PLANKTONIC ROTIFERS FROM A TROPICAL ESTUARY UNDER HIGH MARINE
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ABSTRACT

Studies about the planktonic rotifers of the Passos River estuary, which is very influenced by marine waters, were carried out monthly from August/2009 to September/2010. A 64µm mesh size plankton net was hauled during low tide at two fixed stations in spring tides. Physical parameters as temperature, salinity, transparency and light extinction coefficient were obtained simultaneously. Statistical tests (Man-Whitney) were performed to evaluate possible seasonal and spatial variations. The rotifers were represented by only four species. Although there was no significant seasonal variation, the highest

abundances were registered in the rainy season, with an expressive predominance of *Brachionus plicatilis* Müller, 1786. However, a population pick was registered in the dry season (September/2009; 13182,03 org.m⁻³) and the lowest value was registered in the rainy season (2010 May; 7,56 org.m⁻³). *Brachionus plicatilis* Müller, 1786 was highlighted as salinity indicator as well as its extremely opportunistic condition in eutrophic ecosystems, while *Rotaria rotatoria* (Pallas, 1766) and *Rotaria* sp. indicated organic pollution. Due to the constant high salinity regime the estuary showed few species richness.

Keywords: Indicator, Rotifers, Salinity, Northeastern Brazil.

RESUMO

Estudos sobre rotíferos planctônicos no estuário do rio dos Passos, um ambiente altamente influenciado por águas marinhas, foram realizados mensalmente no período de agosto/09 a setembro/10, com uma rede de plâncton com 64 µm de abertura de malha, arrastada em 2 estações fixas nas baixas-mares de sizígia. Foram registrados dados de temperatura, salinidade e de transparência da água e coeficiente de extinção de luz. Foram realizados testes estatísticos para verificar possíveis mudanças sazonais e espaciais (Man-Whitney). Os rotíferos estiveram representados por quatro espécies. Apesar de não ter havido diferença sazonal significativa, as maiores abundâncias

foram registradas no período chuvoso, com predominância expressiva da espécie *Brachionus plicatilis* Müller, 1786. Entretanto, o maior pico populacional foi registrado no período seco (setembro/09; 13182,03 org.m⁻³) e o menor valor foi registrado no período chuvoso (maio/10; 7,56 org.m⁻³). Dentre as espécies encontradas, destacaram-se *Brachionus plicatilis* Müller, 1786, indicadora de influência salina e extremamente oportunista em ecossistemas eutrofizados; além de *Rotaria rotatória* (Pallas, 1766) e *Rotaria* sp. indicadoras de poluição orgânica. Devido a salinidade elevada, o estuário apresentou baixa diversidade de espécies.

Palavras chave: Indicador, Rotíferos, Salinidade, Nordeste do Brasil.

INTRODUCTION

Estuaries are home to very complex systems and are characterized by high productivity (DAY et al., 1989) and, taking into consideration the hydrodynamics of these environments, Pritchard (1967) sets the estuaries as bodies of coastal waters, semi-closed, which features free connection to the open sea, within which, the sea water is gradually diluted by fresh water from the land drainage.

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Therefore, it is a transitional ecosystem between the continent and the ocean. Because they are closely related to the freshwater marshes and mangroves play an important ecological role, as shelter and growth of juvenile species. Even so, some estuaries feature selected marine influence, resulting in salinities above 20, even in situations of low tides.

They are biologically important ecosystems because they are highly productive, but also very dynamic environments where the physical, chemical and biological factors suffer constant modifications (e. g., ESKINAZI-SANT'ANNA & TUNDISI, 1996). Despite this high productivity, these environments have low diversity levels due to stress caused by large variations in salinity during the events of tide, where few species are adapted to live in such conditions.

Zooplankton is a generic term that refers to a group of animals of different categories, with the common feature of the water column as its main habitat. It has a central role in the dynamics of an aquatic ecosystem, especially in nutrient cycling, as well as in the transfer of energy. Respond quickly to environmental changes due to their short life cycle, what makes these bodies to be good biological indicators (ESTEVEZ, 1988; DAY et al., 1989). In estuarine areas the zooplankton plays a key role serving as a link between the phytoplankton and trophic levels above, where any changes in the composition and functioning of the zooplanktonic community affect the state of all the ecosystem (NEUMANN-LEITÃO, 1990; LEVINTON, 1995; NAUMENKO, 2009).

One of the zooplanktonic organisms include the rotifers, which are aquatic or semi-aquatic microscopic invertebrates, whose name stems from the circular ciliation or modified present in the anterior region used for locomotion or feeding, through vibration with rotational appearance (OLIVEIRA-NETO & MORENO, 1999). Rotifers play an important role in the regeneration of nutrients and energy transfer in food webs and have been widely used as indicators of pollution and environmental conditions (MEDEIROS & HADEL, 1999).

Studies on rotifers of estuaries of Pernambuco pointed out the occurrence of 19 families, 29 genera and 85 species, considering nine estuaries where the group was studied (FILHO et al., 2011). These authors suggest that the species *Brachionus plicatilis* (Muller, 1786), *Rotaria rotatoria* (Pallas, 1766), *Filinia longiseta* (Ehrenberg, 1834) and *Platylabus quadricornis* Ehrenberg, 1832 can be considered as the main bioindicators of environmental quality in the State of Pernambuco, due to their high abundance and frequency of occurrence. Even so, more targeted studies to biological aspects, reproductive and trophodynamics of these species are extremely necessary for their use as environmental bioindicators.

The present study aimed to know the structure of the populations of rotifers from Passos River, a shallow saline estuary of northeastern Brazil, during the period of one year. At the same time, the present study sought to identify the indicator species of environmental condition and correlate the populations of rotifers with abiotic parameters of water (transparency, temperature and salinity).

STUDY AREA

The Passos River is located in the environmental protection area of Guadalupe, created by State Decree nº. 19,635, March 13, 1997 (PERNAMBUCO, 1997), and is located in the southern coast of the State of Pernambuco, Brazil. It covers the municipalities of Sirinhaém, Rio Formoso, Tamandaré and Barreiros (Pernambuco) in the Northeast Wet Forest, amounting to a total area of approximately 44.799 ha., of which 32,135 ha. are the continental area and 12,664 ha. are maritime area. The Passos River is one of the tributaries of the Formoso River, suffering high marine influence due to its large aperture with the open sea. This river receives discharge from two other rivers: Pedras (at west of Passos River) and Lemenho (at east of Passos River) (Figure 1).

The climate of the southern coast of Pernambuco, according to the Köppen classification (1940), is of type As', tropical c, distributed during nearly 200 days of the year, with a mean annual rainfall of 2,050 mm. The wettest months are May, June and July, being the most historically drought October, November and December. The annual average temperature is 24°C, ranging between a minimum of 18°C and maximum of 32°C, being strongly influenced by moderating action of the trade winds.

Figure 1 - Map of the South coast of the State of Pernambuco, with detail of the River estuary and location of collection stations. Modified from Falcão (2012).

MATERIAL AND METHODS

The collections were made monthly, August/09 to September/10, at two fixed points, Station 1 located in geographical coordinates $8^{\circ}37'53,67''\text{S}$ and $35^{\circ}5'3,81''\text{W}$; and, Station 2 located at the coordinates $8^{\circ}40'50,50''\text{S}$ and $35^{\circ}6'46,44''\text{W}$.

Samples of plankton, totaling 27 were obtained through horizontal hauls, lasting 5 minutes, using a plankton net with $64\ \mu\text{m}$ mesh opening, 1 m long and 30 cm in diameter. After each collection, the samples were kept in plastic bottles with a capacity of 250 mL. The samples were fixed with 4% formalin neutralized with sodium tetraborate (borax) ($5\ \text{g L}^{-1}$), according to the technique described by Harris et al. (2000).

For analysis of temperature and salinity, water samples were collected through bottle of Kitahara, in two depths (surface and bottom), at low tide of Spring tide, in both stations. The transparency of the water was obtained by a Secchi disk. The light extinction coefficient was calculated from the Secchi disk data in meters through the formula of Poole and Atkins (1929): $K = 1.7/d$, where K is the light extinction coefficient and d the Secchi disk depth.

In the laboratory, the samples were diluted to a volume that ranged from 300 to 2000 mL, homogenized and removed three subsamples of 2 mL with a Stempel pipette. Each subsample was placed in a Sedgwick-Rafter chamber (2 mL volume) and analyzed qualitatively (identification and counting of fee) under a Zeiss microscope. For identification of organisms were used the following references: Koste (1978) and Neumann-Leitão (1986). The rotifers classification system was based on Koste (1978).

RESULTS AND DISCUSSION

Abiotic variables

The temperature of the water showed clear seasonal variation, showing higher values in the dry period, and the maximum value found of 31.1°C on the surface and 31.0°C on the bottom, at the station 1 in February/10. The lowest values were recorded during the rainy season, being the minimum value found of 23.0°C on the surface and 24.0°C in the bottom, at the station 1 in August/09.

The salinity showed a clear seasonal variation, being observed lower values during the rainy season, being the minimum value found in July/10 (14) at station 1 and the maximum found in December/09 (35) in season 2. Station 1 presented the highest salinity fluctuations between the surface and bottom. There was certain homogeneity of salinity, not being observed

vertical stratification. In General, the values were above 20 for most of the year, even though all times of low tides (Table 1).

The study area presented in the course of work little variation in local depth depending on the tide. The depth of the collection stations varied between 3.20 m and 1.90 m. Minimum registered occurred at station 1 in the month of August/09 and the maximum at station 2, in the months of November/09 and February/10.

The extinction coefficient of light had maximum in April/10, 3.95 k to the value of 0.43 m transparency and minimum in December/09, with calculated value of 0.72 k to the 2.35 m of transparency. The transparency of the water showed variation between the stations, with minor depths in the innermost station (Station 1), with the minimum of 0.43 m in April/10 and higher depths in the outermost station (Station 2), with a maximum value of 2.35 m in December/09.

Table 1 – Average value and standard deviation (SD) of temperature (°C), salinity, Secchi (m) and light extinction coefficient (LEC; k), collection at stations 1 and 2 (S1 and S2 respectively) on the surface (S) and bottom (B) of the estuary of Passos River, Pernambuco.

Months	Temperature				Salinity				Secchi		LEC	
	S1_S	S1_B	S2_S	S2_B	S1_S	S1_B	S2_S	S2_B	S1	S2	S1	S2
August/09	23,0	24,0	27,,0	27,0	23	24	27	27	0.60	1.50	2.83	1.13
September/09	29.5	29,0	28,0,	27.5	20	24	29	29	0.82	1.59	2.07	1.07
October/09	30.1	29,0	28,0	28.2	25	26	29	29	1.00	2.32	1.70	0.73
November/09	28.2	28,0	28.8	28,0	28	30	33	33	1.55	2.00	1.10	0.85
December/09	29,0	28.9	29,0	29,0	34	35	35	35	1.20	2.35	1.42	0.72
January/10	29,0	28.5	28.5	28.2	28	33	32	33	1.10	2.12	1.55	0.80
February/10	31.1	31,0	29,0	29,0	28	28	30	31	0.92	1.86	1.85	0.91
March/10	29.2	29,0	27.3	27.3	24	25	30	28	0.91	2.10	1.87	0.81
April/10	29.5	29,0	29.5	29.5	20	20	29	29	0.43	1.44	3.95	1.18
May/10	28.9	28.3	28.8	28.5	25	27	30	30	0.72	2.10	2.36	0.81
June/10	28,0	28.3	27.2	27.3	22	22	27	26	0.77	1.85	2.21	0.92
July/10	26,0	25.9	25.2	25.8	14	14	20	20	0.89	1.84	1.91	0.92
August/10	25.8	25.5	24.9	24.8	17	20	26	26	0.79	1.92	1.34	0.89
September/10	28,0	27,0	25,0	26,0	20	23	31	26	1.12	2.05	1.90	0.83
Mean	28.2	28,0	27.6	27.6	23.4	25.1	29.1	28.7	0.92	1.93	2.00	0.90
SD	2.07	1.79	1.57	1.34	5.17	5.47	3.57	3.77	0.28	0.28	0.71	0.14

Population structure of planktonic rotifers

Composition and frequency of occurrence (%)

The rotifers were represented by four species (Table 2), being distributed in three families and three genera. In the estuary of the Passos River there was a significant dominance of the species *Brachionus plicatilis*. This species was the only considered frequent, with 57.69%, whereas *Rotaria rotatoria* showed low frequency, with 26.92%, and *Lecane luna* and *Rotaria* sp. were considered sporadic, with less than 10% (Table 2).

According to Neumann-Leitão (1990), *B. plicatilis* is a eurithermic widely distributed species and inhabits estuarine and marine waters. In the estuary of the Ipojuca River (Pernambuco), this species was one of three that occurred during dry and rainy seasons, and the other occurred only during the rainy season, always infrequent (NEUMANN-LEITÃO, 1996).

Table 2 – Composition and frequency of occurrence of the species found by station (S1 and S2) and total frequency, at the mouth of the Passos River, PE.

Composition	Frequency of occurrence (%)		
	S1	S2	Total
Filo Rotifera			
Classe Eurotatoria			
Subclasse Monogononta			
Superordem Pseudotrocha			
Ordem Ploima			
Brachionidae			
<i>Brachionus plicatilis</i> (Müller, 1786)	85.74	25	57.69
Lecanidae			
<i>Lecane luna</i> (Müller, 1776)	14.28	0	7.69
Subclasse Bdelloidea			
Philodinidae			
<i>Rotaria rotatoria</i> (Pallas, 1766)	42.85	8.33	26.92
<i>Rotaria</i> sp.	7.14	0	3.84%

Relative abundance (%)

The rotifers had the highest abundances in the rainy season and corresponded, mostly by individuals of the species *Brachionus plicatilis*, with visible spatial differences (Figures 2 and 3). In the months of March, April, May and June/09, the species *Brachionus plicatilis* showed maximum values of abundance at station 1 (Figure 2). In Station 2, these maximum values occurred in the months of April and May/09 (Figure 3). The species was dominant in both seasons, showing values above 70%. The species *Rotaria rotatoria* was considered little abundant, with less than 40%, and the species *Rotaria* sp. e *Lecane luna* were rare with less than 10%.

Figure 2 – Relative abundance of Rotifers found in Station 1 at the Estuary of Passos River, Pernambuco.

Figure 3 — Relative abundance of Rotifers found in Station 2 of the Estuary of the Passos River, Pernambuco.

Density of organisms (org. m⁻³)

The total density of organisms in the two stations was higher in the dry season (figures 4 and 5; Table 3), averaging 1150.6 org. m⁻³, while for the rainy season, the average was about 3.5 times smaller (322.3 org. m⁻³). The dry period presented the largest average at stations 1 and 2 (2355.0 and 12.7 org. m⁻³, respectively), while the rainy season had the lowest averages in both stations (596.0 and 3.1 org. m⁻³, respectively). *Brachionus plicatilis* was the most abundant, and due to large differences in values it was made exclusive graphics for this species (Figures 4 and 5). At the mouth of the Passos River, also there were peaks in the dry period, with highlights for the month of September/09 (13,182.0 org. m⁻³; Table 3).

In the estuary of the Mossoró River (state of Rio Grande do Norte), although high marine influence is registered on certain occasions, the rotifers showed high densities and abundance in stations where the salinity were low; however, the species *Brachionus plicatilis* appeared in all stations showing constancy throughout the sampled period, which confirms that the species is eurihaline (SERPE et. al., 2010). It was also the specie that occurred in most stations and periods, showing higher densities between the identified rotifers in the estuarine system of the Santa Cruz Channel (Pernambuco) (PORTO-NETO et. al., 1999). At the estuary of Capibaribe River (Pernambuco), this species was also very abundant in spring tide, especially during the dry period, with extremely high peaks (around 147,384 org. m⁻³; SILVA, 1996).

Figure 4 — Density (org. m⁻³) of *Brachionus plicatilis* collected at Station 1 in the Passos River estuary, Pernambuco.

Figure 5 — Density (org. m⁻³) of *Brachionus plicatilis* collected at Station 2 in the Passos River estuary, Pernambuco.

Seasonal and spatial variations

According to the Mann-Whitney test, there was significant difference for the total density of rotifers between the Station 1 and Station 2 ($p < 0.0001$), showing that occurred spatial variation. Comparing each species in both stations, there was significant difference for the species *Brachionus plicatilis* ($p = 0.0003$). However, no significant difference occurred to *Rotaria rotatoria* ($p = 0.3788$), *Rotaria* sp. ($p = 0.3788$) and *Lecane luna* ($p = 0.2685$). According to the Man-Whitney test there was no significant difference between the dry and rainy seasons for both stations (Station 1: $p = 0.1317$; Station 2: $p = 0.2442$), indicating no seasonal differences.

Table 3 - Density of planktonic rotifers species at Stations 1 and 2 (S1 e S2) at the estuary of the Passos River, Pernambuco.

The	Months	<i>Brachionus plicatilis</i>		<i>Rotaria rotatoria</i>		<i>Rotaria</i> sp.	<i>Lecane luna</i>	
		S1	S2	S1	S2	S1 S2	S1	S2
	August/09	243.0	0.0	2.3	15.1	0.0 0.0	0.0	0.0
	September/09	13182.0	61.0	0.0	24.0	7.6 0.0	7.6	0.0
	October/09	651.1	0.0	0.0	0.0	0.0 0.0	0.0	0.0
	November/09	662.5	0.0	89.4	0.0	0.0 0.0	0.0	0.0
	December/09	11.4	0.0	2.3	0.0	0.0 0.0	0.0	0.0
	January/10	0.0	0.0	0.0	0.0	0.0 0.0	0.0	0.0
	February/10	18.3	0.0	4.5	0.0	0.0 0.0	0.0	0.0
	March/10	61.9	29.0	0.0	0.0	0.0 0.0	0.0	0.0
	April/10	511.2	11.3	0.0	0.0	0.0 0.0	0.0	0.0
	May/10	2888.6	7.6	7.6	27.0	0.0 0.0	0.0	0.0
	June/10	53.4	0.0	22.0	22.0	0.0 0.0	0.0	0.0
	July/10	0.0	0.0	14.0	14.0	0.0 0.0	0.0	0.0
	August/10	302.6	0.0	20.6	20.0	0.0 0.0	2.3	0.0
	September/10	324.0	0.0	20.0	23.0	0.0 0.0	0.0	0.0
	Mean	1350.7	7.8	13.0	10.4	0.5 0.0	0.7	0.0

Estuary of the Passos River (PE) compared to other Brazilian NE estuaries

The estuary of the Passos River showed a community of rotifers comprised of only 4 species – a small number when compared with other estuarine systems in the Brazilian Northeast, where diversity has been shown to be high (NEUMANN-LEITÃO, 1992; NEUMANN-LEITÃO, 1994; VITÓRIO, 2006; MEDEIROS et al., 2010; SERPE et al., 2010; FILHO et al., 2011). However, other estuaries showed a pattern similar to the estuary of the Passos River, with low diversity of rotifers.

In the estuary of Formoso River, close to the area of the present study, for example, *Brachionus plicatilis* was sporadic and *Rotaria* sp. infrequent, both with low abundance (NEUMANN-LEITÃO et al., 1994-1995). In studies carried out by Eskinazi-Sant'anna (2000) at Pina bay estuarine system (Pernambuco), it was registered only *Brachionus plicatilis*, which was very abundant, with nearly 65% at the dry season (February/91) and more than 43% at the rainy season (June/91). Martins et al. (2006), studying the Anil River (state of Maranhão), found low diversity, registering *Brachionus plicatilis*, *Brachionus calyciflorus*, *Lecane* sp., *Monostyla* sp. (= *Lecane* sp., now) and *Proales* sp. However, rotifers dominated the community (93.53%), outranking *Brachionus plicatilis*, that showed 91.67% of frequency of occurrence. At the Passos River, *Brachionus plicatilis* was frequent and dominant, while *Rotaria rotatoria* showed low frequency and abundance; *Rotaria* sp. and *Lecane luna* were sporadic and rare.

According to Eskinazi-Sant'Anna & Tundisi (1996) and Medeiros et al. (2010), the discharge of rivers, the transparency and salinity gradients are what control the seasonal variation, playing important roles in the distribution of rotifers and composition of zooplankton. Salinity, in particular, is one of the factors that most influence the survival and distribution of estuarine organisms (NYBAKKEN & BERTNESS, 2005). In studies conducted in the estuary of Capibaribe River (Pernambuco), Silva et al. (1996) registered 25 species of rotifers, and contributed to this high diversity certain species that are well adapted to low salinity and organic pollution.

According to Pejler (1977), the genus *Brachionus* is quite representative in tropical regions, which justifies its wide distribution and abundance in the study area. The occurrence of *Brachionus plicatilis* in estuarine areas has already been cited by several authors (DOLAN & GALLEGOS, 1992; PARANAGUA & NEUMANN-LEITÃO, 1980, 1981; MEDEIROS et al., 2010). It is worth mentioning that this species is, for some authors (see review of CIROS-PÉREZ et al.,

2001), a likely complex of subspecies (or species), and this fact needs to be emphasized in future studies to determine new standards in environmental qualification of our estuaries. The Philodinidae family was represented by genera *Rotaria*, being *Rotaria rotatoria* the only species identified, and according to Ricci (1987) it is organic a pollution indicator' species. There was another representative of the genera which could not be identified. The only species of the family Lecanidae has been *Lecane luna*, whose occurrence was sporadic, it is not possible to infer more details on the same. The species has also occurred in other regions of the Brazilian Northeast, such as estuarine area of Mossoró River (state of Rio Grande do Norte) (SERPE, 2010) and São Francisco River estuary (between the states of Sergipe and Alagoas) (NEUMANN-LEITÃO et al., 1999).

Why the estuary of Passos River showed lower richness of rotifers?

In the estuary of the Passos River a high salinity was observed, with an average of 29.2 in the dry period, and 23.9 in the rainy season, which justifies the low richness of rotifers. The average salinity in the bottom layer throughout the sampled period was 26.8, whereas the average salinity in surface layer was 26.2, i.e. very close, showing that the marine influence and mixing dynamics are strong in this estuary.

The presence and domination of *Brachionus plicatilis* over the period of study is also justifiable, because it is a euryhaline species, extremely opportunistic, indicator of saline and eutrophic ecosystems (KOSTE, 1978). At Passos River estuary, changes in salinity were weakly influenced by the period of the year. In terms of composition of rotifers, it was observed a small change in respect to annual periods, when it was recorded only two species in the dry period. Natural influences such as seasonality and salinity may well influence the distribution of these species in certain environments as shown in the studies of Serpe et al. (2010) and Medeiros et al. (2010).

Despite the low diversity of rotifers, *Brachionus plicatilis* and *Rotaria rotatoria* can be considered "keys" in the estuary of Passos River. *Brachionus plicatilis*, in particular, was more abundant in the innermost station, whose average salinity differed between 4 and 5 points in relation to the outermost station. Studies on rotifers in other estuaries from Pernambuco also have emphasized the occurrence of few species (FILHO et al., 2011), outranking *Brachionus plicatilis* that was dominant in studies carried out by Paranaguá & Koenig (1977, 1980), Paranaguá & Neumann-Leitão (1980, 1981) and Sant'Anna (1993), having these authors also demonstrated that this species occurs in greater abundance and more frequently in periods with low salinities, corroborating with the present study, even this species being resistant to sharp variations of salinity.

CONCLUSIONS

1. The area studied showed a low species richness of rotifers, due to the high salinity, which limited the occurrence of a greater number of species;
2. Among the species found *Brachionus plicatilis* is a saline indicator species and *Rotaria rotatoria* and *Rotaria* sp. are organic pollution indicators;
3. *Brachionus plicatilis* stood out at the mouth of the Passos River, and this fact is associated to the high salinity registered, due to the strong marine influence in the area.

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