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Actuotaphonomic of fish microteeth accumulations in intertidal environments: a case study in Atalaia Beach, Northeast Amazon, Brazil

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RESUMO

Foi realizado o estudo das acumulações de microdentes de peixes em ambiente de intermaré na Praia do Atalaia,nordeste amazônico, Brasil, a partir da análise de 18 amostras de sedimentos recentes retirados de furos de 50cm. Não foram encontrados espécimes no material, resultado este, influenciado por fatores decorrentes da própria natureza da área, tais como, dinâmica praial, temperatura e baixa profundidade da lâmina d'água. Entretanto, este resultado assemelha-se com o encontrado em depósitos miocênicos de intermaré da mesma região, reforçando a utilização da tafonomia atual como ferramenta de suporte para estudos paleoecológicos.

KEY-WORDS:
Intertidal
Accumulations
Microteeth

ABSTRACT: ACTUOTAPHONOMIC OF FISH MICROTEETH ACCUMULATIONS IN INTERTIDAL ENVIRONMENTS: A CASE STUDY IN ATALAIA BEACH, NORTHEAST AMAZON,

BRAZIL. A study of fish microteeth accumulations in the intertidal environment was carried out inAtalaiaBeach, northeast Amazon, Brazil, from the analysis of 18 samples of recent sediments taken from 50cm holes. No specimens were found in the material, a result influenced by factors arising from the very nature of the area, such as Beach dynamics, temperature and shallow water depth. However, this result resembles the one found in intertidal Miocene deposits of the same region, reinforcing the use of current taphonomy as a support tool for paleoecological studies.

PALABRAS-CLAVE:
Intermareal
Acumulaciones
Micro dientes

RESUMEN: ACUMULACIONES ACTUOTAFONOMITACAS DE MICRO DIENTES DE PECES EN AMBIENTES INTERMAREALES: ESTUDIO DEL CASO EN LA PLAYA DE ATALAIA, EL NORESTE DEL AMAZONAS, BRASIL. Se realizó el estudio de las acumulaciones de micro dientes de pescados en ambiente de intermareal en la Playa del "Atalaia", en el noreste amazónico, Brasil, a partir del análisis de 18 muestras de sedimentos recientes retirados de agujeros de 50cm. No fueron encontrados especímenes en el material, resultado influenciado por factores derivados de la propia naturaleza de la zona, tales como, dinámica de playa, temperatura y la baja profundidad de la lámina del agua. Sin embargo, este resultado se asemeja con el encontrado en los depósitos del mioceno de una misma región intermareal, reforzando el uso de la tafonomía actual como una herramienta de apoyo para los estudios paleoecológicos.

Introduction

The intertidal zone is the portion of the tidal flat, slightly inclined, which features fully exposed at low tide and almost entirely covered at high tide (ROSA FILHO *et al*., 2011), subject to strong mechanical wave action during periods of sea waves (SOUZA, 2012). As a result of the alternationbetween submergence and exposure to air, organisms inhabiting this portion of the Beach are forced to endure extreme conditions of moisture, salinity and resistance to direct sunlight, as they are alternately dipped in water and exposed to sunlight (CUNHA, et al., 2007).

However, this high dynamism does not preclude establishing communities of specialized fish, consisting in particular of small specimens (GIBSON, 1998), as these occur mainly in the early stages of development (ROBERTSON& LENANTON, 1984; BLABER et al., 1995; GODEFROID et al. 2001). However, the knowledge referring to communities that inhabit the intertidal zone is still scarcein the fossil record, reflecting the dynamic nature of this deposit, which complicates the process of fossilization (SCHULTZE, 1999). In addition, other factors are critical to the concentration of animal remains, such as post mortem chemical reactions (UNDERWOODet al., 1999), hydraulic selection of sizes and

shapes (BLOB & FIORILLO, 1996) and the very structure of the community (COXet al., 2010).

Currently it is known that the study of the behavior of accumulations of organisms in current deposits is the key to understand them in the fossil record (HOLZ & SIMÕES, 2002). When it comes to coastal deposits, several studies were carried out by addressing the accumulation of invertebrates, especially mollusks and echinoderms (e.g., BOSENCE, 1979; CUMINS et al., 1986; KIDWELL, 2008; GREENSTEIN, 1989). However, with regard to vertebratesthe works basically summarize the behavior of large skeletons such as carcasses of sea turtles (MEYER, 1991) and bone ungulates assemblies (BOAZ et al., 1976; WILSON, 2008), whereas knowledge regarding the accumulation of microscopic skeletal parts, especially fish, is virtually nonexistent (VULLO, 2009).

Microscopic parts, usually microteeth, are common in the fossil and archaeological record (e.g., VASILE & CSIKI, 2010; GRIGORESCO et al., 1999; OLIVEIRA et al., 2008), in research related to oil exploration (JONES, 1996), biostratigraphy (JOHNS et al., 2005) and understanding about sambaqui groups (MACHADO et al., 2011). In the case of Amazonian deposits, there are studies with microscopic parts of fossil fish concentrated in the Pirabas Formation, Eomiocene (MORAES -SANTOS et al., 2005; COSTA et al., 2007; OLIVEIRA et al., 2008; COSTA, 2011).

This geological unit, located primarily in the northeastern state of Para, consists of representative deposits of transitional coastal environments, formed from a complex of barrier islands with the presence of sub-environments such as mangroves and lagoons, and can easily be compared to the environment found in the current North coast (GÓES & ROSSETTI, 2004). Therefore, understanding how thefishmicroremains agglomerate in recent deposits, assists the understanding of this process in the fossil record (CHATTOPADHYAY et al., 2013), thus providing important information for understanding thethanatocoenosis and hence aiding in paleoenvironmental reconstructions.

This paper presents the results of research in recent sediments of fish microteeth accumulation in intertidal environments in the northeast Amazon, specifically in AtalaiaBeach, Salinópolis, Pará, understanding that the location has great similarity with part of Pirabas Formation depositional system and therefore can be easily used in paleoenvironmental reconstructions from analogies.

Study area

The area analysed is located in Salinópolis city (Figure 1), part of Salgado Zone in the state of Pará (PACHECO *et al.*, 2011) and 220 km awayfrom the state capital, Belém, bounded by the parallels 00º35'22 ''S and 00º38'43 ''S and the meridians 47º15'47''W and 47º21'12'. It was selectedin this area a Beachknown as Atalaia(Figure 2) which is approximately 12 km long and has an average width of 400 m (GREGORY, 2005).

Materials and methods

01 plot of 180 meters longwas delimited corresponding to the amplitude of the tide forsedimentcollection. Throughout it, 6 holes were made every 30m, each approximately 50cm in depth (Figure 3), from where three samples relating the base, top and middle part of deposition were removed to collect a total of 18 samples.

In the laboratory, the samples were sieved and 200g subsamples were prepared from the material retained on sieve of 250 mm sieve opening, as this is the interval of highest concentration of microteeth according to COSTA, *et al*. (2007). Once this step was concluded, the subsamples were dried at 50°C, and screened in stereoscopic microscope at the Laboratory of Petrography of Emilio Goeldi Museum.

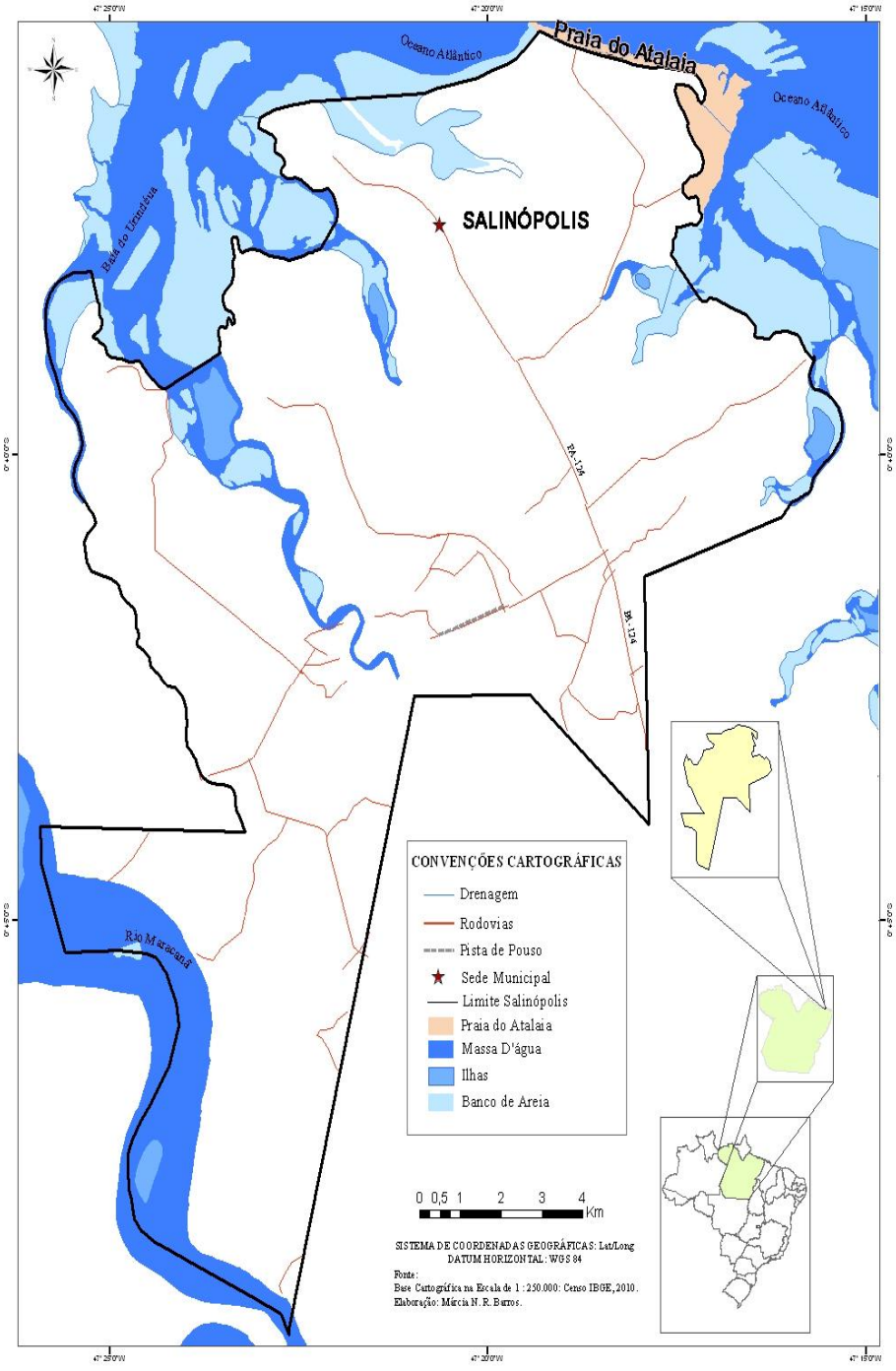

Figure 1: Location map of Salinópolis city.

Figure 2: Locationof the intertidal environment. Source: Barrão, 2009.

Figure 3: Material collection proceedings. (A)Highlight of the distance betweencollected areas and(B) Sediments collection area. Source: Praia, 2012.

Results and discussion

The sorting of the material did not show the presence of fishmicroteeth. This result is similar to the one found by Vullo (2009) for accumulations of microvertebrates on current transitional environments. Nevertheless, even though there are abundant fish populations in the intertidal zone (HAIMOVICI, *et al.*, 1994), many factors influence the absence ofaccumulation of microteeth in this type of environment.

The first factor to be pointed out refers to the fact that AtalaiaBeach is considered to be dissipative (GREGORIO, *et al*., 2005), characterized by accumulations of well-selected,unimodal or bimodal grains, most of themfrom rounded to well rounded (CALLIARI, *et al.*, 2003), indicating considerable transport time of sediments that composes it, until effective accumulation in the depositional environment (HORIKAWA, 1988). These sediments have quartz and micaceous origin of fine sand grain size, unimodal, moderately selected (GREGORY, 2005).

Considering the dynamics of AtalaiaBeach deposits, we highlight the high process of skeletal disarticulation and transport, that may overshadow any microteethaccumulation, because they are strongly governed not only by the type and intensity of the condition of the environment in which they are located, but also the basic anatomy (FLORES-LOPES *et al.*, 2010) and hydraulic behavior of skeletal elements such as shape and size. According to Blob &Fiorillo (1996), triangular shapes are more susceptible to transport. These forms can be compared to microscopic canine teeth (average size of about 50 to 200 µm) present in the genera *Mugil*, *Ancho* and *Lutjanus*, all common in the northeastern Amazon intertidal (PRAIA *et al*., 2011) (Figure 4).

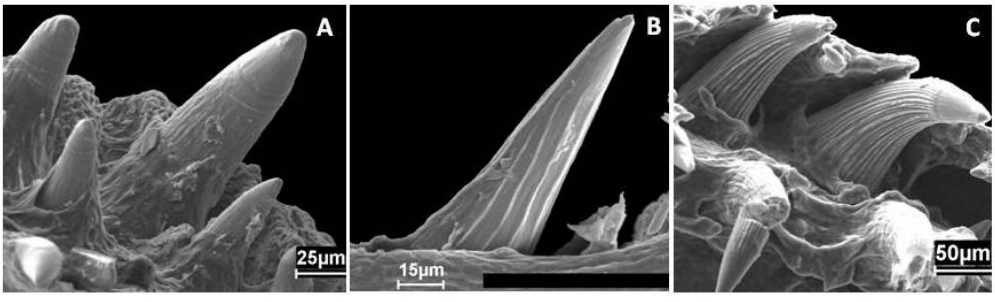

Figure 4: Microdentes recent fish of the intertidal zone of the beach Algodoal-Pa genres A) *Mugil*. B) *Ancho*. C) *Lutjanus.*

The susceptibilities of bones in the transport in aqueous streams of small animals' skeletons show that the threshold speed is relatively high for jaws (DODSON, 1973). This means that any agitation of the water can disperse the bones and impoverish the accumulations, causing them to be easily dispersed or deposited in other places than the source (VULLO, 2009).

In fish, the jaw is the third part of the body to loosen up (HIIL, 1978); it behaves like a background or residual deposit, with a tendency to get buried after

little or no transport (VOORHIES, 1969). Despite the low mobility, the fish teeth have high degree of transport, for they don't have a strong attachment with the presence of tooth roots, as in mammals, but are formed from the fold of the ectoderm called the dental lamina (HILDEBRAND, 1995). Thus, they are more susceptible to environmental variability, such as beating of waves and tidal cycle of the studied site (BROWN& MCLACHILAN, 1990;VASCONCELOS *et al.*, 1999).

The joint action of waves, currents and tides governing the hydraulic behavior of the beach is the same acting on sediment and microteeth. Such set influences on the accumulation of possible fish remains that may be preserved because the intense hydraulic dynamics (tidal cycle and surf wave) inherent to environment contributes to bone fragmentation of organisms (IRMIS & ELLIOTT, 2006), not favoring fish microteeth accumulation.

Besides the factor related tobeach dynamics,agents such as extreme temperatures (averaging 31ºCin the study area) (COSTA, *et al.*, 1992) and shallow water depth, typical of the environment, are crucial in the destruction of microteeth, since these agents are in constant change, thus causing physical stresses that cause the sunlight to fall directly on the microteeth,as they are exposed to the water/sediment interface (SOARES, 2008).

The absence of microteeth was also seen in intertidal,eomiocenicdeposits of Pirabas Formation, exposed in B17-Mine, located in northeastern Pará, where only 5 specimens were recovered in the indicative facies of this environment, a non significant number compared to hundreds of specimens recovered in the representative faciesof other environments described in the outcrop, as lagoon and tidal channel (COSTA, 2011), confirming the downtrend accumulation capacity of microteeth in intertidal environment.

Conclusion

No accumulations of fish microteethoccur in the intertidal zone's analysed plot of AtalaiaBeach. The strong influence of wave action and tidal regime give this kind of environment low potential for accumulation of microvertebrates. Associated with these factors there are also high temperatures and shallow water depth, which hinder the process of preservation. These results are consistent to thoseso far reported in the literature and to the ones regarding the intertidal zone of Pirabas Formation's fossil deposits which outcrop in B-17 Mine (Capanema city, Pará), reinforcing the importance of this type of study as a tool to aid paleoecological descriptions.

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