Spatial Distribution of *Callichirus major* (Say 1818) (Decapoda: Callianassidae) on a sandy beach, Piedade, Pernambuco, Brazil.

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Abstract

Callichirus major (Say 1818), a burrowing shrimp inhabiting sandy beaches, presents increasing economic importance due to its use as live bait. Considering the complete absence of studies concerning its spatial distribution and density along the Brazilian Northeastern coast, this study investigate its ecology at a sandy beach, Piedade, just south from Recife, Pernambuco, Brazil (08°11'S and 34°55'W), from December 1999 to September 2000. Significant differences between burrow densities were found along the 10 sampling months, profiles and beach strata. The beach morphodynamics, measured as a profile of the vertical variation with time, was significantly related to burrow density variation at the upper strata. However, this influence was not reflected on the population structure.

Key words: *Callichirus major*; density; spatial distribution; Piedade beach.

Introduction

The callianassid *Callichirus major* (Say 1818) is registered from the USA east coast, through the Gulf of Mexico, to the Brazilian coast (from Pernambuco state – 08°S to Santa Catarina state – 28°S) (Manning and Felder, 1986; Coelho, 1997). This species presents a cryptic habit, occupying deep individual galleries in sandy beaches, usually bellow the average low tide water level (Frankenberg *et al.*, 1967; Rodrigues and Shimizu, 1997). Their presence is detectable by the occurrence of small burrows with average diameter of 5 mm, frequently surrounded by their faecal pellets (Weimer and Hoyt, 1964; Frankenberg *et al.*, 1967; Rodrigues and Shimizu, 1997).

Together with *C. major* (Say 1818), other thalassinid shrimps, are becoming more and more known and popular on different coastal areas world-wide due to its large use as a live bait in sports and artisanal fisheries (Hailstone and Stephenson, 1961; Wynberg and Branch, 1994; Borzone and Souza, 1996).

Along the Brazilian coast studies about spatial distribution and density variation of callianassids are scarce and make reference only to the species *Callichirus major* (Say 1818) by Rodrigues and Shimizu, (1984); Rodrigues and Shimizu, (1997); Souza and Borzone, (1996); Souza, (1998); Shimizu, (1997), *Neocallichirus mirim* (Rodrigues 1971) by Pezzuto, (1993); Souza and Borzone, (1996) and *Biffarius delicatulus* (Rodrigues and Manning 1992) by Souza and Borzone (1996). For *C. major* (Say 1818), studies are limited to the South and Southeastern Brazilian coast populations which are subjected to characteristic morphodynamic and climatic conditions, no study being available for the Northeastern *C. major* population.

Callianassid population studies point toward several different physical and biological factors that may affect these crustaceans density and distribution along the intertidal area: predatory activity (Posey, 1986; Tamaki *et al.*, 1992); sediment sorting (Phillips, 1971; Hailstone and Stephenson, 1961; Dworschak, 1987; Souza and Borzone, 1996); average size (Hailstone and Stephenson, 1961; Griffis and Chavez, 1988; Witbaard and Duineveld, 1989); inter- (Stamhuis *et al.*, 1997) and intra-specific competition (Hailstone and Stephenson, 1961; Buchanan 1963; Witbaard and Duineveld, 1989; Tunberg, 1986; Felder and Lovett, 1989; Rowden and Jones, 1994); recruitment (Dumbauld *et al.*, 1996; Shimizu, 1997); food availability (Pohl, 1946; Suchanek *et al.*, 1986; Vaugelas *et al.*, 1986); air and water temperature (Posey,

1986, Berkenbusch and Rowden, 1999); salinity (Posey, 1986); and beach morphodynamics (Pohl, 1946; Phillips, 1971; Pezzuto, 1993; Souza and Borzone, 1999).

Nevertheless, environmental factors may also negatively affect the estimation of callianassid densities. Erosional and depositional processes can affect the stability of the shallower part of the burrow and cause its collapse (Howard and Frey, 1975) clearly conducing to the underestimation of the population density as calculated by burrow opening counts.

Considering the number of various factors that affect the determination of callianassid density and distribution patterns, several uncertainties still exist. Besides describing these patterns, in this work the hypothesis that temporal variations of beach profile affect the determination of gallery densities of *C. major* is tested.

Material and Methods

Study area and sampling

The study area was established on Piedade sandy beach, Jaboatão dos Guararapes city, Pernambuco State Brazilian Northeast (08° 11' 18" S and 34° 55' 06" W) within an intertidal area not protected by beachrocks, a common feature of Pernambuco's coast-live (Fig. 1). This area is situated 4 km north from the mouth of Barra de Jangadas estuary, one of the most polluted estuaries of the Recife,.metropolitan area.

Samples were taken during low spring tides (0.0 – 0.2 m) from December 1999 to September 2000, a total of nine sampling days. Within a fixed intertidal area (80 m x 40 m, parallel to the water line) nine transects were marked 10 meters from each other. These transects started at the highest level of *C. major* burrows occurrence and continued for 40 m bellow the water line. This lower limit corresponded to the appearance of the callianassid *Neocallichirus guassutinga* (Rodrigues, 1971). Reference to a fixed point marked 38 m distant on the supratidal area was maintained throughout the sampling period to test for eventual temporal variations of the burrows density and distribution. Along each transect fourty contiguous quadrats of 1 m² were assessed for burrow counts. Each transect was subdivided into seven strata, the first one consisting of four contiguous quadrats and the other consisting of 6 quadrats (Fig. 2).

Beach profile

The beach profile was measured along transect 7 from the fixed reference point down to the water line using a six meter long hose level (Fig. 2). Beach profiles were measured monthly from November 1999 to September 2000 in order to identify seasonal variations of erosional and depositional processes.

Grain Size

Grain size analysis was made only during the period of major beach profile variations: from January through May 2000. Three samples were taken at fixed stations along the beach profile, at 44.5, 57.5 and 70.5 m from the fixed reference point at transect 7. These stations were chosen to coincide with the middle of the animal's collection strata A, B and C (Fig. 2). Samples were collected with a corer (U   6.0cm; h   10cm) pushed 10 cm deep to the sediment.

Granulometric analysis followed the procedure described by Suguio (1973). Sediment statistical parameters as average grain-size, standard deviation (sorting), skewness and kurtosis were obtained using the software ANGRA v. 1.3.

Burrows salinity

Nine water samples for salinity (UPS) measurements within the burrows were taken along transect 7 at 5 meters intervals (Fig. 2). Samples were obtained with the aid of a syringe attached to a silicon hose introduced at least 30 cm into the burrow.

Spatial Distribution and Density

Population density was estimated as the average number of burrow counts per square meter along each transect. Each burrow was considered a distinct individual (Rodrigues, 1983 *apud* Souza, 1998). Maximum density was considered as the average of monthly densities for the strata with higher densities.

Burrows spatial distribution pattern was analysed using the standardised Morisita index (Ip) as proposed by Smith-Gill (1975) *apud* Krebs, (1989). The spatial pattern is considered random, for the 95% confidence interval, when Ip vary between 0.5 and −0.5. A clumped pattern is associated to Ip values greater than 0.5 and a regular pattern is associated to values lower than −0.5. This index was calculated for transect 7 during all sampling dates to investigate the occurrence of spatial pattern variations.

Multifactorial Analysis of Variance (MANOVA) was used to test the existence of significant density differences among transects, months and strata. Bartllet's test was used to test homogeneity of variances with density values converted to natural logarithms [$\ln(x+1)$].

Pearson's correlation was used to evaluate the relationship between beach profile and density variations through time. Profile variation was measured as the difference between mean height at each stratum over two consecutive months. Density variation at each stratum also considered consecutive months. Due to the large density differences between strata all data were standardised for each stratum. For all analysis the significance level used was 0.05.

Animal samplings were done to assess if *C. major* population size structure was influenced by beach profile variation. Samples were taken outside the density study area along three 13 m strata (A, B and C). Strata were delimited considering the same fixed point and limits established for the density study (Fig. 2).

Each month about 100 crustaceans were collected with a suction pump (Hailstone and Stephenson, 1961). Each animal was individually numbered, put in a plastic container and fixed in a saline solution of 4% formalin. Different numbers of animals were collected at each stratum (15, 30 and 60 approximately for strata A, B and C respectively) considering the density differences detected during a preliminary survey.

The population size structure of *C. major* (Say 1818) was based on measures of the dorsal oval region of the animal (Biffar, 1971) without sex distinction. The size structure was compared between stratum C and strata A and B (together) using the Chi-square test (Zar, 1996).
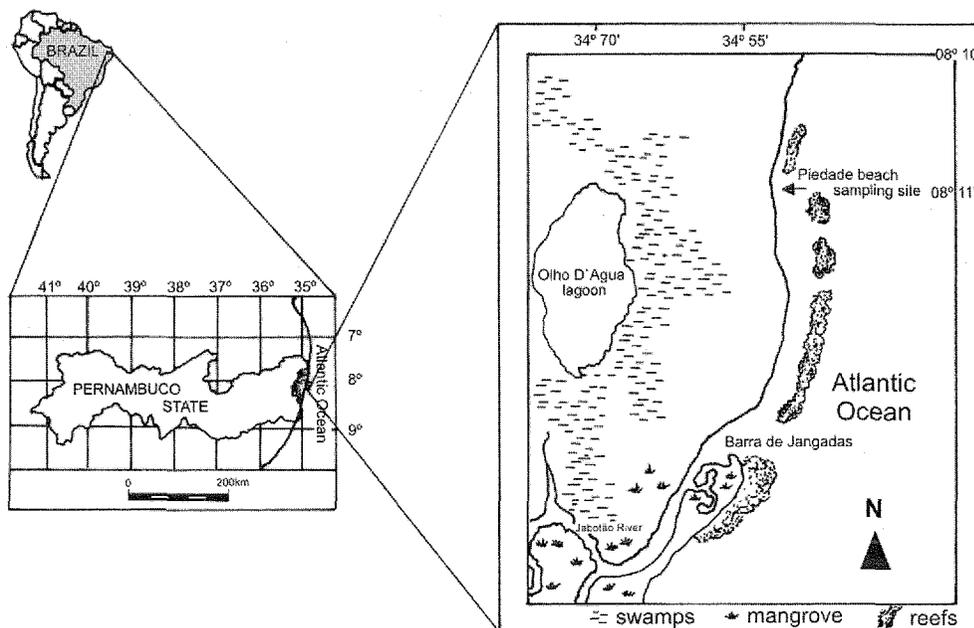

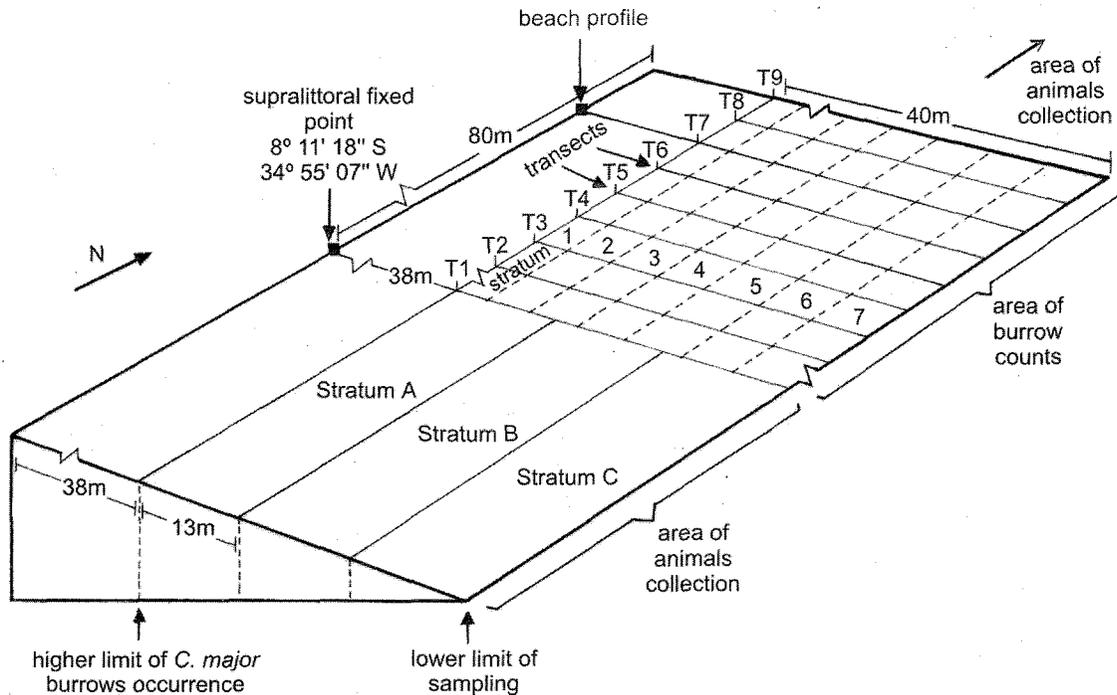Figure 1: Study area location (8°11'18"S / 34°55'07"W).

Figure 2. Sampling design at the midlittoral area of Piedade beach.

Results

Beach Profile

The temporal variation from February to May 2000 of beach profiles within the area of burrows occurrence is shown at Fig. 3. A clear erosional process occurred from February to March 2000. The beach profile in April 2000 is the result of a strong depositional process that reached almost one meter height over the whole beach. From April to May 2000 erosion again took place with the loss of up to one meter of sediment at certain places. From this time onwards only small variations were detected for the beach profile.

Granulometric Parameters

The A stratum was characterised by fine poorly sorted sand during most of the sampling period, average grain size varied from 2.193 to 2.593F, with a single value of 1.476F (medium sand) occurring on February 2000. Standard deviation varied from 1.013 to 1.207F. Sediment was fine skewed only on February 2000, during the other months the sediment was coarse or strongly coarse skewed (Fig. 4).

On stratum B a same pattern was evident with average grain size varying from 2.052 to 2.862F. The presence of medium sized sand occurred one month later than for stratum A. Standard deviations varied from 1.051 to 1.259F. Skewness was very different each month: sediment was coarse skewed on January 2000, almost symmetrical on February 2000, strongly fine skewed on March 2000 and strongly coarse skewed on April and May 2000 (Fig. 4).

Poorly sorted fine sand was also predominant on stratum C during January through March with average values ranging from 2.655 to 2.677F and standard deviations ranging from 1.17 to 1.205F. From March onwards sediment was classified as moderately sorted very fine sand with an average grain size between 3.096 and 3.098F and standard deviation varying from 0.858 to 0.938F. Skewness did not vary and sediment was classified as strongly coarse skewed during all the studied period (Fig. 4).

Burrows salinity

Sampling for measurement of burrow's water salinity was a much time consuming activity, thus, samples were taken, on nine strata only for November 1999 and for January to April 2000. For all collected samples values varied significantly along the beach profile, lower values occurring on strata 1 and 2. From stratum 3 downwards values oscillate with lower variations during February and March 2000. A gradual increase was observed towards the lower mid-littoral area with values approaching those of seawater (Fig. 5).
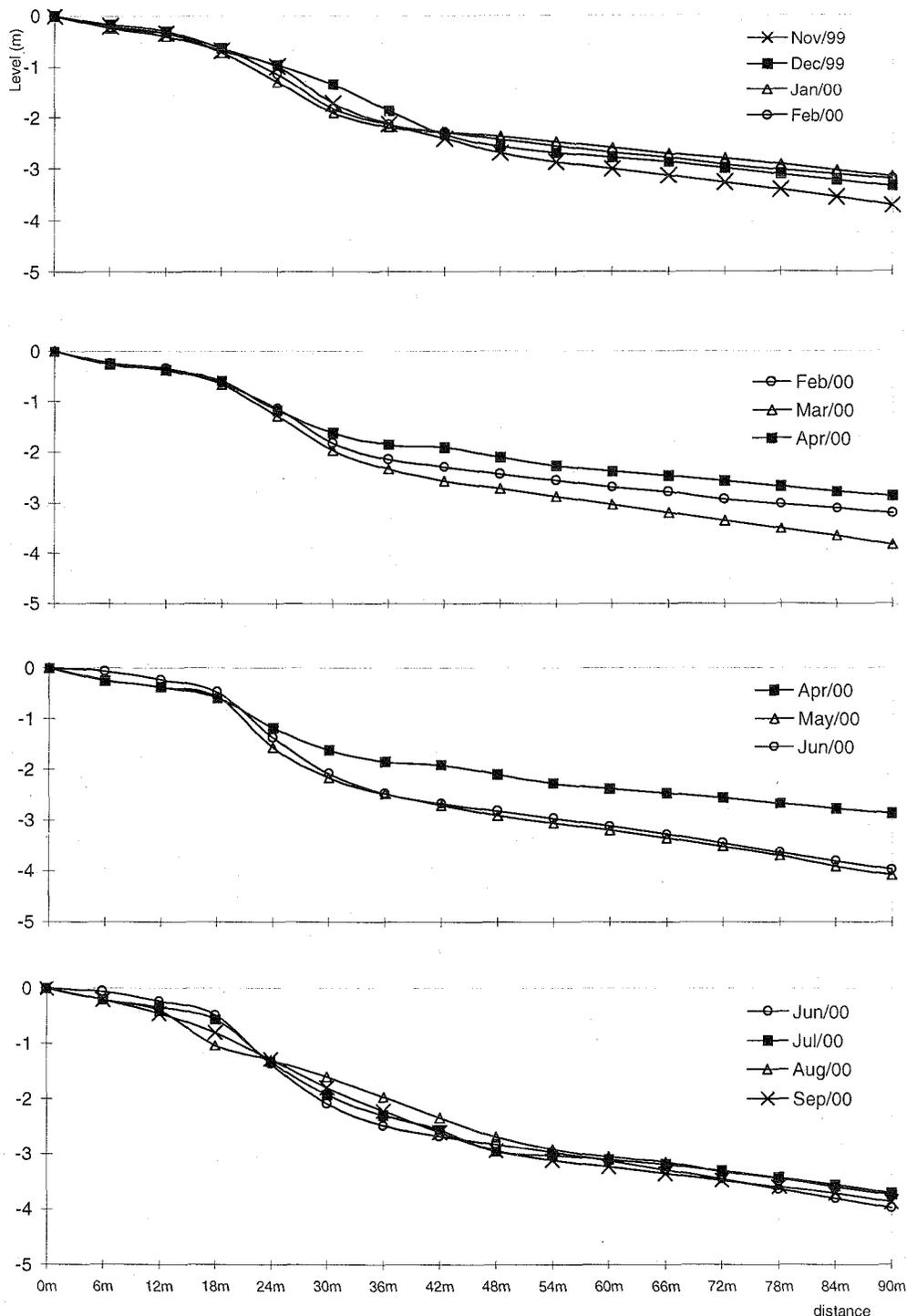
Figure 3: Beach profile in a temporal variation at Piedade beach during the sampling period.

Density and Spatial Distribution

A random pattern of spatial distribution was registered at all strata and during all surveys (all Ip values were between zero and −0.495).

Burrows of *C. major* started 22m seaward from the average high spring tide line increasing its density up to stratum 6. The first 10m (strata 1 and 2) presented very low densities throughout the studied period disappearing completely during the last two months (August and September 2000) (Tables I and II).

Densities varied from 0 to 20 burrows/m² with the highest average density being 6.07 burrows/m² (Table I).
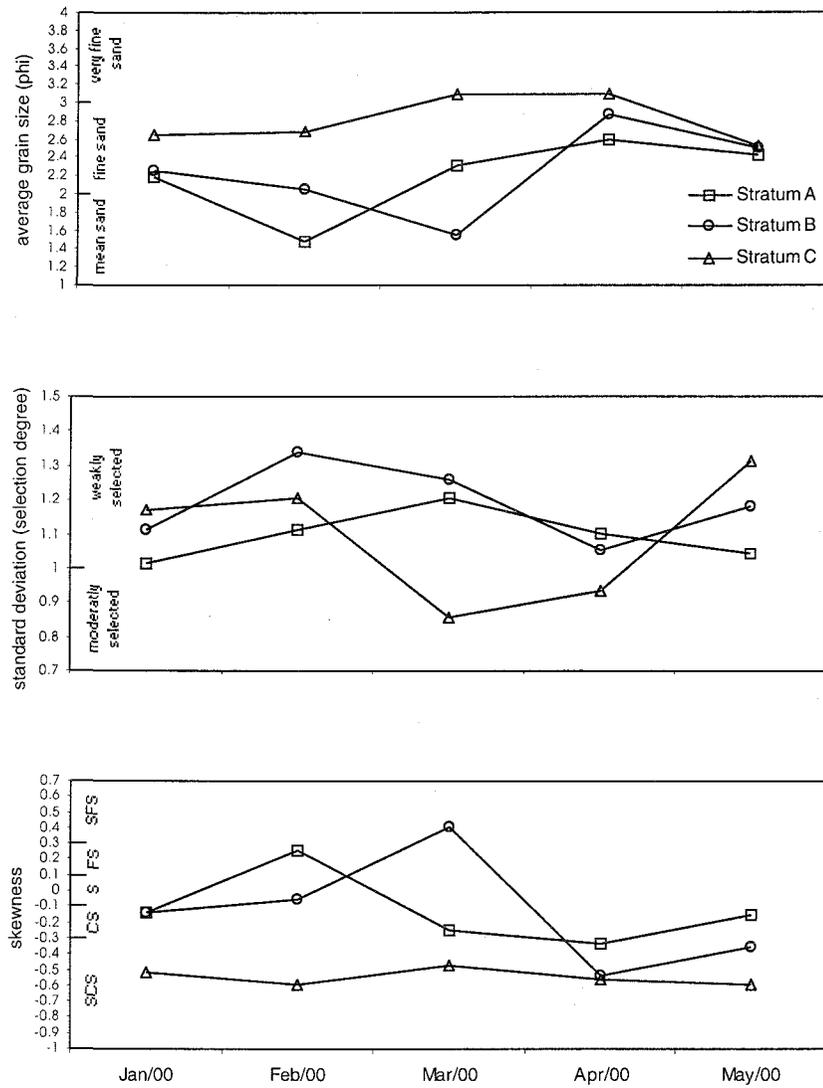
Figure 4: A - Sediment grain size classification at the midlittoral area of Piedade beach; B - selection degree of the sediment at the midlittoral; C – sediment classification according to skewness values at the midlittoral (SCS – strongly coarse skewed; CS – coarse skewed; S – symmetrical; FS – fine skewed; SFS – strongly fine skewed).
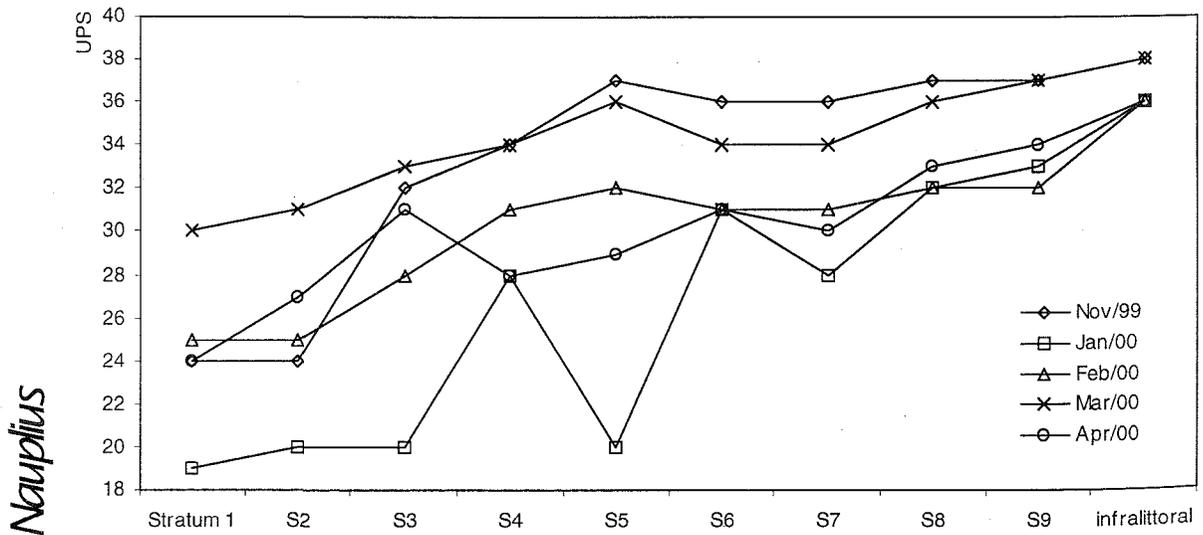

Figure 5: Water salinity within *Callichirus major* galleries at different strata on Piedade beach (November 1999 to April 2000).

Significant density differences were observed between months (F= 39.66; df=8; p< 0.0001), strata (F= 909.68; df= 6; p< 0.0001) and transects (F= 26.72; df= 8; p< 0.0001). Significant differences were also observed for the interaction between month-stratum (F=15.27; df= 48; p< 0.0001), month-transect (F= 3.11; df=64; p< 0.0001) and stratum-transect (F= 6.60; df= 48; p< 0.0001). The Bartlett's test showed that the transformed data variances were homogeneous (χ^2= 302.2965, p=1.000).

Table I: Average and standard deviation of *C. major* burrow's density.m^{-2} along strata and transects at the midlittoral area of Piedade beach.

	Transects								
	1	2	3	4	5	6	7	8	9
Stratum 1	0.19 ±0.52	0.06 ±0.23	0.06 ±0.23	0.03 ±0.17	0.17 ±0.45	0.19 ±0.58	0.14 ±0.42	0.06 ±0.23	0.03 ±0.17
Stratum 2	0.41 ±0.66	0.28 +0.88	0.52 ±0.98	0.24 ±0.70	0.31 ±0.54	0.57 ±0.98	0.54 ±0.96	0.39 ±0.79	0.35 ±0.80
Stratum 3	1.20 ±1.31	0.94 ±1.29	1.98 ±1.83	1.43 ±1.38	1.70 ±1.71	1.78 ±1.42	1.46 ±1.59	1.20 ±1.34	0.96 ±1.15
Stratum 4	2.67 ±1.86	2.50 ±2.80	2.78 ±2.64	2.54 ±2.36	3.09 ±2.03	3.61 ±2.65	3.69 ±2.04	3.52 ±2.68	1.11 ±1.34
Stratum 5	3.93 ±2.48	3.15 ±2.55	2.33 ±2.73	5.31 ±2.95	6.30 ±3.70	5.13 ±2.91	4.63 ±2.57	4.37 ±2.44	2.78 ±2.46
Stratum 6	6.33 ±3.75	3.26 ±3.36	5.81 ±4.76	5.70 ±3.80	8.04 ±4.19	6.26 ±3.14	6.17 ±2.82	7.11 ±3.80	6.00 ±3.30
Stratum 7	4.22 ±3.64	4.72 ±3.22	6.06 ±4.86	5.56 ±4.09	7.19 ±4.11	5.43 ±3.63	4.74 ±3.40	4.81 ±3.30	4.57 ±3.28
general average density	1.68	1.21	1.56	1.71	2.25	2.07	1.96	1.82	1.29

Table II: Average and standard deviation of *C. major* burrow's density.m^{-2} along strata and months at the midlittoral area of Piedade beach.

	Period								
	Dec	Jan	Feb	Mar	Apr	May	Jun	Aug	Sep
Stratum 1	0.21 ±0.40	0.11 ±0.46	0.19 ±0.47	0.22 ±0.48	0.83 ±0.37	0.14 ±0.42	0.05 ±0.23	0 0	0 0
Stratum 2	1.18 ±1.23	0.48 ±0.84	0.46 ±0.74	0.66 ±1.13	0.26 ±0.55	0.39 ±0.76	0.17 ±0.42	0 0	0 0
Stratum 3	2.54 ±1.55	1.96 ±1.70	1.41 ±1.17	2.28 ±1.82	0.68 ±0.69	2.05 ±1.16	0.83 ±1.27	1.37 ±1.32	0.54 ±0.98
Stratum 4	3.92 ±2.61	3.68 ±2.67	3.02 ±2.10	3.04 ±2.07	1.04 ±1.06	2.52 ±2.37	1.44 ±1.30	4.05 ±3.08	2.78 ±1.95
Stratum 5	4.65 ±3.57	5.44 ±2.97	3.15 ±2.19	4.55 ±2.93	2.50 ±2.12	3.35 ±2.97	4.13 ±2.63	5.80 ±3.26	4.35 ±2.84
Stratum 6	5.92 ±3.85	8.67 ±3.93	5.92 ±3.94	6.55 ±3.38	5.20 ±3.22	2.42 ±2.39	6.40 ±3.24	6.65 ±3.73	6.96 ±4.54
Stratum 7	2.98 ±2.48	7.35 ±4.22	4.09 ±2.49	5.59 ±3.14	4.85 ±2.82	1.50 ±1.28	7.70 ±3.54	4.63 ±2.84	8.30 ±4.65
general average density	2.01	2.37	1.66	2.11	1.25	1.05	1.63	1.85	1.72

Correlation values between animal's density and beach profile variations for each stratum were not significant. Nevertheless, higher negative correlation values were found for strata 1, 2, 3 and 4 (r= -0.672, -0.617, -0.602, -0.483 and p= 0.068, 0.103, 0.114, 0.225, respectively; n= 8 for all) and lower positive values were found for strata 5, 6 and 7 (r= 0.150, 0.272, 0.198 and p= 0.723, 0.514, 0.639, respectively; n= 8 for all).

Grouping values for strata 1 to 4 enabled the detection of a significant correlation between density of burrows and beach profile variations (r= -0.5935, n= 32, p= 0.0003). However, grouping strata 5, 6 and 7 did not result in a significant correlation (r= 0.2065, n= 24, p= 0.3329).

Considering the correlation results it was decided to group the *C. major* size structure data into two strata only (A+B and C) for analysis (Table III).

Comparing the size-structure distributions between stratum A+B and stratum C through time, significant differences were detected for December 1999 (χ^2= 12.93 and χ_c^2 = 7.81, gl= 3), January 2000 (χ^2 =10.73 and χ_c^2 = 9.48, gl= 4), July 2000 (χ^2 = 9.94 and χ_c^2= 7.81, gl= 3) and September 2000 (χ^2 = 9.63 and χ_c^2 = 9.48, gl= 4) (Table III). It is interesting to note that, difference was detected between strata size structure during the period of higher beach profile instability (February to May 2000), suggesting that erosion and deposition processes a not affect the sampling of animals for size structure analysis in spite of affecting the observed burrow densities.

Discussion

The random pattern of spatial distribution found for *C. major* at Piedade beach is a common behaviour for this species (Rodrigues, 1983 *apud* Pezzuto, 1993; Rodrigues and Shimizu, 1984; Souza and Borzone, 1996). Rodrigues and Shimizu (1984) associated this behaviour to the random character of post-larvae settlement from the plankton.

Both the upper limit of distribution of *C. major* at Piedade beach and the density increasing towards the infra-littoral area are similar to results obtained by Souza and Borzone (1996), Pezzuto (1993) and Felder and Griffis (1994). The two later papers also register a smaller density decrease on the most seaward strata.

The density decrease occurring on the last stratum at Piedade beach can be explained by the occurrence of a second callianassid (*Neocallichirus guassutinga*) and/or the mollusk *Tivela mactroides* (Born 1778) that could act as competitors for space or food. A similar vertical zonation pattern for both callianassid species was registered in São Sebastião (São Paulo state) by Rodrigues (1971).

Another factor that may affect *C. major* density could be sediment modification, verified by the presence of muddy sediment with a different colour and sulphuric smell, indicating anaerobic decomposition of organic mater (personal observation). In this sense some species are characteristically associated with particular habitats as *Neocallichirus guassutinga* in muddy sediments (Biffar, 1971) and *C. major* (Say 1818) in sandy beaches (Rodrigues *et al.*, 1984; Souza and Borzone, 1996). The preference for specific sediment size or other characteristics is suggested by many authors for a number of species: *Callichirus major* (Say 1818) by Pohl, 1946; Rodrigues *et al.*, 1984; Souza and Borzone 1996; *Callichirus armatus* (=*Glypturus armatus*) (A. Milne Edwards 1970) by Vaugelas *et al.*, 1986; *Callianassa subterranea* (Montagu 1808) by Witbaard and Duineveld, 1989; *Callianassa bouvieri* (Nobili 1904) by Dworschak and Pervesler, 1988; and, *Neocallichirus mirim* (Rodrigues 1971) by Pezzuto, 1993 and Souza and Borzone 1996.

According to Phillips (1971), this preference by specific grain sizes is directly related to theier digging capacity. This author, studying the functional morphology of the third maxilliped of *Callianassa islagrande* (Schimitt, 1935) (= *Callichirus islagrande*), suggested that the foliaceous form of these appendices (morphologically similar to those of *Callichirus major* registered by Pohl, 1946) could be an adaptation to dig in sandy environments. The studied population of *C. major* at Piedade beach is no exception to this pattern since sediment was always dominated by fine sand.

Table III: Size classes distribution of the dorsal oval area of *C. major*.

Months	Classes DO (mm)	Stratum Observed frequency A+B	Expected frequency C
Dec/99 *	< 8	8	25
	8 I- 9	16	12
	9 I- 10	17	9
	10 I-	9	17
an/00 *	< 7	0	10
	7 I- 8	7	10
	8 I- 9	16	16
	9 I- 10	13	17
	10 I-	9	5
Feb/00	< 8	10	13
	8 I- 9	11	22
	9 I- 10	5	15
	10 I-	0	12
Mar/00	< 8	6	11
	8 I- 9	8	20
	9 I- 10	15	18
	10 I-	8	13
Apr/00	< 6	4	7
	6 I- 8	5	4
	8 I- 9	4	16
	9 I- 10	22	18
	I- 10	9	15
May/00	< 5	6	7
	5 I- 6	3	12
	7 I- 8	4	11
	8 I- 9	6	7
	9 I- 10	8	17
	I- 10	7	7
Jun/00	< 6	8	6
	6 I- 8	3	8
	8 I- 9	3	9
	9 I- 10	11	21
	I- 10	5	14
Jul/00 *	< 6	10	8
	6 I- 9	13	12
	9 I- 10	9	15
	10 I-	6	27
Aug/00	< 5	7	8
	5 I- 6	11	13
	6 I- 9	7	9
	9 I- 10	8	18
	I- 10	4	12
Sep/00 *	< 5	1	18
	5 I- 6	12	17
	6 I- 7	10	11
	7 I- 9	5	7
	9 I-	10	18

(*) Denotes months when significant differences were detected by the c² test between the size structure of the strata A+B and C.

The lowest densities of *C. major* burrows occurred at the first two strata (1 and 2) along transects reaching zero counts during August and September 2000. These low densities on the higher level of the intertidal area may well be explained by the limited tolerance to emersion during low tide periods (Griffis and Chavez, 1988; Swinbanks and Murray, 1981; Dworschak, 1987). Thompson and Pritchard (1969) suggested that differences in tolerance to anoxia between *Upogebia* and *Callianassa* were probably caused by the different shape and function of their galleries. Salinity reduction within galleries during low tides, specially at strata 1, 2 and 3 may be the limiting factor for the superior level of occurrence of *C. major*. Salinity within galleries presented values up to 16 UPS bellow sea-water in January 2000. Felder (1978) observed that this species supports only limited salinity variations due to its low osmo-regulatory capability. Salinity within the gallery probably stays bellow seawater values even during high tides, since according to Felder (1978), the interstitial water may influence the water within the burrow.

Significant differences were registered among the sampled strata, transects and months on Piedade beach. A horizontal density gradient was already observed by Pezzuto (1993) who found significant differences between 40m distant transects (but not when comparing 20m distant transects). It should be noted that in this study transects were only 10m distant from each other, thus suggesting the occurrence of smaller scale beach morphological variations.

A major problem for studies of callianassid density is the large variation that may occur through time in the number of observed burrow openings that may not reflect real fluctuations of the population. Factors like individual size, species, sediment type and seasonal variations may cause both decrease or increase of burrows openings counts as well as a higher or lower difficulty in their visualisation leading to super- or sub-estimation of the real number of individuals (Hailstone and Stephenson, 1961; Witbaard and Duineveld, 1989; Atkinson and Nash, 1990 *apud* Stamhuis *et al.*,1997 and Griffis and Chavez, 1988).

For the studied species, *Callichirus major*, the occurrence of only one opening per burrow was already shown by previous studies (Rodrigues, 1983 *apud* Souza, 1998).

Salinity reduction, as well as low temperatures, has been suggested as factors that could reduce the digging activity of callianassid shrimps (Posey 1986; Felder and Griffis, 1994; Berkenbusch and Rowden, 1999). On the other hand, laboratory experiments failed to demonstrate a significant impact of salinity over populations of *Callianassa islagrande* and *C. louisianensis* (Schmitt 1935) (=*Lepidophthalmus louisianensis*) (Phillips, 1971). According to Suchanek *et al.* (1986) digging activity is better related to food availability and a greater sediment remobilization would occur in environments with low nutrients.

Decreasing densities of *C. major* burrows at Piedade beach after April 2000 were probably related to the lower temperatures that may reduce the shrimps digging activity or increased food availability due to intense rainfall, characteristic of this period (Cavalcanti and Kempf, 1967/69). That may have affected the nutrient supply from Barra de Jangadas estuary (Jaboatão and Pirapama rivers) to the study area. The increased nutrient transport would also have increased primary production at the study area since Medeiros (1996) and Rollnic (2002) concluded that longshore drift at this region is preferentially northwards.

Many authors point at beach morphodynamic as a controlling factor of thalassinid density and distribution at the intertidal area because sediment erosion and deposition may disrupt the burrows openings masking real schedules (Howard and Frey, 1975).

Previous studies that used beach profile steepness to infer about the morphodynamic influence over burrows densities used a single or a few sampling dates and did not consider beach seasonal variations. Souza and Borzone (1996), studying *C. major* densities along Paraná state coastal (25° - 26°S) areas, concluded that densities were inversely related to beach declivity. Pohl (1946) studying a population of the same species at two beaches with distinct morphodynamic pattern at North Carolina also found that lower densities were associated to lower declivity. Pezzuto (1993) observed a similar pattern for *Neocallichirus mirim* at Cassino beach (32°S), Rio Grande do Sul state. Phillips (1971) found significant differences for the temporal pattern of variation comparing populations at protected and exposed habitats, with the large fluctuations occurring on exposed coasts.

The present study supports the general relationship between erosion/deposition processes and density fluctuations of thalassinid burrows. This is however an oversimplification of the actual processes affecting densities along the intertidal area. Stratifying the beach intertidal area better clarified the relationship and showed that beach profile variations may have different effects on *C. major* densities at different beach strata.

Population size-structure differences were not observed between strata A+B and C during beach instability period (February through May 2000), suggesting that erosion and deposition affect the animal's density estimates but not the size-structure of the population.

The hypothesis suggesting that smaller animals would have greater difficulties to maintain their burrows opened during beach profile accretion was rejected thus supporting the use of size-structure data even during periods of great density variations.

In conclusion, callianassid burrows counts are significantly affected by beach profile variations, not only between beaches but also within a single beach at different strata. Differential responses along transect were not related to population size-structure differences thus enabling the use of random samples of the burrows to study the population dynamics. It is also suggested that the observed low densities of callianassid shrimps at reflective beach environments is not the effect of transitory variations of the beach profile but reflects the need of a greater energetic demand to maintain the upper portion of the gallery, resulting in greater settlement difficulties and lower survival.

Acknowledgements

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