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Contributions to Moa's Shellmound: fish microfossils analysis

Graduate Biologist Sauri Moreira Machado
Museu Paraense Emílio Goeldi. Avenida Perimetral da Ciência nº1901, Terra Firme, Zip Code: 66077-530, Belem, Para, Brazil. E-mail: sauri.machado@gmail.com

Graduate Biologist Zoneibe Augusto Silva Luz
Museu Paraense Emílio Goeldi. Avenida Perimetral da Ciência nº1901, Terra Firme, Zip Code: 66077-530, Belem, Para, Brazil. E-mail: zoneibe.luz@gmail.com

Doctor José Francisco Berrêdo Reis da Silva
Museu Paraense Emílio Goeldi. Avenida Perimetral da Ciência nº1901, Terra Firme, Zip Code: 66077-530, Belem, Para, Brazil. E-mail: berredo@museu-goeldi.br

Doctor Maura Imazio da Silveira
Museu Paraense Emílio Goeldi. Avenida Perimetral da Ciência nº1901, Terra Firme, Zip Code: 66077-530, Belem, Para, Brazil. E-mail: maura@marajoara.com

Doctor Sue Anne Regina Ferreira da Costa
Museu Paraense Emílio Goeldi. Avenida Perimetral da Ciência nº1901, Terra Firme, Zip Code: 66077-530, Belem, Para, Brazil. E-mail: sue.costa@gmail.com

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ABSTRACT

This study is the presentation of the material from fish microfossils collected in Moa's Shellmound, located in Saquarema, Rio de Janeiro state. The new use of two associated techniques: the flotation and re-screening using different granulometric sizes, allowed the recovery of 1662 Euteleostean microteeth, in fossilization process by substitution. These were initially separated into nine types, which will be used in future for more refined taxonomic descriptions. Thus, contributing to increased information about the Moa's Shellmound, considered an important indicators of prehistoric fishermen populations who inhabited the brazilian coast.

PALAVRAS-CHAVES:
Sambaqui,
Zooarqueologia
Microdentes

RESUMO – CONTRIBUIÇÕES A ZOOARQUEOLOGIA DO SAMBAQUI DO MOA/RJ: ANÁLISE DE MICROVESTÍGIOS DE PEIXES. Este trabalho é a apresentação do material de

microvestígios de peixes coletados no Sambaqui do Moa, localizado em Saquarema, estado Rio do Janeiro. A utilização inédita de duas técnicas associadas: a de flotação e repeneiragem utilizando granulometrias diferenciadas possibilitou a recuperação de 1662 microdentes de Euteleostei, em processo de fossilização por substituição. Estes foram separados inicialmente em nove tipos que serão utilizados futuramente para descrições taxonômicas mais refinadas. Contribuindo, assim, com o aumento de informações a cerca do Sambaqui do Moa, considerado um importante indício das populações de pescadores pré-históricos que habitaram o litoral brasileiro.

PALABRAS-CLAVES:
Sambaqui,
Zooarqueología
Microdientes

RESUMEN – CONTRIBUCIÓN A LA ZOOARQUEOLOGÍA DEL SAMBAQUI DE MOA/RJ: ANALISIS DE MICROVESTÍGIOS DE PECES. Este trabajo es la presentación del material de micro vestigios de pescados recolectados en el Sambaqui do Moa, ubicado en Saquarema, en la provincia de Rio de Janeiro. La utilización inédita de dos técnicas asociadas: la de flotación y retamización utilizando granulometrías diferenciadas, lo que posibilitó la recuperación de 1662 micro dientes de Euteleostei, en proceso de fosilización por sustitución. Estos fueron separados inicialmente en nueve tipos que serán utilizados futuramente para descripciones taxonómicas más esmerada. Contribuyendo, así, con el aumento de informaciones acerca del Sambaqui do Moa, considerado un importante indicio de las poblaciones de pescadores pre-históricos que habitaron el litoral brasileño.

1. Introduction

The shellmounds are archaeological sites distributed not only along the Brazilian coast, as in other world regions, like United States, Australia, Peru, Iberia and Israel (LLORCA; CAHIZA, 2007; TERREROS, 2001; ZOHAR *et al.*, 2001). These characterized as deposits mainly formed by shells and distributed in surface and depth. And can be represented by elevations of rounded shape and varying size, reaching 500 m. long as some shellmounds located in south of Santa Catarina (DeBLASIS *et al.*, 2007; GASPAR, 2000).

Recognized as works of natural and human activity, the shellmounds are the physical register of a prehistoric fishermen population, even if important regional differences exist, and there is no available data on the regional political structures of the same, the homogeneity of the lithic and bone industries, as well as structural features the sites themselves, it's possible affirm that all the shellmounds of the Brazilian coast belonged to the same sociocultural system (SCHEEL-YBERT *et al.,* 2003).

These sites are rich in archaeological remains, whether organic or mineral origin, allow the investigation of technological and cultural patterns of preterit populations (GONZALEZ et al., 2003). Just as variations in sea level (SCHEEL-YBERT *et al.*, 2006; ZOHAR *et al.*, 2001), and paleoenvironments, in the latter case, mainly using bioindicators species (CASTILHO; SIMÕES-LOPES, 2001; EVANS, 1972; SCHEEL-YBERT *et al.*, 2006).

Among the recorded shellmounds in Brazil coats, stands out Moa's Shellmound, located in Itaúna neighborhood, city of Saquarema, Rio de Janeiro state (Figure 1-A) (KNEIP, 1994). This stands out not only for its size (area around 2.800m²), but also by the diversity of vestiges found along the three strata, horizontally recognized at the site during excavation (Figure 1-B) (SILVEIRA, 2001).

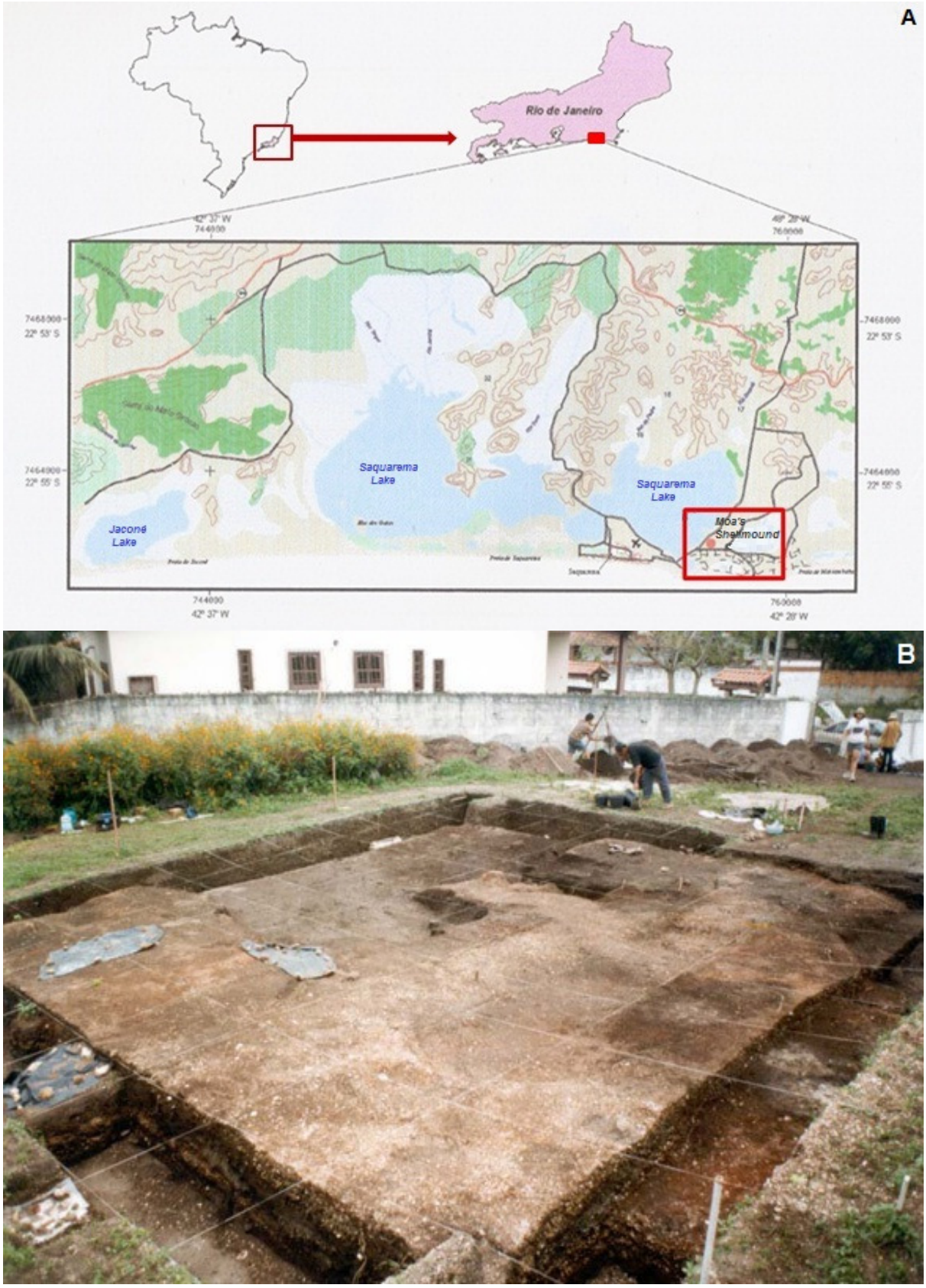

Figure 1. (A) Moa's Shellmound localization and (B) View of the area excavated (Source: SILVEIRA, 2001).

Moa's Shellmound is divided into three stratigraphies that represents different stages of occupation and were determined by natural levels excavated by Silveira (2001), dating by Applied Nuclear Physics Laboratory of the Geosciences Institute and Physics Institute of UFBa and based on criteria such as soil color, composition, quantity of shells and bones of vertebrates as well as human burials. From the deepest to the most superficial stratigraphies can be briefly described as:

Stratum 3: Sand with patches of red clay and red dye most of them associated to burials, and some patches of coal. Munsell color 5YR between 2.5 / 2 and 3 / 2; 2.5YR 3/2 or 7.5YR 5/2. Is dated by C^{14}, 3960 ± 200 BP, possibly representing the beginning of the occupation has little trace amounts of shellfish in relation to other stratigraphies.

Stratum 2: Brown soil, Munsell color 10YR 3 / 4, with red patches, Munsell 5YR 3/3 or 2.5YR 3/4, most of them associated to burials, and some patches of coal. Probably correspond to the time of intense exploration of the area, and where there is the greater abundance of zooarchaeological material, and human burials. It is a discontinuous stratum, in other word, in some points does not occur.

Stratum 1: Sand and red soil, Munsell color 5YR between 2.5 / 2 and 3 / 3. It's probably related to the last occupation, dated by C^{14}, 3610 ± 190 BP. The remains found in stratum 1, for the others are smaller and highly fragmented, probably because of being closer to the surface. The zooarchaeological material from Moa's Shellmound is composed of invertebrates (molluscs and crustaceans) and vertebrates (fishes, amphibians, reptiles, birds and mammals) (SILVEIRA, 2001).

Among the bone faunal remains recovered during excavations in this site fish remains are makes up over 70% of the expected. According SCHEEL-YBERT (2005), this can be explained because fishes were the main source of food for preterit groups. However, all fragments were recovered from samples with naked eye, made during the excavations. As some groups of fish have skeletal microscopic shares, for example, rays of the family Dasyatidae and Rhinobatidae (CAPPETTA, 1987), the number of fish recovered so far in Moa' Shellmound would be underestimated.
For microfossils recovery in archaeological samples, in general, is used screening of samples in the laboratory with different granulometric intervals (JAMES, 1997), which influence not only the abundance, but also the diversity of the species collected, especially the group of fish, favored at intervals of less than 3 mm (ZOHAR; BELMAKER, 2005).

Fish microscopic remains, like otoliths, scales, teeth and vertebrae, contribute to analysis of diet, customs and technology (BUTLER; CHATTERS, 1994, ZOHAR *et al.*, 2001) of these social groups. As the recovery of species distributions ancient, until now absent for certain areas (ZOHAR; BELMAKER, 2005), which will thus be used not only in refinements of paleoenvironmental reconstructions, but also in biogeographic distribution models (CHAIX; MENIEL, 1997).

Therefore, this article is the result of the first step toward the use of this unprecedented collecting effort for microscopic zooarchaeological material from Moa's Shellmound, with the purpose not only to test the technique, but also to present, for the first time, specimens of fish microteeth recovered sediment from the site, aiming to stimulate new approaches in the area of study.

2. Material and Methods

Altogether 117 samples were collected in an area of 120 m². In first step it was excavated to the base (approximately 1 m. deep), four trenches with the following measures (Table 1):

Table 1. The four trenches and the measures excavated in Moa's Shellmound.

Trench	Measure
Trench 1 (T1)	1m x 18 m.
Trench 2 (T2)	1m x 9 m.
Trench 3 (T3)	1m x 10 m.
Trench 4 (T4)	1m x 8 m.

These trenches surrounding the area that later was checkered by square meters and after the established stratigraphy was excavated by artificial stripping levels of 10 x 10 cm and natural levels following the stratigraphies 1,2 and 3.

The result of the excavation was 72 samples of stratum 1, 7 of stratum 2 and 38 of 3. In the first stage, they went through the wet-screening, (JOHNSON *et al.*, 1994), where the less dense material floats on the surface, being named as the light fraction, and what precipitates in the container is called the heavy fraction. These samples will be re-screening, this time to dry, using granulometric intervals of 60 or 250mm mesh sifter automatic frequency at 2.5 for 5 min. and separated into subsamples of 50g, then to pass through the triage process.

Morphological Analysis

Due to the difficulty of identification, this first time, specimens were classified into broader taxonomic groups, but to facilitate the recognition of different occurrences were marked morphological features of them, which helped further specific identifications.

The first step was to determine general morphologies following Hillson (1986). In Moa's Shellmound was found three general types: canines, incisors and molars (Figure 2).

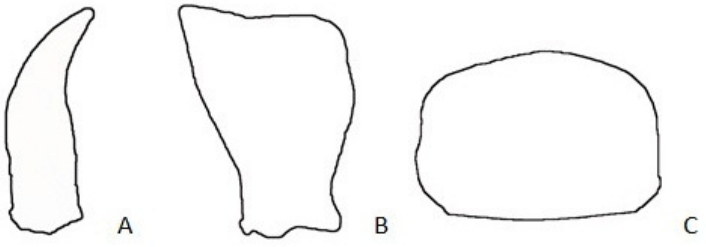

Figure 2. The contour of the teeth general Morphologies found in Moa's Shellmound / RJ: Canines in lateral view (A), Incisor in lingual view (B) Molar and lateral view (C).

The dental morphological variations found following some of the latest features presented in Coded Utilitarian Ichthyolith Identification System (CUIIS), used for microscopic skeletal remains of fish fossils, described in Johns *et al.* (2005), and summarized below (Figure 3).

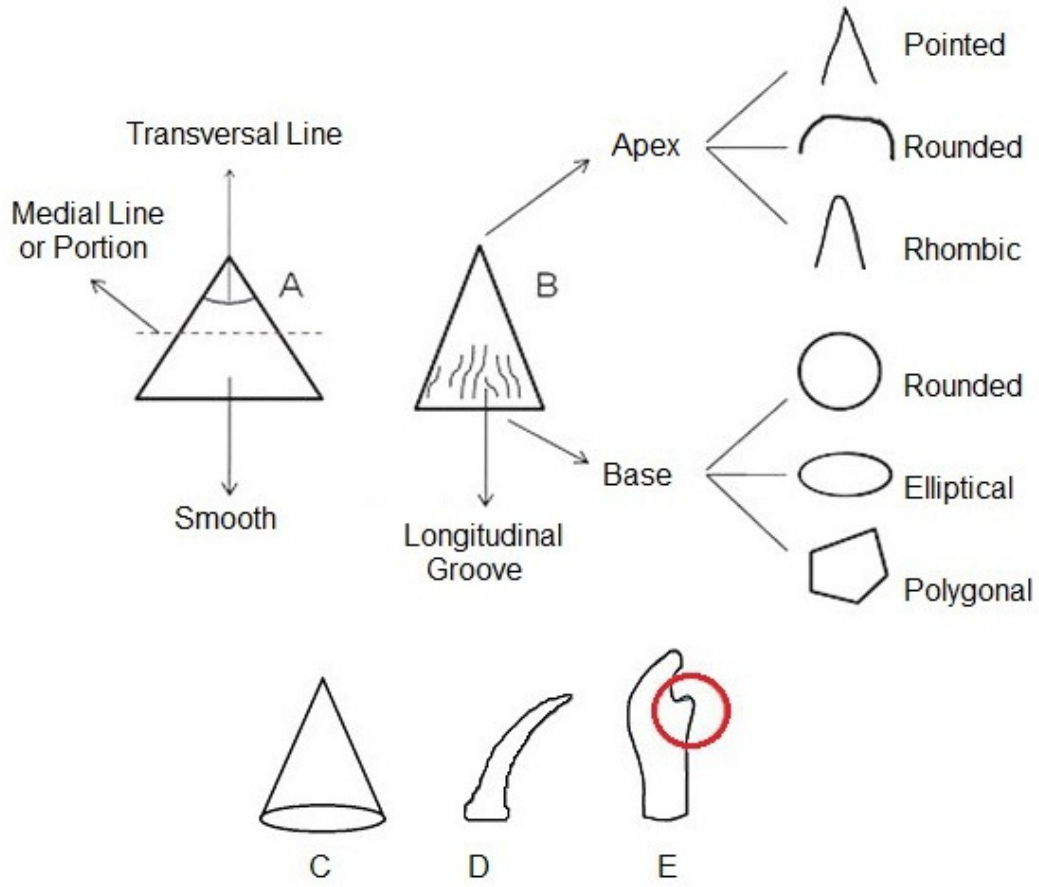

Figure 3. Types of features of dental crown and their definitions: (A) format equilateral triangle, (B) isosceles triangle format, (C) Conical format with repectives apex and bases (D) Tooth with curvature, (E) Tooth with hooking upwards highlighted in transverse cut.(JOHNS et al., 2005 adapted by authors)

Chemical Analysis

The biogeochemical analysis of fossils contributes to understanding the fossilization processes and preservation conditions of animals or plants remains of archaeological sites (SCHLESINGER, 2005; LIMA *et al.*, 2006). In the case of fish, for example, their remains are more vulnerable to degradation than the records of other vertebrates (LYMAN, 2001), are usually preserved: otoliths, teeth, vertebrae and scales (ZOHAR; BELMAKER, 2005, OLIVEIRA *et al.*, 2008). Moreover, the quantity of fish macroscopic remains, when collected, is small compared to microfossils, citing as an example the research of Machado *et al.* (2009), which recovered more than two thousand fish microfossils basically composed of microteeth.

Aimed to ascertain the level of specimens preservation, for the purpose were used microteeth six from each strata. Each specimen underwent micro-analysis by semiquantitative EDS detector (Energy Dispersive Spectropscopy) mark Gresham, equipped with Be (beryllium) window and the Q500 IXRF multichannel analyzer, using its own software. Analyses were obtained with accelerating voltage of 15 kV and reading time of 30 sec.

3. Results and Discussion

Morphological Characterization

Altogether 1662 specimens were recovered, among pharyngeal and jaw teeth of fishes, which in this moment of difficulty accurate identifications are classified within the subdivision Euteleostei. But we should also consider that most of the specimens probably belong to species of fish families who inhabited the coastal area, the environment where it has probably fishing for them. Since the goal of this work is mainly the presentation of the material, then by parsimony, remained the more general classification of nine types were recognized where described as:

Class: Actinopterygii
Subclass: Neopterygii
SubDivision: Euteleostei A
(Figure 4-A)

Material: Lots 55 teeth MPEG-001-ZA, 3 teeth MPEG-002-ZA 19 teeth and MPEG-003-ZA.
Occurrence: Stratigraphies1, 2 and 3.
Description: Teeth with smooth enamel, canine, height and width are approximately equal. In transversal section the base is rounded or slightly elliptical. Apex in lateral view shows rhombic shape.

SubDivision: Euteleostei B
(Figure 4-B)

Material: Lots 32 teeth MPEG-001-ZA and 14 teeth MPEG-003-ZA.
Occurrence: Stratigraphies1 and 3.
Description: Canine tooth with surface smooth, long stem, as a result of the overall height is approximately 4 times greater than width. Displays hooking back up at the top of the crown, similar to that found in teeth of some fish groups. Transverse cut in the base presents round, while the apex in lateral view is pointed or rhombic.

SubDivision: Euteleostei C
(Figure 4-C)

Material: 129 teeth Lots MPEG-001-ZA, 16 teeth MPEG-002-ZA and 64 teeth MPEG-003-ZA.
Occurrence: Stratigraphies1. 2 and 3.
Description: Canine tooth with simple crown surface without streaking, slight bend in the upper part is present. In transversal cut the base is rounded, in lateral view the apex is rhombic and pointed. These teeth are common in several groups belonging to the Perciform order, especially the family Gobiidae (PARENTI;THOMAS, 1998).

SubDivision: Euteleostei D
(Figure 4-D)

Material: Lots 58 teeth MPEG-001-ZA, 7 teeth MPEG-002-ZA and 33 teeth MPEG-003-ZA.
Occurrence: Stratigraphies1, 2 and 3.

Description: Canine tooth without curvature, with smooth crown surface. In Transverse cut the base presents is rounded, and in lateral view the apex is pointed and rhombic. What distinguishes this type is the presence of a transverse line in the midline of the tooth, which can be mild or marked, and in the latter case turns out to cause a slight centripetal depression in the tooth midline.

SubDivisão: Euteleostei E
(Figure 4-E)

Material: Lots 48 teeth MPEG-001-ZA, 5 teeth MPEG-002-ZA and 6 teeth MPEG-003-ZA.
Occurrence: Stratigraphies1, 2 and 3.
Description: Canine tooth with smooth crown surface. Displays the height approximately 4 times greater than width. The crown in lip view is markedly convex, while in lingually view is concave, which in lateral view gives to tooth an appearance similar to letter "C". In cross section the basal region is round, whereas in lateral apex is pointed.

SubDivisão: Euteleostei F
(Figure 4-F)

Material: Lots 90 teeth MPEG-001-ZA and 4 teeth MPEG-003-ZA.
Occurrence: Stratigraphies1 and 3.
Description: Canine tooth with crown divided by a transversal line. The upper triangular, smooth and slightly curved, is less wide than the stem. This is long and cylindrical, making up over half the total height of the tooth, and presents the lower longitudinal grooves. In transversal cut, the base is rounded, and in lateral view the apex is rhombic.

SubDivisão: Euteleostei G
(Figure 4-G)

Material: Lots 23 teeth MPEG-001-ZA, 3 cloves MPEG-002-ZA and 10 teeth MPEG-003-ZA.
Occurrence: Strata1, 2 and 3.
Description: Canine tooth flattened lip-lingually, forming an edge that surrounds the tooth from base to apex. The crown has a smooth surface, and in lateral view, shows a slight curvature toward the tongue. In transversal section the base is elliptical, while the apex is rhombic in side view.

SubDivisão: Euteleostei H
(Figure 4-H)

Material: Lots 24 teeth MPEG-001-ZA, 2 teeth MPEG-002-ZA and 6 teeth MPEG-003-ZA.
Occurrence: Stratigraphies1, 2 and 3.
Description: Incisor tooth with triangular shape on the contrary, in other words, base narrower than the apex. This presents flattened labio-lingually, forming an edge, the upper region of the tooth. In transversal section the basal region has approximately polygonal shape.

SubDivisão: Euteleostei I
(Figure 4-I)

Material: 298 teeth Lots MPEG-001-ZA, 40 teeth MPEG-002-ZA and 89 teeth MPEG-003-ZA.
Occurrence: Stratigraphies1, 2 and 3.
Description: Molar tooth crown with a round shape, width greater than height, rounded base and apex rounded and extended.

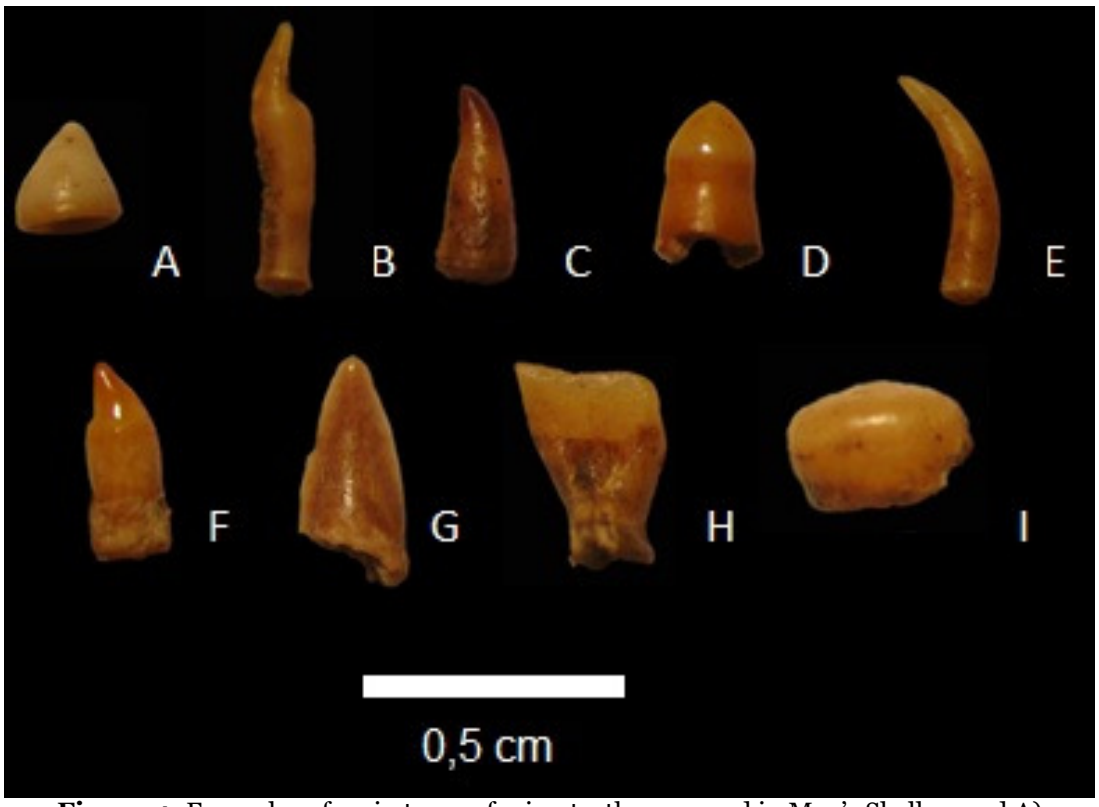

Figure 4. Exemples of main types of microteeth recovered in Moa's Shellmound A) Euteleostei A in lateral view, B) Euteleostei B in lateral view, C) Euteleostei C in lateral view, D) Euteleostei D in front view, E) Euteleostei E in lateral view F) Euteleostei F in lateral view, G) Euteleostei G em vista lingual, H) Euteleostei H in lingually view e I) Euteleostei I in lateral view.

4. Biogeochemical Characterization

The teeth of fish, as well as other bones and scales are composed of calcium phosphate ($Ca_3(PO4)_2$) associated with other elements (LIMA *et al.*, 2006, OLIVEIRA, 2007). Since calcium phosphate, it is possible to analyze the level of teeth preservation and if they have had their basic chemical compound replaced by fossilization.

Chemical analysis by EDS indicates high concentrations of phosphorus (P) and calcium (Ca), compared to magnesium (Mg), aluminum (Al), silicium (Si), manganese (Mn) and iron (Fe), which are not part of the natural constitution of the fish teeth (Figure 5). The third element in abundance, except for oxygen (O), is carbon (C), whose concentrations may indicate significant initial processes of fossilization (LYMAN, 2001) by replacing the original chemical composition of teeth

(calcium phosphate) by carbonates (Table 2) that probably originate by mollusks shells, are also part of the shellmound composition.

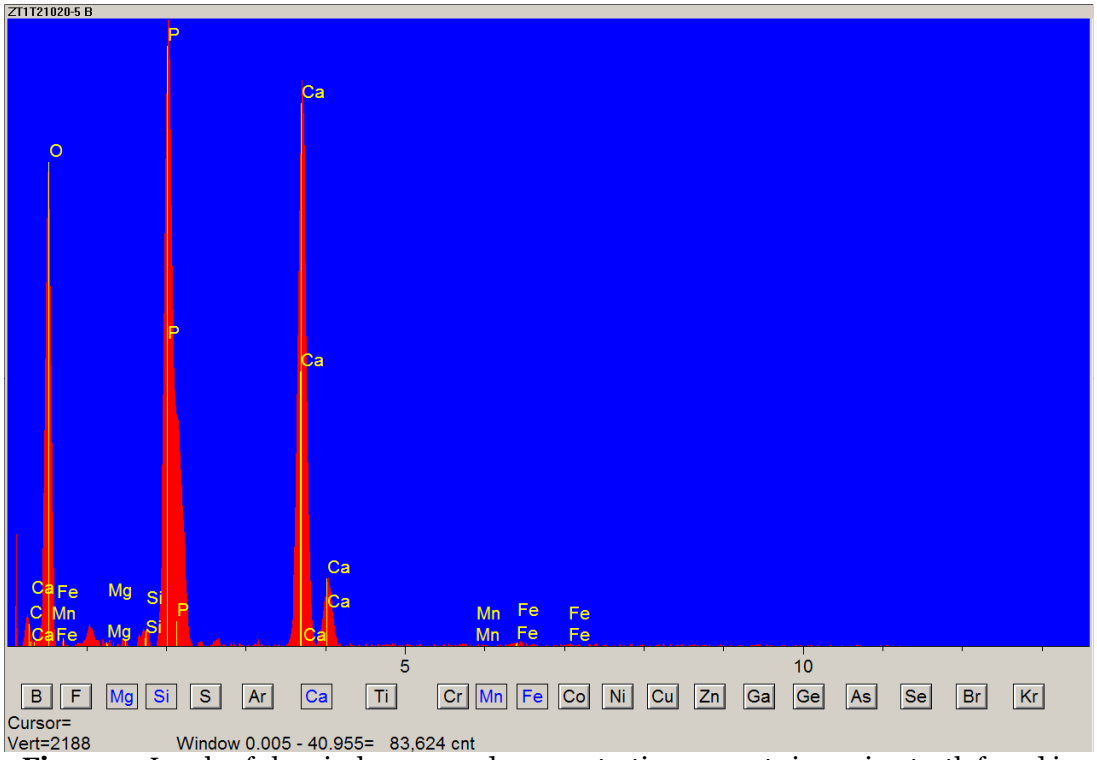

Figure 5. Levels of chemical compounds concentration presents in a microteeth found in Moa's Shellmound, where O, P and Ca have higher peak concentrations.

Table 2. Concentration of elements analyzed by EDS for a specimen of a stratum, highlighted O, P and Ca. *PPM (Parts Per Million)

Element	ppm*
C	5,223
O	57,479
Mg	0,142
Al	1,152
Si	0,446
P	15,581
Ca	20,242
Mn	0,108
Fe	0,627
Total	100

The chemical substitution is also evident when comparing the levels of P, Ca and C in each stratum (Table 3 and Figure 6). In the stratum 3, C content (carbonate) is higher, corresponding to lower values of P, supposedly with replacement more advanced by the teeth fossilization, compared with the low content of Ca. The decreased concentrations of P and Ca can be explained by the high acidity of tropical

soils in the upper strata, which prevents the precipitation of carbonate (LYMAN, 2001).

Table 3. Concentration of Ca, P and C by stratum.

Stratum	P ppm	Ca ppm	C ppm
1	16,859	23,732	1,072
2	17,245	25,548	1,824
3	15,128	23,757	4,826

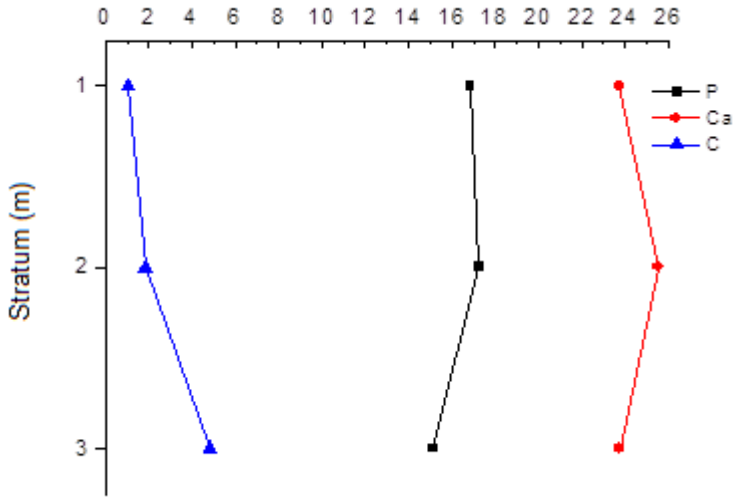

Figure 6. Concentration levels of P, Ca and C present in microteeth found in the geological stratum of Moa's Shellmound.

5. Conclusion

This work is the first effort of gathering to present the scientific community of microscopic fish skeletal debris, derived of sediments from Moa's Shellmound. The study proved to be effective, as this first time enabled the rescue of 1662 specimens, where nine main types were recognized, which will serve as a basis for future studies of taxonomic finest. The biogeochemical analysis of fossils contributed to understanding the fossilization processes and preservation conditions fish remains from Moa's Shellmound. The differences in the analysis presented and in biogeochemistry of carbon (C), calcium (Ca) and phosphorus P, concentration, between the stratigraphiescorroborates the substitution as fossilization principal process of these teeth conservation, enhancing the potential of this material for zooarchaeological studies and other of shellmounds.

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References

BUTLER, V. L.; CHATTERS, J. C. The Role of Bone Density in Structuring Prehistoric Salmon Bone Assemblages. *Journal of Archaeological Science*. v. 21, p. 413-424. 1994.

CAPPETTA, H. *Handbook of Paleoichthyology* v. 3B. Semper Bonis Artbus, 1987.

CASTILHO, P. V.; SIMÕES-LOPES, P. C. Zooarqueologia dos mamíferos aquáticos e semi-aquáticos da Ilha de Santa Catarina, sul do Brasil. *Revista brasileira de Zoologia*. v. 18, n. 3, p. 719 – 727. 2001.

CHÁIX, L.; MÉNIEL P. *Éléments D'Archéozoologie*. Paris: Errance; 1997.

DeBLASIS, P.; KNEIP, A.; SCHEEL-YBERT, R.; GIANNINI, P. C.; GASPAR, M. D. Sambaquis e Paisagem, Dinâmica natural e arqueologia regional no litoral sul do Brasil. *Arqueologia Sul-americana*. v. 3, n.1, p. 29-61. 2007.

GASPAR, M. *Sambaqui: arqueologia do litoral brasileiro*. Rio de Janeiro. 1.ed. Jorge Zahar Editora, 2000.

GONZALEZ, M. M. B. & AMENOMORI, S. N. Osteologia e Utilização de Dentes de Tubarão-branco, *Carcharodon carcharias* (Linnaeus, 1758) (Elasmobranchii, Lamnidae) em Sambaquis do Estado de São Paulo. *Revista do Museu de Arqueologia e Etnologia da Universidade de São Paulo,* v.13, p. 25-37. 2003.

HILLSON, S. *Teeth*. 1.ed. Cambridge University Press, 1986.

JAMES, S. R. Methodological Issues Concerning Screen Size Recovery Rates and Their Effects on Archaeofaunal Interpretations. *Journal of Archaeological Science*. v. 24, p.385–397. 1997.

JOHNSON, G. D.; MURRY, P. A.; STORER, J. E. Recovery of vertebrate microfossils. *Proceedings of the South Dakota Academy of Science*, v. 73, p. 211-230. 1994.

LIMA, R.J.C.; SARAIVA, ANTONIO A.F.; LANFREDI, S.; NOBRE M.A.L.; FREIRE, P.T.C.; SASAKI, J.M. Caracterização Espectroscópica de Peixe do Período Cretáceo (Bacia do Araripe). *Química Nova,* v. 30, n. 1, p. 22-24. 2007.

LLORCA, J.G.; CAHIZAP.A. Aprovechamiento de Recursos Faunísticos en Las Lagunas de Guanacache (Mendoza, Argentina). Análisis Zooarqueológico de La Empozada y Altos de Melién II. *Revista de Antropología Chilena*. Chungara, v. 39, n. 1, p. 117-133. 2007.

LYMAN, R. L. *Vertebrate Taphonomy*. 4. ed. Cambridge University Press, 2001.

OLIVEIRA, M. *Desenvolvimento e caracterização De fosfato de cálcio fluoretado para Aplicação em Esmalte Dentário*. Tese (Doutorado em Engenharia Metalúrgica e de Minas) Programa de Pós-Graduação em da Universidade de Minas Gerais. Belo Horizonte 2007.

OLIVEIRA, S. F. C. C.; TOLEDO, P. M.; COSTA, S. A. R. F. Escamas de tubarões (Pisces: Chondrichthyes) da Formação Pirabas (Eomioceno), Pará, Brasil. *Boletim do Museu Paraense Emílio Goeldi, Ciências Naturais*, Belém, v. 3, n. 3, 241-254. 2008.

PARENTI, L. R.; THOMAS K. R. Pharyngeal Jaw Morphology and Homology in Sicydiine Gobies (Teleostei: Gobiidae) and Allies. *Journal of Morphology* v.237, p. 257-274. 1998.

MACHADO, S.M.; LUZ, Z.A.S; SILVEIRA, M.I.; COSTA, S.A.R.F. Contribuições a Zooarqueologia – Análise de Microvertebrados provenientes do Sambaqui do Moa. *Livro de Resusmos Do XV Congresso Sociedade de Arqueologia Brasileira,* Belém, p. 152. 2009.

SCHEEL-YBERT,R.; EGGERS,S; WESOLOWSKI,V.; PETRONILHO,C.C.; BOYADJIAN,C.H.; DeBLASIS,P.A.D.; BARBOSA-GUIMARÃES,M.; GASPAR, M.D. Novas Perspectivas na Reconstrução do Modo de Vida dos Sambaquieiros: Uma abordagem Multidisciplinar. *Revista Antropologia,* São Paulo, v. 16: p.109-137. 2003.

SCHEEL-YBERT, R.; AFONSO, M. C.; BARBOSA-GUIMARÃES, M.; GASPAR, M. D.; YBERT, J-P. Considerações sobre o papel dos sambaquis como indicadores do nível do mar. *Quaternary and Environmental Geosciences*. v.1, n. 1, p.3-9. 2006.

SCHLESINGER, W.H. *Biogeochemistry*. Fisrt Edition. Ed. Elsevier. 2005.

SILVEIRA, M. I. *Você é o que você come Aspectos da subsistência no Sambaqui do Moa Saquarema/RJ*. Tese (Doutorado em Arqueologia) - Faculdade de Filosofia, Letras e Ciências Humanas, Universidade de São Paulo, São Paulo, 2001.

TERREROS, J. Y. S. D. L. La subsistencia en el Pleistoceno Superior en la Península Ibérica: problemas tafonómicos y zooarqueológicos. *Espacio, Tiempo y Forma, Serie I, Prehistoria y Arqueología*, v. 14, p. 47-78. 2001.

ZOHAR, I.; DAYAN, T.; GALILI, E.; SPANIER, E. Fish Processing During the Early Holocene: A Taphonomic Case Study from Coastal Israel. *Journal of Archaeological Science*. v. 28, p.1041-1053. 2001.

ZOHAR, I. & BELMAKER, M. Size does matter: methodological comments on sieve size and species richness in fishbone assemblages. *Journal of Archaeological Science*. v.32, p. 635-641. 2005.