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SPATIO-TEMPORAL CHARACTERIZATION OF INTERTIDAL MACROFAUNA AT PRAINHA BEACH (RIO DE JANEIRO STATE)

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Abstract:

Variations in the density, richness and distribution of the intertidal macrofauna species were studied on a sandy beach along time. Monthly samples were taken from June 1993 through May 1995 at Prainha beach, State of Rio de Janeiro. Three transects were established, each with five strata parallel to the waterline. Strata were located between above drift line zone and the upper of the sublittoral area. From each stratum four replicates were randomly taken with a 0.04 m^2 sampler. This beach is constituted by medium sands (0.40 to 0.49 mm). The slope varied from 1/5.26 to 1/12.99 and the width of the beach varied from 46.7 to 63.2 m. Prainha was classified as a reflective beach (Dean's $\Omega = 1.13$). Monthly richness varied from 4 to 7 species. **Emerita brasiliensis** (Decapoda), **Excirolana braziliensis** (Isopoda) and **Pseudorchestoidea brasiliensis** (Amphipoda) were the main species accounting for 95 % of the community. The abundance of these three species varied continuously along the sampling period. **Emerita brasiliensis** was more abundant in summer and spring; followed by **P. brasiliensis** in autumn. **E. braziliensis** was more abundant in winter. Seasonal variation in the density of the macrofauna was connected with recruitment and reproduction activities. The supralittoral zone was characterized by holes of the ghost crab **Ocypode quadrata** and **Phaleria testacea**. **E. braziliensis** and **P. brasiliensis** showed continuous migration in the midlittoral zone, occupying the same stratum in most of the months. **Emerita brasiliensis** characterized the upper sublittoral area.

Key-words: macrofauna , sandy beaches, intertidal region, zonation.

Resumo:

"Caracterização espaço-temporal da macrofauna da zona entre-marés da Prainha, RJ"

Com a finalidade de conhecer a variação temporal da macrofauna de uma praia arenosa exposta, em relação à riqueza de espécies, distribuição e abundância, foram realizadas coletas mensais de junho de 1993 a maio de 1995. As amostras foram obtidas em 3 transectos, divididos em 5 estratos, paralelos à linha d'água. Os estratos foram localizados entre a zona acima da linha de deposição e a região superior do sublitoral. Em cada estrato, foram realizadas 4 amostras aleatórias com um amostrador de 0,04 m^2. A largura da praia variou entre 46,7 à 63,2 m e o declive de 1/5,26 à 1/12,99. O tamanho médio de grão variou entre 0,40 e 0,49 mm. O estado morfodinâmico foi caracterizado como refletivo (Ω Dean = 1,13). A riqueza mensal variou de 4 a 7 espécies. **Emerita brasiliensis** (Decapoda), **Excirolana braziliensis** (Isopoda) e **Pseudorchestoidea brasiliensis** (Amphipoda) foram as espécies mais abundantes, totalizando 95% da comunidade. A abundância destas 3 espécies variou continuamente ao longo do período amostral. **Emerita brasiliensis** foi a espécie mais abundante nas primaveras e verões; seguida de **P. brasiliensis** nos outonos e **E. braziliensis** foi a mais abundante durante os invernos. A variação sazonal na densidade da macrofauna foi relacionada ao recrutamento e atividades reprodutivas. O supralitoral foi caracterizado por **Ocypode quadrata** (Decapoda) e por **Phaleria testacea** (Coleoptera). **E. braziliensis** e **P. brasiliensis** apresentaram migrações contínuas ao longo do mediolitoral, havendo sobreposição das espécies na mesmas áreas em determinados meses. **Emerita brasiliensis** caracterizou a zona superior do sublitoral.

Palavras-chave: macrofauna, praias arenosas, região entre-marés, zonação.

Introduction

Zonation studies of the macrofauna sandy beaches have been performed by several authors. McLachlan & Jaramillo (1995) reviewed works about zonation around the world, examined different beach types and analysed variations in term of zoogeographic patterns. However only a few studies on seasonal changes of the intertidal macrofauna zonation on tropical sandy beaches are available (Ansell *et al.*, 1972; Jaramillo, 1978; Dexter, 1979). In general, invertebrates of sandy beaches grow fast and have a short life, showing significant variation in population densities. The scarceness of seasonal studies could be related to the difficulty on obtaining at the same time all enviromental data that could account spatial and temporal pattern of the macrofauna. Several environmental factors have been recognized for its important influences in the macrofauna's composition and abundance. These include sand particle size, beach face slope, sediment moisture and wave action (Salvat, 1964; Croker, 1977; Dexter, 1979; McLachlan *et al.*, 1981; Wendt & McLachlan, 1985; Jaramillo & Gonzalez, 1991). Besides abiotic factors, reproductive activities have been pointed out as one of the reasons for the great variation in the population dynamics (Boesh, 1973; Dexter, 1984; Bamber, 1993). The objective of this study is to examine density, richness and distribution of the intertidal macrofauna along time on an exposed sandy beach in the State of Rio de Janeiro.

Materials & Methods

Prainha Beach is located in the Brazilian southeastern region in the State of Rio de Janeiro (fig. 1). Rocks limit this beach which is approximately 800 m long. The beach was sampled from June/93 to May/95. The sampling area was determined through a species-area curve. An area of 2 m^2 was thus selected as it was able to catch more than 90% of all the species. A pilot survey with fourteen strata was carried out. The number of strata were defined by means of a cluster analysis. Dendrograms were constructed from Bray-Curtis similarity matrices, based on an average linkage with unweighted distances (Pielou, 1984). Three transects were extended from above the drift line to below the swash line and 5 sampling strata parallel to the waterline were marked: a) The supralittoral zone corresponds to the subterrestrial fringe of Dahl (1952) and the zone of drying or dry sand above the normal high tide mark wetted only by spray of Salvat (1964) (stratum 5); b) The intertidal zone - it corresponds to Dahl's midshore, localized from the drift line down to just above the effluent line. This zone was divided into upper intertidal (stratum 4), middle intertidal (stratum 3) and lower intertidal (stratum 2); c) sublittoral upper zone, which corresponds to Dahl's sublittoral, where the sand is permanently saturated with water (stratum 1) (30 cm water layer). From each stratum, four replicate quadrats of 0,04 m^2 were randomly taken to a depth of 25 cm and sieved through 1 mm mesh. The residue in the sieves was fixed in 5 % formalin for further analysis. The analysis included species identification and counting. Sand samples for particle size analysis were taken at

each stratum with a plastic corer of 3,5 cm diameter to a depth of 10 cm. Samples were oven dried at 70° C and sieved through a nest of screens at intervals in order to determine mean particle size and sorting parameters (Folk & Ward, 1957). The beach face slope of each transect was measured by the height difference between the site (Emery, 1961). A modal morphodynamic beach state was determined using Dean's parameter (Wright & Short, 1984) and tide range parameter (RTR) (Masselink & Short, 1994). The relationship between species density and the abiotic factors (sand particle size and beach face slope) was estimated by linear regression analysis. The same analysis was used to estimate the relationship between the beach face slope and the location of **Pseudorchestoidea brasiliensis** and **Excirolana braziliensis**. The location applies to the distance between the water line and the stratum with the greatest abundance of species which means 80 %. The F-test was used to test the significance of the correlation coefficient.

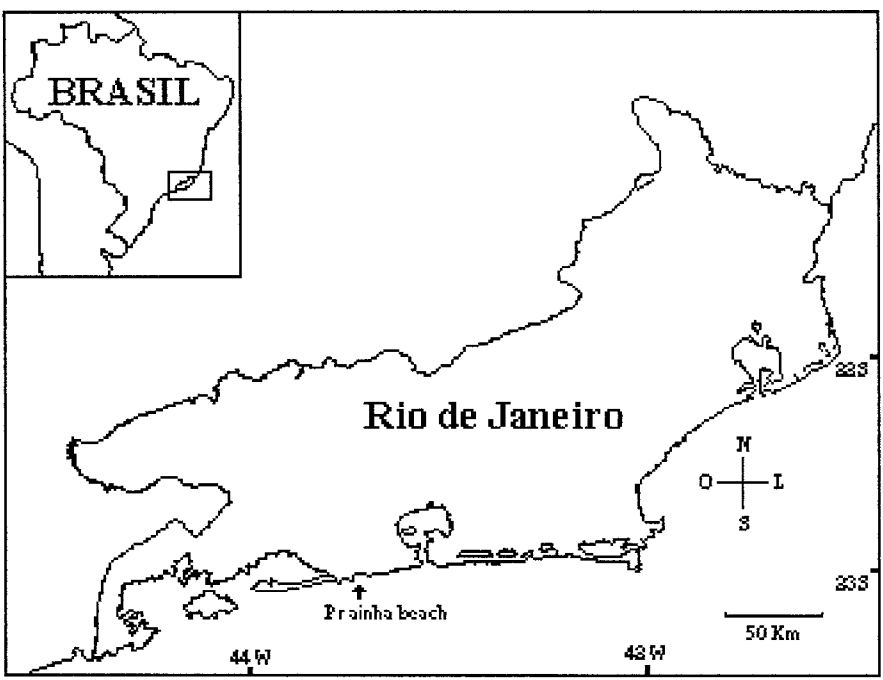

Figure 1. Localization of Prainha beach, Rio de Janeiro State, Brazil.

Results

Prainha beach is constituted of medium sands (0.40 to 0.49 mm). The slopes varied from 1/5.26 to 1/12.99. The minimum width of the beach measured 42.69 m in April 1994 and the maximum width was 64.86 m in September 1993. Prainha was classified as a reflective beach, The modal Ω Dean's was 1.13 and modal RTR (tidal parameter) was 1.1. A summary of some physical characteristics as particle size, slope and beach width is shown on table 1.

Table I. Abiotic factors of the stations during the sampling period. (observation number =3).

Abiotic factors Stations	Average mean particle size and standard deviation (mm)	Average beach face slope and standard deviation (1/m)	Average width of the beach and standard deviation (m)
Winter 93	0.40 (0.04)	1/10.44 (0.82)	54.36 (3.09)
Spring 93	0.40 (0.03)	1/10.78 (5.05)	63.16 (1.70)
Summer 94	0.42 (0.03)	1/9.22 (1.40)	52.19 (6.01)
Autumn 94	0.40 (0.01)	1/7.34 (1.58)	57.01 (2.99)
Winter 94	0.44 (0.03)	1/10.52 (1.42)	46.68 (3.13)
Spring 94	0.45 (0.06)	1/9.75 (2.57)	51.33 (5.82)
Summer 95	0.43 (0.02)	1/7.52 (0.02)	54.64 (3.77)
Autumn 95	0.49 (0.05)	1/9.52 (0.75)	48.80 (4.53)

Ten species were found in the Prainha beach intertidal community. The richness varied monthly from 4 to 7 species, from which three species accounted for 95 % of the abundance of the total community. **Emerita brasiliensis** (Decapoda), **Excirolana braziliensis** (Isopoda) and **Pseudorchestoidea brasiliensis** (Amphipoda) were considered the main species of the community (table 2). The abundance of the most common species has varied continuously along time. Although the polychaete **Hemipodus olivieri** and the beetle **Phaleria testacea** were collected almost every month, their densities were considered as low when compared to crustaceans.

During winter **Excirolana braziliensis** was the most abundant species (close to 50%) and **Pseudorchestoidea brasiliensis** was the second most important species (close to 35%). During spring and summer, the abundance of **Emerita brasiliensis** represented more than 60% of the community. In summer **Pseudorchestoidea brasiliensis** displayed twice the abundance of **Excirolana braziliensis** (table 3).

Emerita brasiliensis had peaks of density in November and December of 1993 and in October, November and December of 1994 (fig. 2). The highest density values of **Pseudorchestoidea brasiliensis** were registered in August 1993, July 1994 and February 1994 and 1995 (fig. 3), while the highest densities of **Excirolana braziliensis** occurred in August 1993, June 1994, April and May 1995 (fig. 4).

The subterrestrial fringe was characterized by holes of **Ocypode quadrata** and **Phaleria testacea**. The midlittoral zone was characterized by the cirolanid **Excirolana braziliensis** and by the talitrid **Pseudorchestoidea brasiliensis**. These

species migrated continuously to the midlittoral zone (strata 4, 3 and 2), occupying the same stratum during most of the months (fig. 5 and 6). **Emerita brasiliensis** was characteristic of the swash zone. The distribution of these species along the beach is shown in figure 7.

Table. II. Monthly richness and density (Ind.*m^{-2}) of species. Species - 1-**Emerita brasiliensis**, 2-**Excirolana braziliensis**, 3-**Pseudorchestoidea brasiliensis**, 4-**Hemipodus olivieri**, 5-**Donax hanleyanus**, 6-**Phaleria testacea**, 7-**Pisionidens indica**, 8-**Lepidopa richmondi**, 9-**Bledius bonariensis**, 10-Diptera Larvae

	Species										
Months	1	2	3	4	5	6	7	8	9	10	Richness
Jun/93	15.4	33.8	63.6	1.8		2.9					5
Jul/93	17.5	123.3	42.5	1.7							4
Aug/93	9.8	160.3	121.9	2.2		2.7	0.4				6
Sep/93	11.6	69.6	50.5	4.9	0.5	5.4					6
Oct/93	10.9	77.3	108.6			14.8					4
Nov/93	879.2	51.2	42.5	0.4		5					5
Dec/93	618.7	75	57.3	1		9.4	0.5	0.5			7
Jan/94	342.3	33.2	75.5	5.8		2.9					5
Feb/94	27.6	45.8	189.1	2.1		2.1					5
Mar/94	24.5	57.3	82.8	1.4		7.3					5
Apr/94	239.7	113.8	106.3	2.7							4
May/94	9.6	72.5	110	2.5		2.5	0.4	1.3			7
Jun/94	1.2	339.6	95.8	1.3		2.5		0.4			6
Jul/94	10.8	60	122.5	0.4		1.7					5
Aug/94	45.5	79.9	58.9	1.3		6.3				0.4	6
Sep/94	114.6	37.9	85			2.1	1.3				5
Oct/94	1305.8	26.2	22.9	2.9	0.4	8.3					6
Nov/94	1283.3	20	54.6	0.4		17.1					5
Dec/94	774.5	33.9	38.4	9.8	0.4	14.3			1.8		7
Jan/95	496.2	59.2	77.1	6.7		19.2					5
Feb/95	193.3	40.8	140.4	1.7		30	0.4			0.4	7
Mar/95	177.9	16.2	38.8			11.3				0.4	5
Apr/95	70.5	99.5	23.7	1.3		14.7					5
May/95	148.7	99.1	30.4	1.8		4.9					5
Total	6829.5	1825.6	1838.9	54	1.4	187.3	3.1	1.8	2.2	1.3	
%	63.56	16.99	17.11	0.5	0.01	1.75	0.03	0.02	0.02	0.01	

Table III. Average density (ind.* m^{-2}) and percentage of the 3 main macrofauna species in the season of the sampling period. Winter (June, July, August); Spring (September, October, November); Summer (December, January, February) and Autumn (March, April, May).

Species / Stations		**Emerita brasiliensis**	**Excirolana braziliensis**	**Pseudorchestoidea brasiliensis**
Winter	93	14.25 (7.13%)	105.80 (52.91%)	75.99 (38.00%)
Spring	93	300.57 (67.76%)	66.08 (14.08%)	67.18 (15.13%)
Summer	94	329.55 (66.40%)	51.33 (10.34%)	107.28 (21.62%)
Autumn	94	91.26 (32.81%)	81.20 (29.19%)	99.69 (35.84%)
Winter	94	19.20 (6.95%)	159.83 (57.86%)	92.42 (33.46%)
Spring	94	901.25 (90.64%)	28.06 (2.82%)	54.17 (5.48%)
Summer	95	488.04 (75.52%)	44.64 (6.91%)	85.30 (13.20%)
Autumn	95	132.37 (53.72%)	71.64 (29.07%)	30.92 (12.55%)

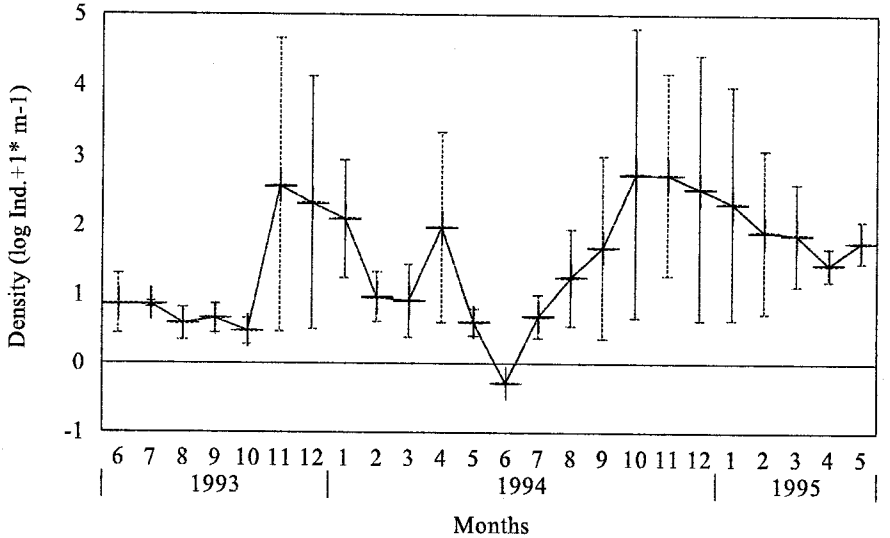

Figure 2. Densities of **Emerita brasiliensis** for the period June 1993 to May 1995. The vertical bars represent the standard error.

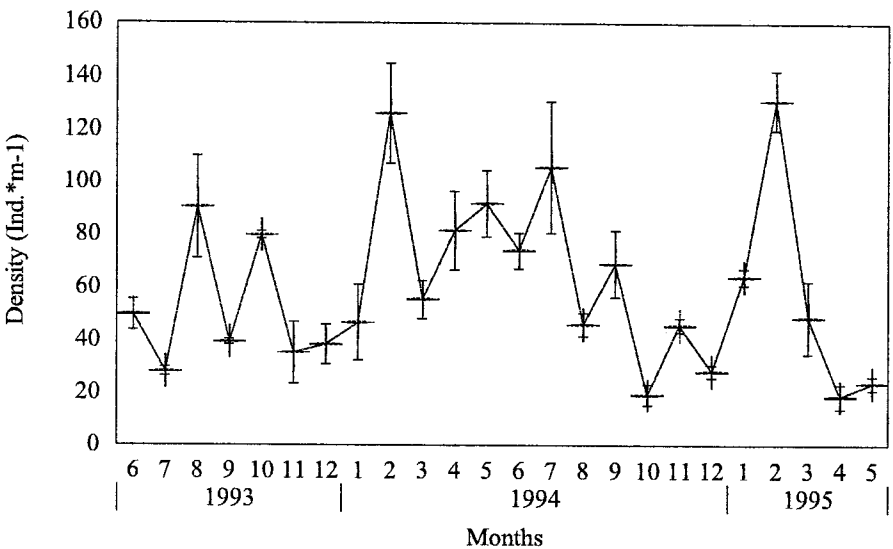

Figure 3. Densities of **Pseudorchestoidea brasiliensis** for the period June 1993 to May 1995. The vertical bars represent the standard error.

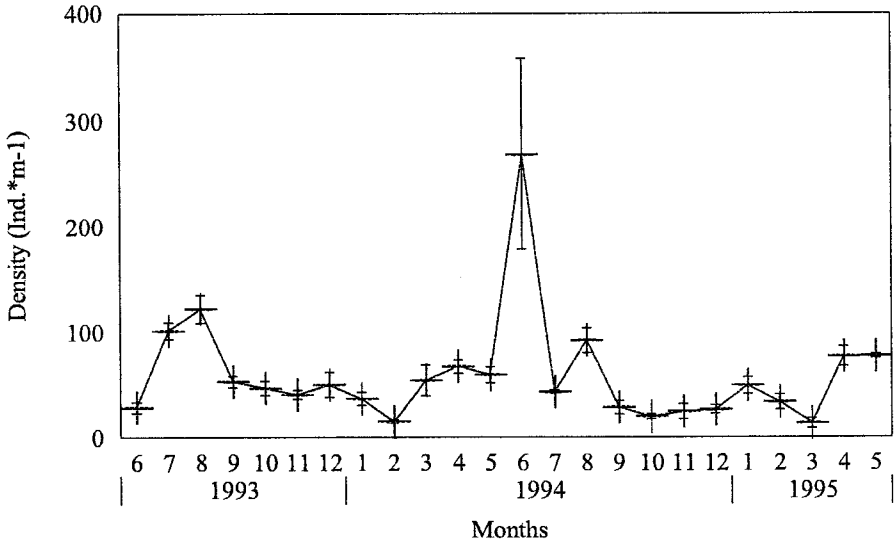

Figure 4. Densities of **Excirolana braziliensis** for the period June 1993 to May 1995. The vertical bars represent the standard error.

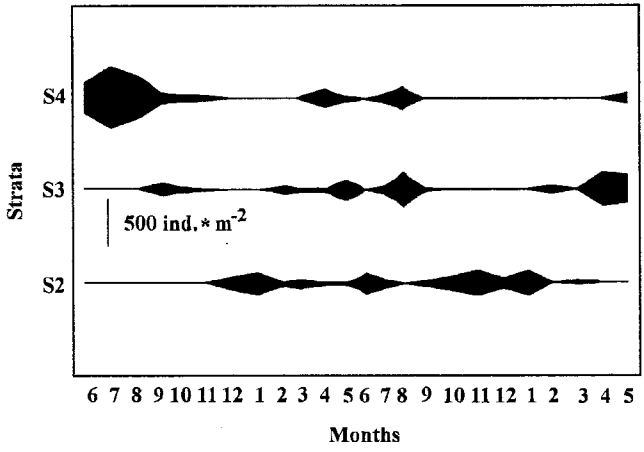

Figure 5. Distribution of **Excirolana braziliensis** along midlittoral (strata 2, 3 e 4), during sampling period.

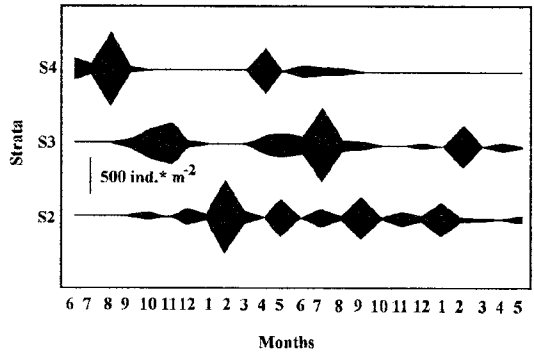

Figure 6. Distribution of **Pseudorchestoidea brasiliensis** along midlittoral (strata 2, 3 e 4), during sampling period.

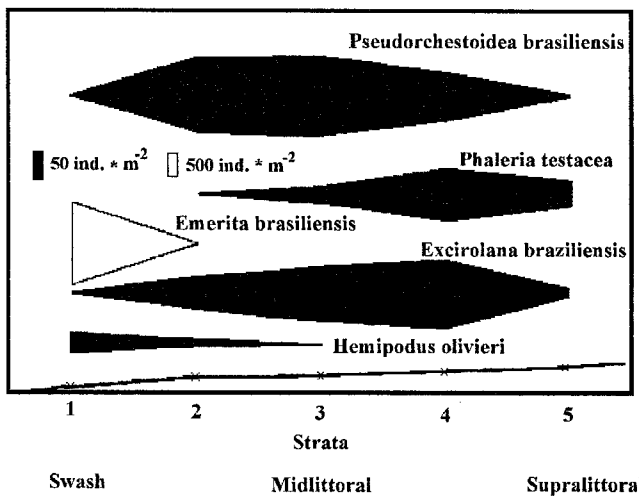

Figure 7. Intertidal distribution of the main species during sampling period.

Abiotic factors like sand particle size and beach face slope didn't show significant correlation with the density of the main species (**Emerita brasiliensis**, **Pseudorchestoidea brasiliensis** and **Excirolana braziliensis**) (table 4).

The regression equation y (slope)=4.82+0.17 (distance between water line and the most abundant stratum) represents the relationship between the beach face slope and the location of **Pseudorchestoidea brasiliensis**. The correlation coeficient found for this relation is r=0.52. For **Excirolana braziliensis** this correlation didn't show any significant values.

Table IV. Abiotic factors - density of the main species in Prainha beach. correlation coeficient (r), observation number (n) and probability level (P).

Relationship	r	n	P
density of the **Emerita brasiliensis** - sand particle size	-0.10	72	0.49
density of the **Emerita brasiliensis** - beach face slope	-0.15	72	0.22
density of the **Excirolana braziliensis** - sand particle size	0.08	72	0.22
density of the **Excirolana braziliensis** - beach face slope	0.21	72	0.56
beach face slope - the location of **Excirolana braziliensis**	0.14	64	0.32
density of the **Pseudorchestoidea brasiliensis** - sand particle size	-0.02	72	0.86
density of the **Pseudorchestoidea brasiliensis** - beach face slope	0.01	72	0.97
beach face slope - the location of **Pseudorchestoidea brasiliensis**	0.52	56	0.02

Discussion

Prainha beach, classified as a reflective beach, has shown low evenness and low richness in species. Dexter (1984) observed that dissipative beaches often exhibit greater stability in the macrofauna composition and greater evenness of species distribution than more reflectives beaches. Beaches that show a high hydrodynamism (reflective beaches) present hostile environment conditions and low availability of niches, thus providing the species domination (McLachlan *et al.*, 1993).

No significant correlation between the analysed abiotic factors (sand particle size and beach face slope) and the seasonal fluctuations of the macrofauna density were observed. Nevertheless the moisture and food input can be important factors in seasonal oscillation, but it was not possible to evaluate the influence of these two factors.

The seasonal variations of the macrofauna's abundance at Prainha beach apparently can be related to reproductive biology (recruitment and breeding peaks). Studies on the population biology of **Emerita brasiliensis** and **Pseudorchestoidea brasiliensis** show that the recruitment and ovigerous female peaks occur in spring and summer (Veloso *et al.*, 1995; Cardoso & Veloso, 1996), when the greatest abundances were observed. **Excirolana braziliensis**, besides spring and summer recruitment, also shows density peak in winter. The continuous recruitment of these species creates a mixture of cohorts. These cohorts can show differences in growth rate and life span, thus increasing the monthly density variations (Veloso *et al.* 1995; Cardoso & Veloso, 1996). Authors like Boesch (1973), Dexter (1984) and Souza & Gianuca (1995), also correlated the density fluctuations to biotic factors as life cycle and recruitment.

Recently, McLachlan & Jaramillo (1995) reviewed studies about zonation, emphasizing the macroinvertebrates dynamics of sandy beaches, the zonation of which changes according to space and time. According to McLachlan & Jaramillo (**op. cit.**),

the species mobility on reflective beaches is greater because of the proper dynamic sediment and a less distinct and permanent zonation. The distribution of species on Prainha beach (reflective) displayed similar zonation pattern to the one proposed by Dahl (1952), with typical species of sublittoral, midlittoral and supralittoral zones. However, **Pseudorchestoidea brasiliensis** and **Excirolana braziliensis** have not shown a constantly strip distribution since they change their position continuously all over the midlittoral zone, overlapping each other in most months (fig. 5 and 6). Many authors (Dahl, 1952; Jaramillo, 1978 and 1987; Dexter, 1979; Clarke & Peña, 1988 and McLachlan, 1990) mentioned **Orchestoidea brasiliensis** located in supralittoral zone (dry zone), above the cirolanids; Defeo *et al.*, 1992 observed that **Orchestoidea brasiliensis** and **Excirolana braziliensis** were distributed not only in the supralittoral but also in the high levels of the midlittoral zone. However, **Pseudorchestoidea brasiliensis** in this study was observed mainly in midlittoral zone.

The continuous migration that has been observed could be associated to the seasonal response to enviroment changes as could be verified at the position of **Pseudorchestoidea brasiliensis** in relation to the slope of the beach, and to endogenous activity rhythms. The studies of Klapow (1972), Hastings & Naylor (1980) e Jones & Hobbins (1985) have shown that endogenous activities are usual in crustacean, impacting directly the zonation maintenance.

A curious relation to be verified between **Pseudorchestoidea brasiliensis** and **Excirolana braziliensis** is the resource partitioning, since they are both scavengers, abundant and occupy the same distribution area. There are three hypothesis which may be taken into account : a) there are enough feeding resources for both species; b) reflective beaches restrict density to levels below competitive potencial; or c) dietary differences, activity rhythms and food sites that are probably involved.

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