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SEASONAL STRATIFICATION OF THE ESTUARINE MACROINFAUNA OF THE PATOS LAGOON ESTUARY, SOUTHERN BRAZIL.

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Keywords: Macroinfauna, stratification, seasonal variation, soft bottom, estuary, Patos Lagoon.

ABSTRACT

Stratified samples were seasonally collected to analyze the vertical distribution of the macroinfauna and sedimentological characteristics in a soft bottom estuarine habitat of the Patos Lagoon, southern Brazil. Physical-chemical characteristics of the sediments were quite similar among all sampling periods. Significant differences among strata were resulting of decrease of mean grain size and sorting coefficient and, an increase of fine sediment fractions at deeper layer. Highest macroinfauna densities were always observed in the surface sediments (0-5 cm of depth), with values varying from 63.5 to 90.3 % of the total collected organisms at summer and winter period, respectively. Among numerically dominant organisms, the pelecypod *Erodona mactroides* and the polychaete *Nephtys fluviatilis* were exclusively found at superficial strata (0-5 cm). Otherwise, the tanaid *Kalliapseudes schubarti* and the polychaetes *Heteromastus similis and Laeonereis acuta*, although distributed along all strata, display a clear preference for sub-superficial sediments (0-10 cm of depth). Temporal changes or vertical partitioning were not observed. The weak correlation with sedimentary characteristics suggests that macroinfauna stratification pattern has been probably related to biological factors such as feeding mode and/or body size of the species.

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INTRODUCTION

In soft-bottoms habitats, macrofaunal organisms are distributed across a 3-dimensional space, although their vertical distribution within sediment is frequently neglected. The pattern of vertical distribution of infauna is an important aspect of the structure, species interactions, and organism activity in soft bottom sediments. The vertical position of organisms may indicate their accessibility to epibenthic predators (Virnstein, 1979; Bemvenuti, 1987) as well as their susceptibility to sediment disturbance (Tamaki, 1987; Palmer, 1988; Posey *et al.*,1996). Both predation and physical disturbance act mainly on upper layer of sediments, where their effects are more visible on surface populations than on deeper ones.

In general, the vertical distribution of infaunal organisms within sediment is related to physical properties of sediment (e.g. main grain size, fines percentages), which may directly act as a physical barrier limiting the locomotion and burrowing activities (Rosa-Filho & Bemvenuti, 1998) or indirectly, limiting the vertical distribution of oxygen availability (Coull, 1988). Competition by space or food can also result in species vertical partitioning (Josefson, 1989). Moreover, for many species, position in the sediment column may change (becoming deeper) as the individual grows (Hines & Comtois, 1985).

In this study, seasonal stratified samples were collected to analyze the vertical distribution of the macroinfauna and its relationship with sedimentological characteristics in a soft bottom estuarine habitat of the Patos Lagoon.

MATERIAL AND METHODS

IThis study was carried out in a shallow water area located near the east margin of Pombas Island (32° 01' 505 S, 052° 07' 708 W, Patos Lagoon Estuary, Southern Brazil), where two sampling points were sampled at May 2001 (autumn), August (winter), November (spring) and February 2002 (summer). At each sampling point six faunal samples were taken using a PVC corer (100 mm of internal diameter) and each sample was subdivided into three levels: 0-5 cm (superficial layer), 5.1-10 cm (intermediate layer) and 10-15 cm (deep layer). Macroinfaunal samples were sieved through a 0.3 mm mesh size and fixed in 4% neutralized formaldehyde. In the laboratory, organisms were sorted under a stereomicroscope, counted and preserved in 70% alcohol. The density of benthic

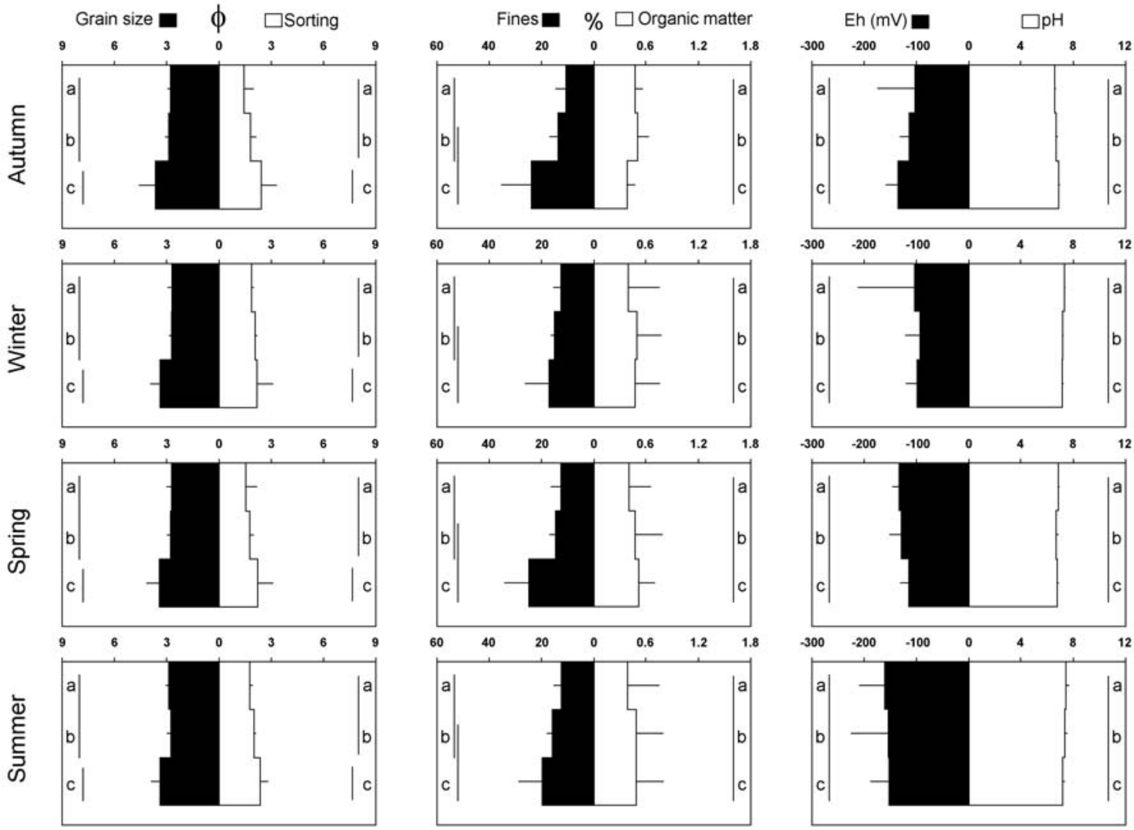

Fig. 1.

Mean values (+ 1SD) of the physical-chemical sedimentary data obtained for each stratum at each sampling time. Vertical lines link strata with similar characteristics (p>0.05). These strata were: a, 0-5 cm; b, 5-10 cm; c, 10-15 cm.

invertebrates was expressed as number of individuals/m².

Additional stratified samples were taken to determine physical-chemical characteristics of sediment. Both RDP (Eh) and pH values were measured in situ and samples were collected to posterior sediment analysis. Granulometric data were obtained through sieving and pipette analysis and, dried samples were then burned at 550°C for 60 min in order to determine organic content (Suguio, 1973).

Data of each variable were analyzed through a three-factor ANOVA with the factors season (autumn, winter, spring and summer; fixed factor), sampling point (random factor) and sediment layer (fixed factor). In the events with no significant sampling point effect, using a significance level of $p<0.25$, according to the recommendation of Glasby (1997)((, the data of both sampling points were pooled and analyzed as a two-factor ANOVA, testing for differences among season and sediment layer. All data were tested for normality (Kolmogorov-Smirnov test) and homogeneity of variances (Cochran test and standard deviations-means plots) prior to their use in statistical tests (Underwood, 1997). Absolute values (e.g. macroinfauna density, mean grain size) were log (x+1) transformed while percentage data (i.e. fines fractions, organic matter content) were arcsine of the square root transformed (Underwood, 1997) to assure variance homogeneity and normal distribution when necessary. In cases in which ANOVA results were significant ($p<0.05$), Tukey's multiple comparison test was applied to determine specific differences (Underwood, 1997).

A similarity matrix was constructed using the Bray-Curtis measure of similarity and a classification analysis was carried out with non-metric multi-dimensional scaling ordination (nMDS) on square root transformed data of abundance (Clarke & Warwick, 1994). In order to examine the relationship between stratification pattern of the infaunal organisms and sedimentary characteristics, a Spearman rank correlation (r) was computed between the Bray-Curtis similarity faunal matrix and the Euclidean distance matrix derived from physical-chemical sedimentary data. The significance of the correlation was determined using a permutation procedure (Clarke & Warwick, 1994).

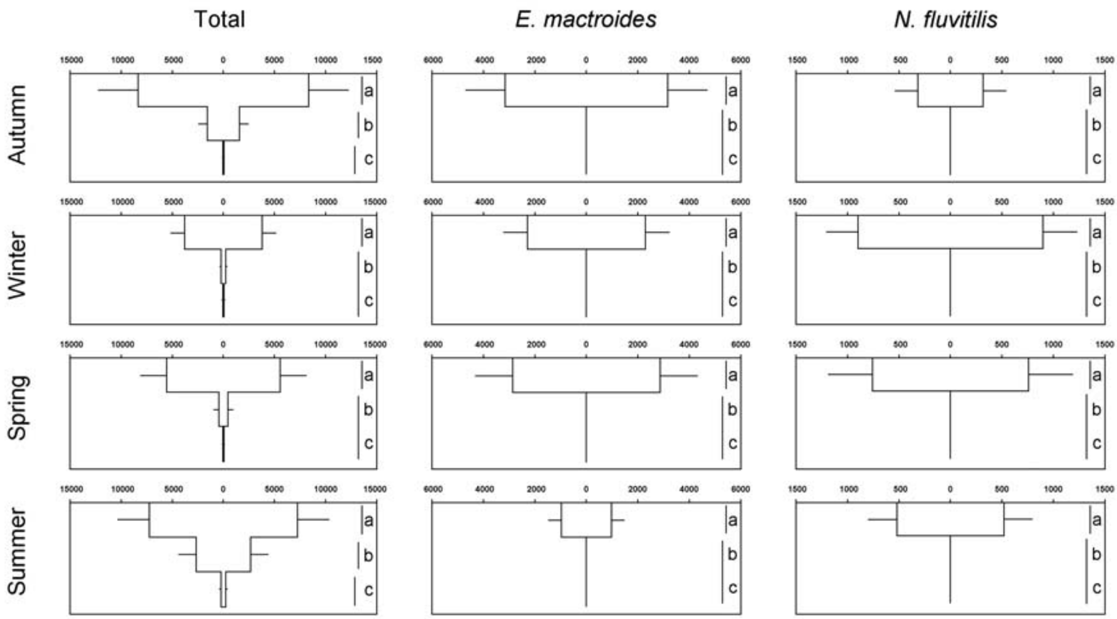

Fig. 2.
Mean density (+ 1SD) of the total infauna, E. mactroides and N. fluviatilis at each stratum for each sampling time. Vertical lines link strata with similar characteristics (p>0.05). These strata were: a, 0-5 cm; b, 5-10 cm; c, 10-15 cm.

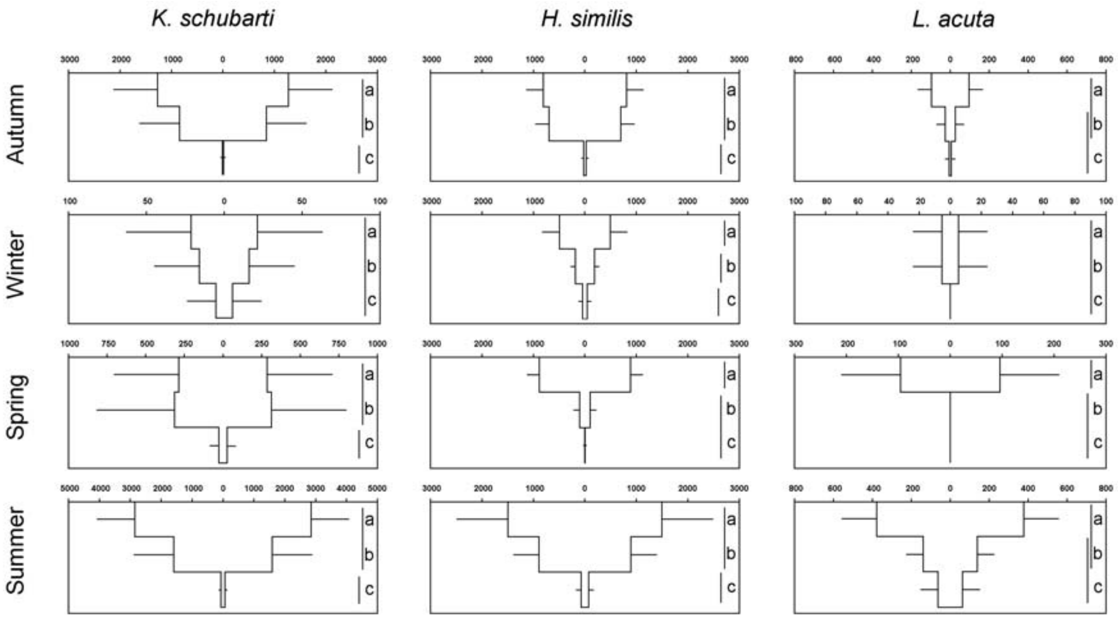

Fig. 3.
Mean density (+ 1SD) of the K. schubartii, H. similis and L. acuta at each stratum for each sampling time. Vertical lines link strata with similar characteristics (p>0.05). These strata were: a, 0-5 cm; b, 5-10 cm; c, 10-15 cm.

RESULTS

Macroinfauna density and abiotic parameters were not significantly different among 'sampling points' ($p>0.25$). Consequently all data of both sampling points were pooled and analyzed as a two-factor ANOVA for the influence of season and sediment layer.

Most of physical-chemical sedimentary characteristics were similar ($p> 0.05$) among all sampling periods (Fig. 1). Significant differences among strata were resulting of decrease of both mean grain size and sorting, and increase of fines fractions at deeper strata (Fig. 1). The first two strata (i.e. superficial and intermediate layers) were composed by poorly sorted fine sand with fine fractions ranged from 10.83 to 16.14 %, whereas the deepest layer was composed by very poorly sorted finest sand with fine fractions ranged from 17.24 to 25.21 %. The organic matter content, RDP and pH values were similar among both sediment layers and seasons (Fig. 1).

During the study period a total of 9,762 individuals were collected represented by 7 species. The most abundant infaunal organisms were the pelecypod *Erodona mactroides*, the tanaidacean *Kalliapseudes schubartii*, the polychaetes *Heteromastus similis*, *Nephtys fluviatilis* and *Laeonereis acuta*, accounting for more than 90 % of the total organisms.

Macroinfauna density showed a clear seasonal pattern. The highest values were registered in summer (20,287 ind./m^2) while lowest at winter period (8,185 ind./m^2). Throughout the entire study period, highest densities were always observed in the surface sediments (Fig. 2), with values varied from 63.5 to 90.3 % of the total of collected organisms at summer and winter period, respectively.

Among numerically dominant organisms, Erodona mactroides and Nephtys fluviatilis were exclusively found at the superficial layer (Fig. 2). *Kalliapseudes schubarti*, *Heteromastus similis and Laeoereis acuta* had shown wide vertical distribution occurring on all strata (Fig. 3). However, these three species showed lower densities at deeper layer compared to superficial layer during most of sampling periods (Fig. 3) except in winter, where distribution of both *K. schubarti* and *L. acuta* were quite similar among the strata.

MDS ordination of macroinfaunal data revealed a clear distinction of community structure among the sediment layers, particularly between the superficial and the other two layers, regardless seasonality. However, Spearman rank shown that these infaunal stratification pattern was weak correlated to physical-chemical sedimentary properties (r = 0.143 and p = 0.036).

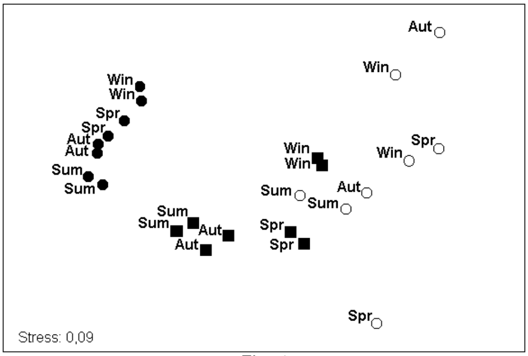

Fig. 4.
nMDS ordination on square root transformed data of the infauna abundance. Sum, summer; Spr, spring; Win, winter; Aut, autumn;●, 0-5 cm; ■, 5-10 cm;○, 10-15 cm.

DISCUSSION

Macrofauna community of shallow areas of Patos Lagoon Estuary is composed by a small number of species with higher dominance of infaunal organisms (Bemvenuti *et al.,* 1978; Capitoli *et al.*, 1978; Bemvenuti, 1987; Bemvenuti, 1994; Bemvenuti, 1997a). In these areas, macrofauna density present marked seasonal fluctuations (Bemvenuti, 1987; Bemvenuti, 1997a; Bemvenuti & Netto, 1998; Rosa, 2003). High macrofauna density is observed during summer periods resulting from recruitment process influenced by increase of salinity and temperature. During this period higher density is also observed at superficial layers of sediment due recruitment process of macrofauna (Bemvenuti, 1987, Bemvenuti, 1997a; Rosa, 2003)

In our study, higher density observed during summer period is also probably resultant of recruitment process of organisms and, thus responsible by higher density in superficial sediment layers. However, higher densities at superficial layers were observed in all seasons, suggesting that this community inhabits preferentially surface sediment layers. Also, temporal changes in the vertical position were not evident for any species. This vertical distribution pattern within sediment was also observed in other studies (Johnson, 1967; Josefson, 1989; Netto & Lana, 1995; Guidetti *et al*., 2000), which had suggested that highest macrofauna densities are concentrated in the superficial layer of the sediments for mudflat bottoms.

The observed infaunal stratification pattern was weakly correlated to physical-chemical characteristics of the sediment suggesting that other factors such as feeding mode and/or body size could be acting as a limiting factor on the access of these species to the deeper strata.

Among the species that were exclusively found at superficial layer, *Erodona mactroides* is a suspension feeder which has short siphons. The biological feature is probably responsible for its superficial distribution in the sediment. The polychaete *Nephtys fluviatilis* is a predator which actively moves on the sediment surface searching for preys as showed by Fauchald & Jumars (1979) and Zajac & Whitlatch (1988). In the Patos Lagoon, *N. fluviatilis* essentially preys on meiofaunal organisms such as ostracods (Bemvenuti, 1997b) which are limited to the upper 2 cm of the sediment (Rosa & Bemvenuti, 2005). Thus, the vertical position of this polychaete is probably related to vertical distribution of their preys.

The tanaid K. schubartii inhabits U-shaped tubes down to 15 cm into sediment and its burrowing capacity is limited by fines sedimentary fractions content (Rosa-Filho & Bemvenuti, 1998). However, it is doubtful that this has been the factor responsible by the low densities of this organism in deep strata. The deeper layer was composed by finer sediments with higher amounts of fine fractions than intermediate and superficial layers. Furthermore, the presence of the individuals in deepest stratum indicates that sediment characteristics did not limit the burrowing capacity of these crustaceans. As *E. mactroides*, these tanaids are suspension feeders and their preference by superficial and sub-superficial layers are probably also related to its feeding mode.

On the other hand, both polychaetes *L. acuta* and *H. similis* are deposit feeders. The first species feed on microphytobenthos at the surface of the sediments whereas *H. similis* ingests detritus in the sediment. Although the feeding mode similarity, both polychaetes shown highest densities at the superficial than deeper layers indicating no vertical partitioning among them.

For *L. acuta* the body size was probably the factor limiting their vertical distribution. During this study, no individual of *L. acuta* longer than 5 cm length was collected. The absence of higher individuals of this species in other places of the estuarine region of Patos Lagoon has already been documented (Pinto & Bemvenuti, 2003), but the reasons for this pattern are still unknown.

In the case of the polychaete *H. similis*, most studies had described the species as deep burrowers (Bemvenuti et al., 1978; Bemvenuti, 1988; Bemvenuti, 1994; Netto & Lana, 1995; Bemvenuti, 1997a), although its vertical position had just been analyzed by Netto & Lana (1995), which had compared the macrofauna densities among two layers (0-5 and 5-10 cm of depth) at a tidal flat of Paranaguá Bay. According to these results, *H. similis* was numerically dominant at deeper layer (i.e., 5-10 cm of depth) than superficial one.

Contrarily to obtained in Paranaguá Bay, our results shown that *H. similis* densities at the superficial layer were higher (e.g., winter and spring) or equal (autumn and summer) than in the intermediate layer (i.e., 5-10 cm of depth) suggesting that polychaete distribution into the sediment is not so deep. However, this could also be due to spatial differences in the habitat characteristics.

Our results indicate that macroinfaunal assemblages were composed by species that preferentially inhabit superficial and intermediate layers resulting in higher superficial densities during all seasons. This vertical pattern apparently is more related to biological traits of the organisms such as feeding mode or body size than to the physical-chemical sedimentary properties. However, this pattern could be not applied to whole estuarine region of the Patos Lagoon without more spatial replication to confirm this stratification pattern. These findings could to contribute to a better understanding of the ecological process in the estuarine region of the Patos Lagoon by indicate the availability of these organisms to other trophic levels and its susceptibility to sediment disturbances as well.

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