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Research Article

Assemblage of Benthic Macroinvertebrates in Soft Bottoms of the RIÍTO ARM, Rancheria River Deltaic System

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ABSTRACT

Benthic macroinvertebrates associated with soft bottoms are a key element in the balance of aquatic ecosystems, as they play an important role in ecological processes, such as nutrient cycling, dispersal and particle capture, among others. For this reason, the objective of this work was to analyze the assembly of benthic macroinvertebrates associated with soft bottoms in the Riíto arm of the estuarine deltaic system of the Ranchería River, in the department of La Guajira (Colombia). This system has been shown to be highly changeable in previous studies, so it is necessary to carry out environmental monitoring. During the period from September 2022 to January 2023, temperature, pH, conductivity, transparency, depth, alkalinity and hardness of the water were measured in situ, as well as sediment samples were taken to determine its granulometry and organic matter, and to analyse benthic macroinvertebrates, at three sampling sites: Desembocadura (DB), Mirador (EM) and Villa Fátima (VF) along the El Riíto arm in the Rancheria River delta. Two species were found: Pyrgophorus platyrachis and Mytilopsis leucophaeta. The density of organisms was higher in MS, with 62.5 individuals per square meter, although the sampling sites presented only a slight separation according to their physicochemical characteristics, mainly due to the variability of oxygen saturation and mean sand. Only fine sand was associated with the density of P. platyrachis as the dominant species of the El Riíto arm (87.1 % of the total abundance). It is concluded that, according to the composition and abundance of organisms, DB and VF are different from EM, since the latter site showed the highest densities of organisms, which indicated slightly more favorable conditions for them. Likewise, it was evidenced that the physicochemical variability within the estuary is mainly temporary.

Keywords: soft bottoms, estuarine ecosystems, composition, abundance and diversity of molluscs.

INTRODUCTION

Lotic systems are considered one of the most important natural resources for life (Jonsson, Malmqvist, & Hoffsten, 2001). However, in recent decades, these ecosystems have suffered major impacts caused by human activities, leading to a substantial reduction in aquatic biota and, in some cases, its disappearance. (Lara-Lara et al., 2008). The Georgia Adopt-A-Stream Staff (2004), establishes that the animal assemblages that make up aquatic communities function as environmental indicators that make it possible to predict the environmental deterioration of the system; therefore, these benthic organisms have been commonly used for the biomonitoring of aquatic systems (Springer, 2010); These organisms present a wide diversity in terms of sizes, life forms, food, behavior and, in addition, respond quickly to disturbances, since most of them have little mobility, long life cycles, low tolerance to stress and are closely associated with sediment. (Hanson, Springer, & Ramirez, 2010)These are areas where particulate and even toxic organic material accumulates. In addition, they are closely linked to the pelagic food web, so they are also important in nutrient cycling by transporting contaminants to higher trophic levels.

Lotic ecosystems experience anthropogenic alterations, such as the containment and regulation of watercourses, which cause alterations in the magnitude of flows and in the frequency of fluctuations. Additionally, they experience natural impacts ranging from hurricanes and tornadoes to extreme or highly changing climates, which influence the composition and abundance of aquatic biota, which can result in ecosystem imbalance. (Hurtado, García Trejo, & Gutiérrez Yurrita, 2005). Deltaic systems are exposed to modifications derived from river discharges and domestic waste, factors that lead to abrupt alterations in salinity, sediments and organic matter. (Pagola-Carte & Saiz-Salinas, 2001; Salen-Picard & Arlhac, 2002). The Rancheria River, located in La Guajira, Colombia, plays a crucial role for biological development, as well as playing a significant role as a habitat for numerous species. However, it experiences environmental damage from human activities, making it a site with a characteristic pressure linked to fishing. (Molina-Bolívar, Jiménez-Pitré, & Bastidas-Barrannco, 2018).

The estuary of the Ranchería River is not exempt from environmental challenges, since the wastewater from the city of Riohacha is discharged into the Riíto branch (Lema Vélez & Polanía, 2007). High levels of coliforms have also been recorded (Molina-Bolívar & Jiménez-Pitre, 2017). The system exhibits high temporal variability, particularly notable due to its location in a region with insufficient rainfall (Lema Vélez & Polanía, 2007). This variability is especially manifested during climatic periods such as El Niño, which makes it a highly changing system (Molina-Bolívar, Jiménez Pitre, & Nava Ferrer, 2017). It is imperative to monitor the invertebrate fauna, especially if information about its macroinvertebrate biota has been accumulated since 2009 (Molina-Bolívar et al., 2018). As areas of great importance due to their biodiversity and biological production, and as sources and/or deposits of material circulating along coastal ecosystems, a thorough study is required to understand the environmental conditions in which they are found, especially in regions with a high probability of adverse effects (extremely dry climate and wastewater discharge). as is the case of the Ranchería River in its Riíto branch (Molina-Bolívar et al., 2018). In addition, benthic macroinvertebrates are essential elements of water bodies, since they accelerate the decomposition of detritus; in addition, they play a crucial role in the food chain (Castellanos & Serrato, 2008). Soft bottoms are the predominant substrate zone for benthos in lotus ecosystems, composed of the accumulation of sedimentary particles that constitute an unstable substrate of low topographic complexity. These provide sustenance and protection to a wide range of organisms that constitute the infauna and epifauna (Guzmán-Alvis & Ardila, 2004).

The need for research of this type lies in its ability to expand and enrich the understanding of the composition, abundance and diversity of these organisms, as well as to understand their long-term dynamics. Consequently, we seek to obtain data that generate a perspective that can explain the variations in the assemblage of benthic macroinvertebrates in the El Riíto arm of the Ranchería River delta, especially in the framework of contemporary environmental modifications derived from global climate change (Heino, Virkkala, & Toivonen, 2009). Therefore, the purpose of this article was to identify the factors that affect the assembly of benthic mollusks in the Riíto branch of the Ranchería River, Colombian Caribbean, during the period between September 2022 and January 2023 within the framework of the project "Base line and environmental monitoring for the validation of environmental quality indices in tourist beaches and mangroves of the coastal coast (Riohacha -La Guajira, Colombia)".

MATERIALS AND METHODS

Study Area

The department of La Guajira, with an approximate area of 20,848 km2, has historically been divided into three regions: Alta Guajira, Media Guajira and Baja Guajira. The delta of the Ranchería River, located northeast of the municipality of Riohacha. It is important to note that the peninsula of La Guajira is frequently subject to the influence of the trade winds from the northeast, which favor conditions of pronounced aridity. Consequently, moisture-laden clouds are directed southwest, resulting in an arid, dry climate and high temperatures in the peninsula. In reality, rainfall is infrequent and usually occurs from September to November, during which time the Tropical Convergence Zone (ITCZ) moves northwards. According to Castellanos & Carabalí (2014). The delta of the Ranchería River flows into the Caribbean Sea, composed of two arms identified as El Riíto and Calancala, respectively (Molina-Bolívar & Jiménez-Pitre, 2017).

Location and Description of Sampling Sites

For this research, the three sampling sites established by Molina-Bolívar et al., (2010) were chosen; specifically DB, EM and VF. The DB (11°33'14.10"N — 72°54'10.72"W): this is located in the transition region between DB and the port of landing for fishing vessels. The sediment is composed primarily of medium sand, with a significant proportion of fine sand, while very fine sand, silt, and clay are present in significant quantities (Molina-Bolívar et al., 2018). The average depth is 140.03 cm. An abundance of *Rhizophora mangle* and *Avicennia germinans* trees is observed. EM (11°33'14.20"N - 72°54' 7.60" W): the sediment present in this place has a silt-clayey constitution, with a considerable amount of medium and fine sand (Molina-Bolívar et al., 2018) It is characterized by having an average depth of 88.04 cm. This region is distinguished by the extension of the mangrove band with the presence of trees of *A. germinans* and *R. Mangle*. VF (11° 33' 01.4" N - 72° 53' 51.2" W): the substrate is composed primarily of very fine sand, silt and clay, with a significant proportion of very fine sand, with a predominance of R. Mangle (Molina-Bolívar et al., 2018).

Sample Collection

The samplings were carried out approximately every fifteen days, from September 2022 to January 2023, with a total of eight samplings, between 7:00 a.m. and 12:00 m., highlighting a period of transition from drought to rainfall. It should be noted that a rapid assessment protocol was implemented for this study (RAMSAR, 2010). In each sampling and sampling site, the physicochemical variables in the water were evaluated, specifically temperature (°C), conductivity (µS/cm), pH and oxygen saturation (%) using a WTW model 3320 multiparameter probe. Additionally, the transparency (cm) was established using a Secchi disk and the depth (m) using a ruler. For the determination of hardness and alkalinity, water samples (500 ml) were collected at each location and stored in marked polyethylene containers (site and sampling). Subsequently, they were refrigerated until they were transported to the laboratory of the University of La Guajira for analysis. In each place and sampling, sediment was collected using an Ekman dredge to determine the organic matter content (%) and the granulometry (% of each fraction); These fragments were placed in properly labeled plastic bags, refrigerated in the laboratory until their analysis. The collection of benthic macroinvertebrates was done in triplicate for each site at random, at a distance of approximately 1.4 meters from the margin. Sediment samples were collected using an Eckman dredge with a catch area of 0.022 m2 (IBP, 1971), and were filtered "in situ" by a 200 µm mesh opening sieve. The contents of these samples were deposited in hermetically sealed plastic bags, to which formalin was incorporated to consolidate the samples. Later, they were transferred to the Laboratory of the University of La Guajira.

Laboratory tests

The incineration and weight loss procedure was used to determine the organic matter content (Páez Osuna, Fernández Pérez, & Lee, 1982). For this purpose, a portion of 20 g was extracted on an analytical balance (± 0.0001g) and dried in an oven at 100 °C for a period of 24 hours. Subsequently, it was subjected to a calcination process in a muffle at a temperature of 550 °C for one hour, underlining that the weight loss reflected the organic matter present in the sample, represented as a percentage (APHA, AWWA, & WEF, 2012). The texture of the sediment (granulometry) was determined by selecting samples in the open air. Subsequently, each one was subjected to a crushing process by a mill to reach a weight of 100 grams. These were filtered through a sieve battery of 740µm (coarse sand), 355µm (medium sand), 180µm (fine sand), 90µm (very fine sand) and 63µm (silt and clay). Separation was carried out using an Octagon Digital CE brand particle size meter for a period of 15 minutes. The remaining particles in each sieve were categorized according to the size of the particle, weighed and the percentage corresponding to each one was determined. The organisms were examined using a stereoscope for quantification and identification until the lowest possible taxonomic level was reached, following the taxonomic keys proposed by Thompson (2004) and Warmke & Tucker Abbott (1997). Only living organisms were taken into account during the sample collection process, thus excluding thanatocenosis.

Data Analysis

Specific richness (S) together with the density of organisms (inds/m2) were established as structural attributes of benthic macroinvertebrates (Magurran, 1988). The determination of significant differences between the sites and months of sampling in relation to physicochemical variables and the density of organisms was performed by analysis of variance (ANOVA) with Tuckey's a posteriori test. In case the data met the parametric assumptions (normality and homogeneity), a Kruskal-Wallis analysis was used. Additionally, a Spearman correlation was implemented to identify possible linear relationships between the abiotic and biotic variables investigated, all through the Statgraphics Centurion XVI software. A cluster analysis was performed using a Bray-Curtis similarity matrix, using Past 3.18 software (Hammer, Harper, & Ryan, 2001).

RESULTS

Physicochemical variables

Oxygen saturation registered an average of 83.8% for the study area, highlighting notable discrepancies (H= 8.65; P= 0.01) between the sampling sites. All stations presented different saturation values, with the lowest saturation levels recorded in DB, with an average value of 79.8% (Table 1). Although a variation in this variable was recorded during the entire study period for the El Riíto arm, no significant temporal differences were detected (H= 9.60; P= 0.21), highlighting November as the month with the lowest oxygen saturation values. The entire study area recorded an average pH of 7.8, with very similar average values between the sampling sites, with 7.7; 7.8 and 7.8 for DB, EM and VF respectively. No significant differences were detected between sites (F= 0.57; P = 0.57), showing homogeneous values throughout the El Riíto arm (Table 1). Additionally, significant variations in pH were identified (H= 16.2; P = 0.02), with fluctuations that show that sampling 1, sampling 2 and sampling 5 exhibit significant differences between them, suggesting that pH exhibits predominantly temporal variability in the study area.

Table 1. Mean values (☐), standard deviation (SD), maximum (Max) and minimum (Min) values of the physicochemical variables of the water in the sampling sites of the El Riíto arm of the deltaic estuary system of the Rancheria River.

VARIABLES	VALUE	SAMPLING SITES		
		DB	IN	VF
Oxygen saturation (%)	☐ ± OF	79.8 ± 2.97 c	86.4 ± 5.99A	85 ± 3.99 b
	Max - Min	82.7 to 73.1	97.0 to 78.7	92.1 to 78.8
pH	☐ ± OF	7.7 ± 0.36 to	7.8 ± 0.15 to	7.8 ± 0.21 to
	Max - Min	8.3 to 7.0	8.1 to 7.6	8.0 to 7.5
Temperature (°C)	☐ ± OF	29.3 ± 0.53	29.3 ± 0.55 to	29.7 ± 0.89 to
	Max - Min	29.9 to 28.4	30.0 to 28.5	31.0 to 28.5
Conductivity (mS / cm)	☐ ± OF	464.2 ± 72	402.8 ± 59.6 to	392.5 ± 64.2 to
	Max - Min	544.0 to 312.0	504.0 to 301.0	501.0 to 300.0
Alkalinity (mg / L CaCO3)	☐ ± OF	107.05 ± 15.6 to	104.06 ± 13	101.73 ± 14.4 to
	Max - Min	129.0 to 91.1	128.0 to 91.1	123.1 80.8
Hardness (mg / L CaCO3)	☐ ± OF	280.6 ± 169.7 to	191.3 ± 122.4 to	241.7 ± 113.8 to
	Max - Min	540.0 to 110.0	420.0 to 28.0	460.0 to 120.0
Transparency (cm)	☐ ± OF	13.1 ± 2.47 to	13.3 ± 3.7 to	12.6 ± 3.65 to
	Max - Min	17.0 to 10.0	18.0 -6.0	19.0 to 8.0
Depth (m)	☐ ± OF	2.48 ± 0.58 b	2.8 ± 0.58 b	3.05 ± 0.49
	Max - Min	3.9 to 2.1	4.1 to 2.2	3.9 to 2.2

Different letters in the same row indicate significant differences at 95% confidence.

The average water temperature in the El Riíto arm was 29.4 °C, with very similar values among the study sites. No significant differences were detected in this variable (F= 1.01; P = 0.38), even when VF exhibited the highest mean value and the greatest variability (Table 1). The temporal dynamics of the temperature showed variations indicative of lower values of this variable in samplings 5 and 6, and notable temperature discrepancies were recorded between the samples (H= 18.4; P = 0.009) throughout the study area. The mean conductivity value for the study area was 419.8 µS/cm, with the highest value recorded in DB with 464.2 µS/cm, followed by ME with 402.8 µS/cm and VF with 392.5 µS/cm. However, no significant differences in conductivity were observed between the sampling sites (F= 2.80; P= 0.08) during the study period (Table 1). In addition, notable differences in conductivity were detected between the samples (H= 14.9; P= 0.03), with variations in this variable throughout the study period. These data suggest that samples 1, 3, and 5 exhibit differences from each other, with average values of 448, 516.3, and 304.3 µS/cm respectively, with November registering the lowest conductivity value throughout the study period.

The El Riíto arm recorded an average alkalinity of 104.2 mg/L of CaCO3. The highest value was recorded in DB with 107.0 mg/L CaCO3, followed by ME with 104.0 mg/L CaCO3, and VF with 101.7 mg/L CaCO3. However, no significant differences in alkalinity were detected between the sampling sites (H= 0.73; P = 0.69) (Table 1). From a temporal perspective, notable differences in alkalinity were detected between the samplings (H= 20.5; P= 0.004), with considerable variability in this variable that mainly distinguishes samplings 1, 2, 4, 5 and 7 from each other, which shows a significant temporal variation. The average hardness in the El Riíto arm was 237.9 mg/L CaCO3, with the highest value recorded in the DB with 280.6 mg/L CaCO3, followed by VF with 241.7 mg/L CaCO3 and finally EM with 119.3 mg/L CaCO3. However, no significant differences in hardness were observed between the sampling sites (F= 0.85; P= 0.44), which indicates a homogeneous distribution of this variable (Table 1). From a temporal perspective, significant differences were observed in hardness (H= 14.7; P= 0.03), with a notable variability throughout the study period, with samples 1, 5, 6 and 7 showing differences between them, with the lowest values recorded in December.

Transparency in the study area registered an average value of 13 cm, in EM it presented the highest value with 13.3 cm, followed by DB with 13.1 cm and finally VF with 12.6 cm. However, no significant differences were detected between the sampling sites (F= 0.09; P = 0.91), which suggests a homogeneity in this specific variable for the entire study area (Table 1). During the research period, significant differences in transparency were detected between the samples carried out (F= 12.38; P < 0.001), mainly highlighting sampling 1, 2 and 4. This sampling experienced a progressive increase throughout the aforementioned months, and then decreased, which resulted in a fluctuation of this variable during the study period. The depth in the estuarine system registered an average of 2.77 m in the study area, with VF registering the highest average value with 3.05 m.

However, this average value showed significant differences (H= 6.72; P = 0.03), compared to the EM and DB sites, which registered average values of 2.80 and 2.48 m respectively (Table 1). In addition, notable differences in depth were observed during the sampling months (F= 6.18; P= 0.0013), distinguishing sampling 5, which has the highest average value (3.96 m), from the rest of the months or days of sampling. The lowest average value was recorded in December (2.2 m), after the greatest depth observed, which indicates a significant fluctuation of this variable.

The average value of organic matter present in the sediment in the El Riíto arm was 7.2 %. The presence of significant differences in organic matter between the sampling sites (F= 7.07; P= 0.004), particularly between DB (8.12 %) and ME (6.37 %), while VF did not vary at any of the sites (Table 2). At the temporal level, no significant variations in organic matter were detected between the samplings (F= 0.96; P= 0.49), although a slight variation in this variable was observed throughout the research period.

In relation to the sediment collected in the DB, the average percentage of coarse sand was 58.6%, medium sand 19.1%, fine sand 13.7%, very fine sand 4.7% and silt-clay 2.5%. In contrast, in EM, the coarse sand fraction presented an average value of 54.9%, medium sand of 23.2%, fine sand of 12.4%, very fine sand of 4.8% and silt-clay of 3.4%. VF was characterized by an average of 58.3% coarse sand, 19.5% medium sand, 12.8% fine sand, 4.8% very fine sand and 3.5% silt-clay. It is emphasized that the significant differences (P > 0.05) for the particle size fractions did not show significant differences between the sampling sites, with the exception of silt and clay (H= 11.35; P= 0.0034). In VF, higher values were presented, compared to the rest of the sampling sites (Table 2). No significant variations were detected between the particle size fractions of the sediment (P > 0.05).

Table 2. Mean values (☐), standard deviation (SD), maximum (Max) and minimum (Min) values of the physicochemical variables of the sediment in the sampling sites (DB, EM and VF) of the El Riíto arm in the deltaic system of the Rancheria River.

VARIABLES	VALUES	SAMPLING SITES		
		DB	IN	VF
Organic material	☐ ± OF	8.1 ± 0.91 to	6.3 ± 0.87 b	7.3 ± 0.99 ab
	Max - Min	9.5 to 7.0	7.5 to 5.0	9.0 - 6, 0
Gross sand	☐ ± OF	58.6 ± 1.95 to	54.9 ± 5.6 to	58.3 ± 1.6 to
	Max - Min	62.8 to 56.5	59.4 to 42.8	60.4 to 54.7
Half Arena	☐ ± OF	19.1 ± 0.42	23.2 ± 6.08 to	19.5 ± 3.08 to
	Max - Min	19.8 to 18.5	35.6 to 18.9	26.4 to 15.5
Fine Sand	☐ ± OF	13.7 ± 1.04 to	12.4 ± 2.27 to	12.8 ± 2.62 to
	Max - Min	15.6 to 12.2	14.8 to 7.9	17.6 to 8.0
Very fine sand	☐ ± OF	4.7 ± 0.97	4.8 ± 0.85 to	4.8 ± 1.43 to
	Max - Min	5.8 to 2.5	5.7 to 3.0	7.8 to 2.7
Silt and clay	☐ ± OF	2.5 ± 0.34 b	3.4 ± 1.87 b	3.5 ± 0.37 to
	Max - Min	3.0 to 1.9	8.0 to 2.3	4.1 to 2.9

Different letters in the same row indicate significant differences at 95% confidence.

Benthic macroinvertebrates

In the investigated region, a cumulative total of fifty-four (54) specimens were collected, classified in the phylum Mollusca, represented by *P. platyrachis* (Thompson, 1968); Littorinimorpha: Cochliopidae *and M. leucophaeta* (Conrad, 1831); Myida: Dreissenidae. Species-specific richness (S) was quantified as two (2) distinct species. The highest density was observed at the EM site (62.52 ind/m2), followed by DB (24.63 ind/m2) and, finally, VF (15.16 ind/m2), suggesting that no statistically significant variations were identified between the sampling sites (H= 1.95; P= 0.376). Throughout the study, there was a small variation in density values, with an upward trend culminating in a maximum average value in December (sample 7) of 106.1 inds/m2, before a subsequent decline. However, it is pertinent to emphasize that no significant differences were observed (H= 9.14; P = 0.24) among the samples collected in the area of the El Riíto arm (Figure 1).

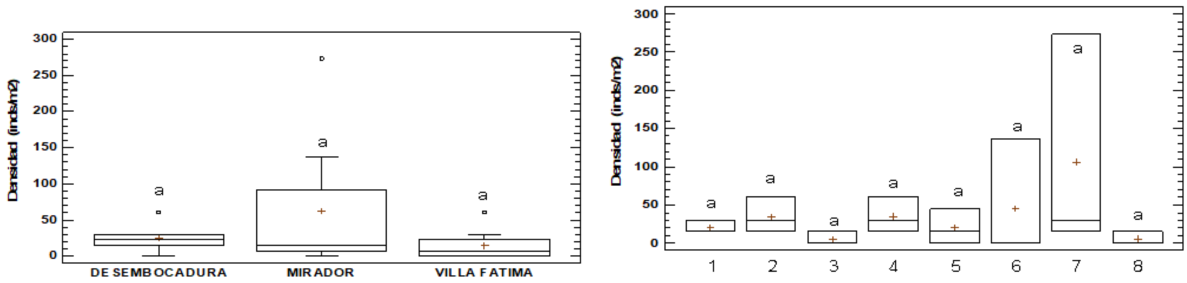

Figure 1. Organism density values for each of the sampling sites of the El Riíto arm, in the Ranchería River delta. A) Sampling sites; B) Sampling (1-8). Different letters indicate significant differences at 95% confidence.

For each of the sampling sites and throughout the period studied, the density was observed fluctuating, however, the highest average value recorded was obtained in the MS with 272.7 inds/m², while in some months no organisms were found in some sites, such as October (sampling 3) for the ME and VF, as well as during December (sampling 6) for DB and VF (Figure 4). The density values are represented by the snail *P. platyrachis* both for each of the sampling sites and for the entire study area, with an average density of 29.7 inds/m² (87.1 %), with respect to *M. leucophaeta* with 4.4 inds/m² (12.9 %) (Table 3). Specifically for each of the sampling sites, a constant dominance of the snail *P. platyrachis* was observed, with a higher density in ME (54.9 inds/m²), while *M. leucophaeta* also registers its highest density value in this particular sampling site (Table 3).

Table 3. Average density (inds/m2) and relative abundance (%) values for each of the species found by each sampling site and for the entire El Riíto arm, in the

delta the Rancheria River.

Species	Density (inds/m2)						Arm The Riíto	
	DB		IN		VF			
	inds/m2	**%**	**inds/m2**	**%**	**inds/m2**	**%**	**inds/m2**	**%**
Pyrgophorus platyrachis	22,7	92,3	54,9	87,9	11,4	75	**29,7**	**87,1**
Mytilopsis leucophaeta	1,9	7,7	7,6	12,2	3,8	25	**4,4**	**12,9**
Total	24,6	100	62,5	100	15,2	100	**34,1**	**100**

Based on the species composition identified in each of the sampling sites, it was determined that DB and VF show a higher degree of similarity to each other (66%), while these sites show a lower degree of similarity to EM (48%). This observation allows us to infer the existence of two distinct groups (Figure 2); however, it is essential to note that these discrepancies are mainly attributed to the abundance of species rather than to their composition, with EM having the highest population densities. A direct correlation was identified between the overall density and density of *P. platyrachis* in combination with very fine sand, meaning that an increase in the proportion of this sediment fraction corresponded with elevated density levels (Table 4); conversely, no correlation was identified between any other physicochemical variable and the biological variables examined in this study.

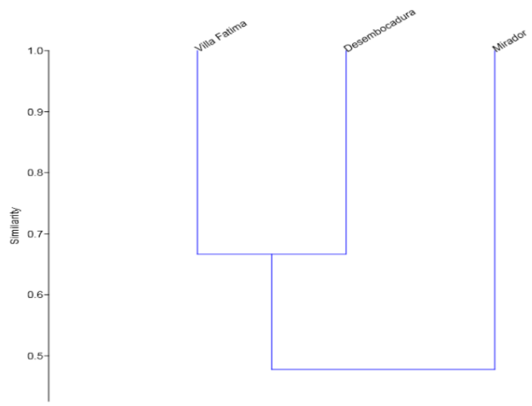

Figure 2. Analysis of clustering between the sampling sites in the El Riíto arm, in the Rancheria River delta.

Table 4. Correlation values obtained between the physicochemical and biological variables in the El Riíto branch, delta of the Ranchería River.

Physicochemical variables	Biological Variables		
	Density *P. platyrachis* (Inds/m²)	Density *M. leucophaeta* (Inds/m²)	Density Total (Inds/m²)
Oxygen Saturation (%)	r= -0,11 p= 0,59	r= 0,40 p= 0,05	r= 0,40 p= 0,05
pH	r= 0,34 p= 0,09	r= 0,08 p= 0,67	r= 0,08 p= 0,67
T (°C)	r= -0,11 p= 0,60	r= -0,07 p= 0,70	r= -0,07 p= 0,70
Conductivity (µS/cm)	r= 0,08 p= 0,68	r= -0,34 p= 0,09	r= -0,34 p= 0,09
Alkalinity (mg CaCO3/L)	r= 0,01 p= 0,94	r= -0,36 p= 0,08	r=-0,36 p= 0,08
Dureza (mg CaCO3/ L)	r= 0,10 p= 0,60	r= -0,36 p= 0,07	r= -0,36 p= 0,07
Transparency (cm)	r= -0,13 p= 0,52	r= 0,13 p= 0,51	r= 0,13 p= 0,51
Depth (m)	r= -0,15 p= 0,46	r= 0,26 p= 0,21	r= 0,26 p= 0,21
Arena Gruesa (%)	r= -0,07 p= 0,72	r= 0,13 p= 0,50	r= 0,13 p= 0,50
Arena Media (%)	r= -0,18 p= 0,36	r= -0,21 p= 0,29	r= -0,21 p= 0,29
Playing Fina (%)	r= 0,28 p= 0,16	r= -0,06 p= 0,76	r= -0,06 p= 0,76
Very fine sand (%)	**r= 0,42 p= 0,04**	r= 0,09 p= 0,65	**r= 0,46 p= 0,02**
Silt and Clay (%)	r= -0,18 p= 0,37	r= 0,24 p= 0,24	r= 0,24 p= 0,24
Organic Matter (%)	r= 0,06 p= 0,74	r= -0,11 p= 0,60	r= 0,11 p= 0,57

r: correlation coefficient / P: probability (alpha = 0.05). In bold, values with significant relationships.

DISCUSSION

The findings derived from this study indicate a markedly decreased richness of benthic macroinvertebrate taxa in the El Riíto arm throughout the period examined, with only two taxa identified; in addition, there is a pronounced dominance of the gastropod *P. platyrachis*, which constitutes more than 80% of the total abundance of organisms, suggesting that the prevailing environmental conditions disproportionately favor this species in relation to with the temporal *bivalve M. leucophaeta* ; alteration is observed when contrasting the composition and abundance metrics of the El Riíto arm between December 2008 and July 2009, which showed a specific richness that exceeded 30 species, and average abundances that exceeded 1000 ind/m2 (Molina-Bolívar et al., 2018), substantially higher than the densities recorded in the current research (34.1 individuals/m2). illuminating the dynamic ecological fluctuations within the Rancheria River estuary. Even more worrying is the observation that exclusively representatives of molluscs are present, with the absence of other taxa such as annelids (Polychaeta and Oligochaeta) or arthropods (Insecta and Decapoda), which were previously documented in the El Riíto arm (Molina-Bolívar et al., 2018).

The most outstanding environmental characteristics in the present study are low conductivity (low salinity), as well as values of pH, temperature, alkalinity, hardness, transparency and depths significantly fluctuating at the temporal level, which explain that the sampling was carried out in a time between drought and rainfall, where rainfall perhaps had a greater influence, since it explains the decrease in temperature and conductivity to the minimum recorded during sampling 5. as well as a maximum depth during this same month. The rainy season is one of the main factors that generate changes and fluctuations in estuarine systems (Bianchi, 2007; Rodríguez, 2000), in addition to the fact that the months with the highest rainfall in the area of the El Riíto arm are September and November (IDEAM, 2018), which is partly evidenced by the dynamics observed in the present study.

In the Rancheria River delta, highly changing conditions have been evidenced over time, mainly salinity (conductivity), which shows that the estuary is an environment of extreme conditions, with salinities ranging from zero (0) to levels above 60 UPS, which only euryhaline and widely tolerant species can withstand (Molina Bolívar et al., 2017). Therefore, the presence and dominance of *P. platyrachis* in the El Riíto arm, as a temporary condition of favor, since this is a species associated with fresh or brackish waters (Mario Nava Ferrer, Severeyn, & Machado, 2011; Thompson, 2004), hence the maximum density value obtained at the EM station (272.7 inds/m^2), during the month of December (6), which may have been a reflection of some reproductive stimulus due to the drop in conductivity in November, especially since the families Hydrobiidae and Cochliopidae, the latter to which it belongs *P. platyrachis*, are characterized by presenting species with annual life cycles, in addition to their already mentioned condition towards mainly fresh or low-salinity waters (Thompson, 2004). The snail *P. platyrachis*, has already been recorded in the El Riíto arm, as one of the dominant species at the sediment level (2545 inds/m^2), especially in areas far from DB (Molina-Bolívar et al., 2018).

For its part *M. leucophaeta*, belongs to a genus of organisms also associated with fresh and brackish waters (MolluscaBase, 2018)in fact *M. sallei* (synonymous *M. dominguensis*) is the species reported in the sediments of the estuary of the Rancheria River delta (Molina-Bolívar et al., 2018), although they seem to be valid species for science (WoRMS, 2018), it could be a synonymy between the two (*M. leucophaeta* and *M. sallei*). Although some species of this genus have been recorded as exotic in other parts of the world (Fernandes, Salgueiro, Miyahira, & Caetano, 2018; Salgado-Barragán & Toledano-Granados, 2006; Kringpaka Wangkulangkul, 2018), others are common in the Caribbean (Warmke & Tucker Abbott, 1997). The wide variety of substrates in which it can colonize is highlighted *M. leucophaeta*, such as muddy sand, rocks, shells of other organisms, and roots of *R. mangle* (K Wangkulangkul, 2009), however, although there is a low abundance of this species in the sediments of the El Riíto arm for the present study, the dominance of *M. leucophaeata* at the roots of *R. mangle* in the Rancheria River Delta (Molina Bolívar et al., 2017), which also explains the large number of dead shells of this particular bivalve found in the sediment (direct observation).

The larvae of *M. leucophaeata* they are very resistant to sudden environmental changes, however, their optimal salinities are above 5 UPS (at temperatures of 30 ^{Oc}) (Verween, Vincx, & Degraer, 2007), so similar conditions could occur in other species of this genus, especially those reported in brackish waters, such as those associated with the estuary of the Rancheria River delta at certain periods of the year (Molina Bolívar et al., 2017; Molina-Bolívar et al., 2018); as waters with very low conductivities (salinities of approximately 0 UPS) were found during the period studied, low abundances of *M. leucophaeta*, which may be more adapted to brackish or estuarine conditions.

The relationship between biotic and abiotic factors is widely documented in the literature, especially in studies of benthic macroinvertebrates, showing that environmental factors of both water and sediment are closely associated (Cognetti, Sará, & Magazzú, 2001; M Nava Ferrer & Severeyn, 2010), in the latter, organic matter and granulometry are highly conditioning of the composition and abundance of organisms (Soto, Quiroga, Ganga, & Alarcon, 2017); For this reason, the direct correlation obtained between the density of *P. platyrachis* and the content of very fine sand, indicating that in the areas where the largest amount of sand was found, there was an increase in the density of the snail. Molina *et al.,* (2018), found significant relationships between richness and very fine sand in the El Riíto arm; however, the richness found in the present study was very low, and without any relation to the abiotic variables studied during the period September 2017-January 2018.

Environments under changing, even stressful, conditions present adverse effects on biological diversity, where not only natural changes can affect organisms, but also changes that can be attributed to humans, especially in the Rancheria River system, where the El Riíto branch is associated with the city of Riohacha. whose wastewater inputs form a source of pollution (Lema Vélez & Polanía, 2007; Molina-Bolívar & Jiménez-Pitre, 2017). Even cyclical environmental events, such as the El Niño phenomenon, show a strong drought in the Colombian Caribbean area, which brought the Rancheria River delta to very high salinity concentrations (> 60 UPS) (Molina Bolívar et al., 2017), and that may explain the difference in wealth between time periods, as Capetillo-Piñar points out *et al.,* (2016), who recorded a drop in taxonomic diversity during different periods, in their case as a result of the increase in cyclonic activity (hurricane winds) in the Gulf of Batabanó, Cuba.

The combination of environmental events or factors can affect the diversity, composition and abundance of benthic macroinvertebrates, among other organisms throughout aquatic systems, which allows us to infer that the ecology within the El Riíto estuarine system presents a multifactorial condition in time and space; therefore, perhaps, EM showed higher density of organisms, since it exhibited higher oxygen saturation values and lower levels of particulate organic matter, which are favorable for benthoid organisms (Cognetti et al., 2001), compared to DB and VF, which presented lower values in oxygen saturation and higher loads of organic matter, highlighting the relationship between these factors, where the greater the amount of organic matter, the greater the bacterial respiration as a result of the decomposition process, so oxygen decreases (Wetzel, 2001).

It is highlighted that the physicochemical variability observed in the system is mainly temporary, which can in some way affect the organisms, as a consequence of the instability of conditions, although no relationship was observed between the variables and the organisms studied except for the very fine sand; it is important to mention that benthic macroinvertebrates did not show a differentiation based on richness between the stations, but rather according to their abundance, where EM differs from the rest of the stations, mainly due to a higher density of organisms as observed in the clustering analysis.

CONCLUSIONS

The characterization of benthic macroinvertebrates associated with soft substrates in the El Riíto arm of the Rancheria River estuary during the course of the research included the species *P. platyrachis* and M. leucophaeta. The observed limited abundance can be attributed to the low conductivity recorded (indicative of low salinity) together with temporal fluctuations of physicochemical parameters, particularly during prolonged cycles, implying significant temporal variability in these factors. Depending on the composition and density of the organisms, the locations of DB and VF show clear differences with those of EM, since the latter site registered high densities of these organisms, indicating conditions conducive to their proliferation. It is pertinent to recognize that the density of this organism was directly correlated with the very fine sand, which was predominantly inhabited by the gastropod *P. platyrachis*, which emerged as the most representative species in the present study, constituting 87.1% of the total abundance of organisms for the entire El Riíto arm. It is recommended to continue monitoring benthic macroinvertebrates and water quality in the El Riíto branch, as well as throughout the Rancheria River delta, to allow for more accurate temporal comparisons.

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