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Macroinvertebrates associated with *Limnoperna fortunei* (Dunker, 1857) (Bivalvia, Mytilidae) in Río de la Plata, Argentina

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Abstract

An analysis was made of specific richness (*S*), specific diversity (*H*), equitability (*J*), frequency (*F*), dominance (*Dm*) and density (*D*) of the macroinvertebrates associated with the invasive species *Limnoperna fortunei* (Dunker, 1857).

Limnoperna fortunei caused an increase in the specimen number on the rocky environment studied. The species richness and abundance of different taxa of macroinvertebrates, except mollusks was positively related to the presence and density of *L. fortunei*. Autochthonous gastropod species conversely, tended to be displaced.

Introduction

Limnoperna fortunei (Dunker, 1857) is a freshwater species native of rivers and creeks of China and southeast Asia. It was first recorded in America on the Argentinian shore of the Río de la Plata, at Bagliardi Beach (34°55′ S–55°49′ W), September 1991 (Pastorino et al, 1993; Darrigran & Pastorino, 1993; 1995). Before the invasion of *L. fortunei*, the local hard substratum was plane rock, with few invertebrates associated. Its recent settling has provided a microenvironment for the development of benthic microfauna (especially Oligochaeta and Hirudinea) and has changed the composition of the autochthonous malacofauna (Martín & Darrigran, 1994).

The benthic macrofauna on the Argentine shore of the Río de la Plata has been studied since the 1980s. Studies on the benthic invertebrate fauna of Bagliardi Beach include Isopoda (Darrigran & Rioja, 1988), Mollusca (Darrigran, 1991, 1994, 1995), and Hirudinea (Gullo & Darrigran, 1991, Gullo, 1995).

This paper has two objectives:

(1) to study the impact caused by an invading species on the composition of the native fauna.

(2) to analyse the benthic oligochaete fauna.

Materials and methods

Populations of *L. fortunei* settle on every hard substratum available (tight silt-sand or 'caliche', trunks, roots).

At Bagliardi Beach, the hard substratum is a small artificial coastwise rocky intrusion, men made, of approximately 40 m length. This environment bounds the contiguous coast of the Río de la Plata shore and the mouth of an affluent channel (see Figure 1).

Six sampling stations (= sample) were established in this rocky environment.

The littoral macrobenthos develops upon areas protected from tide action. Consequently, the result is an heterogeneos environment with two different physiognomies: fringes with *L. fortunei* as dominant species

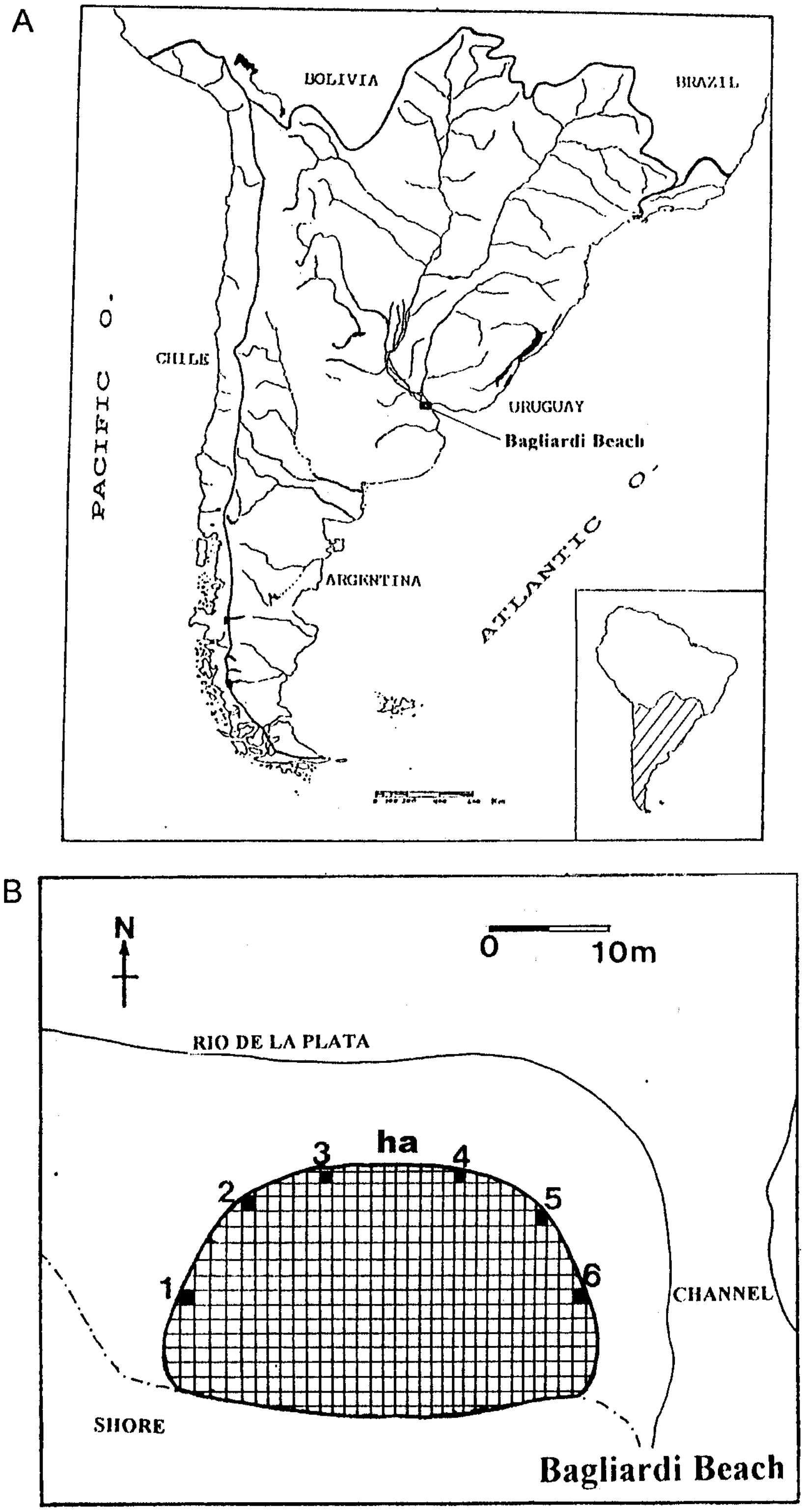

Figure 1. A. Map showing the stations, Bagliardi Beach, on the coast of the Río de la Plata river. ha 1 to 6: stations; B. rocky environments sampled; dashed line: high tides; solid line: low tides.

and areas with no settlements. Samples were taken from the fringes with macrobenthos, from a rectangular area, variable in size.

Twenty-one samplings were made from July 1992 to March 1995. Samples from stations 1, 2 and 3, were fixed in the field with formaldehyde 10 percent. Samples from stations 4, 5 and 6, were taken to the laboratory and observed *in vivo*. Samples were collected with spatula.

The calculated biocenotic parameters (Cornet, 1986) were: Mean Density (D) = [Σ(ni/a)]/M, with M: total number of samples, ni: number of individuals per sample, a: area sampled. Dominance (Dm) = n/N.100, with n: total number of individuals of the considered species, N: total number of individuals of all the species. Frecuency (F) = m/M.100, with m: number of samples with the considered species, M: total number of samples. Considering the dominance and frequency (Rodriguez et al., 1980), species were classified as:

a) Dominant: $Dm \geq 1\%$
b) Constant: $F \geq 50\%$
c) Accessory: $25\% < F < 50\%$
d) Accidental: $F < 25\%$
e) Expansive: $F > 15\%$ and $Dm > 25\%$
f) Diffuse: $F > 15\%$ and $Dm < 25\%$

Likewise, the diversity index of Shannon-Weaver (H) and equitability (J) = e^{H-1}/S-1, with H: Shannon-Weaver index, S: number of species, were calculated. The data were analyzed by Kruskal-Wallis and Chi-square tests (Siegel, 1974) and by Pearson's correlation coefficient (Sokal & Rohlf, 1984).

For similarity analysis, the Jaccard index (J) (Resh & McElray, 1993; Norris & Georges, 1993), was used.

Both extreme stations (samples 1 and 6) were compared with the others, to look for an environmental gradient between them (Contreras et al., 1985).

Abundance values were transformed logarithmically after Gauch, 1986.

Results

The macrofauna associated with the *L. fortunei* population included: Mollusca (Gastropoda), Annelida (Hirudinea, Oligochaeta, Aphanoneura), Turbellaria (Tricladida), Nematoda, Diptera (Chironomidae) and Crustacea (Tanaidacea, Isopoda and Amphipoda) (see Table 1).

The Gastropoda and Hirudinea associated with the byssus of *L. fortunei*, are listed in Table 2. Best represented were the gastropod *Heleobia piscium* (d'Orbigny, 1835) (Dm: 97.76%, F: 76.1%) and the leech *Gloiobdella michaelseni* (Blanchard, 1900) (Dm: 61.67%, F: 95.2%). The leeches *Helobdella adiastola* Ringuelet, 1972 and *Helobdella hyalina* Ringuelet, 1942 were dominant, constant and diffuse. The remaining mollusks, *Helobdella striata* (Ringuelet, 1943) and *H. triserialis triserialis* (Blanchard, 1849), were occasional.

Dominance and frequency of oligochaetes obtained in March 1995, are seen in Table 3. *Limnodrilus hoffmeisteri* Claparede, 1862 and *Nais variabilis* Piguet, 1906 were dominant and expansive, while *Dero (Dero) digitata* (Müller, 1773) was occasional.

A decrease in abundance of *Gundlachia concentrica* d'Orbigny, 1835 and *Chilina fluminea* (Maton, 1809) occurred (Figure 2). The density of *H. piscium* was directly proportional with that of *L. fortunei* (r: 0,36, n: 104, P: 0.01).

The differences between the mean densities of oligochaetes and leeches in March 1995, at 6 stations, were not significant (x^2 0,062; g.l. = 5; $P < 0.01$). The mean density value of leeches in every samples were also not significant (x^2 7407; g.l. = 20; $P < 0.01$).

Diversity (H) and Equitability (J) indices of Hirudines, were very heterogeneous and not positively related to the abundance of *L. fortunei*. The highest value of leeches was recorded at the beginning of the sampling (H = 0.69) with a J = 0.82. (Table 4).

Likewise, leeches abundance was directly proportional with that of *L. fortunei* (r: 0.28, n: 57, P: 0.05).

Diversity and equitability of the oligochaetes is inversely proportional with abundance of *L. fortunei* (r: − 0.86, n:6, P:0.05). Density of oligochaetes is not related to the abundance of the mytilid (r: 0.56, n: 6, P: 0.05).

Jaccard index was used to compare the faunal composition of the sample 1 (March 1995) with the remainders, and sample 6 with the remainders (Figure 3). Differences between extreme samples were not significant. There is an intermediate homogeneous zone with J between 0.5 and 0.8.

Discussion

The data were compared with those obtained by Darrigran & Rioja, 1988; Darrigran, 1991, 1994; Gullo & Darrigran, 1991; before the introduction of *L. fortunei* in the Rio de la Plata (as seen in Table 5). Respect to the macrofauna existing before the settling of *L. fortunei*, 5 other species of Hirudinea and Oligochaeta

Table 1. Presence and absence of the Mollusca Gastropoda, Annelida Hirudinea and Oligochaeta species, in samplings.

Sampling	Jul-92	Aug-92	Sep-92	Oct-92	Dec-92	Jan-93	Feb-93	Mar-93	May-93	Aug-93	Oct-93	Dec-93	Jan-94	Feb-94	Mar-94	Apr-94	Jan-94	Sep-94	Oct-94	Nov-94	Mar-95
Taxa																					
Mollusca Gastropoda																					
Heleobia piscium	+	+	+	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Gundlachia concentrica	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–
Chilina fluminea	+	+	–	+	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	–	–
Biomphalaria straminea	nc	nc	nc	nc	nc	nc	nc	nc	nc	–	–	–	–	–	–	–	–	–	–	–	+
Annelida Oligochaeta																					
Eiseniella tetraedra	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	+	+	+
Limnodrilus hoffmeisteri	–	–	–	–	–	–	–	–	–	–	+	–	+	–	–	–	+	+	+	+	+
Aulodrilus piguetti	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	+	+
Nas variabilis	–	–	–	–	–	–	–	–	–	–	+	–	+	–	–	–	+	+	–	+	+
Pristina leidyi	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	+
Dero (Dero) digitata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	+
Pristinella osborni	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
P. jenkinae	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	+	–	–	–	+
Annelida Aphanoneura																					
Aeolosoma sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	+
Annelida Hirudinea																					
Gloiobdella michaelseni	+	+	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Helobdela adiastola	+	+	+	+	+	+	+	+	+	+	–	+	+	+	+	+	+	+	+	+	+
H. hyalina	+	+	+	+	+	+	+	+	+	+	–	+	+	+	+	+	+	+	+	+	+
H. simplex	+	+	–	+	+	+	+	+	+	–	–	+	+	+	+	+	–	–	+	+	+
H. striata	+	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
H. triserialis triserialis	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–			
H. triserialis lineata	+	+	–	–	–	–	–	–	–	–	–	+	–	+	+	–	–	+	–	–	–
H. triserialis nigricans	–	–	–	–	–	–	+	+	+	–	–	+	+	+	+	+	–	–	–	+	–
Crustacea																					
Amphipoda	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	–	+	–	–	–	–	–	–	–	+	–
Tanaidacea	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	–	–	–	+	–	+	–	–	–	+	–
Isopoda	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc –	–	–	–	–	–	–	–	–	+	–	
Insecta Chironomidae	nc	nc	nc	nc	nc	nc	+	+	+	+	+	+	–	+	–	+	+	–	–	+	–
Turbellaria Tricladia	+	nc	nc	nc	nc	nc	nc	nc	nc	–	–	+	–	+	–	+	–	–	+	+	–
Nematoda	nc	nc	nc	nc	nc	nc	nc	nc	nc	–	–	–	–	–	–	–	+	–	–	+	+

+ = present; – = absent; nc = no considerate.

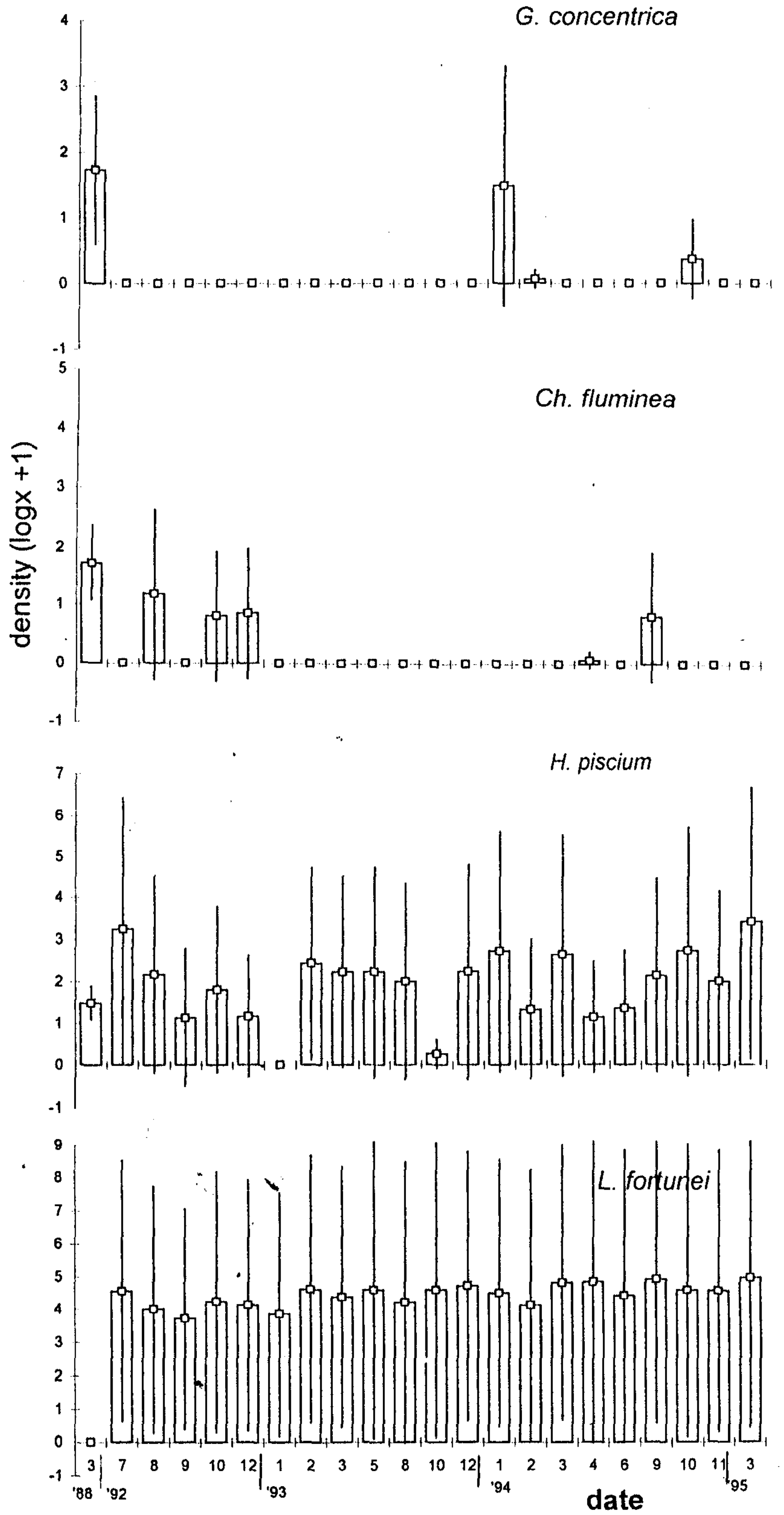

Figure 2. Temporal variation of presence and density, expressed in log.(x + 1), of the autochthonous malacofauna associated to the byssus of *L. fortunei*. March 1988 data, was taken from Darrigran (1991).

Table 2. Faunal features of Gastropoda and Hirudinea of Bagliardi Beach.

Species	Dominancy	Frequency	Fauna characterics
Mollusca Gastropoda			
Heleobia piscium (d'Orb., 1835)	97.76%	76.19%	Dominant, Constant, Expansive
Gundlachia concentrica (d'Orb., 1835)	0.15%	14.28%	Accidental, Diffuse
Chilina fluminea Maton, 1809	1.75%	23.80%	Accidental, Diffuse
Biomphalaria straminea	0.07%	4.76%	Accidental, Diffuse
Annelida Hirudinea			
Gloiobdella michaelseni (E. Bl., 1990)	61.67%	95.2%	Dominant, Constant, Expansive
Helobdella adiastola Ringuelet, 1982	16.97%	95.2%	Dominant, Constant, Diffuse
H. hyalina Ringuelet, 1942	13.46%	90.4%	Dominant, Constant, Diffuse
H. simplex (Moore, 1911)	3.58%	71.42%	Dominant, Constant, Diffuse
H. striata (Ringuelet, 1943)	0.21%	10.52%	Accidental
H. triserialis triserialis (E. Bl., 1849)	0.59%	23.8%	Accidental, Diffuse
H. triserialis lineata	2.65%	33.33%	Dominant, Accessory, Diffuse
H. triserialis nigricans Ringuelet, 1968)	2.98%	42.85%	Dominant, Accessory, Diffuse

Table 3. Faunal features of the Oligochaeta of Bagliardi Beach. March 1995.

Species	Dominancy	Freqency	Fauna characterics
Annelida Oligochaeta			
Eiseniella tetraedra Saigny, 1867	4.72%	100%	Dominant, Constant, Diffuse
Limnodrilus hoffmeisteri Claparede, 1862	41.8%	100%	Dominant, Constant, Expansile
Aulodrilus piguetti Kowalewski, 1914	3.43%	100%	Cominant, Constant, Diffuse
Nais variabilis & Piguet, 1906	39.91%	100%	Dominant, Constant, Expansile
Pristina leidyi Smith, 1896	3.21%	33.3%	Dominant, Accessory, Diffuse
Dero (Dero) digitata (Müller, 1773)	0.43%	16.6%	Accidental, Diffuse
Pristinella osborni (Watton, 1906)	2.57%	33.3%	Dominant, Accessory, Diffuse
P. jenkinae (Steph., 1931)	1.28%	16.6%	Dominant, Accidental, Diffuse
Annelida Aphanoneura			
Aeolosoma sp. Ehrenberg, 1828	2.57%	50%	Dominant, Constant, Diffuse

were found, as well as a decrease in the richness of the malacofauna and an the absence of Isopoda.

The results agree with those of Morton, 1977, in relation to the new environment created by *L. fortunei*. This species facilitates the settlement of other macroinvertebrate populations, mainly Gastropoda, Oligochaeta and Hirudinea. Probably, this microenvironment has structural environmental features as complex as the ones observed by Tsuchiya & Retiere, 1992 in marine mytilid communities, and even more complexity than the base surface of the rocks before the introduction of *L. fortunei* into the environment. Besides, it is independent from the sedimentological and hidrological features of the environment.

The specific richness (S) of the leeches, increased since the introduction of *L. fortunei* into the environment. Gullo & Darrigran, 1991 mentioned only two species for this area. Since July 1992, values increased up to $S = 7$. Increases of the mean density of the leeches are correlated with increases of *L. fortunei* densities. These increases can be related to greater food supply (bij de Vaate, et al., 1993) to the opportunist kind of diet of the leeches (Sawyer, 1986). *Gloiobdella michaelseni* feeds mainly on Chironomidae and on the Planorbidae *Biomphalaria* spp. (Ringuelet, 1985), while *Helobdella triserialis* specializes in feeding almost exclusively on mollusks (Sawyer, 1986).

When the abundance of *L. fortunei* increases, the microenvironment becomes more favorable to some few species, which are more densely represented than the remaining species of the group, as it is observed in the oligochaetes. This effect is also observed in marine microenvironments formed by the byssus of other mytilids (*Mytilus* spp.) (Tsuchiya & Reteiere, 1992). In

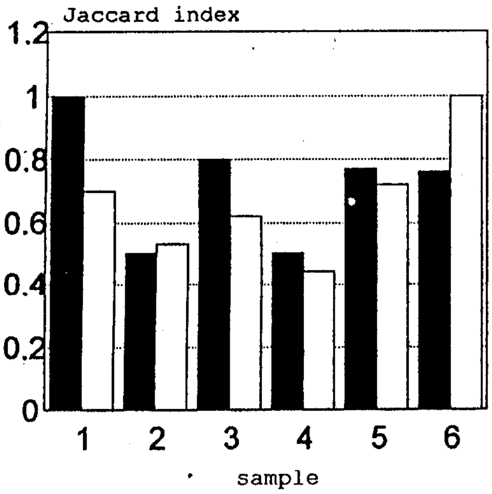

Figure 3. Comparison of the faunal composition between the station 1 and the remainders (in black), and the station 6 and the remainders (in white); sampling of March 1995. Index: Jaccard. Station number: 6.

Table 4. Values of diversity, equitability and specific richness of Hirudines during samplings.

Samplings	Diversity	Equitability	Species richness
Jul/92	0.69	0.82	7
Aug/92	0.64	0.91	5
Sep/92	0.22	0.72	2
Oct/92	0.4	0.67	4
Dec/92	0.5	0.7	5
Jan/93	0.66	0.94	5
Feb/93	0.45	0.64	5
Mar/93	0.54	0.77	5
May/93	0.09	0.3	2
Aug/93	0.25	0.52	3
Oct/93	0.04	0.13	2
Dec/93	0.5	0.59	7
Jan/94	0.42	0.6	5
Feb/94	0.49	0.63	6
Mar/94	0.46	0.6	6
Apr/94	0.42	0.7	4
Jun/94	0.47	0.79	4
Sep/94	0.19	0.32	4
Oct/94	0.14	0.23	4
Nov/94	0.38	0.54	5
Mar/95	0.59	0.66	6

freshwater environments, *Dreissena polymorpha* (Pallas, 1771) develops an adequate microenvironment for the settlement of one species of *Limnodrilus* Claparede, 1862, that processes the excrements and pseudoexcrements of the environment (bij de Vaate et al., 1993), and also for *Nais variabilis* that feeds on detritus and bacteria (Harper et al., 1981a, b).

Table 5. Macrofauna before 1991. Rocky environment of Bagliardi Beach.

Taxa	Reference
Gastropoda	
Gundlachia concentrica	Darrigran (1991)
Chilina fluminea	Darrigran (1991)
Heleobia piscium	Darrigran (1991)
Hirudinea	
Gloiobdella michaelseni	Gullo & Darrigran (1991)
Helobdella striata	Gullo & Darrigran (1991)
Isopoda	
Pseudosphaeroma platense	Darrigran & Rioja (1988)

In the microenvironment formed by the rocky substratum of Bagliardi Beach, there is a positive correlation between the high density of *L. fortunei* and the presence of the Gastropoda *H. piscium*. However, other Gastropoda species, *G. concentrica* and *Ch. fluminea*, formarly constant and numerous in this environment, were affected or disturbed in its occurrence and numerosity (Darrigran, 1994; Martin & Darrigran, 1994). Coincident with the introduction of *L. fortunei*, it was detected the accidental presence only in the sampling of April 1994 of another Gastropoda species, not common in the rocky environment of Bagliardi Beach, *Biomphalaria straminea* Dunker, 1848 (Pulmonata, Planorbidae).

The structure of the taxocenosis formed by the macroinvertebrates associated to this microenvironment, mollusks excluded, is favored by the presence and high density of *L. fortunei*. On the contrary, the autochthonous gastropods of this environment are generally displaced. It is not recorded hitherto the incorporation of other stable molluscan species.

This microenvironment would be structurally complex, related to an increase of the number of species (Pianka, 1982), an increase of the competence and an increase of specialization for the habitat. These subjects will be entered upon in future researches.

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