On the benthic molluscs of Banco Inglés (Río de la Plata, Uruguay)

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Abstract

On the benthic mollusks of Banco Inglés (Río de la Plata, Uruguay).— We describe the specific richness and community structure of benthic molluscs on a shallow–water sandy bank (Banco Inglés) in the Río de la Plata estuary. From a total of 25 macroinvertebrate taxa collected, that included one ophiuroid, one bryozoan, four crustaceans and four polychaete species, molluscs were the dominant taxon, with 15 species recorded. These were one species of Polyplacophora, eight Bivalvia and six Gastropoda (one exotic), representing 11 families and 11 genera. In terms of mean relative abundance, the molluscan assemblage was dominated by the deposit–feeder bivalve *Corbula caribaea,* averaging ca. 30% of the individuals of the macroinfauna. The alien species *Rapana venosa* was noted in two stations, represented by one and four specimens. We used null model analysis to test for nonrandomness in the structure of the molluscan communities of the area. The analysis supported the null hypothesis that co–occurrence patterns could not be distinguished from those that might arise by random processes.

Key words: Benthos, Biodiversity, Banco Inglés, Uruguay.

Resumen

Sobre los moluscos bentónicos del Banco Inglés (Río de la Plata, Uruguay).— Describimos la riqueza específica y estructura de la comunidad de moluscos en un banco arenoso somero (Banco Inglés) en el Río de la Plata. En total, de los 25 taxones de macroinvertebrados colectados, que incluyeron una especie de ofiuroideos, una de briozoo, cuatro de crustáceos y cuatro de poliquetos, los moluscos fueron el grupo dominante. Dentro de las 15 especies de moluscos recolectadas se constató la presencia de una especie de Polyplacophora, ocho de Bivalvia y seis de Gastropoda (una exótica), representando 11 familias y 11 géneros. En términos de abundancia relativa media, la asociación de moluscos estuvo dominada por el bivalvo depositívoro *Corbula caribaea*, promediando aprox. 30% del total de individuos de la macrofauna. La especie exótica *Rapana venosa* fue registrada en dos estaciones, representada por uno y cuatro individuos. Se utilizaron modelos nulos parar evaluar patrones en la estructura de la comunidad de moluscos en el área. Los análisis apoyaron la hipótesis nula de que los patrones de co–ocurrencia no pudieron diferenciarse de aquellos originados por procesos aleatorios.

Palabras clave: Bentos, Biodiversidad, Banco Inglés, Uruguay.

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Introduction

In view of the rapid and radical degradation of aquatic habitats worldwide, particularly at coastal areas, an increasing amount of research is being undertaken to determine the specific composition in benthic communities. Growing efforts are being made to describe, map and understand biodiversity patterns at a wide range of spatial scales (Gray et al., 1990; Gray, 2001).

The information describing species composition and patterns of distribution of the macrofauna of Río de la Plata includes recent reviews by Masello & Menafra (1996), Mianzán et al. (2000) and some large scale, integrative approaches (Giberto, 2003; Giberto et al., 2004; Giménez et al., 2005). In spite of this, only a few estuarine sites on the Uruguayan coastline have been studied with respect to species composition and community structure, explicitly Montevideo Bay and adjacent areas (Scarabino et al., 1975; Venturini et al., 1999; Danulat et al., 2002; Venturini et al., 2004), the Solís Grande subestuary (Bier, 1985; Muniz & Venturini, 2001), the Valizas stream and Rocha lagoon (Nión, 1979; Corbellini, 1983; Jorcín, 1999). Furthermore, all these sites are shallow and / or intertidal habitats. At a large spatial scale, the estuarine benthic community of Río de la Plata is structured mainly in response to physical variables such as bottom type, salinity and the presence of the turbidity front (Giberto et al., 2004). Little is known, however, about the role of biological processes in structuring benthic communities at a local scale.

In the Río de la Plata area, molluscs have received far more attention than other zoological groups (Scarabino, 1999). Molluscs specific richness is often used as a surrogate for total specific richness since their taxonomy is relatively well known, thus making species identification more reliable, and because evidence suggests a positive correlation between mollusc and non–mollusc site specific richness (Mianzán et al., 2002). Molluscs are in general the dominant group of the benthic assemblages at the Río de la Plata and Uruguayan shelf (Milstein et al., 1976; Roux et al., 1993). However, benthic sub–tidal and shallow shelf environments are almost unexplored, taxonomic and faunal data for benthic animals are inadequate, and basic knowledge about specific composition and community structure at most estuarine sites is not available (Calliari et al., 2003).

This paper aims to describe the molluscan assemblage at Banco Inglés, an estuarine, shallow–water bank in the Río de la Plata, and to explore the possible effect of species interactions on the community structure.

Material and methods

Study area

Banco Inglés is a shallow (depth 0.8 to 10 m) sandy bank, located nearshore in the mid–region of the Río de la Plata, a coastal plain, micro–tidal estuary with predominant sediments composed of fine fractions, mainly silts and clays (Framiñan & Brown, 1996; López, 1997). It is situated between 35º 10' – 35º 20' S and 55º 50' – 56º 00' W, near the Canal Oriental, 10 km SE of Montevideo (fig. 1). Together with Banco Ortíz, Barra del Indio and Banco Rouen, located in the mid–outer zone of the river, it conforms a noticeable complex of sediment bars and plains (Framiñan & Brown, 1996; López, 1997). Salinity at the study area is highly variable on an annual and interannual basis (0–30), being strongly influenced by high–salinity marine waters and the freshwater runoff (Guerrero et al., 1997a, 1997b; Guerrero & Piola, 1997).

Sampling and laboratory methods

The sampling was carried out during October 2005 as part of an ecological impact assessment. Benthos samples and environmental data came from two different sources: faunal samples were taken with an epibenthic dredge (frame = 50 x 20 cm, mesh size = 1.5 cm; 6 samples) and with a Van Veen grab (aperture = 50 x 30 cm; 3 samples). Each dredge sample consisted of a 10' haul, at an average speed of 2 knots, covering an approximate area of 180 m^2. Latitude and longitude for the stations is provided in table 1. Following collection, samples were sieved through a 1 mm screen onboard and preserved for analysis in 5% formalin. In the laboratory, all invertebrates were sorted, identified and counted under a stereomicroscope. Sediment samples for granulometric analysis were taken from a subsample of the van Veen grab. In the laboratory, sediment samples were dried for 24 h at 60°C, weighed, and wet–sieved in a mesh of 0.063 mm to separate the silt and clay fractions. The resulting sand fraction was then dried again, weighed and mechanically sieved through a series of meshes from 4 mm up to 0.063 (interval 1 φ), following Buchanan (1984). The resulting fractions were weighed again and the percentages of each sediment fraction were calculated.

Data analysis

Species incidence (as number of stations where the species was recorded / total samples) and frequency of occurrence (as nº of individuals of sp_i / total nº of individuals, N) were calculated for all samples. In addition, number of taxa (S), dominance (D = S [(ni / n) 2], where ni is number of individuals of taxon i), Equitability (E = H' / ln S) and Shannon H' (Shannon & Weaver, 1949) based on natural logarithm, Simpson 1–D (Simpson, 1949) and Margalef (M = S – 1 /Log N) indexes were also calculated. This was done with all the macrofaunal community (i.e. including all mollusc, crustacean, echinoderm and polychaete species collected) to provide meaningful measures of community structure. Only live macrofaunal animals were considered. It should be noted, however, that data from
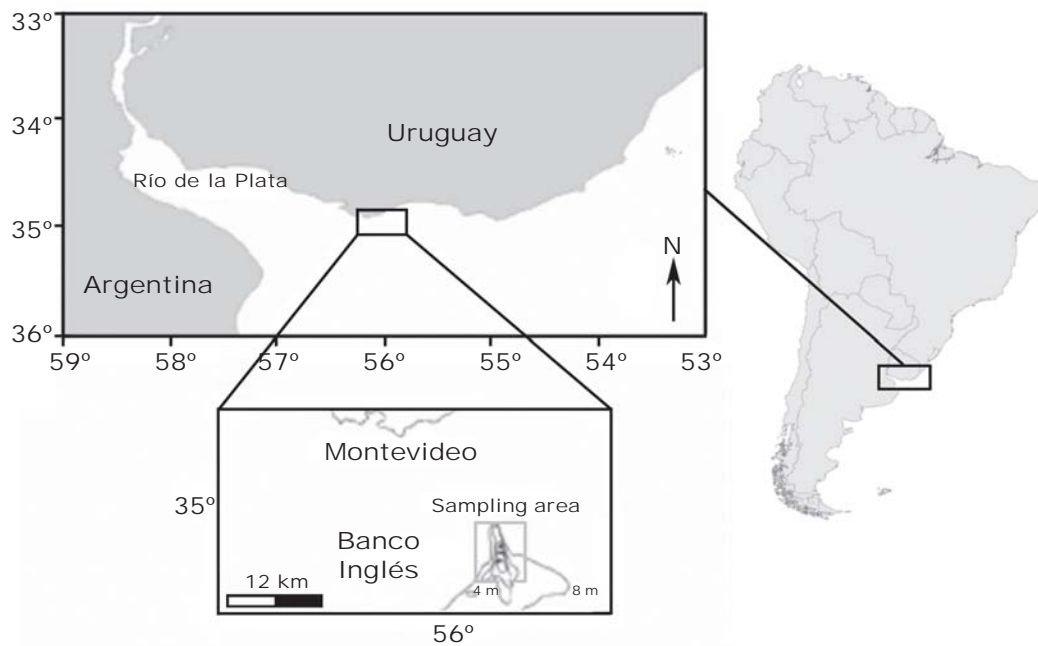
Fig. 1. Map of the study area. The zone comprising the Banco Inglés is shown, delimited by the 8 m isobath. The sampling area is delimited by a rectangle.

Fig. 1. Mapa del área de estudio. Se muestra la zona que comprende el Banco Inglés, delimitada por la isobata de 8 m. El área de muestreo se indica por medio de un rectángulo.

the epibenthic dredge are considered semi–quantitative. For this reason, we avoid the use of the term "density" when referring to taxa abundances; values from the epibenthic dredges must be considered as "capture per unit effort". In spite of this, we analyzed sample composition regardless of the sampling method to allow us to integrate and compare samples from both sources. The accuracy of the sampling effort was assessed by both sample and individual–based rarefaction curves following Gotelli & Entsminger (2001), using molluscs data only. Expected species accumulation curves were constructed, and total numbers of mollusc species were estimated using Jacknife 1 and Chao 1 richness estimators (Burnham & Overton, 1979; Chao, 1984). Whereas Jacknife 1 and Chao1 estimate total species richness, including species not present in any sample, rarefaction curves estimate species richness for a sub–sample of the pooled total species richness, based on all species actually discovered.

In order to assess the effects of species interactions, we used null model analysis to test for non–randomness in the structure of the molluscan communities at Banco Inglés. The analysis tested the null hypothesis that co–occurrence patterns could not be distinguished from those that might arise by random processes. We used two simulations and co–occurrence indexes following Gotelli & Entsminger

(2001). The first simulation (ECOSIM Sim2, fixed rows–equiprobable columns) randomizes the occurrence of each species among the sites, assuming the sites are equally probable. The co–occurrence index employed was C–score. The second simulation (ECOSIM Sim4, fixed rows–proportional columns) holds the observed number of species per site fixed, randomizing their occurrences among sites. Unlike Sim2, the probability of occurrence is proportional to the observed column total. The index employed was number of species combinations.

Results

The samples were taken in depths ranging from 7.60 to 9.30 m. Location of the sampling points is given in table 1. The sediment was mainly composed of sand (> 99.87%), while mud fractions (silt and clay) were barely present (< 0.14%). Following Wentworth (1932) and Folk & Ward (1957), the sediment was characterized as medium to fine sand, with a poor to moderate selection.

From a total of 25 taxa of macroinvertebrates collected, including one ophiuroidean, one bryozoan, four crustaceans and four polychaete worms, molluscs were the dominant taxon, with 15 species recorded. These were one Polyplacophora, eight Bivalvia and six Gastropoda (one exotic), repre-

Table 1. Stations (T1–T6. Epibenthic dredges; D1–D3. Van Veen grabs), depth (d, in m), latitude (S) and longitude (W), number of taxa and individuals between brackets (N (n)), dominance (D), equitability (J), and Shannon (H'), Simpson (1–D) and Margalef (M) diversity indexes for all samples.

Tabla 1. Estaciones (T1–T6, rastras; D1–D3, dragas Van Veen), profundidad (m), latitud S y longitud W, número de taxones e individuos entre paréntesis (N (n)), dominancia (D), equidad (J), e índices de diversidad de Shannon (H'), Simpson (1–D) y Margalef (M) para todas las muestras.

Stations	d	S	W	N (n)	D	J	Diversity indexes		
							H'	1–D	M
T1	8.41	35º 10.351'	55º 55.280'	6 (15)	0.23	0.9	0.51	0.26	0.76
T2	9.30	35º 10.503'	55º 55.701'	13 (84)	0.18	0.81	0.5	0.32	0.37
T3	8.80	35º 09.346'	55º 55.161'	9 (28)	0.24	0.8	1.099	0.5278	1.61
T4	7.60	35º 09.210'	55º 55.531'	5 (16)	0.27	0.88	1.617	0.7733	1.846
T5	8.00	35º 08.122'	55º 55.285'	8 (23)	0.1871	0.89	2.078	0.8226	2.708
T6	8.80	35º 08.166'	55º 55.562'	11 (107)	0.38	0.57	1.755	0.7628	2.401
D1	8.60	35º 08.978'	55º 55.899'	3 (14)	0.74	0.46	0.51	0.25	0.75
D2	8.20	35º 08.170'	55º 55.153'	2 (15)	0.68	0.72	0.5	0.32	0.37
D3	8.40	35º 10.161'	55º 55.621'	5 (12)	0.47	0.68	1.09	0.53	1.61

senting 11 families and 11 genera. A list of all collected species is presented in table 2. Voucher material for each species is deposited at the Museo Nacional de Historia Natural y Antropología of Montevideo (MUNHINA).

The number of taxa collected (considering the whole benthic assemblage) ranged from two to 13, whereas the maximum number of individuals per sample was 107. Values of Shannon–Weaver diversity index ranged from 0.50 to 2.08, the maximum being reached in station T5, where Simpson (0.82) and Margalef (2.70) indexes also peaked (table 2).

In terms of mean relative abundance, the molluscan community was dominated by the suspension–feeder bivalve *Corbula caribaea* d'Orbigny, 1853, averaging ca. 30% of the macroinvertebrates. In contrast, *Turbonilla* sp., *Sphenia fragilis* Carpenter, 1857, *Corbula* sp. and *Crassinella marplatensis* Castellanos, 1970 were present as single specimens in one station. The alien species *Rapana venosa* (Valenciennes, 1846) was recorded in two stations, represented by one and four specimens (table 1). Rarefaction curves did not reach an asymptotic value. Richness estimators Jacknife 1 and Chao 1 indicated an expected richness of 20 and 29 molluscs species respectively (fig. 2).

Both co–occurrence analyses supported the null hypothesis that co–occurrence patterns could not be distinguished from those that might arise by random processes. Only a weak evidence of negatively associated distributions was observed in Sim2 C–score (*p*–observed < expected = 0.081; table 3).

Discussion

Although all recorded species have been previously reported for the Uruguayan coast (Scarabino, 2003a, 2003b, 2004), the described assemblage shares no species with other previously reported intertidal or shallow subtidal benthic communities found in the Uruguayan coast (e.g. Scarabino et al., 1975; Venturini et al., 1999; Danulat et al., 2002; Venturini et al., 2004; Giménez et al., 2005). In contrast, the studied fauna contains species previously reported from the sandy and muddy bottoms of the Río de la Plata (e.g. Giberto et al., 2004), although few quantitative data are available for most of them. The lack of previous quantitative data is of particular concern, since an invasive exotic species, the rapa whelk *R. venosa*, has been observed in Río de la Plata waters since the late 1990s (Scarabino et al., 1999). In this vein, any effect of this invader on the native molluscan assemblage will be hard to detect, but it is possible to argue, that the native populations of bivalves could be affected by the activity of this large, predatory species (ICES, 2004; Savini & Occhipinti–Ambrogi, 2006). This possibility is further supported by the fact that this species is capable of reaching extremely high densities at the Río de la Plata (F. Scarabino, pers. comm). Baseline quantitative data for potential molluscan prey (or species affected by other interactions) are thus required to evaluate the effects of this species on the native malacofauna.

Concerning the faunal features of the study area, previous studies have suggested that benthic

Table 2. Collected species, number of stations where the species was recorded and incidence (as % of total stations). Dredge values are shown in brackets. Mean and standard deviation of species' relative abundance (calculated for all macroinvertebrates) are given for each sampling device and species: RAD. Relative Abundance Dredge; RAG. Relative Abundance Grab.

Tabla 2. Especies recolectadas, número de estaciones donde se recolectó cada especie e incidencia (como % de estaciones totales). Los valores de la muestra con fraga se muestran entre paréntesis. Se dan, para cada especie y método de muestreo, el valor medio y la desviación estándar de las abundancias relativas (calculadas para todos los macroinvertebrados). (For abbreviations see above.)

Species	Stations	Incidence	RAD (mean ± SD)	RAG (mean ± SD)
Class Polyplacophora				
Chaetopleura angulata (Spengler, 1797)	5	0.56	0.09	
Class Bivalvia				
Ostrea puelchana d'Orbigny, 1842	4	0.44	0.19	
Pitar rostratus (Koch in Philippi, 1844)	2 (1)	0.33 (0.33)	0.01 ± 0.005	0.03 ± 0.05
Mactra isabelleana d'Orbigny, 1846	2	0.22	0.02	
Corbula caribaea d'Orbigny, 1853	4 (3)	0.44 (1)	0.04 ± 0.05	0.77 ± 0.09
Corbula patagonica d'Orbigny, 1846	1 (1)	0.11 (0.33)	0.001 ± 0.002	0.02 ± 0.05
Corbula sp.	(1)	0.33		0.02 ± 0.04
Sphenia fragilis Carpenter, 1857	1	0.11	0.001	
Crassinella marplatensis Castellanos, 1970	1	0.33	0.03	
Class Gastropoda				
Parvanachis sp.	3 (1)	0.33 (0.33)	0.11 ± 0.13	0.06 ± 0.11
Buccinanops deformis (King & Broderip, 1836)	4	0.44	0.05 ± 0.04	
Buccinanops cochlidium (Dillwyn, 1817)	2	0.22	0.01 ± 0.01	
Crepidula protea d'Orbigny, 1835	5	0.56	0.07 ± 0.06	
Rapana venosa (Valenciennes, 1846)	2	0.22	0.03 ± 0.09	
Turbonilla sp.	1	0.11	< 0.001 (< 0.001)	

diversity and densities of bottom invertebrates in the Río de la Plata estuary are relatively low when compared with the adjacent marine waters (Boschi, 1988; Mianzan et al., 2002). The latter authors found a humped pattern, with the highest richness in the shallow marine shelf, and the lowest in the estuarine zone, when comparing variability in biodiversity among the zones defined in a regional, macroscale study. However, the number of molluscan taxa recorded here is similar to those found in neighbouring systems traditionally considered as more species–rich, like the Uruguayan Atlantic rocky shores (e.g. Borthagaray & Carranza, 2007). This can be explained in part by the presence of some hard substrata, epibiotic species, such as the chiton *Chaetopleura angulata* or the gastropod *Crepidula protea*. Since no hard substrata other than empty bivalve shells (mainly *Ostrea puelchana* and *Pitar rostratus*) seems to be present at the sandy bottoms of Banco Inglés, these species' shells may be of ecological importance, increasing spatial heterogeneity and providing resources (i.e. refuges, stress free space, etc) that allow the presence of these epibiotic species at the area (Gutierrez et al., 2003). The scavenger snails *B. cochlidium* and *B. deformis* are also a conspicuous faunistic component of the Banco Inglés assemblage, and constitute the only large gastropods present before the arrival of *R. venosa*. Pagurid crabs mainly tend to occupy the shells of these species, although we have observed that bivalves (*M. isabelleana*) are also utilized by these crustaceans. Although unusual, this association has been reported recently for the Brazilian coast (Garcia et al., 2003). Concerning another large bivalve species, *Ostrea pulchella,* we found only small specimens (i.e < to 3 cm), and these were mainly attached to older, larger (> 5 cm) empty shells, suggesting a changing community structure.

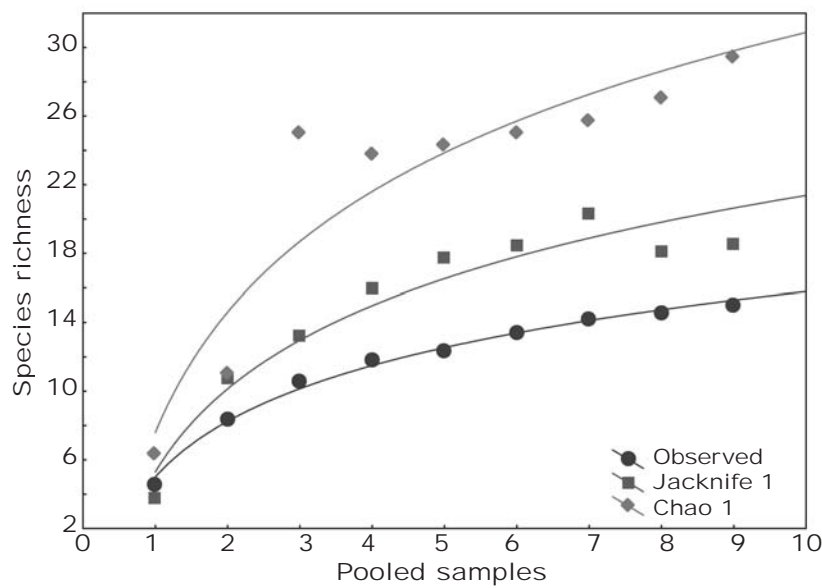Fig. 2. Sample–based rarefaction curve (note that the curve did not reach an asymptotic value) and total expected richness according to Jacknife 1 and Chao 1 richness estimators.

Fig. 2. Curva de rarefacción basada en las muestras (nótese que la curva no alcanza un valor asintótico) y riqueza total esperada de acuerdo a los estimadores Jacknife 1 y Chao 1.

Regarding the sampling devices, the epibenthic dredge always collected more taxa than the Van Veen grab; from five to 13 taxa with the former as compared to two to five (table 2) for the latter. The epibenthic dredge recorded all molluscan taxa, with the exception of a small, unidentified species of *Corbula* recorded from a grab sample. Thus, as indicated by the rarefaction curve and the richness estimators, it is highly probable that more species will be recorded if the sampling effort is enhanced. The diversity of small–sized species, in particular, is likely to be underestimated due to the small area covered by the grabs and the mesh size used.

In relation to community structure, contrasts between comparable community descriptors (i.e. mean values and standard deviation of Margalef index) obtained here with those provided by Giberto et al. (2004) showed that Banco Inglés presented higher

Table 3. Results of co–occurrence analysis. Co–occurrence indexes C–score and number of species combinations are given for each simulation. Variance of simulated indexes and *p*–values are also shown. Simulations employed were Sim2 (Fixed rows–equiprobable columns) and Sim4 (Fixed rows– proportional columns): Msi. Mean of simulated índexes; Vsi. Variance of simulated indexes; O. Observed; E. Expected.

Tabla 3. Resultados del análisis de co–occurrencia. Se muestran los índices C–score de co– ocurrencia y número de combinaciones de especies. Tambien se muestra la varianza de los índices simulados y los valores p. *Las simulaciones empleadas fueron Sim2 (Filas fijas–columnas equiprobables) y Sim4 (Filas fijas–columnas proporcionales): Msi. Media de los índices simulados; Vsi. Varianza de los índices simulados; O. Observado; E. Esperado.*

| | Species | | | | *p*–values | |
Simulation	combinations	C–score	Msi	Vsi	(O ≤ E)	(O ≥ E)
SIM2		1.205	1.487	0.033	0.081	0.926
SIM4	6.000		5.996	0.004	1.000	0.996

values than the inner Rio de la Plata (1.38 ± 0.86 *vs* 0.87 ± 0.36) despite larger between–sample variability and the relatively small area here surveyed (ca. 55 km^2). This supports the idea that the topographic and sedimentologic (i.e. presence of sandy sediments) discontinuities evident in Banco Ingles, together with the coexistence of mixohaline and strictly estuarine species, increase local diversity. The molluscan assemblage showed little evidence of being structured by biological processes, as obseved in the co–occurrence analysis. Our observations are in agreement with the prediction that stressing environments, such as estuarine habitats, are structured mainly in response to the physical environment. A common caveat for this conclusion is that the spatial scale of biological interactions may be smaller than the area covered by the sampling devices: at a spatial scale beyond those at which individuals interact or among groups of species that are weakly interactive or not interactive, biological interactions will be hard to detect.

Conclusions

The sampled mollusc community is considered a heterogeneous assemblage, containing some species that are also present in the adjacent marine zones but able to tolerate low salinity conditions. It is also rather diverse considering the expected faunistic and ecological features of the study area, that is, the low diversity typically found at most estuarine sites, especially in Río de la Plata coastal waters. The analysis supported the null hypothesis that co–occurrence patterns could not be distinguished from those that might arise by random processes, suggesting that the local community is structured mainly in response to the physical environment. Although more sampling efforts are needed to complete our knowledge of the malacofauna at Banco Inglés, the results from the present study are particularly valuable as they document the composition of the molluscan assemblage at this site and may serve as a basis for future studies dealing with ecological impact on this environment.

Acknowledgements

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