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THE INFLUENCE OF TIDAL AND RAINFALL CYCLES ON INTERTIDAL NEMATODES: A CASE STUDY IN A TROPICAL SANDY BEACH

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ABSTRACT

The present study describes the nematode assemblage of the bay of Tamandaré (Brazil), a tropical sandy beach, during the low, flood, high and ebb tides of two consecutive tidal cycles in four different months of the year (May, July, September and November). The nematode assemblage was dominated by *Metachromadora* and *Perepsilonema* and varied significantly between months and tides. Densities were lower in July, and changes in assemblage structure occurred during the transitional periods between rainy and dry months, which showed the influence of rainfall. Flood and ebb tides appeared to exercise the greatest influences over the tidal cycle, although the patterns were not very clear. Identification at genera/species level is recommended for future studies, to better understand the patterns of nematode assemblages during tidal cycles.

RESUMO

O presente estudo descreve a associação de nematódeos da Baía de Tamandaré (Brasil), praia arenosa tropical típica, durante as marés (baixa, enchente, alta e vazante) de dois ciclos de maré consecutivos, em quatro meses diferentes do ano (Maio, Julho, Setembro e Novembro). A associação de nematódeos foi dominada por *Metachromadora* e *Perepsilonema* e variou significativamente entre meses e marés. Densidades foram mais baixas em julho e as mudanças na associação ocorreram durante meses de transição entre chuvoso e seco mostrando a influência do ciclo de chuvas. No ciclo de maré a enchente e vazante pareceram exercer a maior influência, embora os padrões não fossem muito claros. Recomenda-se que os estudos devam ser feitos ao nível de gêneros/espécies para melhor compreensão dos padrões das associações de nematódeos durante ciclos de marés.

Descriptors: Brazil, Intertidal environment, Marine nematodes, Meiobenthos, Seasonal variations, Tides.
Descritores: Brasil, Ambiente intermareal, Nematódeos marinhos, Meiobentos, Variações sazonais, Marés.

INTRODUCTION

The term “sandy beach” has been used in literature to characterize a series of environments that vary from high energy beaches with strong waves, to sheltered estuarine flats (McPALACHLAN, 1983). These environments are the most dynamic of all marine ecosystems and are predominant in the coastal zone of both temperate and tropical regions (McLACHLAN; TURNER, 1994).

In sandy beaches, biotic and abiotic features such as sediment, microphytobenthos, oxygen, temperature and organic matter regulate meiobenthos (GIERE, 2009). However, all these characteristics are directly regulated by the energy of waves and tidal amplitude, especially in the intertidal region where their effects are more prominent (McLACHLAN, 1983). During the tidal cycle, changes occur in the sediment column directly influencing the zonation of organisms (FENCHEL, 1978; PALMER; BRANDT, 1981). However, most studies have only sampled fauna during low tide, and have not considered other stages of the cycle (DYE, 1978).

Nematodes are highly heterogeneous and frequently the most abundant meiobenthos group in sandy beaches in coastal zones (HEIP et al., 1982). Nevertheless, few ecological studies identify them at genera/species level, and studies that do are mostly restricted to temperate regions, such as Europe

(GHESKIERE et al., 2004, GHESKIERE et al., 2005, KOTWICKI et al., 2005, MARIA et al., 2012) and Canada (SHARMA; WEBSTER, 1983). In tropical regions, studies have been performed in Australia (NICHOLAS; HODDA, 1999, NICHOLAS, 2001, HOURSTON et al., 2005), Ecuador (CALLES et al., 2005) and French Polynesia (GOURBAULT et al., 1995). Despite the extensive coastline of Brazil, and the high diversity of the group in sandy beaches (VENEKEY et al., 2010), only a few surveys in the country have studied nematodes at low taxonomic levels (BEZERRA et al., 1997; NETTO et al., 2007; MARIA et al., 2008; MARIA et al., 2013, VENEKEY et al., 2014; MELO et al., 2013). Whether studied at phylum, or low taxonomic levels, temporal studies of marine nematodes usually employ a monthly or seasonal scale, and mostly compare periods with or without rain.

The present study describes the effect of complete tidal cycles on nematode assemblage in a tropical sandy beach (Tamandaré, Pernambuco, Brazil) during rainy and dry periods of the year, testing the main hypothesis that assemblage structure is influenced by tides.

MATERIAL AND METHODS

The sampling station (08º45’58’’S, 35º05’96’’W) is located in the bay of Tamandaré, about 110 km south of Recife, Pernambuco, Brazil (Fig. 01). This sandy beach is characterized by quartz sediments, varying from fine to medium grain size (SOUZA–SANTOS et al., 2003), and the adjacent subtidal area has coral reef formations arranged parallel to the coast (MAIDA; FERREIRA, 1997). According to the criteria of MCLACHLAN (1980) the study area can be classified as a sheltered beach. The tidal amplitude in the area is about 2.5 m, and the cycle is semidiurnal. The climate is hot and humid, of type Aws, according to the Köppen system (mean lowest temperature in the colder months: >18°C). Based on the averages over the last 50 years, the region has two seasons: a dry summer season extending from September to February and a rainy winter season from March to August, with half of the annual rainfall occurring between May and July (SEMA – Science, Technology and Environment Department of Pernambuco state). There are around 12-13 hours of daylight per day.

Samples were exclusively collected in the upper intertidal zone, at hourly intervals, for 24h, in four different months of 1991: May, July, September and November. At each sampling, six meiofauna replicate cores were collected using a PVC hand-corer (inner diameter of 2.5cm and depth of 10 cm) and fixed immediately in 4% formaldehyde solution. In the laboratory, samples were treated using the routine methods for meiofauna (humid sieving and manual centrifugation) suggested by ELMGREN (1973) and nematodes were sorted using Dollfus plates and a

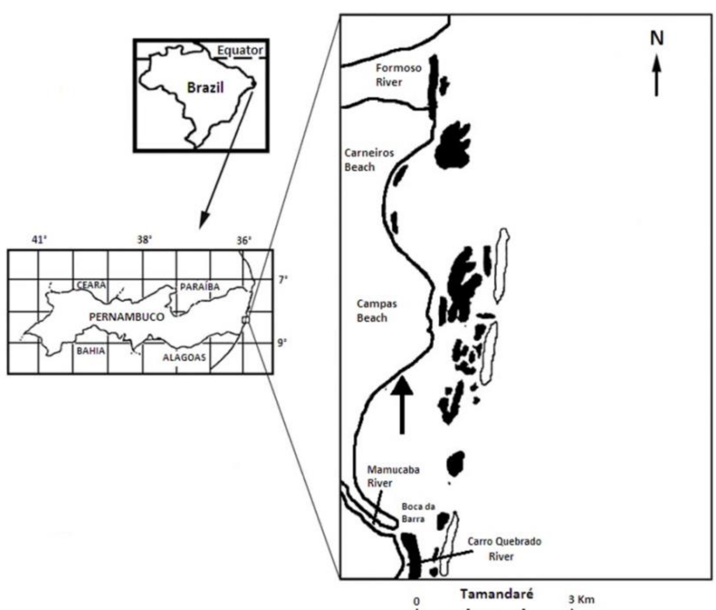

Fig. 1. Map of the sampling site (indicated by the arrow) at Tamandaré beach, Brazil.

stereoscopic microscope. Permanent slides were made for taxonomical identification of nematodes to genus and/or species level, as described by COBB (1917) and DE GRISSE (1969). The mean density for each tide (low, flood, high and ebb) was calculated using the density values obtained during each tidal peak, and at preceding and subsequent times.

Nematode Density (N), richness (S), diversity (Shannon-Wiener index – H' in $\log_e$) and evenness (Pielou index – J') were calculated for each sample. PERMANOVA was applied to assess differences in nematode assemblage structure, after data were transformed to log (x+1) and using the Bray Curtis index. Factors included months, tides and light/dark periods of the day. Pairwise *a posteriori* comparisons were performed when significant differences were detected ($p<0.05$). Multidimensional scaling analysis (MDS) was used to identify differences in nematode assemblage between months, tides and light/dark periods of the day. Statistical analyses were performed using the PRIMER 6.1.13 & PERMANOVA+ 1.0.3 program (ANDERSON et al., 2008).

RESULTS

The nematode assemblage of Tamandaré beach consisted of 48 genera (with 41 named/putative species), 21 families and 4 orders (Table 1). Fluctuations were observed in genera numbers when tides and months were compared (Fig. 02) but differences in richness were significant only in comparisons between months (Pseudo-F=12.896; p=0.0001). Diversity also varied significantly between months, with values ranging from 1.26 to 1.97 in May, 1.58 to 2.24 in July, 1.44 to 2.31 in September and 2.13 to 2.44 in November (Pseudo-F=12.323, p=0.0001). These results indicated that May was the least rich and least diverse month, while November was the richest and most diverse month. July and September provided intermediate results. Evenness values were continuously high (>0.9) and, similar to other measures, only varied significantly between months (Pseudo-F=8.4635, p=0.0004).

Table 1. List of the nematode species found in Tamandaré Beach, Pernambuco State, Brazil.

Phylum Nematoda
Class Adenophorea
Subclass Enoplia
Order Enoplida
Suborder Enoplina

Family Enchelidiidae
Bernardius Fonseca-Genevois, Smol, Decraemer & Venekey, 2009
Bernardius lineatus Fonseca-Genevois, Smol, Decraemer & Venekey, 2009
Eurystomina Filipjev, 1921

Family Ironidae
Trissonchulus Cobb, 1920

Family Oncholaimidae
Viscosia De Man, 1890

Family Oxytominidae
Halalaimus De Man, 1888
Oxystomina Filipjev, 1921
Oxystomina sp.
Wieseria Gerlach, 1956
Wieseria sp.

Family Thoracostomopsidae
Enoploides Ssaweljev, 1912
Mesacanthion Filipjev, 1927
Mesacanthion hirsutum Gerlach, 1953
Trileptium Cobb, 1933
Trileptium stylum Gerlach, 1956
Suborder Tripyloidina

Family Tripyloididae
Bathylaimus Cobb, 1894
Bathylaimus capacosus Hopper, 1962
Order Trefusiida

Family Lauratonematidae
Lauratonema Gerlach, 1953
Lauratonema sp.
Subclass Chromadoria
Order Chromadorida
Suborder Chromadorina

Family Chromadoridae
Acantholaimus Allgén, 1933
Chromadorita Filipjev, 1922
Dichromadora Kreis, 1929
Dichromadora sp.
Endeolophus Boucher, 1976
Innocuonema Inglis, 1969
Neochromadora Micoletzky, 1924
Neochromadora sp.
Parachromadorita Blome, 1974
Parachromadorita sp.

Family Cyatholaimidae
Marylynnia Hopper, 1977
Marylynnia sp.
Paracyatholaimoides Gerlach, 1953
Paracyatholaimoides sp.

Family Desmodoridae
Chromaspirinia Filipjev, 1918
Chromaspirinia sp.
Desmodora De Man, 1889
Desmodora sp.
Metachromadora Filipjev, 1918
Metachromadora sp.1
Metachromadora sp.2
Metachromadora sp.3
Metachromadora sp.4
Family Epsilonematidae
Perepsilonema Lorenzen, 1973
Perepsilonema kellyae Gourbault & Decraemer, 1988
Perepsilonema sp.

Family Microlaimidae
Calomicrolaimus Lorenzen, 1971
Calomicrolaimus formosus Jensen, 1978

Microlaimus De Man, 1880
Microlaimus sp.

Family Selachinematidae
Latronema Wieser, 1954
Latronema botulum Gerlach, 1956
Synonchium Cobb, 1920
Synonchium sp.
Suborder Leptolaimina

Family Ceramonematidae
Metadasynemoides Haspeslagh, 1973
Metadasynemoides sp.
Family Haliplectidae
Haliplectus Cobb, 1913
Haliplectus sp.

Family Leptolaimidae
Camacolaimus De Man, 1889
Cynura Cobb, 1920
Cynura cerambus Andrassy, 1973
Diodontolaimus Southern, 1914
Diodontolaimus sp.
Procamacolaimus Gerlach, 1954
Stephanolaimus Ditlevsen, 1914
Stephanolaimus sp.

Family Tarvaiidae
Tarvaia Allgén, 1934
Tarvaia sp.
Order Monhysterida

Family Axonolaimidae
Axonolaimus De Man, 1889
Axonolaimus sp.

Family Diplopeltidae
Araeolaimus De Man, 1888

Family Xyalidae
Daptonema Cobb, 1920
Daptonema sp.1
Daptonema sp.2
Elzalia Gerlach, 1957
Elzalia sp.
Paramonohystera Steiner, 1916
Pseudosteineria Wieser, 1956
Pseudosteineria scopae Gerlach, 1956
Rhynchonema Cobb, 1920
Rhynchonema sp.1
Rhynchonema sp. 2
Scaptrella Cobb, 1917
Scaptrella sp.
Theristus Bastian, 1865
Theristus sp.1
Theristus sp.2

Family Comesomatidae
Paracomesoma Hope e Murphy, 1972
Paracomesoma sp.
Paramesonchium Hopper, 1967

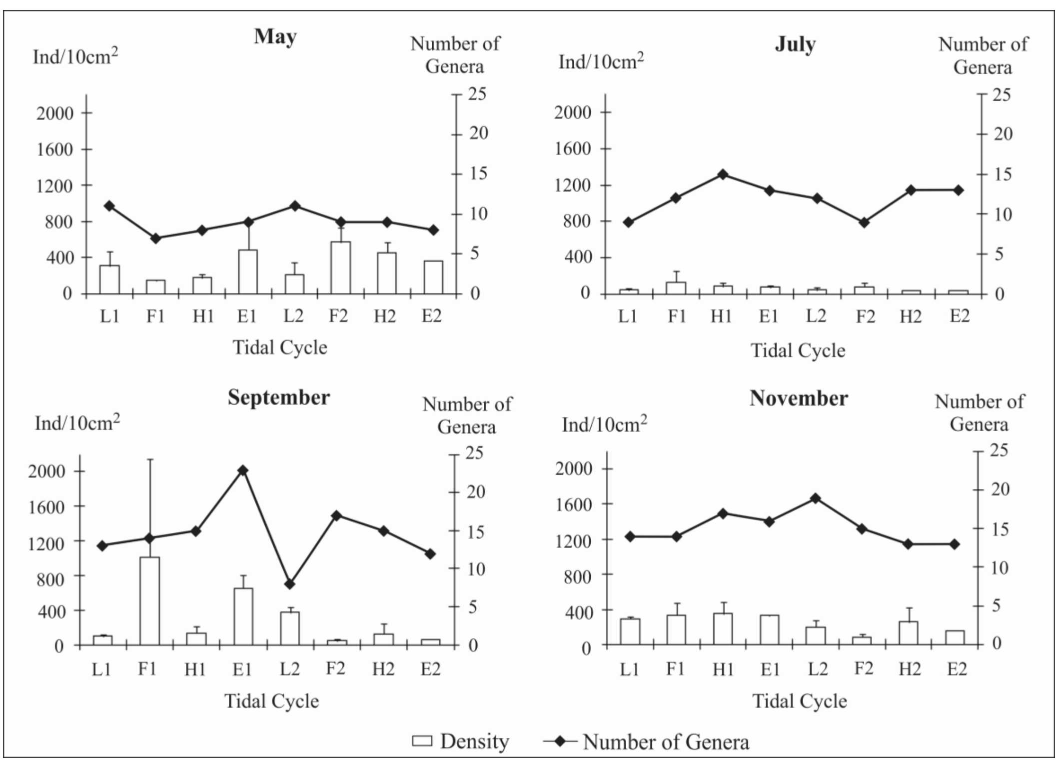

Fig. 2. Mean density (ind./10 cm^2) (bars indicate average ± standard deviations) and number of nematodes genera during two consecutive tidal cycles (1 and 2) in four different months (L = low tide; F = flood tide; H = high tide; E = Ebb tide) at Tamandaré beach, Brazil.

Results from PERMANOVA for nematode assemblage showed significant differences between months and tides, but not for periods of the day (Table 2). Nematode densities were lower in July (38-84 ind/10 cm^2) than in the months of May (146 -570 ind/10 cm^2), September (45-1013 ind/10 cm^2) and November (84-334 ind/10 cm^2) (Fig. 2). Post-hoc pairwise comparisons showed that nematode assemblages were different in each month ((Table2). The differences between months were evident from MDS analysis (Fig. 3).

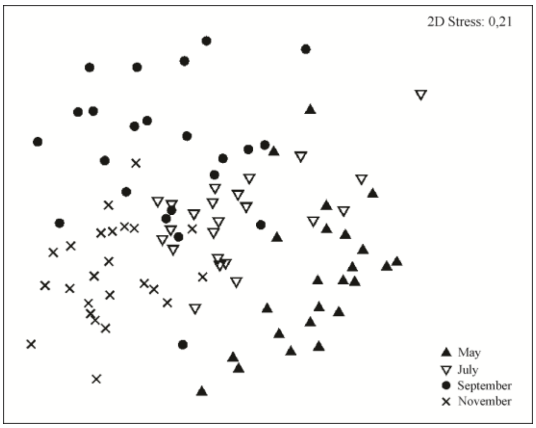

Fig. 3. Non-metric scaling plot of months at Tamandaré beach, Brazil.

Table 2. PERMANOVA results for the structure of nematode assemblages as between monthly, tidal and daily periods on Tamandaré beach, Brazil. Asterisks represent significant differences (p<0.05).

Factor	DF	MS	Pseudo-F	P(perm)
Months	3	21127	19.393	0.0001*
Tides	3	1762	1.6173	0.0449*
Days	1	1268.5	1.1643	0.3296
Months x Tides	9	2052	1.8835	0.0001*
Months x Day Periods	3	2084.2	1.9131	0.0103*
Tides x Day Periods	3	1598.1	1.4669	0.0783
Months x Tides x Day Periods	9	1518.5	1.3938	0.0319*
Residue	62	1089.5		
Total	93			

There was no clear pattern of nematode densities in all months when the four tides (low = L, flood = F, high = H, ebb = E; 1 and 2 = first and second cycles) were compared. Densities varied from 45 (L2 in July) to 373 (L2 in September) ind/10 cm^2 at low tide, and from 45 (F2 in September) to 1013 (F1 in September) ind/10 cm^{2}at flood tide, from 38 (H2 in July) to 452 (H2 in May) ind/10 cm^2 at high tide and from 41 (E2 in July) to 654 (E1 September) ind/10 cm^2 at ebb tide. Post-hoc pairwise comparisons showed that nematode assemblages were different only between flood and ebb tide, and flood and high tide ((Table 3). However when tides from the same month were compared, other significant differences were also found which were not always related to the flood tide (Table 4).

Table 3. Results of the paired tests for the structure of nematode assemblages between months and tides at Tamandaré beach, Brazil. Asterisks represent significant differences (p<0.05).

Factor	T	P(perm)
May x July	4.1038	0.0001*
May x September	4.5083	0.0001*
May x November	6.6653	0.0001*
July x September	2.7109	0.0002*
July x November	4.613	0.0001*
September x November	3.6815	0.0001*
Ebb x Low	1.1234	0.2746
Ebb x Flood	1.507	0.0329*
Ebb x High	0.539	0.9336
Low x Flood	0.847	0.6465
Low x High	1.3024	0.1223
Flood x High	1.7884	0.0074*

Table 4. Results of the paired tests for the structure of nematode assemblages between tides in each month at Tamandaré beach, Brazil. Asterisks represent significant differences (p<0,05).

Factor	T	P(perm)
May		
Ebb x Low	0.701	0.775
Ebb x Flood	1.298	0.159
Ebb x High	1.313	0.174
Low x Flood	1.746	0.012*
Low x High	2.146	0.004*
Flood x High	1.459	0.132
July		
Ebb x Low	1.471	0.099
Ebb x Flood	1.821	0.021*
Ebb x High	0.798	0.758
Low x Flood	0.735	0.727
Low x High	1.652	0.048*
Flood x High	2.037	0.006*
September		
Ebb x Low	1.473	0.056
Ebb x Flood	1.057	0.372
Ebb x High	1.011	0.461
Low x Flood	1.264	0.114
Low x High	1.237	0.152
Flood x High	0.522	0.978
November		
Ebb x Low	1.007	0.443
Ebb x Flood	2.044	0.006*
Ebb x High	0.498	0.909
Low x Flood	1.547	0.043
Low x High	0.721	0.841
Flood x High	1.937	0.003*

In May *Metachromadora* (with 4 species) was the most abundant genus for all tides, varying from 49 to 89%. The presence of the *Calomicrolaimus* and *Mesacanthion* genera, represented by the single species *C. formosus* and *M. hirsutum*, contributed with 14 and 10% during the first and second ebb tide, respectively. Other genera represented less than 10% of the nematode assemblage (Fig. 4). In July *Metachromadora* remained the most abundant genus, but was less expressive than in May (27 to 40%). The genera/species *Perepsilonema* (2 species), *Axonolaimus* sp., *Marylynnia* sp., *Microlaimus* sp., *Pseudosteineria scopae* and *Theristus* (2 species) occasionally comprised more than 10% of the assemblage. In September, *Metachromadora* represented more than 10% of total abundance only at second ebb tide. In that month the genus *Perepsilonema* was most abundant (from 39 to 85%) in all stages of the two consecutive tide cycles, with the exception of the second ebb when *Microlaimus* sp. was the dominant taxon, with 22%. In November *Perepsilonema* comprised more than 10% of total abundance during the first flood only. In that month *Microlaimus* sp. (L1, H2 and E2), *Axonolaimus* sp. (F1 and F2) and *Pseudosteineria scopae* (H1, E1 and L2) were dominant. Other species such as *Mesacanthion hirsutum*, *Bathylaimus capacosus* and *Bernardius lineatus* occasionally represented more than 10% of the total (Fig. 4).

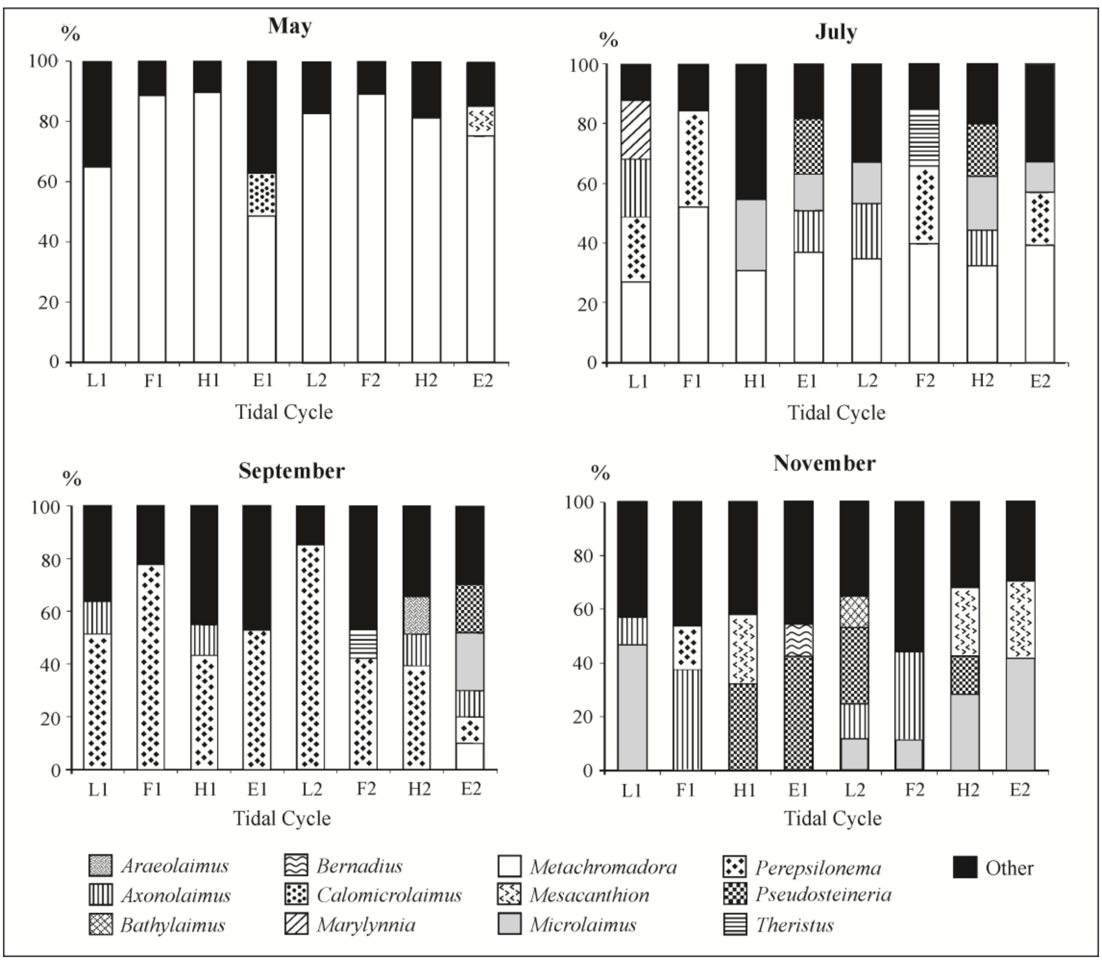

Fig. 4. Relative abundance of nematode genera during two consecutive tidal cycles (1 and 2) in four different months (L = low tide; F = flood tide; H = high tide; E = Ebb tide) at Tamandaré beach, Brazil.

Discussion

The number of genera occurring in Tamandaré (48 genera) is similar to other Brazilian sandy beaches: 39 genera in Istmo de Olinda – Pernambuco (T. N. C. BEZERRA, pers. comm.*) 39 genera in Bananal Beach – Rio de Janeiro (MARIA et al., 2008) and 46 genera in Coqueiros Beach – Rio de Janeiro (MARIA et al., 2008). All 48 genera had already been recorded on the Brazilian coast (VENEKEY et al., 2010) with the exception of *Bernardius* which was recently described by FONSECA-GENEVOIS et al. (2009) as a new genus with specimens collected in Tamandaré during the present study. Apart from the new species *Bernardius lineatus*, of the nine species identified by name, *Bathylaimus capacosus*, *Cynura cerambus* and *Mesacanthion hirsutum* were found for the first time in Brazil. The lack of records of these species in previous Brazilian studies does not mean that they are not present in other areas. This result is a consequence of the fact that few studies have been undertaken in Brazil with nematode identification at species level.

The highest nematode density at Tamandaré beach was 1,013 ind/10 cm^2. This value is in accordance with those found in similar habitats worldwide, whether in temperate (GHESKIERE et al., 2005 in Italy: 130 – 2001 ind/10 cm^2) or tropical regions (BEZERRA et al., 1996 in Brazil: 380 - 4681 ind/10 cm^2). Variation was observed in densities, as well as in taxonomic composition. As the tide amplitude was similar between months, it can be deduced that the differences found are due to other environmental factors. Many studies of meiofauna and nematodes associate changes in density with seasonal variations (HEIP et al., 1985). In temperate regions, where seasons are well defined, low densities are usually recorded in winter and associated mainly with reductions in microphytobenthic biomass (RUDNIK et al., 1985; SANTOS et al., 1996). In tropical regions the few studies that exist associate changes in nematode density with rain cycles (PATTNAIK; RAO, 1990; INGOLE; PARULEKAR, 1998; VENEKEY et al., 2014).

In terms of minimum and maximum densities during the study (38 and 1,013 ind/10 cm^2), in May, densities fluctuated from low to medium and a clear dominance of *Metachromadora* was observed. In July densities and genera abundances were more or less constant. In September fluctuations were high, and again a clear dominance of one genus was observed, in this case *Perepsilonema*. In November density fluctuations varied from low to medium and the composition, dominance and abundance of genera were the most uniform during the study. Variations therefore appear to be connected to monthly seasonal variations. In the year studied, 536.3, 355.5, 59.2 and 61.2mm of precipitation were registered at Recife's Meteorological Station for May, July, September and November, respectively (INMET, 2013). May and July may, therefore, be considered as rainy and September and November as dry. Both PERMANOVA and MDS presented a clear monthly distinction, the difference between them being evident. The change in genera dominance in sandy beaches occurred mainly during months that are transitional either from dry to rainy periods (May) or from rainy to dry periods (September), as had previously been observed in Ecuador by CALLES et al. (2005). In terms of monthly differences, densities were distinctly lower in July, with values that were consistently less than 150 ind/10 cm^2, results similar to those found by BEZERRA et al. (1996) who also found lower nematode densities in July when studying a tropical sandy beach, Istmo de Olinda (also in Pernambuco state, Brazil), during a one-year period, with monthly samplings.

In temperate regions it has previously been found that most animals use sediment layers immediately below the surface, migrating to lower depths (HARRIS, 1972) during the winter. On Tamandaré, and also on Istmo de Olinda, only the first 10 cm of the sediment was sampled without stratification, and it was therefore impossible to ascertain whether density variations occurred within the sediment column. However, certainly nematodes disperse/migrate through the sediment or water column.

Among the genera the dominance of *Metachromadora* (family Desmodoridae) in May and of *Perepsilonema* (family Epsilonematidae) in July was remarkable. On sandy beaches with medium sands, such as Tamandaré, families like Desmodoridae, Draconematidae and Epsilonematidae can become dominant (HEIP et al., 1985). Their presence in this kind of environment can be attributed to their morphological characteristics which include numerous ambulatory setae that are often used to attach to sediment grains (RAES et al., 2007). This later behavior can specially favor these taxa's dominance in intertidal regions. The presence of *Metachromadora* is very common in Brazilian sandy beaches (VENEKEY et al., 2010), and it can even be one of the dominant genera in this type of environment (GHESKIERE et al., 2005). The genus *Perepsilonema* has also already been recorded in high abundance in other tropical sandy beaches (GOURBAULT; DECRAEMER, 1993), including some on the Pernambuco coast (BEZERRA et al., 1996; VENEKEY et al., 2014). Other taxa such as *Axonolaimus* (family Axonolaimidae), *Theristus*

(*) BEZERRA, T. N.C., 2001. Dra. University of Gent, Belgium).

(family Xyalidae) and *Pseudosteineria* (family Xyalidae) appeared occasionally with more than 10% of total nematode abundance. These genera are non-selective deposit feeders according to WIESER'S (1953) classification and, due to their more generalist feeding habit, can become abundant. Particularly Xyalidae is a very common family in all types of marine environments and is frequently recorded with high abundances in fine to medium sands (HOURSTON et al., 2005; MORENO et al., 2006; MUNDO-OCAMPO et al., 2007). Furthermore, the differences in genera richness and diversity between months and tides were mainly caused by the presence or absence of rare genera (*Acantholaimus*, *Chromaspirinia*, *Dichromadora*, *Halalaimus*, *Paracomesoma*, *Stephanolaimus* and *Tarvaia*).

The interstitial habitat of sandy beaches has the ability to adapt in accordance with local energy fluctuations as it presents the dynamic characteristics which maintain sand grains, water and air in constant movement (BROWN; McLACHLAN, 1990). The adaptation to sediment erosion and deposition is dependent on beach energy (FLEMMING; FRICKE, 1983), and although these processes are influenced by many factors, tides are the most important (HULINGS; GRAY, 1976). On Tamandaré, nematodes reacted to tide changes and, in terms of the tidal cycle, flood and ebb tides seemed to have the greatest influence. However, the patterns were not very clear possibly because tides interact with waves and wind to determine energy variation and thus sand and water movements.

According to HULINGS and GRAY (1976) tides are determining factors for zonation and abundance of meiofauna. It is evident that sandy beaches are sensitive to changes in environmental factors, especially to waves and tides conditions, responding rapidly to different levels of energy (FLEEMING; FRICKE, 1983). The influence of tidal cycles in the vertical distribution of organisms is demonstrated by cyclical changes in the interstitial habitat associated with processes of movement in the sediment, hydrodynamic changes caused by currents, and differences in wave energy that act on the sediment column (BOADEN, 1968). Generally animals have ascendant movements during flood tide, when the sediment is saturated by water, resulting in high densities, and move in the opposite direction during ebb tide, when the first sediment layers become dry, resulting in low densities (McLACHLAN et al., 1977). In Tamandaré this pattern was only observed in the two consecutive tidal cycles in July and in the second tidal cycle in May. (SILVA, A. P. C. 2014, pers. comm.*) who studied only flood and ebb tides in Maracaípe, a sandy beach also in the south of the Pernambuco littoral, did not find any significant variations in nematodes densities, suggesting that they are resistant to the hydrodynamic changes that occur during tides. This observation is valid not only at phylum level but also for genera composition and abundance, according to (PEREIRA, L. L., 2008, pers. comm.*) according to who studied the same samples as (SILVA, A. P. C., 2006, pers. comm.**). Alternatively, many authors suggest that nematodes are influenced by tides (BOADEN; PLATT, 1971; PALMER; GUST, 1985; FEGLEY, 1987; PALMER 1988). The results in Tamandaré partly agree with this last group of authors, although it seems that either biotic/abiotic factors other than tides should be considered, or the studies should be undertaken at species level to better understand the variation in nematode assemblages during tidal cycles. VENEKEY et al. (2011), for instance, when studying the influence of tides on one isolated species, *Mesacanthium hirsutum*, unexpectedly found higher densities during high or ebb tides, but not in flood tides. Concerning *Metachromadora* and *Perepsilonema*, the most abundant genera recorded on Tamandaré, both have annulated cuticles that can offer strong protection in stressful habitats such as intertidal regions. BOADEN and PLATT (1971) had already noticed that nematodes with strong cuticles can be dominant in upper layers of the sediment in environments with tidal influence.

The results of the present study showed the clear effect of rainfall and tides on nematodes, showing that the ecology of nematode assemblage structure can be better understood using studies that identify to lower taxonomic levels. The identification of nematodes at genera level, and when possible at species level, is recommended for future studies. Furthermore, the sampling design of future studies should take into consideration that nematode genera/species do not all possess the same movement or migration patterns.

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