Biodiversity of Marine Molluscs from Sambaqui da Tarioba, Rio das Ostras, Rio de Janeiro (Brazil)

Biodiversidad de Moluscos Marinos del Sambaqui Da Tarioba, Rio das Ostras, Rio de Janeiro (Brasil)

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ABSTRACT

Shellmounds are archaeological sites found in almost all coastal areas around the world that have been recognized as artificial constructions dating between 8.000 and 2.000 years B.P. The Sambaqui da Tarioba has a malacological inventory with a total of 47 species. This set of species was accumulated over long periods, therefore, constitute a sample of the past diversity of molluscs in this region. To assess the representativeness of the shellmounds as a sampler of the marine molluscs diversity, data from this archaeological site were compared with present day inventory of molluscs from Rio de Janeiro coast. To describe the malacological diversity, two indices were used: average taxonomic distinctness (AvTD), defined as the average taxonomic path length between any two randomly chosen species, traced through a phylogenetic classification of the full set of species involved and variation in taxonomic distinctness (VarTD), which reveals the evenness of the distribution of taxa across the hierarchical taxonomic tree. The results indicate that the set of species recorded for Sambaqui da Tarioba is able to recover the biodiversity of a random sample of 47 species from the total inventory of molluscs recorded for Rio de Janeiro. This means that the malacological taxonomic diversity recorded for the Sambaqui da Tarioba is representative of that which is currently present in the coast of Rio de Janeiro state. This demonstrates that the use of shellmounds as a proxy of Holocene biodiversity can be a promising approach.

Key Words: Shellmounds, Biodiversity, Marine Molluscs, Taxonomic Distinctness, Archaeozoology.

RESUMEN

Los concheros son sitios arqueológicos que se encuentran en casi todas las zonas costeras de todo el mundo y que han sido reconocidas como construcciones artificiales fechadas entre 8.000 y 2.000 años A.P. El conchero de Tarioba contiene un total de 47 especies de moluscos.

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Este conjunto de especies acumulado durante largos períodos constituye una muestra de la diversidad malacológica del pasado en la región. Para evaluar la representatividad de las especies marinas en los concheros se comparó la diversidad de los moluscos del Holoceno y del Reciente en la costa del estado de Río de Janeiro. Para analisar la diversidad malacológica, se utilizaron dos índices: distinción taxonómica promedio (AvTD), que se define como la longitud del camino promedio taxonómico entre dos especies escogidas al azar, trazada a través de una clasificación filogenética de la serie completa de las especies involucradas y la variación en la diferenciación taxonómica (VarTD), lo que revela la uniformidad de la distribución de los taxa a través del árbol taxonómico jerárquico. Los resultados indican que el conjunto de las especies registradas para el conchero da Tarioba son capaces de recuperar significativamente la biodiversidad de una muestra aleatoria de 47 especies del inventario total. Esto significa que la diversidad taxonómica registrada para el conchero de Tarioba es representativa de la malacofauna de la costa del estado de Río de Janeiro. Lo cual demuestra la utilidad de los registros zooarqueológicos como un proxy de la biodiversidad del Holoceno.

Palabras Claves: Sambaquis, Biodiversidad, Moluscos Marinos, Distinción Taxonómica, Arqueozoología.

INTRODUCTION

Shellmounds, sambaquis or shellmiddens are artificial constructions built by prehistoric human populations dating back 8000-2000 years BP (Lima *et al.* 2003). They consist primarily of food debris, such as mollusc shells, crustaceans and sea urchins carapaces, mammals' bones, stone artifacts, fire debris and human burials (Gaspar 2000). Mollusc shells are very abundant in sambaquis enabling the recovery of information about the diversity of these animals during the Holocene (Reitz & Wing 2008).

The archaeological site of Sambaqui da Tarioba, located in the municipality of Rio das Ostras, state of Rio de Janeiro (22°31'40"S, 41°56'22"W), was discovered in 1967 and was well preserved at the time. However, the first phase of digging took place only in 1998-99, when 2/3 of the site had already been destroyed. As a result of this digging, the Sambaqui da Tarioba Museum was created, presenting an in situ sample of the material recovered during the excavation. Datings obtained for the site range from 3,620 to 3,440 years BP (Dias *et al.* 2001). In 2007, excavation of another part of this site was carried out, which was located on a plot of land next to the museum.

The Sambaqui da Tarioba has a malacological inventory with a total of 47 species, including bivalves and gastropods (a list of these species and their ecological setting are detailed in Souza *et al.* 2010). This set of species was accumulated over long periods of prehistoric human exploration of their territory, therefore, constituting a sample of the past diversity of molluscs in this region (Dias *et al.* 2001, Trindade 2001, Lima 2000, Figuti 1993). To assess the representativeness of the shellmounds as a sampler of the marine molluscs diversity of the past, patterns of biodiversity recorded for the Sambaqui da Tarioba were compared with those found in an inventory of species recorded for Rio de Janeiro coast. The null hypothesis on test was that phylogenetic diversity of marine molluscs found in this shellmound retrieves the current pattern of diversity. The possibility of using shellmounds as a sampler of Holocene biodiversity opens the prospect of studying the evolution of patterns of biodiversity along the Brazilian coast over the last ten thousand years.

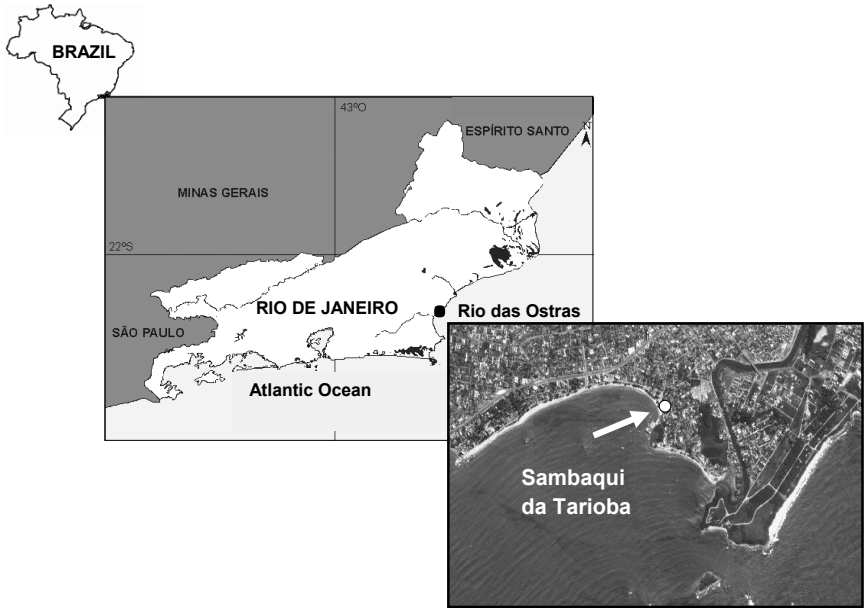

Figure 1: Location of Sambaqui da Tarioba, Rio das Ostras, Rio de Janeiro, Brazil.

Figure 1: Ubicación del Sambaqui da Tarioba, Rio das Ostras, Rio de Janeiro, Brasil.

METODOLOGY

Sampling

Malacological material from the Sambaqui da Tarioba was obtained from the discarded material of previous excavations by authorization of the responsible archaeologist Denise Chamum Trindade. The shell matter was separated from the sediment and other faunal remains by means of a 0.5 mm sieve and/or brush. The malacological material was sorted in its totality by the following procedure: a) selection of bivalves and gastropods; b) cleaning with the help of a brush, in those cases where there was much sediment adhering to the shells and c) washing the shells so as to facilitate observation.

Shells were identified at the lowest possible taxonomic level, based on: Souza *et al.* (2011) and Rios (1994, 2009). The following shell characteristics were analyzed: a) bivalves - shape, type of hinge and sculpture, presence and shape of muscle scars, palial sinus and palial line; b) gastropods - shape, type of spire and sculpture, outer lip, columellar folds, siphonal and posterior canals. After identification, the shells were bagged, labeled and placed in boxes.

Statistical analysis

Two data matrices were produced in order to compare patterns of mollusc diversity. The "master list" was a list of all marine molluscs recorded for the Sambaqui da Tarioba (Souza *et al.* 2010) plus all species of marine molluscs recorded for the state of Rio de Janeiro (Rios 2009, 1994). The following criteria were used in order to standardize the data: (a) distribution in the area that comprises the State of Rio de Janeiro; (b) shell size greater than or equal to 5 mm; (c) not unique to oceanic islands; (d) benthic; (e) occurring up to 30 m deep. Additional information was obtained from the sites Malacolog (http://www.malacolog.org) and Conquiliologistas do Brasil (http://www.conchasbrasil.org.br). Taxonomic classification was compiled for each species. The second matrix displays presence and absence data for all species compiled in the "master list".

To describe the malacological 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 or phylogenetic classification of the full set of species involved (Clarke & Warwick 1998). It is mathematically defined as:

AvTD $$\Delta^+ = \left[\sum\sum_{i<j} \omega_{ij}\right] \Big/ [s(s-1)/2]$$

where S is the number of species, ωij is the taxonomic distances through the classification tree between every pair of species (the first from species i and the second from species j), and the double summation ranges over all pairs i and j of these species (i e j). 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 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 samples. It is given by:

VarTD $$\Lambda^+ = \left[\sum\sum_{i\neq j} (\omega_{ij} - \bar{\omega})^2\right] \Big/ [s(s-1)]$$

where W is the branch length between pairs of species, S is the number of species observed in that sample and W is the average taxonomic distinctness for the sample as defined above. 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, 2001b). In this approach, a randomization test was used to detect the expected delta+ and lambda+ values derived from a regional species pool (master list). If the measured value for Sambaqui da Tarioba falls outside the 95% probability limits, then statistically it cannot be considered representative of the "master list". If the values fall within these limits then the shellmound is not significantly different in taxonomic structure from the "mater list" (Tomilieri & Anderson 2010, Clarke & Warwick 2001b). It is useful to examine both AvTD and VarTD because they capture independent aspects of the taxonomic diversity in a data set. These index were calculated using *Primer-E v.5* (Clarke & Warwick 2001a, 1998).

RESULTS

The inventory of marine molluscs from Sambaqui da Tarioba showed a value of taxonomic distinctness which is high and deviant from the average, although not statistically significant (Figure 2). Therefore, it is possible to conclude that the pattern of marine molluscs diversity for this shellmound retrieves the diversity pattern found in current days. This holds not just for the exploration area of prehistoric human populations, but also for a much larger region such as the whole Rio de Janeiro coast. This conclusion stands not only for a geographical point of view, but also from the standpoint of the ecological characteristics, since the "master list" comprises a range of environments which surpass those that the 47 species recorded for the Sambaqui da Tarioba can encompass.

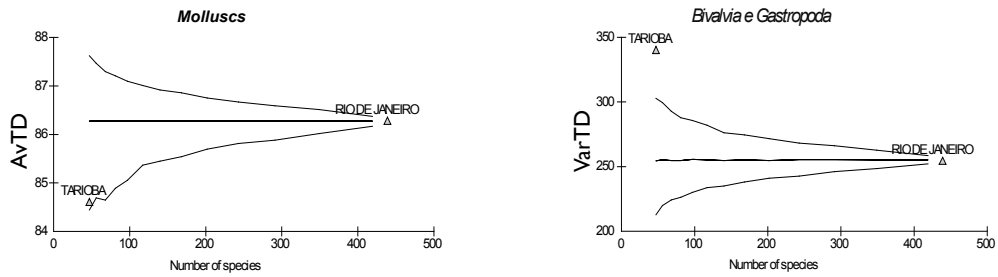

Figure 2: Average taxonomic distinctness and variation in taxonomic distinctness of marine molluscs species. The triangles represent the values found for the Sambaqui da Tarioba and Rio de Janeiro and lines (funnel) represent the limit of 95%.

Figure 2: Distinción taxonómica promedio y variación de la distinción taxonómica de las especies de moluscos marinos. Los triángulos representan los valores encontrados para el Sambaqui da Tarioba y Río de Janeiro y las líneas (embudo) representan el límite del 95%.

Marine molluscs variation of the taxonomic distinctness deviated significantly for the Sambaqui da Tarioba indicating non-random sampling (Figure 2). This result is expected since shellmounds are artificial accumulation of shells that were selected by prehistoric populations according to its utility as food, ornament, tools and other functions. Although, this selective collection can explain part of the variation of taxonomic distinctness, comparisons between different geographical scales (such as those performed here: local scale-Sambaqui da Tarioba *versus* regional scale-Rio de Janeiro state) can have also influenced the high variance found.

Analysis done separately for bivalves and gastropods showed the group of bivalves presenting the higher taxonomic distinctness average and variance, however, not deviating significantly from the expected from a random sampling (Figure 3). Gastropods group is less deviant and closer to the expected average for a sample of equivalent size (Figure 4). These results indicate that gastropods have a higher phylogenetic diversity when compared with Bivalvia, even though the number of species is higher for the latter. This is evidence that none of the two, bivalves or gastropods, was responsible alone for the statistically significant deviation in the variation of taxonomic distinctness observed for marine molluscs as all.

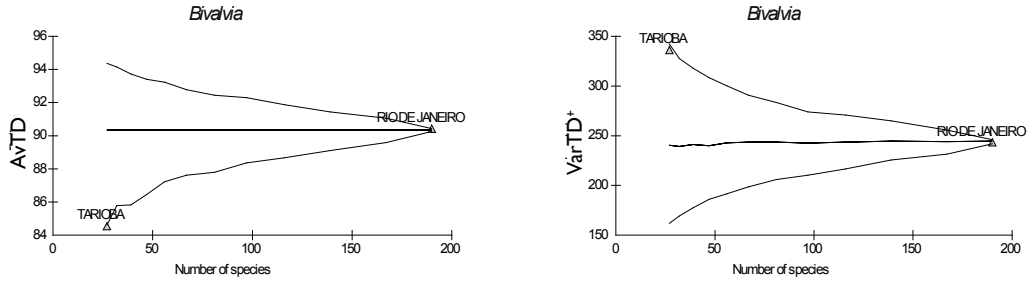

Figure 3: Average taxonomic distinctness and variation in taxonomic distinctness of the species of bivalves. The triangles represent the values found for the Sambaqui da Tarioba and Rio de Janeiro and lines (funnel) represent the limit of 95%.

Figure 3: Distinción taxonómica promedio y variación de la distinción taxonómica de las especies de bivalvos. Los triángulos representan los valores encontrados para el Sambaqui da Tarioba y Río de Janeiro y las líneas (embudo) representan el límite del 95%.

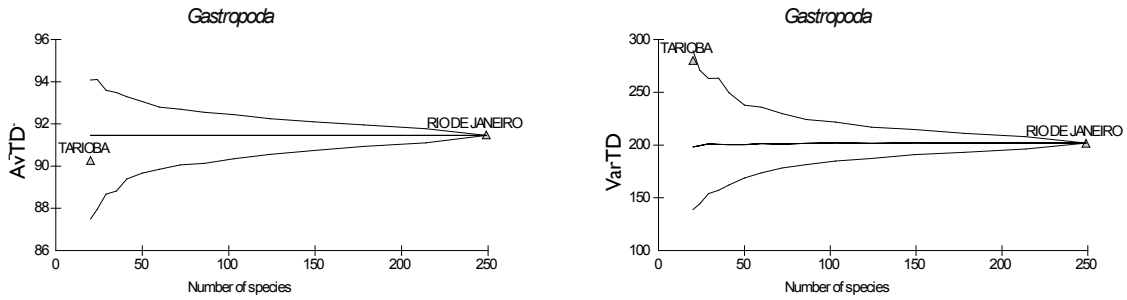

Figure 4: Average taxonomic distinctness and variation in taxonomic distinctness of the species of gastropods. The triangles represent the values found for the Sambaqui Tarioba and Rio de Janeiro and lines (funnel) represent the limit of 95%.

Figure 4: Distinción taxonómica promedio y variación de la distinción taxonómica de las especies de gasterópodos. Los triángulos representan los valores encontrados para el Sambaqui da Tarioba y Río de Janeiro y las líneas (embudo) representan el límite del 95%.

CONCLUSION

The results presented here clearly indicate that the set of species recorded for Sambaqui da Tarioba is able to recover the biodiversity of a random sample of 47 species from the "master list". This means that the malacological taxonomic diversity recorded for the Sambaqui da Tarioba is representative of that which is currently present in the coast of Rio de Janeiro state. However, the average taxonomic distinctness is on the limit of statistic significance. This result is expected due to the fact that shellmounds represents an artificial accumulation of shells. A peculiar and quite evident feature of archaeological sites is that the presence of organisms is related to the selectivity of the populations that built them. Diverse factors, such as culture, preferences, technical level, food taboos, and the way the shells were discarded and/or utilized as building material certainly played a relevant role on the composition of the fauna found in shellmounds. Other questions to be considered are differences in species preservation potential and the researcher choices (objectives, excavated area, type of mesh used etc.). Moreover, the comparisons were made between two very distinct ecological meshes (local *versus* regional scales). A more appropriate test should compare only the local scale (Rio das Ostras region *versus* Sambaqui da Tarioba). However, an inventory of the malacological fauna of the Rio das Ostras region is not currently available.

In summary, the main conclusion reached in this work is that despite any methodological limitation, the inventory of malacological fauna from Sambaqui da Tarioba is not significantly different in taxonomic structure from the full list of species from the Rio de Janeiro coast ("master list"). This demonstrates that the use of shellmounds as a proxy of Holocene biodiversity can be a promising approach.

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