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STRUCTURAL VARIATION OF THE MEIOFAUNA COMMUNITY FROM GUADALUPE BEACH (PERNAMBUCO - BRAZIL)

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ABSTRACT

The meiofauna community plays an important role in the energy flow of benthic systems, and its horizontal and vertical distribution depends on the granulometry, organic matter and physic-chemical factores (salinity, temperature, O_2). In this sense, we aimed to analyze the structure and space-time variation of the meiofauna community on the Pontal de Guadalupe beach. For the biosedimentological analysis, samples were collected in the dry (October/2013) and rainy (May/2013) periods during the low tide. In each period, four (4) equidistant transects were established perpendicular to the beach line in 100 meters (02 in the upper mesolittoral and 02 in the lower mesolittoral). The mean of the meiofauna density indicated were in agreement with the literature for sandy beaches from the south coast of Pernambuco, and the meiofauna taxonomic composition was also in accordance with the results from other sandy beaches studies. In particular, to those from the south coast of Pernambuco, it presents the same qualitative-quantitative pattern. The high Nematoda abundances found in the meiofauna samples were expected, since the relevant literature describes that the global pattern of relative abundance of the large meiofauna groups in the tropics points to nematodes as the most representative. Regarding the spatial distribution in the two studied periods, we recorded the highest abundance, density and richness of the meiofauna organisms at the upper mesolittoral area. Regarding the temporal distribution, the highest densities recorded was in the rainy season, which can be due to the increase of rainfall caused by sedimentary deposition processes. The ecological studies of meiofauna are of extreme importance for the understanding of the natural processes of a sandy beach. In addition, the evaluation of the ecological role and the environmental and temporal changes of meiofauna communities can be applied in environmental monitoring programs, since this group is considered an important bioindicator of environmental impacts.
Key-Words: Copepoda, Nematoda, sandy beach ecology, seasonal distribution.

RESUMO

A comunidade meiofaunística desempenha um papel importante no fluxo de energia dos sistemas bentônicos, e sua distribuição horizontal e vertical depende da granulometria, da matéria orgânica e dos fatores físico-químicos (salinidade, temperatura, O2). Nesse sentido, procuramos analisar a estrutura e a variação espaço-temporal da comunidade da meiofauna na praia do Pontal de Guadalupe. Para a amostragem biosedimentológica foram realizadas duas coletas, sendo uma no período seco e outra no chuvoso, em transectos perpendiculares à linha de praia. Em cada período, foram coletadas amostras em quatro transectos (02 pontos no mediolitoral superior (MS) e 02 no mediolitoral inferior (MI)), sendo extraídas 04 réplicas do sedimento em cada ponto. A média da densidade da meiofauna registrada foi de acordo com a literatura para as praias arenosas do litoral sul de Pernambuco. A composição taxonômica da meiofauna também apresenta similaridade com os resultados de outros estudos de praias arenosas. Em particular, para aqueles do litoral sul de Pernambuco, apresenta o mesmo padrão qualitativo-quantitativo. A abundância elevada de Nematoda encontrada nas amostras era esperada, uma vez que a literatura relevante aponta para os nematóides como os mais representativos, nos trópicos. Em relação à distribuição espacial nos dois períodos estudados, registramos as maiores abundância, densidade e riqueza dos organismos da meiofauna no mediolitoral superior. Com relação à distribuição temporal, as maiores densidades observadas foram na estação chuvosa, o que pode ter sido devidas ao aumento da precipitação causada pelos processos de deposição sedimentar. Os estudos ecológicos da meiofauna são de extrema importância para a compreensão dos processos naturais de uma praia arenosa. Além disso, a avaliação do papel ecológico e das mudanças ambientais e temporais das comunidades de meiofauna pode ser aplicada em programas de monitoramento ambiental, uma vez que este grupo é considerado um importante bioindicador dos impactos ambientais.

Palavras-chave: Copepoda, Distribuição Sazonal, Ecologia praias arenosas, Nematoda.

INTRODUCTION

The meiobenthos term was created by Mare (1942) to classify small invertebrate animals based on their habitat and body size, which ranges from 0.044 to 0.5 mm. Therefore, it is considered as part of the meiofauna, the invertebrate animals with interstitial habits that are retained in a mesh with openings ranging between 500 µm and 44 µm. The Permanent Meiofauna is composed by the animals that spend their entire life cycle within these corporeal limits. Meanwhile, larvae, eggs and young individuals from the macrofauna are considered as Temporary Meiofauna (Giere, 2009).

According to Higgins & Thiel (1988) about two thirds of the 33 metazoan phyla present, at least, one phase as a meiofaunal component. These organisms community plays an important role in the energy flow of benthic systems, acting in the remineralization of organic debris, making them available for higher trophic levels (Alkemade *et al*., 1992).

The sediment characteristics have been cited as one of the most important factors for the establishment of marine benthic communities (Ansari *et al*., 1990; Hooge, 1999). Giere (2009) highlighted that the colonization of sand by meiobenthos is determined by the grain size, grain structures, the roughness of edges, the shape of grain surfaces and cracks on it. Therefore, the abundance and biomass of benthic organisms are generally higher towards fine grains due to a concomitant increase in food availability (Heip *et al*., 1992). Vanaverbeke *et al*. (2011) empathized that the diversity increases in the opposite direction due to a decrease in dominance.

According to Giere (2009), in sandy beaches, the meiofauna horizontal and vertical distribution depends on the granulometry, organic matter and physic-chemical factors (salinity, temperature, O_2).

The temporal variability of meiofauna in these habitats occurs in small (related to tidal cycle and changes in moisture in the sediment), averages (daily basis, related to changes in temperature) and long scales (linked to the seasons) (McLachlan & Brown, 2006). In addition to the environmental characteristics, the biological interactions and the life history of the species add complexity to the spatial and temporal variability of meiofauna on sandy beaches (Giere, 2009; Kaiser *et al*., 2005).

The Guadalupe Beach is located at the Guadalupe environmental protection area (*APA – Área de Proteção Ambiental*), created in 1997, where there are remnants of Atlantic forest, mangroves, marine environments (reef strings) and sandy coastal plains. The beach stands out for the diversity of marine life, including coral species endemic to Brazil and ichthyofaunal richness, especially in the reef environments. Commercial fishing activities are developed, especially fish, octopus and lobster, as well as subsistence fishing (small-scale coastal fishing). It is a motivated area for tourist visitation, great attraction of the economic diversification of the region (Pernambuco, 2011).

In this sense, we aimed to analyze the structure and space-time variation of the meiofauna community on the Pontal de Guadalupe beach. Thought the identification of the main groups and its correlation to the sedimentological parameters, we tested the hypothesis of a structural variation in the meiofauna community, considering a spatial and temporal change through the studied transects.

MATERIALS AND METHODS

Study area

The area is located on the south coast of the State of Pernambuco involving part of the municipalities of Ipojuca and Sirinhaém (Pernambuco, 2011). It is comprised between the parallels 8º 37’ 48’’ S and 35º 07’ 30’’ W, and is approximately 36 km from the Suape Port (Figure 1).

Figure 1. Studied area: Praia de Guadalupe, Pernambuco, Brazil. Fonte: Access: https://www.google.com.br/maps/place/Praia+de+Guadalupe/@-8.6876167,-35.0874047,17z/data=!3m1!4b1!4m5!3m4!1s0x7aa83aa1eedf18b:0x77cbfeb49ee98f99!8m2!3d-8.6876167!4d-35.085216. 07/02/2017.

According to the Köppen classification, the Guadalupe Beach is considerate a Wet Hot Tropical area, with average temperatures of 21.4 °C and 28.6 °C (Andrade & Lins, 1971; Nimer, 1979). Characterized by two distinct periods in the pluviometry regime: a rainy season, from March to August (autumn-winter) and a dry season, which runs from September to February (spring-summer).

Field Methodology

For the biosedimentological analysis, samples were collected in the dry (October/2013) and rainy (May/2013) periods during the low tide. In each period, four (4) equidistant transects were established perpendicular to the beach line in 100 meters (02 in the upper mesolittoral and 02 in the lower mesolittoral) (Figure 2).

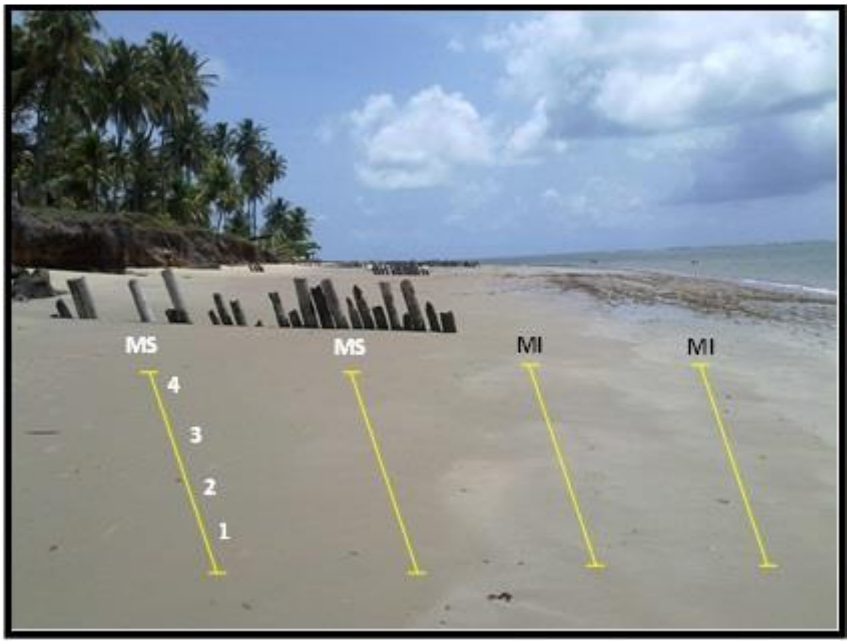

Figure 2. Sampling sites with four transects 2 at the upper mesolittoral (MS) and 2 at the lower mesolittoral (MI), with 4 replica each.

In each transect, five samples were taken (4 for biosedimentological and 1 for granulometry analyses) with a PVC cylinder of 10 cm long and 3.5 cm diameter, which was inserted in the sediment until the first 10 cm. The sampling was made during the low tide and the samples were placed in to plastic containers, fixed in 10% saline formalin.

Laboratory methodology

For the meiofauna separation, a manual elutriation with a 1,000 mL Becker was performed. The supernatant was poured into geological sieves with mesh openings ranging between 0.045 mm and 0.5 mm, and then placed on a Dolffus plate composed by 200 squares of 0.25 cm^2 each. The meiofaunistic animals were identified under stereomicroscope up to Order level.

The granulometric analyzes were performed according to the method of Suguio (1973). The analyses were developed at the Laboratory of Marine Communities (LACMAR) at the Federal University of Pernambuco. The sediment samples were submitted to dehydration in an oven at 100 °C for 24 hours. Later, the dried samples were gently disaggregated to avoid breaking the grains. Primarely, it was weighted 100g of each sample and separated by sieving the gross sediments using a sieve of 2.000mm and 0,062 mm mesh openings.

After drying, the material retained in the 0.062 mm sieve was subjected to the sieving process by rot-up agitation with mesh sieves with intervals corresponding to the Krumbein granulometric scale (Suguio, 2003), for 15 minutes. After the sieving, the fraction retained in each sieve was weighed in a digital scale. Afterwards, the fraction contained in each mesh had its weight measured in a precision scale and the data obtained were analyzed using the parameters of

Folk & Ward (1957) and the textural classification of Shepard (1954).

Data analysis

For matter of analysis, the sampling points were coded as: MSs (upper mesolittoral dry season), MSc (upper mesolittoral rainy season), MIs (lower mesolittoral dry season) and MIc (lower mesolittoral rainy season).

The density of the large meiofauna groups was expressed as total number of individuals per 10 cm $^{-2}$, through the mean of the replicates.

Multivariate analyses were performed using the PRIMER v6.0 software package (Clarke, 2006). The samples were included as a fixed factor, the biotic data was square root transformed and a similarity matrix was constructed using the Bray-Curtis measure of similarity.

One-way analysis of similarities (ANOSIM) was performed to test for significant differences ($p>0.05$) in the meiofauna community structure between the different locations. Similarity of percentages (SIMPER) was executed to identify the taxa that contribute most to the difference between the groups. Besides that, the Univariate Diversity Indices such as Species richness (Margalef), Pielou´s evenness (J´), Shannon-Wiener function (log_e) and Hill´s index (N1) were calculated by DIVERSE analysis. On the Excel program, an Analysis of Variance (ANOVA) was performed to check if the diversity indices were significantly different between the communities', and after a t Test was performed to test which community is different from one another.

RESULTS

Sedimentological analysis

The sediments present in the sampling sites on the beach of Guadalupe presented similar characteristics. In the rainy season in the upper and lower mesolittoral regions, the medium and fine grain sand predominated, while in the dry period the fine grain sand predominated (Figure 3A and 3B, respectively).

Identification of the meiofauna and stablishing the communities

The meiofauna specimens were identified as representants of 14 taxa: Nematoda, Turbellaria, Copepoda, Oligochaeta, Gastrotricha, Polychaeta, Acari, Gastropoda, Bivalve, Nemertea, Tardigrada, Kinorhyncha, Isopoda and Ostracoda. However, the Isopoda, Kinorhyncha and Nemertea groups were recorded only during the rainy season.

The mean of the meiofauna density in the two studied seasons ranged from 323 to 3680 ind/10cm^2. Specifically in the rainy season, the highest densities were recorded in the upper mesolittoral (MSc) (418 - 3680 ind /10cm^2). While in the same season, the lower mesolittoral (MIc) varied between 323 and 2519.7 ind/10cm^2. In the dry season, the density in the upper mesolittoral (MSs) ranged between 810 and 1457.2 ind/10cm^2. Meanwhile, in the lower mesolittoral (MIs), in the same period, the density varied between 397 and 1357 ind /10cm^2.

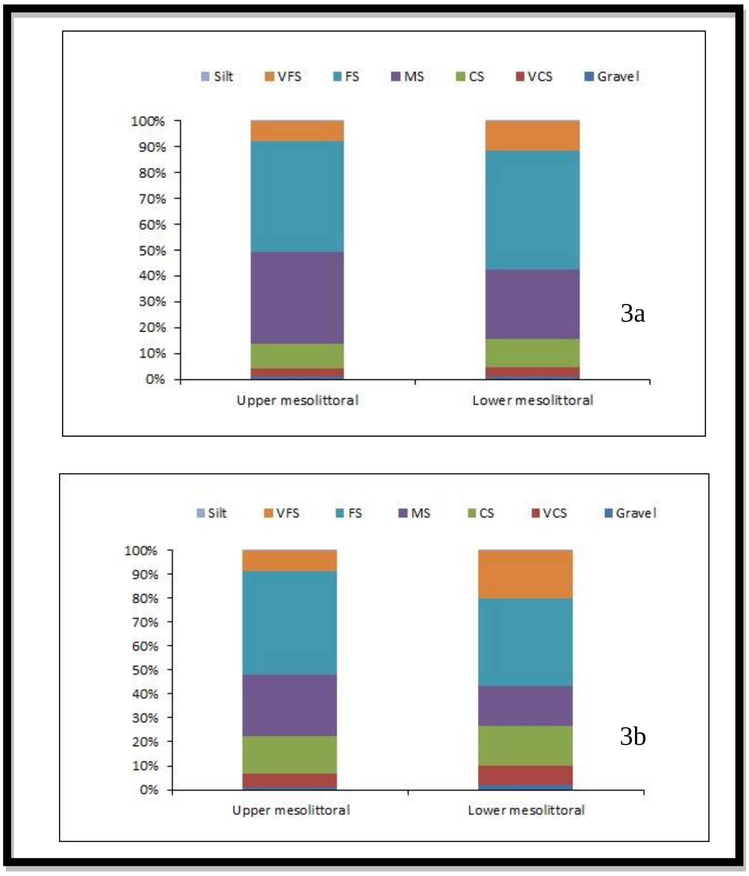

Figure 3. Sedimentological analysis: granulometric composition (%) of Silt, very fine sand (VFS), fine sand (FS), medium sand (MS), coarse sand (CS), Very coarse sand (VCS) and Gravel. 3A: Rainy season. 3B: Dry season.

The community with the highest relative abundance was in the upper mesolittoral, during the rainy season (MSc). Within it, the group with the highest abundance was Nematoda followed by Copepoda (Figure 4A). Meanwhile, in the lower mesolittoral, Nematoda was considered to be more abundant and all other groups considered being rare (Figure 4B). Moreover, during the dry season, at the upper mesolittoral (MSs), the most abundant groups were Nematoda and Gastrotricha, followed by Turbellaria and Copepoda (Figure 4C). The most abundant taxa, in the lower mesolittoral (MIs) were Nematoda, Gastrotricha and Turbellaria (Figure 4D). The other groups in both periods were considered rare, always representing less than 6% of the total of individuals.

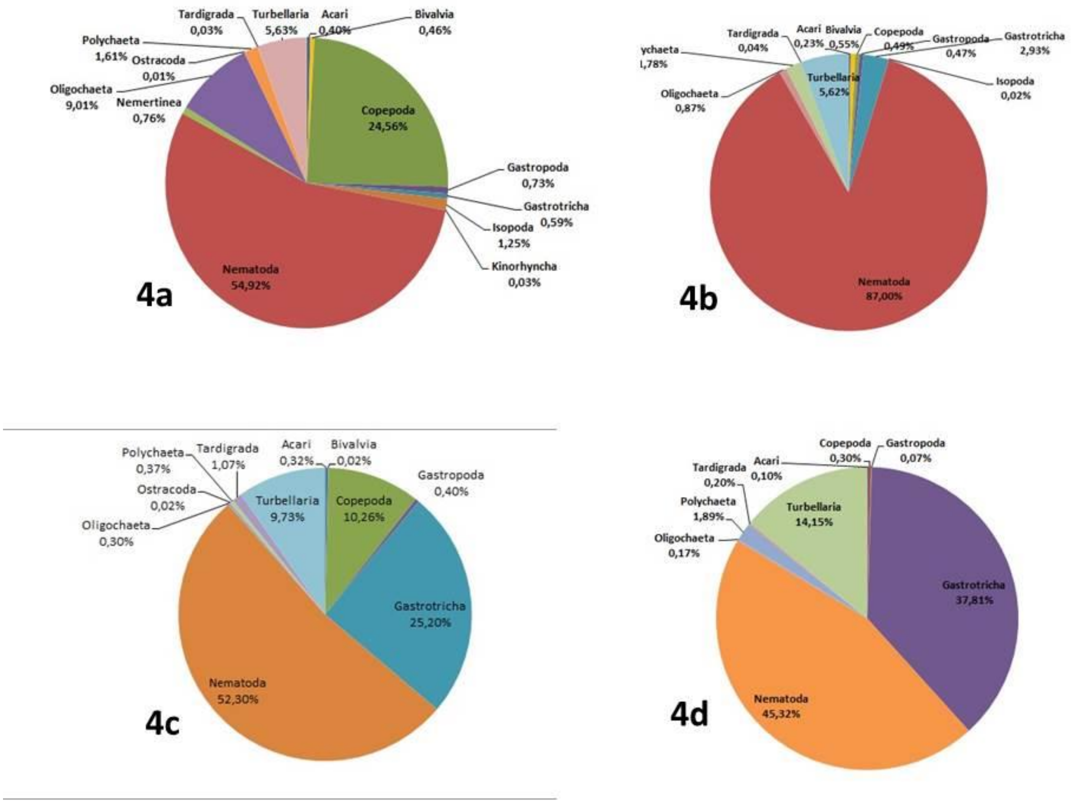

Figure 4. Relative abundancy (%) of the taxa from the meiofaunal community of the Praia de Guadalupe. 4A: Upper mesolittoral, in the rainy season. 4B: Lower mesolittoral, in the rainy season. 4C: Upper mesolittoral, in the dry season. 4D: Lower mesolittoral, in the dry season.

Statistical analysis

The ANOSIM analysis showed a significant difference between the communities MSs, MSc, MIs and MIc (p=0.1%). Although, the results showed a hight permutation (999), the Global R value was very low (0,158) and in the Pairwise Tests, the statistic R value were also low.

The SIMPER analysis indicated that the highest dissimilarity between the communities' was between MSc and MSs (average dissimilarity of 50.94%).

Nematoda and Gastrotricha were the most responsible for the dissimilarity between the communities'. Meanwhile, Nematoda, Turbellaria and Gastrotricha were the most responsible for the similarity within the communities'. Specific in the upper mesolittoral, during the rainy season, besides Nematoda and Turbellaria, Copepoda and Oligochaeta were also responsible for the similarity within this community.

The average similarity within MSc was 49.06% and 4 groups were necessary to reach 92.61% of Cum%: Nematoda (60.14%), Turbellaria (21.64%), Copepoda (6.25%), Oligochaeta (4.58%). Meanwhile, the average similarity within MSs was 61.50%, and 3 groups were necessary to reach 93.29% of Cum%: Nematoda (54.03%), Turbellaria (20.29%), Gastrotricha (18.98%). The community MIs has the highest similarity within the group (67.11%)

with only 3 meiofauna groups necessary to reach 96.32% of Cum%: Nematoda (44.55%), Turbellaria (23.09%) and Gastrotricha (18.67%).

The Univariate Diversity Indices results showed that there was a significant difference on the richness between the upper mesolittoral, during the rainy season (MSc), and the lower mesolittoral, during the rainy season (MIc) (p=0.003). A significant difference was also recorded between the upper mesolittoral, during the rainy season (MSc), and the lower mesolittoral, during the dry season (MIs) (p=0.007); the upper mesolittoral, during the dry season (MSs), and the lower mesolittoral, during the rainy season (MIc) (p=0,025); and, between the upper mesolittoral, during the dry season (MSs), and the lower mesolittoral, during the dry season (MIs) (p=0,043).

The Shannon index resulted in a significant difference between upper mesolittoral, during the rainy season (MSc), and the lower mesolittoral, during the rainy season (MIc) (p=0,002); and, between the upper mesolittoral, during the dry season (MSs), and lower mesolittoral, during the rainy season (MIc) (p=0,002). The N1 were significantly different between upper mesolittoral, during the rainy season (MSc), and the lower mesolittoral, during the rainy season (MIc) (p=0,004); and, between the upper mesolittoral, during the dry season (MSs), and lower mesolittoral, during the dry season (MIs) (p=0,008).

DISCUSSION

The mean of the meiofauna density of 323 to 3680 ind/10cm^2 was corroborated by Kotiwicki *et al.* (2005) which indicated that the density of meiofauna, on tropical sandy beaches, are around 538±137 ind/10cm^2. The mean meiofauna densities recorded in this study was also similar to the results from Maranhão *et al*. (2000), Maranhão (2003), Silva (2006), Chaddad *et al*. (2013) and Chaddad (2015), which are from different sandy beaches studies on the south coast of Pernambuco, but also touristic environment with constantly anthropogenic impact.

The meiofauna taxonomic composition of the Pontal de Guadalupe beach is accordance with the results from other sandy beaches studies (Rafaelli & Hawkins, 1996, Rodríguez *et al*., 2003, Di Domenico & Almeida, 2005, Gomes *et al*., Santos, 2010). In particular, to those from the south coast of Pernambuco, it presents the same qualitative-quantitative pattern (Castro *et al*, 1999; Silva, 2006; Chaddad *et al*, 2013; Chaddad, 2015).

The high Nematoda abundances found in the meiofauna samples were expected, since the global pattern of relative abundance of the large meiofauna groups in the tropics points to nematodes as the most representative (Coull, 1988; Rudnick *et al*., 1985; Montagna & Harper, 1996; Albertelli *et al*., 1999; Soltwedel, 2000; Nozais *et al*., 2001; Danovaro *et al*., 2002 and Giere, 2009). The high success of Nematoda it can be due to the diversity of feeding strategies, high tolerance to various environmental stressors and facility to burial in the sediment (Bouwman, 1983; Giere 2009).

The abundance of the other dominant taxa, Turbellaria, Gastrotricha, Oligochaeta and

Copepoda are in concordance with Giere (2009) which describe theses taxa as preferably living in the interstitial of fine sand enriched with debris. Fine sediments tend to accumulate more organic matter than coarse sediments (Little, 2000), so this factor may have expressed a higher number of taxa in that period. Giere (2009) highlighted that tardigrades have a preference for coarser sands; thus, its low presence on the Pontal de Guadalupe beach it may be due to the nature of the sedimentary substrate. Moreover, Albuquerque *et al*. (2007) results showed a high density of tardigrades in a sandy beach in Rio de Janeiro, however the area is not subject to urban or industrial occupation and has undergone little anthropogenic impact (Costa, 1998).

Regarding the spatial distribution in the two studied periods, we recorded the highest abundances, densities and richness of the meiofauna organisms at the upper mesolittoral area. Our results agrees with McLachlan (1980) which points out that the retention zone (upper mesolittoral area) is the most adequate to the existence of rich and dense meiofauna populations, based on the balance between water, oxygen and physical estability due to the hidrodynamis variation (McLachlan, 1983). The statistical model showed by Albuquerque *et al*. (2007) also showed a significant difference in meiofauna density among the coastal zones, with a higher abundance at the retention zone.

The Guadalupe Beach is very narrow, not exceeding 20 m wide, with very low slope (CPRH, 2009). It is important to notice that Guadalupe Beach has a greater depth in the whole system of 12.3 m, near the reefs located in front of the Ponta de Guadalupe, and the marine erosion, observed in the Guadalupe Beach is mainly due to the diffraction/refraction of non-local waves, caused by the existence of reefs in the vicinity of this beach (CPRH, 2009).

Regarding the temporal distribution, the highest densities in the rainy season are corroborated by Swedmark (1964) and Albuquerque *et al*. (2007), where they describe that some meiofauna groups may become abundant with the increase of rainfall caused by sedimentary deposition processes. The richness of the same sampling sites didn´t variate between the dry and rainy seasons, which is in contrast with Souza-Santos *et al*. (2003) and Gomes & Rosa-Filho (2009) that showed an increase in both density and richness, in the dry period. However, Souza-Santos *et al*. (2003) results are from a different type of sandy beach (Tamandaré), that although it is geographically close, the two locations are separated by an estuary. Meanwhile, the study developed by Gomes & Rosa-Filho (2009) took place at the Amazon region, where, even during the dry season, still have a high humidity climate.

CONCLUSION

Regarding the spatial distribution, the highest abundances, densities and richness of the meiofauna organisms were identified at the upper mesolittoral area. Meanwhile, the highest densities were recorded during the rainy season.

Based on the results obtained, the meiofauna community from Guadalupe Beah is in concordance with the distribution pattern described on the literature for tropical sandy beaches, especially when the sediment is compose mainly by fine sand.

The ecological studies of meiofauna are of extreme importance for the understanding of the natural processes of a sandy beach. In addition, the evaluation of the ecological role and the environmental and temporal

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