumulation the signal of functional diversity was still present and, therefore, the sambaquis can be used as proxy for biodiversity.

For the inventories of sambaquis and of present time information were added information concerning the alimentary habit of each species. Feeding guilds were defined based on Antolí & García-Cubas (1985), Rios (1994, 2009) and Arruda *et al*. (2003). Each species was defined just for one of the categories established. The number of species for each of the feeding guilds present in each inventory was defined. To compare the patterns of biodiversity through their functional diversity, a Mann-Whitney test was performed to verify if the number feeding guilds was different among sambaquis and present day inventories.

RESULTS

The list of bivalves is presented in Table 2 and Table 3 shows the list of gastropods. The characteristics of the inventories are summarized in Table 4. Archaeozoological vestiges represent 30% of the species living in present day (37% for bivalves and 23% for gastropods) and six out of seven (85%) of the feeding guilds registered in the present time inventory are also represented in sambaquis.

SPECIES	SAMBAQUIS	PRESENT TIMES
Adrana electa (A. Adams, 1856)	0	1
Adrana patagônica (d'Orbigny, 1845)	0	1
Adrana tellinoides (G. B. Sowerby I, 1823)	0	1
Amarilladesma mactroides (Reeve, 1854)	1	1
Ameghinomya antiqua (P. P. King, 1832)	1	1
Ameritella diantha (Boss, 1964)	0	1
Amiantis purpurata (Lamarck, 1818)	1	1
Anadara brasiliana (Lamarck, 1819)	0	1
Anadara chemnitzii (Philippi, 1851)	1	1
Anadara notabilis (Röding, 1798)	1	1
Anatina anatina (Spengler, 1802)	0	1
Anomalocardia flexuosa (Linnaeus, 1767)	1	1
Anomia ephippium Linnaeus, 1758	1	1
Anomia simplex d'Orbigny, 1853	1	1
Arca imbricata Bruguière, 1789	1	1
Arca zebra Swainson, 1833	0	1
Arcinella brasiliana (Nicol, 1953)	1	1
Arcopsis adamsi (Dall, 1886)	0	1
Ardeamya petitiana (d'Orbigny, 1845)	0	1
Atrina seminuda (Lamarck, 1819)	1	1
Austromacoma constricta (Bruguière, 1792)	0	1
Bankia campanellata Moll & Roch, 1931	0	1
Bankia carinata (J.E. Gray, 1827)	0	1
Bankia cieba Clench & R. D. Turner, 1946	0	1
Bankia destructa Clench & R. D. Turner, 1946	0	1
Bankia fimbriatula Moll & Roch, 1931	0	1
Bankia gouldi (Bartsch, 1908)	0	1
Barbatia candida (Helbling, 1779)	1	1
Barnea truncata (Say, 1822)	0	1
Botula fusca (Gmelin, 1791)	0	1
Brachidontes exustus (Linnaeus, 1758)	1	1
Callpita eucymata (Dall, 1890)	0	1
Cardiomya ornatissima (d'Orbigny, 1853)	0	1
Cardites floridanus (Conrad, 1838)	0	1
Caribachlamys sentis (Reeve, 1853)	0	1
Caryocorbula swiftiana (C. B. Adams, 1852)	1	1
Cavilinga blanda (Dall in Dall & Simpson, 1901)	0	1
Chama congregata Conrad, 1833	0	1
Chama florida Lamarck, 1819	0	1
Chama macerophylla Gmelin, 1791	1	1
Chione cancellata (Linnaeus, 1767)	1	1
Chionopsis crenata (Gmelin, 1791)	1	1
Chlamydoconcha avalvis Simone, 2008	0	1
Chlamys muscosus Wood, 1828	0	1
Chlamys tehuelchus (Orbigny, 1846)	0	1
Clathrolucina costata (d'Orbigny, 1845)	1	1
Codakia orbicularis (Linnaeus, 1758)	1	1
Cooperella atlantica Rehder, 1943	0	1
Corbula operculata Philippi, 1848	0	1
Corbula patagonica d'Orbigny, 1845	0	1
Corbula pulchella Philippi, 1893	0	1
Crassinella lunulata (Conrad, 1834)	0	1
Crassostrea rhizophorae (Guilding, 1828)	1	1
Ctena orbiculata (Montagu, 1808)	0	1
Cyclinella tenuis (Récluz, 1852)	0	1
Cyrtopleura costata (Linnaeus, 1758)	1	1
Dallocardia muricata (Linnaeus, 1758)	1	1
Dendostrea cristata (Born, 1778)	1	0
Dendostrea frons (Linnaeus, 1758)	1	1
Dendostrea frons (Linnaeus, 1758)	0	1
Diplodonta nucleiformis (W. Wagner, 1840)	0	1
Divalinga quadrisulcata (d'Orbigny, 1845)	1	1
Donax gemmula Morrison, 1971	0	1
Donax hanleyanus Philippi, 1847	1	1
Dosinia concentrica (Born, 1778)	1	1
Ennucula puelcha (d'Orbigny, 1842)	0	1
Entodesma brasiliense (Gould, 1850)	0	1
Ervilia nitens (Montagu, 1808)	0	1
Eurytellina alternata (Say, 1822)	0	1
Eurytellina angulosa (Gmelin, 1791)	1	1
Eurytellina gibber (Ihering, 1907)	0	1
Eurytellina lineata (W. Turton, 1819)	0	1
Eurytellina nitens (C. B. Adams, 1845)	0	1
Eurytellina punicea (Born, 1778)	0	1
Eurytellina trinitatis Tomlin, 1929	0	1
Euvola ziczac (Linnaeus, 1758)	1	1
Felaniella candeana (d'Orbigny, 1853)	0	1
Felaniella candeana (d'Orbigny, 1853)	1	1
Globivenus rigida (Dillwyn, 1817)	1	1
Glycymeris longior (G. B. Sowerby I, 1833)	1	1
Glycymeris tellinaeformis (Reeve, 1843)	0	1
Glycymeris undata (Linnaeus, 1758)	1	1
Gouldia cerina (C. B. Adams, 1845)	0	1
Gregariella coralliophaga (Gmelin, 1791)	0	1
Heterodonax bimaculatus (Linnaeus, 1758)	0	1
Iphigenia brasiliensis (Lamarck, 1818)	1	1
Juliacorbula aequivalvis (Philippi, 1836)	0	1
Juliacorbula aequivalvis (Philippi, 1836)	1	0
Laevicardium brasilianum (Lamarck, 1819)	1	1

Lamelliconcha circinata (Born, 1778)	1	1
Lamychaena hians (Gmelin, 1791)	0	1
Leiosolenus aristatus (Dillwyn, 1817)	0	1
Leiosolenus bisulcatus (d'Orbigny, 1853)	0	1
Leptopecten bavayi (Dautzenberg, 1900)	0	1
Leukoma pectorina (Lamarck, 1818)	1	1
Leukoma subrostrata (Lamarck, 1818)	0	1
Lima lima (Linnaeus, 1758)	0	1
Limaria locklini (McGinty, 1955)	0	1
Limaria tuberculata (Olivi, 1792)	0	1
Lioberus castanea (Say, 1822)	0	1
Lirophora latilirata (Conrad, 1841)	0	1
Lirophora paphia (Linnaeus, 1767)	1	1
Lithophaga nigra (d'Orbigny, 1853)	0	1
Lunarca ovalis (Bruguière, 1789)	1	1
Lyrodus massa (Lamy, 1923)	0	1
Macoploma tenta (Say, 1838)	0	1
Mactra isabelleana d'Orbigny, 1846	1	1
Mactra petitii d'Orbigny, 1846	0	1
Mactrellona alata (Spengler, 1802)	0	1
Mactrotoma fragilis (Gmelin, 1791)	1	1
Mactrotoma janeiroensis (E. A. Smith, 1915)	0	1
Malletia cumingii (Hanley, 1860)	0	1
Martesia cuneiformis (Say, 1822)	0	1
Martesia fragilis Verrill & Bush, 1898	0	1
Martesia striata (Linnaeus, 1758)	0	1
Megapitaria maculata (Linnaeus, 1758)	0	1
Megapitaria maculata (Linnaeus, 1758)	1	0
Microcardium tinctum (Dall, 1881)	0	1
Modiolus americanus (Leach, 1815)	0	1
Modiolus carvalhoi Klappenbach, 1966	0	1
Mulinia cleryana (d'Orbigny, 1846)	0	1
Musculus lateralis (Say, 1822)	0	1
Mytella charruana (d'Orbigny, 1842)	1	1
Mytella guyanensis (Lamarck, 1819)	0	1
Mytilaster solisianus (d'Orbigny, 1842)	1	1
Nausitora fusticulus (Jeffreys, 1860)	0	1
Neoteredo reynei (Bartsch, 1920	0	1
Nodipecten nodosus (Linnaeus, 1758)	1	0
Nototeredo knoxi (Bartsch, 1917)	0	1
Nucula semiornata d'Orbigny, 1842	0	1
Ostrea puelchana d'Orbigny, 1842	1	1
Ostrea stentina Payraudeau, 1826	1	1
Oudardia sandix (Boss, 1968)	0	1
Pandora bushiana Dall, 1886	0	1
Panopea abbreviata Valenciennes, 1839	0	1
Papyridea semisulcata (J.E. Gray, 1825)	0	1
Papyridea soleniformis (Bruguière, 1789)	1	1
Parabornia palliopapillata Simone, 2001	0	1
Parvilucina crenella (Dall, 1901)	0	1
Parvilucina crenella (Dall, 1901)	1	0
Parvilucina pectinella (C. B. Adams, 1852)	0	1
Periploma compressum d'Orbigny, 1846	0	1
Periploma margaritaceum (Lamarck, 1801)	0	1
Perna perna (Linnaeus, 1758)	0	1
Petricola bicolor G.B. Sowerby II, 1854	1	1
Phacoides pectinatus (Gmelin, 1791)	1	1
Phlyctiderma semiaspera (Philippi, 1836)	0	1
Pholas campechiensis Gmelin, 1791	0	1
Pinctada imbricata Röding, 1798	1	1
Pinna carnea Gmelin, 1791	0	1
Pitar fulminatus (Menke, 1828)	1	1
Pitar palmeri Fischer-Piette & Testud, 1967	0	1
Pitar rostratus (Philippi, 1844)	1	1
Plicatula gibbosa Lamarck, 1801	1	1
Pododesmus rudis (Broderip, 1834)	0	1
Psammotella cruenta (Lightfoot, 1786)	1	1
Psammotreta brevifrons (Say, 1834)	0	1
Pseudochama cristella (Lamarck, 1819)	1	1
Pseudomacalia antillarum (d'Orbigny, 1853)	0	1
Pteria hirundo (Linnaeus, 1758)	0	1
Radiolucina amianta (Dall, 1901)	0	1
Raeta plicatella (Lamarck, 1818)	0	1
Sanguinolaria sanguinolenta (Gmelin, 1791)	0	1
Semele proficua (Pulteney, 1799)	1	1
Semele purpurascens (Gmelin, 1791)	0	1
Semelina nuculoides (Conrad in Hodge, 1841)	0	1
Semicassis granulata (Born, 1778)	1	1
Serratina aequistriata (Say, 1824)	0	1
Serratina martinicensis (d'Orbigny, 1853)	0	1
Sheldonella bisulcata (Lamarck, 1819)	1	1
Solecurtus cumingianus (Dunker, 1862)	0	1
Solecurtus rhombus (Spengler, 1794)	0	1
Solemya occidentalis Deshayes, 1857	0	1
Solen thuelchus Hanley, 1842	0	1
Solena obliqua (Spengler, 1794)	0	1
Sphenia fragilis (H. Adams & A. Adams, 1854)	0	1
Spondylus tenuis Schreibers, 1793	1	0
Strigilla carnaria (Linnaeus, 1758)	0	1
Strigilla pisiformis (Linnaeus, 1758)	0	1
Tagelus divisus (Spengler, 1794)	0	1
Tagelus plebeius (Lightfoot, 1786)	1	1
Tellina radiata Linnaeus, 1758	0	1
Tellina Linnaeus, 1758	1	0
Tellinella listeri (Röding, 1798)	1	1
Temnoconcha galathaea (Lamarck, 1818)	0	1
Teredo bartschi Clapp, 1923	0	1
Teredo furcifera Martens, 1894	0	1
Teredo navalis Linnaeus, 1758	1	1
Thracia distorta (Montagu, 1803)	0	1
Thracia similis Couthouy, 1839	0	1
Tivela dentaria (Lamarck, 1818)	1	1

Tivela fulminata (Bory de Saint-Vincent, 1827)	1	1
Tivela mactroides (Born, 1778)	1	1
Tivela zonaria (Lamarck, 1818)	1	1
Transennella stimpsoni Dall, 1902	0	1
Transenpitar americana (Doello-Jurado in Carcelles, 1951)	0	1

TABLE 2

List of marine bivalves species in the Sambaquis and present times of the coast of Rio de Janeiro.

SPECIES	SAMBAQUIS	PRESENT TIMES
Acteocina bullata (Kiener, 1834)	0	1
Acteon pelecais Ev. Marcus, 1972	0	1
Adelomelon brasiliana (Lamarck, 1811)	1	1
Aesopus obesus (Hinds, 1844)	0	1
Aesopus stearnsii (Tryon, 1883)	0	1
Agaronia travassosi Lange de Morretes, 1938	0	1
Alaba incerta (d'Orbigny, 1841)	0	1
Amalda josecarlosi Pastorino, 2003	0	1
Americoliva circinata (Marrat, 1871)	1	0
Anachis fenneli Radwin, 1968	0	1
Anachis lyrata (G. B. Sowerby I, 1832)	0	1
Architectonica nobilis Röding, 1798	0	1
Arene microforis (Dall, 1889)	0	1
Asmunda turrita (C. B. Adams, 1852)	0	1
Astralium latispina (Philippi, 1844)	1	1
Atlantilux exigua (C. B. Adams, 1845)	0	1
Atys riiseanus Mörch, 1875	0	1
Aurantilaria aurantiaca (Lamarck, 1816)	1	1
Babelomurex mansfieldi (McGinty, 1940)	0	1
Bellaspira rosea Fallon, 2016	0	1
Bostrycapulus aculeatus (Gmelin, 1791)	1	1
Buccinanops cochlidium (Dillwyn, 1817)	0	1
Buccinanops monilifer (Kiener, 1834)	0	1
Bulla striata Bruguière, 1792	1	1
Bullata analuciae de Souza & Coovert, 2001	0	1
Bullata largillieri (Kiener, 1841)	0	1
Bursa corrugata (Perry, 1811)	0	1
Caecum cycloferum de Folin, 1867	0	1
Calliostoma adspersum (Philippi, 1851)	1	0
Calliostoma bullisi Clench & R. D. Turner, 1960	0	1
Calliostoma carcellesi Clench & Aguayo, 1940	0	1
Calliostoma depictum Dall, 1927	0	1
Calliostoma hassler Clench & Aguayo, 1939	0	1
Calliostoma jujubinum (Gmelin, 1791)	1	1
Calliostoma militare Ihering, 1907	0	1
Calyptraea centralis (Conrad, 1841)	0	1
Cancellaria petuchi Harasewych, Petit & Verhecken, 1992	0	1
Cassis tuberosa (Linnaeus, 1758)	1	0
Cerithiopsis gemmulosa (C. B. Adams, 1850)	0	1
Cerithium atratum (Born, 1778)	1	1
Cerithium litteratum (Born, 1778)	1	1
Chicoreus spectrum (Reeve, 1846)	0	1
Cirsotrema dalli Rehder, 1945	1	1
Colubraria obscura (Reeve, 1844)	0	1
Columbella mercatoria (Linnaeus, 1758)	1	1
Conasprella centurio (Born, 1778)	0	1
Conasprella jaspidea (Gmelin, 1791)	0	1
Conus clerii Reeve, 1844	0	1
Conus daucus Hwass in Bruguière, 1792	0	1
Conus regius Gmelin, 1791	1	0
Conus villepinii P. Fischer & Bernardi, 1857	0	1
Conus ziczac archetypus Crosse, 1865	0	1
Coralliophila aberrans (C. B. Adams, 1850)	0	1
Coralliophila caribaea Abbott, 1958	0	1
Cosmioconcha helenae (Costa, 1983)	0	1
Costoanachis sertulariarum (d'Orbigny, 1839)	0	1
Crassispira fuscescens (Reeve, 1843)	0	1
Crepidula intratesta Simone, 2006	0	1
Crepidula plana Say, 1822	0	1
Crepidula protea (d'Orbigny, 1841)	0	1
Cryoturris adamsii (E. A. Smith, 1884)	0	1
Cymatium femorale (Linnaeus, 1758)	0	1
Cyphoma gibbosum (Linnaeus, 1758)	0	1
Cyphoma intermedium (G. B. Sowerby I, 1828)	0	1
Cypraecassis testiculus (Linnaeus, 1758)	0	1
Diodora cayenensis (Lamarck, 1822)	0	1
Diodora dysoni (Reeve, 1850)	0	1
Diodora meta (Ihering, 1927)	0	1
Diodora patagonica (d'Orbigny, 1839)	0	1
Diodora Gray, 1821	1	0
Distorsio constricta (Broderip, 1833)	0	1
Duplicaria gemmulata (Kiener, 1837)	0	1
Echinolittorina lineolata (d'Orbigny, 1840)	0	1
Echinolittorina ziczac (Gmelin, 1791)	1	1
Engina goncalvesi Coltro, 2005	0	1
Engina turbinella (Kiener, 1836)	0	1
Epitonium albidum (d'Orbigny, 1842)	0	1
Epitonium angulatum (Say, 1831)	0	1
Epitonium candeanum (d'Orbigny, 1842)	0	1
Epitonium krebsii (Mörch, 1875)	0	1
Epitonium nautlae (Mörch, 1875)	0	1
Epitonium nitidella (Dall, 1889)	0	1
Epitonium novangliae (Couthouy, 1838)	0	1
Epitonium striatellum (Nyst, 1871)	0	1
Epitonium unifasciatum (Sowerby II, 1844)	0	1
Eulimastoma franklini Pimenta, 2012	0	1
Eulithidium affine (C. B. Adams, 1850)	0	1
Eulithidium bellum (M. Smith, 1937)	0	1

Euspira catena (da Costa, 1778)	1	1
Euterebra riosi (Bratcher & Cernohorsky, 1985)	0	1
Favartia cellulosa (Conrad, 1846)	1	1
Favartia glypta (M. Smith, 1938)	0	1
Fenimorea nivalis Fallon, 2016	0	1
Fissurella clenchi Pérez Farfante, 1943	0	1
Fissurella rosea (Gmelin, 1791)	0	1
Fissurella Bruguière, 1789	1	0
Fusinus brasiliensis (Grabau, 1904)	1	1
Fusinus frenguellii (Carcelles, 1953)	0	1
Fusinus verrucosus (Gmelin, 1791)	0	1
Gemophos auritulus (Link, 1807)	1	0
Halistylus columna (Dall, 1890)	0	1
Haminoea elegans (Gray, 1825)	0	1
Haminoea petitii (d'Orbigny, 1841)	0	1
Hastula hastata (Gmelin, 1791)	0	1
Heliacus bisulcatus (d'Orbigny, 1842)	0	1
Heliacus cylindricus (Gmelin, 1791)	0	1
Hemitoma octoradiata (Gmelin, 1791)	0	1
Hespererato maugeriae (J.E. Gray, 1832)	0	1
Hesperisternia karinae (Nowell-Usticke, 1959)	0	1
Impages cinerea (Born, 1778)	1	1
Iselica anomala (C. B. Adams, 1850)	1	1
Ithycythara hyperlepta Haas, 1953	0	1
Ithycythara lanceolata (C. B. Adams, 1850)	0	1
Jaspidella jaspidea (Gmelin, 1791)	0	1
Kurtziella rhysa (R. B. Watson, 1881)	0	1
Lamellaria mopsicolor Ev. Marcus, 1958	0	1
Lampanella minima (Gmelin, 1791)	0	1
Latirus Montfort, 1810	1	0
Leucozonia granulilabris (Vermeij & Snyder, 2004)	0	1
Leucozonia nassa (Gmelin, 1791)	1	1
Leucozonia ocellata (Gmelin, 1791)	0	1
Linatella caudata (Gmelin, 1791)	0	1
Lithopoma tectum (Lightfoot, 1786)	1	1
Littoraria angulifera (Lamarck, 1822)	0	1
Littoraria flava (King, 1832)	1	1
Lobatus costatus (Gmelin, 1791)	0	1
Lottia subrugosa (d'Orbigny, 1846)	1	1
Lottia subrugosa (d'Orbigny, 1846)	1	0
Lucapina sowerbii (Sowerby I, 1835)	0	1
Lucapinella henseli (Martens, 1900)	0	1
Lucapinella limatula (Reeve, 1850)	0	1
Luria cinerea (Gmelin, 1791)	0	1
Macrocypraea zebra (Linnaeus, 1758)	1	1
Marshallora nigrocincta (C. B. Adams, 1839)	0	1
Melampus coffea (Linnaeus, 1758)	0	1
Melampus monile (Bruguière, 1789)	1	1
Melanella conoidea (Kurtz & Stimpson, 1851)	0	1
Melanella polita (Linnaeus, 1758)	0	1
Modulus modulus (Linnaeus, 1758)	1	1
Monoplex parthenopeus (Salis Marschlins, 1793)	1	1
Monoplex pilearis (Linnaeus, 1758)	0	1
Morula nodulosa (C. B. Adams, 1845)	1	1
Morum oniscus (Linnaeus, 1767)	0	1
Muricopsis necocheana (Pilsbry, 1900)	0	1
Mysouffa cumingii (A. Adams, 1855)	0	1
Naria acicularis (Gmelin, 1791)	0	1
Nassarius scissuratus (Dall, 1889)	0	1
Natica livida Pfeiffer, 1840	0	1
Natica menkeana Philippi, 1851	0	1
Neritina virginea (Linnaeus, 1758)	0	1
Neritina zebra (Bruguière, 1792)	0	1
Niso interrupta (G. B. Sowerby I, 1834)	0	1
Niveria maltbiana (Schwengel & McGinty, 1942)	0	1
Niveria suffusa (J.E. Gray, 1827)	0	1
Nototriphora decorata (C. B. Adams, 1850)	0	1
Odostomella carceralis Pimenta, Absalão & Alencar, 2000	0	1
Oliva fulgurator (Röding, 1798)	0	1
Olivancillaria auricularia (Lamarck, 1811)	0	1
Olivancillaria carcellesi Klappenbach, 1965	1	1
Olivancillaria deshayesiana (Ducros de Saint Germain, 1857)	0	1
Olivancillaria orbignyi (Marrat, 1868)	0	1
Olivancillaria urceus (Röding, 1798)	1	1
Olivancillaria vesica (Gmelin, 1791)	1	1
Olivella arionata Absalão, 2000	0	1
Olivella floralia (Duclos, 1844)	0	1
Olivella minuta (Link, 1807)	0	1
Olivella mutica (Say, 1822)	0	1
Olivella olssoni van Regteren Altena, 1971	0	1
Olivella puelcha (Duclos, 1835)	1	0
Olivella Swainson, 1831	1	0
Opalia crenata (Linnaeus, 1758)	0	1
Opalia hotessieriana (d'Orbigny, 1842)	0	1
Parthenina biumbilicata Pimenta, 2012	0	1
Parvanachis obesa (C. B. Adams, 1845)	1	0
Pedipes mirabilis (Megerle von Mühlfeld, 1816)	0	1
Petaloconchus myrakeenae Absalão & Rios, 1987	0	1
Petaloconchus varians (d'Orbigny, 1839)	0	1
Semicassis labiata (Perry, 1811)	0	1
Phrontis alba (Say, 1826)	0	1
Phrontis karinae (Nowell-Usticke, 1971)	0	1
Phrontis vibex (Say, 1822)	1	1
Phyllonotus oculatus (Reeve, 1845)	0	1
Phyllonotus pomum (Gmelin, 1791)	0	1
Pilsbryspira leucocyma (Dall, 1884)	0	1
Pisania pusio (Linnaeus, 1758)	0	1

Plesiothyreus hamillei (P. Fischer, 1857)	0	1
Polinices hepaticus (Röding, 1798)	1	1
Polinices lacteus (Guilding, 1834)	1	1
Polinices uberinus (d'Orbigny, 1842)	0	1
Polygona infundibulum (Gmelin, 1791)	0	1
Polystira florencae Bartsch, 1934	0	1
Polystira formosissima (E. A. Smith, 1915)	0	1
Prunum apicinum (Menke, 1828)	0	1
Prunum fulminatum (Kiener, 1841)	0	1
Prunum martini (Petit de la Saussaye, 1853)	0	1
Psilaxis krebsii (Mörch, 1875)	0	1
Pugilina morio (Linnaeus, 1758)	1	1
Pugilina tupiniquim Abbate & Simone, 2015	0	1
Pusula pediculus (Linnaeus, 1758)	0	1
Pyrgocythara albovittata (C. B. Adams, 1845)	0	1
Pyrgocythara guarani (d'Orbigny, 1841)	0	1
Retilaskeya emersonii (C. B. Adams, 1839)	0	1
Seila adamsii (H. C. Lea, 1845)	1	1
Semicassis granulata (Born, 1778)	0	1
Sigatica semisulcata (Gray, 1839)	0	1
Simnialena uniplicata (G. B. Sowerby II, 1849)	1	0
Sinum maculatum (Say, 1831)	0	1
Sinum perspectivum (Say, 1831)	1	1
Siphonaria hispida Hubendick, 1946	0	1
Siphonaria pectinata (Linnaeus, 1758)	0	1
Siratus senegalensis (Gmelin, 1791)	1	1
Siratus tenuivaricosus (Dautzenberg, 1927)	0	1
Smaragdia viridis (Linnaeus, 1758)	0	1
Solariella carvalhoi Lopes & Cardoso, 1958	0	1
Stigmaulax cayennensis (Récluz, 1850)	0	1
Stigmaulax sulcatus (Born, 1778)	0	1
Stramonita haemastoma (Linnaeus, 1767)	1	0
Stramonita haemastoma (Linnaeus, 1767)	0	1
Stramonita rustica (Lamarck, 1822)	0	1
Strombus pugilis Linnaeus, 1758	0	1
Syntomodrillia lissotropis (Dall, 1881)	0	1
Tectonatica pusilla (Say, 1822)	0	1
Tegula viridula (Gmelin, 1791)	1	1
Tenaturris fulgens (E. A. Smith, 1888)	0	1
Terebra brasiliensis (E. A. Smith, 1873)	0	1
Terebra protexta (Conrad, 1846)	0	1
Terebra Bruguière, 1789	1	0
Terebra spirosulcata Simone, 1999	0	1
Terebra taurina (Lightfoot, 1786)	0	1
Thaisella mariae (Morretes, 1954)	0	1
Thylacodes decussatus (Gmelin, 1791)	0	1
Tonna galea (Linnaeus, 1758)	1	1
Trachypollia turricula (Maltzan, 1884)	1	0
Tritonoharpa lanceolata (Menke, 1828)	0	1
Trivia candidula (Gaskoin, 1836)	0	1
Trochomodulus carchedonius (Lamarck, 1822)	0	1
Turbonilla aracruzensis Pimenta & Absalão, 2004	0	1
Turbonilla atypha Bush, 1899	0	1
Turbonilla rachialis Pimenta & Absalão, 2004	0	1
Turbonilla rushii Bush, 1899	0	1
Turbonilla uruguayensis Pilsbry, 1897	0	1
Turritella hookeri Reeve, 1849	0	1
Urosalpinx haneti (Petit de la Saussaye, 1856)	1	1
Vermicularia fargoi Olsson, 1951	0	1
Volvarina avena (Kiener, 1834)	0	1
Volvarina serrei (Bavay, 1913)	0	1
Zidona dufresnei (Donovan, 1823)	1	1

TABLE 3

List of marine gastropods in the Sambaquis and present times of the coast of Rio de Janeiro.

	Bivalves	Gastropods	Mollusks	Feeding Guilds
Sambaquis	70	55	125	6
Present time	189	231	420	7

TABLE 4

Number of species of Mollusks, of the two classes (Bivalves and Gastropods) and of feeding guilds in the two inventories (sambaquis and present time).

Taxonomic distinctness results are not statistically deviant from the average of taxonomic distinctness of 1000 random samples of the same size for gastropods (p=56.3%) tested independently and for mollusks (p=90.7%) as a whole (Figure 2). Therefore, the taxonomic distinction found in sambaquis are comparable with those from random samples, having the differences found among them a chance of occurrence by chance alone higher than 50%. Variation of the taxonomic distinctness is also not statistically deviant for both gastropods (p=37%) and mollusks (p=19.6%). However, bivalves deviate significantly to both average (p= 1.8%) and variation (p= 1.2%) of taxonomic distinctness. This result shows that the characteristic of artificial accumulation can have an effect in the variation of the taxonomic distinctness. Finally, the Mann-Whitney test (Table 5) showed that for functional diversity there is no significant differences among sambaquis and present times feeding guilds composition or number of species (p=0.30).

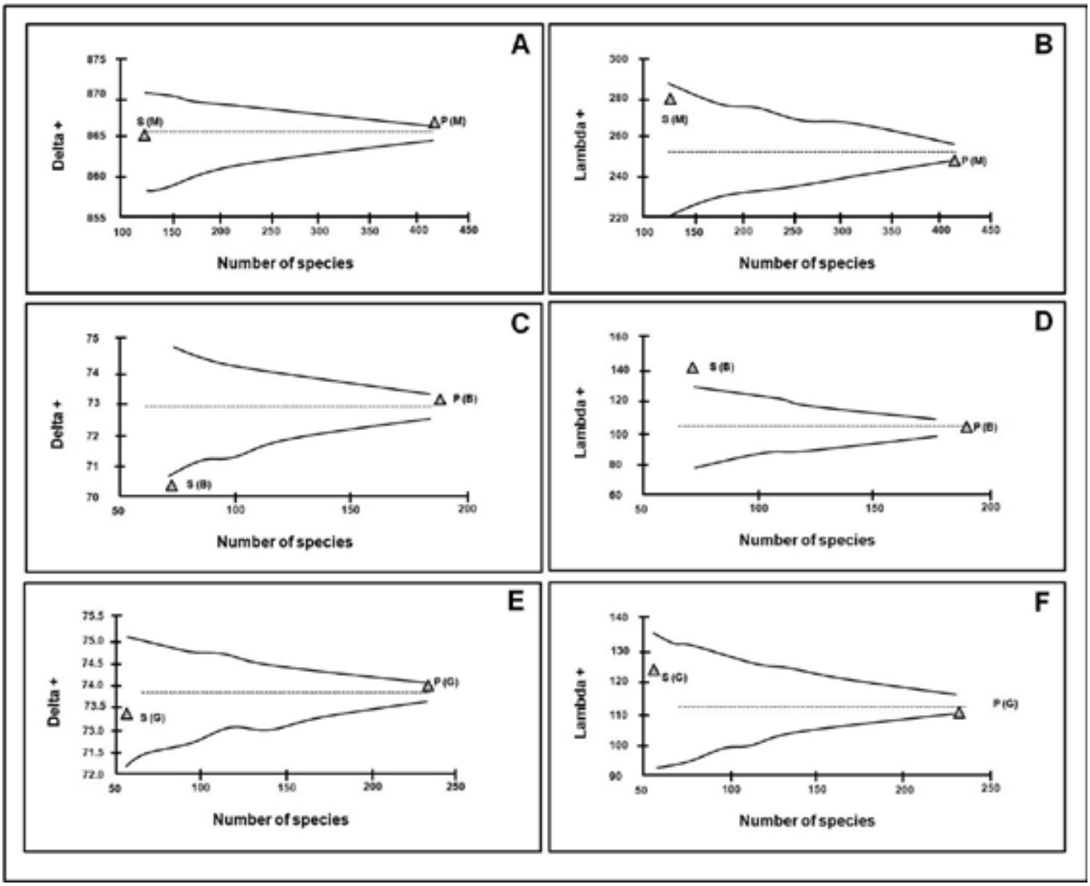

FIGURE 2

The graphs show results for average taxonomic distinctness (Delta +) and variation in taxonomic distinctness (Lambda +) for the inventories. The triangles represent the values found for the sambaquis (S) and present times (PT) and the lines (funnel) represent the limit of 95% confidence. B, G and M stands for Bivalves, Gastropods and Mollusks respectively.

	Sambaquis	Present times	Mann-Whitney
Suspensivorous	44	58	
Carnivorous	16	26	
Herbivorous	05	10	$p = 0.30$
Saprophagous	01	02	
Parasite	00	02	
Xilophagous	01	04	
Depositivorous	02	04	

TABLE 5

Number of species of the different feeding guilds in the two inventories and the probability of these numbers being significantly different (Mann-Whitney test). For this test were used only the species which it was possible to define unambiguously their feeding guild, therefore, the number of species is less than the total number of species registered both for sambaquis and present times.

DISCUSSION

An outstanding problem regarding biodiversity studies is how to bring to the field an historical and evolutionary perspective. Long term information on patterns of animal's diversity is generally absent, scarce or inadequate. Shell mounds are considered an example of the last case. As artificial monuments, they are not recognized as proxies for biodiversity studies since all their biological remains were accumulated following cultural demands such as the use of the animals for food, ornaments, construction material etc. It is axiomatic that, in order to extrapolate regional biodiversity of any group of organisms from a death assemblage at one location, that assemblage must have been constituted by processes which randomize the species composition from a wide range of habitats and must not be biased by the over-representation of species characterizing a habitat or a location. Thus, sambaquis are, in principle, not adequate as proxy for biodiversity since they are notoriously artificial accumulations subject to many cultural bias and taphonomic processes.

However, the first noticeable feature emerging from the results obtained here is that sambaquis kept information on 30% of the species which were inventoried for present day mollusks communities. That is a surprising result as information regarding nowadays species includes the full range of environments for the whole area of study and for several different sampling methods utilized by malacologists (see Rios, 1994, 2009 for the array of methods used to produce his books on Brazilian Seashells). In contrast, sambaqui people gathering practices were restricted to manual collection carried out during low tide or by the use of simple tools manufactured of shells, bones or animal teeth and lithic artifacts. This activity was also limited to relatively nearby areas of the exploitation areas of people from sambaquis (Waselkov, 1987). Furthermore, Souza *et al*. (2010a) showed that single malacological inventories for large areas such as São Paulo Coast (Arruda *et al*., 2003) and Southeast Brazilian Coast (Denadai *et al*., 2001) were able to sample as little as 6.5% and 3.4% respectively of the total number of species for these areas. Comparing with other taxa found in sambaquis, Mendes *et al*. (2018) showed that only 17.6% of all fish species found in the coast of Rio de Janeiro were found in an inventory of all sambaquis for the same region. Therefore, 30% is by no means a negligible number of species on such circumstances. The same is true regarding the feeding guilds, but in this case, the fact that one single species would account for the presence of the alimentary habit in the inventory is the obvious explanation for the absence of only one feeding guild in the sambaquis inventory.

In order to test the quality of all this information kept in sambaquis, two biodiversity inferences were made, one regarding taxonomic distinctness and the other trophic diversity of the mollusk fauna present in the sambaquis archaeological vestiges. Both, for taxonomic distinctness and trophic diversity, sambaquis showed to be representative of the biodiversity of the regional mollusks living fauna of the same region, holding the case that sambaquis can be used as a surrogate for patterns of biodiversity from late Holocene. This result is in accordance with previous tests (Faria *et al*., 2014; Pádua *et al*., 2016; Silva *et al*., 2017).

The ecology of the predominant species found in sambaquis has been used as a paleo-environmental proxy for long (Morey *et al*., 2002; Sandweiss, 2003; Fa, 2008; Van Der Schriek *et al*., 2008; Souza *et al*., 2010a; Mendes *et al*., 2014). For instance, Amesbury (2007) working on archaeological sites from the Mariana Islands observed a reduction in the abundance of *Anadara antiquata* (Linnaeus, 1758) starting 4000 BP. On the Brazilian coast a decrease of mollusc biodiversity during the Holocene was inferred by Beauclair *et al*. (2016) studying sambaquis around Lagoa de Araruama (Rio de Janeiro), what was also described by Souza *et al*. (2016) studying sambaquis of three different localities from the Southeast Brazilian Coast (Rio de Janeiro, Santa Catarina and São Paulo). In all these cases, the decrease in the mollusc diversity was associated with the changes in sea level that happened in the period. However, regarding the use of sambaquis as proxy of biodiversity have been much discussion and distrust. The results showed here dispel doubts that sambaquis can be used as good surrogates from past biodiversity. Therefore, the distrust can be exchanged for a promising horizon of research about evolution of patterns of biodiversity using sambaquis as proxy for this aim.

CONCLUSIONS

The results presented here in this study have shown that malacological vestiges from sambaquis are good repositories of information on pattern of biodiversity, both from a taxonomic distinctness and functional diversity standpoints. Therefore, studies on diversity which has been based mainly on patterns of communities' geographical variation can now benefit from long term information such as those from sambaquis which date from Late Holocene. One of the great advantages associated with long run information on biodiversity is that it can be used to identify environmental changes beyond timescales of direct human experience, bringing to biodiversity studies a historical and evolutionary perspective.

ACKNOWLEDGMENTS

The authors would like to thank CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) and CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) due to scholarships for MR Duarte (PNPD) and SC Pádua (PIBIC) respectively.

REFERENCES

Amesbury, J.R. 2007: Mollusk collecting and environmental change during the prehistoric period in the Mariana Islands. *Coral Reefs* 26: 947-958.

Antolí, V.F. & García-Cubas, A. 1985: Sistemática y ecología de moluscos em las lagunas costeras Carmen y Machona, Tabasco, México. *Anales del Instituto de Ciencias del Mar y Limnologia de la Universidad Nacional Autônoma de Mexico* 12: 145-198.

Arruda, E.P.; Domaneschi, O. & Amaral, A.C.Z. 2003: Mollusc feeding guilds on sandy beaches in São Paulo State, Brazil. *Marine Biology* 143: 691-701.

Baiser, B.; Ardeshiri, R.S. & Ellison, A.M. 2011: Species richness and trophic diversity increase decomposition in a co-evolved food web. *PLoS ONE* 6(5): e20672.

Baisre, J. 2010: Setting a baseline for Caribbean fisheries. *Journal of Island and Coastal Archaeology* 5: 120-147.

Beauclair, M.A.; Duarte, M.R. & Silva, E.P. 2016: Sambaquis (shell mounds) and mollusk diversity in the past history of Araruama Lagoon, Rio de Janeiro, Brazil. *Pan-American Journal of Aquatic Sciences* 11: 47-59.

Clarke, K.R. & Warwick, R.M. 1998: A taxononomic distinctness index and its statistical properties. *Journal of Applied Ecology* 35: 523-531.

Denadai, M.R.; Amaral, A.C.Z. & Turra, A. 2001: Spatial distribution of molluscs on sandy intertidal substrates with rock fragments in south-eastern Brazil. *Estuarine, Coastal and Shelf Science* 53: 733-743.

Fa, D. 2008: Effects of tidal amplitude on intertidal resource availability and dispersal pressure in prehistoric human coastal populations: The Mediterranean-Atlantic transition. *Quaternary Science Reviews* 27: 2194-2209.

Faria, R.G.S.; Silva, E.P. & Souza, R.C.C.L. 2014: Biodiversity of Marine Molluscs from Sambaqui da Tarioba, Rio das Ostras, Rio de Janeiro (Brazil). *Revista Chilena de Antropologia* 29(1): 49-54.

Lima, T.A. 2000: Em busca dos frutos do mar: os pescadores-coletores do litoral centro-sul do Brasil. *Revista USP* 44: 270-327.

Lima, T.A.; Macário, K.D.; Anjos, R.M.; Gomes, P.R.S.; Coimbra, M.M. & Elmore, E. 2002: The antiquity of the prehistoric settlement of the central-south Brazilian coast. *Radiocarbon* 44: 733-738.

— 2003: AMS dating of early shellmounds of the southeastern Brazilian coast. *Brazilian Journal of Physics* 33: 276-279.

Lindbladh, M.; Brunet, J.; Hannon, G.; Niklasson, M.; Eliasson, P.; Eriksson, G. & Ekstrand, A. 2007: Forest history as a basis for ecosystem restoration: a multidisciplinary case study in a south Swedish temperate landscape. *Restoration Ecology* 15: 284-295.

Mendes, A.B.; Silva, E.P. & Souza, R.C.C.L. 2014: Biodiversity of Marine Fishes from Shellmounds of Ilha Grande Bay, Rio de Janeiro, Brazil. *Revista Chilena de Antropología* 29: 55-59.

Mendes, A.B.; Duarte, M.R. & Silva, E.P. 2018: Biodiversity of Holocene marine fish of the southeast coast of Brazil. *Biota Neotropica* 18(1): e20170394.

Morey, D.F.; Crothers, G.M.; Stein, J.K.; Fenton, J.P. & Herrmann, N.P. 2002: The fluvial and geomorphic context of Indian Knoll, an Archaic shell midden in West-Central Kentucky. *Geoarchaeology* 17(6): 521-553.

Padua, S.C.; Duarte, M.R. & Silva, E.P. 2016: Recuperação de padrões de biodiversidade a partir de vestígios zooarqueológicos de sambaquis. In: *III Encuentro Latinoamericano de Zooarqueologia*, Aracaju, Brasil.

Rios, E.C. 1994: *Seashells of Brazil*. FURG, Rio Grande.

— 2009: *Compendium of brazilian sea shells*. Evangraf, Rio Grande.

Sandweiss, D.H. 2003: Terminal Pleistocene through mid-Holocene archaeological sites as paleoclimatic archives for the Peruvian coast. *Palaeogeography, Palaeoclimatology, Palaeoecology* 194(1-3): 23-40.

Scheel-Ybert,R.;Eggers,S.;Wesolowski,V.;Petronilho, C.C.; Boyadjian, C.H.; Gaspar, M.D.; Barbosa-Guimarães, M.; Tenório, M.C.; Deblasis, P. 2009: Subsistence and lifeway of coastal Brazilian moundbuilders. *Treballs d' Etnoarqueologia* 7: 37-53.

Silva, E.P.; Pádua, S.C.; Souza, R.C.C.L. & Duarte, M.R. 2017: Shell Mounds of the Southeast Coast of Brazil: Recovering Information on Past Malacological Biodiversity. In: Mondini, M.; Muñoz, A.S. & Fernández, P.M. (eds.): *Zooarchaeology in the Neotropics*. Springer International Publishing, New York.

Souza, R.C.C.L.; Trindade, D.C.; Decco, J.; Lima, T.A. & Silva, E.P. 2010a: Archaeozoology of marine mollusks from Sambaqui da Tarioba, Rio das Ostras, Rio de Janeiro, Brazil. *Zoologia* 27: 363-371.

Souza, R.C.C.L., Lima, T.A. & Silva, E.P. 2010b: Holocene molluscs from Rio de Janeiro state coast, Brazil. *Check List* 6(2): 301-308.

— 2011: *Conchas Marinhas de Sambaquis do Brasil*. Technical Books Editora, Rio de Janeiro.

— 2012: Remarks on the biodiversity of marine molluscs from late Holocene Brazilian shell mounds. In: Christine, L. (ed.): *Proceedings of the General Session of the 11th International Council for Archaeozoology Conference*. Archaeopress, Oxford.

Souza, R.C.C.L.; Lima, T.A.; Duarte, M.R. & Silva, E.P. 2016: Changes in patterns of biodiversity of marine mollusks along the Brazilian coast during the late Holocene inferred from shell-mound (sambaquis) data. *Holocene* 26(11): 1802-1809.

Van Der Schriek, T.; Passmore, D.G.; Mugica, F.F.; Stevenson, A.C.; Boomer, I. & Rolão, J. 2008: Holocene palaeoecology and floodplain evolution of the Muge tributary, Lower Tagus Basin, Portugal. *Quaternary International* 189: 135-151.

Villagran, X.S. & Giannini, P.C.F. 2014: Shell mounds as environmental proxies on the southern coast of Brazil. *The Holocene* 24(8): 1009-1016.

Waselkov, G.A. 1987: Shellfish gathering and shellmidden archaeology. In: Schiffer, M.B. (ed.): *Advances in Archaeological Method and Theory* 10: 93-210. Academic Press, New York.

Worms Editorial Board 2018: *World Register of Marine Species*. Available from http://www.marinespecies.org at VLIZ. Accessed 2018-10-01. doi:10.14284/170.