Composition and intra-annual variation of the macroinfauna in the estuarine zone of the Pando Stream (Uruguay)

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(With 5 figures)

Abstract

We studied the temporal patterns of macroinfaunal distribution in the estuarine portion of Pando Stream, Uruguay. We found a very low number of species and a high dominance of the polychaete *Heteromastus similis*. There were clear seasonal patterns in abundance with almost all species peaking in autumn, coinciding with the periods of higher salinity. Minimal values were found in winter and spring when salinity was at a minimum. We suggest that the seasonal pattern is a consequence of the combined effects of recruitment, and of high osmotic stress and disturbance during the periods of freshwater discharge that are common in winter and spring.

Keywords: estuarine benthos, seasonal patterns, Uruguay.

Composição e variação intra-anual da macroinfauna da área estuarina do Arroio Pando (Uruguai)

Resumo

Estudamos os padrões temporais da distribuição da macroinfauna da área estuarina do Arroio Pando, Uruguai. Foi encontrado um baixo número de espécies e uma grande dominância do poliqueto *Heteromastus similis*. Houve claros padrões sazonais na abundância, com uma maior presença das espécies no outono, período este coincidente com valores de maior salinidade. Os valores mínimos foram encontrados no inverno e na primavera, quando a salinidade era mínima. Sugerimos que o padrão sazonal é conseqüência dos efeitos misturados do recrutamento, do elevado stress osmótico e dos distúrbios durante os períodos da descarga da água doce, semelhantes no inverno e na primavera.

Palavras-chave: bentos estuarino, padrões sazonais, Uruguai.

1. Introduction

Benthic fauna of estuaries is characterized by a low number of species which usually reach relatively high abundance and biomass. Throughout the year, the community of benthic organisms may fluctuate cyclically due to the life cycles of the species, and temporal variations in the abiotic (e.g. salinity) and biotic (e.g. predation pressure) factors (Bemvenuti, 1988; Day et al., 1989; Levinton, 1995; Thiel and Potter, 2001). Spatial distribution of benthic fauna may be patchy due to patchiness in the characteristics of the sediments.

A great part of the Uruguayan coast belongs to the estuarine region of Río de la Plata. This is a coastal plain estuary draining the second largest basin of South America (Guerrero et al., 1997; Mianzan et al., 2001). On the Uruguayan coast, several streams and rivers are open to the estuary constituting very shallow and protected habitats as compared with the deeper and more exposed main portion of the estuary of the Río de la Plata. Recently, the necessity of an evaluation of temporal changes in benthic communities has been identified as a priority in research of estuarine habitats of Uruguay (Calliari et al., 2003). The few investigations focusing on temporal variation in estuarine macrobenthos of the Uruguayan coast (e.g. Cardezo, 1989; Jorcín, 1999) had the temporal resolution of about 3 months. However, a higher temporal resolution is required to correctly evaluate the dynamics of these communities and formulate hypotheses and models that will eventually be tested.

The objective of this study is to characterize the temporal variations in the structure of the benthic community of the estuarine area of Pando Stream (55° 51.75' W and 34° 47.75' S) with a monthly temporal resolution. This stream drains a basin of 824 km^2 and is open to the estuarine area of Río de la Plata. It is affected by industrial activities and by the urban waste of the city of Pando (Amorín and Cabal, 1996). The mouth of the stream is a touristic and residential area, used as a recreational and fishing location during summer (Amorín and Cabal, 1996). The stream also constitutes a part of the nursery area of several commercially important fish (Richly et al., 2003).

2. Materials and Methods

The mouth of Pando Stream (Figure 1) is located about 30 km from Montevideo city. The stream has a low slope and a relatively permeable soil that affects sedimentation and water run-off (Amorín and Cabal, 1996). It receives the waters of the Tropa Vieja Stream in its final section and its mouth is connected to the Río de la Plata. Available data of salinity and temperature are restricted to autumn (S = 5-15; 13-14 °C) and summer (S = 17-20; 21-23 °C). During the last decade the mouth of the stream has been moving eastward due to the erosion on the east side and the sand deposition on the western side (Amorín and Cabal, 1996).

Samples were taken monthly between September 2002 and June 2003 (exceptions: December 2002 and May 2003, due to strong winds). Two transects were established parallel to the section of the stream, with three sampling stations in it, two located near the margins and one in the middle of the stream (Figure 1, Stn 4-9). The samples were collected with an Eckman grab with an area of 529 cm^2; sediments were sieved through a mesh of 0.5 mm; organisms were preserved in formaline 8% for determination in the laboratory.

Salinity and temperature was measured (WTW conductimeter) at 3 stations along the stream (Figure 1). In

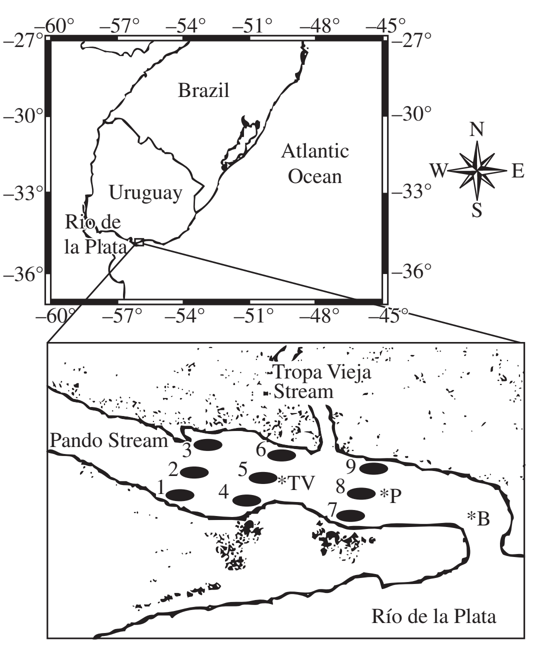

Figure 1. Study area at the mouth of Pando Stream showing sampling stations for monthly changes in abundance (Stn. 4-9), for relationships with sediment characteristics in November (additional stations 1-3), and sites for measurement of salinity and conductivity (B: Boca; P: Pescadores; e TV: Tropa Vieja).

November 2002 sediment samples were collected using a corer of 5 cm of diameter in the stations where biological samples were taken (Figure 1, Stn 4-9), and an additional transect for macroinfauna and sediment was sampled (Figure 1, Stn 1-3). They were used for analyses of sediment fractions: the samples were dried, weighed and the mud fraction was separated by sieving the wet sediment through a mesh of 0.63 µm. The remaining fraction was dried again and mechanically sieved through a series of meshes differing in 1 phi. Sediments were classified using the granulomethric classification of Wentworth (Arocena et al., 1999).

The community was characterized based on the distribution and abundance of the organisms. Principal coordinate analysis (PCO: Anderson, 2003) and cluster analysis were used on a matrix of 6 species (variables) and eight sampling occasions (objects). Data were square root transformed; the similarity matrix was calculated using the Bray-Curtis index, and UPGMA method of agglomeration (Legendre and Legendre 1998). Pearson's correlation was used to investigate if PCO axes were related to temperature and salinity. Further relationships between faunal abundance, salinity and temperature were also explored by Pearson's correlation (Ludwig et al., 1988) using the abundance data obtained on all sampling occasions. With the data from November 2002, the relationship between the sediment characteristics and abundance of the fauna was investigated.

3. Results

3.1. Environmental variables

The temperature changed seasonally with a maximum value of 25.9 °C in February and a minimum of 12.4 °C in June (Figure 2). The spatial variations in temperature showed no clear trend and they were low (<1.7 °C). Surface salinity fluctuated markedly between values <2 in winter and spring, and 14.6 in February (Figure 2). The bottom salinity followed the same pattern but with slightly larger values (2 in January, 30 in March). The variability among sampling stations was low (S < 1), with the highest values towards the mouth of the stream.

Sediments were dominated by poor to moderately selected medium sand, with varying percentage of mud (1-23%). The proportion of mud in the sediment was low (<5%) at the margins of the upper and lower transects, and high (>10%) in the centre of the studied area.

3.2. Macroinfauna

Twelve species of benthic macroinvertebrates were found. The lowest abundance and species richness were found in September and October while the highest values occurred between February and June (Figure 3). The most frequent species were the polichaetes *Heteromastus similis*, *Laeonereis culvieri*, *Nephtys fluviatilis*, the clam *Erodona mactroides* and the snail *Heleobia australis* (Table 1), comprising 94% of the total macrofaunal abun-

Table 1. Frequency of monthly occurrence and relative abundance of macrobenthic species of Pando Stream, between September 2002 and June 2003.

Taxon and Species	Monthly occurrence (%)	Relative abundance
ANNELIDA, POLYCHAETA		
Heteromastus similis	100	20.33
Laeonereis culvieri	87.5	22.65
Nephtys fluviatilis	62.5	2.20
Unidentified polychaete	12.5	0.05
MOLLUSCA		
Erodona mactroides	100	21.29
Heleobia australis	50	27.62
Brachidontes darwinianus	37.5	0.28
Tagelus plebeius	12.5	0.05
CRUSTACEA		
Cyrtograpsus angulatus	12.5	0.05
Excirolana sp.	12.5	0.05
Unidentified ostracods	12.5	5.36
INSECTA		
Ephemeroptera larvae	12.5	0.05

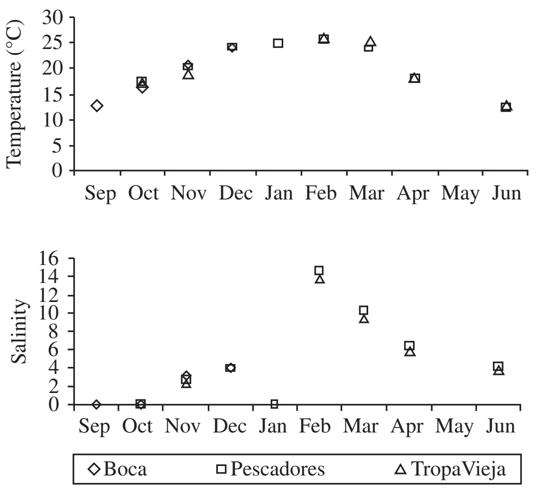

Figure 2. Surface water temperature and salinity, at Pando Stream between September 2002 and June 2003.

dance. In June high numbers of an unidentified ostracod were found (89 ind. at Stn 7). We also found *Balanus improvisus* settled on wood and shells of *E. mactroides*, but it was not further considered.

Principal coordinate (PCO) and cluster analyses aggregated the sampling occasions in three groups: 1) September-October; 2) November-January; and 3) February-June (Figure 4). Group 1 indicates low abundances in September and October for all species but *H. similis* and *E. mactroides*; group 2 high abundances of *E. mactroides* in November-January; group 3 high abundance of most species between February and June (Figure 3). The species abundance peaked in different months (Figure 3). For *E. mactroides*, the peak of abundance occurred in November, when 98% of the 170 individuals collected ranged from 18 to 34 mm; although small individuals were found on all sampling occasions, the highest abundance was observed in January, when 28% of the 43 individuals collected ranged from 2 to 14 mm.

The first axis of the PCO was significantly correlated with salinity (Figure 5) but not with temperature ($p > 0.05$). The abundance of *H. similis* and *L. culvieri* were significantly and positively correlated with salinity, but only for *L. culvieri* was the correlation with temperature significant (Table 2).

For the nine stations sampled in November, only the abundance of *H. similis* showed a significant correlation ($r = 0.670$, $p < 0.05$) with the percentage of mud of the sediment; the correlations between the mud content and *E. mactroides* ($r = 0.478$), and *L. culvieri* ($r = –0.383$) were not significant.

4. Discussion

4.1. Environmental variables

Temperature and salinity showed a clear seasonal pattern at the mouth of Pando Stream, with a winter characterized by cold freshwater and a summer dominated by warm estuarine water. As expected for a temperate region, temperatures were highest at the end of the summer while the lowest values were reached at the end of winter. This is consistent with the patterns described for the South Atlantic estuaries such as the Río de la Plata (Nagy et al., 1997) and Patos Lagoon (Chao et al., 1985). The temporal patterns of salinity at Pando Stream are most likely affected by patterns of rainfall occurring on its basin and by changes in the position of the salinity front of Río de la Plata. Thus, decreases in salinity in Pando Stream should occur through increased freshwater

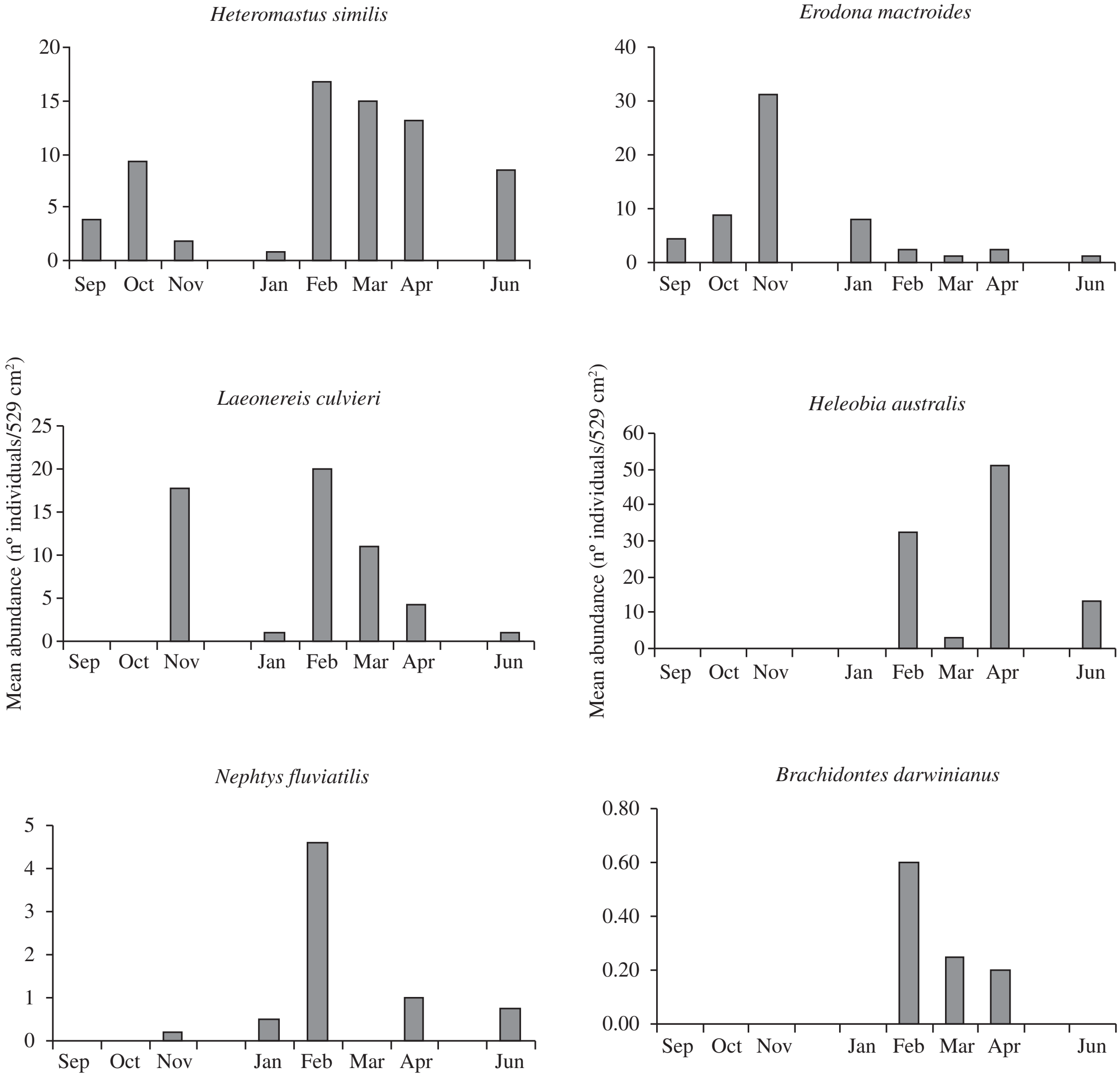

Figure 3. Mean monthly abundance of the main macroinfauna species found at six stations at Pando Stream.

Table 2. Relationship between mean monthly abundance of the main macroinfauna species at five stations, and temperature and salinity at Pando Stream. Significant correlations ($p < 0.05$) are shown in bold type.

	Temperature	Salinity
Heteromastus similis	0.172	**0.479**
Erodona mactroides	0.049	0.230
Laenereis culvieri	**0.519**	**0.562**
Heleobia australis	0.052	0.281

discharge from up-river, but also from Río de la Plata. The low salinities registered in January were related to heavy rainfall occurring a few days before our sampling excursion.

4.2. Macroinfauna

The benthic community at the mouth of Pando Stream was characterized by a low species richness and by high abundance of polychaetes (mainly *Heteromastus similis*), which is characteristic of the estuarine areas of the South Atlantic region (Bemvenuti et al., 1978; Capitoli et al., 1978; Ieno and Bastida, 1998; Muniz and Venturini, 2001; Danulat et al., 2002).

The patterns of species abundance may result from the interaction of their specific patterns of recruitment and mortality. In temperate latitudes, seasonal patterns of reproduction cause pulses due to incorporation of recruits and subsequent mortality (Boesch, 1977; Holland

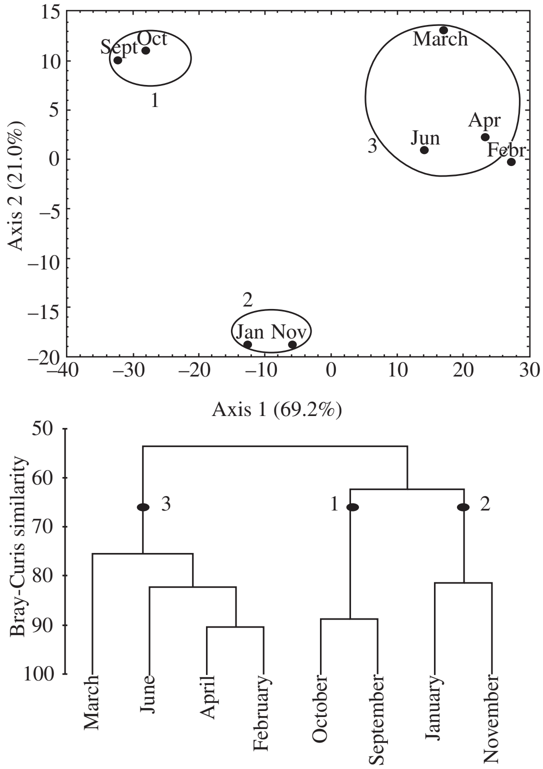

Figure 4. Principal coordinate analysis (PCO) and cluster analysis of mean abundance of macroinfauna at the mouth of Pando Stream after root-root transformation and Bray-Curtis similarity index. For PCO, the percentage explained by each axis is given in parenthesis.

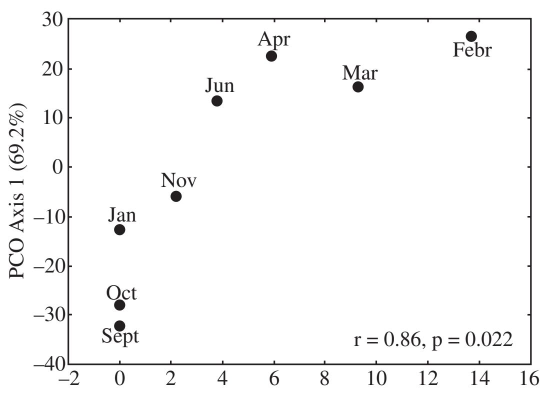

Figure 5. Relationship between the coordinates of mean monthly abundance of macroinfauna and salinity recorded at the mouth of Pando Stream.

et al., 1987). This seemed to be the case for most species found in Pando Stream, which showed a seasonal pattern of abundance. Predation, osmotic stress or disturbance by storms, droughts and sediment anoxia seem to be the main causes of mortality of estuarine benthic invertebrates (Holland et al, 1987; Day et al., 1989; Levinton, 1995; Rundle et al., 1998). For Pando Stream the low depth (<2 m) should preclude the occurrence of anoxic conditions, but disturbance through increased freshwater flow or predation by fish and epibenthic crabs should not be discarded as a source of mortality or emigration.

For Pando Stream the combined effect of osmotic stress and disturbance should explain the low number of species between September and January. River runoff should affect mainly epibenthic species such as *Heleobia australis*, and errant polychaetes such as *Nephtys fluviatilis* as in the case of Valizas Stream (Jorcín, 1999). Predation by fish (*Micropogonias furnieri*) and crabs (*Callinectes sapidus*, *Cyrtograpsus angulatus*), mainly in spring and summer, may further reduce macrofaunal abundance. From February to June, the mouth of Pando Stream was characterized by brackish water, coinciding with the peaks of abundance of almost all species (exception: *E. mactroides*). Brackish water entering through the mouth and the high temperature in late summer and early autumn may facilitate the recovery of populations: while high temperature should increase growth and reproduction, brackish water from the open coast should reduce osmotic stress, allow retention of individuals within the stream, and increase immigration of benthic and pelagic (larval) stages from the Río de la Plata. The presence of the brown mussel *Brachidontes darwinianus*, a highly abundant species in the exposed coast of the Río de la Plata estuary, should be explained by the transport of larvae from the open coast.

The exception to the process described above may occur for *Heteromastus similis* and *Erodona mactroides*. Jorcín (1999) speculated that the burrowing capacity of these two species made them less susceptible to be washed out by currents. *H. similis* burrows up to a depth of 15 cm in the sediment, avoiding epibenthic predation (Bemvenuti, 1988) and perhaps erosion. However, another burrower, *L. culvieri*, should have followed the same pattern as *E. mactroides* and *H similis*. *H. similis* appears to recruit all year round as evidenced by the presence of juveniles in all months (Ieno & Bastida, 1998), perhaps being able to rapidly recover from disturbance caused by freshwater flow or predation. For *E. mactroides*, recruitment can be discarded as an explanation for the peak of abundance in November, because almost all individuals collected in that month ranged from 18 to 34 mm; and recruits (<14 mm) appeared in January when the abundance was low. *E. mactroides* is actually a surface burrower (Bemvenuti et al., 1978), a fact that may increase the susceptibility to be transported by currents. The only explanation we can offer for the peak in abundance in November is that large individuals must have been transported from the head of the river to the sampled area, while small individuals might have been transported further to the open coast.

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