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Distribution of Benthic Macro Invertebrates in the Estuarine Ecosystem the Riito, Riohacha - Colombian Guajira

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Abstract

Objective: The research was aimed to describe the distribution of benthic macro invertebrates associated with estuarine ecosystem the Riito (ER) in Riohacha, La Guajira. **Methods:** The benthic macro invertebrates were evaluated in three sites: The Quebrada (LQ), Villa Co familiar (VC) and the mouth (DB) during the period between December (2008) and July (2009). The physical and chemical variables that were identified were: salinity (UPS), water temperature (ºC), Turbidity (cm), alkalinity (mg/l $CaCO_3$), hardness (mg/l $CaCO_3$), pH, OD (mgL^{-1}) % saturation of OD (%), depth (cm), granulometry (%), organic matter (%), the air temperature (°C), precipitation (mm) and humidity. The sediment and biological samples were taken with an Ekman dredge (0.02 m^2). **Findings**: The taxa Artropoda (Malacostraca, Ostracoda and Insecta), Mollusca (Bivalvia and Gasteropoda) and Annelida (Polychaeta) were the populations collected. The average was the 15.995 ind*m^{-2}; the lower value was obtained in December (121 ind*m^{-2}) and the highest in July (3,348 ind*m^{-2}). LQ presented the highest density (4778 ind*m^{-2}). The taxon present at all sites was Tynaponinae, the rich were gender Tubifex and platyrachis Pyrgophorus. The diversity (H') was 0.75 1.24 on LQ; in VC and 1.63 in DB, the richness (R1) was 1.00 1.79 on LQ; in VC and 2.55 in DB and equity (E) 0.66 0.65 in DB, in VC and 0.92 in DB. **Application**: The distribution community structure of agencies such as the abundance, species richness, and the physical and chemical variables of the water, sediment and environmental were correlated. The variations and fluctuations of saturation of OD, Sand Media and very fine sand, silt and clay regulated communities.

Keywords: Benthic Macro Invertebrates, Distribution, Estuarine Ecosystem

1. Introduction

Estuaries are semi-closed areas on the coast where the fresh water of the rivers mixes with the sea water when they are[1]. These systems are developed during transgressions that cause the flood and the disappearance of the deltas[2]. This allows them to be unique environments inhabited by fewer species than other coastal environments but of great importance for the aquatic ecosystems. There are only two types of estuaries as the aquatic system that dominates, dominated by the energy of the waves and dominated by the Tides[3].

The benthic macro invertebrates are some of the most used as indicators of water quality in aquatic environments[4]. These organisms live in intimate contact with the sediment and act as shapers of the place they live. Generally, they are able to reflect different anthropogenic disturbances through changes in its structure, composition or function[5]. The Riito (ER) has an average width of 23.7 m and an average depth of 1.14 m. In times of drought, these values are reduced drastically, but even so, the navigation through the channel becomes accessible to approximately 2 Km. The greater width and depth corresponds to the locations called mouth (DB) and the

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Quebrada (LQ), where the waters reach its highest speed and erosive effects on the edges. To this should be added the negative effect by increasing deforestation and inappropriate land use along its basin.

2. Materials and Methods

The estuarine ecosystem ER is part of the delta of the River Rancheria, in Riohacha, La Guajira in Colombia; it has an extension of 7.2 Km. For the study, three sites were selected: DB is located to 11°33.01"N and 71°58.15"W, on It is a dock for boats of fishermen, activity that produces an effect on the ecological balance of the place. The sediment in this site mainly consists of sand media, a significant fraction of Sand and very fine sand, silt and clay in appreciable quantities. The average depth is 140.03 cm. and the predominant vegetation is trees of *Rhizophora mangle* and *Avicennia germinans*. The second sampling site was called Villa Comfamiliar (VC) located the 11°33.04"N and 71°58.30"W, which is affected by mainly by household waste; the sediment is constitution Limo – Clay with a significant amount of Sand Media and Fine. This place presents an average depth of 88.04 cm, characterized by the presence of a strip of trees of *A. germinans*. Finally, the Quebrada (LQ) is located at the 11° 37.57" N and 71° 50.36" W, near the bridge over the River Rancheria that joins the cities of Barranquilla and Cartagena; the substrate is mainly by Very Fine Sand, Silt, and Clay constitution, with a significant fraction of very fine sand. The body of water in this locality presents depths in excess of 115 cm, where *Albizzea saman*.

Eight samples with a monthly frequency between December 2008 and July 2009 in the three sites; between 9:00 and 15:00 covering the periods of drought and rain; the samples were collected along transects from coast to coast each 2 m and in triplicate (two for the macro benthos and one for the particle size) with an Ekman dredge 0.022 collection area (m^2). In the laboratory of Biology of the University of La Guajira samples were passed through a sieve of 200 µm to separate the invertebrates and subsequently identify them under a magnifying glass stereoscopic to the lowest possible taxonomic level using specialized literature[6-17].

It was determined "in situ" the physico-chemical variables such as salinity (UPS), water temperature (°C), the dissolved oxygen (mgL^{-1}), the oxygen saturation (%) and transparency (cm), for each sampling site and in each month of sampling. For the alkalinity (mgL^{-1} $CaCO_3$) and hardness (mgL^{-1} $CaCO_3$), samples of water (500 ml) of each site and stored in bottles of polyurethane Labeled with the name of the site, then cold were transported to the laboratory of Chemistry of the University of La Guajira for further analysis by the method of EDTA and titling in H_2SO_4. The determination of physico-chemical variables was performed using the methodology described in the Standard Methods[18]. For the particle size of sediment samples were taken (approx. 500grs), then placed in polyurethane bags properly labeled. These samples were dried for later analysis, where he weighed 100 g of dry sediment, which were passed on to a battery with sieves of 850, 355, 212 and 150 µm pore-size respectively in a granulometro Octagon Digital EC with agitation for 15 minutes.

The statistical analysis was carried out using the Software Statgraphis Centurion XVI.II. Tests were used ANOVA and Kruskal-Wallis test to detect significant differences between the variables and the sampling sites. Also, a Spearman's correlation coefficient to observe the relationship between the ecological parameters and the physical and chemical variables. Finally, we performed a cluster analysis (Jaccard Similarity Index) between the samplings (temporal variation) and sites (spatial variation). For the ecological analysis of the macro-invertebrate community used the 5.1 Software first and Past 3.19 to study and compare the density and diversity between stations using the indices of the Shannon-Wiener diversity (H'), Margalef richness (R1), equity of Hill (E1).

3. Results and Discussion

Average salinity in the study area was 9.12 UPS, decreasing of DB at LQ. SNo significant differences were observed between the months of sampling (Kruskal-Wallis test; ρ=0.001, F=31.63) and between sites (Kruskal-Wallis, ρ=0.04; F=4.69). This variable is a determining factor in the estuarine environments, due to their spatial and temporal gradients produce clear changes in the faunal composition and density. The effect of seasonality (rain-drought) and high evaporation rates, determined the variations. During the rainy period were presented lower values due to the entry of water from the watershed that drains this ecosystem and that causes a dilution effect of the materials dissolved in the water. The average temperature of the water was 28.6ºC and increased slightly from LQ and DB. For each site is presented a homogeneous distribution and noted significant differences between the sampling (Kruskal-Wallis, ρ = 0.03 F= 5.05) fact probably due to temporary changes that affected the salinity. In the estuaries also occur marked fluctuations in temperature due to the shallow depth in a wide surface of the water mirror[6].

The oxygen saturation (%) of the submitted values that ranged between 65.82% and 103.5%. There were not significant differences between sites or between sampling (ρ =0.36 F=1.19 and ρ = 0.39 F= 0.97). The dissolved oxygen (mgL-1) presented values ranging between 1.8 mgL^{-1} in DB, 7.53 mgL^{-1} in VC and 5.07 mgL^{-1}on LQ. This variable did not present significant differences between samples and between sites (ρ=0.33 K-W=7.92); (ρ=0.10 K-W= 4.44). However, the progressive increase in each study can have several explanations. One of the possible factors is the process of photosynthesis and mixing the water produced by the wind; which could be observed with intensities strong mainly in DB and VC. The behavior of the OD showed negative association with the salinity of the water. In estuaries, this behavior is normal and it was demonstrated that an increase in the salinity and temperature, decreases the solubility of oxygen in waterq[19].

The transparency ranged between 6 and 89 cm. This variable showed significant differences between sampling (Kruskal-Wallis, ρ=0.028 F=3.11). With the evidence of Fisher's LSD multiple ranges were identified similar groups of 3 months; the first is made up of December and May, the second the months of April and June and the third and most different formed by January, February, March and July. In general, this ecosystem is characterized by shallow in comparison with the adjacent marine environments and therefore the action of the rains and wind moderately affect the transparency of its waters.

The alkalinity ranged between 44.32 and 258.4 mgL^{-1} of $CaCO_3$. There were no statistical differences among the study sites but if between the months of sampling (Kruskal-Wallis, ρ <0.0001; F=18.13). The test of Fisher's LSD multiple range indicates that there are two homogeneous groups, one that forms the months January, February, March and July in which are presented the highest values (maximum value), while in the months of December, April, May and June were presented smaller values (minimum value). The temporal variation of this parameter has been associated with rainfall, and the activity of agencies involved in the cycle of CO_2, such as molluscs that his death released significant amounts of carbonates. Another cause is the precipitation of $CaCO_3$ and its resuspension by effect of the tide and the wind from calcareous soils[20]. The values of this parameter, correspond to very absorbing water and thus contribute to the development of the estuarine biota due to the ability to buffer changes in pH[21].

The hardness of the waters of the estuarine complex the Riíto had a variation from 42 up to 778 mgL^{-1} CaCO3. There were no statistical differences with respect to the months of study (Kruskal- Wallis, ρ =0.0003; F=8.24). The test of Fisher's LSD multiple ranges indicated that there are three homogeneous groups, one consisting of the months March and July; another for the months of February and April. The latter is formed by the month of December. As well as the hardness, alkalinity, indicates in aquatic ecosystems the ability self-regulating or cushion that at a time can present the system and therefore its incidence in the pH and reflects the nature of the geological formations with which the waters are in contact[22].

With regard to the granulometry, the sediment obtained in DB, was made up of very thick sand fraction, with an average of 6.5%, 17.9% Gravel, sand, 28.6% Average 25.3%, fine sand and very fine sand, silt and clay, 21.7%. In VC the fraction of sediment was represented by the fraction of very thick sand with an average of 6.5%, 7.7% Gravel, sand Average 15.9% 27.3%, fine sand and very fine sand, silt and clay, 43.6%. LQ was characterized by presenting the following fractions of sediment; 18.9% Very Coarse Sand, Gravel, sand 13.7% Average 7%, 11.9 % of very fine and very fine sand, silt and clay, 48.3%. In general in ER were averages of the fraction of AMG 10.6%, 13.1% Gravel, sand Average 16.7% 21.5%, fine sand and very fine sand, silt and clay, 37.91%. With regard to the sampling, the percentage of the Very Thick sand showed significant differences (Kruskal-Wallis, p=0.002; F=12.69) showing the influence of drought. For its part, the fraction of Coarse Sand presented no significant differences with respect to their distribution among sites (Kruskal-Wallis, ρ = 0.004; F=11.63). The fraction of Sand Media presented significant differences between samples and between sites (Kruskal-Wallis, p = 0.02; F=6.10 and the Kruskal-Wallis, p = 0.03; F=3.66), the Sand did not present significant differences between the sampling or between sites. On the contrary, the fraction of very fine sand silt clay presented differences in their distribution between the samplings (Kruskal-Wallis, $p = 0.04$; $F=4.80$). The results of the granulometry in ER correspond to the typical pattern of deposition of sediments present in the estuaries. The fine grains (silt-clay) that are suspended are easily drawn toward protected places such as mangroves. On the contrary, the larger particles are deposited in coastal areas such as beaches and coastal areas by the effect of tides and currents[23]. In the studied area collected a total of 420 individuals, belonging to 55 taxa. Due to the absence of studies in the area, 41 are new records for the Colombian Guajira (Table 1).

Table 1. Taxa reported in the estuarine ecosystem the Riito, Riohacha (Colombiam Guajira)

Phylum	Clase	Orden	Familia	Género	Especie	DB	VC	LQ
Artropoda	Insecta	Ephemeroptera	Caenidae	*Caenis* *				X
			Tricorythodea	*Tricorythodes* *				X
			Tipuludae	*Tipula* *				X
		Díptera	Syrphidae	Syrphoidea *				X
			Culicidae	*Culex* *				X
			Ceratopogonidae	*Probezzia* *				X
				Sp1				X
			Chironomidae	*Chironomus* *			X	X
				Subfam. Tanyponinae *		X	X	X
		Hemíptera	Pleidae	*Paraplea* *				X
			Pseudococcida	*Ferrisia* *			X	
		Coleóptera	Elmidae	Sp2				X
		Odonata	Gomphidae	Sp3				X
	Crustacea	Amphidoda	Gammaridae	Gammarus *		X	X	
			Coropiidae	*Corophium* *			X	
	Malacostraca	Decapada	Ocypodidae	Uca		X		
			Portunidae	*Callinectes*			X	
			Panaeidae	Paneaus *		X		
Annelida	Oligochaeta	Heptotaxida	Tubificidae	*Tubifex* *		X		X
	Hirudinea	Glossiphoniiformes	Glossiohiniidae	*Hirudininae**				X
	Polychaeta	Capitellida	Capetellidade	*Capitellida**				X
		Sorbeoconcha	Annicolidae	*Annicola* *				X
			Ancylidae	*Hebatancylus* *				X
Mollusca	Gasterópoda	Mesogastropoda	Littorinidae	*Littorina* *				X
			Hydrobiidae	*Pyrgophorus* *				X
			Conidae	Anachis	*A. obesa* *	X		
			Littorinidae	Littorina	*L. sp*	X		
			Turbunillidae	Turbinilla	*T.sp*	X		
			Olivadae	Oliva	*O. reticularis* *	X		
			Nassaridae	Nassarius	*Nassariuns sp*	X		
					N. antillanus *	X		
		Sorbeoconcha	Annicolidae	Anodata *	*A. sp*	X		
				Amnícola*	*A. sp*	X		

		Cephalaspidea	Bullidae	Bulla	*B. Striata* *	X		
		Archaeograstropoda	Marginallidae	Bullata	*B. Cf. Ovaliformis* *	X		
			Fissurellidae	Hemitoma	*H. sp*	X		X
			Cerithiidae	Bittium	*B. Varium* *	X		
			Caecidae	Caecum	*C. antillarum* *	X		
			Neritidae	Neritina	*N. reclivata* *	X		
	Bivalva	Veneridea	Corbiculacea	*Polymesoda* *				X
			Crassitelidae	Crassinella	*C. lunulata* *	X		
			Sphaeriidae	*Eupera* *				X
			Dreissenidae	*Mytilopsis* *			X	
		Unionoidea	Unionidae	*Anodonta* *				X
		Pteroida	Veneridae	Anamelocardia	*A. brasiliana* *	X		
				Chione	*C. cancellata* *	X		
				Tivela	*T. mactroides* *	X		
		Filibranchia	Cardiidae	Trachycardium	*T. muricatum* *	X		
			Pteriidae	Pteria	*P. sp*	X		
			Arcidae	Arca	*A. zebra* *	X		
				Anadra	*A. chemnitzi* *	X		
					A. ovalis *	X		
		Mytiloida	Chamidae	Chama	*C. macerophyla* *	X		
			Mytilidae	Brachidontes	*B. exustus* *	X		
		Solemyoida	Dreissenudae	Mytilopsis	*M. dominguensis* *	X		
		Neotaenioglosa	Hodrobiidae	Pyrgophorus	*P. platyrachis* *	X		
		Myoida	Corbulidae	Corbula	*C. contracta* *	X		

In DB are totaled 33 taxa within three rows, Mollusca: Classes Clamshell (14) and (14), Gasteropoda Artropoda: Malacostracea (2 classes), Crustacea (1), Insecta (1) and Annelida: class Oligochaeta (1). In VC were collected only seven taxa belonging to two rows: Artropoda: Classes; Insecta (3), Malacostracea (2) and Crustacea (1). The Mollusca: Class; Bivalvia (1). And LQ are reported 23 taxa belonging to the Row Artrópoda: Class Insecta (12), Anelida: Classes Oligochaeta (1), Hirudin (1) and Polychaeta (3). Finally, for the phylum Mollusca: Gasteropoda (3 classes) and Bivalvia (3). In DB, the density of the species was dominated by the mollusc *Anadara chemnitzi* (500 ind*m^{-2}), the gender of the annelid Tubifex (364 ind*m^{-2}) and the shrimp Peneaus sp (136 ind*m^{-2}). In VC the dominant species were formed by the arthropods Chironomus (662 ind*m^{-2}), Corophium (1318 ind*m^{-2}) and Gammarus (1000 ind*m^{-2}). For LQ the dominance of species was represented by the annelid worms of the genus Tubifex (2818 ind*m^{-2}), an unidentified species of the family Capitellidae (1409 ind*m^{-2}) and Hebetancylus (1138 ind*m^{-2}). However the second dominant species was the gastropod *Pyrgphorus platyrachis* (2545 ind*m^{-2}). In general, the average density for the entire area was 15995 ind*m^{-2}.

In terms of the ecological richness (R1) the highest values recorded at each sampling station were dominated by DB with 4.41, followed by LQ with 3.15 and 1.85 with VC. The diversity of species in R can be considered high if compared with other estuarine areas in the Caribbean. The records obtained indicate the dominance of some taxa with similar densities, perhaps due to the sensitivity of the macrobentonicos assemblages of areas environmental disturbances employees to evaluate the effects of pollution and the degree of erosion of the basins[7,6]. Such is the case of the annelid Tubifex (3181 ind*m^{-2}), the mollusc *P. platyrachis* (2590 ind*m^{-2}), the arthropod Corophium sp (1318 ind*m-2) and the annelid worms of the family Capitellidae (1409 ind*m^{-2}). The above, seems to indicate that these bodies, typical of estuaries, have adapted successfully to the stressful conditions of this system. The values of the index of Shannon - Wiener is recorded in each LQ sites, can be explained by the favorable environmental conditions present at the time of sampling, in addition to the reproductive processes of the various agencies. To evaluate and compare with other locations in the Caribbean, the data recorded for the estuarine ecosystem ER is within the range of registered in Caño Sagua (Venezuelan Guajira) and in the estuary of Santos (Brazil) [24-26]. For the values of the index of equity (equity of Hill) registered at each of the sites of samples was 1.00. In ER equity Hill presented the same trend as the diversity and wealth.

To assess the relationship of the biotic attributes (relative abundance, diversity, wealth and equity), with physical and chemical variables of the water and sediments are a test of the Spearman correlation coefficient (rs). Stand out statistically significant relationships between the relative abundance and saturation of oxygen. The wealth and the alkalinity and oxygen saturation and the equity of the sand and very fine sand, silt, and clay. The relative abundance and wealth are related with the saturation of oxygen. This may be related to the hydrodynamic action of the waves carry sediments of greater size and weight compared to the coastal areas, these areas the most optimal for the benthic fauna. It is important to highlight that the variations of the density attributed to the size of the grain (Sand Media and Very Fine sand, silt, and clay)[27].

The Jaccard similarity test showed that from the point of view of the association of species with respect to the sampling in DB, are divided into two groups; the first group is constituted by the sampling of the months of February, June and July. These samples were characterized by the climate of the period of drought. The second group corresponds to the samplings of December, January, March and May. In VC with respect to the samples are divided into two groups. The first group is constituted only for the sampling of March, May and June corresponding to the transition dry. The second group corresponds to the other months of sampling for the period of rains; and on LQ with respect to time, also identified two groups, The first group is made up of the sampling of February, June and July, which corresponds to the climate change in the dry season to the rainy season and the second group make up the rest of the months which correspond to the rainy season. Which indicates that, from the point of view of the species composition of the DB, VC, and LQ through the sampling time present marked differences, mainly by the change of seasons.

4. Conclusion

In general terms the benthic invertebrate fauna of the estuarine ecosystem ER in the Colombian Guajira was represented by three rows: Mollusca, Annelida and Arthropoda. The mollusks were the dominant group in DB, the annelid on LQ and VC. The physico-chemical parameters that explain the dynamics of the estuarine ecosystem the Riíto are salinity and oxygen saturation (%).It was noted that relate to the community of benthic macro invertebrates with physico-chemical variables that the alkalinity, oxygen saturation, the sand media and the very fine sand-silt and clay, regulate the composition and distribution of benthic macro invertebrates. It was identified that this ecosystem presents a typical zonation with a classical behavior estuarine, which distinguish the Gaza dominated by the sea, a central zone which presents a mixed character in relation to the salinity and a region dominated by fluvial contributions.

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